

CHAPTER

27

Flight Controls

**CHAPTER 27
FLIGHT CONTROLS**

Subject/Page	Date	COC	Subject/Page	Date	COC
27-EFFECTIVE PAGES			27-02-00		
1 thru 15	Sep 05/2018		1	May 05/2015	
16	BLANK		2	May 05/2015	
27-CONTENTS			3	May 05/2015	
1	Sep 05/2016		4	May 05/2015	
2	Sep 05/2016		5	May 05/2015	
3	May 05/2018		6	May 05/2015	
4	Jan 05/2017		7	May 05/2015	
5	Jan 05/2017		8	Sep 05/2016	
6	Jan 05/2017		9	Sep 05/2016	
7	Jan 05/2017		10	Sep 05/2016	
8	Jan 05/2017		11	Sep 05/2016	
9	Jan 05/2017		12	Sep 05/2016	
10	Jan 05/2017		13	Sep 05/2016	
11	Jan 05/2017		14	Sep 05/2016	
12	Jan 05/2017		15	Sep 05/2016	
13	Jan 05/2017		16	Sep 05/2016	
14	Jan 05/2017		17	Sep 05/2016	
15	Jan 05/2017		18	Sep 05/2016	
16	Jan 05/2017		19	Sep 05/2016	
27-00-00			20	Sep 05/2016	
1	Sep 05/2016		21	Sep 05/2016	
2	Sep 05/2016		22	Sep 05/2016	
3	May 05/2015		23	Sep 05/2016	
4	BLANK		24	Sep 05/2016	

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25	Sep 05/2016		47	Sep 05/2016	
26	Sep 05/2016		48	Sep 05/2016	
27	Sep 05/2016		49	Sep 05/2016	
28	Sep 05/2016		50	Sep 05/2016	
29	Sep 05/2016		51	Sep 05/2016	
30	Sep 05/2016		52	Sep 05/2016	
31	Sep 05/2016		53	Sep 05/2016	
32	Sep 05/2016		54	Jul 25/2018	
33	Sep 05/2016		55	Jul 25/2018	
34	Sep 05/2016		56	Sep 05/2016	
35	Sep 05/2016		57	Sep 05/2016	
36	Sep 05/2016		58	Sep 05/2016	
37	Sep 05/2016		59	Sep 05/2016	
38	Sep 05/2016		60	Sep 05/2016	
39	Sep 05/2016		61	Sep 05/2016	
40	Sep 05/2016		62	Sep 05/2016	
41	Sep 05/2016		63	Sep 05/2016	
42	Sep 05/2016		64	Sep 05/2016	
43	Sep 05/2016		65	Sep 05/2016	
44	Sep 05/2016		66	Sep 05/2016	
45	Sep 05/2016		67	Sep 05/2016	
46	Sep 05/2016		68	Sep 05/2016	

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27-02-00 (cont.)			27-03-00 (cont.)		
69	Sep 05/2016		21	May 05/2015	
70	BLANK		22	May 05/2018	
27-03-00			23	May 05/2018	
1	May 05/2015		24	May 05/2018	
2	May 05/2015		25	May 05/2018	
3	May 05/2015		26	May 05/2018	
4	May 05/2015		27	May 05/2018	
5	Sep 05/2016		28	May 05/2018	
6	Sep 05/2016		29	May 05/2018	
7	May 05/2015		30	May 05/2018	
8	May 05/2015		31	May 05/2018	
9	May 05/2015		32	May 05/2018	
10	May 05/2015		33	May 05/2018	
11	May 05/2015		34	May 05/2018	
12	May 05/2015		35	May 05/2018	
13	Sep 05/2016		36	May 05/2018	
14	Sep 05/2016		37	May 05/2018	
15	May 05/2015		38	May 05/2018	
16	May 05/2015		39	May 05/2018	
17	May 05/2015		40	May 05/2018	
18	Sep 05/2016		41	May 05/2018	
19	Sep 05/2016		42	BLANK	
20	Sep 05/2016				

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27-11-00			27-11-00 (cont.)		
1	Sep 05/2016		25	Sep 05/2016	
2	Sep 05/2016		26	Sep 05/2016	
3	May 05/2015		27	Sep 05/2016	
4	May 05/2015		28	Sep 05/2016	
5	May 05/2015		29	Sep 05/2016	
6	May 05/2015		30	Sep 05/2016	
7	May 05/2015		31	Sep 05/2016	
8	May 05/2015		32	Sep 05/2016	
9	May 05/2015		33	Sep 05/2016	
10	May 05/2015		34	Sep 05/2016	
11	Sep 05/2016		35	Sep 05/2016	
12	Sep 05/2016		36	Sep 05/2016	
13	May 05/2015		37	Sep 05/2016	
14	May 05/2015		38	Sep 05/2016	
15	May 05/2015		39	Sep 05/2016	
16	May 05/2015		40	Sep 05/2016	
17	May 05/2015		41	Sep 05/2016	
18	Sep 05/2016		42	Sep 05/2016	
19	Sep 05/2016		43	Sep 05/2016	
20	Sep 05/2016		44	Sep 05/2016	
21	Sep 05/2016		45	Sep 05/2016	
22	Sep 05/2016		46	Sep 05/2016	
23	Sep 05/2016		47	Sep 05/2016	
24	Sep 05/2016				

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Subject/Page	Date	COC	Subject/Page	Date	COC
27-11-00 (cont.)			27-11-00 (cont.)		
48	Sep 05/2016		71	Sep 05/2016	
49	Sep 05/2016		72	Sep 05/2016	
50	Sep 05/2016		73	Sep 05/2016	
51	Sep 05/2016		74	BLANK	
52	Sep 05/2016		27-21-00		
53	Sep 05/2016		1	May 05/2015	
54	Sep 05/2016		2	May 05/2015	
55	Sep 05/2016		3	May 05/2015	
56	Sep 05/2016		4	Sep 05/2016	
57	Sep 05/2016		5	Sep 05/2016	
58	Sep 05/2016		6	Sep 05/2016	
59	Sep 05/2016		7	Sep 05/2016	
60	Sep 05/2016		8	Sep 05/2016	
61	Sep 05/2016		9	Sep 05/2016	
62	Sep 05/2016		10	Sep 05/2016	
63	Sep 05/2016		11	Sep 05/2016	
64	Sep 05/2016		12	Sep 05/2016	
65	Sep 05/2016		13	Sep 05/2016	
66	Sep 05/2016		14	Sep 05/2016	
67	Sep 05/2016		15	Sep 05/2016	
68	Sep 05/2016		16	Sep 05/2016	
69	Sep 05/2016		17	Sep 05/2016	
70	Sep 05/2016		18	Sep 05/2016	

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27-21-00 (cont.)			27-21-00 (cont.)		
19	Sep 05/2016		41	Sep 05/2016	
20	Sep 05/2016		42	May 05/2015	
21	Sep 05/2016		43	Sep 05/2016	
22	Sep 05/2016		44	Sep 05/2016	
23	Sep 05/2016		45	Sep 05/2016	
24	Sep 05/2016		46	Sep 05/2016	
25	Sep 05/2016		47	Sep 05/2016	
26	Sep 05/2016		48	Sep 05/2016	
27	Sep 05/2016		49	Sep 05/2016	
28	Sep 05/2016		50	Sep 05/2016	
29	Sep 05/2016		51	Sep 05/2016	
30	Sep 05/2016		52	Sep 05/2016	
31	Sep 05/2016		53	Sep 05/2016	
32	Sep 05/2016		54	Jul 25/2018	
33	Sep 05/2016		55	Sep 05/2016	
34	Sep 05/2016		56	Sep 05/2016	
35	Sep 05/2016		57	Sep 05/2016	
36	Sep 05/2016		58	Sep 05/2016	
37	Sep 05/2016		59	Sep 05/2016	
38	Sep 05/2016		60	Sep 05/2016	
39	Sep 05/2016		61	Sep 05/2016	
40	Sep 05/2016		62	May 05/2018	

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Subject/Page	Date	COC	Subject/Page	Date	COC
27-21-00 (cont.)			27-30-00 (cont.)		
63	Sep 05/2016		12	Sep 05/2016	
64	Sep 05/2016		13	May 05/2015	
65	Sep 05/2016		14	May 05/2015	
66	Sep 05/2016		15	May 05/2015	
67	Sep 05/2016		16	May 05/2015	
68	Sep 05/2016		17	May 05/2015	
69	Sep 05/2016		18	May 05/2015	
70	Sep 05/2016		19	May 05/2015	
71	Sep 05/2016		20	May 05/2015	
72	Sep 05/2016		21	May 05/2015	
73	Sep 05/2016		22	May 05/2015	
74	BLANK		23	May 05/2015	
27-30-00			24	May 05/2015	
1	May 05/2015		25	May 05/2015	
2	May 05/2015		26	May 05/2015	
3	May 05/2015		27	May 05/2015	
4	May 05/2015		28	May 05/2015	
5	May 05/2015		29	May 05/2015	
6	May 05/2015		30	May 05/2015	
7	May 05/2015		31	May 05/2015	
8	May 05/2015		32	May 05/2015	
9	May 05/2015		33	May 05/2015	
10	May 05/2015		34	May 05/2015	
11	Sep 05/2016				

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27-30-00 (cont.)			27-30-00 (cont.)		
35	May 05/2015		57	May 05/2015	
36	May 05/2015		58	May 05/2015	
37	May 05/2015		59	May 05/2015	
38	May 05/2015		60	May 05/2018	
39	Sep 05/2016		61	May 05/2015	
40	Sep 05/2016		62	May 05/2015	
41	May 05/2015		63	May 05/2015	
42	May 05/2015		64	BLANK	
43	Sep 05/2016		27-32-00		
44	Sep 05/2016		1	May 05/2015	
45	May 05/2015		2	May 05/2015	
46	May 05/2015		3	May 05/2015	
47	May 05/2015		4	BLANK	
48	May 05/2015		27-41-00		
49	May 05/2015		1	May 05/2015	
50	May 05/2015		2	May 05/2015	
51	May 05/2015		3	May 05/2015	
52	May 05/2015		4	May 05/2015	
53	May 05/2015		5	May 05/2015	
54	Sep 05/2016		6	May 05/2015	
55	Sep 05/2016		7	May 05/2015	
56	Sep 05/2016		8	May 05/2015	
			9	May 05/2015	
			10	May 05/2015	

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27-41-00 (cont.)			27-41-00 (cont.)		
11	May 05/2015		33	May 05/2015	
12	May 05/2015		34	May 05/2015	
13	May 05/2015		35	May 05/2015	
14	May 05/2015		36	May 05/2015	
15	May 05/2015		37	May 05/2015	
16	May 05/2015		38	May 05/2015	
17	May 05/2015		39	May 05/2015	
18	May 05/2015		40	May 05/2015	
19	May 05/2015		41	May 05/2015	
20	May 05/2015		42	Sep 05/2016	
21	May 05/2015		43	Sep 05/2016	
22	May 05/2015		44	Sep 05/2016	
23	May 05/2015		45	Sep 05/2016	
24	May 05/2015		46	Sep 05/2016	
25	Sep 05/2016		47	Sep 05/2016	
26	Sep 05/2016		48	Sep 05/2016	
27	May 05/2015		49	Sep 05/2016	
28	May 05/2015		50	Sep 05/2016	
29	Sep 05/2016		51	Sep 05/2016	
30	Sep 05/2016		52	Sep 05/2016	
31	May 05/2015		53	Sep 05/2016	
32	May 05/2015		54	Sep 05/2016	

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27-41-00 (cont.)			27-51-00 (cont.)		
55	Sep 05/2016		7	Sep 05/2016	
56	Sep 05/2016		8	Sep 05/2016	
57	Sep 05/2016		9	Sep 05/2016	
58	Sep 05/2016		10	Sep 05/2016	
59	Sep 05/2016		11	Sep 05/2016	
60	BLANK		12	Sep 05/2016	
27-48-00			13	Sep 05/2016	
1	May 05/2015		14	Sep 05/2016	
2	May 05/2015		15	Sep 05/2016	
3	May 05/2015		16	Sep 05/2016	
4	May 05/2015		17	Sep 05/2016	
5	May 05/2015		18	Sep 05/2016	
6	May 05/2015		19	Sep 05/2016	
7	May 05/2015		20	Sep 05/2016	
8	May 05/2015		21	Sep 05/2016	
9	May 05/2015		22	Sep 05/2016	
10	BLANK		23	Sep 05/2016	
27-51-00			24	Sep 05/2016	
1	May 05/2015		25	Sep 05/2016	
2	May 05/2015		26	Sep 05/2016	
3	May 05/2015		27	Sep 05/2016	
4	Sep 05/2016		28	Sep 05/2016	
5	Sep 05/2016				
6	Sep 05/2016				

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27-51-00 (cont.)			27-51-00 (cont.)		
29	Sep 05/2016		51	Sep 05/2016	
30	Sep 05/2016		52	Sep 05/2016	
31	Sep 05/2016		53	Sep 05/2016	
32	Sep 05/2016		54	Sep 05/2017	
33	Sep 05/2016		55	Sep 05/2016	
34	Sep 05/2016		56	Sep 05/2016	
35	Sep 05/2016		57	Sep 05/2016	
36	Sep 05/2016		58	Sep 05/2016	
37	Sep 05/2016		59	Sep 05/2016	
38	Sep 05/2017		60	Sep 05/2016	
39	Sep 05/2016		61	Sep 05/2016	
40	Sep 05/2017		62	Sep 05/2016	
41	Sep 05/2016		63	Sep 05/2016	
42	Sep 05/2017		64	Sep 05/2016	
43	Sep 05/2016		65	Sep 05/2016	
44	Sep 05/2017		66	Sep 05/2016	
45	Sep 05/2016		67	Sep 05/2016	
46	Sep 05/2017		68	Sep 05/2016	
47	Sep 05/2016		69	Sep 05/2016	
48	Sep 05/2017		70	BLANK	
49	Sep 05/2016		27-58-00		
50	Sep 05/2017		1	May 05/2015	
			2	May 05/2015	

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27-58-00 (cont.)			27-61-00 (cont.)		
3	May 05/2015		9	May 05/2015	
4	Sep 05/2017		10	May 05/2015	
5	May 05/2015		11	May 05/2015	
6	May 05/2015		12	May 05/2015	
7	May 05/2015		13	May 05/2015	
8	BLANK		14	May 05/2015	
27-59-00			15	May 05/2015	
1	May 05/2015		16	May 05/2015	
2	May 05/2015		17	May 05/2015	
3	May 05/2015		18	May 05/2015	
4	May 05/2015		19	May 05/2015	
5	May 05/2015		20	May 05/2015	
6	May 05/2015		21	May 05/2015	
7	May 05/2015		22	May 05/2015	
8	BLANK		23	May 05/2015	
27-61-00			24	May 05/2015	
1	Sep 05/2016		25	May 05/2015	
2	Sep 05/2016		26	Sep 05/2016	
3	May 05/2015		27	Sep 05/2016	
4	May 05/2015		28	Sep 05/2016	
5	May 05/2015		29	Sep 05/2016	
6	May 05/2015		30	Sep 05/2016	
7	May 05/2015				
8	May 05/2015				

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27-61-00 (cont.)			27-62-00		
31	Sep 05/2016		1	May 05/2015	
32	Sep 05/2017		2	May 05/2015	
33	Sep 05/2016		3	May 05/2015	
34	Sep 05/2016		4	May 05/2015	
35	Sep 05/2016		5	May 05/2015	
36	Sep 05/2016		6	May 05/2015	
37	Sep 05/2016		7	May 05/2015	
38	Sep 05/2016		8	May 05/2015	
39	Sep 05/2016		9	May 05/2015	
40	Sep 05/2016		10	May 05/2015	
41	Sep 05/2016		11	May 05/2015	
42	Sep 05/2016		12	May 05/2015	
43	Sep 05/2016		13	May 05/2015	
44	Sep 05/2016		14	May 05/2015	
45	Sep 05/2016		15	Sep 05/2016	
46	Sep 05/2016		16	Sep 05/2016	
47	Sep 05/2016		17	May 05/2015	
48	Sep 05/2016		18	BLANK	
49	Sep 05/2016		27-81-00		
50	Sep 05/2016		1	May 05/2015	
51	Sep 05/2016		2	May 05/2015	
52	BLANK		3	May 05/2015	
			4	May 05/2015	
			5	Sep 05/2016	

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27-81-00 (cont.)			27-81-00 (cont.)		
6	Sep 05/2016		29	May 05/2015	
7	May 05/2015		30	May 05/2015	
8	May 05/2015		31	May 05/2015	
9	May 05/2015		32	Sep 05/2017	
10	May 05/2015		33	May 05/2015	
11	May 05/2015		34	May 05/2015	
12	May 05/2015		35	May 05/2015	
13	May 05/2015		36	Sep 05/2017	
14	May 05/2015		37	May 05/2015	
15	May 05/2015		38	May 05/2015	
16	May 05/2015		39	May 05/2015	
17	May 05/2015		40	May 05/2015	
18	May 05/2015		41	May 05/2015	
19	May 05/2015		42	Sep 05/2017	
20	May 05/2015		43	May 05/2015	
21	May 05/2015		44	May 05/2015	
22	May 05/2015		45	May 05/2015	
23	May 05/2015		46	May 05/2015	
24	May 05/2015		47	May 05/2015	
25	May 05/2015		48	May 05/2015	
26	May 05/2015		49	May 05/2015	
27	May 05/2015		50	May 05/2015	
28	May 05/2015				

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51	May 05/2015		5	May 05/2015	
52	May 05/2015		6	Sep 05/2017	
53	May 05/2018		7	May 05/2015	
54	May 05/2018		8	May 05/2015	
55	May 05/2015		9	May 05/2015	
56	May 05/2015		10	BLANK	
57	May 05/2015				
58	May 05/2015				
59	May 05/2015				
60	BLANK				
27-88-00					
1	May 05/2015				
2	May 05/2015				
3	May 05/2015				
4	May 05/2015				
5	May 05/2015				
6	May 05/2015				
7	May 05/2015				
8	BLANK				
27-89-00					
1	May 05/2015				
2	May 05/2015				
3	May 05/2015				
4	May 05/2015				

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<u>CH-SC-SU</u>	<u>SUBJECT</u>	<u>PAGE</u>	<u>EFFECT</u>
27-00-00	FLIGHT CONTROLS - INTRODUCTION	1	ARO ALL
27-02-00	PRIMARY FLIGHT CONTROL SYSTEM - INTRODUCTION	2	ARO ALL
27-02-00	PFCS - GENERAL DESCRIPTION	4	ARO ALL
27-02-00	PFCS - COMPONENT LOCATION	6	ARO ALL
27-02-00	PFCS - FLIGHT CONTROLS ARINC 629 BUS INTERFACES	8	ARO ALL
27-02-00	PFCS - SYSTEMS ARINC 629 BUS INTERFACES	10	ARO ALL
27-02-00	PFCS - ANALOG INTERFACES	12	ARO ALL
27-02-00	PFCS - ELECTRICAL POWER DISTRIBUTION	14	ARO ALL
27-02-00	PFCS - HYDRAULIC POWER AND ACE DISTRIBUTION	16	ARO ALL
27-02-00	PFCS - ACE - COMPONENT LOCATION	18	ARO ALL
27-02-00	PFCS - ACE - FUNCTIONAL DESCRIPTION	20	ARO ALL
27-02-00	PFCS - PFC - COMPONENT LOCATION	22	ARO ALL
27-02-00	PFCS - PFC - FUNCTIONAL DESCRIPTION	24	ARO ALL
27-02-00	PFCS - PFC CONTROL LAWS - FUNCTIONAL DESCRIPTION	28	ARO ALL
27-02-00	PFCS - PFC DISCONNECT SWITCH	30	ARO ALL
27-02-00	PFCS - OPERATIONAL MODES - FUNCTIONAL DESCRIPTION	33	ARO ALL
27-02-00	PFCS - FUNCTIONAL DESCRIPTION	36	ARO ALL
27-02-00	PFCS - AUTOPILOT - GENERAL DESCRIPTION	38	ARO ALL
27-02-00	PFCS - AUTOPILOT - FUNCTIONAL DESCRIPTION	40	ARO ALL
27-02-00	PFCS - FLIGHT CONTROL SHUTOFF VALVES - LOCATION	42	ARO ALL

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FLIGHT CONTROLS

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FLIGHT CONTROLS - INTRODUCTION

General

The flight controls keep the airplane at the desired attitude during flight. They consist of movable surfaces on the wing and the empennage. The flight controls change the lift of the wing and the empennage.

There are two types of flight controls: the primary flight control system and the high lift control system.

Primary Flight Control System

The primary flight control system (PFCS) uses a fly-by-wire control system with digital and analog electronic equipment. It receives commands from the flight crew and the autopilot and causes the control surfaces to move.

The PFCS controls the attitude of the airplane during flight. The control surfaces operated by the PFCS are:

- One aileron on each wing
- One flaperon on each wing
- Seven spoilers on each wing
- One horizontal stabilizer
- One elevator on each side of the horizontal stabilizer
- One tabbed rudder.

High Lift Control System

The high lift control system (HLCS) uses a fly-by-wire control system with digital electronic equipment. It receives commands from the flight crew and causes the flaps and slats to move.

Operation of the HLCS increases the wing lift so the airplane can takeoff and land at lower speed and higher weight. The high lift devices operated by the HLCS are:

- Seven leading edge slats on each wing
- One Krueger flap on each wing
- One single slotted outboard flap on each wing
- One double slotted inboard flap on each wing.

Operation of the HLCS also causes the ailerons and the flaperons to move. They droop on both wings when the high lift devices extend.

Benefits of the Fly-By-Wire System

The fly-by-wire design of the flight controls permits:

- A more efficient structure design
- Increased fuel economy
- A smaller vertical fin
- A smaller horizontal stabilizer
- Reduced weight
- Improved controls and protections.

Abbreviations and Acronyms

- ACE - actuator control electronics
- ACMS - airplane condition monitoring system
- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- ADM - air data module
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AIMS - airplane information management system
- ARINC - Aeronautical Radio, Inc.
- BAP - bank angle protection
- B/D - backdrive
- CMCS - central maintenance computing system
- CPU - central processing unit
- EDIU - engine data interface unit
- EHS - electrohydraulic servo valve
- EICAS - engine indication and crew alerting system
- FCDC - flight controls direct current

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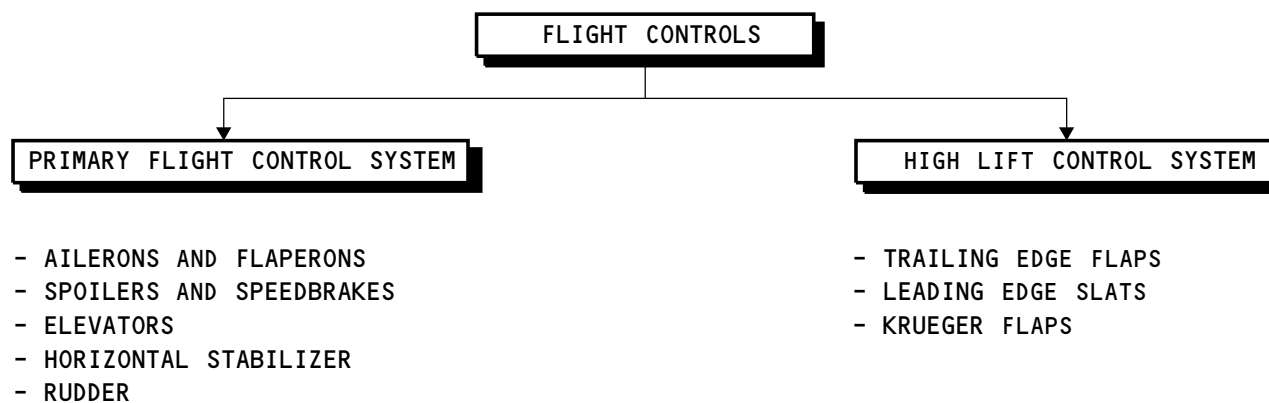
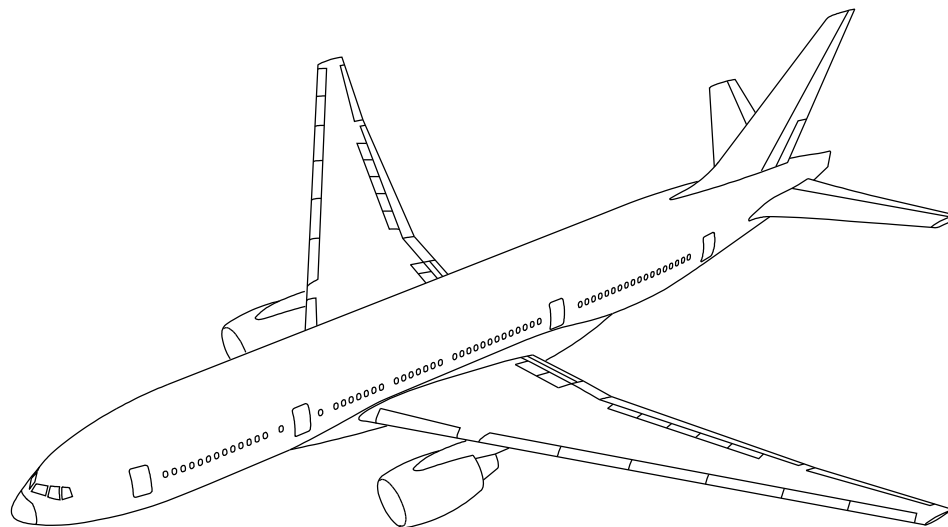
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FLIGHT CONTROLS - INTRODUCTION

- FMCS - flight management computer system
- FSEU - flap/slat electronics unit
- HLCS - high lift control system
- LIB - left inboard
- LOB - left outboard
- LVDT - linear variable differential transformer
- MCP - mode control panel
- MFD - multi functional display
- PCU - power control unit
- PDU - power drive unit
- PFC - primary flight computer
- PFCS - primary flight control system
- PMG - permanent magnet generator
- PSA - power supply assembly
- PSEU - proximity sensor electronic unit
- RIB - right inboard
- ROB - right outboard
- RVDT - rotary variable differential transformer
- SAARU - secondary attitude air data reference unit
- SOL - solenoid
- SOV - shutoff valve
- STCM - stabilizer trim control module
- TAC - thrust asymmetry compensation
- WEU - warning electronic unit
- WOW - weight on wheels



FLIGHT CONTROLS - INTRODUCTION

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PRIMARY FLIGHT CONTROL SYSTEM - INTRODUCTION

Purpose

The primary flight control system (PFCS) controls the airplane flight attitude in relation to the three basic axes:

- Longitudinal
- Lateral
- Vertical.

Roll Control

The roll control uses the ailerons, flaperons, and spoilers to control the airplane attitude about the longitudinal axis. During a bank of the airplane, the aileron and flaperon on one wing move in an opposite direction from the aileron and flaperon on the other wing. The spoilers move up only on the down wing and do not move on the up wing.

Pitch Control

The pitch control uses the horizontal stabilizer and the elevator to control the airplane attitude about the lateral axis. The stabilizer controls long term pitch changes. The elevator supplies short term pitch control.

Yaw Control

The yaw control uses the rudder to control the airplane attitude about the vertical axis. The rudder has a tab which moves to increase the effectiveness of the rudder.

Speedbrakes

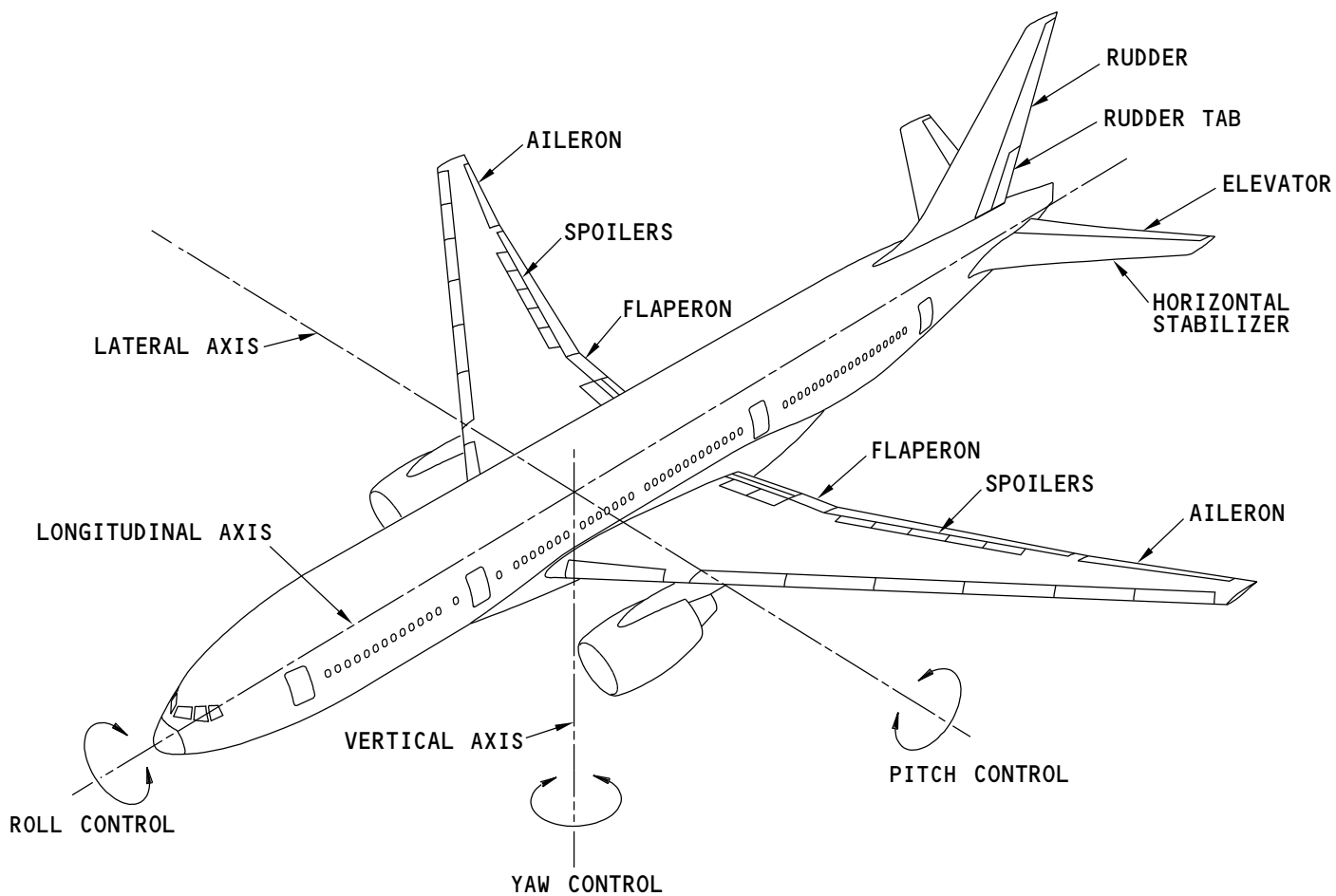
The PFCS also includes the speedbrakes. In addition to roll control, the spoilers also act as speedbrakes in the air and on the ground. They deploy on both wings to increase drag and to decrease the amount of lift the wings supply.

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PRIMARY FLIGHT CONTROL SYSTEM - INTRODUCTION

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PFCS - GENERAL DESCRIPTION

General

The pilots or the autopilot commands control the PFCS. The pilots can override the autopilot.

Manual Operation

Position transducers change the pilots' manual commands of the control wheel, the control columns, the rudder pedals, and the speedbrake lever to analog electrical signals. These signals go to the four actuator control electronics (ACEs). The ACEs change the signals to digital format and send them to the three primary flight computers (PFCs).

The PFCs have interfaces with the airplane systems through the three flight controls ARINC 629 buses. In addition to command signals from the ACEs, the PFCs also receive data from:

- The airplane information management system (AIMS)
- The air data inertial reference unit (ADIRU)
- The secondary attitude air data reference unit (SAARU).

The PFCs calculate the flight control commands based on control laws and flight envelope protection functions. The control laws supply stability augmentation in the pitch and yaw axes and flight envelope protections in all three axes. The digital command signals from the PFCs go to the ACEs.

The ACEs change these command signals to analog format and send them to the power control units (PCUs) and the stabilizer trim control modules (STCMs). The ACEs and the PCUs form control loops which control the surfaces based on the PFCs commands.

One, two or three PCUs operate each control surface. One PCU controls each spoiler, two PCUs control each aileron, flaperon, and elevator, and three PCUs control the rudder. The PCUs contain a hydraulic actuator, an electrohydraulic servo valve, and a position feedback transducer.

When commanded, the servo valve causes the hydraulic actuator to move the control surface. The position transducer sends a position feedback signal to the ACEs. The ACEs then stop the PCU command when the position feedback signal equals the commanded position.

Two STCMs control hydraulic power to the motors and brakes of the horizontal stabilizer.

Autopilot Operation

The PFCs receive autopilot commands from all three autopilot flight director computers (AFDCs). The PFCs use the autopilot commands in the same manner as the pilots' manual commands. In addition, the PFCs supply the backdrive signals to the backdrive actuators through the AFDCs. The backdrive actuators move the control wheels, control columns, and rudder pedals in synchronization with the autopilot commands. The movement of the flight deck controls supplies visual indications to the flight crew.

PFCS Modes of Operation

The PFCS has three modes of operation: normal, secondary, and direct.

Normal mode operates when the necessary data are available for the PFCs and the ACEs. All the control laws, protection functions, and the AFDCs operate.

When the PFCS detects the loss of important air and attitude data, the PFCS operation changes to secondary mode. The PFCs and the ACEs operate but the PFC control laws and protection functions downgrade. The autopilot cannot operate in secondary mode.

In direct mode, the PFCs are not used. The ACEs set the position of the control surfaces in direct response to analog pilot control inputs.

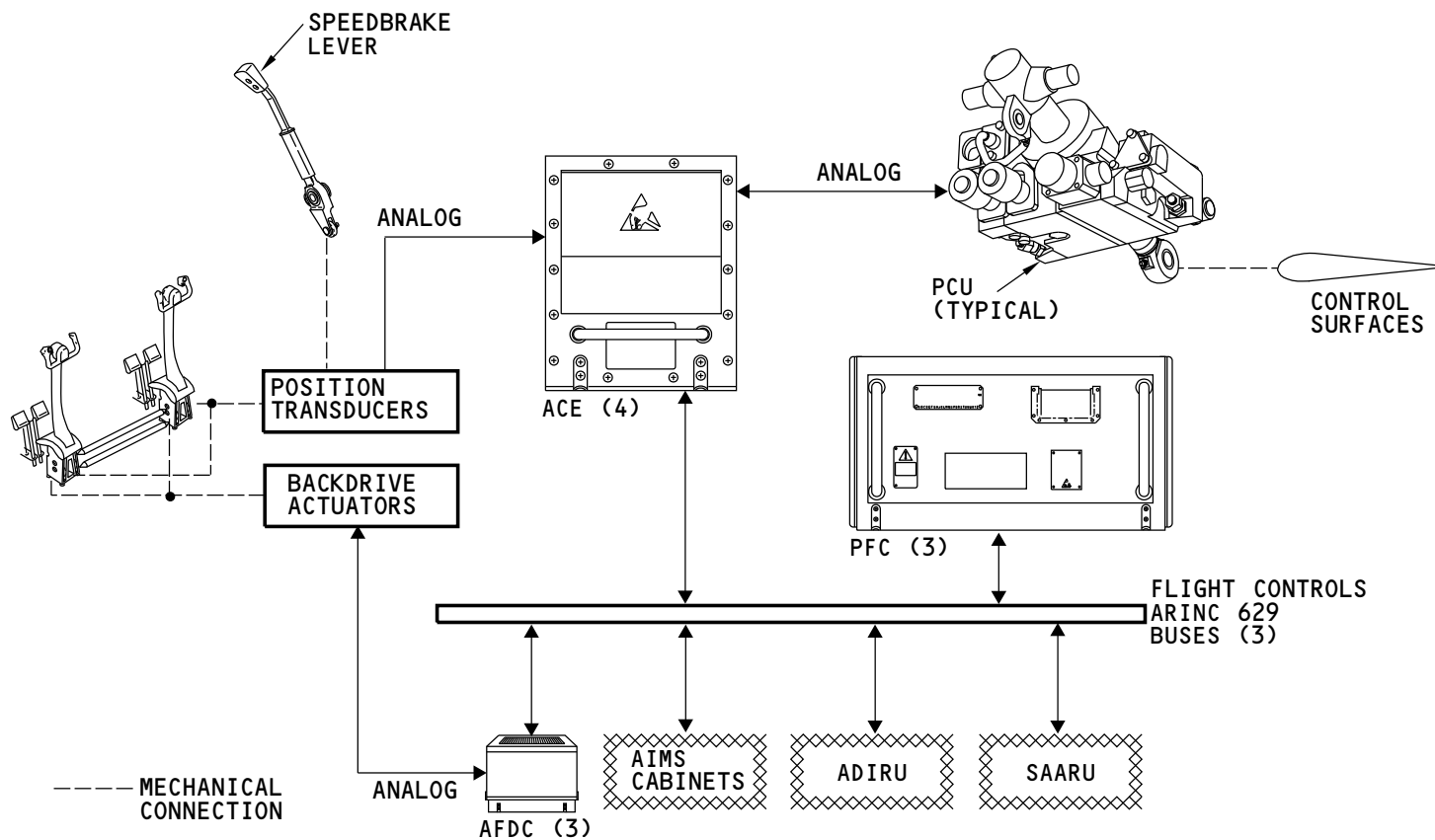
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PFCS - GENERAL DESCRIPTION

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**PFCS - COMPONENT LOCATION****Flight Deck Controls**

The control wheel, control column, and rudder pedal position transducers are below the flight deck floor in the forward equipment center. The speedbrake lever position transducers are in the control stand. The location of these transducers is shown in other sections.

Main Equipment Center

The E1, E2, and E3 racks contain most of the electronic equipment of the PFCS.

The E1 rack contains:

- The left PFC
- The L1 ACE
- The L2 ACE.

The E2 rack contains:

- The center PFC
- The center ACE
- The SAARU.

The E3 rack contains the ADIRU.

Forward Cargo Compartment

The E16 rack, forward of the forward cargo door, contains the right PFC.

The E5 rack, aft of the forward cargo door, contains the right ACE.

Control Surfaces

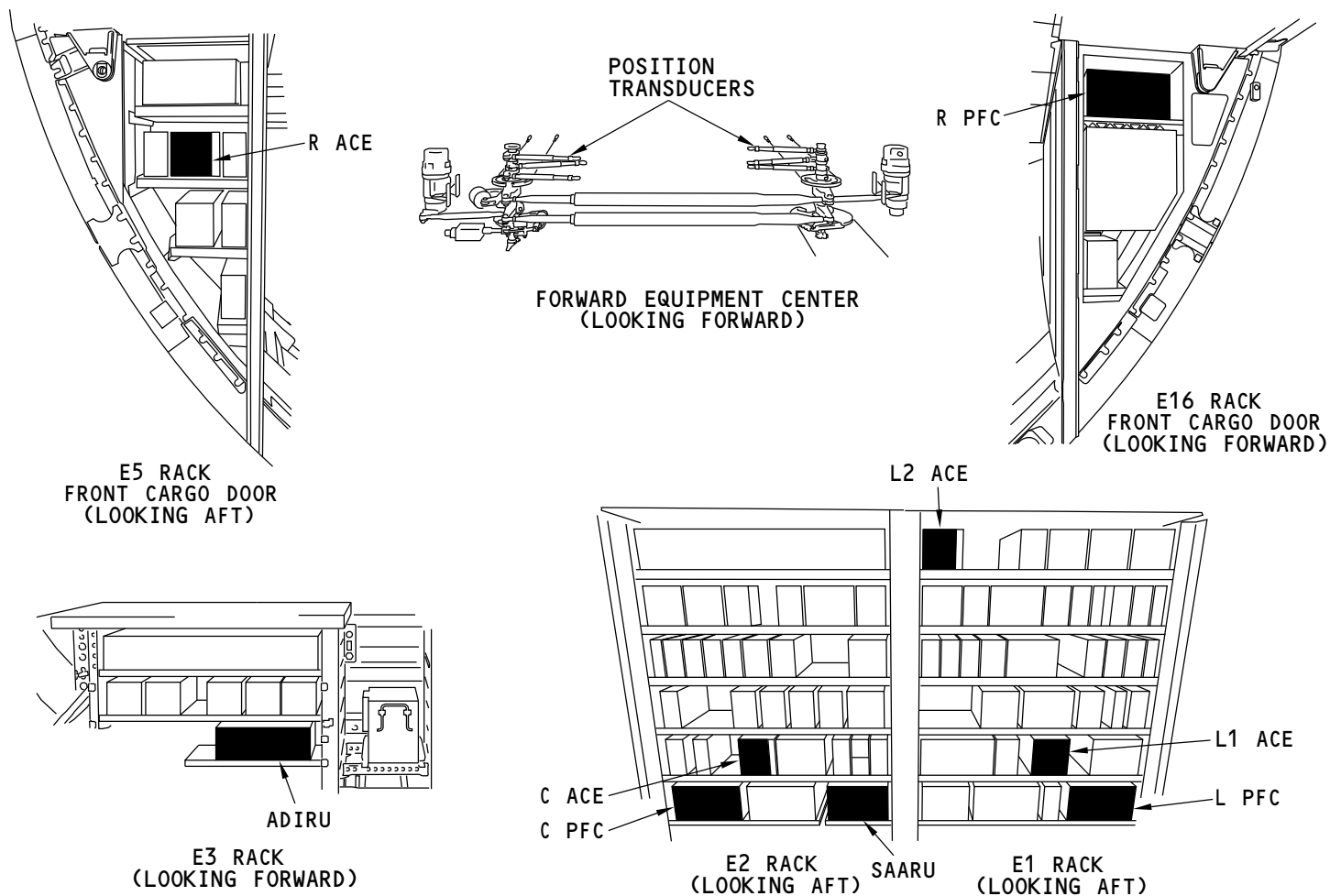
Each PCU connects directly to its related control surface on the wing and the empennage. The ballscrew actuator of the horizontal stabilizer is in the stabilizer compartment. The location of the PCUs and the ballscrew actuator is shown in their specified sections.

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PFCS - FLIGHT CONTROLS ARINC 629 BUS INTERFACES

General

ARINC 629 digital data buses supply the principal means of communication among airplane systems. Three dedicated flight controls ARINC 629 buses connect the PFCS to:

- The three autopilot flight director computers (AFDC)
- The two airplane information management system (AIMS) cabinets
- The air data inertial reference unit (ADIRU)
- The secondary attitude air data reference unit (SAARU).

Physical separation of the buses, and redundant LRUs, protects against multiple failures due to one event.

PFCS Interface

The three primary flight computers (PFCs) and the four actuator control electronics (ACEs) have interfaces with the flight controls data buses.

The L PFC, C PFC and R PFC receive data from all three flight controls data buses but transmit data only on their on-side data bus. (On-side means that the relationship is with equipment of the same side. For example, the left bus is the on-side bus for the left PFC.)

Each ACE receives data from all three PFCs through the three flight controls data buses. Each ACE processes control data from its on-side PFC. If this data is not valid, the ACE processes data from an alternate PFC. The ACEs process some data from the other PFCs at all times. For example, this occurs during data validation and voted commands. The ACEs transmit only on their on-side bus.

AFDS Interface

The autopilot flight director system (AFDS) interfaces with the PFCS through the autopilot flight director computers (AFDCs). Each AFDC transmits to its on-side flight controls data bus, but receives data from all three buses. The AFDCs receive backdrive commands, engagement status, and other data from the PFCs. The AFDCs transmit pitch, roll and yaw commands and engage requests to the PFCs.

AIMS Interface

The two AIMS cabinets receive data from all three flight controls data buses, but normally transmit only to their on-side bus. During tests on the ground, the AIMS cabinets transmit also to the center bus.

The PFCS supplies information to the AIMS for:

- The primary display system (PDS), (flight, synoptic, and EICAS displays)
- The central maintenance computing system (CMCS)
- The airplane condition monitoring system (ACMS)
- The flight management computing system (FMCS)

ADIRS Interface

The air data inertial reference system (ADIRS) consists of the air data inertial reference unit (ADIRU) and the secondary attitude air data reference unit (SAARU).

The ADIRU and SAARU supply air data variables and inertial data to the PFCs. The ADIRU receives data from all three buses and transmits data to the left and right flight controls data buses. The SAARU also receives data on all three buses, but transmits data only to the center flight controls data bus.

Air Data Modules

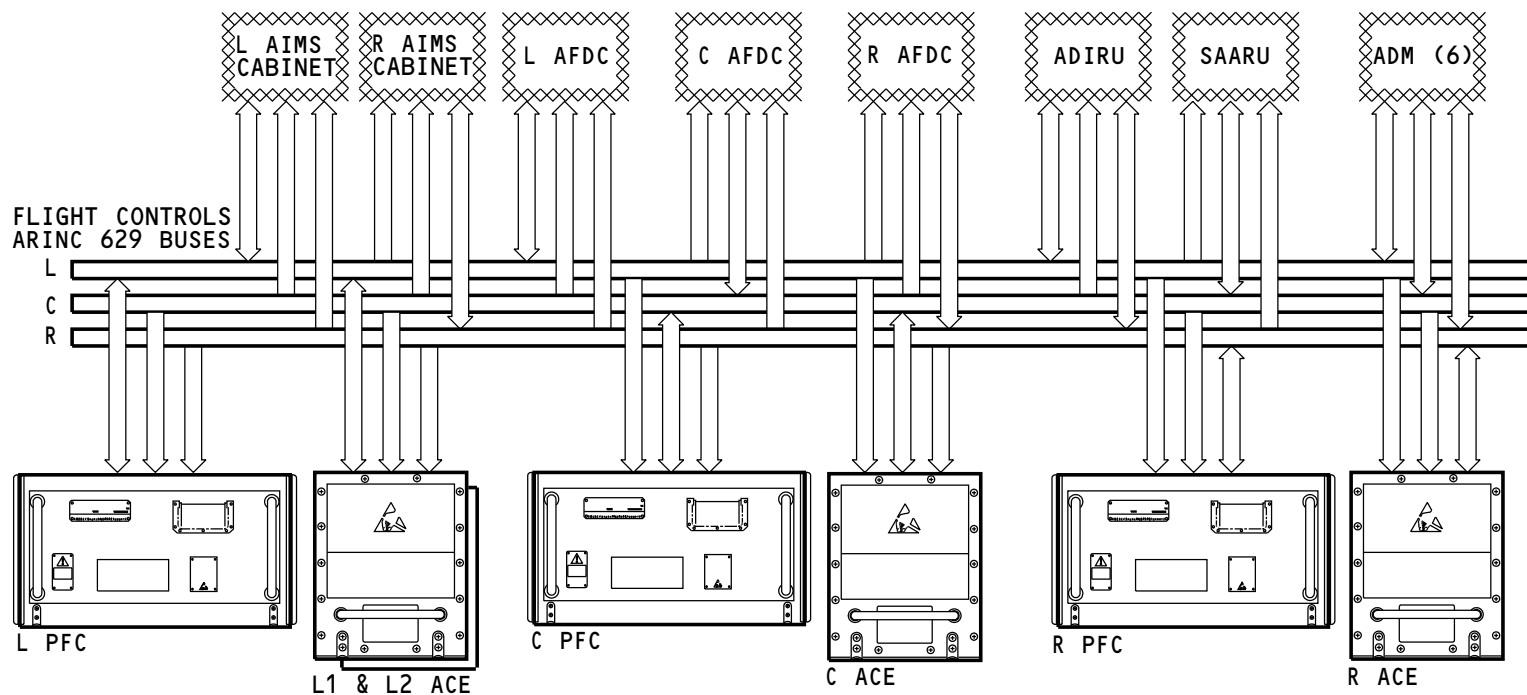
Six air data modules (ADMs) supply pitot and static air data to the ADIRU and the SAARU. The ADMs transmit these data through the flight controls ARINC 629 buses.

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PFCS - FLIGHT CONTROLS ARINC 629 BUS INTERFACES

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PFCS - SYSTEMS ARINC 629 BUS INTERFACES

General

Many components of the PFCS transmit to and receive information from other airplane systems. Data on the systems ARINC 629 buses goes through the AIMS data conversion gateway function and then to the flight control ARINC 629 buses. The PFCS uses information from:

- The flap/slat electronics units (FSEUs)
- The proximity sensor electronics units (PSEUs)
- The left and right systems card files.

The PFCS transmits information to the left and right warning electronic units (WEUs).

The PFCS also uses radio altimeter data supplied through AIMS.

FSEU Interface

The FSEUs supply flaps and slats signals to the PFCs for the gain functions of the control laws. These signals show the retracted or not retracted condition of the flaps and the slats. The FSEUs also supply a signal to the ACEs.

PSEU Interface

The PSEUs supply truck tilt signals and associated fault messages to the PFCS. The truck tilt signals are used together with the weight on wheels and radio altimeter functions to operate the auto speedbrake.

Systems Card Files Interface

The two systems card files supply signals from the hydraulic interface module (HYDIM) cards and the weight on wheels (WOW) cards to the PFCS.

The HYDIM cards supply hydraulic systems condition signals to the PFCS. They also supply data about the truck tilt pressure sensors.

The WOW cards supply air/ground signals to the PFCS. These signals supply air/ground information to the PFCS.

WEU Interface

The PFCS sends stabilizer and rudder trim position signals to the WEUs. The WEUs supply a takeoff warning if the stabilizer is out of green band or the rudder trim is out of normal limits.

The PFCs receive stall data from the WEUs for stall protection.

Engine Data Interface Units

The left and right engine data interface units (EDIUs) receive the N1 speed and calculate the thrust for each engine. The EDIUs supply these data to the AIMS and to the PFCS for the thrust asymmetry compensation (TAC) function.

Radio Altimeter Interface

The three radio altimeters supply information to AIMS for use by the PFCS for the flare function during manual landing. The PFCS inhibits the radio altimeter test when ground speed is more than 40 knots and during flight.

Indications

The status message PFCS INTERFACE shows because of one of these faults:

- There is a disagreement with the flap discrete signals in two or more ACEs
- Only two of the four FSEU channels are available
- Only two of the four digital WES channels are available
- Only one of the two truck tilt pressure data sources is available
- Thrust data from one of the left or right EDIU channels does not agree with the others
- Loss of the backup generator (BUG)
- Data from the two WOW cards does not agree.

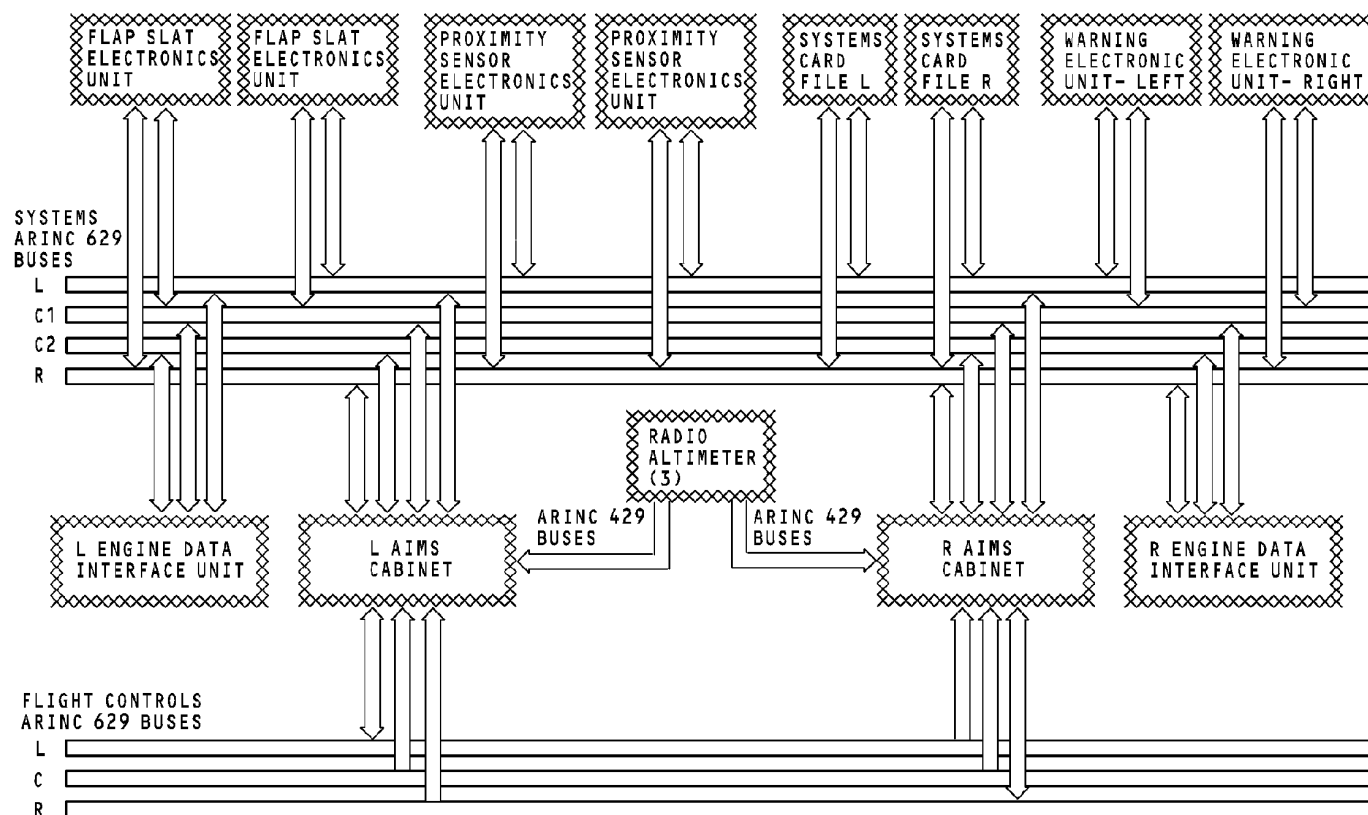
These conditions cause the message to show in normal, secondary, and direct modes.

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PFCS - SYSTEMS ARINC 629 BUS INTERFACES

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PFCS - ANALOG INTERFACES

General

All analog interfaces with the PFCS go to the ACE. The primary inputs/outputs are:

- Rudder trim selector
- Manual trim cancel switch
- Pitch trim switches
- Flight control position transducers
- Flight control force transducers
- FSEUs
- Primary flight computers DISC/AUTO switch
- Thrust asymmetry compensation switch
- AIMS cabinets
- PCUs.

Rudder Trim Selector and Manual Trim Cancel Switch

The rudder trim selector and the manual trim cancel switch supply signals to the ACEs. These signals show the pilot commands for rudder trim.

Pitch Trim Switches

The pitch trim switches supply signals to the ACEs to show the pilot pitch trim commands.

Flight Control Position Transducers

The flight control position transducers supply electrical inputs to the ACEs. They show the position of the:

- Control wheel
- Control column
- Rudder pedals
- Speedbrake lever.

Flight Control Force Transducers

The pitch and roll force transducers supply signals to the ACEs. The signals show when the pilot applies a force to the control wheel or control column.

FSEUs

The FSEUs supply a signal to each ACE showing that the flaps and slats are retracted or not retracted.

Primary Flight Computers DISC/AUTO switch

The primary flight computers DISC/AUTO switch supplies a signal to each ACE that shows the switch position. Switch positions are AUTO or DISC.

Thrust Asymmetry Compensation Switch

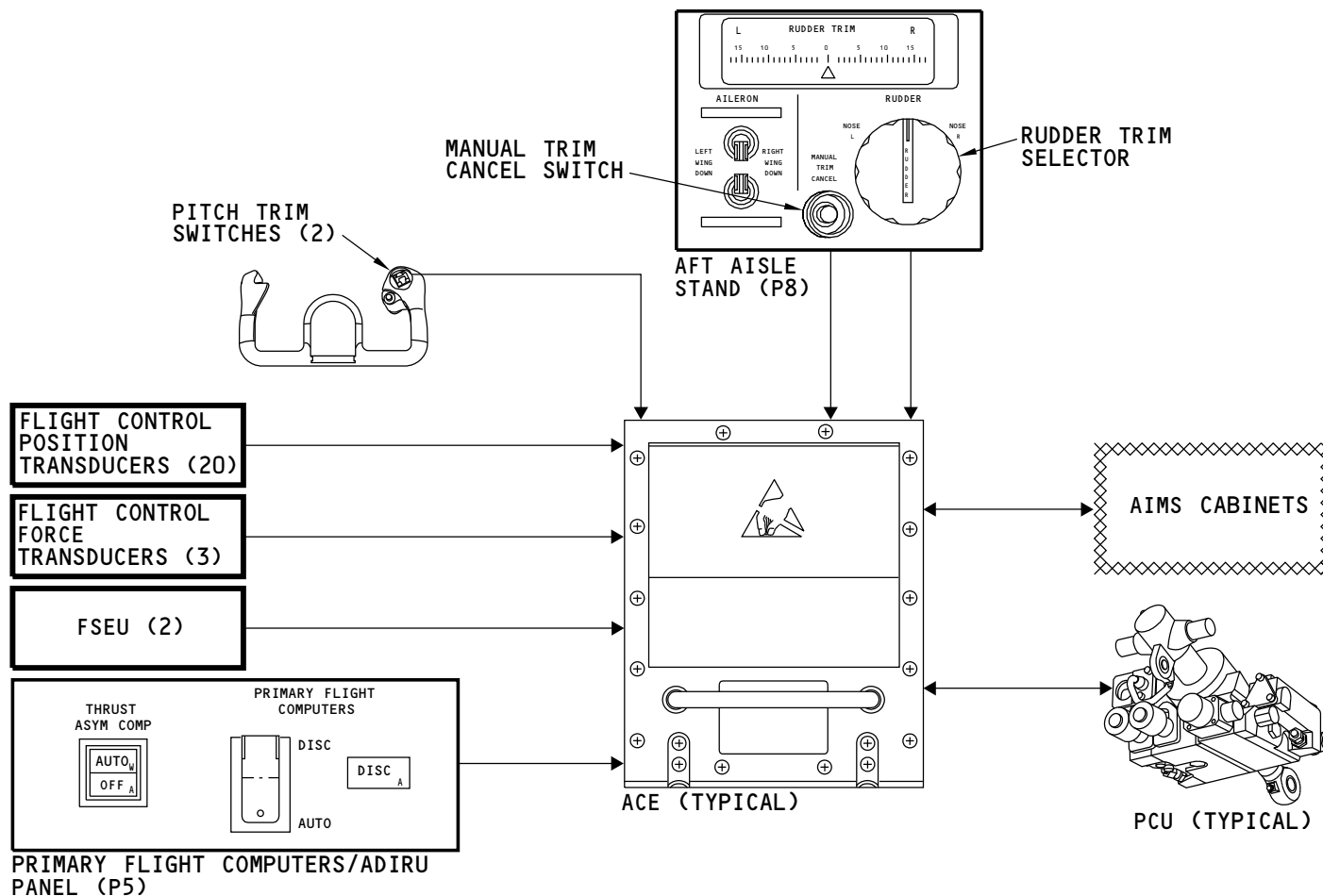
The thrust asymmetry compensation (TAC) switch supplies a signal to the C ACE that shows the switch position. The switch positions are AUTO or OFF.

AIMS Cabinets

Each ACE supplies two signals to both AIMS cabinets. The signals show that the ACE is in the direct mode and the ACE power supply is correct.

PCUs

The ACEs supply command signals to the PCUs. The PCUs supply position feedback signals to the ACE.



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PFCS - ANALOG INTERFACES

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**PFCS - ELECTRICAL POWER DISTRIBUTION****General**

Because the electrical power supply to the PFCS is very critical, a high level of redundant power is available.

Power Supply Assembly

Three identical power supply assemblies (PSAs) supply 28v dc to the components of their on-side portion of the PFCS. The PSAs supply electrical power to the ACEs, the PFCs, the PCUs and the STCMs. In addition, the PSAs supply power for the rudder trim, the auto speedbrake, the ADMs and the SAARU.

See the flight controls dc power section for more information (SECTION 24-35).

PSA Power Sources

During flight, the left PSA normally receives primary power from one permanent magnet generator (PMG) on the left engine. The right PSA receives primary power from one PMG on the right engine. The center PSA receives primary power from two PMGs, one on each engine. The PSAs change the ac variable electrical power from the PMGs to 28v dc.

If the primary power is not available or not within specified limits, the left and right PSAs change to secondary power from the left and right 28v dc buses. Secondary power to the center PSA is from the captain's flight instrument bus.

When the airplane is on the ground and no engines are running, the PSAs normally change to secondary power.

If primary and secondary power is not available or not within specified limits, the PSA changes to backup power. The left and center PSAs receive backup power from the hot battery bus. The right PSA has no backup power.

Each PSA has a dedicated flight control dc battery (FCDC BATT). It supplies the flight control components with power for one minute during PSA switching.

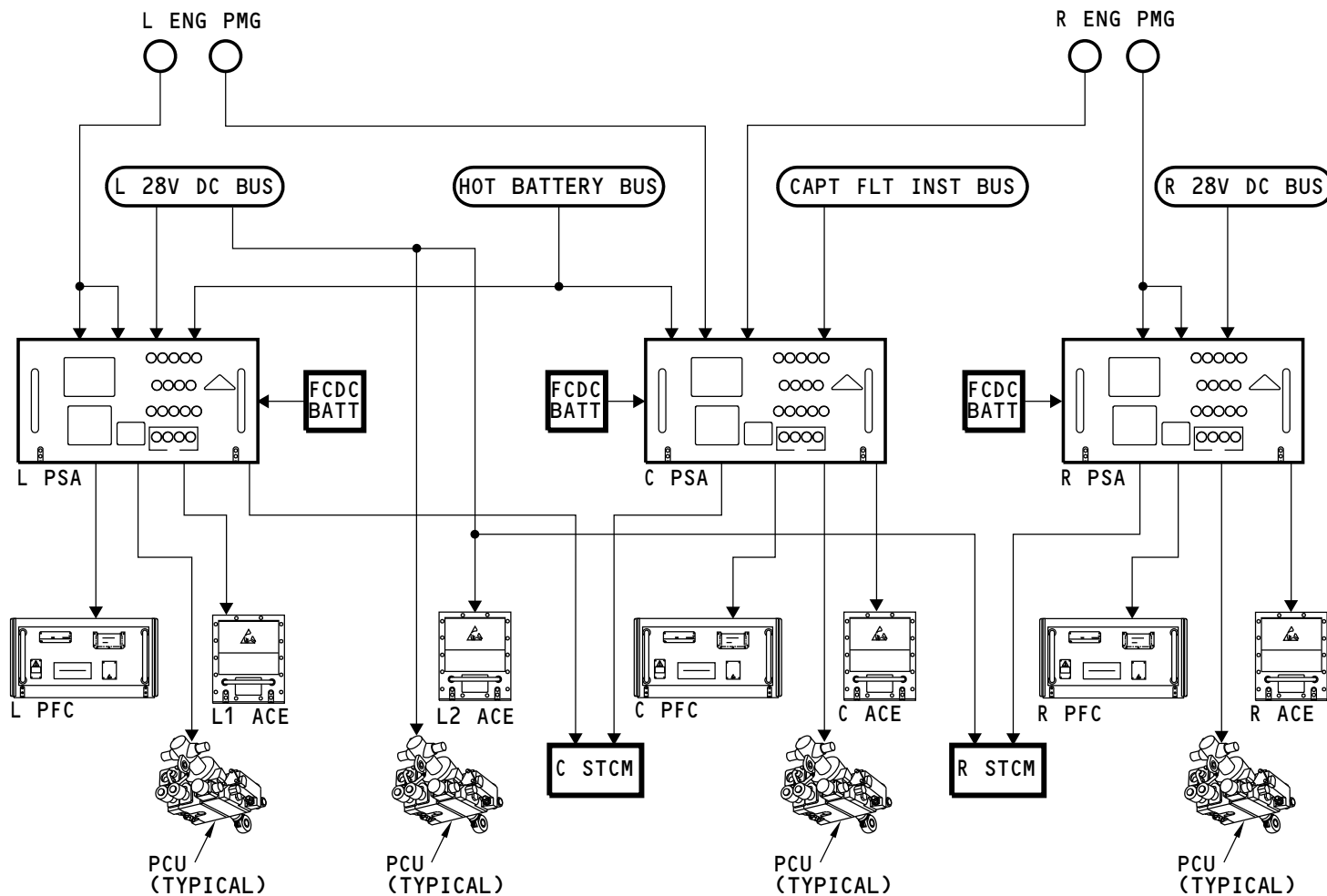
Power to L2 ACE

The L2 ACE and its related PCUs have only one power supply from the left 28v dc bus in the P110 left power management panel. In addition, the left 28v dc bus supplies power for the stabilizer commands, the elevator feel and the aileron/rudder trim module.

Training Information Point

There are circuit breakers on the front of the PSAs and the P110 left power management panel. They control power to the components of the PFCS.

If electrical power is shutdown with a PFC deactivated or removed, the FCDC battery discharges. To prevent FCDC battery discharge, open the applicable circuit breakers on the PSA. When electrical power is available, close the circuit breakers.



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PFCS - ELECTRICAL POWER DISTRIBUTION

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PFCS - HYDRAULIC POWER AND ACE DISTRIBUTION

Hydraulic Power Distribution

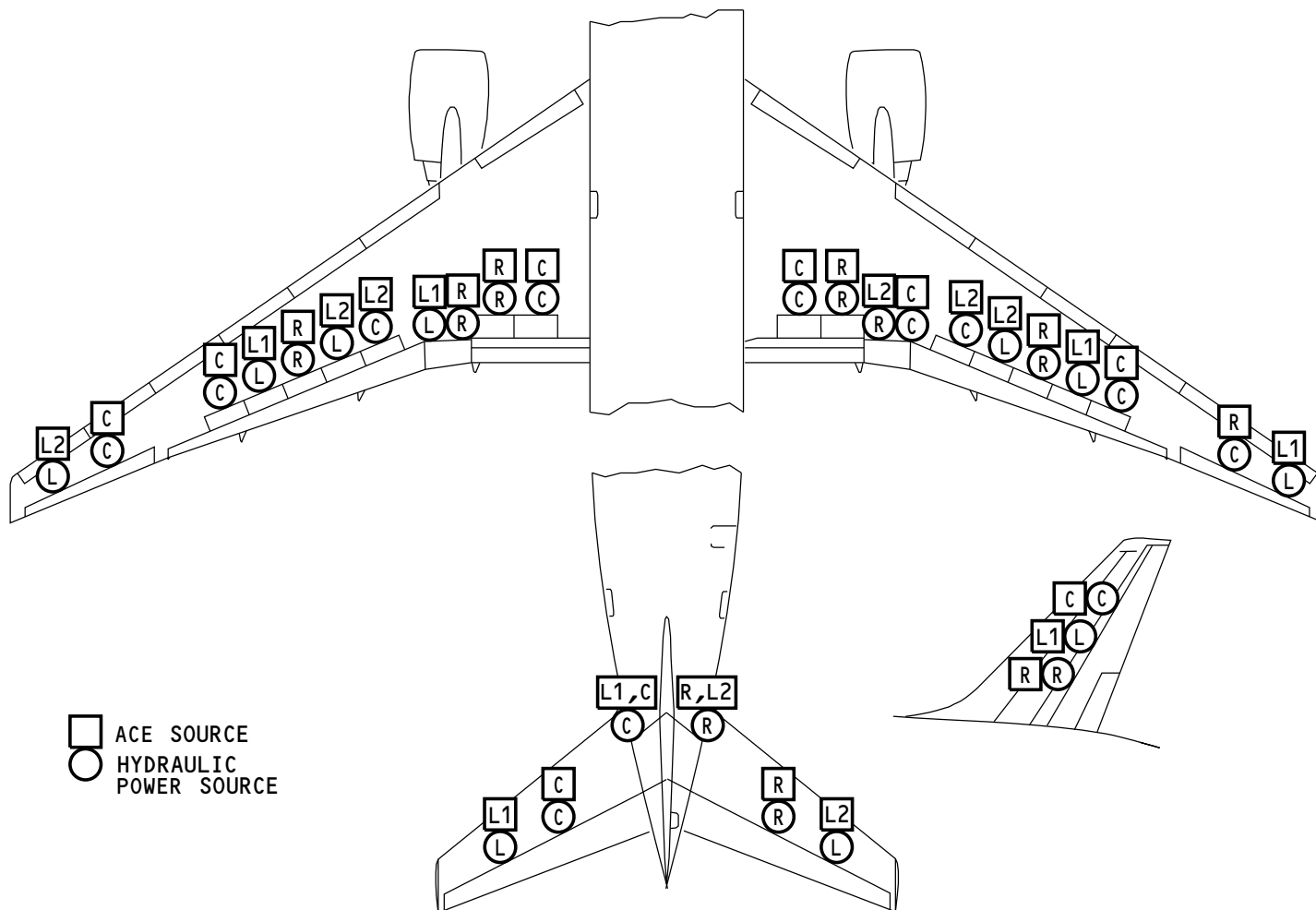
All three hydraulic systems supply power to operate the PCUs of the primary flight controls. The hydraulic distribution is:

- The left aileron: L and C
- Spoiler 1: C
- Spoiler 2: L
- Spoiler 3: R
- Spoiler 4: L
- Spoiler 5: C
- The left flaperon: L and R
- Spoiler 6: R
- Spoiler 7: C
- Spoiler 8: C
- Spoiler 9: R
- The right flaperon: R and C
- Spoiler 10: C
- Spoiler 11: L
- Spoiler 12: R
- Spoiler 13: L
- Spoiler 14: C
- The right aileron: C and L
- The left elevator: L and C
- The right elevator: R and L
- The rudder: L, C and R
- The stabilizer actuator: C and R.

ACE Distribution

The distribution of the four ACEs among the PCUs is in a manner that each PCU for a surface receives commands from a different ACE. The distribution is:

- The left aileron: L2 and C
- Spoiler 1: C
- Spoiler 2: L1
- Spoiler 3: R
- Spoiler 4: L2
- Spoiler 5: L2
- The left flaperon: L1 and R
- Spoiler 6: R
- Spoiler 7: C
- Spoiler 8: C
- Spoiler 9: R
- The right flaperon: L2 and C
- Spoiler 10: L2
- Spoiler 11: L2
- Spoiler 12: R
- Spoiler 13: L1
- Spoiler 14: C
- The right aileron: R and L1
- The left elevator: L1 and C
- The right elevator: R and L2
- The rudder: L1, C and R
- The stabilizer actuator: L1 and C for the left motor/brake, and R and L2 for the right motor/brake.



PFCS - HYDRAULIC POWER AND ACE DISTRIBUTION

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**PFCS - ACE - COMPONENT LOCATION****Purpose**

The actuator control electronics (ACE) supplies interfaces between the pilot controls and the ARINC 629 buses. The ACE controls the power control units (PCU) for the ailerons, flaperons, spoilers/speedbrakes, elevators and rudder.

The ACE controls the stabilizer through two stabilizer trim control modules (STCM). The ACE also controls the rudder trim actuator and the elevator feel actuator.

Physical Description

The ACE weighs approximately 23 lb (10 kg). The ACE is actively cooled.

There are ten program pin pairs on each ACE. The program pins supply information on ACE location and airplane configuration.

Location

The four identical ACEs are:

- L1 ACE (left 1)
- L2 ACE (left 2)
- C ACE (center)
- R ACE (right)

There are three ACEs in the main equipment center:

- C ACE on shelf E2-5
- L2 ACE on shelf E1-1
- L1 ACE on shelf E1-5

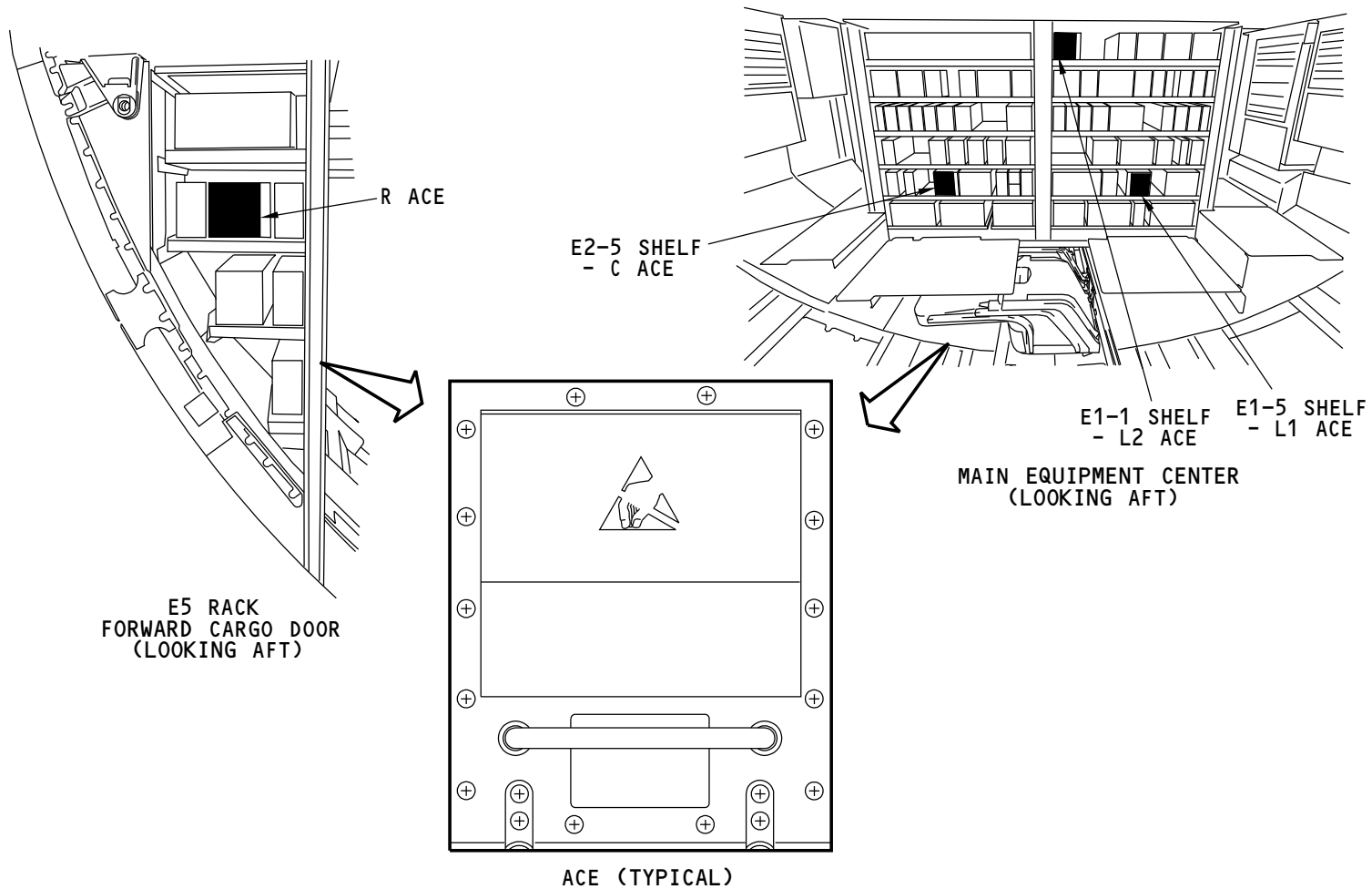
The R ACE is on the E5-2 shelf, aft of the forward cargo door.

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PFCS - ACE - COMPONENT LOCATION

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PFCS - ACE - FUNCTIONAL DESCRIPTION

General

The ACE is a signal converter and controls the direct mode.

The primary functions of the ACE are:

- A/D converter
- D/A converter
- Direct mode select logic
- Direct mode command calculation
- PCU servo loop control
- Excitation power supply.

The ACE operates in all three PFCS modes. Operation of the ACE in direct mode is different than in normal and secondary mode. In normal and secondary mode, the ACE relays input signals from airplane sensors to the PFC and command output signals from the PFC to the PCUs. In direct mode, the ACE processes the input signals with internal hardware and sends command output signals to the PCUs.

A/D Converter

The analog inputs from the position and force transducers go to the A/D converter which changes them from analog to digital format. The transducers send signals from:

- The control wheels
- The control columns
- The rudder pedals
- The speedbrake lever.

The pitch rate sensor is internal to the ACE. It sends analog input signals to the A/D converter and to the direct mode internal hardware. The ACE supplies the signals to the PFC for secondary mode.

The digital signals then go to the ARINC 629 buses.

D/A Converter

Digital commands from the buses go to the D/A converter which changes them from digital to analog format. They then go to the PCU servo loop to control the surfaces.

Direct Mode Select Logic

The pilots can manually switch the ACE to the direct mode. The PFC disconnect switch commands all ACEs to the direct mode.

The PFC automatically changes the ACE to the direct mode when data is not available from all three flight control buses or when internal monitors find failures. The ACE internal logic executes the command.

Direct Mode Command Calculation

In direct mode, the command calculation uses control laws contained in the ACE hardware. Position transducers, force transducers and the pitch rate sensor supply input signals. The analog command output signals go directly to the PCUs.

PCU Servo Loop Control

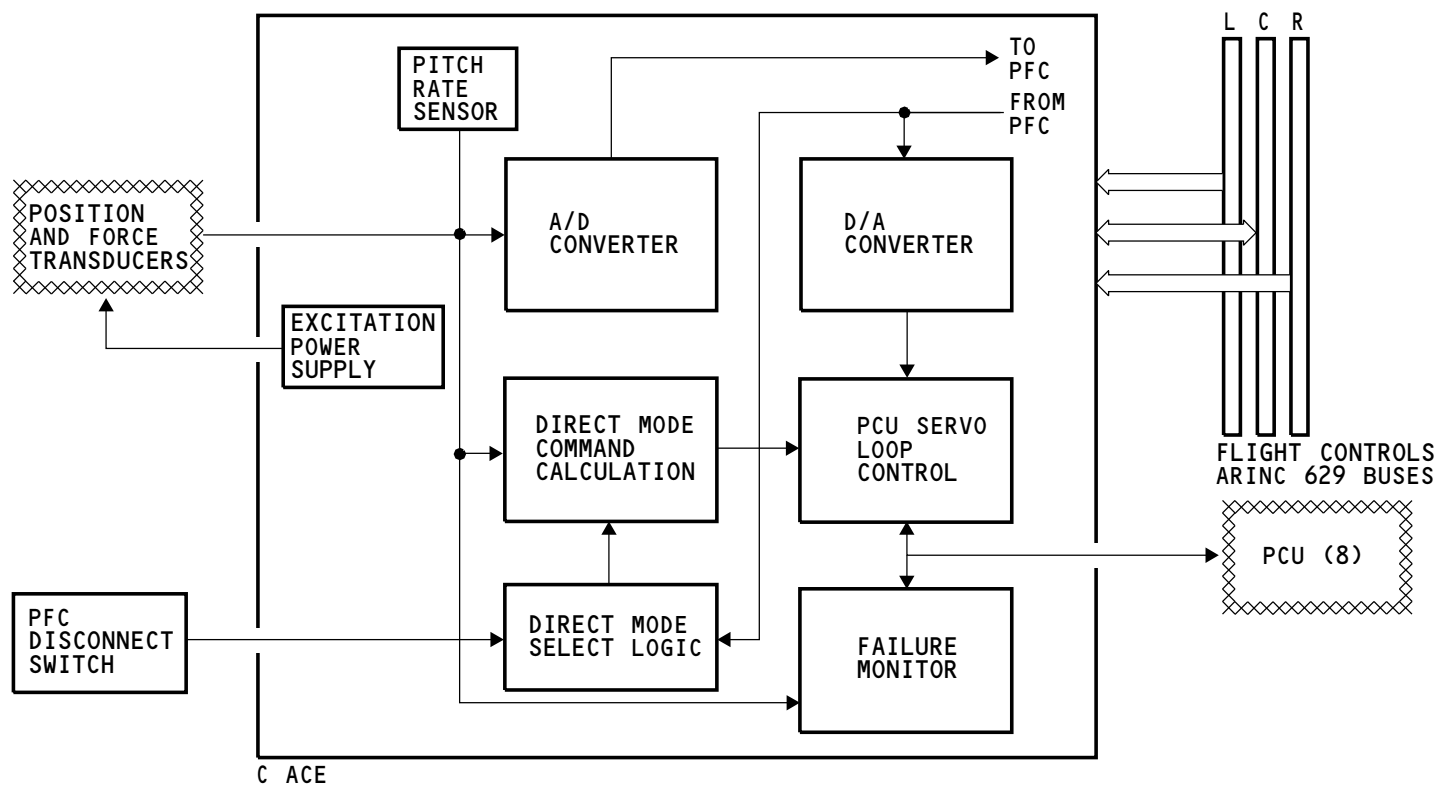
The ACE contains the servo loop control to each PCU. This servo loop operates in all three PFCS modes.

Failure Monitor

The failure monitor controls power to solenoids on the PCUs. When there is a failure, the ACE de-energizes solenoids on the effected PCUs.

Excitation Power Supply

The ACE has power supply circuits that supply 7v AC, 1800 Hz excitation power to the position and force transducers.



NOTE: CENTER ACE SHOWN. OTHERS SIMILAR.

PFCs - ACE - FUNCTIONAL DESCRIPTION

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PFCS - PFC - COMPONENT LOCATION**Purpose**

The primary flight computers (PFC) calculate surface commands for the ailerons, flaperons, speedbrakes, spoilers, elevators, rudder and stabilizer.

These are the functions of the PFC:

- Calculate control surface commands using pilot and autopilot inputs
- Calculate commands for variable elevator feel and backdrive actuators
- Supply stability augmentation
- Supply flight envelope protection
- Send signals for flight deck annunciations
- Send signals for maintenance messages.

Physical Description

The PFC weighs approximately 38 pounds (17 kg). The PFC is passively cooled.

There are thirty-two program pins on each PFC. The program pins supply the following information:

- Airplane type
- Airplane model
- Channel Identification (L,C,R)
- Parity (odd).

You load the software of the PFC through the maintenance access terminal (MAT). There are no software options.

Location

The three identical and interchangeable PFCs are:

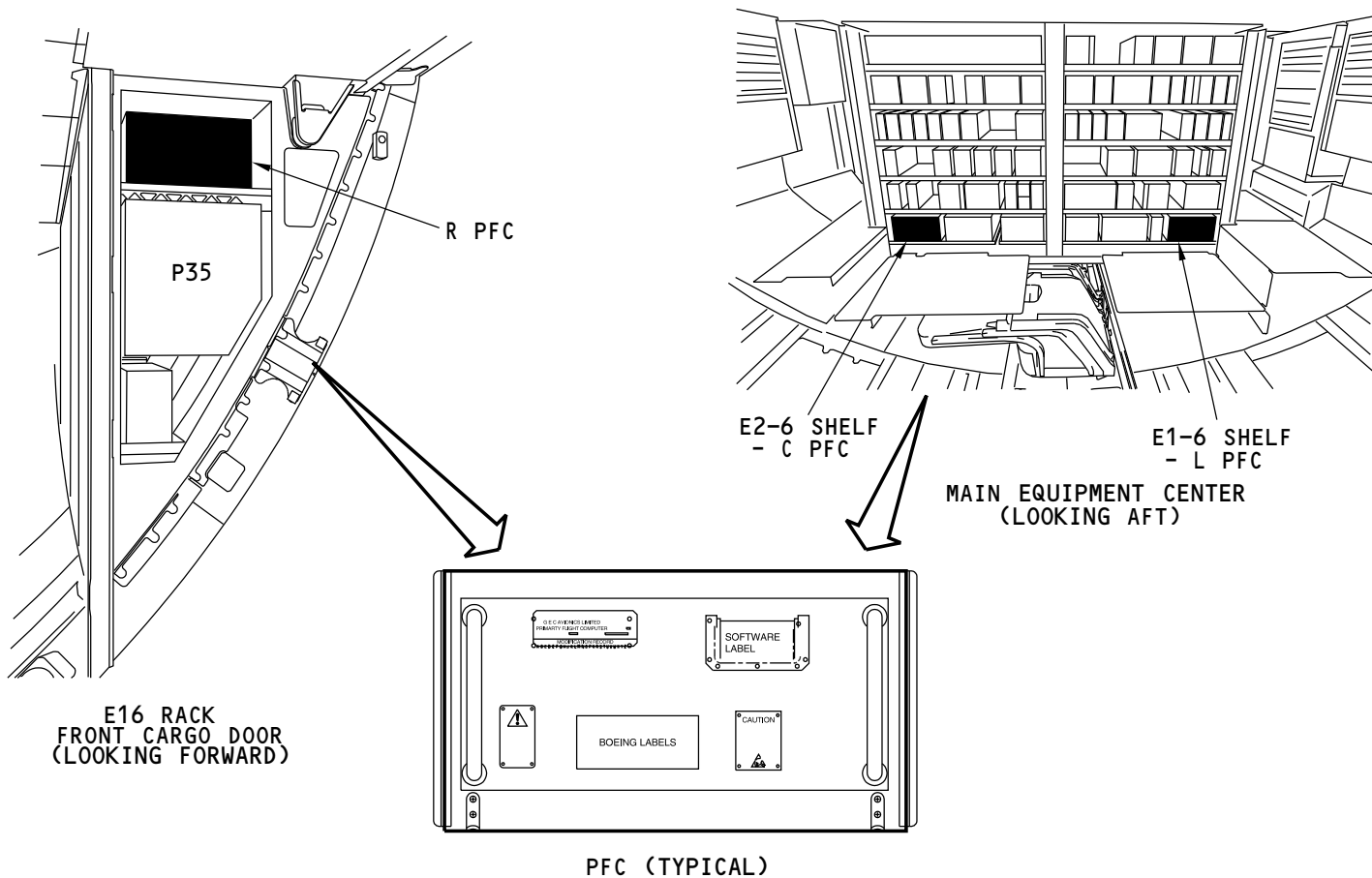
- L PFC (left)
- R PFC (right)
- C PFC (center).

The L and C PFCs are in the main equipment center. The L PFC is on the E1-6 shelf and the C PFC on the E2-6 shelf. The R PFC is in the E16 rack aft of the front cargo door.

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PFCS - PFC - COMPONENT LOCATION

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PFCs - PFC - FUNCTIONAL DESCRIPTION

General

Each PFC has three independent lanes operated by three different part number CPUs. The CPUs are of different design in order to prevent common hardware failures in multiple lanes. The lanes have identical software and capabilities. This is done to get the necessary redundancy. You use the MAT to load PFC software.

When the airplane initially gets electrical power on the ground, the PFCs do tests between lanes and between PFCs. These tests check the compatibility of software, hardware, airplane type and airplane model. Any lane or PFC that fails the tests is declared a failure.

Each lane has:

- An input signal monitor
- A set of control laws
- A cross-lane monitor
- A PFC output selector.

The PFC operates in two modes: normal and secondary. In normal mode, all the functions of the PFC operate. The PFC selects the secondary mode when there is a loss of important air and attitude sensor data from the ADIRU and SAARU. The secondary mode is a degraded mode in which only specified functions of the PFC operate.

Lane Functions

The three lanes can become any one of these three lanes:

- Command lane
- Standby lane
- Monitor lane.

The command lane transmits its command output signals to the flight controls ARINC 629 buses. The command lane also has a lane monitoring function to find and isolate failures in the standby and monitor lanes.

The standby lane transmits test data only. The standby lane becomes the command lane and transmits its command output signals to the buses when a failure causes the command lane to shut down. The standby lane does monitoring functions to find and isolate failures in the command and monitor lanes.

The monitor lane transmits test data only. The monitor lane command output signals are used internally to find failures in the command and standby lanes. The monitor lane becomes the standby lane when the command lane shuts down.

Lane Selection

When the airplane initially gets electrical power, each PFC starts a lane selection procedure. This procedure automatically sets the function of each lane in each PFC. Each PFC must select a different lane for its command lane.

At the end of each flight, the lane selection in each PFC changes to decrease the exposure time for potentially latent failures.

Input Signal Monitor

Each lane gets input signals from sensors on the captain's and first officer's sides of the flight deck. Dual and triple sensors on each side supply input signals. The input signal monitor of each lane sets which input signal to use by mid-value selection and averaging.

The mid-value selection compares the signal values of each side and selects the signal that has the middle value. The input signal monitor then averages the mid- values from the captain's and the first officer's sides.

This selection causes each independent process software to receive the same input signal. This selection also removes signals that are out of tolerance.

Control Laws

Each lane has a set of control laws to calculate the proposed command output signals. The command lane sends proposed commands to the other two PFCs.

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PFCS - PFC - FUNCTIONAL DESCRIPTION

Cross-Lane Monitor

The cross-lane monitor does a check of the validity of the proposed signals generated by all three lanes. If a cross-lane monitor finds a lane fault, it temporarily inhibits the transmission of the lane's data on the flight controls ARINC 629 buses. The monitor lets the faulty lane try to operate as many as four times during a flight. If the lane still cannot operate without failure, then the monitor latches the failed lane so it can no longer operate.

If the command lane fails, the cross-lane monitor shuts it down and causes the standby lane to do the function of the command lane. If a second lane is defective, the PFC shuts down.

PFC Output Selector

Each lane has a PFC output selector to supply a common set of PFC command output signals for use by the ACEs. This function makes sure that all PFC generated command output signals are identical to each other. The PFC output selector operates only in the command lane.

The PFC output selector gets the proposed command output signals from all three PFCs. The PFC output selector compares the three proposed signals and makes a selection by the mid-value process. Only the PFC output selector of the command lane then transmits the selected command output signal to the flight controls ARINC 629 buses and the ACEs.

PFC Self Test

At the end of each flight, the PFCs do an automatic PFC self test to find component failures and confirm failures found in flight.

The following indications can be expected while PFC self test is running and can be considered normal:

- EICAS Advisory and Status message "NO AUTOLAND" will be displayed continuously.
- "PRI FLIGHT COMPUTERS" and "FLIGHT CONTROLS" caution messages, and "FLIGHT CONTROL SYS" maintenance message may flash on and off.
- The EICAS Flight Controls synoptic indications will flash, and the PFCS mode indication will change repeatedly.

- The PFCS mode on the Flight Control maintenance page will change repeatedly.

Lane Availability and Indications

The three PFCs supply a total of nine lanes on the airplane. When there is no failure, the lane availability is referred to as the 3-3-3 lane configuration. If a PFC has a failed lane, the lane availability is 2. The PFC shuts down if there is a second lane failure or if all three lanes fail. In that case, the lane availability is 1 or 0.

The table below shows the indication on the primary display system and the operating mode for each combination of lane availability.

LANE AVAILABILITY	PFCS MODE	MESSAGE	MESSAGE TYPE
3-3-3	NORMAL	NONE	NONE
3-3-2	NORMAL	NONE	NONE
3-2-2	NORMAL	PFC CONTROL LANES	STATUS
3-3-1/0	NORMAL	PFC CHANNEL	STATUS
3-2-1/0	NORMAL	FLIGHT CONTROL SYS	STATUS
3-1/0-1/0	NORMAL	FLIGHT CONTROL SYS	STATUS
2-2-2	NORMAL	FLIGHT CONTROL SYS	STATUS
2-2-1/0	NORMAL	FLIGHT CONTROL SYS	STATUS
2-1/0-1/0	NORMAL	FLIGHT CONTROL SYS	STATUS

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PFCS - PFC - FUNCTIONAL DESCRIPTION

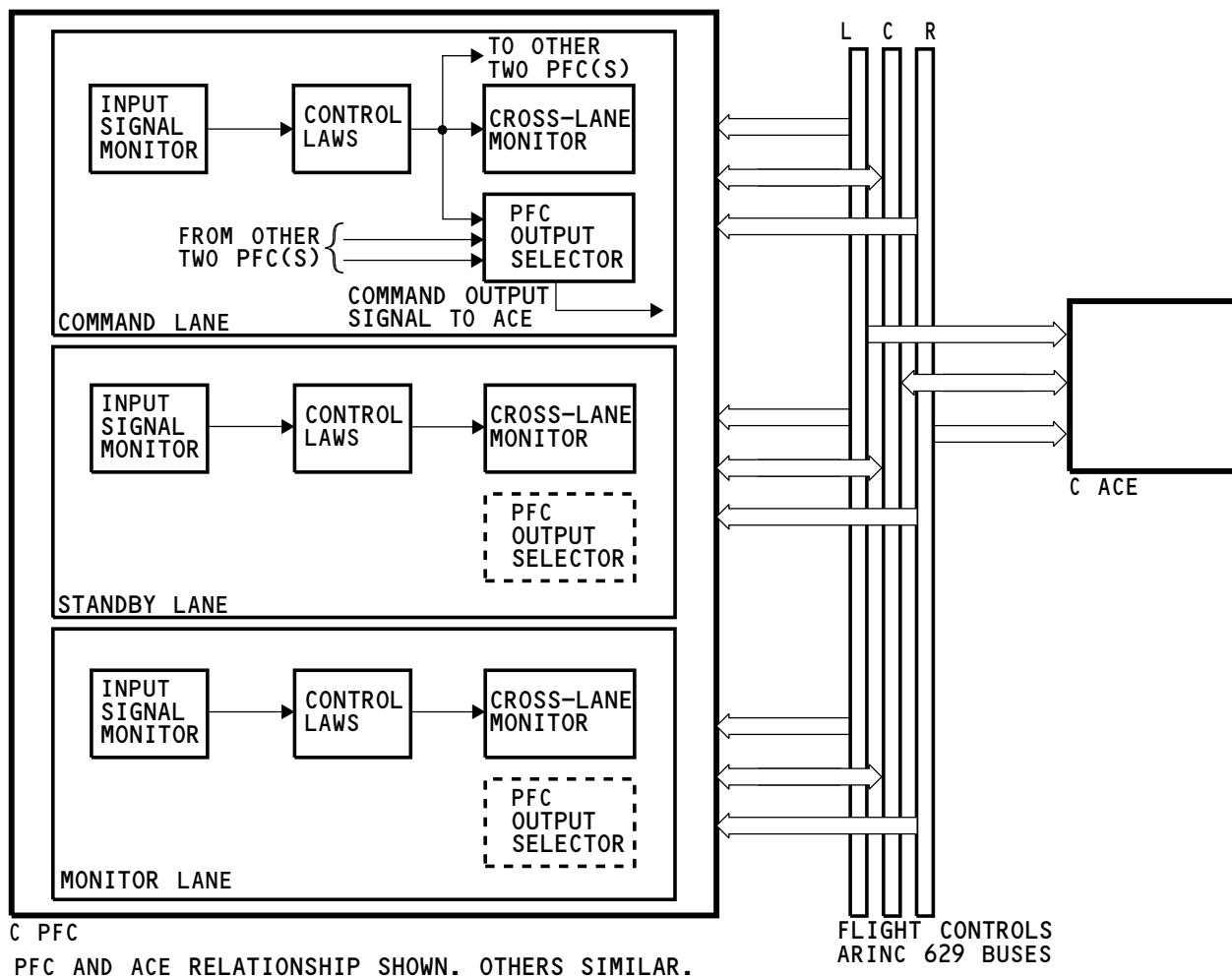
(Continued)

LANE AVAILABILITY	PFCS MODE	MESSAGE	MESSAGE TYPE
1/0-1/0-1/0	DIRECT	PRI FLIGHT COMPUTERS	CAUTION
		AUTO SPEEDBRAKE	ADVISORY
		THRUST ASYM COMP	ADVISORY
		FLIGHT CONTROL SYS	STATUS
		AUTO SPEEDBRAKE	STATUS
		THRUST ASYM COMP	STATUS

The system operates normally with one PFC lane failed, in the 3-3-2 configuration. There is no flight deck indication in this configuration.

The EICAS caution message FLIGHT CONTROL MODE indicates that the PFCS is in secondary mode.

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PFCs - PFC - FUNCTIONAL DESCRIPTION

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PFCs - PFC CONTROL LAWS - FUNCTIONAL DESCRIPTION

General

The PFCs software includes the flight control laws. They calculate the control surface commands to set the desired airplane stability and control. The calculation uses data inputs from the pilots, the autopilot, and other data from the air and inertial sensing systems.

The PFCs calculate control commands for:

- The ailerons, flaperons and spoilers for roll control
- The ailerons and some spoilers for lockout during cruise
- The ailerons and flaperons for droop control during flap extension
- The spoilers during speedbrake control in flight and on the ground
- The elevators for pitch control
- The elevator feel actuator
- The stabilizer for elevator offload (long term pitch trim), column cutout, and stabilizer auto shutdown
- The rudder for yaw control, yaw damping, rudder ratio, and wheel-rudder cross-tie
- The rudder trim actuator.

The control laws also include stability augmentation and protection functions.

Stability Augmentation

There is a stability augmentation function for the pitch and yaw control. Stability augmentation controls the airplane attitude to simulate the natural reaction of the airplane that the pilots expect.

The control laws calculate yaw damping and turn coordination commands. A gust suppression function makes the ride quality better and reduces the pilots' work load.

In pitch stability augmentation, the PFCs use the control laws to calculate the elevator control commands for speed stability and flare compensation.

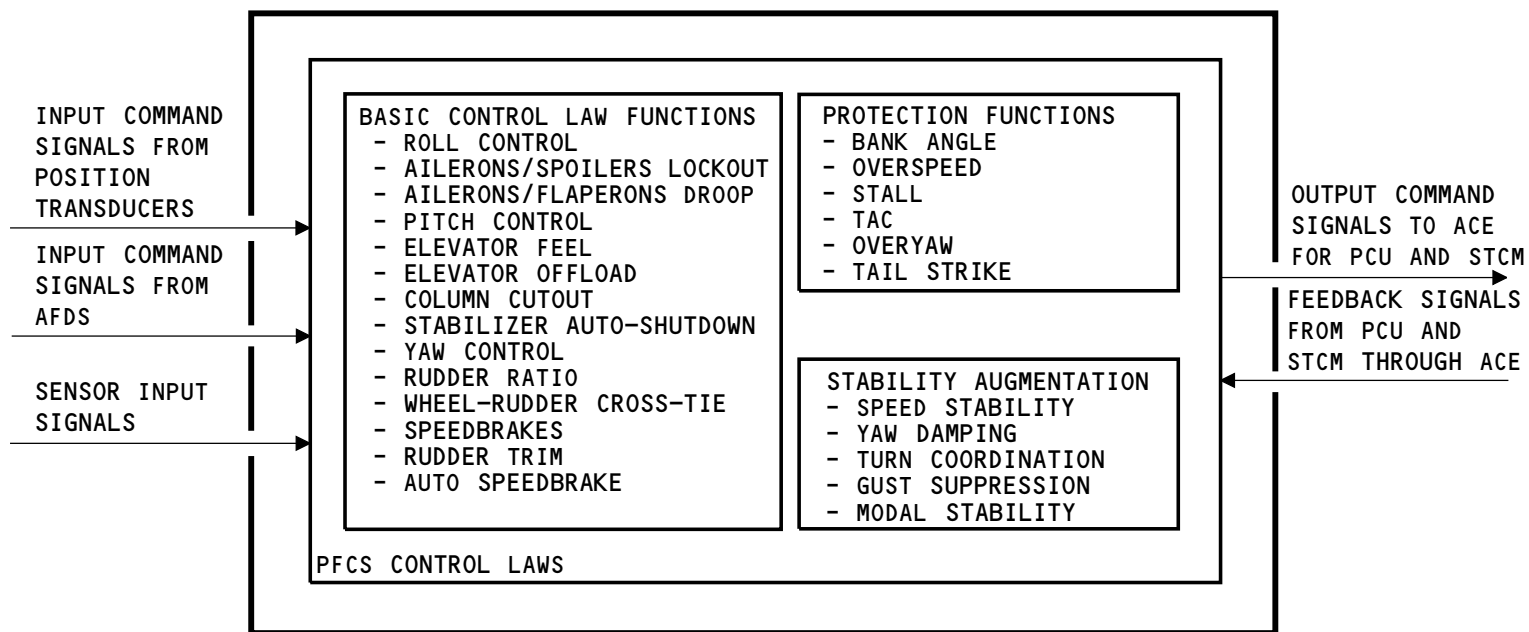
Protection Functions

The control laws contain several different limits to supply flight envelope protection in the three axes of control. The PFCs calculate protection functions for:

- Bank angle
- Overspeed
- Stall
- Thrust asymmetry compensation
- Overyaw
- Tail Strike.

The bank angle protection supplies a roll command opposite to the bank. The overspeed protection supplies a pitch up command when the speed is more than the maximum. The stall protection supplies a pitch down command. The thrust asymmetry compensation (TAC) automatically controls the rudder movement to make allowance for asymmetrical thrust from the engines. The overyaw protection operates through the wheel-rudder cross-tie function to decrease the yaw command.

The bank angle and the stall protections supply more resistive force to the controls. The pilots can override the protection functions when they move the controls more than the limit. There is no increased force on the controls for the other protection functions.



PRIMARY FLIGHT COMPUTER (TYPICAL)

PFCs - PFC CONTROL LAWS - FUNCTIONAL DESCRIPTION

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**PFCS - PFC DISCONNECT SWITCH****Purpose**

The PFC disconnect switch lets the pilot select the direct mode of operation.

Physical Description

The PFC disconnect switch is a guarded toggle switch with two positions: AUTO and DISC. The switch is guarded in the AUTO position. An amber PFC disconnect (DISC) light is next to the switch.

Location

The PFC disconnect switch and light are on the P5 panel in the flight deck.

Functional Description

The PFC disconnect switch sends a discrete signal to each ACE. The ACE then transmits this signal to its on-side PFC through the flight controls ARINC 629 buses.

When the PFC disconnect switch is in the AUTO position, PFCS mode selection is automatic. The pilots can set the switch to DISC to select the direct mode of operation.

The amber DISC light shows when the PFCS is in direct mode, regardless of how the direct mode was engaged.

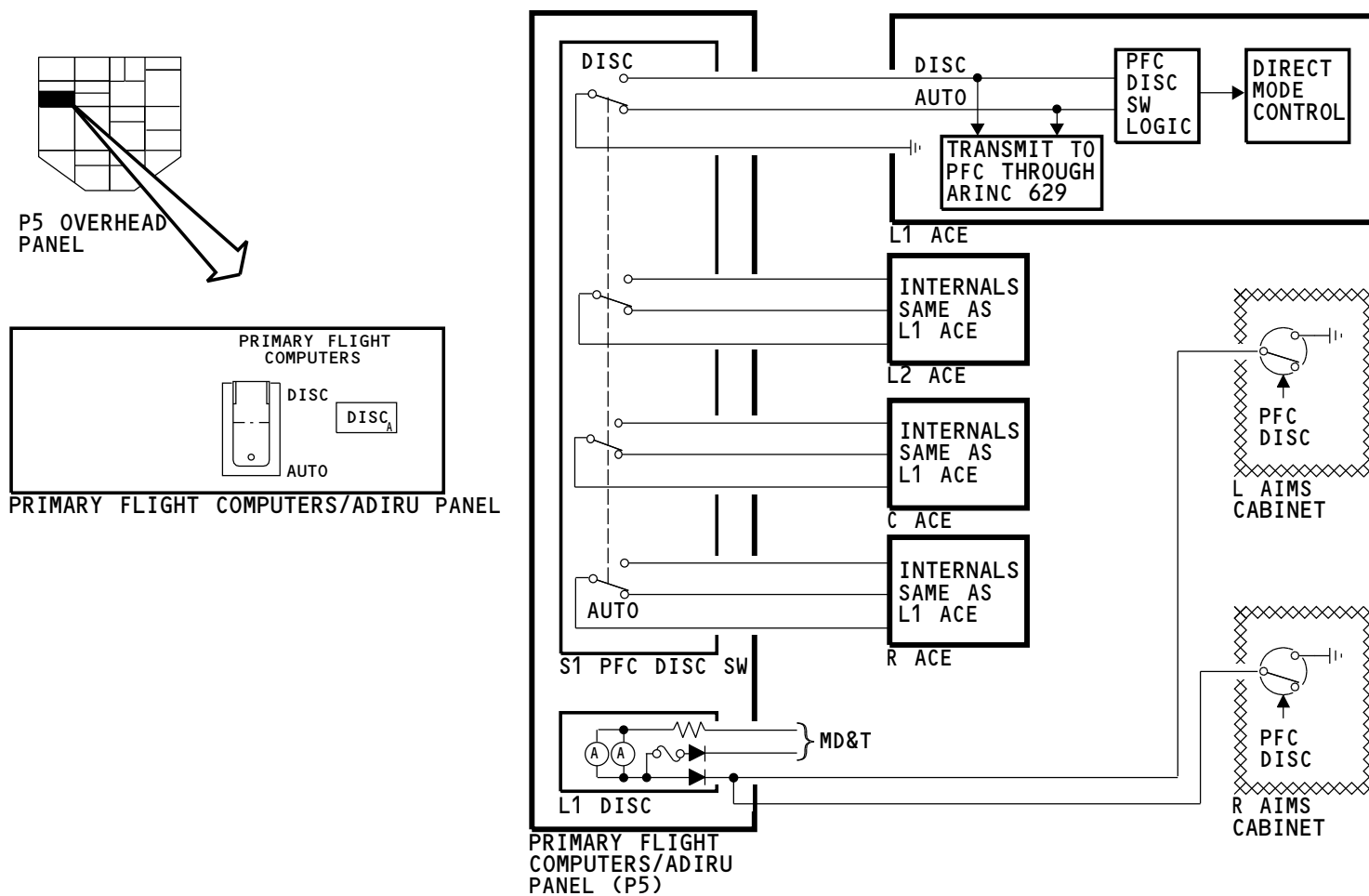
Indications

The EICAS caution message PRI FLIGHT COMPUTERS shows that all the ACEs that have power are in the direct mode and the PFC is not in the hydraulic OFF self-test mode. The message shows when the PFC disconnect switch is in the DISC position.

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PFCS - PFC DISCONNECT SWITCH

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PFCS - OPERATIONAL MODES - FUNCTIONAL DESCRIPTION

General

These are the three modes of PFCS operation:

- Normal
- Secondary
- Direct.

During the PFCS normal and secondary mode operation, both the PFCs and the ACEs are in operation. In the secondary mode, the PFC's operation downgrades. During the direct mode, only the ACEs operate in response to direct analog inputs.

The PFCS selects the mode of operation. On the ground with ground speed less than 40 knots, the PFCs automatically select the highest mode available based on the inputs from the ADIRU and SAARU. In flight, the pilots cycle the PFC disconnect switch on the P5 panel, or move it back to the AUTO position to cause the selection of the highest mode available.

During PFCS mode changes, there is a smooth change to the new commands.

Normal Mode

The PFCS selects the normal mode when all these conditions are met:

- The PFC disconnect switch, on the P5 panel, is in the AUTO position
- The needed input data is available
- At least one PFC and three ACEs are in normal mode.

All the control laws, the protection functions, and the stability augmentation of the PFCs are active in the normal mode. The autopilot operates only in normal mode.

Secondary Mode

The PFCS selects the secondary mode when it detects the loss of important air and attitude sensor data from both the ADIRU and the SAARU. The PFCS also selects the secondary mode when two ACEs are in direct mode.

A simplified set of control laws operate the PFCS in secondary mode. The protection functions are not available. Gain schedules and limits are a function of flap data discretes from the ACEs. Pitch stability augmentation uses pitch rate data from the ACEs. Yaw damper augmentation uses inertial data from the ADIRU and the SAARU if available.

Direct Mode

The PFCS selects the direct mode when there are failures that make the normal and secondary modes unreliable. If three ACEs are in direct mode, the PFCS switches the last ACE to the direct mode. The PFC disconnect switch also causes the selection of the direct mode.

The PFCs do not control the surfaces in the direct mode. Position transducer signals from the control wheels, columns and pedals go directly to the ACEs which use them to control the PCUs. The protection functions are not available.

When the PFCS is in direct mode, whether automatically or manually, the DISC amber light shows next to the PFC disconnect switch.

Manual Switching

The PFCS goes to the direct mode of operation when the pilots move the PFC disconnect switch to the DISC position.

If the pilots cycle the PFC disconnect switch or move it again to the AUTO position, the PFCS goes from the direct mode to the highest mode available. The PFCS selects the mode based on the validity of available data.

If the PFCS is in the secondary or direct modes and the normal mode becomes available, the PFCS may select the normal mode. To do this in the air, you must cycle the PFC disconnect switch. If the airplane is on the ground and ground speed is less than 40 knots, then the PFCS selects the normal mode automatically.

Indications

The EICAS caution message FLIGHT CONTROL MODE shows when the PFCS is in secondary mode.

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**PFCS - OPERATIONAL MODES - FUNCTIONAL DESCRIPTION**

The EICAS caution message PRI FLIGHT COMPUTERS shows when all ACEs under power are in direct mode and the PFC is not in the hydraulic OFF self-test mode.

On the status display, the status message FLIGHT CONTROL SYS shows when the PFCS does not operate at minimum dispatch requirement levels. Some of the faults that cause the FLIGHT CONTROL SYS status message are listed below. Other PFCS faults can also cause the FLIGHT CONTROL SYS status message.

- Failure of more than one column, wheel, or speedbrake lever position transducer
- Failure of a pedal transducer
- Failure of a rudder or elevator PCU
- Failure of more than one aileron or flaperon PCU
- Failure of the PCU for spoiler 4 or spoiler 11
- Failure of two or more PCUs that are not part of the same symmetrical spoiler pair (spoilers pairs 1/14, 2/13, 3/12, 5/10, 6/9, and 7/8)
- Failure of a STCM
- Failure of an elevator feel actuator
- Failure of a PFC and at least one lane in another PFC
- Failure of an ACE or at least one ACE is in direct mode
- Failure of the stabilizer control
- Failure of the actuator confidence test
- Failure of a PSA, a flight controls ARINC 629 bus, or a WES channel.

The EICAS caution message FLIGHT CONTROLS shows when the flight control system has lost substantial capabilities. Any one of these faults causes the message to show:

- The stabilizer is not operative
- Two elevator PCUs and one stabilizer path are not operative
- The wheel, column, or pedal position transducers for the captain and first officer disagree by more than 15 percent of full range with the airplane on the ground

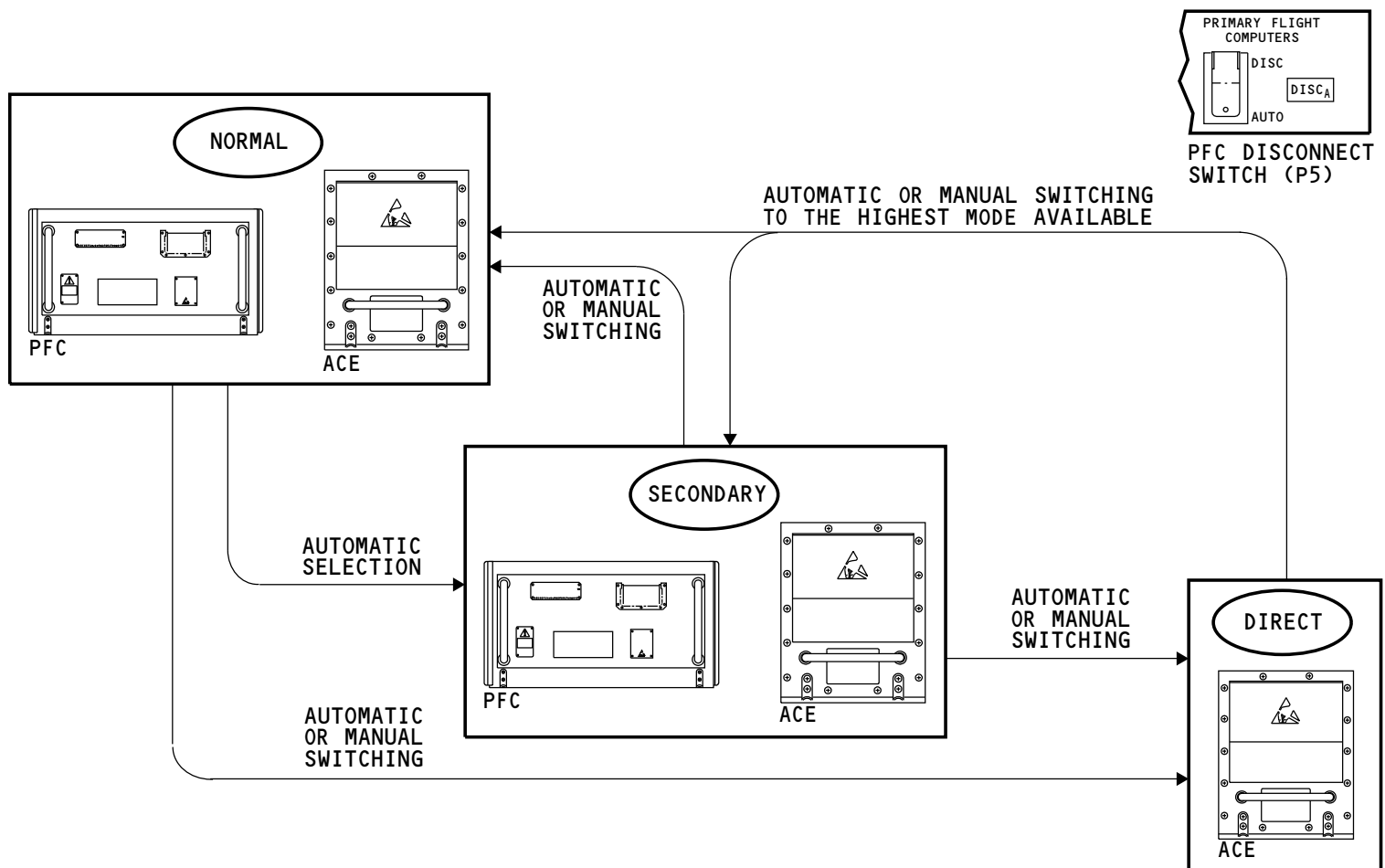
- The elevator force fight equalization function is defective.

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PFCs - OPERATIONAL MODES - FUNCTIONAL DESCRIPTION

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PFCS - FUNCTIONAL DESCRIPTION

General

The primary flight control system supplies roll, pitch and yaw control to set the desired airplane attitude.

At the end of each flight, the PFCs do internal tests and select the function of each lane.

At the completion of power-up and with the hydraulic systems pressurized, the PFCs command the surfaces to slowly move to agree with the command from the control wheels, control columns and rudder pedals.

On the ground without the engines running, the system receives electrical power from a secondary source. When the engines start, the system automatically switches to the PMGs as its primary power source.

Roll Control

The roll control causes the ailerons, flaperons and spoilers to move. When the pilots move a control wheel, six position transducers send analog signals to the PFCs through the ACEs. The PFCs select the signal to process. The control laws, protection functions and stability augmentation of the PFCs, calculate the command output signals. After selection of one signal among the three supplied by the PFCs, the PFCs send the command output signal to the ACEs. The ACEs then command the control surface PCUs. PCU position transducers send feedback signals to the ACEs.

The PFCs also control:

- The aileron lockout during cruise
- The aileron and flaperon droop when the flaps extend.

Speedbrake Control

When the pilots move the speedbrake lever, four position transducers send analog signals to the PFCs through the ACEs. The PFCs then calculate the command output signals. After selection of one signal, the PFCs send the selected signal to the ACEs. The ACEs then command the spoiler PCUs. PCU position transducers send feedback signals to the ACEs.

Pitch Control

The pitch control causes the elevators and the horizontal stabilizer to move. When the pilots move a control column, six position transducers send analog signals to the PFCs through the ACEs. The PFCs process these signals and command the elevator PCUs in the same manner as the roll control.

When there is a command to the elevator that lasts longer than a calculated time, the elevator offload function of the PFCs send stabilizer command signals to the ACEs. The ACEs then command the stabilizer trim control modules (STCMs) which hydraulically control the stabilizer ballscrew actuator. The movement of the stabilizer then causes the elevator to fair.

Yaw Control

The yaw control causes the rudder to move. When the pilots move the control pedals, four position transducers send analog signals to the PFCs through the ACEs. The PFCs process these signals and command the rudder PCUs in the same manner as the roll control. The PFCs also control changes in the rudder ratio, gust suppression and wheel-rudder cross-tie functions.

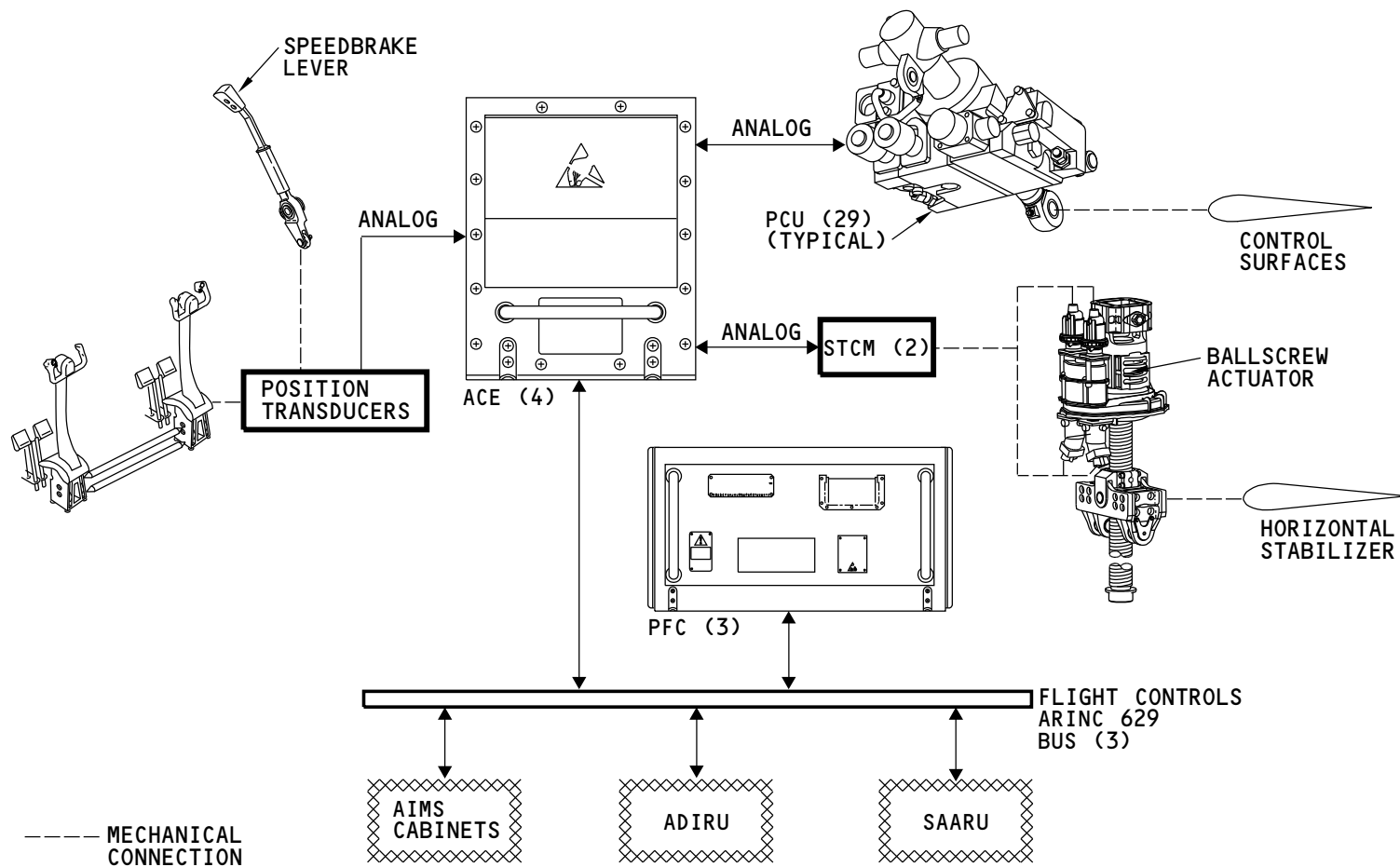
The PFCs control the rudder trim when the pilots move the rudder trim selector or the manual trim cancel switch. The thrust asymmetry compensation (TAC) function automatically controls the rudder trim to correct for asymmetrical thrust of the engines.

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PFCS - FUNCTIONAL DESCRIPTION

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PFCS - AUTOPILOT - GENERAL DESCRIPTION

General

With the autopilot engaged, the PFCS receives command inputs from the AFDCs. The PFCS processes these commands in the same manner as manual inputs from the pilots.

The autopilot function of autopilot flight director system (AFDS) supplies automatic control of the:

- Altitude
- Vertical speed
- Flight path angle
- Heading
- Track
- Airspeed
- Approach
- Go-around.

The AFDS does not have servos to move the primary flight control surfaces. The autopilot commands go to the PFCs. The PFCs use these commands to supply surface commands to the ACEs. The PFCs also supply backdrive commands to the AFDCs.

Autopilot Components

The components of AFDS are:

- One mode control panel (MCP)
- Three autopilot flight director computers (AFDCs)
- Six backdrive actuators
- Two control wheel disengage switches.

Autopilot Engagement

There are two autopilot engage switches on the MCP. When the pilot pushes either momentary action switch, the PFCs receive a request to engage the autopilot function. If conditions are correct, the PFCs permit all the available AFDCs to engage in the pitch and roll axes during cruise.

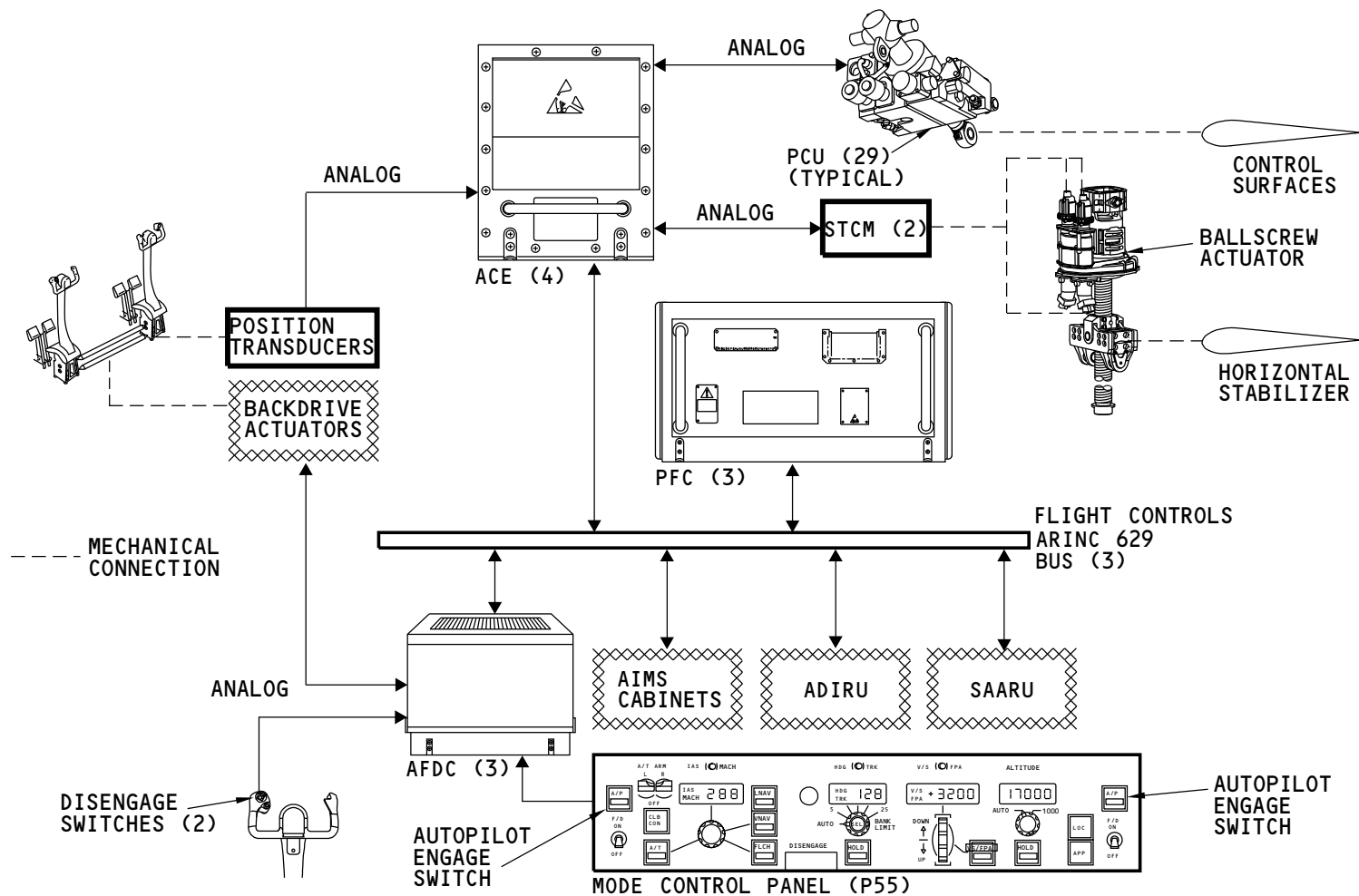
The autopilot yaw axis engages only during the approach and autoland phase of flight. In yaw, the autopilot can control adverse yaw (engine out) and crab angle.

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PFCS - AUTOPILOT - GENERAL DESCRIPTION

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**PFCS - AUTOPILOT - FUNCTIONAL DESCRIPTION****General**

The autopilot flight director computers (AFDCs) calculate roll, pitch and yaw commands to control the airplane automatically. Based on pilot selection, the AFDCs also calculate pitch/roll engage request, yaw engage request and other discrete signals.

Normal Operation

The autopilot commands and discrete engage signals go from the AFDCs to the PFCs through the flight controls ARINC 629 buses. Each PFC receives these inputs from the three AFDCs. The PFC selects a command signal by mid-value selection. This process selects the middle value of the three, not the average value.

The PFC selects the discrete signals by majority selection.

The PFCs filter and limit the autopilot command signals before their use in the control laws. The PFCs process and change the autopilot command signals to surface commands and backdrive commands. The surface commands from the PFCs go to the ACEs to move the flight control surfaces.

Autopilot commands go to the rudder only during automatic approach and landings.

In manual control (no autopilot engaged), the PFCs supply bank angle protection through use of the AFDS wheel backdrive actuators.

Backdrive Operation

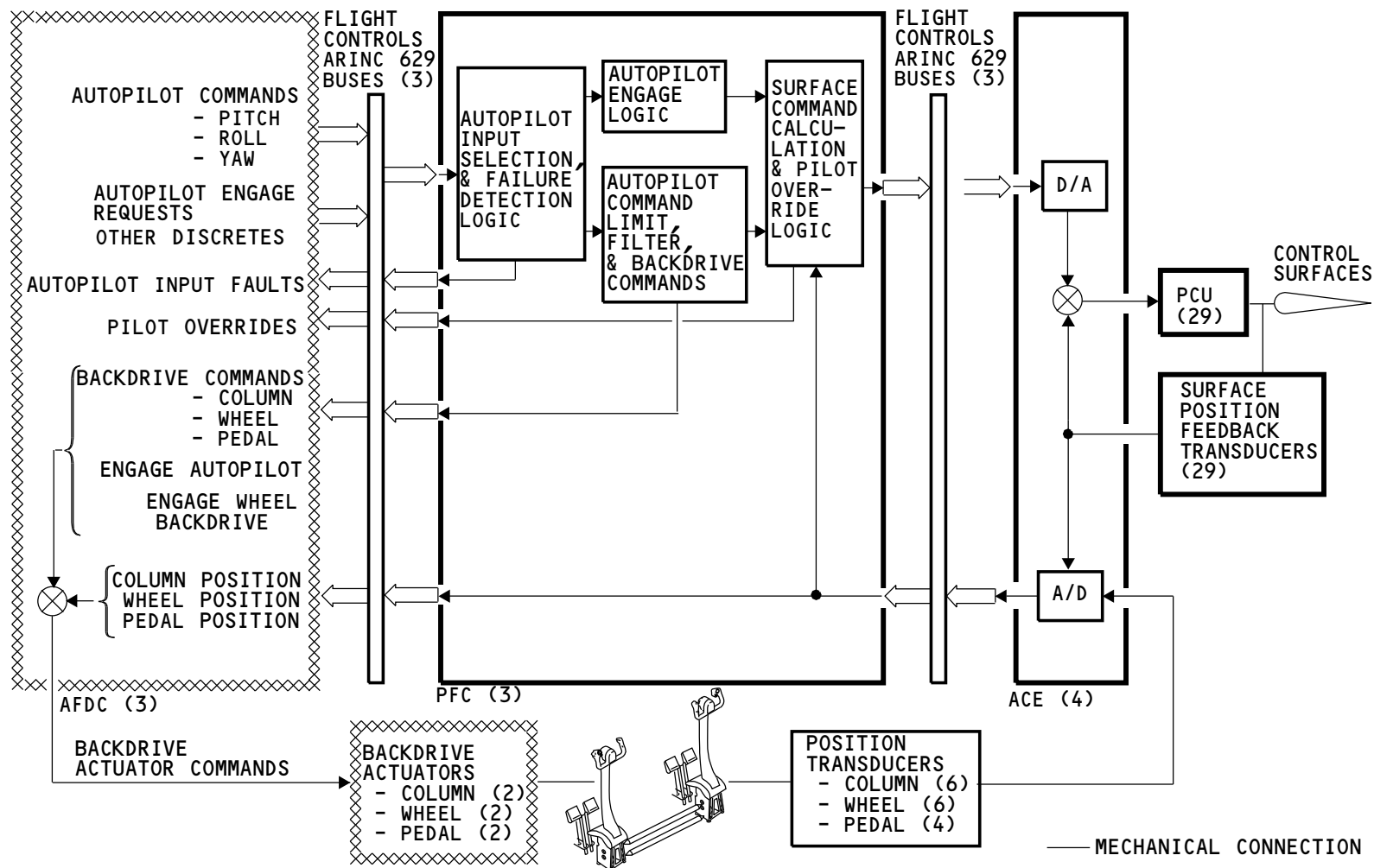
The PFCs send column, wheel and rudder pedal backdrive commands to the AFDCs to operate the backdrive actuators. In cruise, one wheel and one column backdrive actuator operate. Actuator selection alternates at each autopilot engagement. In autoland all backdrive actuators operate. When commanded, the actuators move the control columns, control wheels and rudder pedals to a position that represents the AFDC commands. These movements supply tactile and visual feedback to the pilots.

Position transducers on the columns, control wheels and rudder pedals supply position feedback to the PFCs and AFDCs through the ACEs. The AFDCs use the signal to make sure that the backdrive actuators operate correctly.

Non-normal Operation

For both command and discrete signals, if an input is not valid or failed, the PFC removes it from the calculation. If a second input is not valid, the PFC uses the remaining input. This permits the system to operate with a single AFDC.

When the PFC detects a pilot override in any axis, it disengages all engaged AFDCs.



PFCS - AUTOPILOT - FUNCTIONAL DESCRIPTION

M40941 S000617293_V1

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**PFCS - FLIGHT CONTROL SHUTOFF VALVES - LOCATION****Purpose**

The flight control shutoff valves (SOV) permit the maintenance technicians to stop hydraulic power to the primary flight control actuators.

When 28v dc power is available, the flight control SOVs for the left and right systems can operate in the air or on the ground. The flight control SOVs for the center system can operate only on the ground.

Location

The flight control SOVs for the left hydraulic system are on the left wing, aft of the rear spar, and inboard of the left flaperon. The wing SOV is outboard of the tail SOV.

The flight control SOVs for the center hydraulic system are on the aft bulkhead of the left landing gear wheel well. The tail SOV is the top one, the wing SOV is the bottom one.

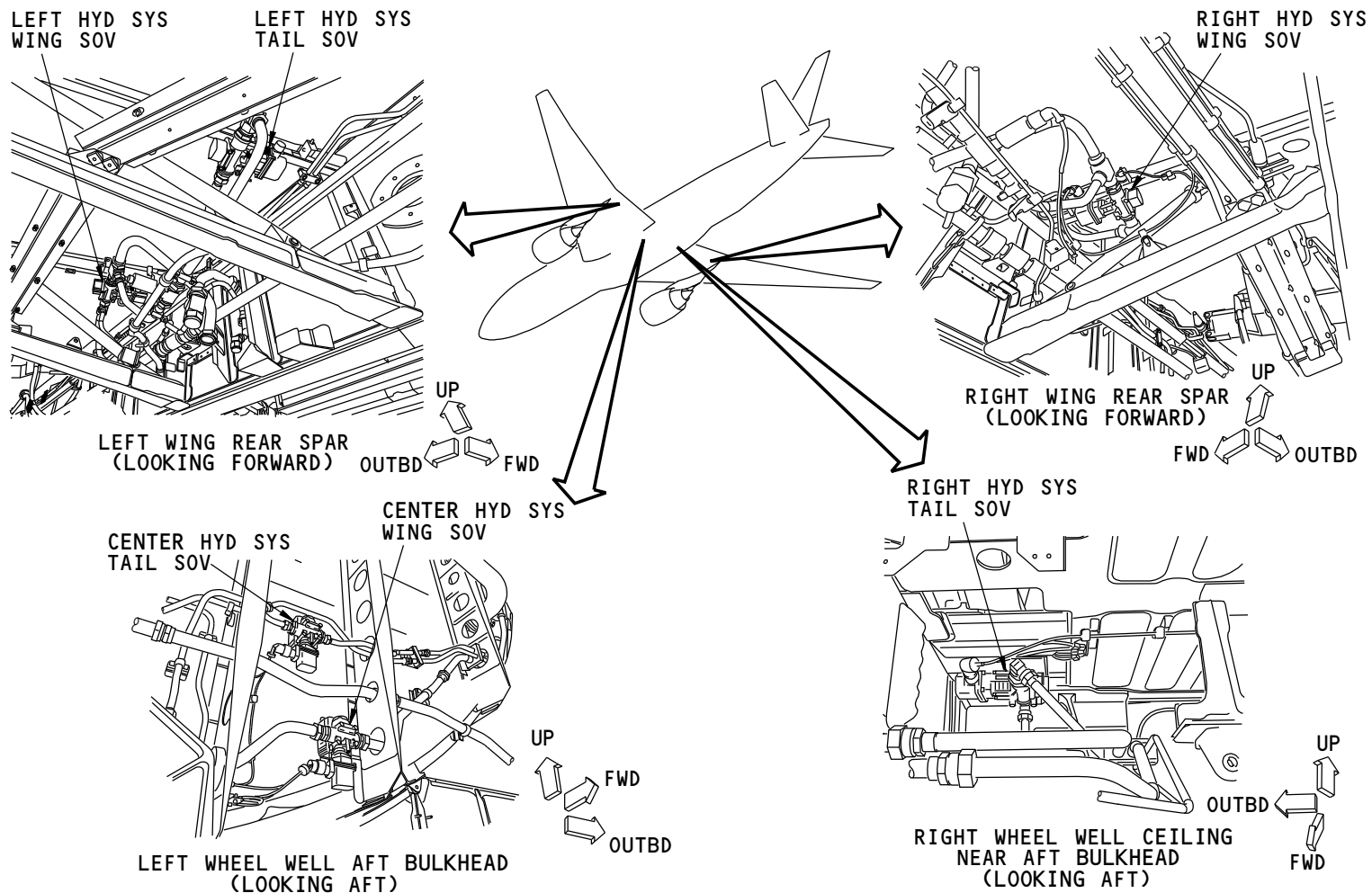
The wing shutoff valve for the right hydraulic system is on the right wing, aft of the rear spar, and inboard of the right flaperon.

The tail shutoff valve for the right hydraulic system is on the ceiling of the right landing gear wheel well, near the aft bulkhead.

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M40942 S000617294_V1

PFCS - FLIGHT CONTROL SHUTOFF VALVES - LOCATION

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PFCS - FLIGHT CONTROL SHUTOFF VALVES - PHYSICAL DESCRIPTION

Physical Description

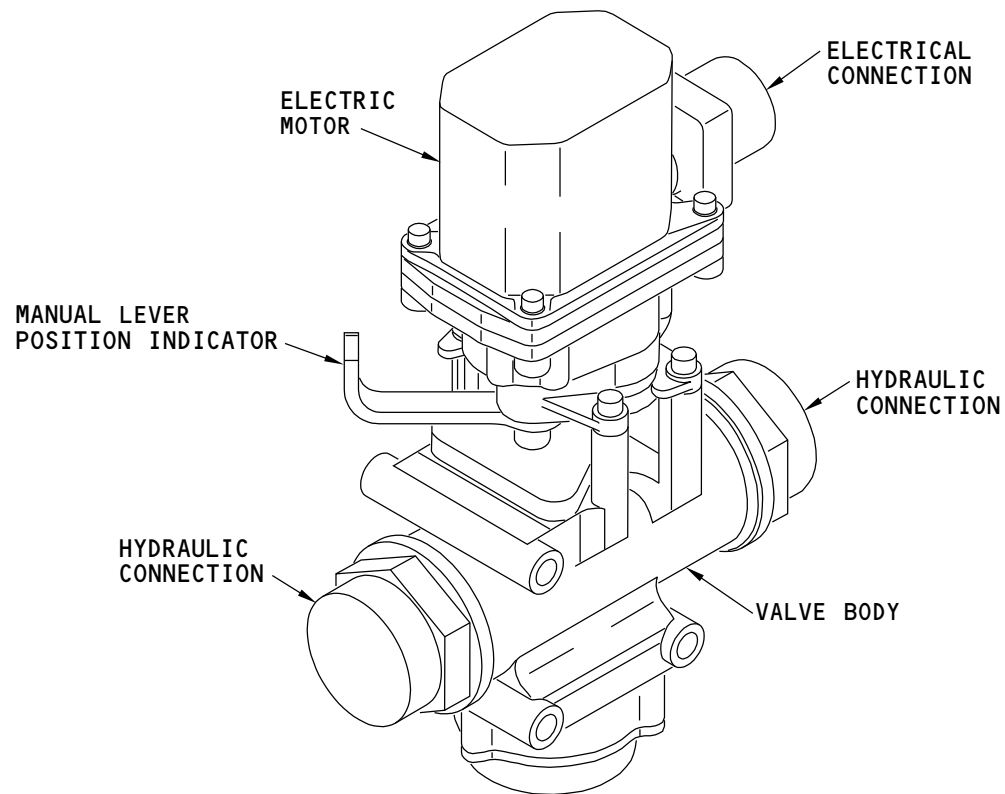
There are six identical valves on the airplane.

Each valve is a two position, two way, ball valve operated by a 28v dc electric motor. The valve has a lever that shows the position of the valve. The maintenance crew may move the lever to operate the valve by hand.

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FLIGHT CONTROL SHUTOFF VALVE

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PFCS - FLIGHT CONTROL SHUTOFF VALVES - PHYSICAL DESCRIPTION

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**PFCS - FLIGHT CONTROL SHUTOFF VALVES - CONTROLS AND DISPLAYS****Controls**

The control switches for the flight control SOVs are on the P61 overhead maintenance panel.

There are six guarded toggle switches. Three are for the tail SOVs and three are for the wing SOVs.

Each toggle switch has two positions, NORM and SHUTOFF. In the NORM position, the switch commands the valve to open. In the SHUTOFF position, the switch commands the valve to close.

Displays

Below each toggle switch, there is an amber VALVE CLOSED light. The light shows when the valve is not open.

An advisory message FLT CONTROL VALVE shows on the EICAS display when one or more flight control shutoff valves are not open.

Training Information Point

After the third tail flight control SOV is closed during maintenance operations, there can be an uncommanded movement of the rudder and/or elevator until the residual hydraulic pressure trapped between the SOVs and the power control units (PCUs) bleeds down.

If a command is made to move the rudder or elevator while the residual hydraulic pressure is high, the related control surface can move rapidly.

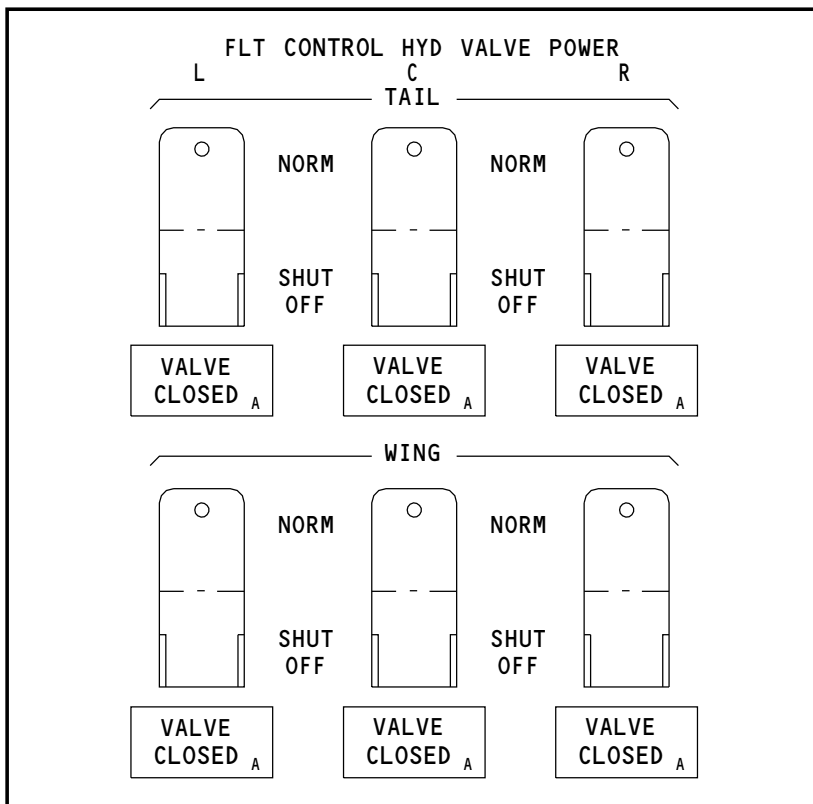
For any maintenance action that requires closure of the tail flight control SOVs, do at least one of these:

- Keep all personnel and equipment clear of the rudder and elevator sweep areas for at least one minute after the third tail flight control SOV closes to let the surface move and stop
- Depressurize all the hydraulic systems before you close the tail flight control SOVs to prevent control surface movement.

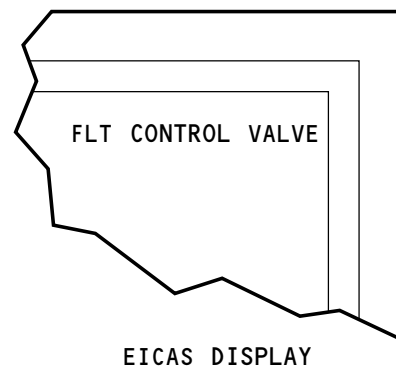
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FLIGHT CONTROL HYDRAULIC POWER PANEL (P61)



EICAS DISPLAY

PFCS - FLIGHT CONTROL SHUTOFF VALVES - CONTROLS AND DISPLAYS

M40945 S000617296_V1

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**PFCS - FLIGHT CONTROL SHUTOFF VALVES - FUNCTIONAL DESCRIPTION****General**

This description is for the tail flight control SOV for the center system. The other flight control SOVs operate in a similar manner. This does not include the left and right SOVs which do not use air/ground signals.

The 28v dc left and right main buses supply power to the flight control SOVs.

Functional Description

The valve has two positions: open and closed. A 28v dc electric motor opens and closes the valve. Two limit switches stop power to the motor at the end of the valve movement. A position indicating switch sends a signal to the HYDIM cards when the valve leaves the open position. This switch stops the signal to the HYDIM cards when the valve is fully open.

A pair of contacts in one of the air/ground relays controls power to close the valve on the center SOVs.

Operation

When the control switch is in the NORM position, the valve opens. When the valve is fully open, the related amber light VALVE CLOSED does not show. The advisory message FLT CONTROL VALVE does not show on the EICAS display.

When the control switch is in the SHUTOFF position, the valve closes when the airplane is on the ground. As the valve leaves the open position, the amber VALVE CLOSED light shows on the P61 panel. The advisory message FLT CONTROL VALVE shows on the EICAS display.

Training Information Point

Ground maintenance personnel use the flight control SOVs to isolate certain portions of the flight controls during troubleshooting and other maintenance work.

Only the center flight control SOVs use an air/ground signal. This signal prevents closure of the valves when the airplane is in the air.

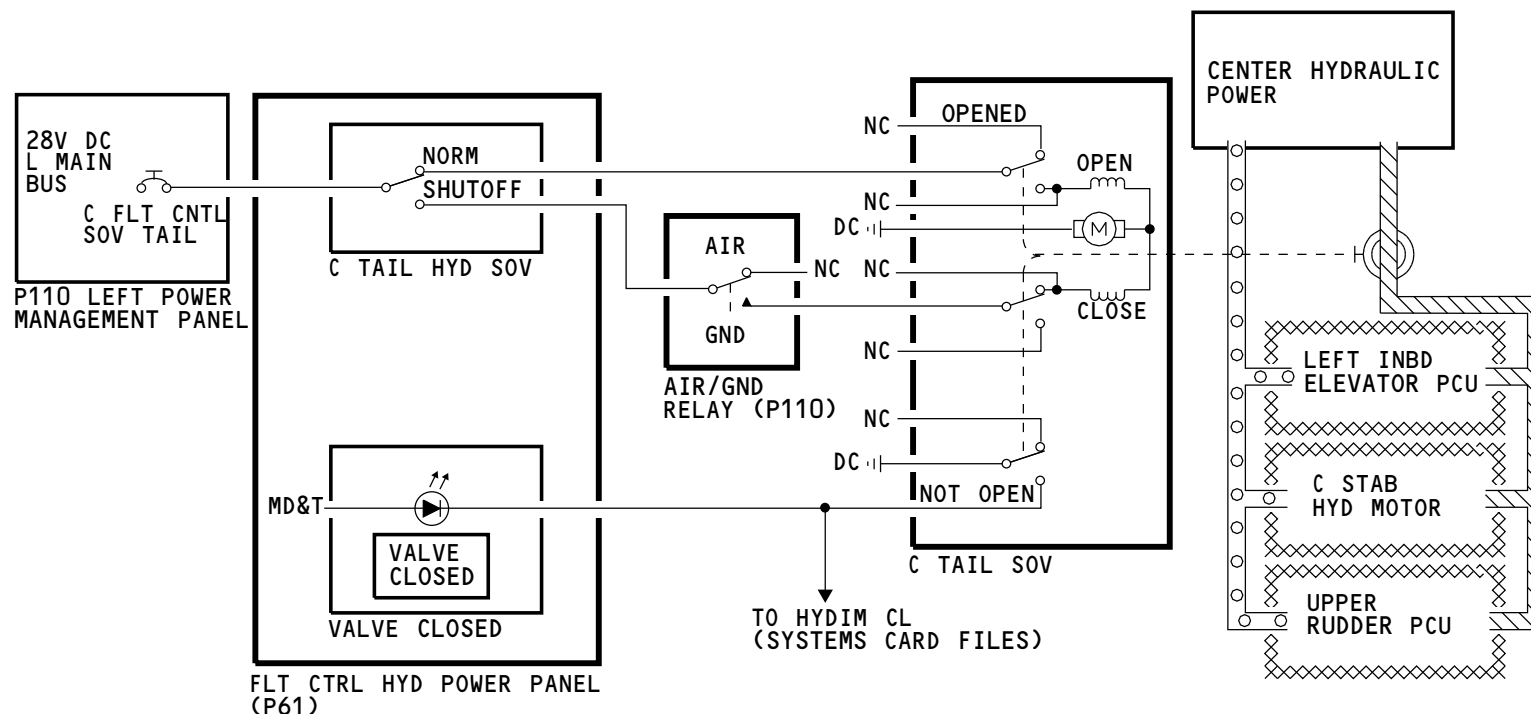
The left and right flight control SOVs can be closed in the air or on the ground.

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NOTE: TAIL SOV FOR CENTER HYDRAULIC SYSTEM SHOWN.
THIS IS TYPICAL OF THE OTHER SHUTOFF VALVES.
ONLY THE CENTER FLIGHT CONTROL SOV USES THE
AIR/GROUND RELAY.

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PFCS - FLIGHT CONTROL SHUTOFF VALVES - FUNCTIONAL DESCRIPTION

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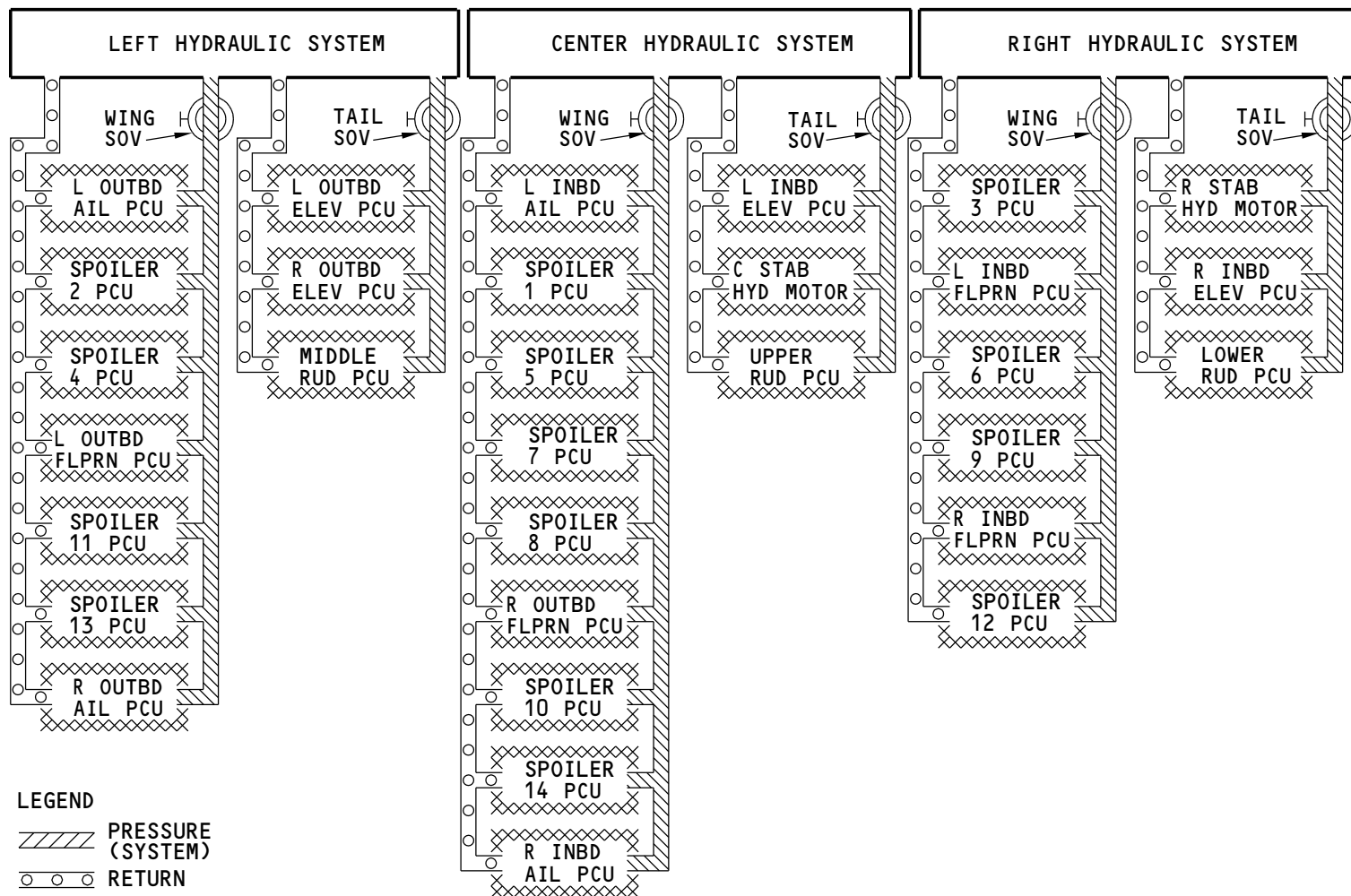


PFCS - FLIGHT CONTROL SHUTOFF VALVES - DISTRIBUTION/CONTROL

General

The graphic shows the wing and tail SOVs for the three hydraulic systems. It also shows the PFCS control surfaces that each valve controls.

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PFCS - FLIGHT CONTROL SHUTOFF VALVES - DISTRIBUTION/CONTROL

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**PFCS - INDICATIONS - FLIGHT CONTROLS SYNOPTIC DISPLAY****General**

The flight controls synoptic display gives the flight crew a graphical overview of the flight control system. The display includes individual positions and failures for each flight control surface.

Normal Conditions

Under normal conditions the indications are white. The pointer on the labeled scales shows the position of the control surfaces.

The spoiler position indicators fill white from the bottom up.

The stabilizer and the rudder trim indicators show the stabilizer and rudder position in degrees. The direction of rudder trim is next to the indicator.

Defective Conditions

When a surface does not operate, a defective condition indicator replaces the scale and pointer or the moving band. The color of this indicator is amber.

Unknown Conditions

When the status of a control surface is unknown, the pointer does not show on the scale. In the case of the spoilers, there is no moving band.

Other System Information

At the bottom of the synoptic display, individual indicators show the condition of:

- The hydraulic power supply systems
- The PFCS mode of operation
- The ACE operation.

The PFCS mode condition shows in green when in normal mode. In secondary or direct mode, the indication shows in amber.

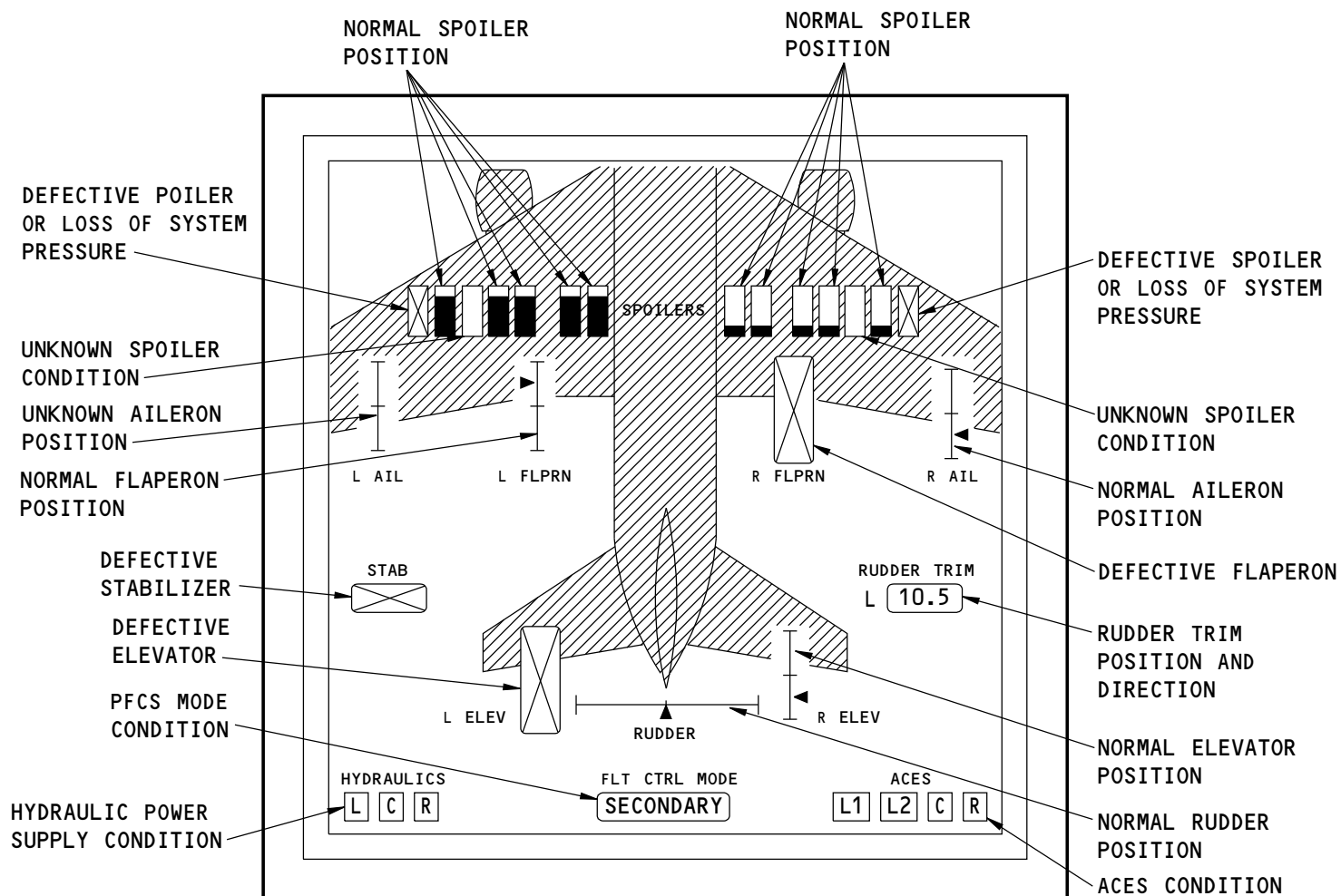
The condition of the hydraulic power supply systems or the ACEs shows only when there is a failure of one of the systems or ACE. The indicator for the failed system or ACE is amber. The others are green.

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PFCS - INDICATIONS - FLIGHT CONTROLS SYNOPTIC DISPLAY

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PFCS - INDICATIONS - MAINTENANCE PAGE - CONTROLS AND VARIABLES

General

There are three PFCS maintenance pages. Page one contains data for the control inputs and variables.

Maintenance personnel use the maintenance pages to do maintenance functions such as rigging or do a check of the discrete inputs and outputs of the PFCS components.

These are the three different display modes:

- Real time mode
- Manual event mode
- Auto event mode.

The word MANUAL or AUTO at the top of the page identifies the manual event or the auto event page. The message that caused the auto event is at the bottom left of the page. The time of the event is at the bottom right.

Variables and Controls

The top of the page shows:

- Roll rate in degrees per second
- Yaw rate in degrees per second
- Altitude in feet
- Roll angle in degrees
- Angle of attack in degrees
- CAS in knots
- ADIRU pitch rate in degrees per second
- ACE pitch rate in degrees per second for each ACE.

Directly below, the page shows the column, wheel and pedal position for the captain's and the first officer's controls. The position shows the displacement, in inches, of each LVDT.

The page then shows the column and wheel force for the captain's and the first officer's controls. The indication shows the force in lb.

The speedbrake lever position is in degrees of RVDT rotation for each of the four RVDTs.

The rudder trim and elevator feel show the actuator extension in inches. Rudder trim position 1 refers to the rudder trim actuator position RVDT. Position 2 refers to the rudder trim position transducer. Elevator feel position 1 refers to the left feel actuator position. Position 2 refers to the right feel actuator.

The gust suppression differential pressure shows in psid. The modal suppression shows in units of gravitational acceleration (g).

An X shows next to the indication if any of the above position, force or pressure transducer signals is invalid.

The lower part of the page shows the PFCS mode of operation and the autopilot engagement status. Up to three protection mode activity messages can show at the lower right of the page. These messages will only show if they are active and they will show in this priority order:

- TAC
- Stall protection
- Bank angle protection
- Overspeed protection
- Flare compensation.

The NORMAL or SECONDARY messages show if the PFC is in the normal or secondary mode. When the PFCS is in direct mode, the PFC mode shows SECONDARY.

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FLIGHT CONTROL AUTO PG 1/3									
ROLL RATE		-0.70		YAW RATE		+2.39		ALTITUDE 2000	
ROLL ANGLE		-0.18		ANGLE OF ATTACK		+5.23		CAS 257	
ADIRU				PITCH RATE		L1 L2 C R			
PITCH RATE		+0.15		ACE INT XDCR		+0.15 +0.15 +0.15 +0.15			
				EXT XDCR		+0.15 +0.15 +0.15 +0.15			
CAPT F/O									
		COLUMN		WHEEL		PEDAL		COLUMN WHEEL PEDAL	
POSITION 1		+0.16	+0.57	-0.42	+0.16	+0.57	-0.42		
2		+0.16	+0.57	-0.42	+0.16	+0.57	-0.42		
3		+0.16	+0.57		+0.16	+0.57			
FORCE 1		+54.3	+16.8		+54.3	+16.8			
2		+54.3			+54.3				
		SPD BRK HANDLE		RUD TRIM		ELEVATOR FEEL		SUPPRESSION GUST MODAL	
POSITION 1		+0.00	+0.05	+1.00	UPR	+1.2	L +0.06		
2		+0.00	+0.05	+1.00	LWR	+1.2	R +0.06		
3		+0.00							
4		+0.00							
PFC MODE:		AUTOPILOT:		PROT MODE ACTIVITY:					
NORMAL		DISENGAGED		BANK ANGLE PROT					
				OVERSPEED PROT ACT					
STABILIZER					DATE 17 JAN 91 UTC 18:44:33				

**PFCS - INDICATIONS - MAINTENANCE PAGE - SURFACE POSITION****General**

The second PFCS maintenance page contains surface position information and actuator hydraulic data.

The graphic shows the maintenance page in auto event mode caused by a stabilizer fault.

Hydraulic System Pressure

The hydraulic pressure for each of the three systems shows in psi.

If a hydraulic system signal is invalid, the field is blank.

Surface Position

The surface position is in inches of displacement of the LVDT of each PCU. Surface position data shows for:

- Spoilers
- Flaperons
- Ailerons
- Rudder
- Elevators.

The stabilizer position is in degrees of rotation of the RVDT of each stabilizer position module.

Differential Pressure Indication

PCU FORCE shows the flaperons actuator force in pounds. DELTA PRESS shows the differential pressure across the PCU actuator piston. The data shows in psi for the rudder and the elevators.

Failure Indications

When a PCU is shutdown, an amber S shows adjacent to the surface position indication.

If a PCU position signal is invalid, an amber X shows adjacent to the surface position indication or adjacent to the S if the PCU is also shutdown.

When the stabilizer position signal is invalid, an amber X shows adjacent to the stabilizer position.

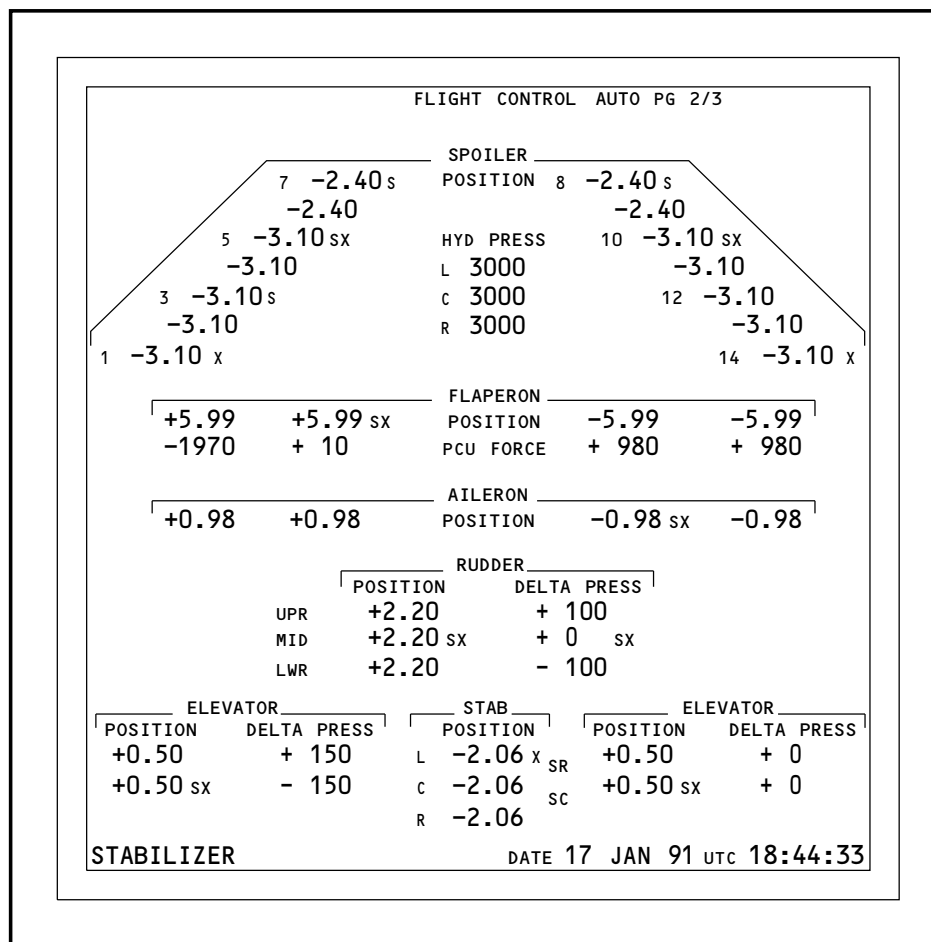
An amber SR or SC shows adjacent to the stabilizer position indication if there is a shutdown of either the right or center STCM.

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PFCS - INDICATIONS - MAINTENANCE PAGE - SURFACE POSITION

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PFCS - INDICATIONS - MAINTENANCE PAGE - ANALOG DISCRETES

General

The third PFCS maintenance page contains the status of analog discretetes. Normal indications are white. Failure indications are amber.

The graphic shows the maintenance page in auto event mode caused by a stabilizer fault.

ACE Discrete Indications

For each of the four ACEs, the page shows the status of the discrete signals.

The FSEU trailing edge and leading edge retracted signal shows as a YES or NO. If the signal is defective, the field becomes blank.

The PFC disconnect switch position status shows as AUTO or DISC. If the switch signal is invalid, OPEN or CLOSED shows in amber if the contacts are defective in the open or closed position. If the switch is defective and does not supply a signal, the field is blank.

The ACE mode of operation shows as NORMAL or DIRECT. If the ACE mode signal is invalid, the indication shows FAULT in amber.

The indication for the rudder manual trim cancel switch signal is in the L1 column. The indication shows as YES if the switch is pushed or NO if released. If the switch signal is invalid, the indication shows FAULT in amber.

The indication for the rudder trim armed signal is in the R column. The indication shows as YES if armed and NO if not armed. If the armed signal is invalid, the indication shows FAULT in amber.

The rudder trim rate signal is in the R column. The indication shows FAST or SLOW dependent on the condition. If the trim rate signal is invalid, the indication shows FAULT in amber.

The rudder trim direction is in the L1 column. The indication shows LEFT or RIGHT dependent on the rudder direction command. The indication shows NO if there is no rudder trim command. The indication shows L&R in amber if the trim command is for both directions at the same time. The indication shows FAULT in amber if the trim signal is not valid.

The rudder trim brake released indication is in the R column. The indication shows YES when the brake is released or NO when it is not. If the signal is not valid, the field is blank.

The pitch trim arm and control signal indications show in these columns:

- L1 for captain arm
- C for captain control
- L2 for first officer arm
- R for first officer control.

The indication shows UP or DOWN depending on which direction the pilot moves the trim switches. The indication shows NO if the pilot does not move the trim switches. The indication shows UP&DN in amber if the switches signal both up and down commands. If the signal is not valid, the field is blank.

The indication for the STCM brake release pressure is in the C and R columns. The indication shows YES if the brake is released or NO if it is not. If the signal is not valid, the field is blank.

The indication for the STCM hydraulic shutoff relay power is in the C and R columns. The indication shows YES if the relay has power or NO if it does not. If the signal is not valid, the field is blank.

The auto speedbrake limit switch signal is on the L1 column. The indication shows YES if the auto speedbrake actuator is in the retracted position. It shows NO if the actuator is not retracted. If the signal is not valid, the field is blank.

The TAC switch position signal shows in the C column. The signal can be OFF or AUTO. If the signal is not valid, the field becomes blank.

AIMS Discrete Indications

The AIMS monitors the alternate pitch trim lever arm and control switches for activity and direction. The indication in the ACTIVE columns shows YES when the pilot makes a lever command or NO when there is no command. If the signal is not valid, the indication shows FAULT in amber.

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PFCS - INDICATIONS - MAINTENANCE PAGE - ANALOG DISCRETES

The indication in the DIRECTION column shows UP or DOWN dependent on the direction of the alternate pitch trim command. If the signal is not valid, the indication shows FAULT in amber.

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FLIGHT CONTROL AUTO PG 3/3				
ACE ANALOG DISCRETES:	L1	L2	C	R
FSEU 1 TE & LE RETRACTED	YES	YES	YES	YES
FSEU 2 TE & LE RETRACTED	NO	NO	NO	NO
PFC DISCONNECT SWITCH	AUTO	AUTO	AUTO	AUTO
ACE MODE	DIRECT	NORM	NORM	NORM
RUD MTC SWITCH PUSHED	YES	--	--	--
RUD TRIM ARMED	--	--	--	YES
RUD TRIM RATE	--	--	--	FAST
RUD TRIM DIRECTION	LEFT	--	--	--
RUD TRIM BRK RELEASED	--	--	--	YES
CAPT PITCH TRIM ARM	UP	--	--	--
CAPT PITCH TRIM CTRL	--	--	UP	--
F/O PITCH TRIM ARM	--	NO	--	--
F/O PITCH TRIM CTRL	--	--	--	NO
STCM BRK RELEASE PRESS	--	--	YES	YES
STCM HYD SO RLY POWER	--	--	YES	YES
ELEV FEEL ENGAGED	--	YES	YES	--
SPDBRK ACTR RETRACTED	YES	--	--	--
TAC SWITCH POSITION	--	--	AUTO	--
AIMS ANALOG DISCRETES:	L		R	
	ACTIVE	DIRECTION	ACTIVE	DIRECTION
ALTN PITCH TRIM LEVER ARM	YES	UP	YES	UP
ALTN PITCH TRIM LEVER CTRL	YES	UP	YES	UP
STABILIZER	DATE 17 JAN 91 UTC 18:44:33			

PFCS - INDICATIONS - MAINTENANCE PAGE - ANALOG DISCRETES

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PFCs - SYSTEM TESTS
General

The PFCs control the operation of the MAT tests. There are 54 system tests for the PFCs.

These are the tests:

- Actuator Confidence
- Actuator Control Electronics Monitors
- Air/Ground System to PFC Interface
- Alternate Pitch Trim Levers
- Column Force Transducer
- Column Position
- Elevator Feel System
- Flap/Slat Electronics Unit Interface to ACE
- Flap/Slat Electronics Unit to PFC Interface
- Gust Suppression Pressure Transducers
- Left Aileron Actuator Confidence
- Left Aileron Alignment
- Left Aileron Position
- Left Elevator Actuator Confidence
- Left Elevator Alignment
- Left Elevator Oscillation Monitor
- Left Elevator Position
- Left Flaperon Actuator Confidence
- Left Flaperon Alignment
- Left Flaperon Position
- Modal Suppression Accelerometer
- Pedal Position
- PFC Disconnect Switch
- Primary Flight Computer Reset
- Primary Flight Computer (C) Lane Reset

- Primary Flight Computer (L) Lane Reset
- Primary Flight Computer (R) Lane Reset
- Primary Flight Computer Self Test
- Radio Altimeter Test Inhibit to PFC Interface
- Right Aileron Actuator Confidence
- Right Aileron Alignment
- Right Aileron Position
- Right Elevator Actuator Confidence
- Right Elevator Alignment
- Right Elevator Oscillation Monitor
- Right Elevator Position
- Right Flaperon Actuator Confidence
- Right Flaperon Alignment
- Right Flaperon Position
- Rudder Actuator Confidence
- Rudder Alignment
- Rudder Position
- Rudder Trim System
- Speedbrake System
- Spoiler 1, 7, 8, 14 System
- Spoiler 2, 13 System
- Spoiler 3, 6, 9, 12 System
- Spoiler 4, 11 System
- Spoiler 5, 10 System
- Stabilizer System
- Transmitter Reset Test
- Warning Electronic System to PFC Interface
- Wheel Force Transducer
- Wheel Position.

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PFCS - SYSTEM TESTS

Actuator Confidence Test

This test checks the proper operation of the power control unit servo valve monitors and for proper operation of the bypass, blocking, and pressure reducing functions of the primary power control units and the motor-operated valve in each of the stabilizer control modules.

Actuator Control Electronics Monitors

This test is to make sure the internal monitors necessary for flight safety in the L1, L2, C and R actuator control electronics operate correctly.

Air/Ground System to PFC Interface

This test does a check of the proper operation of the weight on wheel (WOW) system interface to the primary flight computers (PFCs). The test resets latches associated with the WOW system interface.

Alternate Pitch Trim Levers

This test checks for proper operation of the switches for the alternate pitch trim levers. This test can reset latches for the alternate pitch trim levers.

Column Force Transducer

This test checks for proper operation of the force transducers for the pilot and co-pilot control columns. This test can reset latches for control column force transducers. This test is similar to the wheel force transducer test.

Column Position

This test checks for proper operation of the transducers for the pilot and co-pilot control columns. This test can reset latches for control column transducers. This test is similar to the pedal position test and the wheel position test.

Elevator Feel System

This test checks for proper operation of the elevator feel units. This test can reset latches for the elevator feel units. This test can also set the configuration of either elevator feel unit to 3 different elevator feel settings.

Flap/Slat Electronics Unit Interface to ACE

This test checks for proper operation of the interface between the FSEUs and the ACEs. This test can also set the configuration of either FSEU to its flaps and slats retracted state or its flaps and slats not retracted state for fault isolation purposes. This test can reset latches associated with the analog wiring between the ACEs and the FSEUs.

Flap/Slat Electronics Unit to PFC Interface

This test checks for proper operation of the flap slat electronic units. This test can reset latches for the flap slat electronic units.

Gust Suppression Pressure Transducers

This test checks the proper operation of the gust suppression transducers. This test can reset latches for the gust suppression transducers.

Left Aileron Actuator Confidence

This test checks the proper operation of the bypass and blocking/damped functions of the left aileron power control units. This test is similar to the actuator confidence tests for the other surfaces.

Left Aileron Alignment

This procedure aligns the power control units for the left aileron. This procedure can also check alignment of the left aileron power control units. This test is similar to the alignment tests for the other surfaces.

Left Aileron Position

This test checks for proper operation of the position transducers for the left aileron. This test can reset latches for left aileron position transducers. This test is similar to the position test for the other surfaces.

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PFCS - SYSTEM TESTS

Left Elevator Oscillation Monitor

This test checks that the left elevator power control units are operating within the allowable oscillatory force fight tolerances. This test can reset oscillatory force fight latches for the left elevator. This test is similar to the right elevator oscillation monitor test.

Modal Suppression Accelerometer

This test checks for proper operation of the two modal suppression accelerometers. This test can reset latches for the modal suppression accelerometers.

PFC Disconnect Switch

This test checks for proper operation of the PFC DISC switch. This test can reset latches for the PFC DISC switch.

Primary Flight Computer Reset

This test resets a primary flight computer to operational capability after a channel does not operate because the other primary flight computers prevent it.

Primary Flight Computer (C) Lane Reset

This test restores the center primary flight computer to operational capability after a center primary flight computer lane becomes inoperative due to external interface faults or from a maintenance operation. This test is similar to the lane reset tests for the other PFCs.

Primary Flight Computer Self Test

This test checks internal primary flight computer functions and cross channel functions of the primary flight control computers.

Radio Altimeter Test Inhibit to PFC Interface

This test makes sure that the primary flight computer can put the radio altimeters in test inhibit mode.

Rudder Trim System

This test checks for proper operation of the rudder trim actuator and the rudder trim switch. This test can reset latches for the rudder trim actuator.

Speedbrake System

This test checks for proper operation of the speedbrake lever transducers, the auto speedbrake thrust reverse switch, and the auto speedbrake actuator limit switch. It will reset latches for the speedbrake lever transducers, the auto speedbrake thrust reverse switch, the radio altimeter and the landing gear truck tilt switch.

Spoiler 1,7,8,14 System

This test checks for proper operation of spoiler pairs 1,14 and 7,8. This test can reset latches for spoiler pairs 1,14 and 7,8. This test is similar to the system tests for the other spoiler surfaces.

Stabilizer System

This test checks for proper operation of the stabilizer position transducers, the stabilizer arm and control solenoid operated valves, the stabilizer rate valves, the stabilizer hydraulic shut off valves and the stabilizer brake. This test can reset fault latches for the stabilizer position transducers, it can also reset stabilizer control module disengage latches.

Transmitter Reset Test

This test resets the latches for the primary flight computers ARINC 629 bus transmitters.

Warning Electronic System to PFC Interface

This test resets latches in the primary flight computer caused by the warning electronic system.

GROUND TESTS

SELECT ATA SYSTEM (55)

- 24 MAIN AC ELECTRICAL POWER GENERATION SYSTEM
- 24 BACKUP (VSCF) ELECTRIC POWER SYSTEM (BEP)
- 26 CARGO SMOKE DETECTION SYSTEM
- 26 FIRE EXTINGUISHING SYSTEM
- 27 STALL WARNING MANAGEMENT
- 27 PRIMARY FLIGHT CONTROL SYSTEM
- 27 HIGH LEFT SYSTEM
- 29 HYDRAULIC SYSTEM
- 30 AIRFOIL CONT. ICE PROTECTION SYSTEM

SELECT TEST TYPE

 SYSTEM TEST

 OPERATIONAL TEST

 LRU REPLACEMENT TEST

SELECT SYSTEM TEST (54)

- ACTUATOR CONFIDENCE
- ACTUATOR CONTROL ELECTRONICS MONITORS
- AIR/GROUND SYSTEM TO PFC INTERFACE
- ALTERNATE PITCH TRIM LEVERS
- COLUMN FORCE TRANSDUCER
- COLUMN POSITION
- ELEVATOR FEEL SYSTEM
- FLAP/SLAT ELECTRONICS UNIT INTERFACE TO ACE

CONTINUE

HELP

GO BACK

ACTUATOR CONFIDENCE

ACTUATOR CONTROL ELECTRONICS MONITORS

AIR/GROUND SYSTEM TO PFC INTERFACE

ALTERNATE PITCH TRIM LEVERS

COLUMN FORCE TRANSDUCER

COLUMN POSITION

ELEVATOR FEEL SYSTEM

FLAP/SLAT ELECTRONICS UNIT INTERFACE TO ACE

PFCS - LRU REPLACEMENT TESTS**General**

These are the LRU replacement tests for the PFCSs and the ACEs:

- Actuator Control Electronics (L1) Replacement
- Actuator Control Electronics (L2) Replacement
- Actuator Control Electronics (C) Replacement
- Actuator Control Electronics (R) Replacement
- Center Primary Flight Computers and Couplers
- Left Primary Flight Computers and Couplers
- Right Primary Flight Computers and Couplers.

Actuator Control Electronics (L1) Replacement

This test is to make sure the L1 actuator control electronics has been replaced correctly. This test also resets any fault latches in the primary flight computer caused by the actuator control electronics. This test is similar to the replacement test for the other ACEs.

Center Primary Flight Computer and Couplers Replacement

This test does a check of the proper installation of the center primary flight computer and all associated ARINC 629 couplers. This test is similar to the replacement test for the other PFCSs.

GROUND TESTS

SELECT ATA SYSTEM (55)

- 24 MAIN AC ELECTRICAL POWER GENERATION SYSTEM
- 24 BACKUP (VSCF) ELECTRIC POWER SYSTEM (BEP3)
- 24 CARGO SMOKE DETECTION SYSTEM
- 26 FIRE EXTINGUISHING SYSTEM
- 27 STALL WARNING MANAGEMENT
- 27 PRIMARY FLIGHT CONTROL SYSTEM
- 27 HIGH LEFT SYSTEM
- 29 HYDRAULIC SYSTEM
- 30 AIRFOIL COM. ICE PROTECTION SYSTEM

SELECT TEST TYPE

◇ SYSTEM TEST

OPERATIONAL TEST

◆ LRU REPLACEMENT TEST

SELECT LRU REPLACEMENT TEST (7)

ACTUATOR CONTROL ELECTRONICS (L1) REPLACEMENT

ACTUATOR CONTROL ELECTRONICS (L2) REPLACEMENT

ACTUATOR CONTROL ELECTRONICS (C) REPLACEMENT

ACTUATOR CONTROL ELECTRONICS (R) REPLACEMENT

CENTER PRIMARY FLIGHT COMPUTER AND COUPLERS

LEFT PRIMARY FLIGHT COMPUTER AND COUPLERS

RIGHT PRIMARY FLIGHT COMPUTER AND COUPLERS

CONTINUE

HELP

GO BACK

SELECT LRU REPLACEMENT TEST

(7)

ACTUATOR CONTROL ELECTRONICS (L1) REPLACEMENT
ACTUATOR CONTROL ELECTRONICS (L2) REPLACEMENT
ACTUATOR CONTROL ELECTRONICS (C) REPLACEMENT
ACTUATOR CONTROL ELECTRONICS (R) REPLACEMENT
CENTER PRIMARY FLIGHT COMPUTER AND COUPLERS
LEFT PRIMARY FLIGHT COMPUTER AND COUPLERS
RIGHT PRIMARY FLIGHT COMPUTER AND COUPLERS

PFCS - LRU REPLACEMENT TESTS

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PFCS - ACTUATOR CONFIDENCE TEST AND ACE MONITOR TEST INDICATIONS

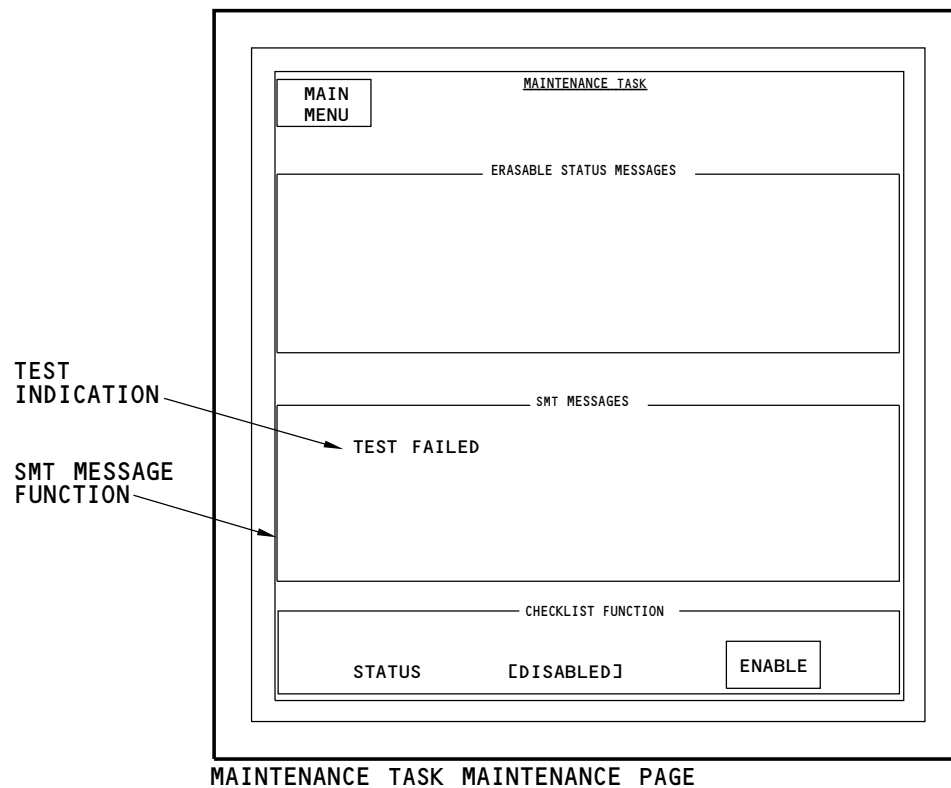
General

It is necessary to do the actuator confidence test (ACT) and the ACE monitor test (AMT) at specified times. You use the MAT to do these tests. The status of these tests shows on the maintenance task maintenance page.

A TEST PASSED or a TEST FAILED message shows in the scheduled maintenance task (SMT) message function on the maintenance task maintenance page on the MFD. The PFCs send data to the AIMS to show test pass/fail and test active. Only one of the above messages shows, and only while the test is active. These messages are not latched, and they erase once the test is not active. The test is not active when the MAT test is complete.

See the primary display system section for more information on the maintenance task maintenance page (SECTION 31-61).

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PFCS - ACTUATOR CONFIDENCE TEST AND ACE MONITOR TEST INDICATIONS

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HIGH LIFT CONTROL - INTRODUCTION

General

The high lift control system (HLCS) improves the takeoff and landing performance of the airplane. The HLCS includes the trailing edge flaps and the leading edge slats.

Trailing Edge Flaps

During takeoff, the trailing edge flaps increase the lift of the wing. During landing, the flaps increase the lift and drag. The flaps are not used during cruise. There is one double-slotted inboard flap and one single-slotted outboard flap on each wing.

Leading Edge Slats and Krueger Flaps

During takeoff and landing, the leading edge slats and Krueger flaps increase the lift of the wing. These surfaces are not used during cruise. There are seven slats and one Krueger flap on each wing.

Abbreviations and Acronyms

- ACE - actuator control electronics
- ACMS - airplane condition monitoring system
- ADIRU - air data inertial reference unit
- AIMS - airplane information management system
- altn - alternate
- ARINC - Aeronautical Radio, Inc.
- CMCS - central maintenance computing system
- EICAS - engine indication and crew alerting system
- FMCS - flight management computing system
- FSEU - flap/slat electronics unit
- HLCS - high lift control system
- HYDIM - hydraulic interface module
- LVDT - linear variable differential transformer
- MAT - maintenance access terminal
- PDU - power drive unit

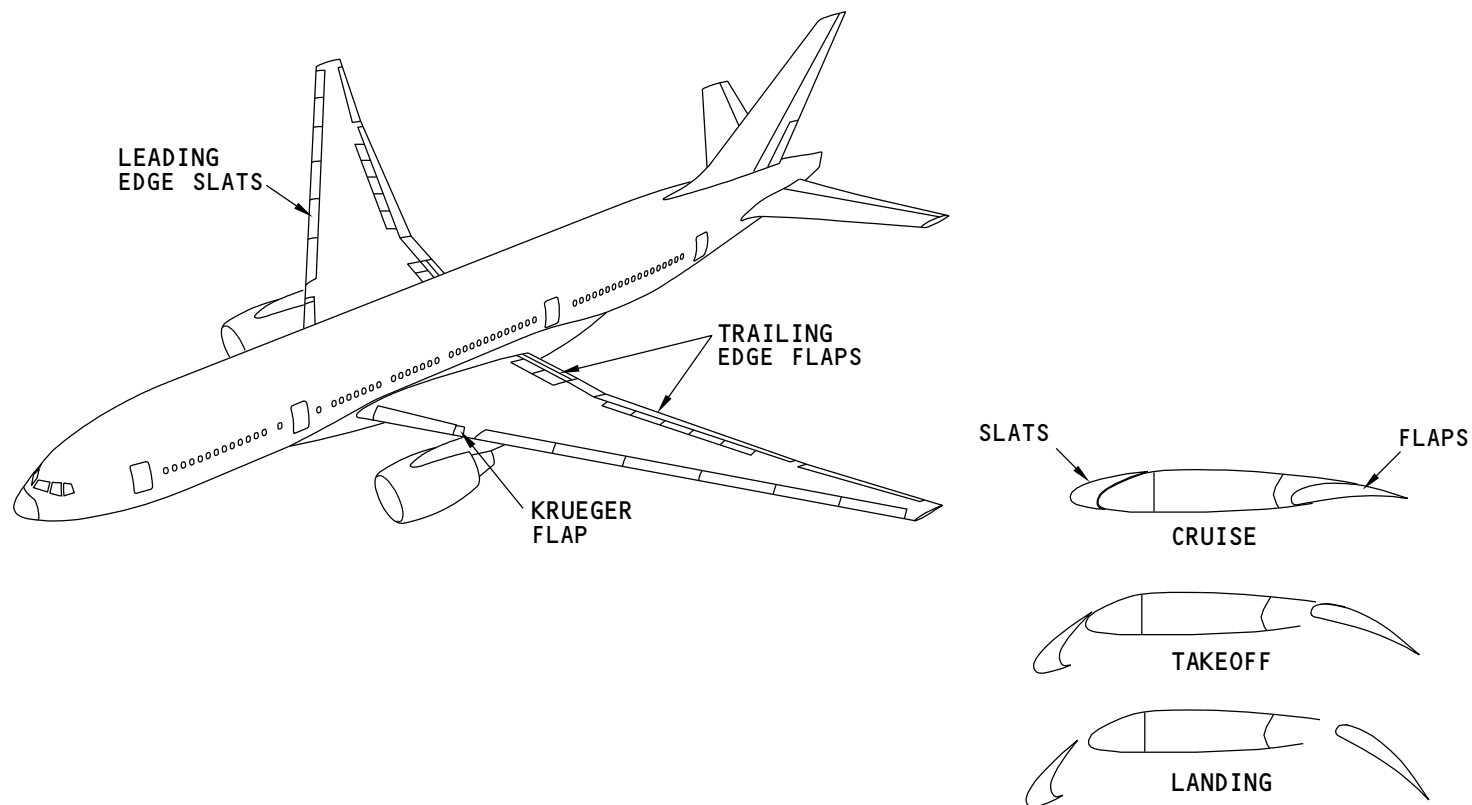
- PFCS - primary flight control system
- PSEU - proximity switch electronic unit
- RVDT - rotary variable differential transformer
- SAARU - secondary attitude air data reference unit
- sec - secondary
- WEU - warning electronic unit
- WOW - weight-on-wheels

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HIGH LIFT CONTROL - INTRODUCTION

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HIGH LIFT CONTROL - GENERAL DESCRIPTION

General

The HLCS controls the operation of the:

- Trailing edge flaps
- Leading edge slats
- Krueger flaps.

The HLCS has these three modes of operation:

- Primary
- Secondary
- Alternate.

In the primary mode, hydraulic power moves the flaps and slats. In the secondary and alternate modes, electrical power moves the flaps and slats.

In the primary and secondary modes, the control is closed-loop. Closed-loop control stops the command when a feedback signal equals the command. In the alternate mode, the control is open-loop. Open-loop control stops the commands only when you stop the input or when the surfaces are at a limit.

Primary Mode

The flap lever position sensors send input signals to the flap/slat electronic units (FSEUs). The FSEUs use the flap lever position to calculate the flap and slat commands. The FSEUs also receive data from the systems ARINC 629 buses.

The FSEUs send the flap and slat commands to the flap and slat primary control valves. These valves supply hydraulic pressure to the flap and slat power drive units (PDUs). Hydraulic motors in the PDUs then move the flap and slat mechanisms.

The flap/slat priority valve controls the amount of hydraulic flow to the flap and slat primary control valves. The flap/slat priority valve gives priority of hydraulic power to the primary flight control system (PFCS) over the HLCS.

As the flaps and slats move, position sensors send a position feedback signal to the FSEUs. The FSEUs stop the flap and slat commands when the position feedback signals equal the commanded position.

The flap and slat skew sensors monitor the alignment of the flaps and slats. If the flaps or slats are out of alignment, the skew sensors send a signal to the FSEUs. The FSEUs then prohibit movement of the failed system in the primary and secondary modes.

The primary mode also uses the autoslat priority valve if the airplane approaches a stall condition. This valve gives the slats priority of the hydraulic power over the main landing gear system during an autoslat command.

Secondary Mode

In the secondary mode, the FSEUs receive input signals from the flap lever position sensor. The FSEUs then energize secondary/alternate control relays. These relays energize bypass solenoids in the primary control valves to stop hydraulic power to the hydraulic motors. These relays also control electrical power to the flap and slat electric motors in the PDUs. The electric motors then move the flap and slat mechanisms.

As the flaps and slats move, position sensors send a position feedback signal to the FSEUs. The FSEUs command the relays to stop the electric motors when the flaps and slats are at the commanded position.

The secondary mode also uses the flap and slat skew sensors. If the flaps are out of alignment, the FSEUs prohibit movement of the flaps in the secondary mode. This is also true for the slats.

Alternate Mode

The pilots manually control the alternate mode with the switches on the alternate flaps panel. The arm switch on this panel sends a discrete to the FSEUs to disengage the primary and secondary modes. This switch also energizes two of the secondary/alternate control relays. These two relays energize bypass solenoids in the primary control valves to stop hydraulic power to the hydraulic motors. The primary control valves also create a hydraulic loop to permit the hydraulic motors to be backdriven.

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HIGH LIFT CONTROL - GENERAL DESCRIPTION

The alternate flaps selector sends commands through limit switches to energize the other secondary/alternate control relays. These relays control electrical power to the flap and slat electric motors on the PDUs. The limit switches remove electrical power from these relays when the flaps and slats are at their limits.

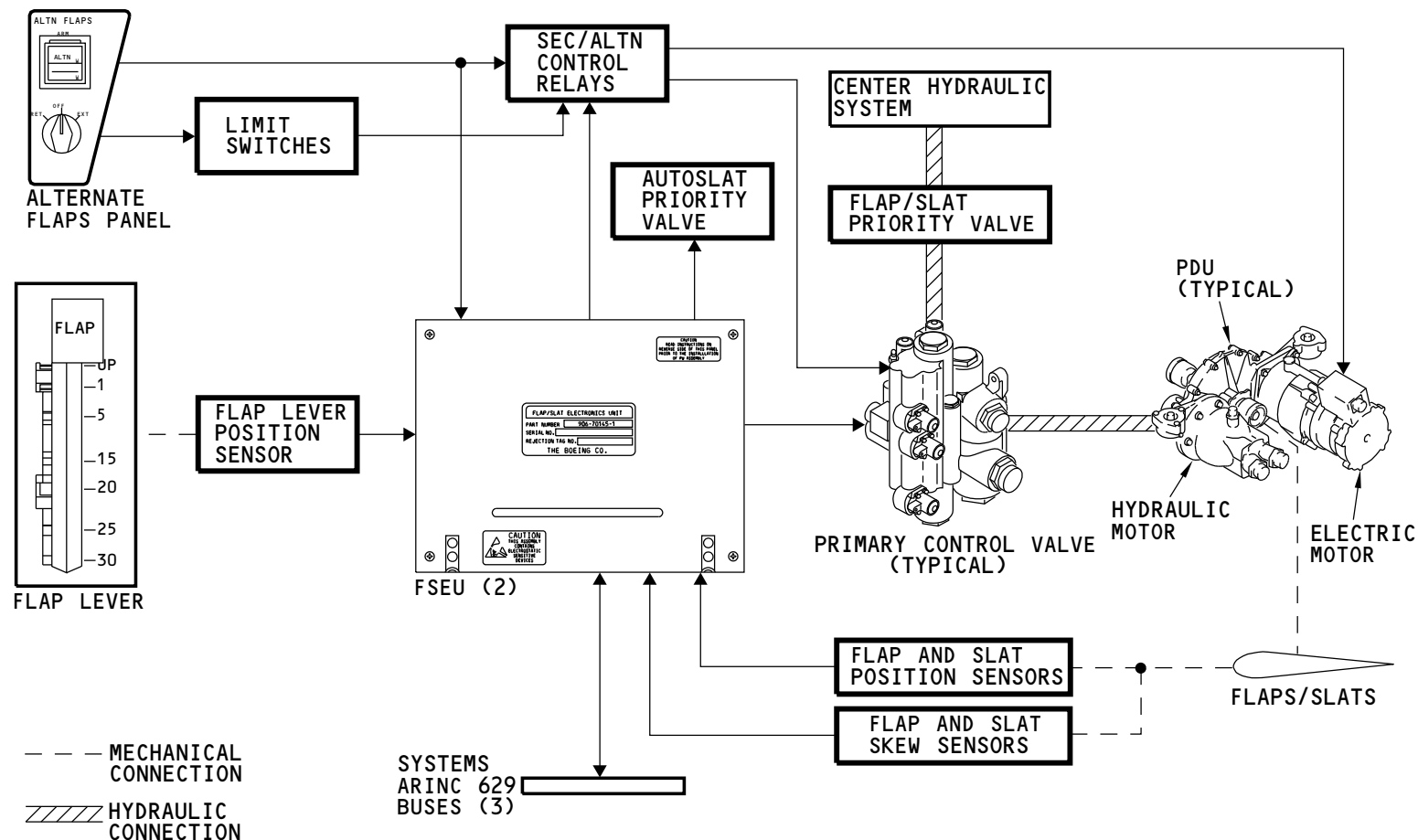
The electric motors then move the flap and slat mechanisms. The flaps and slats move until the pilot moves the alternate flaps selector to OFF, or the flaps and slats are at their limits.

The alternate mode control does not use the flap and slat position sensors or skew sensors. But, the FSEUs continue to receive signals from these sensors for EICAS messages and position indication.

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HLCS - GENERAL DESCRIPTION

HIGH LIFT CONTROL - GENERAL DESCRIPTION

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HIGH LIFT CONTROL - INTERFACES - SYSTEM REDUNDANCY

General

The HLCS has two identical lanes for the primary mode and the secondary mode. One lane has control of the HLCS. The other lane monitors the HLCS. The FSEUs automatically transfer control to the other lane after a post-flight self test of the FSEUs or after disengagement from the alternate mode. The FSEUs also switch control to the other lane if:

- A component fails in the control lane
- The command and feedback disagree.

Each lane has these components:

- An FSEU
- Two RVDTs in the flap lever position sensor
- Flap primary control valve solenoid coils
- Slat primary control valve solenoid coils
- Flap position sensors
- Slat position sensors.

The following components are not in the HLCS lanes:

- The flap and slat skew sensors
- The autoslat priority valves
- The secondary/alternate control relays

FSEUs

One FSEU is in each lane. Only the FSEU in the control lane sends the flap and slat commands to the flap and slat primary control valves.

Flap Lever Position Sensor

Each lane uses two of the four RVDTs in the flap lever position sensor.

Flap and Slat Primary Control Valve Solenoid Coils

The flap and slat primary control valves have dual-coil solenoids. Each lane controls one of the coils in each solenoid.

Flap and Slat Position Sensors

Each wing has two flap position sensors and two slat position sensors. Each lane uses one flap position sensor and one slat position sensor from each wing.

Flap and Slat Skew Sensors

There are four pairs of flap skew sensors and three pairs of slat skew sensors on each wing. One FSEU receives inputs from half of the skew sensors, and the other FSEU receives inputs from the other half.

Autoslat Priority Valve

Either FSEU can control the autoslat priority valves.

Secondary/Alternate Control Relays

Either FSEU can control the secondary/alternate control relays.

Fault Annunciation

The status message FLAP/SLAT CONTROL 1 shows if:

- A component fails in lane 1
- The command and feedback disagree in lane 1.

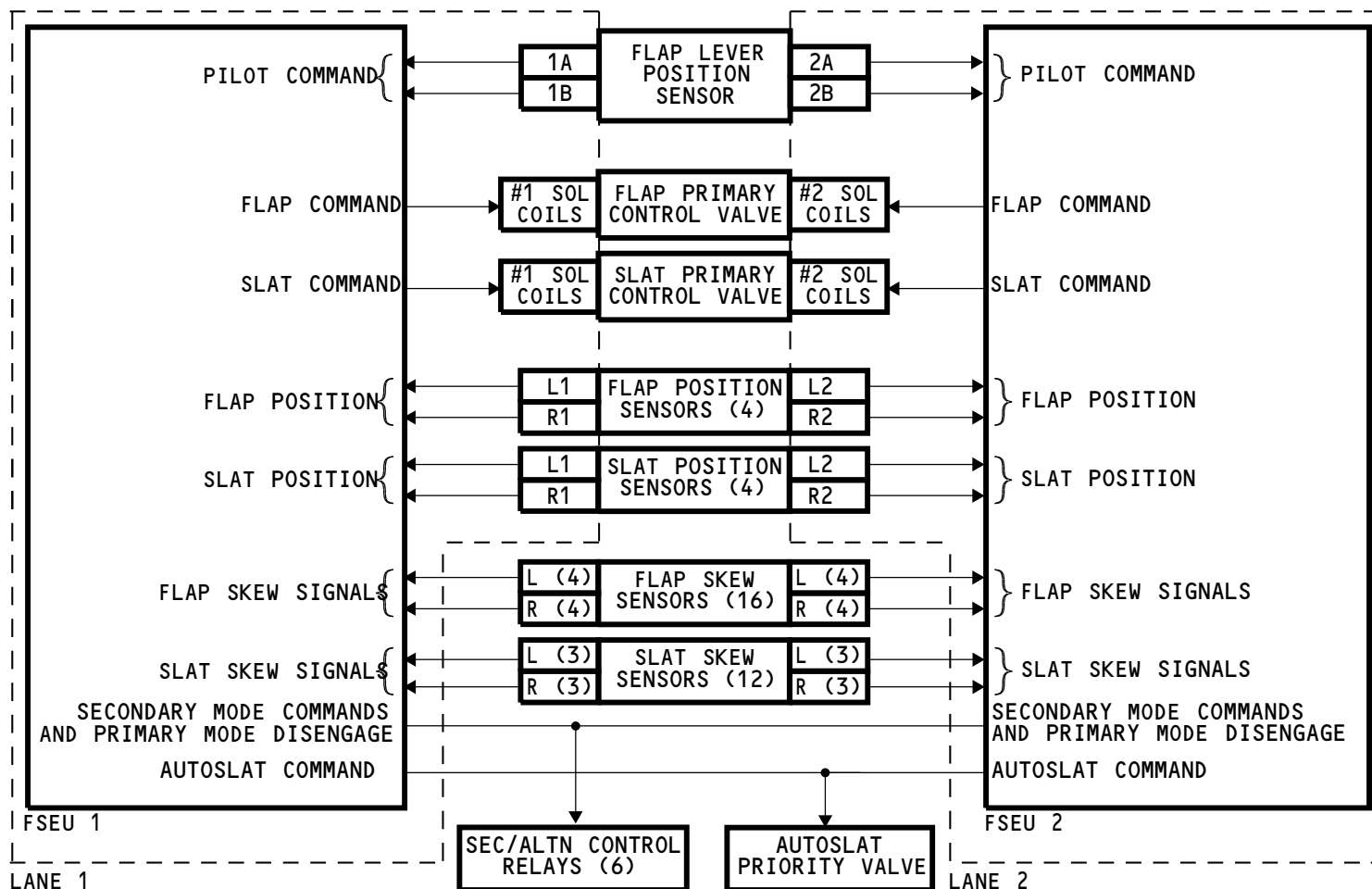
The same logic is true for the FLAP/SLAT CONTROL 2 status message in lane 2.

The caution message FLAP/SLAT CONTROL shows if both lanes fail.

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HIGH LIFT CONTROL - INTERFACES - SYSTEM REDUNDANCY

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HIGH LIFT CONTROL - INTERFACES - SYSTEMS ARINC 629 BUSES

General

The FSEUs connect the HLCS to many other airplane systems through the systems ARINC 629 buses. Some of these systems use these components:

- Two warning electronics units (WEUs)
- Two airplane information management system (AIMS) cabinets
- Two systems card files.

FSEU Interface

The FSEUs connect to three of the systems ARINC 629 buses. FSEU 1 transmits and receives data on the left and center 1 buses through separate connections. FSEU 1 receives data through two more connections for redundancy.

The connections for FSEU 2 are almost the same as the connections for FSEU 1. The difference is that the FSEU 2 communicates with the right and C1 buses instead of the left and C1 buses.

WEU Interface

The WEUs transmit data for the autoslat function.

AIMS Interface

The FSEUs supply information to the AIMS for:

- The flap/slat position indications on EICAS
- The flap/slat maintenance page
- The central maintenance computing system (CMCS)
- The protection functions in the primary flight control system (PFCS)
- And many other systems and functions.

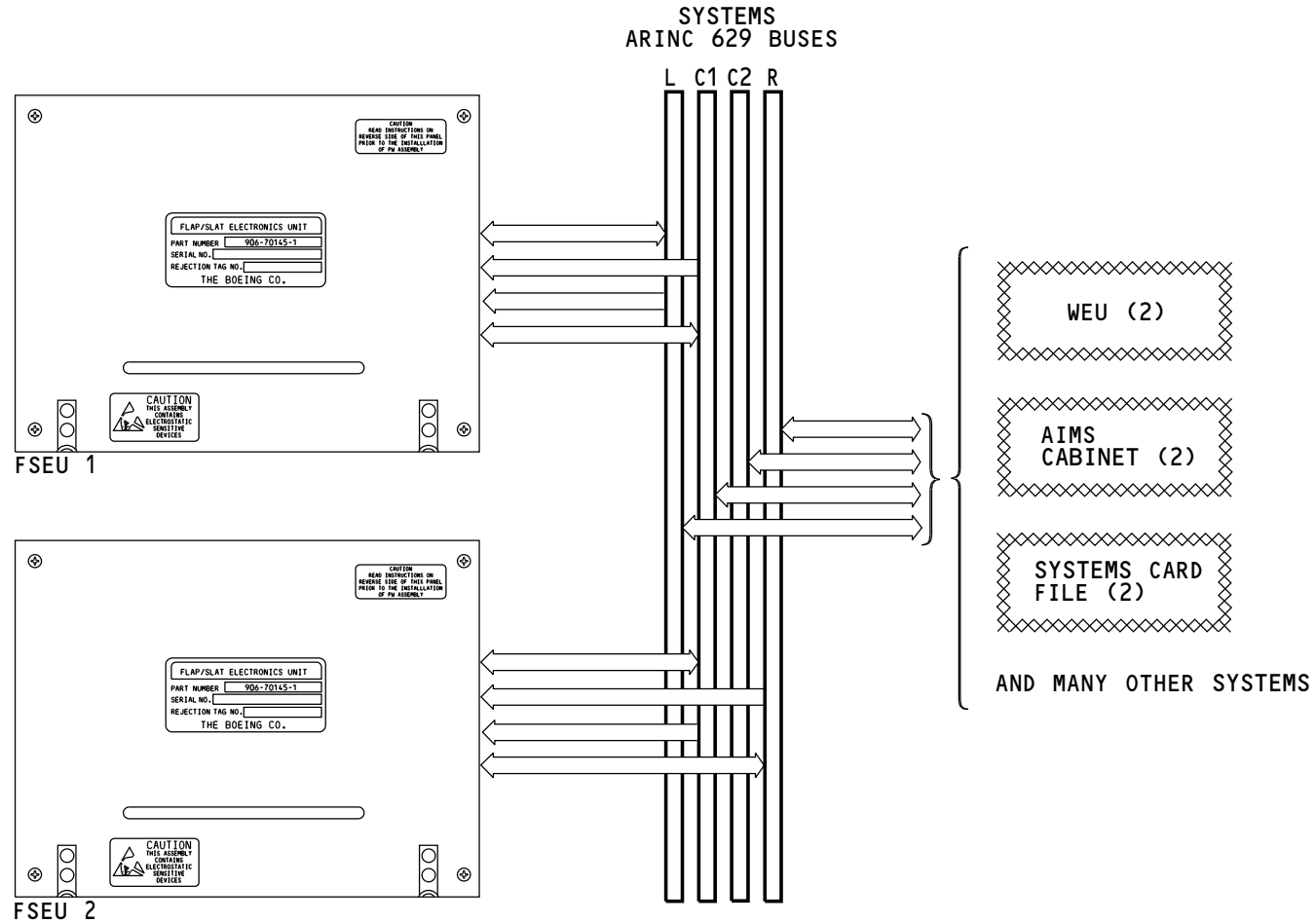
Information that the FSEUs receive from the AIMS cabinets include air data from the ADIRU and SAARU and data from many other systems.

Systems Card File Interface

The hydraulic interface module (HYDIM) and the weight on wheels (WOW) cards are in the systems card file.

The HYDIM cards supply hydraulic pressure data to the FSEUs. The center hydraulic isolation system command from the HYDIM cards disables the slats in the primary mode. The FSEUs also send the flap and slat commands to the HYDIM cards.

The WOW cards supply air/ground data to the FSEUs.



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HIGH LIFT CONTROL - INTERFACES - SYSTEMS ARINC 629 BUSES

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HIGH LIFT CONTROL - INTERFACES - ANALOG AND DISCRETE SIGNALS

General

These components electrically control the flaps and slats in the primary, secondary, and alternate modes:

- FSEUs
- Flap lever position sensor
- Alternate flaps arm switch
- Alternate flaps selector
- Flap and slat primary control valves
- Autoslat priority valve
- Secondary/alternate control relays
- Flap and slat position sensors
- Flap and slat skew sensors.

The ACEs receive flap position discrete signals from the FSEUs for some of the functions in the PFCS.

FSEUs

The two FSEUs use analog and discrete inputs to calculate the flap and slat commands in the primary and secondary modes. They also use digital information on the systems ARINC 629 buses.

Flap Lever Position Sensor

The flap lever position sensor sends the flap lever commands to the FSEUs.

Alternate Flaps Arm Switch

The alternate flaps arm switch sends a discrete to the FSEUs to disengage the primary and secondary modes. This switch also controls two relays, which control power to a solenoid in the flap and slat primary control valves.

Alternate Flaps Selector

The alternate flaps selector controls the grounds for four relays, which control power to the flap and slat electric motors. The wiring for these grounds is through the flap and slat limit switches.

Flap and Slat Limit Switches

The flap and slat limit switches stop the movement of the flaps and slats in the alternate mode. When the flaps and slats are at their limits, the limit switches remove the grounds for some of the sec/altn control relays.

Secondary/Alternate Control Relays

The secondary/alternate control relays control power to the flap and slat electric motors in the secondary and alternate modes. These relays also control a solenoid in the flap and slat primary control valves to stop the hydraulic operation of the flaps and slats.

Flap and Slat Electric Motors

The flap and slat electric motors move the flap and slat drive systems in the secondary and alternate modes. They receive electrical power through the sec/altn control relays.

Flap and Slat Primary Control Valves

The flap and slat primary control valves control the direction and speed of the flap and slat movement. The FSEUs control most of the solenoids in the flap and slat primary control valves. The sec/altn control relays control one solenoid in the flap and slat primary control valves. These two solenoids stop the hydraulic operation of the flaps and slats.

Autoslat Priority Valve

The autoslat priority valve limits the flow of hydraulic fluid to the main landing gear system. The FSEUs control a solenoid in this valve during autoslat operation.

Flap and Slat Position Sensors

The flap and slat position sensors supply flap and slat position signals to the FSEUs. The FSEUs use this data for:

- Control feedback
- Position indication
- Fault monitoring.

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HIGH LIFT CONTROL - INTERFACES - ANALOG AND DISCRETE SIGNALS

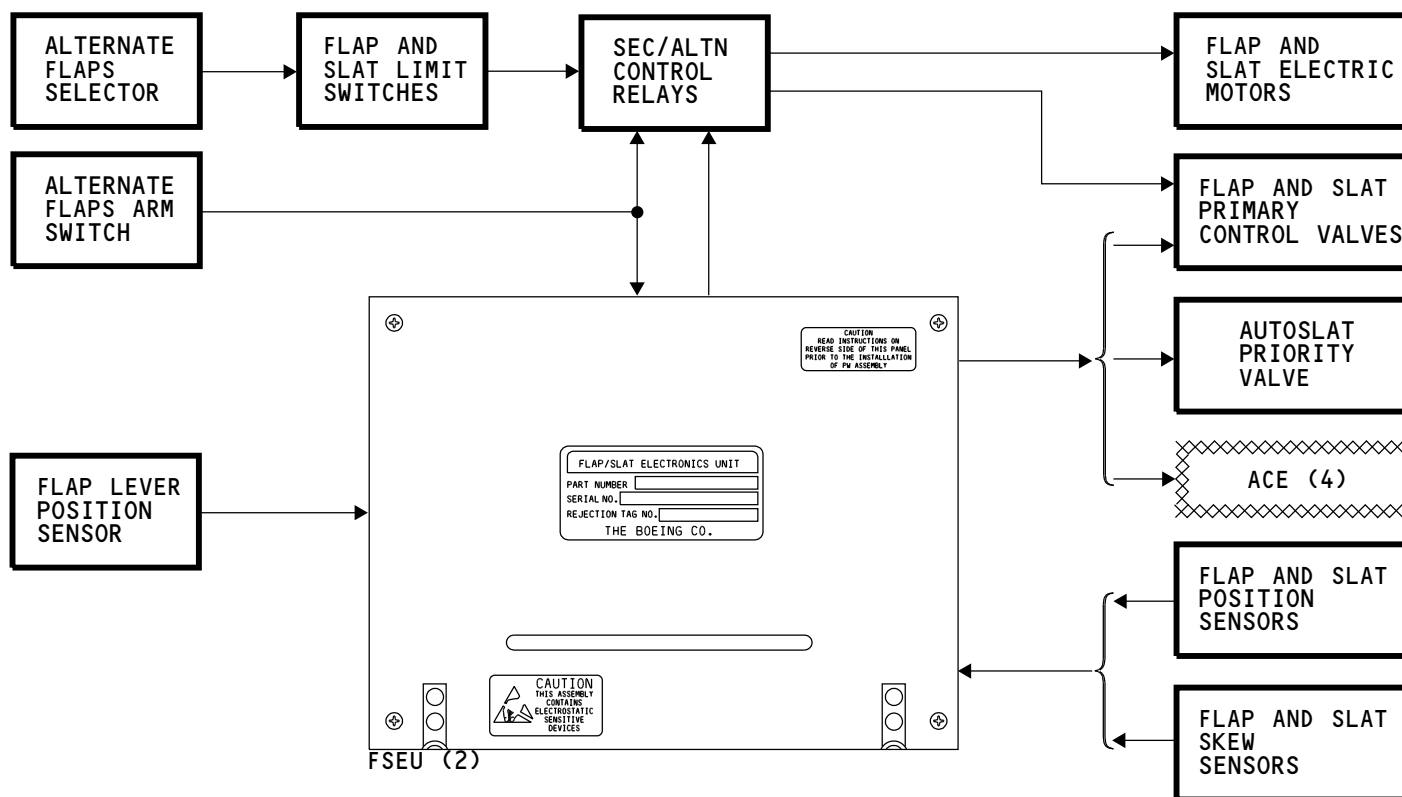
Flap and Slat Skew Sensors

The flap and slat skew sensors supply signals to the FSEUs. The FSEUs use these signals to monitor the alignment of the flaps and slats.

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HIGH LIFT CONTROL - INTERFACES - ANALOG AND DISCRETE SIGNALS

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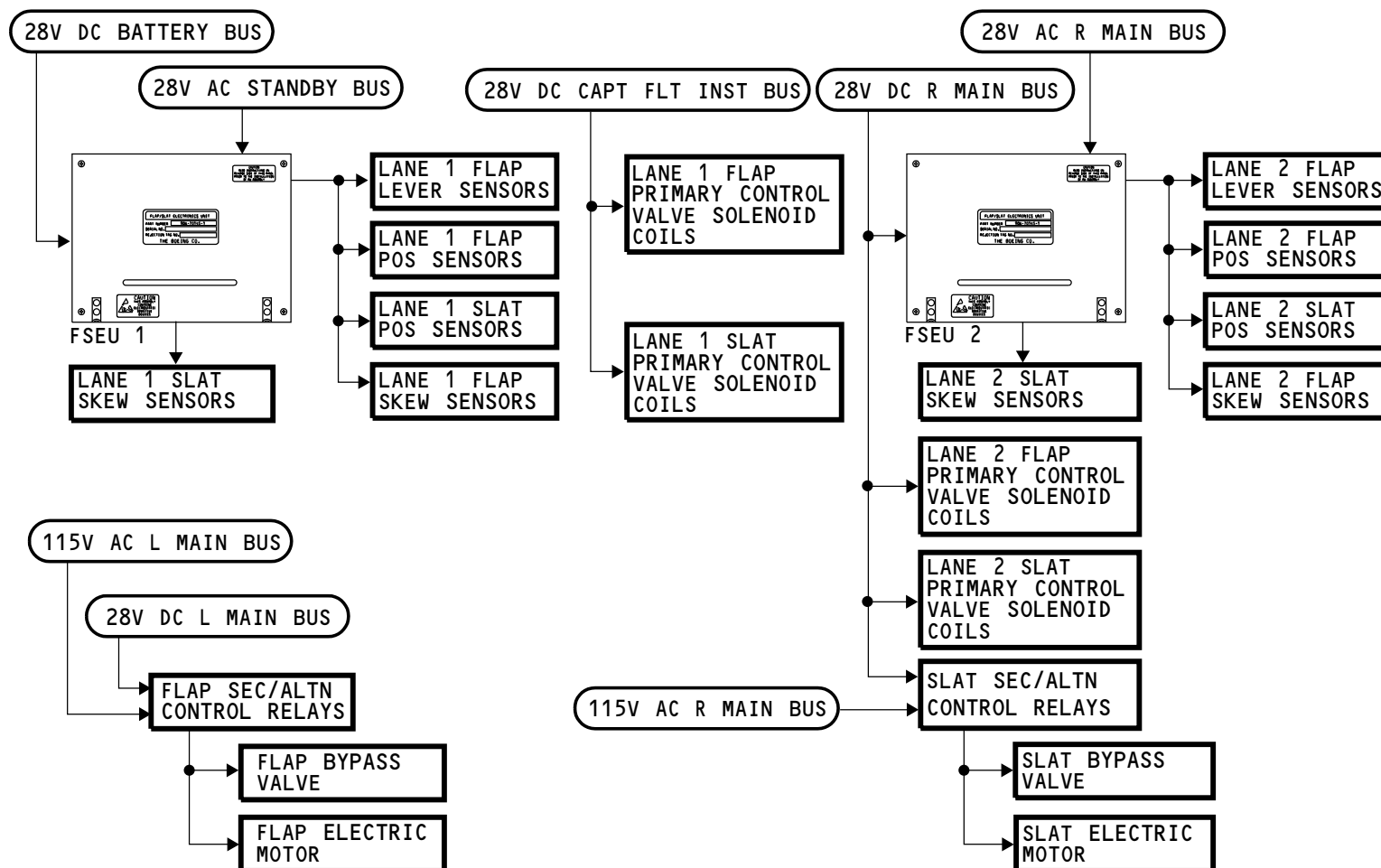
HIGH LIFT CONTROL - INTERFACES - ELECTRICAL POWER

General

Multiple buses supply electrical power to the HLCS. The HLCS receives electrical power from the:

- 28v dc battery bus
- 28v dc captain's flight instrument bus
- 28v ac standby bus
- 28v dc right main bus
- 28v ac right main bus
- 28v dc left main bus
- 115v ac left main bus
- 115v ac right main bus.

These buses permit the separation of electrical power between lane one and lane two. The components in lane one get power from separate buses than the components in lane two.



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HIGH LIFT CONTROL - INTERFACES - ELECTRICAL POWER

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HIGH LIFT CONTROL - MODE SELECTION

General

The flaps and slats operate in one of three modes:

- Primary mode
- Secondary mode
- Alternate mode.

The FSEUs change the operational mode for any of these conditions:

- There are component failures
- There are position failures
- The center hydraulic reservoir quantity is low
- The secondary mode auto test is active
- The airplane is in a ground maintenance condition
- You use the alternate flaps arm switch.

The primary and secondary flap modes are independent of the primary and secondary slat modes. Thus, the flaps may be in the secondary mode while the slats are in the primary mode. This supplies the fastest system response to the flap lever commands.

The alternate flap mode is not independent of the alternate slat mode. Thus, when the alternate mode engages, both the flaps and slats are in the alternate mode.

Primary Mode Selection

The primary mode is automatically selected when there is a flap lever command. At that time, one lane is in control while the other lane is in standby.

If there is a component failure in the control lane, it causes a lane change. The flaps and slats continue to operate in primary mode.

These are the four types of component failures that cause a lane change:

- Flap lever position sensor failure
- Solenoid coil failure on the primary control valve for the flaps or the slats

- Flap or slat position sensor failure
- FSEU failure.

During normal conditions, the flaps and slats operate in the primary mode. If a component fails in lane 1 and lane 1 is in control, lane 2 becomes the control lane. In this condition, the flaps and slats stay in the primary mode. This failure condition causes the FLAP/SLAT CONTROL 1 status message to show.

If lane 2 is in control when a component fails in lane 2, lane 1 becomes the control lane and the FLAP/SLAT CONTROL 2 status message shows.

If there is a detected component failure in the standby lane while the control lane operates properly, the applicable status message, FLAP/SLAT CONTROL 1 or 2, shows. The control lane remains in control.

Secondary Mode Selection

After a lane change, if the original failure or an additional one prevents the flaps or slats to operate in primary mode, the FSEU in control changes to the secondary mode operation for the flaps or the slats.

If the failures are with flap components only, only the primary flap mode disengages and the flaps operate in secondary mode. The slats operation continues in the primary mode. This condition causes the FLAPS PRIMARY FAIL caution message to show. The same is true for the slats. But in this case, the SLATS PRIMARY FAIL caution message shows.

If the failures affected both the flaps and slats, such as both FSEUs, both the primary flap mode and the primary slat mode disengage. This condition causes both the FLAPS PRIMARY FAIL and SLATS PRIMARY FAIL caution messages to show.

After the flaps and slats fully retract, the secondary mode disengages and the primary mode engages. Then the FLAPS PRIMARY FAIL and/or the SLATS PRIMARY FAIL message erases.

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HIGH LIFT CONTROL - MODE SELECTION

The FSEU in control engages the secondary mode for the flaps or slats if there is a flap or slat disagree in primary mode. There is a disagree when the flaps or slats do not move when commanded or move too slowly. The FSEU in control disengages the primary mode for the flaps or the slats and engage the secondary mode. This condition causes the FLAPS PRIMARY FAIL or the SLATS PRIMARY FAIL caution message to show.

When the center hydraulic system pressure is low, it does not permit the hydraulic motors to operate the flaps and slats. The FSEU in control engages the secondary mode for the flaps and slats. The operation stays in the secondary mode until the flaps and slats are in the retracted position or until the center hydraulic system pressure is more than 2000 psi after it was less than 1000 psi.

Flaps and Slats Drive Shutdown

If there are component failures that affect the operation of both flaps and slats, the flaps and slats can no longer operate in primary and secondary mode. The FLAP/SLAT CONTROL caution message shows. In addition, the FLAP/SLAT CONTROL 1 and the FLAP/SLAT CONTROL 2 status messages also show.

The FSEUs declare and latch a flaps or slats drive shut down for any one of these position failures:

- Disagreement in secondary mode (the flaps or slats do not move with a secondary mode command or move too slowly)
- Asymmetry (the flaps or slats on one wing do not align with the flaps or slats on the other wing)
- Skew (a flap or slat on one wing is out of alignment).

If there is a secondary mode disagree, an asymmetry or a skew, the FSEUs disengage both the primary and secondary modes and shut down the drive system for the flaps or the slats.

A shut down of the slats drive with the slats at the UP position, at the sealed position, or between, causes the flaps operation to be limited to the 20-unit position. If the slats are at the gapped position when the slats drive shuts down, the flaps can operate to the full extend. A shut down of the flaps drive will not let the slats extend to the gapped position.

The shut down of the flaps or the slats drive causes the FLAPS DRIVE or the SLATS DRIVE caution message to show.

Alternate Mode Selection

The only way to engage and disengage the alternate mode is to use the alternate flaps arm switch. When the pilot pushes on the alternate flaps arm switch, the primary and secondary modes disengage in both FSEUs and the alternate mode engages. This causes the FLAP/SLAT CONTROL caution message to show.

When the pilot releases the alternate flaps arm switch, the alternate mode disengages and the FSEUs try to engage the primary mode. If the primary mode is disabled, the FSEUs try to engage the secondary mode. If the secondary mode is also disabled, you must use the alternate mode to move the flaps and slats.

Center Hydraulic Quantity

If the hydraulic quantity in the center hydraulic system reservoir is low, the FSEUs disengage the primary slat mode. The FSEUs then engage the secondary mode for the slats only. If both engines continue to operate for more than 10 seconds, then the primary mode re-engages.

Secondary Mode Auto Test

During the secondary mode auto test, both the primary flap mode and the primary slat mode disengage. The secondary mode engages for both the flaps and slats. If the flaps and/or slats fail to extend during the test, the FLAPS SECONDARY FAIL and/or SLATS SECONDARY FAIL status message shows.

Ground Maintenance Condition

The FSEUs inhibit the secondary mode operation when the airplane is in a ground maintenance condition. You must use the secondary mode inhibit override function on the MAT to enable the secondary mode in this condition.

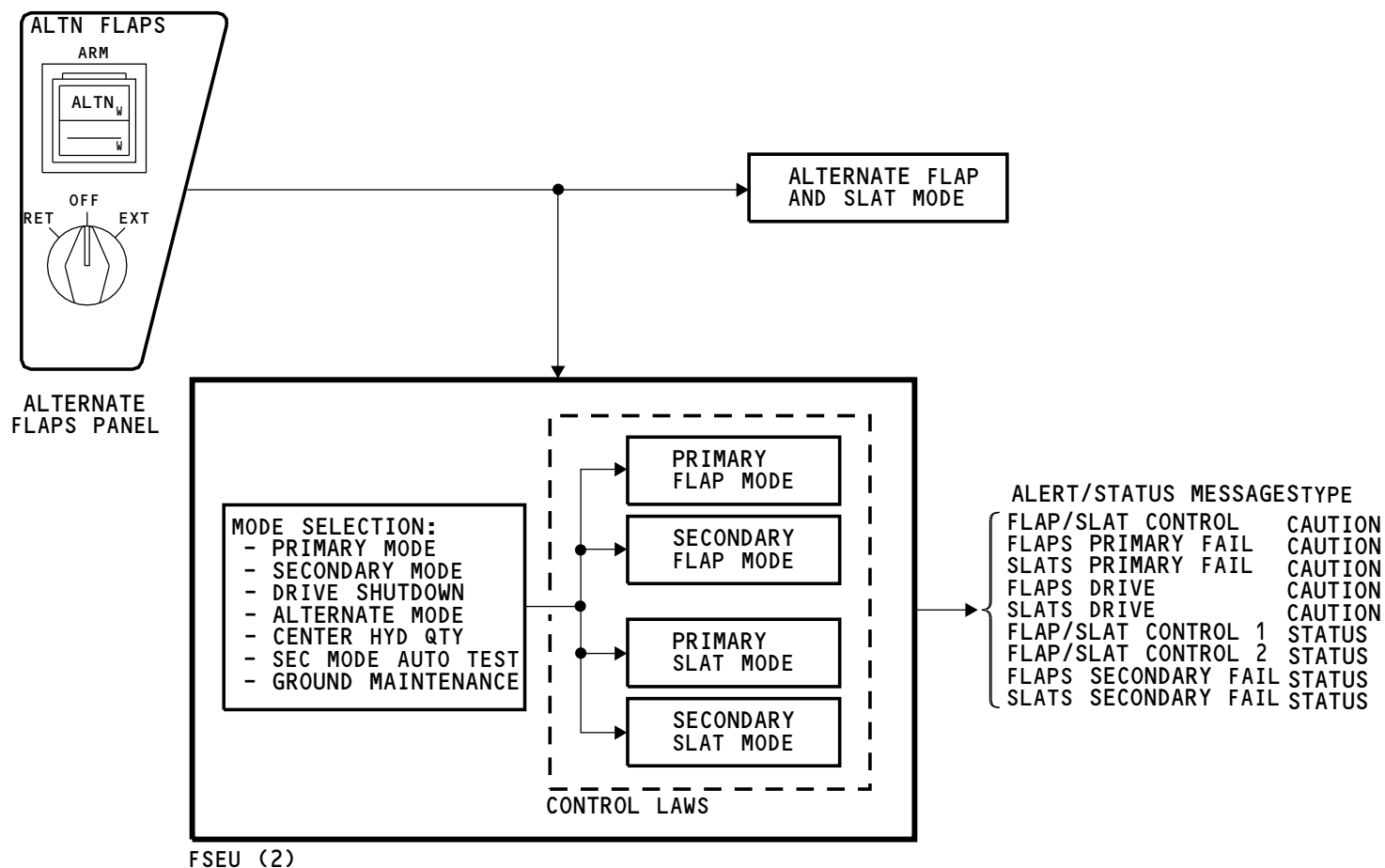
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HIGH LIFT CONTROL - MODE SELECTION

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HIGH LIFT CONTROL - PRIMARY MODE FLAP AND SLAT SEQUENCE

General

The flaps and slats extend and retract in sequence. The extension and retraction sequence is different between the three modes.

Flap and Slat Positions

In the primary mode, the flap lever commands the flaps and slats to move to the commanded position. At flap lever positions UP and 1, the flaps are fully retracted. At flap lever positions 5 through 30, the flap positions are the same as the flap lever positions.

The slats have three positions: up, sealed, and gapped. The slats are at the sealed position when the flap lever is at 1, 5, 15, or 20. The slats are at the gapped position when the flap lever is at 25 or 30.

Flap load relief is available in the primary mode. Load relief operation is described later.

Flap lever detent up is for cruise. Detent 1 is for climb-out and approach. Detents 5, 15, and 20 are the takeoff settings. Detents 25 and 30 are the landing settings.

Flap and Slat Extension and Retraction

During extension from the retracted position, the slats extend to the sealed position while the flaps stay retracted. When the slats are at the sealed position, the flaps begin to extend. When the flaps are at the 20 unit position, the flaps stop moving. The slats then extend to the gapped position. When the slats are in the gapped position, the flaps move to the fully extended position.

The retraction sequence is the reverse of the extension.

Extension and Retraction Time

The extension time is the same as the retraction time.

It takes 54 seconds to move the slats and flaps from the UP position to the 30-unit position. The detailed times are:

- 11 seconds to move the slats from the retracted position to the sealed position
- 24 seconds to move the flaps from the retracted position to the 20-unit position
- 6 seconds to move the slats from the sealed position to the gapped position
- 13 seconds to move the flaps from the 20-unit position to the 30-unit position.

Flap Operation With Slats Drive Shutdown

When the slats fail to move to the commanded position in primary and secondary mode, the FSEUs shutdown the slats drive. With a slats drive shutdown, the flaps continue to operate in primary mode. The flaps move to their commanded position independently of the slat position. If the slats are not at the gapped position when the slats drive shutdown occurs, the flaps cannot move more than the 20-unit position. If the slats are at the gapped position when the slats drive shutdown occurs, the flaps can move more than the 20-unit position.

Training Information Point



CAUTION

YOU MUST WAIT 30 MINUTES AFTER 12 MINUTES OF OPERATION IN THE PRIMARY MODE. THE FLAP NO-BACK BRAKE CAN BECOME TOO HOT.

HIGH LIFT CONTROL - PRIMARY MODE FLAP AND SLAT SEQUENCE

**CAUTION**

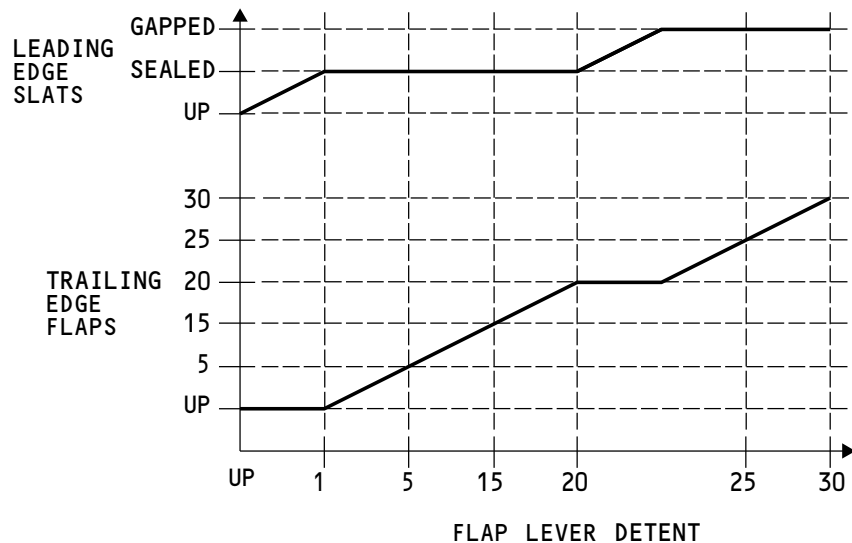
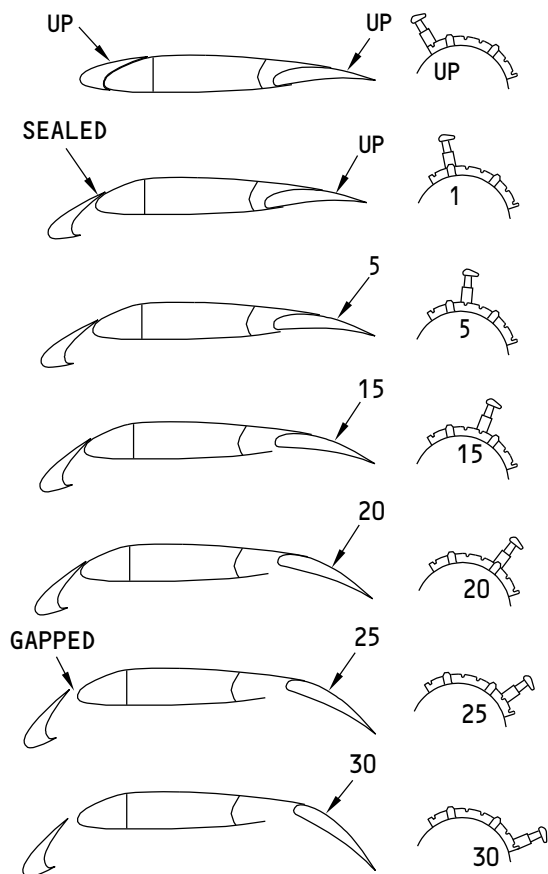
MAKE SURE THE ADP ACCESS DOOR IS FULLY OPEN OR FULLY CLOSED WHEN YOU MOVE THE TRAILING EDGE FLAPS. THE FLAPS CAN HIT THE DOOR IF IT IS NOT FULLY OPEN OR CLOSED. THIS CAN CAUSE DAMAGE TO EQUIPMENT.

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HIGH LIFT CONTROL - PRIMARY MODE FLAP AND SLAT SEQUENCE

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HIGH LIFT CONTROL - SECONDARY MODE FLAP AND SLAT SEQUENCE

General

The sequence of the flap and slat extension and retraction in the secondary mode is almost the same as in the primary mode.

Flap and Slat Positions

In the secondary mode, the flap lever commands the flaps and slats to move to the commanded position. The flap positions are the same as in the primary mode.

The slats extend to the gapped position when the flap lever is at any position except up.

Slat load relief is available in secondary mode. The slats retract to the sealed position when the airspeed is more than 256 knots. Load relief operation is described later.

Flap and Slat Extension and Retraction

During extension, the slats extend to the gapped position before the flaps extend. When the slats are at the gapped position, the flaps extend to the commanded position.

The sequence of the flap and slat retraction is the reverse of the flap and slat extension.

Extension and Retraction Time

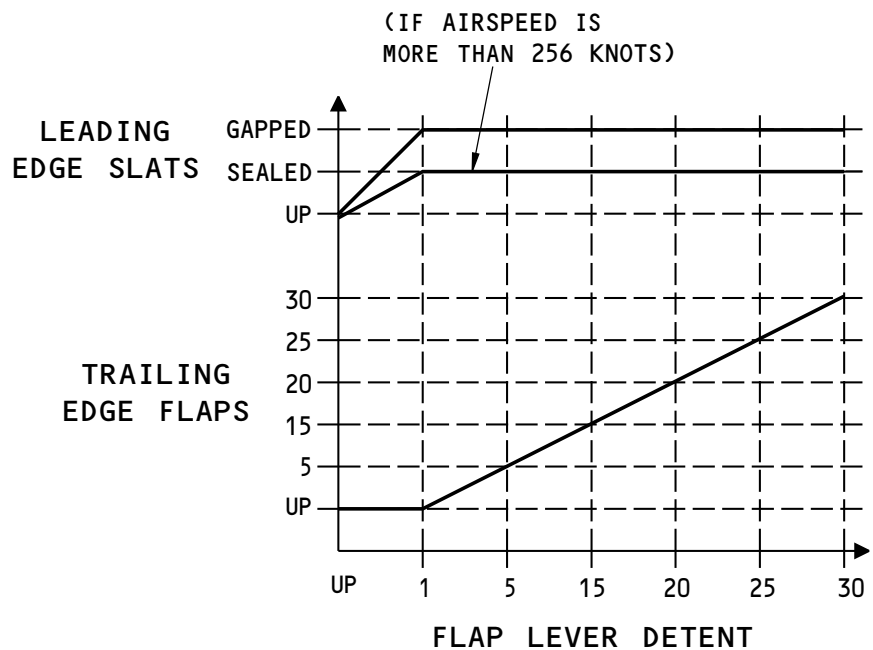
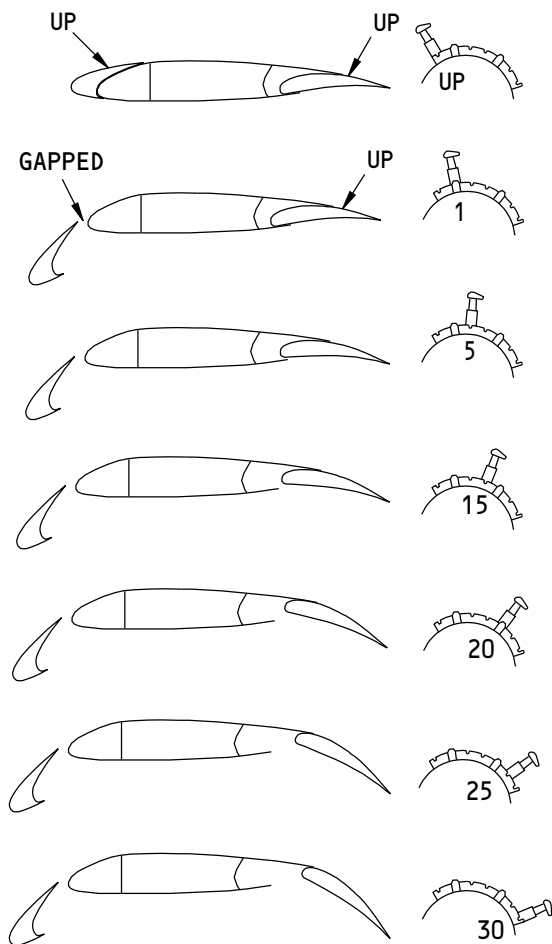
The extension time is the same as the retraction time.

It takes 5 minutes and 8 seconds to move the slats and the flaps from the UP position to the 30-unit position. The detailed times are:

- 1 minute and 25 seconds to move the slats from the retracted position to the gapped position
- 3 minutes and 43 seconds to move the flaps from the retracted position to the 30-unit position.

Flap Operation With Slats Drive Shutdown

When the slats fail to move to the commanded position in primary and secondary mode, the FSEUs shutdown the slats drive. With a slats drive shutdown, the flaps continue to operate in primary mode. The flaps move to their commanded position independently of the slat position. If the slats are not at the gapped position when the slats drive shutdown occurs, the flaps cannot move more than the 20-unit position. If the slats are at the gapped position when the slats drive shutdown occurs, the flaps can move more than the 20-unit position.



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HIGH LIFT CONTROL - SECONDARY MODE FLAP AND SLAT SEQUENCE

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**HIGH LIFT CONTROL - ALTERNATE MODE FLAP AND SLAT SEQUENCE****General**

The alternate flaps arm switch sets the alternate mode. The alternate flaps selector controls the direction of the flap and slat movement.

Extension

When the arm switch is set to ARM and the selector is set to EXT, the slats move to the sealed position and the flaps move to the 20 unit position. They move at the same time. It takes 2 minutes and 33 seconds.

A detent holds the selector in the EXT position. If the selector is set to OFF while the flaps and slats move, the movement stops.

Retraction

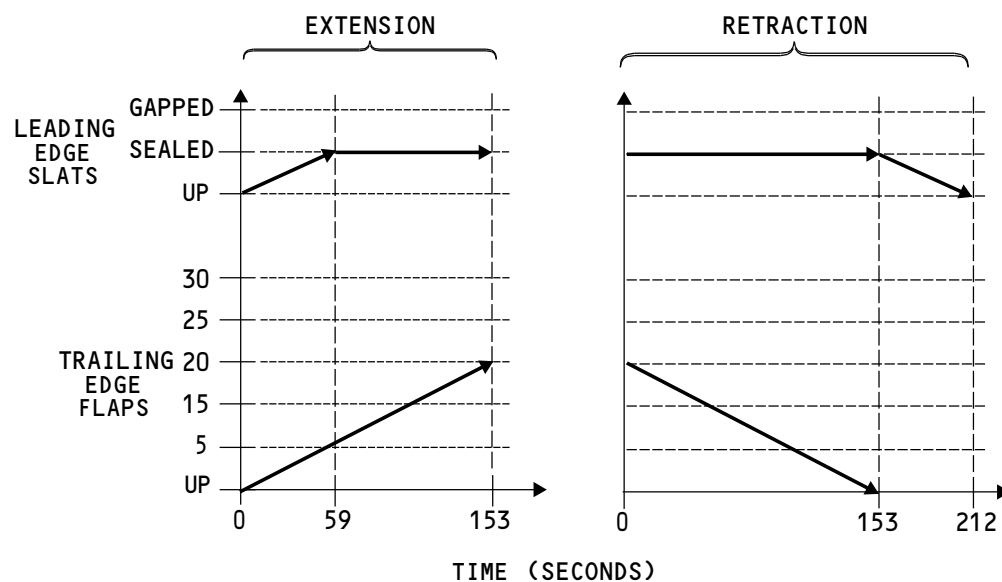
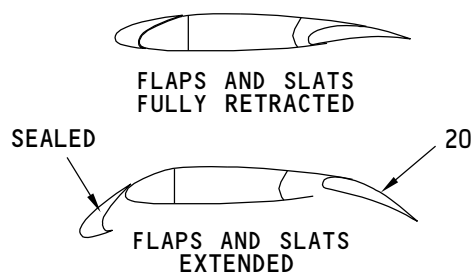
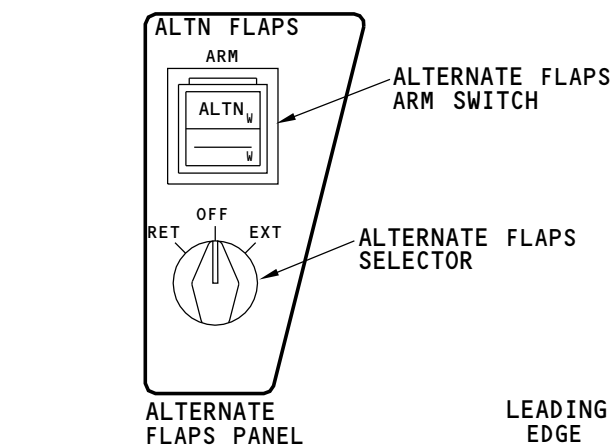
When the arm switch is set to ARM and the selector is set to RET, the flaps retract first, then the slats. Flap retraction takes 2 minutes and 33 seconds. The slats take 59 seconds. Total flap and slat retraction time is 3 minutes and 32 seconds.

A detent holds the selector in the RET position. If the selector is set to OFF while the flaps and slats move, the movement stops.

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HIGH LIFT CONTROL - ALTERNATE MODE FLAP AND SLAT SEQUENCE

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HIGH LIFT CONTROL - INDICATIONS - POSITION DISPLAYS

General

The flap and slat position display is on the EICAS display or the EICAS compacted engine display. There are three different displays for the flaps and slats:

- Primary
- Secondary
- Alternate.

Only one display shows at a time.

Primary Mode Display

The primary mode display shows when both the flaps and slats are in the primary mode. This display shows the position of both the flaps and slats. The display is black when the flaps and slats are fully retracted. When the flaps or slats extend, a white tape fills the display from the top down.

A command bar and detent number show the flap lever position. When you move the flap lever, the flap lever detent number and command bar show. While the flaps and slats move, the command bar and detent number are magenta. When the flaps and slats are in the flap lever commanded position, the command bar and detent number change to green.

The primary mode display goes out of view 10 seconds after the flaps and slats are fully retracted.

Secondary Mode Display

The secondary mode display shows when either the flaps or slats are in the secondary mode. This display has separate indications for:

- The left wing flaps
- The right wing flaps
- The left wing slats
- The right wing slats.

The two upper indications show the slat positions. The two lower indications show the flap positions. All four indications are black when the flaps and slats are fully retracted. When the slats extend, a white tape fills the upper indications from the bottom up. When the flaps extend, a white tape fills the lower indications from the top down.

The secondary mode display shows a command bar and detent number. These operate the same as for the primary mode display.

After the flaps and slats are fully retracted, the secondary mode display goes out of view and the primary mode display shows. After 10 seconds, the primary mode display also goes out of view.

If the flaps (or slats) drive system fails, the related indications change from white to amber.

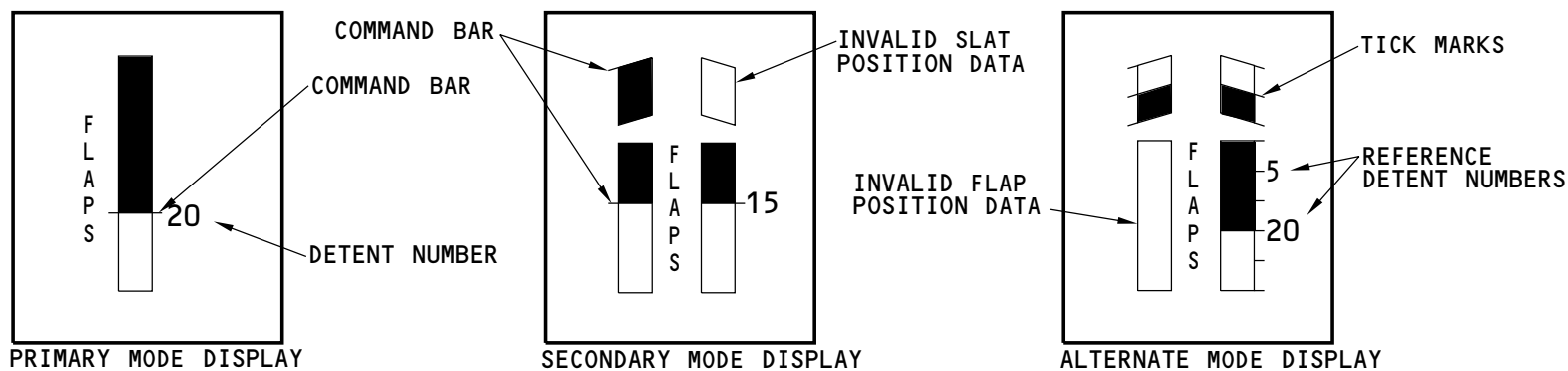
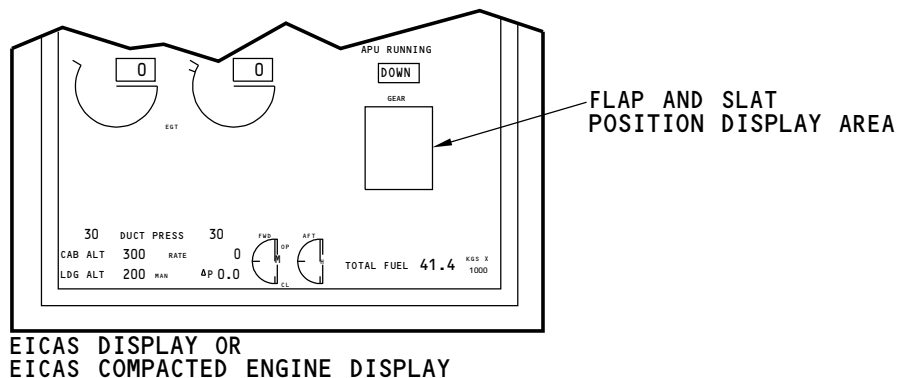
If the left (or right) slat position data is invalid, the left (or right) upper tape and command bar go out of view. If the left (or right) flap position data is invalid, the left (or right) lower tape and command bar go out of view. If the flap lever position data is invalid, the detent number goes out of view.

Alternate Mode Display

The alternate mode display shows when you push the alternate flaps arm switch.

The alternate mode display has almost the same format as the secondary mode display. The difference is that the alternate mode display does not have the command bar, but has tick marks and reference detent numbers to identify the flap and slat positions.

If the left (or right) slat position data is invalid, the left (or right) upper tape and tick marks go out of view. If the left (or right) flap position data is invalid, the left (or right) lower tape, tick marks, and reference detent numbers go out of view.



HIGH LIFT CONTROL - INDICATIONS - POSITION DISPLAYS

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HIGH LIFT CONTROL - INDICATIONS - MAINTENANCE PAGE FORMAT

General

The high lift maintenance page format contains data from each FSEU. This includes the following data:

- Systems ARINC 629 data buses
- Flap lever position sensors
- Slat commands
- Slat position sensors
- Slat skew sensors
- Flap commands
- Flap position sensors
- Flap skew sensors.

There are three different display modes:

- Real time mode
- Manual event mode
- Auto event mode.

The word MANUAL or AUTO at the top of the page identifies the manual or auto event page. The message that caused the auto event is at bottom left of the page. The time of the event is at the bottom right.

Systems ARINC 629 Data Buses

The top of the page shows data that each FSEU receives from the systems ARINC 629 data buses. The first row shows the control status of each FSEU. The status of the FSEU is one of the following:

- IN CONTROL; the FSEU is in control of the HLCS
- ALTN ARM; the alternate mode is armed
- LOADING; the FSEU is loading software
- TEST; the FSEU is in test
- FAULT; the FSEU has detected a lane fault
- STANDBY; none of the other status words are applicable.

The page then shows the airspeed in knots and the center hydraulic system pressure in psi. If this data is invalid, there is no indication.

Below these are the status of the commands for autoslat, load relief, and to the autoslat priority valves. At the bottom of this list is the air/ground status.

Flap Lever Position Sensor

The top left of the page shows the voltage of each RVDT in the flap lever position sensor. If some of this data is invalid, there is no indication for the bad value.

Slat Commands

The left center of the page shows the status of the slat commands from the FSEU in control. The status of the slats drive command is one of the following:

- PRI EXT; the slats are commanded to extend in the primary mode
- PRI RET; the slats are commanded to retract in the primary mode
- SEC EXT; the slats are commanded to extend in the secondary mode
- SEC RET; the slats are commanded to retract in the secondary mode.

The status of the slat drive mode is one of the following:

- LO SPD; the slats are moving at low speed in the primary mode
- HI SPD; the slats are moving at high speed in the primary mode
- CLUTCH; the electric motor clutch is engaged.

The status of the shutoff valve command is either OPEN or CLOSED.

Slat Position Sensors

The right center of the page shows the position of the slat position sensors in degrees of sensor rotation. If some of this data is invalid, there is no indication for the bad value.

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HIGH LIFT CONTROL - INDICATIONS - MAINTENANCE PAGE FORMAT

Slat Skew Sensors

The center of the page shows the status of the slat skew sensors. The page shows one of the following for each sensor:

- NEAR; the target is near the sensor
- FAR; the target is far from the sensor
- FAIL; the sensor is defective.

If some of this data is invalid, there is no indication for the bad value.

Flap Commands

The bottom left of the page shows the status of the flap commands from the FSEU in control. The status of the flap drive command is one of the following:

- PRI EXT; the flaps are commanded to extend in the primary mode
- PRI RET; the flaps are commanded to retract in the primary mode
- SEC EXT; the flaps are commanded to extend in the secondary mode
- SEC RET; the flaps are commanded to retract in the secondary mode.

The status of the flaps drive mode is one of the following:

- LO SPD; the flaps are moving at low speed in the primary mode
- HI SPD; the flaps are moving at high speed in the primary mode
- CLUTCH; the electric motor clutch is engaged.

The status of the shutoff valve command is either OPEN or CLOSED.

Flap Position Sensors

The bottom right of the page shows the position of the flap position sensors in degrees of sensor rotation. If some of this data is invalid, there is no indication for the bad value.

Flap Skew Sensors

The bottom of the page shows the voltage of the flap skew sensors in volts. If some of this data is invalid, there is no indication for the bad value.

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FLAP/SLAT AUTO									
		FSEU 1			FSEU 2				
FLAP LEVER		STATUS		STANDBY		IN CONTROL			
1A	9.00	AIRSPEED		200		200			
1B	8.47	C SYS PRESS		3000		3000			
2A	8.91	AUTOSLAT		CMD		NOT CMD			
2B	9.05	LOAD RELIEF		NOT CMD		CMD			
		PRIORITY VLV		OPEN		CLOSED			
		AIR/GND		AIR		AIR			
		SLATS			SLAT POS				
		DRIVE CMD		PRI EXT		L		R	
		MODE		LO SPD		1 200.40		200.40	
		S/O VLV CMD		CLOSED		2 198.80		198.80	
SLAT 2		SLAT 7		SLAT 8		SLAT 13			
1	FAR	OUTBD INBD		INBD OUTBD		1 FAIL			
2	NEAR	1 FAR FAR		1 FAIL FAR		2 NEAR			
		2 NEAR NEAR		2 NEAR NEAR					
		FLAPS			FLAP POS				
		DRIVE CMD		PRI EXT		L		R	
		MODE		LO SPD		1 200.40		200.40	
		S/O VLV CMD		CLOSED		2 198.80		198.80	
OUTBD FLAP		INBD FLAP		INBD FLAP		OUTBD FLAP			
L1	L2	L3	L4	R5	R6	R7	R8		
1	3.50	3.50	1 3.50	3.50	1 3.50	3.50	1 3.50	3.50	
2	3.49	3.49	2 3.49	3.49	2 3.49	3.49	2 3.49	3.49	
SLATS DRIVE									
DATE 23 JUN 90 UTC 18:54:04									

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HIGH LIFT CONTROL - INDICATIONS - MAINTENANCE PAGE FORMAT

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HIGH LIFT CONTROL - SYSTEM TESTS

General

The FSEUs control the operation of the MAT tests. All the MAT tests for the HLCS are interactive tests. You are able to select which FSEU to control each of the tests. There are no MAT operational tests for the HLCS.

The system tests for the HLCS include:

- Primary System Test - FSEU 1
- Primary System Test - FSEU 2
- Secondary System Test - FSEU 1
- Secondary System Test - FSEU 2.

All of these tests can test the flaps only, the slats only, or both. Also, all of these tests will cause the flaps and slats to move.

Primary System Test - FSEU 1 (FSEU 2)

This test makes sure that FSEU 1 (FSEU 2) can control the HLCS correctly in hydraulic mode.

Secondary System Test - FSEU 1 (FSEU 2)

This test makes sure that FSEU 1 (FSEU 2) can control the HLCS correctly in electric mode.

Training Information Point

The MAT tests for the HLCS use a ground test software in the FSEUs that is different than the test software used during flight. If the MAT test fails, the maintenance message will be different than the maintenance message reported by the flight test software.

GROUND TESTS

SELECT ATA SYSTEM (55)

- 24 MAIN AC ELECTRICAL POWER GENERATION SYSTEM
- 24 BACKUP (VSCF) ELECTRIC POWER SYSTEM (BEPS)
- 26 CARGO SMOKE DETECTION SYSTEM
- 26 FIRE EXTINGUISHING SYSTEM
- 27 STALL WARNING MANAGEMENT
- 27 PRIMARY FLIGHT CONTROL SYSTEM
- 27 HIGH LIFT SYSTEM**
- 29 HYDRAULIC SYSTEM
- 30 AIRFOIL CONT. ICE PROTECTION SYSTEM

SELECT TEST TYPE

- ☐ SYSTEM TEST
- ☒ OPERATIONAL TEST
- ☐ LRU REPLACEMENT TEST

SELECT SYSTEM TEST (4)

- PRIMARY SYSTEM TEST-FSEU 1
- PRIMARY SYSTEM TEST-FSEU 2
- SECONDARY SYSTEM TEST-FSEU 1
- SECONDARY SYSTEM TEST-FSEU 2

CONTINUE

HELP

GO BACK

SELECT SYSTEM TEST

(4)

PRIMARY SYSTEM TEST-FSEU 1
 PRIMARY SYSTEM TEST-FSEU 2
 SECONDARY SYSTEM TEST-FSEU 1
 SECONDARY SYSTEM TEST-FSEU 2

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HIGH LIFT CONTROL - SYSTEM TESTS

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HIGH LIFT CONTROL - LRU REPLACEMENT TESTS**General**

The LRU replacement tests for the HLCS include:

- FSEU 1
- FSEU 2
- Flaps primary control valve test - FSEU 1
- Flaps primary control valve test - FSEU 2
- Slats primary control valve test - FSEU 1
- Slats primary control valve test - FSEU 2
- Inboard slat skew test - FSEU 1
- Inboard slat skew test - FSEU 2.

FSEU 1 (FSEU 2)

This test makes sure that FSEU 1 (FSEU 2) is operating correctly.

Slats Primary Control Valve Test-FSEU 1 (FSEU 2)

This test makes sure that FSEU 1 (FSEU 2) controls the slats primary control valve correctly. During this test, the slats will move.

Flaps Primary Control Valve Test-FSEU 1 (FSEU 2)

This test makes sure that FSEU 1 (FSEU 2) controls the flaps primary control valve correctly. During this test, the flaps will move.

Inboard Slat Skew Test-FSEU 1 (FSEU 2)

This test makes sure that FSEU 1's (FSEU 2's) inboard slat skew/loss sensors operate correctly. During this test, the slats will move.

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GROUND TESTS

SELECT ATA SYSTEM (55)

- 24 MAIN AC ELECTRICAL POWER GENERATION SYSTEM
- 24 BACKUP (VSCF) ELECTRIC POWER SYSTEM (BEP5)
- 26 CARGO SMOKE DETECTION SYSTEM
- 26 FIRE EXTINGUISHING SYSTEM
- 27 STALL WARNING MANAGEMENT
- 27 PRIMARY FLIGHT CONTROL SYSTEM
- 27 HIGH LIFT SYSTEM**
- 29 HYDRAULIC SYSTEM
- 30 AIRFOIL COM. ICE PROTECTION SYSTEM

SELECT TEST TYPE

☐ SYSTEM TEST

☒ OPERATIONAL TEST

☐ LRU REPLACEMENT TEST

SELECT LRU REPLACEMENT TEST (8)

FSEU 1

FSEU 2

SLATS PRIMARY CONTROL VALVE TEST-FSEU 1

SLATS PRIMARY CONTROL VALVE TEST-FSEU 2

FLAPS PRIMARY CONTROL VALVE TEST-FSEU 1

FLAPS PRIMARY CONTROL VALVE TEST-FSEU 2

INBOARD SLAT SKEW TEST-FSEU 1

INBOARD SLAT SKEW TEST-FSEU 2

CONTINUE

HELP

GO BACK

SELECT LRU REPLACEMENT TEST

(8)

FSEU 1

FSEU 2

SLATS PRIMARY CONTROL VALVE TEST-FSEU 1

SLATS PRIMARY CONTROL VALVE TEST-FSEU 2

FLAPS PRIMARY CONTROL VALVE TEST-FSEU 1

FLAPS PRIMARY CONTROL VALVE TEST-FSEU 2

INBOARD SLAT SKEW TEST-FSEU 1

INBOARD SLAT SKEW TEST-FSEU 2

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HIGH LIFT CONTROL - LRU REPLACEMENT TESTS

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HIGH LIFT CONTROL - SPECIAL FUNCTIONS

General

The secondary mode inhibit override function permits movement of the slats and flaps with the PDU electric motors while on the ground.

You can select which FSEU controls the flaps and slats when you use this function.

The FSEUs inhibit the secondary mode operation when the airplane is in a ground maintenance condition. Three conditions are necessary for the ground maintenance condition to occur. First, the center hydraulic system pressure must be low. Second, either:

- The airplane is on the ground, or
- The ground speed is less than 40 knots.

Third, either:

- Both engines are not running, or
- One engine is not running and external power is available.

Operation

When you use this function, the FSEUs permit the use of the PDU electric motors to move the flaps and slats. You can then use the flap lever to control the position of the flaps and slats.

After you enable the secondary mode inhibit override, you have 15 seconds to move the flaps and slats using the flap lever. After 15 seconds, the secondary mode inhibit override stops. If the surfaces are in motion when the inhibit override stops, the surfaces continue to move to the commanded position.

If you use the secondary mode inhibit override when there is no failure of the primary mode, the flaps and slats operate the same as the primary mode. The FSEU sends commands to the electric motors of the flaps and slats power drive units. The flaps/slats sequence is the same as in primary mode (slats sealed with flap lever position 1 through 20, slats gapped with flap lever position 25 and 30). The flaps/slats indication on the EICAS display shows the primary mode display.

If you use the secondary mode inhibit override when there is a failure of the primary mode, the flaps/slats operate the same as the secondary mode. The FSEU sends commands to the electric motors of the flaps and slats power drive units. The flaps/slats sequence is the same as in secondary mode (slats gapped with flap lever position 1 through 30). The flaps/slats indication on the EICAS display shows the secondary mode display.

For example, you could cause a failure of the primary mode if on the ground you move the flap lever with the center hydraulic system depressurized before you enable the secondary mode inhibit override.

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SPECIAL FUNCTIONS

SELECT ATA SYSTEM

- 22 AUTOPILOT FLIGHT DIRECTOR SYSTEM
- 24 ELMS P110 POWER MANAGEMENT PANEL
- 31 AIMS - DISPLAY SYSTEM
- 24 ELMS P210 POWER MANAGEMENT PANEL
- 24 ELMS P310 POWER MANAGEMENT PANEL
- 27 HIGH LIFT SYSTEM
- 29 HYDRAULIC SYSTEM
- 31 AIMS - DISPLAY SYSTEM
- 31 AIMS - FLIGHT DATA RECORDER SYSTEM
- 32 AIR/GROUND SYSTEM

(22)

SELECT FUNCTION

- SECONDARY MODE INHIBIT OVERRIDE - FSEU 1
- SECONDARY MODE INHIBIT OVERRIDE - FSEU 2

(2)

CONTINUE

HELP

GO BACK

SELECT FUNCTION

(2)

SECONDARY MODE INHIBIT OVERRIDE - FSEU 1
SECONDARY MODE INHIBIT OVERRIDE - FSEU 2

HIGH LIFT CONTROL - SPECIAL FUNCTIONS

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AILERON AND FLAPERON CONTROL - INTRODUCTION

General

The ailerons and flaperons control the flight attitude of the airplane about the longitudinal axis. They also increase the wing lift with the high lift system during takeoff, approach and landing.

The ailerons are on the wing outboard trailing edge.

The flaperons are standard inboard ailerons which also operate as flaps. They are between the inboard and the outboard flaps on the wing trailing edge.

Roll Control

During roll control, the aileron and flaperon on one wing move up, and the aileron and flaperon of the other wing move down.

The pilots manually command a roll correction with the rotation of the control wheels. When engaged, the autopilot automatically commands the ailerons and the flaperons. During autopilot operation, actuators backdrive the control wheels.

The spoilers also supply roll control. See the spoiler and speedbrake control section for more information (SECTION 27-61).

Aileron Lockout

On the ground and during flight below cruise speed, the ailerons and flaperons are fully operational. At cruise speed, the ailerons fair to the wing surface and lock out. The flaperons supply roll control.

Aileron and Flaperon Droop

During extension of the flaps, the ailerons and flaperons droop to increase the lift of the wing. The ailerons and flaperons of both wings move down. When drooped, the ailerons and flaperons are fully operational for roll control.

Abbreviations and Acronyms

- ACE - actuator control electronics
- ACMS - airplane condition monitoring system

- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- ADM - air data module
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AIMS - airplane information management system
- ARINC - Aeronautical Radio, Inc.
- BAP - bank angle protection
- B/D - backdrive
- CAS - calibrated airspeed
- CMCS - central maintenance computing system
- CPU - central processing unit
- EHSV - electrohydraulic servo valve
- EICAS - engine indication and crew alerting system
- FCDC - flight controls direct current
- FMCS - flight management computing system
- FSEU - flap/slat electronics unit
- HLCS - high lift control system
- LAM - landing attitude modification
- LIB - left inboard
- LOB - left outboard
- LRU - line replaceable unit
- LVDT - linear variable differential transformer
- MCP - mode control panel
- MEC - main equipment center
- Mdiv - maximum design dive Mach number
- MFD - multi-function display
- Mmo - maximum operating Mach number
- PCU - power control unit
- PDU - power drive unit

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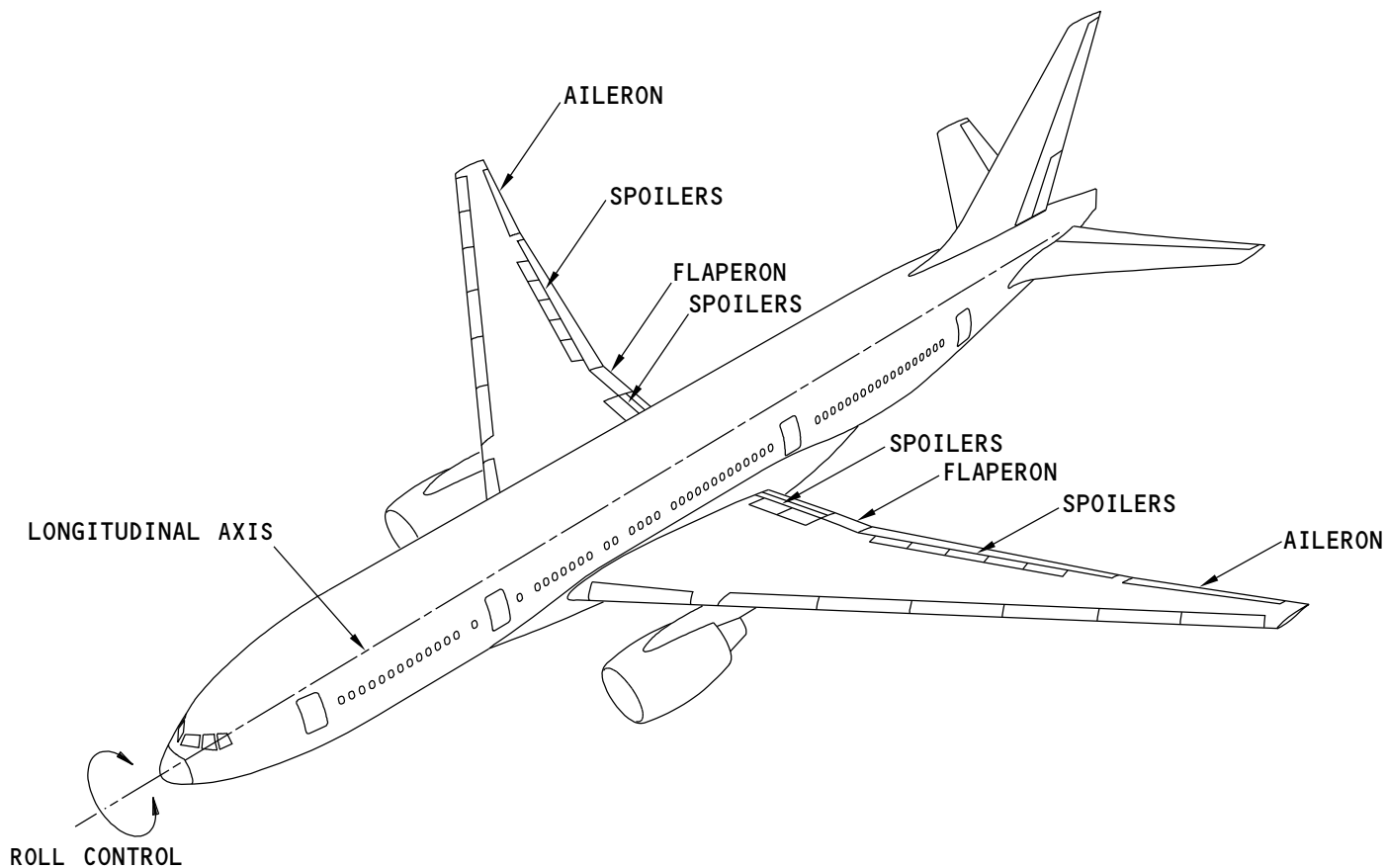
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AILERON AND FLAPERON CONTROL - INTRODUCTION

- PFC - primary flight computer
- PFCS - primary flight control system
- PFD - primary flight display
- PMG - permanent magnet generator
- PSA - power supply assembly
- PSAS - pitch stability augmentation system
- PSEU - proximity sensor electronics unit
- RIB - right inboard
- ROB - right outboard
- RVDT - rotary variable differential transformer
- SAARU - secondary attitude air data reference unit
- sol - solenoid
- SOV - shutoff valve
- STCM - stabilizer trim control module
- TED - trailing edge down
- TEU - trailing edge up
- Vdive - maximum design dive speed
- Vmo - maximum operating limit speed
- WEU - warning electronic unit
- WOW - weight-on-wheels



AILERON AND FLAPERON CONTROL - INTRODUCTION

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AILERON AND FLAPERON CONTROL - GENERAL DESCRIPTION

General

The pilots manually command the ailerons and flaperons; the autopilot automatically commands them.

Manual Operation - Control Wheels

The flight crew uses two conventional control wheels to control roll. A wheel jam breakout mechanism supplies a mechanical link between the control wheels. If a control wheel jams, the other continues to control.

Six position transducers change the flight crew commands of the control wheel to analog electrical signals. These signals go to the four actuator control electronics (ACEs). The ACEs change the signals to digital format and send them to the three primary flight computers (PFCs) through the flight controls ARINC 629 buses.

The PFCs use the control wheel position data, along with data from the ADIRU and AIMS, to calculate control surface commands. The PFCs send the digital commands to the ACEs, which change them to analog signals. The ACEs send the analog position commands to the power control units (PCUs) which move the control surfaces. The position transducers on the actuator pistons supply position feedback to the ACEs.

Manual Operation - Aileron Trim

The aileron trim switches and the trim actuator permit the flight crew to trim out unwanted control wheel forces. When the pilots move the aileron trim switches on the aisle stand, the switches send a signal to the aileron trim actuator. The trim actuator moves the control wheels and the position transducers through the feel and centering mechanism. This changes the neutral position of the control wheels. The transducers send a signal to the ACEs and PFCs to move the ailerons and flaperons.

When the autopilot is engaged or the bank angle protection (BAP) is active, the aileron trim does not operate.

Autopilot Operation

When engaged, the autopilot flight director computers (AFDCs) control the roll rate and attitude of the airplane. The AFDCs supply roll commands to the PFCs through the flight controls ARINC 629 buses. The PFCs use these inputs to calculate position commands for the ailerons and flaperons in a similar manner as for the manual operation.

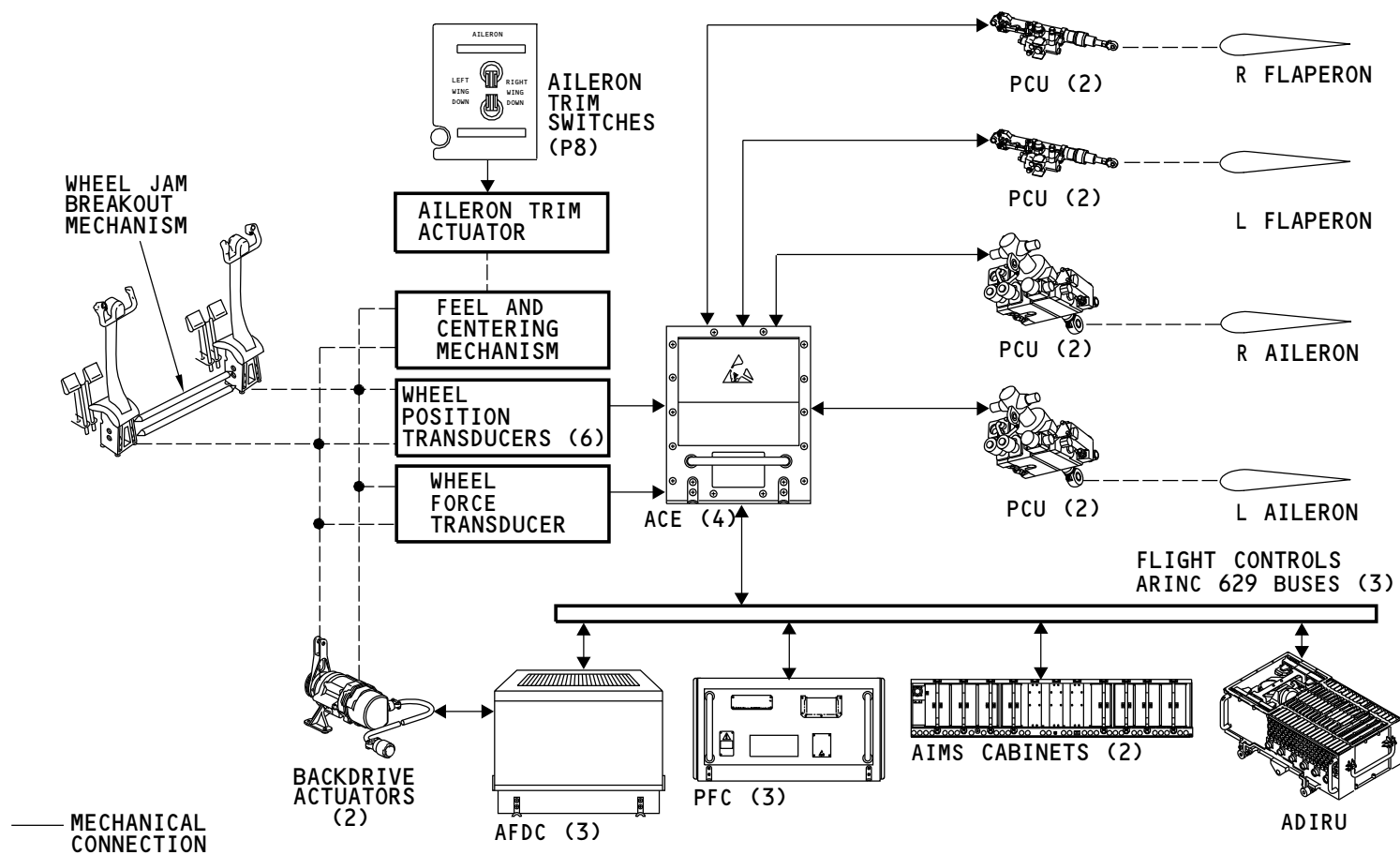
The PFCs also calculate wheel backdrive commands. The PFCs send these commands to the AFDCs, which calculate control wheel movement commands for the backdrive actuator. The backdrive actuator moves the wheels the same amount as the pilot would move them manually for the same surface movement. The flight crew can override the autopilot through the use of enough force on the wheel to overcome the backdrive actuator.

The AFDCs prevent the aileron trim operation when the autopilot is engaged.

Bank Angle Protection

A bank angle protection (BAP) function in the PFCs supplies protection in both manual and autopilot operation when the bank angle is more than 35 degrees.

The AFDCs prevent the aileron trim operation when the bank angle protection (BAP) is active.



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AILERON AND FLAPERON CONTROL - GENERAL DESCRIPTION

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**AILERON AND FLAPERON CONTROL - COMPONENT LOCATIONS****General**

The aileron and flaperon control components are in three areas:

- The wings
- The flight deck
- Below the flight deck floor.

See the primary flight controls section for more information about the location of PFCS electronic components (SECTION 27-02).

Wing Components

The aileron and flaperon control surfaces and their PCUs are on the wings. Two PCUs directly connect to each surface. Access to the aileron PCUs is by hinged access panels on the lower wing. Access to the flaperon PCUs is by removable lower skin panels.

Flight Deck Components

The control wheels and aileron trim switches are in the flight deck. The aileron trim switches are on the P8 aft aisle stand panel.

Components Below the Flight Deck

The rest of the forward controls are below the flight deck floor and above the nose gear wheel well. These are the:

- Wheel position transducers
- Wheel force transducer
- Wheel cable drums
- Feel and centering mechanism
- Wheel jam breakout mechanism
- Wheel backdrive actuators.

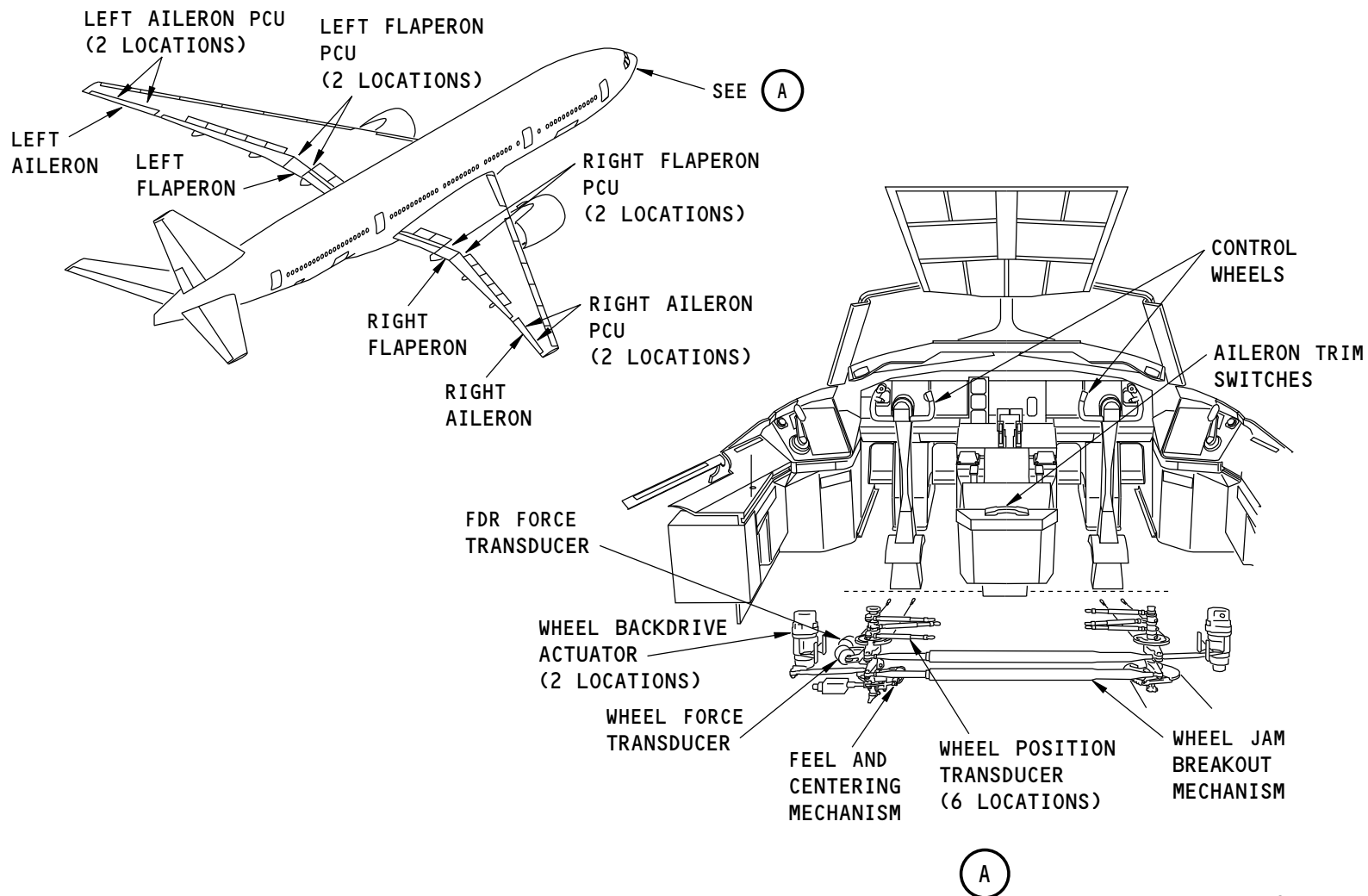
Access to these components is through the main equipment center (MEC), and then forward along the nose gear wheel well.

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AILERON AND FLAPERON CONTROL - COMPONENT LOCATIONS

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AILERON AND FLAPERON CONTROL - ANALOG AND DISCRETE INTERFACES

General

All of the aileron and flaperon control electrical interfaces within the PFCS go through the ACEs. Each ACE has interfaces with these components:

- Wheel position transducers
- Wheel force transducer
- Aileron PCUs
- Flaperon PCUs.

The aileron trim switches and trim actuator have mechanical interfaces with the aileron and flaperon control system.

Aileron Trim Switches and Trim Actuator

Two trim switches supply power to the trim actuator. The trim actuator moves the control wheels and the wheel position transducers by rotation of the feel and centering mechanism.

Wheel Position Transducers

There are six position transducers, three for each control wheel. Each transducer is a linear variable differential transformer (LVDT) that sends analog signals to the ACEs. These analog signals represent the control wheel position and its movement.

Wheel Force Transducer

There is one force transducer, with two LVDTs, that sends analog signals to the ACEs. These signals show the amount of force the pilots apply to the control wheels.

Aileron PCUs

Each of the four aileron PCUs receives analog and discrete electrical signals from the ACEs. The discrete signals are for the bypass and blocking solenoids. The analog signal is for the electrohydraulic servo valve (EHSV).

Each of the four aileron PCUs sends analog feedback signals to the ACEs. These signals are from the EHSV position LVDT, the actuator position LVDT and the null LVDT.

Flaperon PCUs

Each of the four flaperon PCUs receives analog and discrete electrical signals from the ACEs. The discrete signals are for the bypass solenoid. The analog signal is for the EHSV.

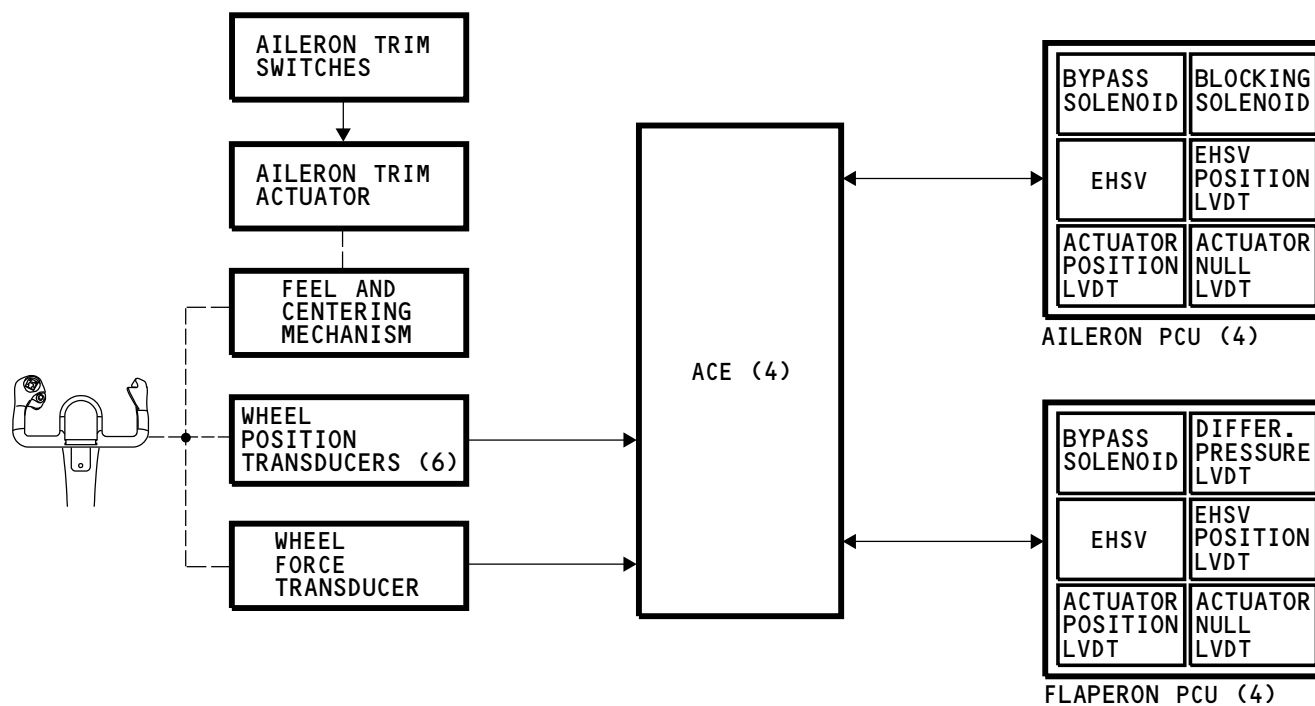
Each of the four flaperon PCUs sends analog feedback signals to the ACEs. These signals are from the EHSV position LVDT, the actuator position LVDT and the null LVDT. A differential pressure LVDT sends signals about the difference of pressure between both sides of the PCU piston.

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AILERON AND FLAPERON CONTROL - ANALOG AND DISCRETE INTERFACES

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AILERON AND FLAPERON CONTROL - FORWARD CONTROLS

General

The forward controls of the aileron and flaperon control system include:

- Control wheels
- Wheel drums and shaft assemblies
- Wheel jam breakout mechanism
- Wheel position and force transducers
- Wheel backdrive actuators
- Wheel damper
- Feel and centering mechanism
- Travel stops.

The forward controls are below the flight deck.

Control Wheels

Each pilot has a control wheel. The control wheels turn to supply manual input to the aileron and flaperon control.

Wheel Cable Drums and Shaft Assemblies

A pair of control cables connects each control wheel to a cable drum. The left and right cable drums bearing mount on their drive shaft assembly. The cable drums indirectly move the shaft assemblies through the force limiters and the force transducer. There is a lost motion device on each wheel cable drum.

Wheel Jam Breakout Mechanism

The wheel jam breakout mechanism has two identical force limiters and two lost motion devices. If the control wheel jams, the force limiters allow the other control wheel to continue roll control. The upper force limiter connects the two wheel cable drums. The lower force limiter connects the right and left shaft assemblies. The lost motion devices allow the control wheel cable drums to move the left or right shaft assembly in case of failure.

Wheel Position and Force Transducers

Six wheel position transducers, on the airframe structure, connect to cranks at the top of the left and right shaft assemblies.

The wheel force transducer connects the left cable drum to the left crank.

Wheel Backdrive Actuators

Two wheel backdrive actuators connect to the cranks on the left and right shaft assemblies. The backdrive actuators are part of the autopilot system. See the autopilot flight director system section for more information on the backdrive actuators (SECTION 22-11).

Wheel Damper

The left shaft assembly connects to a wheel damper. The wheel damper absorbs control wheel vibrations.

Feel and Centering Mechanism

The feel and centering mechanism is at the bottom of the left shaft assembly. The aileron trim actuator connects directly to the feel and centering mechanism.

Travel Stops

Travel stops are at the bottom of the shaft assemblies. They limit the shaft assemblies, cable drums and position transducers movement to 65 degrees of control wheel travel.

Spoiler Control Quadrant

The spoiler control quadrant is at the bottom of the right shaft assembly. The spoiler control quadrant connects by a pair of cables to the controls of spoilers 4 and 11.

See the spoiler and speedbrake control section for more information (SECTION 27-61).

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AILERON AND FLAPERON CONTROL - FORWARD CONTROLS

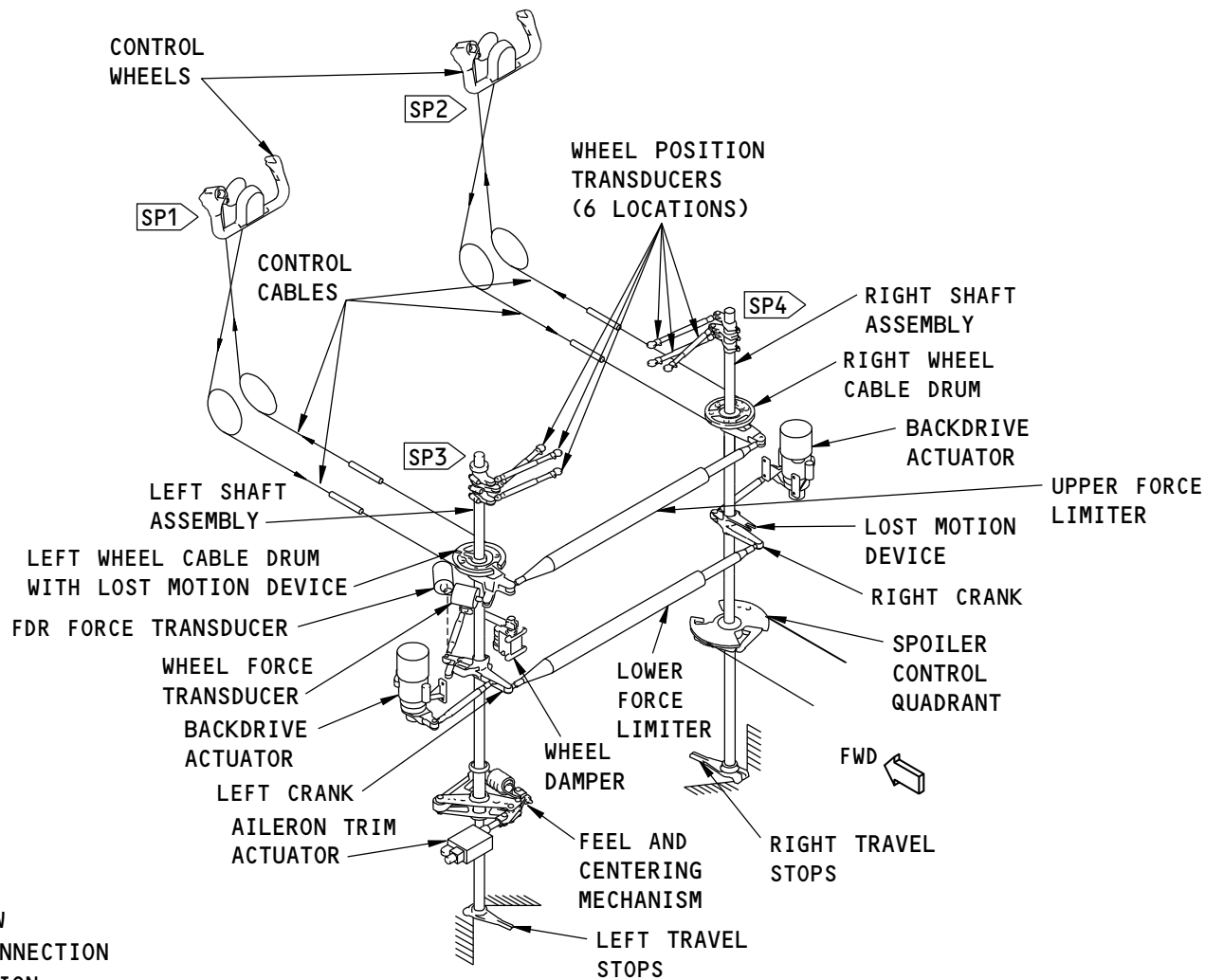
Training Information Point

You use four rig pins to adjust the system.

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NOTE: EXPANDED VIEW

----- MECHANICAL CONNECTION

SPX RIG PIN LOCATION

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AILERON AND FLAPERON CONTROL - FORWARD CONTROLS

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**AILERON AND FLAPERON CONTROL - CONTROL WHEEL****Purpose**

The flight crew uses two control wheels for roll control command.

Physical Description

The control wheels are 12.25 inch diameter cast assemblies. They are conventional in design. The outboard side of each wheel contains the pitch trim switches and the autopilot disconnect switches. An aileron trim indicator placard is on the top of the control wheel.

A maintenance access cover on the control column permits inspection of the cables.

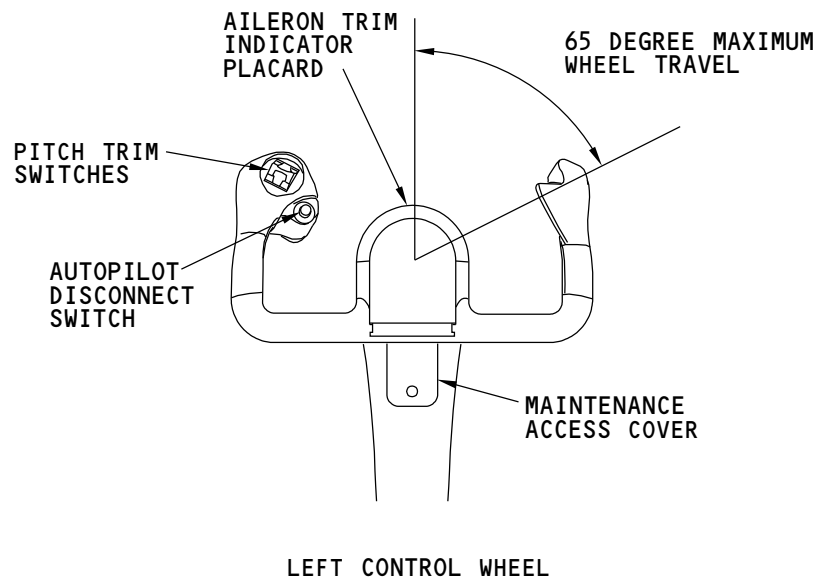
Functional Description

When the pilot turns the control wheel, the control column cable drums turn and move the control cables. Stops mechanically keep the control wheel movement to a limit of 65 degrees right and left.

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AILERON AND FLAPERON CONTROL - CONTROL WHEEL

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AILERON AND FLAPERON CONTROL - WHEEL CABLE DRUM**Purpose**

The wheel cable drums transmit the wheel cable motion to the force transducer and upper force limiter.

Physical Description

The wheel cable drums are cast assemblies. The right and left drums are not the same. Both drums have attachment points for the upper force limiter, which is part of the wheel jam breakout mechanism.

The left drum has an additional attachment point for the wheel force transducer. The left drum is bearing mounted on a sleeve which is spline mounted on the left shaft assembly. If there is a failure, the sleeve and left drum can connect through a lost motion device. The lost motion device permits connection after a control wheel rotation of 7.8 degrees in either direction.

The right drum is bearing mounted on the right shaft assembly. The right drum has a peg on the bottom side which is part of the lost motion device. If there is a failure, the lost motion device lets the right drum connect to the right shaft assembly after a control wheel rotation of 2.9 degrees in either direction.

Location

The wheel cable drums are on the shaft assemblies. They are between the flight deck floor and the nose gear well. Access to the drums is through the MEC, along the nose gear wheel well, or through the flight deck floor access panels.

Functional Description

When the pilots move the control wheels, the wheel cables turn the wheel drums.

Training Information Point

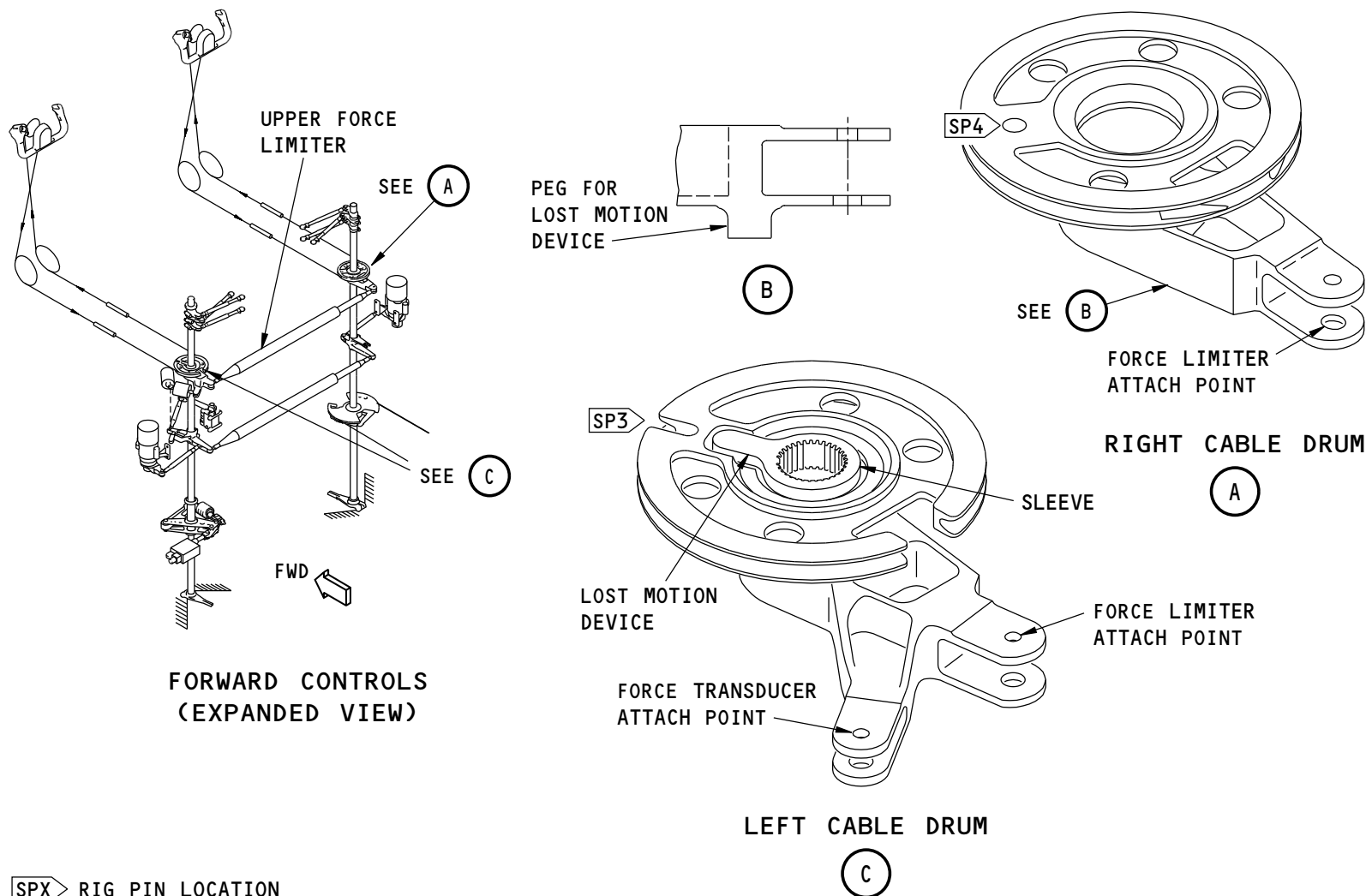
Each wheel cable drum has a rig pin hole.

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AILERON AND FLAPERON CONTROL - WHEEL CABLE DRUM

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AILERON AND FLAPERON CONTROL - WHEEL JAM BREAKOUT MECHANISM

Purpose

The wheel jam breakout mechanism supplies a load path for roll control. In normal operation, the mechanism permits either pilot to make roll control commands. If there is a jam of a control wheel, the breakout mechanism permits the pilot to operate the other control wheel. If the cable or connection breaks, the other control wheel still operates.

Physical Description

The wheel jam breakout mechanism has two identical force limiters and two lost motion devices.

Force Limiter

Each force limiter is a pogo. It contains an inner and outer rod and a spring. It takes a 50 lb (23 kg) force at the control wheel to breakout the force limiters.

The upper force limiter attaches directly to the two wheel cable drums. The lower force limiter attaches to the two cranks on the left and right shaft assemblies.

Lost Motion Devices

There is a lost motion device on the left and right cable drums.

If there is a failure, the left cable drum motion device connects the drum to the left shaft assembly after a control wheel rotation of 7.8 degrees.

The lost motion device on the right drum is a peg and notch type mechanism. The right wheel cable drum has a peg on the bottom surface which inserts in the slot of the right crank, directly below it. If there is a failure, the right lost motion device connects the right wheel cable drum to the right crank after a control wheel rotation of 2.9 degrees.

Location

The wheel jam breakout mechanism is between the flight deck floor and the nose gear wheel well. Access is through the MEC, then along the left side of the nose gear wheel well.

Functional Description - Normal Operation

In normal operation, the two force limiters supply the load path for roll control.

Movement of the left wheel cable drum goes through the upper force limiter to move the right cable drum and the right control wheel. The movement also goes through the force transducer to the left crank. The left crank moves the left shaft assembly. It also moves the right crank and the right shaft assembly through the lower force limiter.

Movement of the right wheel cable drum goes through the upper force limiter to move the left cable drum and the left control wheel. The rotation of the left cable drum moves both shaft assemblies in the same manner as above.

Functional Description - Failure Mode

The wheel jam breakout mechanism permits the pilot to continue roll command if either wheel jams or a connection breaks.

If a right control wheel jams, the captain can operate the left wheel after overriding the 50 lb (23 kg) force of the breakout mechanism and the force of the feel and centering mechanism.

If the left control wheel jams, the first officer can operate the right control wheel after overriding only the force of the breakout mechanism. The right lost motion device engages after 2.9 degrees of control wheel movement. The lost motion device then turns the right shaft assembly.

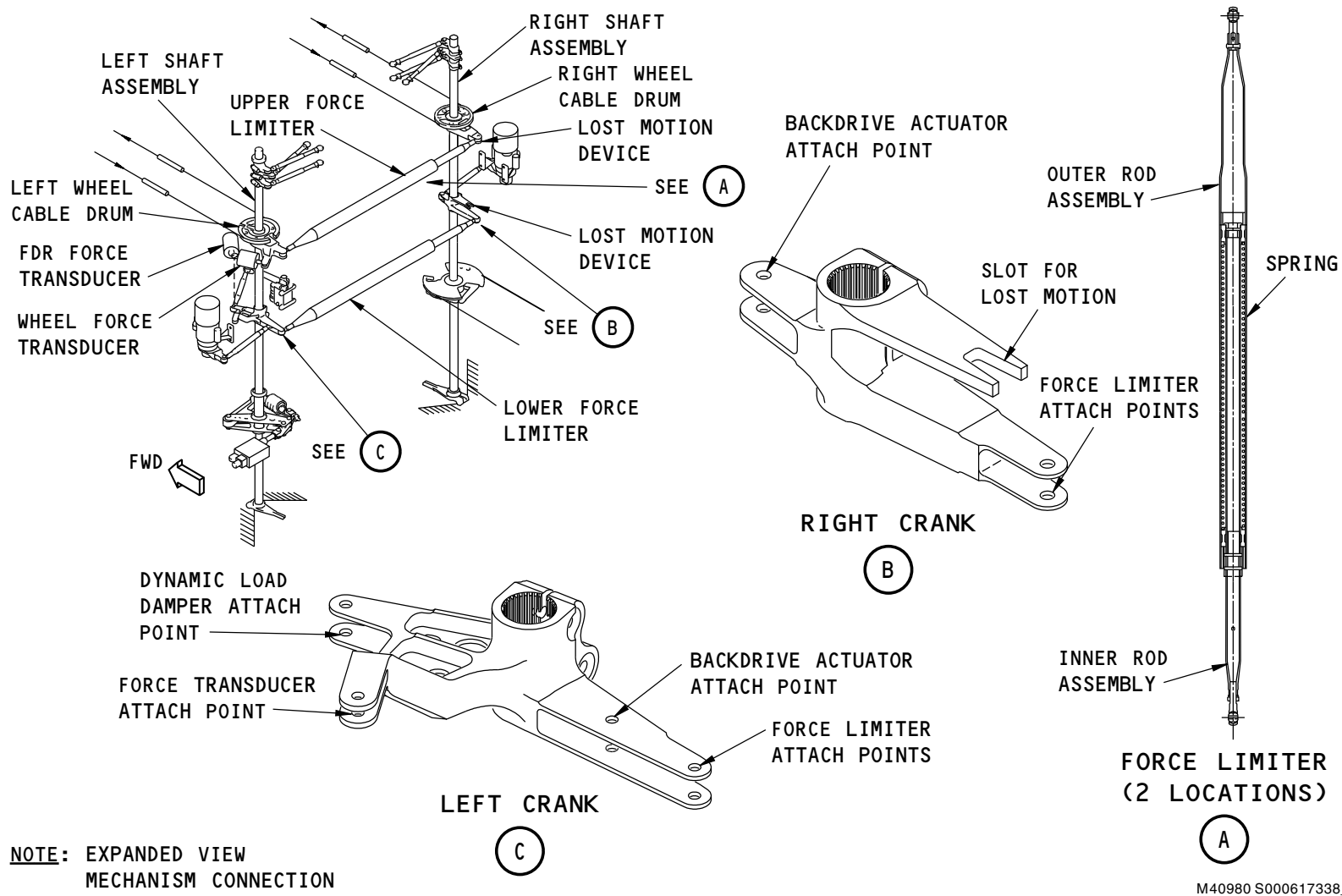
If a control cable breaks between the control wheel and the cable drum, the pilot operates the other control wheel to control roll.

If a connection with the force transducer breaks, control roll through the motion device on the right cable drum. The right lost motion device engages after 2.9 degrees of control wheel movement.

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AILERON AND FLAPERON CONTROL - WHEEL JAM BREAKOUT MECHANISM

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AILERON AND FLAPERON CONTROL - WHEEL DAMPER

Purpose

The wheel damper absorbs control wheel vibrations and brings the wheel control system to rest with minimum oscillation.

Physical Description

The wheel damper is an LRU and weighs approximately 1.6 lb (0.7 kg).

The wheel damper is the same as the pedal damper and the two column dampers. There are four of these dampers on the airplane.

The wheel damper is on the structure of the left shaft assembly mechanism. A damper crank and a control rod connect the damper shaft to the left crank. The control rod is not adjustable.

The wheel damper has an input shaft. The wheel damper uses a fluid to absorb vibrations that go to the shaft. A window on the wheel damper shows the position of the fluid level indicator.

The damper crank, on the damper shaft, has a pair of rivets. These shear out in case of a jam of the wheel damper.

Location

The wheel damper is on the mechanism of the left shaft assembly, between the flight deck floor and the left side of the nose gear wheel well. Access is through the MEC, then along the left side of the nose gear wheel well.

Functional Description

As the left shaft assembly turns, it turns the shaft of the wheel damper which absorbs the vibration of the wheel control system. The wheel damper adds a small force to the wheel control system.

Training Information Point

Put a pin through the inspection hole in the damper crank to check the rivet condition.

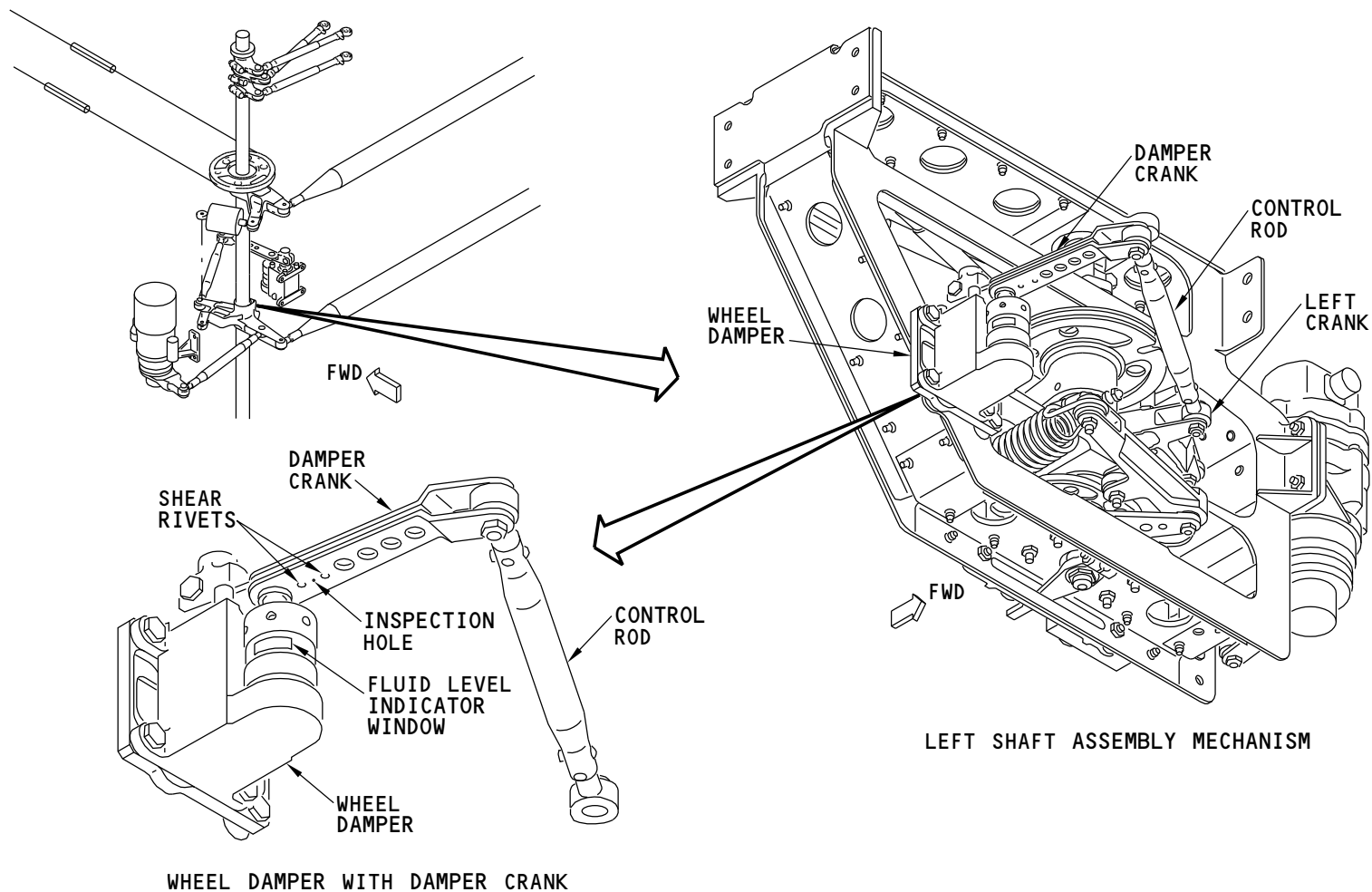
If the fluid level indicator shows a green band width of 1/16 inch or less, the fluid level is low. Then it is necessary to replace the wheel damper.

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AILERON AND FLAPERON CONTROL - WHEEL DAMPER

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AILERON AND FLAPERON CONTROL - AILERON FEEL AND CENTERING MECHANISM

Purpose

The aileron feel and centering mechanism supplies feel and centering forces to the aileron and flaperon control system. The aileron trim actuator supplies aileron trim control. The aileron trim moves the neutral position of the ailerons, the flaperons and the control wheels.

Physical Description

The aileron feel and centering mechanism consists of a single cam and roller unit. The cam attaches by a spline to the left shaft assembly and turns with it. The follower assembly has a roller which rolls on the cam surface. Two cranks hold the follower assembly. The cranks are bearing mounted on the left shaft assembly. A fitting attaches the two cranks together and to the trim actuator rod end. Two extension springs, between the fitting and the follower assembly, keep the roller on the cam.

The aileron trim actuator is a line replaceable unit (LRU). It is a 28v dc electrical, fixed rate motor which moves a non-reversible acme screw. The actuator attaches to the structure. The rod end of the actuator connects to the fitting of the feel and centering assembly.

Location

The aileron feel and centering mechanism is at the bottom of the left shaft assembly, between the flight deck floor and the nose gear wheel well. Access is through the MEC, then along the left side of the nose gear wheel well.

Functional Description

As the left shaft assembly and cam turn, the cam follower moves, which extends the two extension springs. The springs supply a feel force to the control wheels. The feel force varies from 5 lb (2 kg) to a maximum of 14 lb (6 kg) at 65 degrees of control wheel travel.

When the pilots release the control wheels, the springs force the cam follower back to the cam detent. This returns the system to the neutral trimmed position. The neutral, or zero feel force position, changes with trim input.

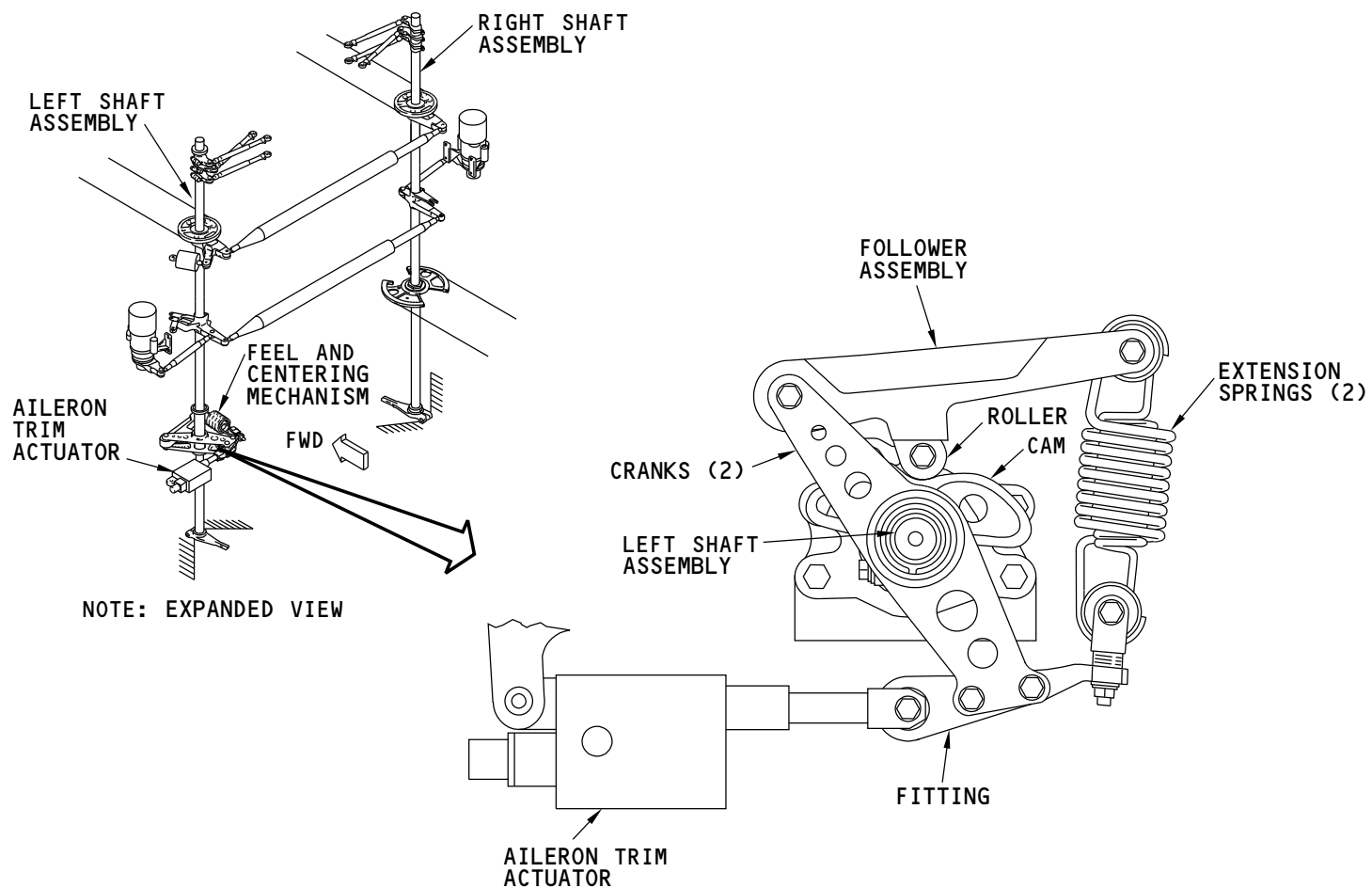
During trim operation, the aileron trim actuator moves the fitting assembly and cranks, which then move the cam follower assembly. Since the extension springs keep the cam follower in the cam detent, the trim actuator causes the cam and the left shaft assembly to turn. This also turns the right shaft assembly, the control wheels and the control wheel position transducers. The control wheels are backdriven and the ailerons and flaperons move.

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AILERON AND FLAPERON CONTROL - AILERON FEEL AND CENTERING MECHANISM

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**AILERON AND FLAPERON CONTROL - AILERON TRIM****Purpose**

The pilots use the aileron trim switches to adjust the trim of the airplane about the longitudinal axis.

Location

Dual aileron trim switches are on the aft end of the P8 aft aisle stand. The aileron trim indicator placards are on top of each control column.

Functional Description

The pilot controls the roll trim with the two aileron trim switches. The switches command the aileron trim actuator. One switch does the arm function and the other does the control function. The pilot must operate both switches at the same time to supply power to the trim actuator.

The electrical load management system (ELMS) controls the electrical power to the aileron trim switches through the aileron trim inhibit relay. The ELMS receives wheel backdrive actuator engagement signals from the AFDCs.

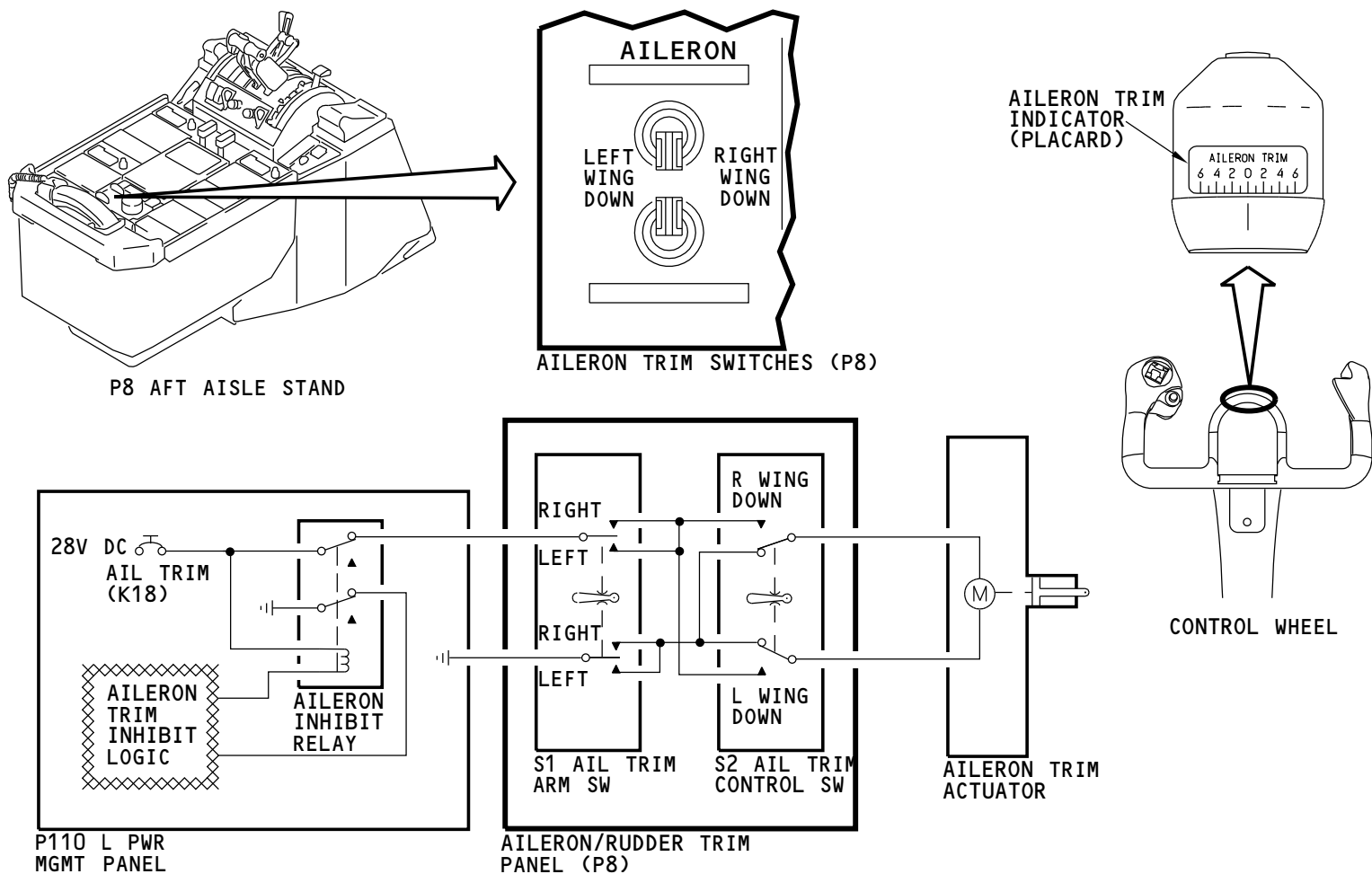
When none of the wheel backdrive actuators is engaged, ELMS keeps the aileron trim inhibit relay deenergized. Electrical power then goes to the aileron trim switches. The arm switch supplies electrical power and motor ground to the control switch which then supplies the direction of the motor rotation.

When one or both wheel backdrive actuator is engaged, the ELMS energizes the aileron trim inhibit relay which stops power to the aileron trim switches. This prevents the operation of the aileron trim during autopilot operation and bank angle protection (BAP) activation.

The aileron trim actuator moves the control wheels at a rate of 2.6 degrees per second. The roll trim authority is 30 degrees of control wheel rotation in both directions.

The aileron trim indicator placards show the amount of trim in units. Each unit indicates 5 degrees of control wheel rotation.

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AILERON AND FLAPERON CONTROL - AILERON TRIM

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**AILERON AND FLAPERON CONTROL - WHEEL POSITION TRANSDUCERS****Purpose**

The six wheel position transducers measure the position of the control wheels. The transducers send analog electrical signals to the ACEs.

Physical Description

Each wheel position transducer is an LVDT. The ACEs supply 7v ac, 1800 Hz excitation power.

The six wheel position transducers are identical to the six column position transducers, the four pedal position transducers, and the rudder trim position transducer.

Three wheel position transducers are on the right shaft assembly and three are on the left shaft assembly. The position transducers attach at one end to the lateral control support bracket assembly. They attach to the transducer crank at the other end.

Each transducer crank attaches to its shaft assembly with a spline. The spline has a missing tooth to help locate the crank on the shaft. Each transducer crank has two shear rivets to allow override of a jammed position transducer.

Each position transducer has an electrical cable which connects to the ACE connector bracket. This bracket has three receptacles, one for each position transducer. Each receptacle is identified by a placard. The order in which each position transducer connects to the receptacles of the connector bracket determines the transducer-to-ACE relationship.

Location

The six wheel position transducers are between the flight deck floor and the nose gear wheel well. Access is by the access hatch of the MEC, then along the left side of the nose gear wheel well.

Functional Description

When the right and left shaft assemblies turn in response to a control wheel input, the control wheel position transducers extend or retract. Each position transducer sends an analog electrical signal to one ACE.

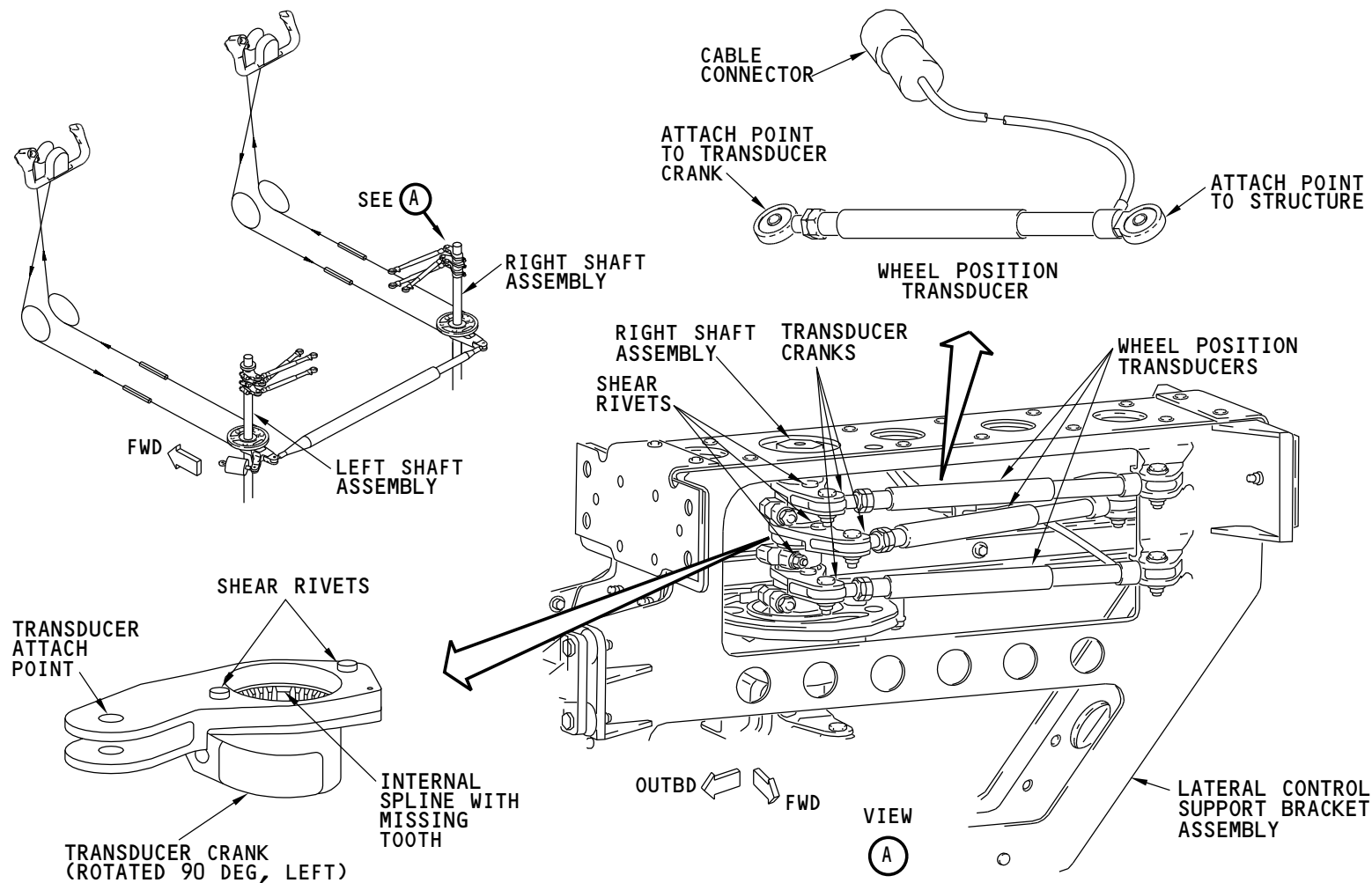
Indications

The status message CONTROL WHEEL XDCR shows when one of the wheel position transducers is defective. When two or more wheel position transducers are defective, the status message FLIGHT CONTROL SYS shows.

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AILERON AND FLAPERON CONTROL - WHEEL POSITION TRANSDUCERS

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**AILERON AND FLAPERON CONTROL - WHEEL FORCE TRANSDUCER****Purpose**

The wheel force transducer measures the total force from the captain and the first officer to the control wheels. The wheel force transducer sends analog electrical signals to the ACEs. The PFCs use these signals for the bank angle protection function.

Physical Description

The wheel force transducer is a spring with two electrically isolated LVDTs inside. The ACEs supply 7v ac, 1800 Hz excitation power.

The wheel force transducer is different from the two elevator force transducers.

The wheel force transducer attaches to the wheel left cable drum and to the left crank of the left shaft assembly.

Each LVDT has a separate cable which connects to the ACE connector bracket. This bracket has two receptacles, one for each LVDT of the force transducer. The order in which each LVDT connects to the connector bracket determines the interface of the LVDT with the ACE.

Location

The wheel force transducer is on the left shaft assembly, between the flight deck floor and the nose gear wheel well. Access is through the MEC, then along the left side of the nose gear wheel well.

Functional Description

When the pilot applies a force to the control wheel, the wheel force transducer spring extends or compresses. The LVDTs measure the spring movement.

The signal from one LVDT goes to the L2 ACE, and the other to the C ACE.

Indications

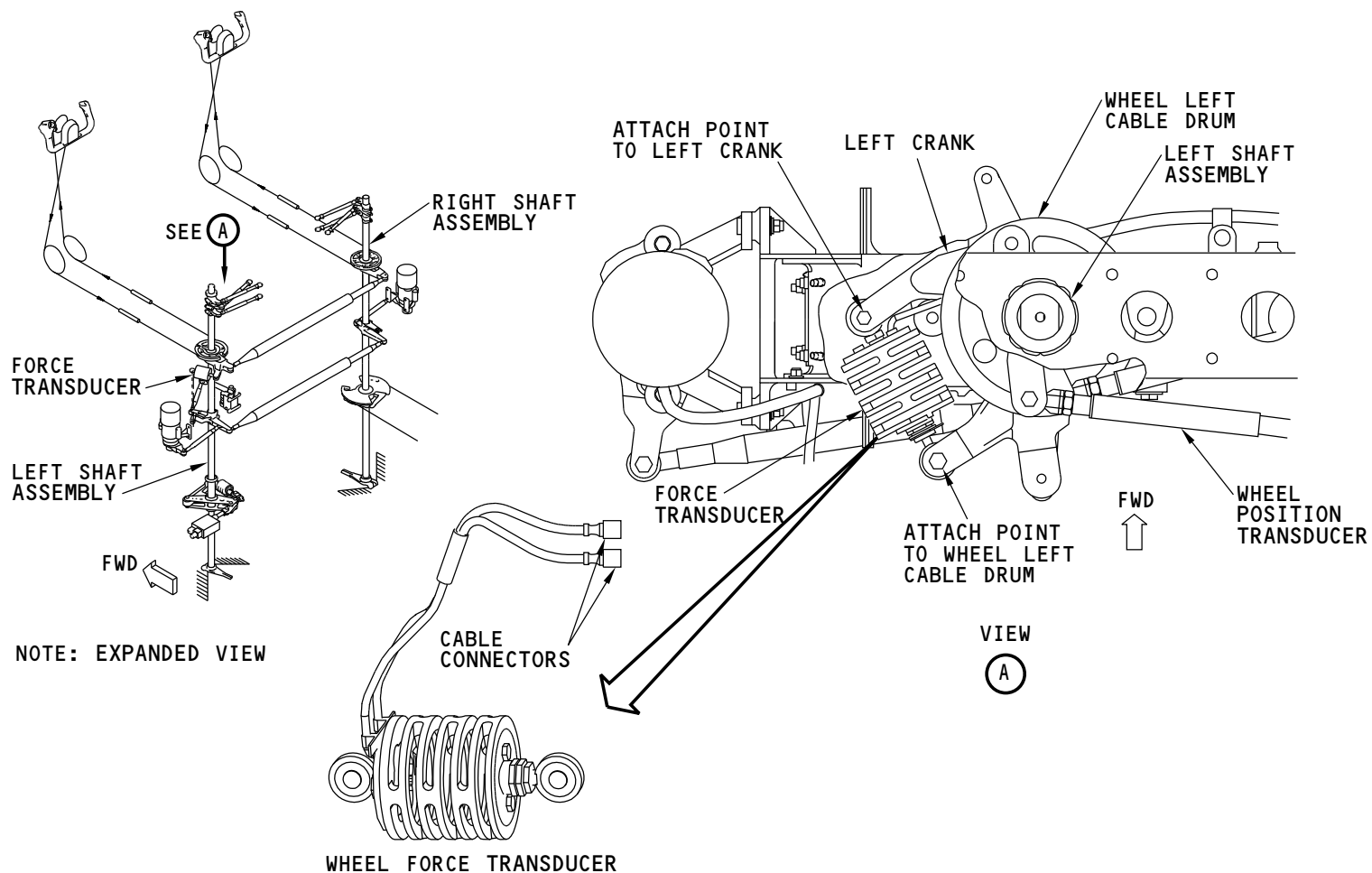
When both LVDTs of the wheel force transducer fail, the status message BANK ANGLE PROTECT shows.

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AILERON AND FLAPERON CONTROL - WHEEL FORCE TRANSDUCER

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**AILERON AND FLAPERON CONTROL - AILERON PCU - LOCATION****Purpose**

The aileron PCUs move the ailerons. Electrical command signals from the ACEs operate the aileron PCUs. Each aileron has two PCUs.

Location

The two PCUs are outboard on the wing rear spar. Access to the PCUs is by two hinged panels on the lower wing.

The kick link connects the PCU to the rear spar fittings. The actuator rod connects to the aileron at the aileron surface attach fitting. The reaction link connects to the aileron at the aileron attach fitting at the hinge line.

Two electrical connectors of different sizes connect to the upper side of the PCU.

Hydraulic tubing connects to ports, one on each side of the PCU. This tubing has fuses and check valves to help prevent the loss of hydraulic fluid if there is damage to the PCUs or hydraulic tubing. The fuses and check valves in the left hydraulic system are inboard of spoilers 1 and 14 in each wing. The fuses and check valves in the center hydraulic system are outboard of spoilers 1 and 14 in each wing.

Training Information Point

Removal and installation of the aileron PCU is in one assembly with the reaction link and the kick link.

To move the actuator for maintenance, depressurize the hydraulic systems. You get access to the manual bypass on the under side of the PCU. Turn the manual bypass to the bypass position while moving the aileron. After release of the manual bypass, it closes.

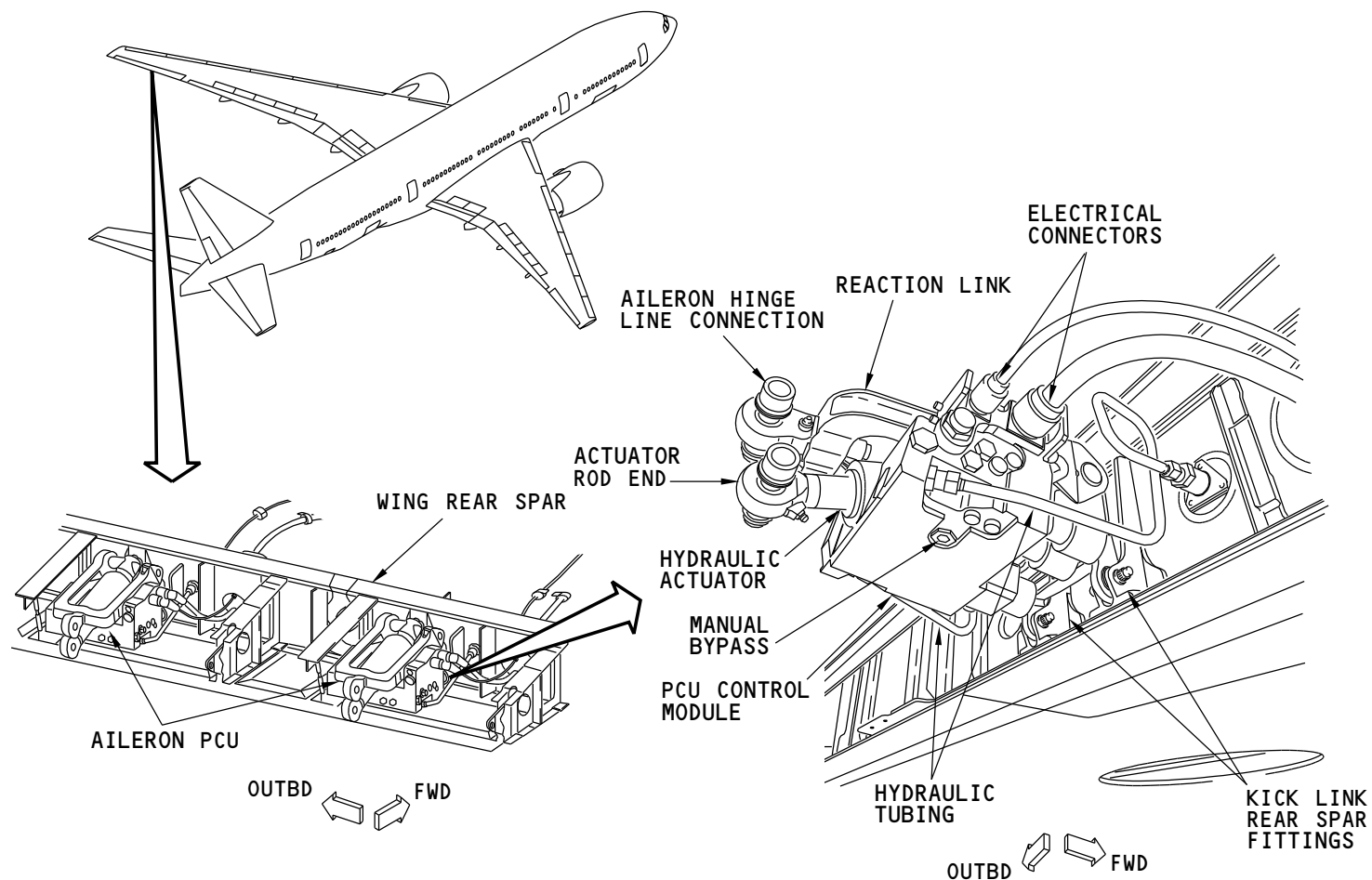
During installation of the aileron PCU, it is necessary to adjust the actuator null LVDT. Remove the LVDT access cover to adjust the LVDT.

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AILERON AND FLAPERON CONTROL - AILERON PCU - LOCATION

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AILERON AND FLAPERON CONTROL - AILERON PCU - PHYSICAL DESCRIPTION

Physical Description

All four aileron PCUs are identical. Each aileron PCU, with its reaction link and kick link, weighs about 38 lb (17 kg).

The aileron PCU contains a hydraulic actuator with a control module. The control module contains:

- An electrohydraulic servo valve (EHSV)
- A bypass solenoid valve
- A blocking solenoid valve
- A mode selector valve
- An extension check and relief valve with manual bypass
- Two bypass check valves
- Two anti-cavitation check valves
- A thermal relief valve
- A compensator/relief valve
- An inlet check valve
- An inlet filter.

Hydraulic Actuator

The actuator piston has an LVDT that sends actuator position feedback signals to the ACE. The actuator piston also has a null LVDT to adjust the null position of the actuator piston LVDT during adjustment of the control surface.

EHSV

The EHSV controls the hydraulic power to the extend and retract sides of the actuator. The EHSV has an LVDT that sends EHSV position feedback signals to the ACE.

Bypass Solenoid Valve

The bypass solenoid valve controls the pilot pressure from the hydraulic system to the mode selector valve and the extension check and relief valve.

Blocking Solenoid Valve

The blocking solenoid valve controls the pilot pressure from the actuator to the mode selector valve and the extension check and relief valve.

Mode Selector Valve

Pilot pressure from the bypass or blocking solenoid valves commands the mode selector valve in one of three positions:

- Normal
- Bypass
- Blocking/Damped.

Extension Check and Relief Valve with Manual Bypass

The extension check and relief valve opens when the PCU is in normal mode. It also opens in bypass mode by the pilot pressure trapped between the bypass check valves and the thermal relief valve.

The extension check and relief valve has a manual bypass. The manual bypass permits the actuator to extend manually for maintenance.

Bypass Check Valves

The two bypass check valves permit pressure from either side of the actuator to reach the blocking solenoid valve.

Anti-cavitation Check Valves

The two anti-cavitation check valves permit return fluid from the compensator/relief valve to flow to the actuator. This prevents cavitation of the actuator during rapid backdrive of the PCU.

Thermal Relief Valve

The thermal relief valve protects the actuator from thermal expansion of the hydraulic fluid.

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**AILERON AND FLAPERON CONTROL - AILERON PCU - PHYSICAL DESCRIPTION****Compensator/Relief Valve**

The compensator/relief valve holds a small quantity of fluid above hydraulic system return pressure. This fluid is available to the actuator to prevent cavitation.

Inlet Check Valve

The inlet check valve keeps the hydraulic fluid in the actuator when the hydraulic system power is lost.

Inlet Filter

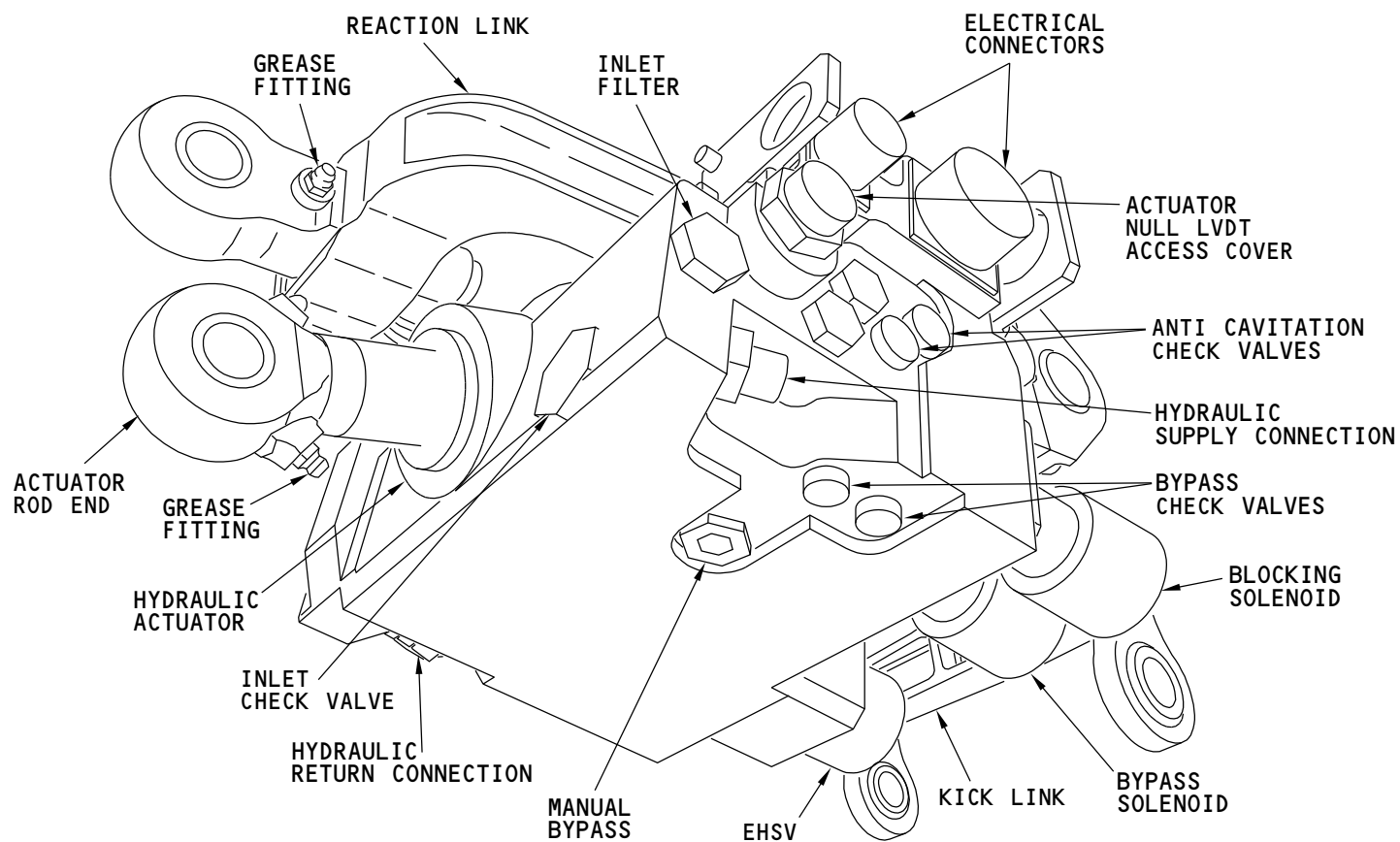
The inlet filter protects the actuator from solids in the hydraulic fluid.

Training Information Point

Only the bearings in the actuator rod end and the reaction link, where they attach to the aileron, require lubrication.

All the other bearings at the kick link and the reaction link are teflon coated bearings. They do not require lubrication.

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AILERON AND FLAPERON CONTROL - AILERON PCU - PHYSICAL DESCRIPTION

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AILERON AND FLAPERON CONTROL - AILERON PCU - FUNCTIONAL DESCRIPTION

General

The aileron PCU operates in three different modes:

- Normal
- Bypass
- Blocking/Damped.

In the normal mode, the ACE energizes both the bypass and blocking solenoids with flight below cruise speed. Above cruise speed, the ACE de-energizes the blocking solenoid.

In the bypass mode, the ACE de-energizes the bypass solenoid.

In the blocking/damped mode, the ACE de-energizes both the bypass and the blocking solenoids.

PCU Operational Matrix

The table below shows the various conditions of the PCU valves in the three modes of operation.

SOLENOID CONDITIONS	PCU MODES OF OPERATION		
	NORMAL	BYPASS	BLOCKING/DAMPED
BYPASS SOLENOID	E*[1]	D*[2]	D*[2]
BLOCKING SOLENOID	*[1]E/D*[2]	E*[1]	D*[2]

*[1] E = ENERGIZED

*[2] D = DE-ENERGIZED

Normal Mode

During operation below cruise speed, the PCU is in normal mode when the ACE energizes both the bypass and the blocking solenoid valves.

Hydraulic system pressure moves the mode selector valve to the normal position and opens the extension check and relief valve. Under these conditions, an electrical command to the EHSV results in the actuator extension or retraction.

Aileron Lockout

With flight at or above cruise speed, the PFCs command, through the ACEs, the ailerons to fair and to lock out. The ACEs energize the bypass solenoid valve but de-energize the blocking solenoid valve of all the aileron PCUs. The PCUs are in normal mode. The PFC command signals to the EHSV keep the ailerons in the faired position.

Bypass Mode

The PCU is in the bypass mode when the ACE de-energizes the bypass solenoid valve and energizes the blocking solenoid valve. This happens when there is a single hydraulic or electrical failure on the PCU.

The bypass solenoid valve blocks hydraulic pressure to the mode selector valve. However, pressure trapped between the bypass check valves and the thermal relief valve moves the mode selector valve to the bypass position. This pressure also keeps the extension check and relief valve open.

Under these conditions, the mode selector valve blocks control pressure from the EHSV to the actuator cylinder. It also allows free hydraulic flow between both sides of the piston on the failed PCU. The adjacent PCU controls the aileron movement and backdrives the failed PCU.

During rapid backdrive of the failed PCU, the compensator/relief valve supplies fluid to the actuator through the anti-cavitation check valves.

If there is a subsequent failure on the adjacent PCU, its ACE de-energizes its bypass solenoid valve. With both PCUs in the bypass mode, the airloads cause the aileron trailing edge to move up approximately 15 degrees from the faired (neutral) position.

Blocking/Damped Mode

The PCU is in the blocking/damped mode when the ACEs de-energize both the bypass and the blocking solenoid valves. This happens when the PCU has no power or the PCU has a failure at or above cruise speed.

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**AILERON AND FLAPERON CONTROL - AILERON PCU - FUNCTIONAL DESCRIPTION**

In the blocking/damped mode, there is no hydraulic pressure on the mode selector valve. Its internal spring moves the valve to the blocking/damped position. The mode selector valve blocks control pressure from the EHSV to the actuator cylinder. It also connects both sides of the actuator through a restriction. Also, the extension check and relief valve closes.

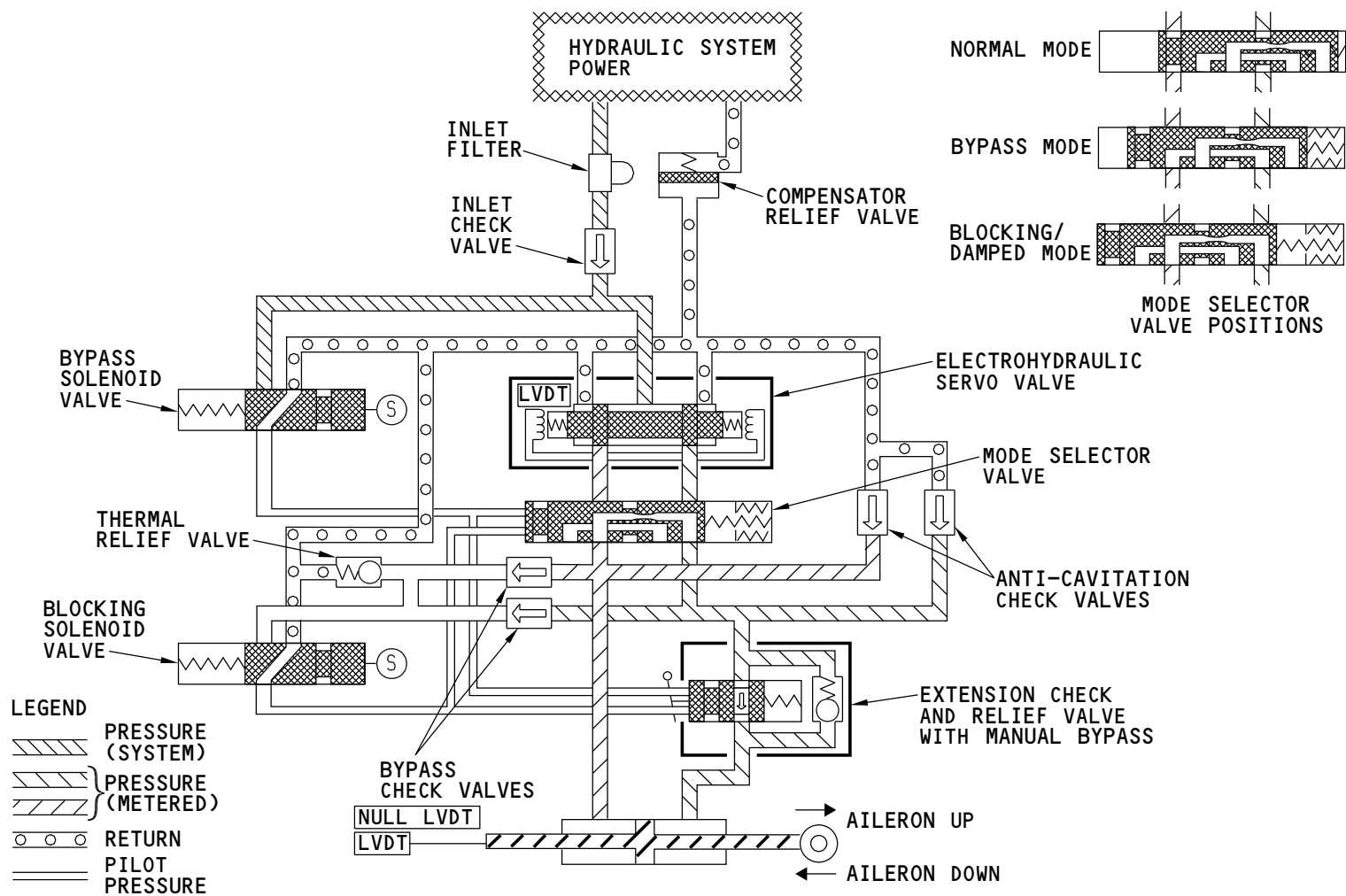
Under these conditions, the actuator cannot extend but can retract very slowly.

During flight at or above cruise speed, when both PCUs of an aileron are in the blocking/damped mode, the closed extension check and relief valve prevents the aileron upward movement caused by aerodynamic lift.

On the ground, with no electrical or hydraulic power on the aileron PCUs, the PCUs are in the blocking/damped mode. The ailerons cannot move up but can move down. Turn the manual bypass to move the ailerons and the PCUs in the up direction.

Indications

The status message AILERON ACTUATOR shows on the status display when one of the aileron actuators is failed. The status message FLIGHT CONTROL SYS shows on the status display when more than one aileron actuator is failed or the actuator confidence test has failed.



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AILERON AND FLAPERON CONTROL - AILERON PCU - FUNCTIONAL DESCRIPTION

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**AILERON AND FLAPERON CONTROL - FLAPERON PCU - LOCATION****Purpose**

The flaperon PCUs move the flaperons. Electrical command signals from the ACEs actuate the flaperon PCUs. Each flaperon has two PCUs.

Location

The two PCUs are on the rear spar of the inboard wing. Access to the PCUs is by a removable lower skin panel below each PCU.

The head end bearing assembly connects the PCU to the rear spar structural fitting. The actuator rod connects to the flaperon surface fitting.

One electrical connector connects to the PCU.

Hydraulic tubing connects to ports near the forward end of the PCU. The hydraulic tubing from these hoses have fuses and check valves to help prevent the loss of hydraulic fluid if there is damage to the PCUs or hydraulic tubing caused by the loss of a flaperon. The hydraulic fuses and check valves for the left and right hydraulic system are near the left flaperon. The fuse and check valve for the center hydraulic system are near the right flaperon.

Training Information Point

The head end bearing assembly stays in place when you remove and install the flaperon PCU.

Installation of the PCUs is with the control modules facing each other. One PCU is up-side-down in relation to its adjacent PCU.

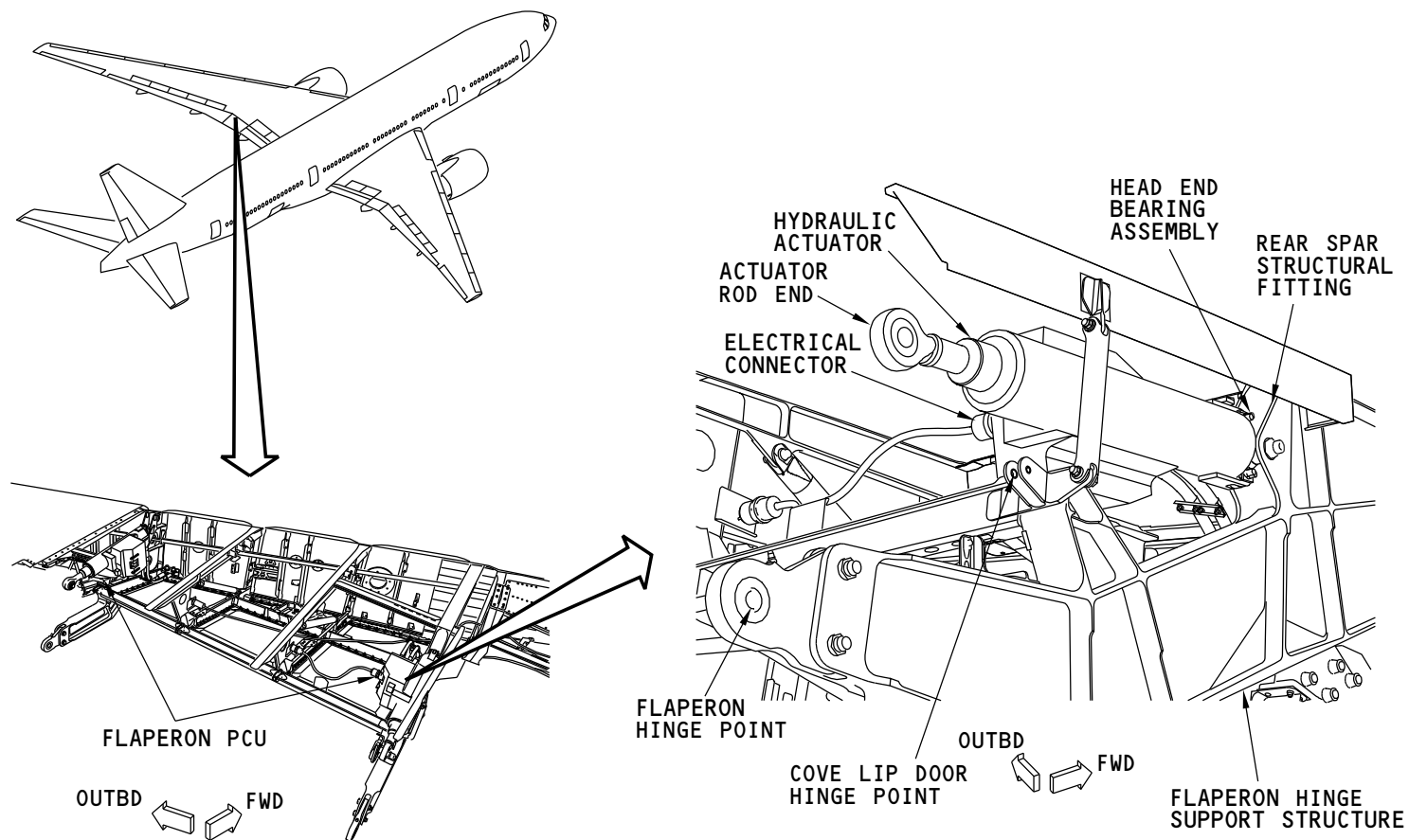
During the adjustment of the flaperon surface, it is necessary to adjust the actuator null LVDT. Remove the LVDT access cover to adjust the LVDT.

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AILERON AND FLAPERON CONTROL - FLAPERON PCU - LOCATION

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AILERON AND FLAPERON CONTROL - FLAPERON PCU - PHYSICAL DESCRIPTION

Physical Description

All four flaperon PCUs are identical. Each flaperon PCU weighs approximately 43 lb (19 kg).

The flaperon PCU contains a hydraulic actuator with a control module. The control module contains:

- An electrohydraulic servo valve (EHSV)
- A bypass solenoid valve
- A mode selector valve
- A differential pressure sensor
- Two relief valves
- An inlet check valve
- An inlet filter.

Hydraulic Actuator

The actuator piston has an LVDT that sends position feedback signals to the ACE. The actuator piston also has a null LVDT to adjust the null position of the actuator during adjustment of the flaperon surface.

EHSV

The EHSV controls the hydraulic power to the extend and retract sides of the actuator. The EHSV has an LVDT that sends EHSV position feedback signals to the ACE.

Bypass Solenoid Valve

The bypass solenoid valve controls the pilot pressure from the hydraulic system to the mode selector valve.

Mode Selector Valve

Pilot pressure from the bypass solenoid valve commands the mode selector valve in one of two positions:

- Normal

- Bypass.

Differential Pressure Sensor

The differential pressure sensor measures the pressure difference across the actuator piston. The sensor operates an LVDT which sends signals to the ACE.

Relief Valves

The two relief valves protect the actuator from high pressure due to thermal effects or excessive loading conditions.

Inlet Check Valve

The inlet check valves keeps the hydraulic fluid in the actuator when the hydraulic system experiences pressure fluctuations due to system demands.

Inlet Filter

The inlet filter protects the actuator from solids in the hydraulic fluid.

Training Information Point

Only the bearing in the actuator rod end, where it attaches to the flaperon, requires lubrication.

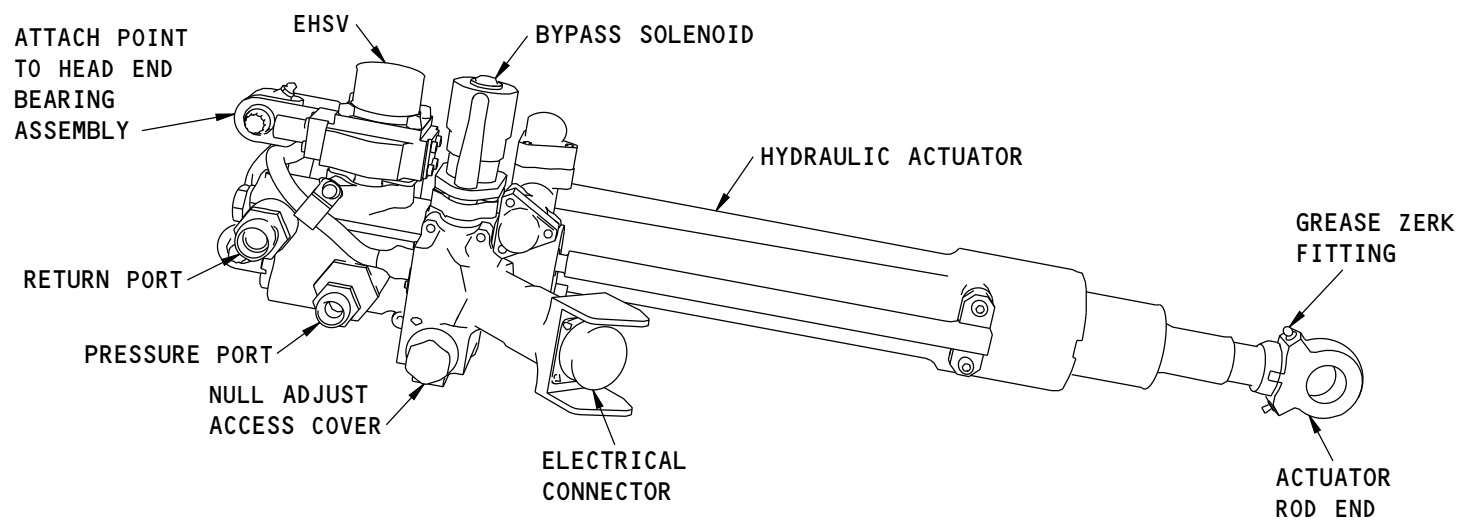
All the other bearings are teflon coated. They do not require lubrication.

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AILERON AND FLAPERON CONTROL - FLAPERON PCU - PHYSICAL DESCRIPTION

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AILERON AND FLAPERON CONTROL - FLAPERON PCU - FUNCTIONAL DESCRIPTION

General

The flaperon PCU operates in two different modes:

- Normal
- Bypass.

In normal mode, the ACE energizes the bypass solenoid valve.

In bypass mode, the ACE de-energizes the bypass solenoid valve.

PCU Operational Matrix

The table below shows the conditions of the PCU bypass valve in the two modes of operation.

VALVE CONDITIONS	PCU MODES OF OPERATION	
	NORMAL	BYPASS
BYPASS SOLENOID	E*[1]	D*[2]

*[1] E = ENERGIZED

*[2] D = DE-ENERGIZED

Normal Mode

The PCU is in normal mode when the ACE energizes the bypass solenoid valve.

Hydraulic system pressure moves the mode selector valve to the normal position. Under these conditions, an electrical command from the ACE to the EHSV results in the actuator extension or retraction.

Bypass Mode

The PCU is in bypass mode when the ACE de-energizes the bypass solenoid. This happens when there is a single hydraulic or electrical failure on the PCU.

The bypass solenoid valve blocks pressure to the mode selector valve which moves to the bypass position.

Under these conditions, the mode selector valve blocks control pressure from the EHSV to the actuator cylinder. It also permits free hydraulic flow between both sides of the failed PCU and the return line. The adjacent PCU controls the flaperon movement and backdrives the failed PCU.

If both PCUs of the same flaperon are in bypass mode, the flaperon can move freely in both directions. In flight, the airloads then cause the flaperon to move up a maximum of 10 degrees.

When the airplane has no power on the ground, the weight of the flaperon causes it to slowly move down to the actuator stop.

Indications

The EICAS status message ACTUATOR PRESS SNSR shows when the differential pressure sensor on one of the flaperon PCUs is defective. The rudder also uses the same message.

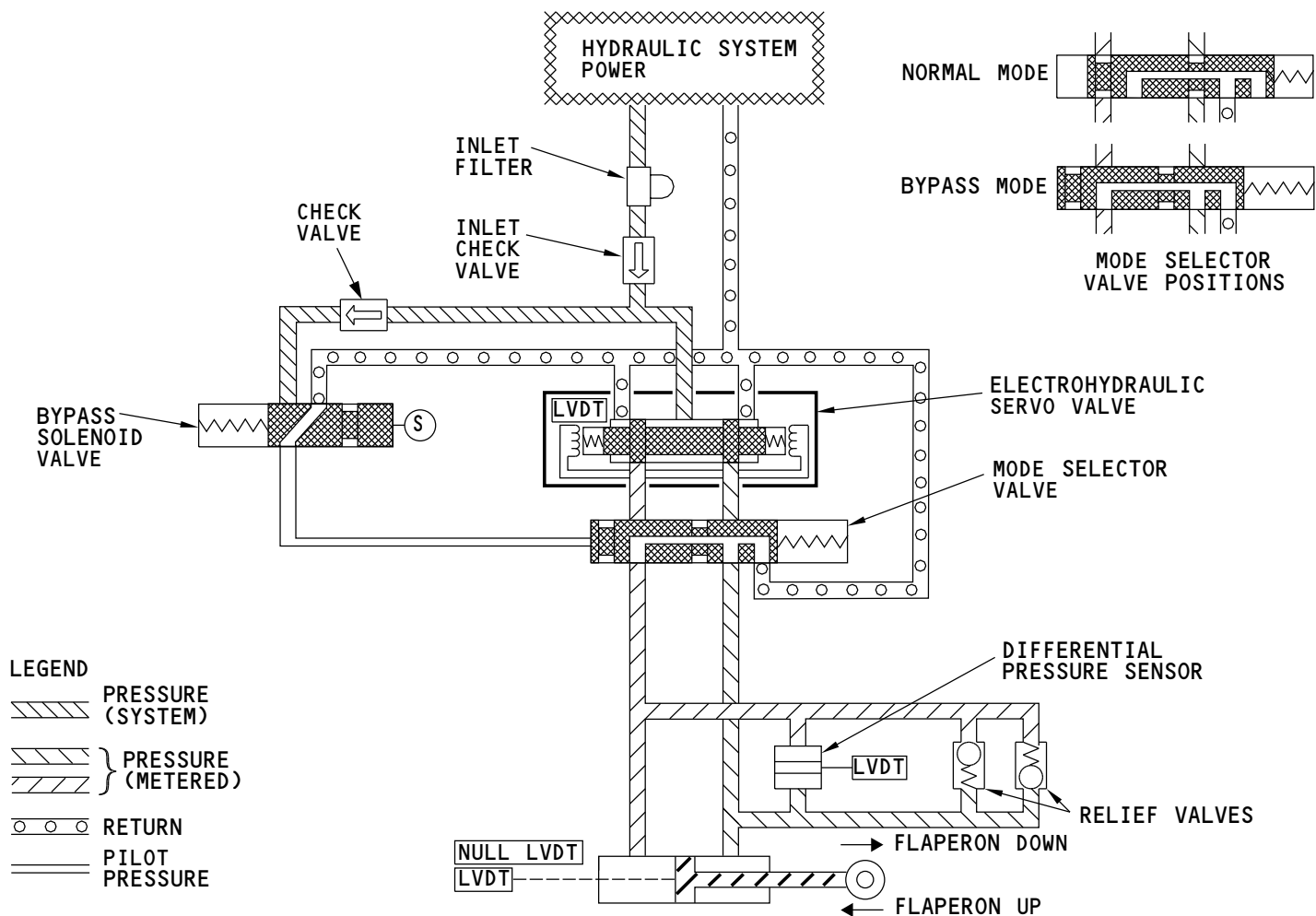
The status message FLAPERON ACTUATOR shows on the status display when one flaperon actuator is failed. The status message FLIGHT CONTROL SYS shows on the status display when more than one flaperon actuator is failed or the actuator confidence test has failed.

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AILERON AND FLAPERON CONTROL - FLAPERON PCU - FUNCTIONAL DESCRIPTION

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AILERON AND FLAPERON CONTROL - AILERON AND FLAPERON PCU - PCU MODES

General

The PFCs and the ACEs control the mode of operation of the aileron PCUs. The ACEs control the bypass solenoid of the PCUs. The PFC sends commands to the ACEs to control the blocking solenoids in Normal mode and Secondary mode.

The ACEs control the mode of operation of the flaperon PCUs.

Aileron PCU Modes

The aileron PCU has three modes:

- Normal
- Bypass
- Blocking/Damped.

The aileron PCU is in the normal mode when there is no failure in the PCU and there is no failure in its on-side ACE. In the normal mode, the ACE energizes the bypass and blocking solenoids below cruise speed. At or above cruise speed, the ailerons are locked out. The ACEs keep the bypass solenoid energized but the PFCs send a command to de-energize the blocking solenoid on all the PCUs. The PCUs are still in the normal mode.

The aileron PCU is in the bypass mode when there is an electrical or hydraulic failure with the PCU or its ACE during flight below cruise speed. The ACE then de-energizes the bypass solenoid. The adjacent PCU, still in the normal mode, moves the aileron and backdrives the failed PCU. If both PCUs on the same aileron are in the bypass mode during flight, the aerodynamic lift moves the aileron trailing edge by about 15 degrees up from the faired position.

The aileron PCU is in the blocking/damped mode when there is a failure with the PCU or its ACE during flight at or above cruise speed. The ACE de-energizes the bypass solenoid of the PCU. The aileron lock out function of the PFC causes the ACEs to de-energize the blocking solenoid of all the PCUs. Under these conditions, the failed PCU is in the blocking/damped mode while the other PCUs are locked out in the normal mode. If both PCUs on the same aileron are in the blocking/damped mode, the aerodynamic lift cannot move the aileron up.

If there is a loss of the center and left hydraulic system power during the time the ailerons are locked out, the PFCs send a command signal to the ACEs to keep the blocking solenoids de-energized. All the ailerons PCUs stay in the blocking/damped mode. This prevents the sudden aileron upfloat and undesired roll of the airplane when the ailerons unlock later in the flight.

On the ground, with no electrical or hydraulic power on the aileron PCUs, the PCUs are in the blocking/damped mode. The aileron cannot move up but it can move down with an outside force.

Flaperon PCU Modes

The flaperon PCUs operate in two modes:

- Normal
- Bypass.

The flaperon PCU is in the normal mode when there is no failure in the PCU or its ACE. The ACE then energizes the bypass solenoid.

The flaperon PCU is in the bypass mode when there is an electrical or hydraulic failure with the PCU or its ACE. The ACE then de-energizes the bypass solenoid. If both PCUs on a flaperon are in the bypass mode, the flaperon can move freely. In flight, the aerodynamic lift then causes the flaperon to move 10 degrees up from the faired position.

When the airplane is on the ground with airspeed less than 85 knots and at least one engine running near takeoff thrust, the flaperon bypass logic of the PFC normal mode operates. This function sends a command signal to the ACEs to put all the flaperon PCUs in the bypass mode. At low airspeed, the weight of the flaperon causes the flaperons to droop. Also, the flaperons can possibly flutter. As the airspeed increases, the airloads gradually float the flaperons to the neutral position.

When the airspeed is approximately 100 knots, the PFCs send a command signal to the ACEs to put all the flaperon PCUs in the normal mode. The PFCs then send commands to the ACEs to gradually move the flaperons to the drooped position.

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AILERON AND FLAPERON CONTROL - AILERON AND FLAPERON PCU - PCU MODES

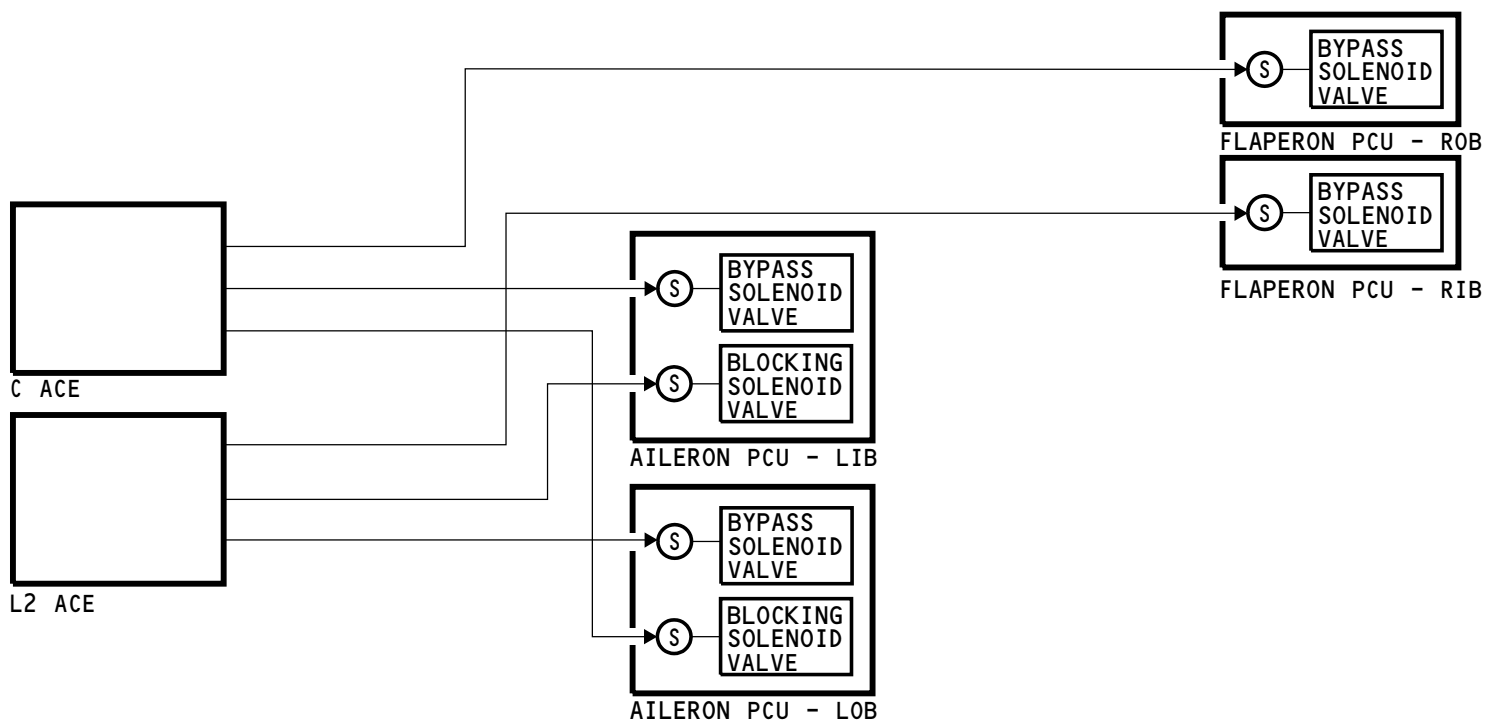
Training Information Point

During an engine test run on the ground with thrust near takeoff level, the flaperon behind the engine can possibly flutter. This is a usual condition.

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AILERON AND FLAPERON CONTROL - AILERON AND FLAPERON PCU - PCU MODES

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**AILERON AND FLAPERON CONTROL - AILERON SURFACES****Purpose**

The ailerons have two purposes. The ailerons supply low speed roll control of the airplane. The flaperons and the flight spoilers help this function. Ailerons also move down (droop) to supplement the high lift system.

Physical Description

The ailerons are light weight composite materials structures. The skin is reinforced graphite/epoxy bonded to a core of Nomex honeycomb. The overall dimensions are approximately 27 in by 259 in (0.7 m x 6.6 m). Each aileron weighs 165 lb (75 kg).

Two adjustable tungsten balance weights prevent flutter if hydraulic power is lost. The aileron attaches to the outboard rear spar with 6 hinges. Jumpers and static dischargers supply electrostatic protection to airplane systems.

Functional Description

The aileron surface deflection limits are at the PCU internal stops. The ailerons have a maximum movement of 33 degrees trailing edge up (TEU) and 19 degrees trailing edge down (TED) for conditions without loads. You measure the aileron movement in relation to the wing fixed trailing edge.

When there are loads, the maximum PFC and ACE command signals move the ailerons to a nominal position of 30 degrees TEU and 15 degrees TED. Aileron trim authority is 30 degrees of control wheel rotation. You adjust the aileron PCUs on the ground so the aileron control surfaces are about 2 degrees below the wing fixed trailing edge.

Training Information Point

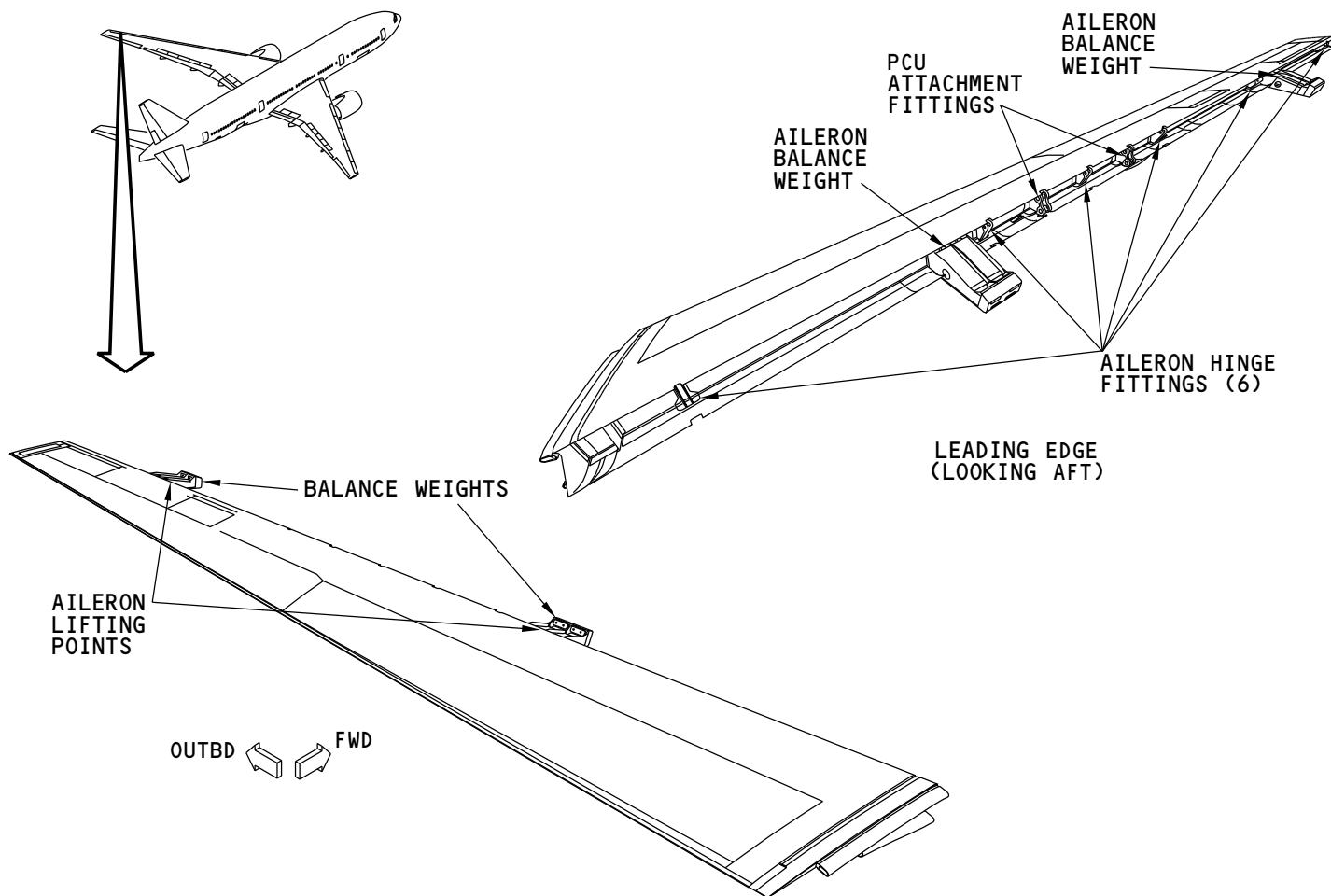
Two hoist attach points are on the upper surface of the aileron front spar for aileron removal and installation.

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AILERON AND FLAPERON CONTROL - AILERON SURFACES

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AILERON AND FLAPERON CONTROL - FLAPERON SURFACES

Purpose

The flaperons have a dual purpose on the 777 airplane. First, flaperons supply roll control of the airplane, assisted by the ailerons and the flight spoilers. Second, flaperons move down (droop) to help the high lift system during takeoff, approach, and landing.

Physical Description

The flaperons are light weight composite materials structures. The skin is carbon fiber reinforced plastic bonded to a core of Nomex honeycomb. The overall dimensions are approximately 62 in by 95 in (1.6 m x 2.4 m). Each flaperon weighs about 110 lb (50 kg).

The flaperon attaches to the airplane structure with 2 hinges. An aluminum strip diverts lightning strikes on the flaperon trailing edge.

A cove lip door at the leading edge of the flaperon supplies a gap when the flaperon is full down to make aerodynamic performance better. The cove lip door attaches to the airplane structure and to the flaperon with two main hinge fittings.

Functional Description

When the flaperon moves down, a mechanical linkage pulls the drive link attachment point of the fitting aft. This rotates the cove lip door up, which supplies a gap along the leading edge of the flaperon.

The flaperon surface deflection limits are at the PCU internal stops. The flaperons have a maximum movement of 11 degrees trailing edge up (TEU) and 37 degrees trailing edge down (TED) for conditions without loads. When there are loads, the maximum PFC and ACE command signals move the flaperons to a nominal position of 10 degrees TEU and 30 degrees TED.

Training Information Point

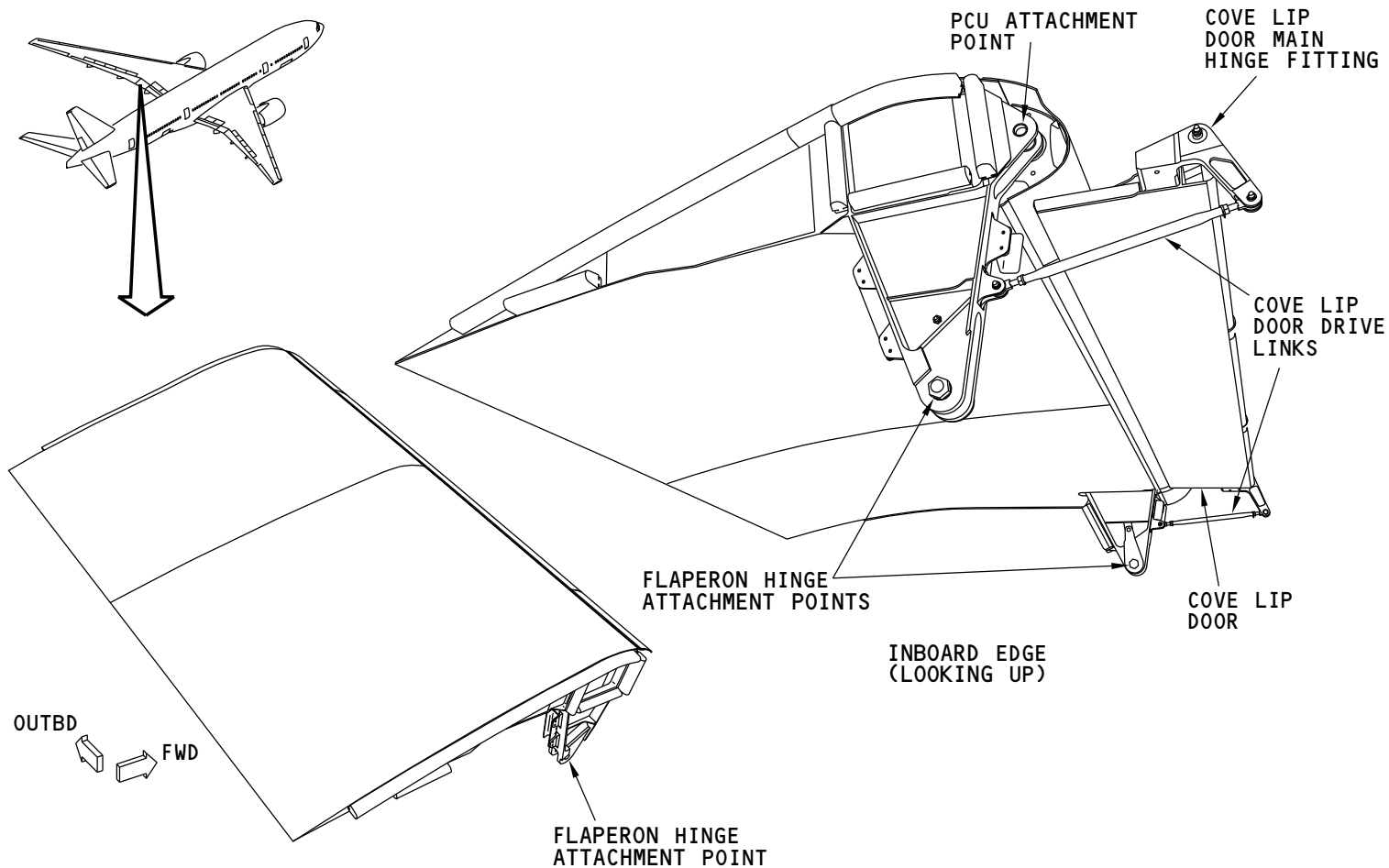
The flaperon PCU attachment fittings supply lifting points for the flaperons.

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AILERON AND FLAPERON CONTROL - FLAPERON SURFACES

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AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION

General

The roll control system for the ailerons and flaperons uses input command signals from the wheel position transducers and the force transducer.

The ACEs receive the input signals and transmit them to the PFCs. The ACEs supply output command signals to the PCUs of the ailerons and the flaperons.

Wheel Position Transducers

The C ACE and R ACE each receive signals from two wheel position transducers. The L1 ACE and L2 ACE each receive signals from one wheel position transducer. After they change the signals to digital format, the ACEs send these signals to the PFCs.

Each PFC receives input signals from all six wheel position transducers. These signals come from the ACEs through the flight controls ARINC 629 buses. Each PFC selects which signal to process by mid-value selection and averaging.

Force Transducers

The two LVDTs of the wheel force transducer send signals to the L2 ACE and the C ACE. The ACEs transmit these signals to their on-side PFCs.

Aileron PCUs

Each ACE sends output command signals to the two PCUs of the same aileron. Two output command signals go to the EHSV and the bypass solenoid of one PCU on the assigned aileron. Another output command signal goes to the blocking solenoid of the adjacent PCU on the same aileron. The PCU sends feedback signals to its assigned ACE from:

- The EHSV position LVDT
- The actuator piston position LVDT
- The actuator null LVDT.

Flaperon PCUs

Each ACE sends output command signals to one flaperon PCU. The output command signals go to the EHSV and the bypass solenoid. The PCU sends feedback signals to its assigned ACE from:

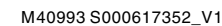
- The EHSV position LVDT
- The differential pressure LVDT
- The actuator piston position LVDT
- The actuator null LVDT.

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**AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP****General**

The ACE contains a servo loop circuit to produce the command signals for the PCUs.

In normal and secondary mode, the PFC sends the command signals to the ACE. In direct mode the ACE calculates the command signals.

Servo Loop Operation

The ACEs use the aileron and flaperon command signals through a servo loop. The command signals then go to the EHSV of the PCUs. The ACEs also use the command signals to monitor for failures.

The movement of the EHSV sends hydraulic pressure to extend or retract the actuator.

The EHSV LVDT measures the movement of the EHSV and supplies a feedback signal to the ACEs. The ACEs use this feedback signal in the failure monitor.

The actuator position LVDT measures the movement of the actuator and supplies a feedback signal to the ACEs through the actuator null LVDT.

The actuator null LVDT is in series with the actuator position LVDT. The actuator null LVDT modifies the signal from the actuator position LVDT.

The actuator position LVDT supplies a feedback signal to the ACEs to close the servo loop. The ACEs use this feedback signal to monitor for failure. The signal also goes to the PFC.

On the flaperon PCUs only, a differential pressure LVDT measures the differential pressure across the actuator piston. The signal from the differential pressure LVDT goes to the ACEs for the servo loop. The signal also goes to the PFCs for force fight equalization.

Failure Monitor

The ACE has a failure monitor to do a check of the correct operation of the PCU. The monitor uses the ACE command signal and the feedback signals from the EHSV LVDT and the actuator LVDT. When the failure monitor finds a fault with the PCU or the ACE, it de-energizes the bypass solenoid of the PCU.

Training Information Point

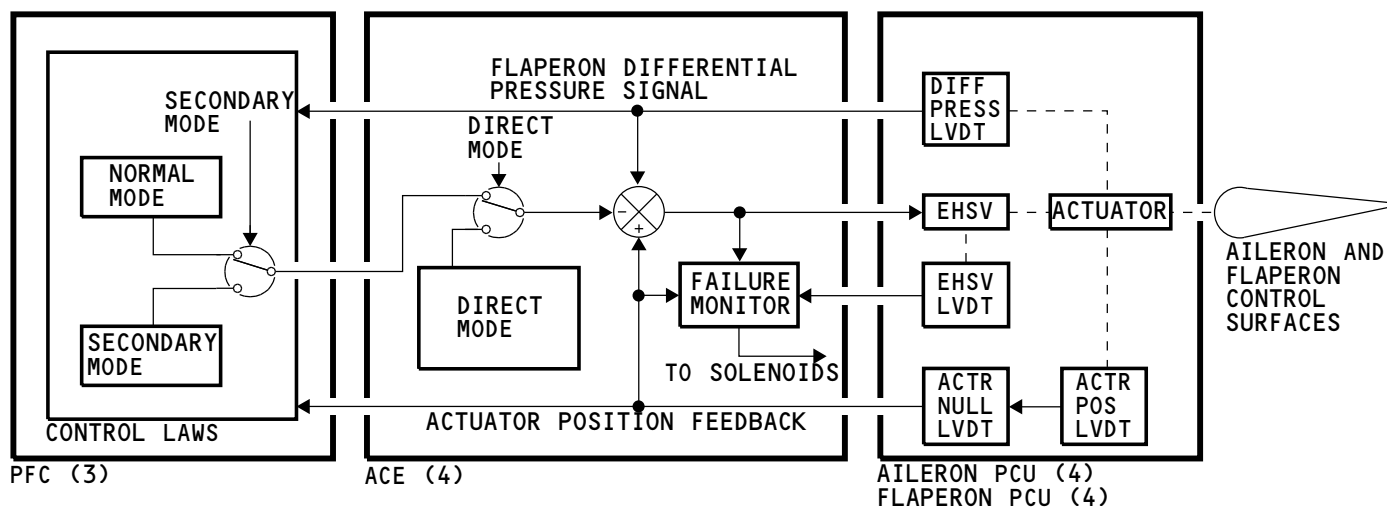
After installation of the aileron or the flaperon PCU, you do a MAT test and adjust the actuator null LVDT to have the control surface at the rig position.

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AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP

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AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

General

In normal mode operation of the PFCS, the PFCs calculate roll control commands based on:

- Aileron schedule
- Flaperon schedule
- Aileron and flaperon droop logic
- Aileron lockout logic
- Flaperon bypass logic
- Landing attitude modification
- Flaperon force fight equalization
- Failure monitor
- Bank angle protection (BAP)
- Autopilot roll commands.

Aileron and Flaperon Schedules

The PFCs receive roll control command signals from the wheel position transducers and from the autopilot. The aileron and flaperon schedules calculate aileron and flaperon input commands. The PFCs invert the commands for the left wing in relation to the commands for the right wing.

The aileron schedule has limits that vary as a function of the flap position data from the FSEU and the airspeed data from the ADIRU. When the flaps are in positions 5 through 30, and the airspeed is more than 65 knots, the PFC limits the aileron trailing edge down movement to 8 degrees. When the airspeed is less than 65 knots, the PFC commands let the aileron move to its maximum trailing edge down position. This lets the pilots to do a full authority check during preflight.

The flaperon schedule has fixed limits that let the surface move through its full authority range.

Aileron and Flaperon Droop

When the flaps extend, the PFCs use flap position data from the FSEUs to calculate aileron and flaperon droop. The PFCs add these droop commands with the signals from the aileron and flaperon schedules.

Aileron Lockout

The aileron lockout logic fairs the aileron at specific airspeed and altitude. The PFCs use computed airspeed (CAS) and altitude data from the ADIRU to calculate an aileron lockout factor. This causes the ailerons to fair to the wing surface and to lock out at cruise speed.

The left and right aileron commands go to the ACEs and then from the ACEs to the EHSV of each aileron PCU. The lockout command also goes to the ACEs, then to the blocking solenoid of each aileron PCU.

Flaperon Bypass Logic

The flaperon bypass logic gets signals from the left and right engine running status and the position of the left and right thrust resolver angles. The logic also gets the CAS signal from the ADIRU and the air/ground signal from the WOW cards.

The logic operates on the ground with at least one engine running and its thrust resolver angle near the takeoff position. With the airspeed less than 85 knots, the logic sends a command signal to all four ACEs to put the flaperon PCUs in bypass mode. This decreases the flaperon actuator fatigue cycles caused by the engine exhaust on the flaperons.

At low airspeed with the flaperon PCUs in bypass mode, the weight of the flaperon may cause the flaperons to move down to the PCU stops. The exhaust flow of the engines may cause the flaperons to flutter. As the airspeed increases during takeoff roll, the airloads may cause the flaperons to float to the neutral position.

When the airspeed is approximately 100 knots, the logic stops operation and sends a command signal to the ACEs to put the flaperon PCUs in the normal mode. The flaperon PCUs then gradually move the flaperons to the commanded position.

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**AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE**

The flaperon bypass logic is inhibited for 30 seconds after an air to ground transition. This prevents the flaperon PCUs to be in bypass during touch and go operation of the airplane.

Landing Attitude Modification

The landing attitude modification (LAM) logic decreases the flaperon droop when the airplane is in an overspeed approach with flaps at the 25-unit or 30-unit position. The PFC calculates the reduction of flaperon droop proportionally to the overspeed increment. Full flaperon droop removal occurs when the airspeed is 20 knots more than the approach landing speed shown in the airplane flight manual.

When the LAM logic is active, it reduces wing lift and causes an increase in angle-of-attack. This increases the nose gear ground clearance.

Flaperon Force Fight Equalization

The PFCs use flaperon PCU differential pressure data from the ACEs to adjust all the flaperon PCU commands to decrease PCU force fight. The PFCs send these adjusted commands to the ACEs and the EHSV of each flaperon PCU.

Bank Angle Protection

The BAP function supplies a control wheel force cue to the pilot when the bank angle is more than 35 degrees. The PFCs use flight data from the ADIRU and signals from the wheel force transducer to calculate backdrive actuator commands which go to the AFDCs. This causes the backdrive actuators to apply a force on the control wheels which increases as the bank angle increases more than 35 degrees.

When the BAP function is active, the ELMS prevents the operation of the aileron trim.

Autopilot Roll Commands

During autopilot operation, the PFCs use the autopilot roll commands to calculate the aileron and flaperon commands. They also calculate the backdrive actuator commands which go to the AFDCs. This causes the backdrive actuators to move the control wheels in the same relationship to the autopilot commands. When the pilots move the control wheels while the autopilot is engaged, the autopilot disengages. The backdrive actuators then disengage and stop movement of the control wheels.

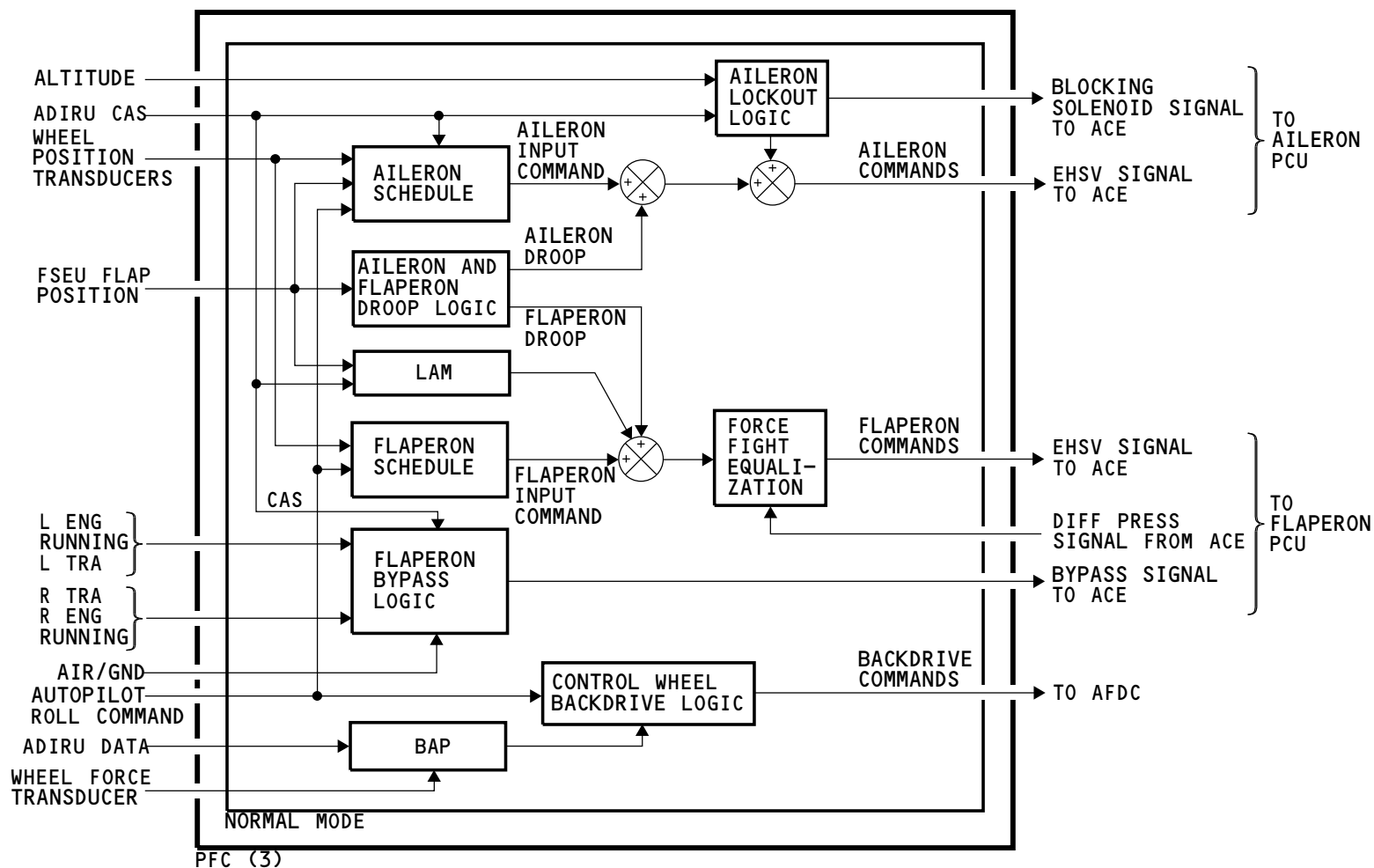
When the autopilot is engaged, the ELMS prevents the operation of the aileron trim.

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AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

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**AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE****General**

In secondary mode operation of the PFCS, the PFCs calculate roll control commands based on:

- Aileron fixed schedule
- Flaperon fixed schedule
- Aileron lockout
- Flaperon droop constant
- Flaperon force fight equalization
- Failure monitor.

Aileron and Flaperon Schedules

The PFCs receive roll control command signals from the wheel position transducers. The aileron and flaperon fixed schedules determine the aileron and flaperon input commands. These schedules supply a fixed and linear relationship between the control wheel command and the aileron and flaperon command. The PFCs invert the commands for the left wing in relation to the commands for the right wing.

Aileron Lockout

The PFCs calculate the aileron commands based on the flaps and slats retracted discrete signal from the ACEs. When the flaps and slats are not retracted, the aileron input commands from the fixed schedule go directly to the ACEs. When the flaps and slats are retracted, the PFCs send a zero position command which fairs the ailerons.

When the flaps and slats are retracted, the PFCs also send a lockout command to the blocking solenoid of the aileron PCUs. When the flaps and slats are not retracted, the PFCs send an unlock command signal to the blocking solenoid of the aileron PCUs.

Flaperon Droop

The PFCs sum the flaperon input commands with the flaperon droop constant. When the flaps and slats are not retracted, the flaperon droop constant causes the flaperons to droop.

Flaperon Force Fight Equalization

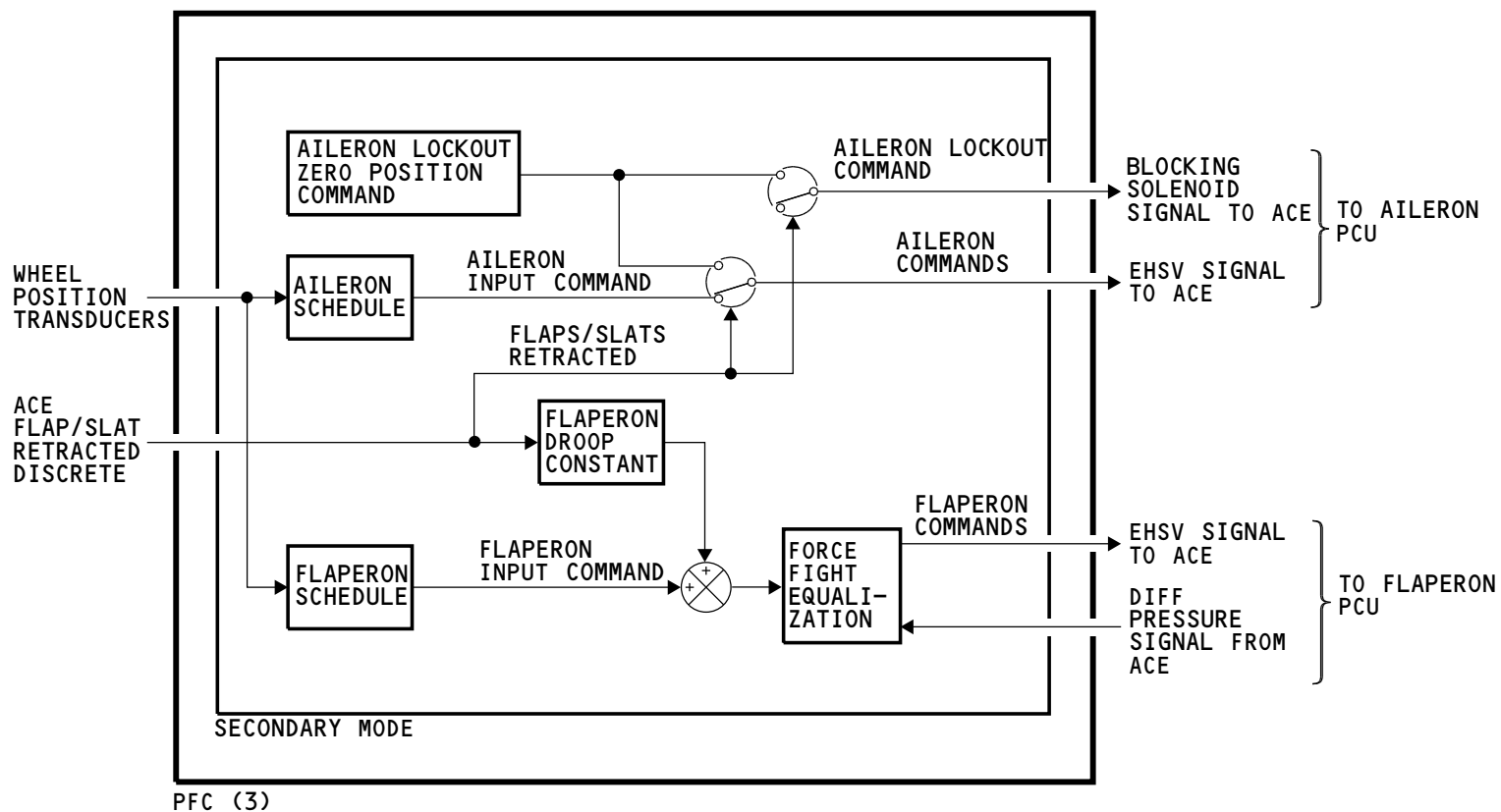
The PFCs use flaperon PCU differential pressure data from the ACEs to adjust the flaperon PCU commands before transmission to the ACEs and the EHSV of each flaperon PCU. This function minimizes flaperon PCU force fight.

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AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE

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AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

General

In direct mode operation of the PFCS, the ACEs calculate roll control commands based on these inputs:

- Aileron fixed schedule
- Flaperon fixed schedule
- Flaperon droop constant
- Failure monitor.

Aileron and Flaperon Roll Commands

The ACEs receive roll command signals from the wheel position transducers. The aileron and flaperon fixed schedules determine the aileron and flaperon input commands. These schedules supply a linear relationship between the control wheel command and the aileron and flaperon command. The ACEs invert the commands for the left wing in relation to the commands for the right wing.

The ACEs calculate the aileron commands based on the flaps and slats retracted discrete signal from the FSEUs. When the flaps and slats are retracted, the aileron fixed schedule selects zero value commands. This causes the ailerons to fair to the wing surface and to lock out.

The ACEs sum the flaperon input commands with the flaperon droop constant. When the flaps and slats are not retracted, the flaperon droop constant causes the flaperons to droop.

The aileron and flaperon commands then go directly to the EHSV of each aileron and flaperon PCU.

If there are any PFCs functional and signals can get to the ACEs, the PFCs control the command signals for the blocking solenoid of the aileron PCUs. When the flaps and slats are retracted, the PFC secondary mode logic sends a command signal to the ACEs. The ACEs then de-energize the blocking solenoid of the aileron PCUs. When the flaps and slats are not retracted, the PFC secondary mode logic sends command signals to the ACEs to energize the blocking solenoid of the PCUs.

Failure Monitor

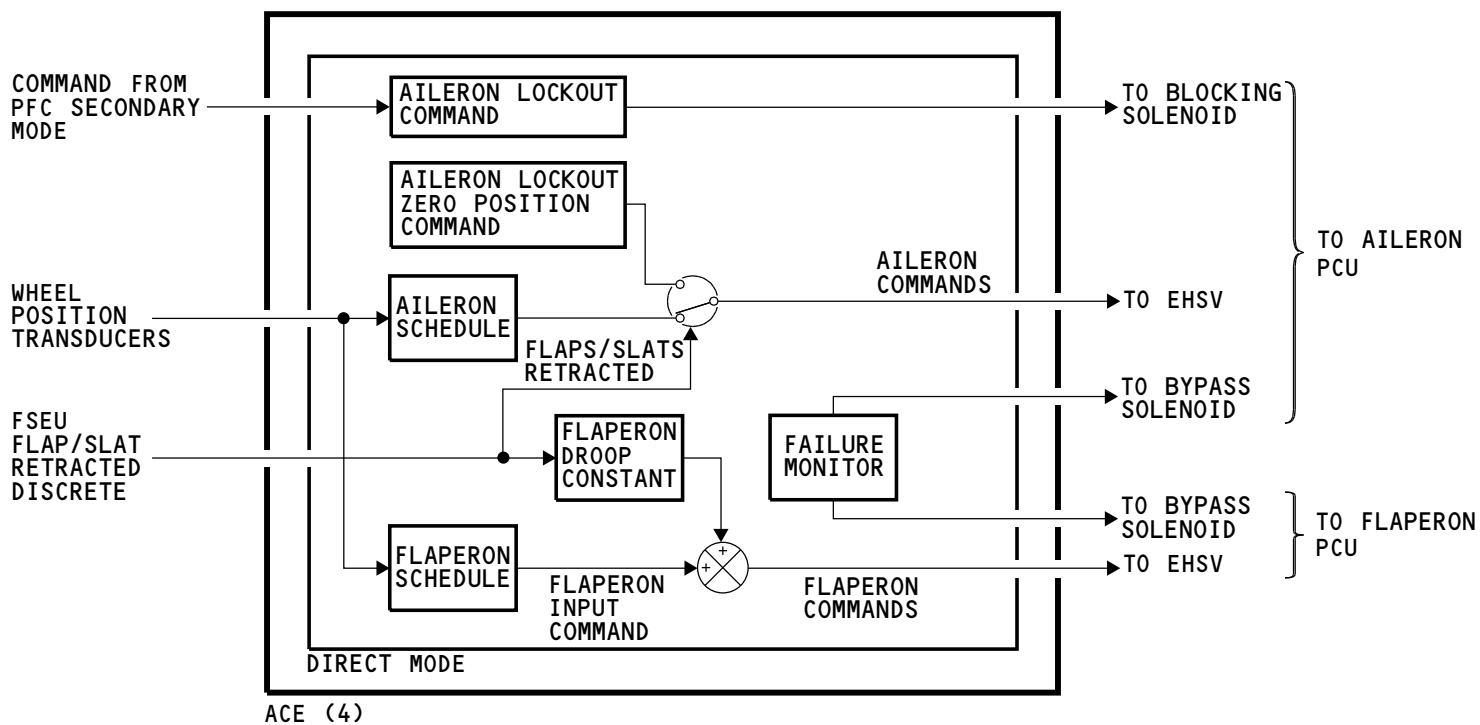
When it finds a failure with the PCU, the PCU wiring or the ACE control loop, the failure monitor sends a signal to the bypass valve of the appropriate PCU.

The failure monitor operates in all three modes, normal, secondary and direct. The failure monitor can also find faults in the ACE, the wheel position and force transducers, and interface wiring.

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AILERON AND FLAPERON CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

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**AILERON AND FLAPERON CONTROL - AILERON AND FLAPERON DROOP****Purpose**

The ailerons and flaperons of both wings move down (droop) to help the high lift system when the flaps are extended. When drooped, the ailerons and flaperons still operate for roll control.

Functional Description

The PFCs and the ACEs command the ailerons and flaperons to droop based on the flap position.

Both ailerons and flaperons droop in normal mode of operation of the PFCS. Only the flaperons droop in secondary and direct mode.

Normal Mode

In normal mode, the ailerons droop at a different rate and schedule than the flaperons.

When the flaps are retracted, the ailerons are at the 2 degrees TED rig position in relation to the wing fixed trailing edge. With the flaps at the takeoff position (5 to 20), the ailerons droop by 8 degrees TED. With the flaps at the landing position (25 and 30), the ailerons move to 0.6 degrees TED.

The flaperons droop to 10 degrees TED when the flaps are at the 5 position. They droop to 20 degrees TED when the flaps are at the 15 or 20 position. They droop to 31 degrees TED when the flaps are at the landing position (25 or 30).

On the ground, the PFCs remove the flaperon droop command in proportion to the speedbrake lever movement from 17 to 55 degrees. When the speedbrake lever goes back to the DOWN position, the flaperons gradually droop to the position commanded by the flaps.

Secondary and Direct Modes

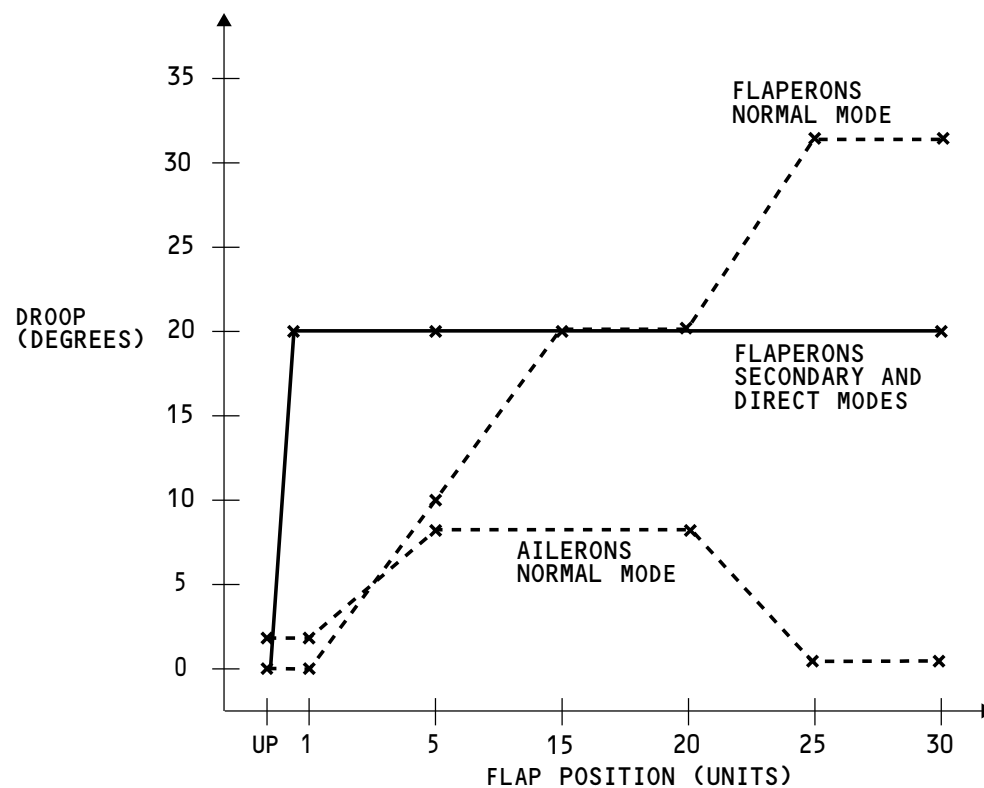
In the secondary and direct modes, the flaperons droop to a constant value of 20 degrees when the flaps and slats are not retracted. The ailerons do not droop.

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AILERON AND FLAPERON CONTROL - AILERON AND FLAPERON DROOP

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**AILERON AND FLAPERON CONTROL - AILERON LOCKOUT****Purpose**

The outboard location of the ailerons and their large surface area could cause large wing torsion loads and loss of lift at high speed. To prevent this, the ailerons align (fair) to the wing surface and lock out during cruise.

Functional Description

Aileron lockout is available in normal, secondary, and direct modes.

In normal mode, the PFCs and the ACEs command the ailerons to lock out based on altitude and computed airspeed (CAS). In secondary and direct modes, the ailerons lock out only when the flaps and slats are retracted.

Normal Mode

In normal mode, the PFCs multiply the aileron command by the lockout factor. The lockout factor is based on airspeed and altitude. For low airspeeds and low altitudes, the lockout factor is one. For high airspeeds and high altitudes, the lockout factor is zero.

If the airspeed is between the zero lockout airspeed and the one lockout airspeed, then the lockout factor is proportional between zero and one. In this condition, the aileron command has reduced authority.

Secondary and Direct Modes

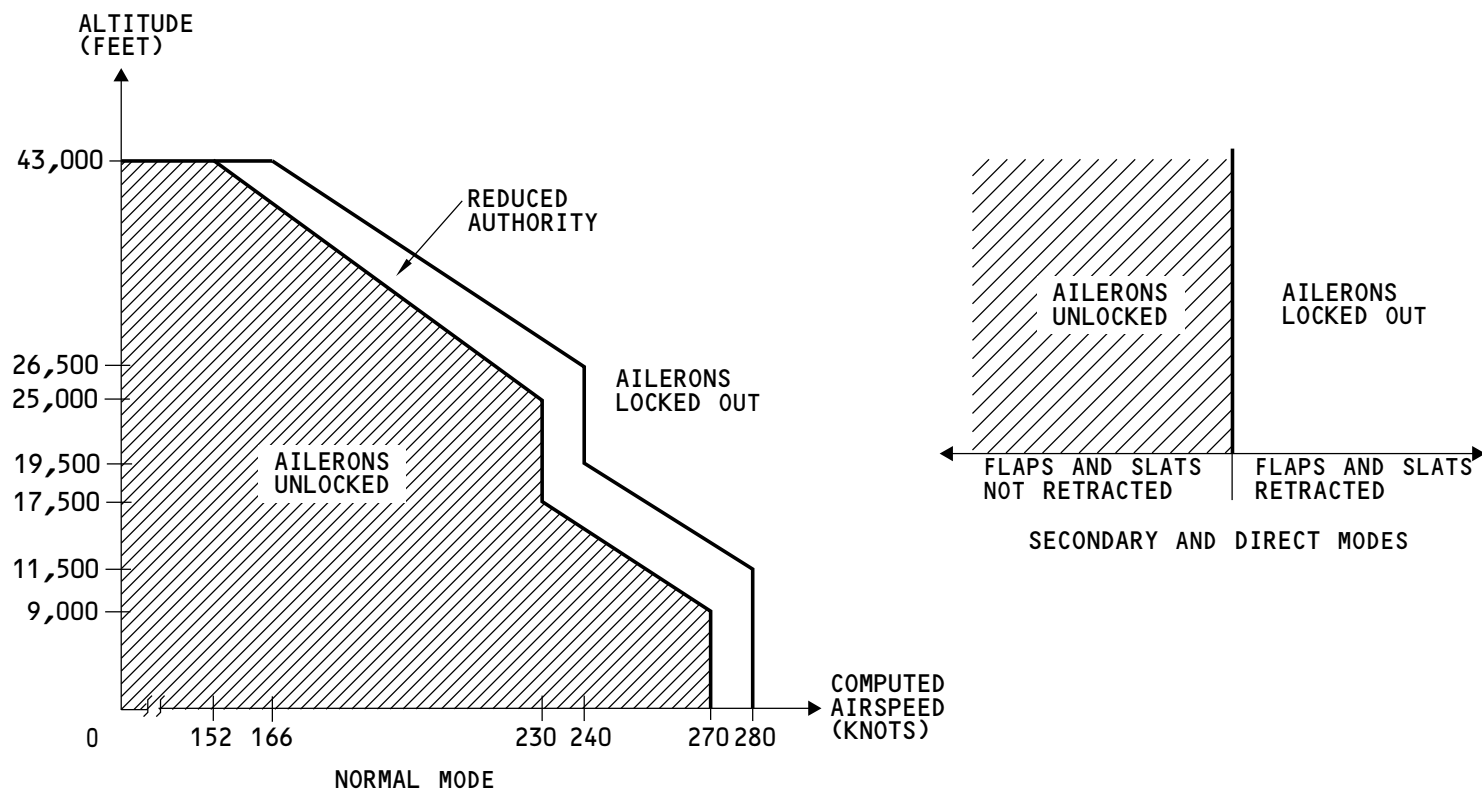
In secondary and direct modes, the PFCs and ACEs use FSEU flaps and slats retracted signals to command lockout. When the flaps and slats are retracted, the ailerons lock out. When the flaps and slats are not retracted, the ailerons are unlocked.

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AILERON AND FLAPERON CONTROL - AILERON LOCKOUT

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AILERON AND FLAPERON CONTROL - BANK ANGLE PROTECTION

Purpose

The bank angle protection (BAP) function of the PFC helps prevent the airplane from rolling to large bank angles. However, the pilot can always override the control wheel forces and remain in full control of roll.

Functional Description

When the bank angle exceeds the nominal value of 35 degrees, BAP increases the control wheel force to the pilot.

BAP operates only in PFCS normal mode and is available in both manual operation and in autopilot.

When the BAP function is active, the ELMS prevents the operation of the aileron trim.

BAP does not operate when the pitch attitude is more than 75 degrees (positive or negative). When the airspeed is between the maximum operating speed (V_{mo}/M_{mo}) and the maximum design dive speed (V_{dive}/M_{dive}), the BAP roll activation value decreases linearly from 35 to 20 degrees.

Manual Operation

The PFCs calculate backdrive actuator commands based on:

- Roll attitude
- Roll rate
- Mach number
- Computed airspeed
- Pitch attitude
- Wheel force.

When the bank angle is more than 35 degrees, the PFC BAP function sends a backdrive command to the AFDCs. The AFDCs send this command to one of the wheel backdrive actuators. The actuator motor applies a torque to turn the control wheels proportionally as the bank angle increases from 35 to 60 degrees.

If the pilot does not move the control wheel, the backdrive actuator moves the control wheels in the opposite direction to the airplane bank. This decreases the airplane bank to 30 degrees. BAP automatically disengages when the bank angle is less than 35 degrees and the pilot takes control of the wheel.

If the pilot wants to maintain or increase the bank angle more than 35 degrees, the pilot must apply a force to the control wheels to override the torque of the backdrive actuator. The wheel force transducer senses the pilot override force and sends a signal to the PFCs. The PFCs use this signal to limit the torque of the backdrive actuator and the force at the control wheels.

Autopilot Operation

In autopilot operation, the BAP function becomes active when the bank angle is more than 35 degrees or the roll rate is more than 15 degrees per second. BAP stops the autopilot roll commands and takes over control of the roll.

The PFC BAP function sends a backdrive command through the AFDCs to one of the wheel backdrive actuators. The backdrive actuator moves the control wheels to decrease the airplane bank below 35 degrees. When the airplane bank is at 35 degrees and the autopilot requests to engage roll control, BAP becomes inactive and returns roll control to the autopilot.

Indications

Indications for BAP are shown on the:

- Multi-function display (MFD) status display
- Primary flight display (PFD)
- Flight control maintenance page.

On the MFD format, the status message BANK ANGLE PROTECT indicates one of these faults:

- Both wheel backdrive actuators are defective
- The wheel force transducer is defective
- The right and left AFDCs are inoperative.

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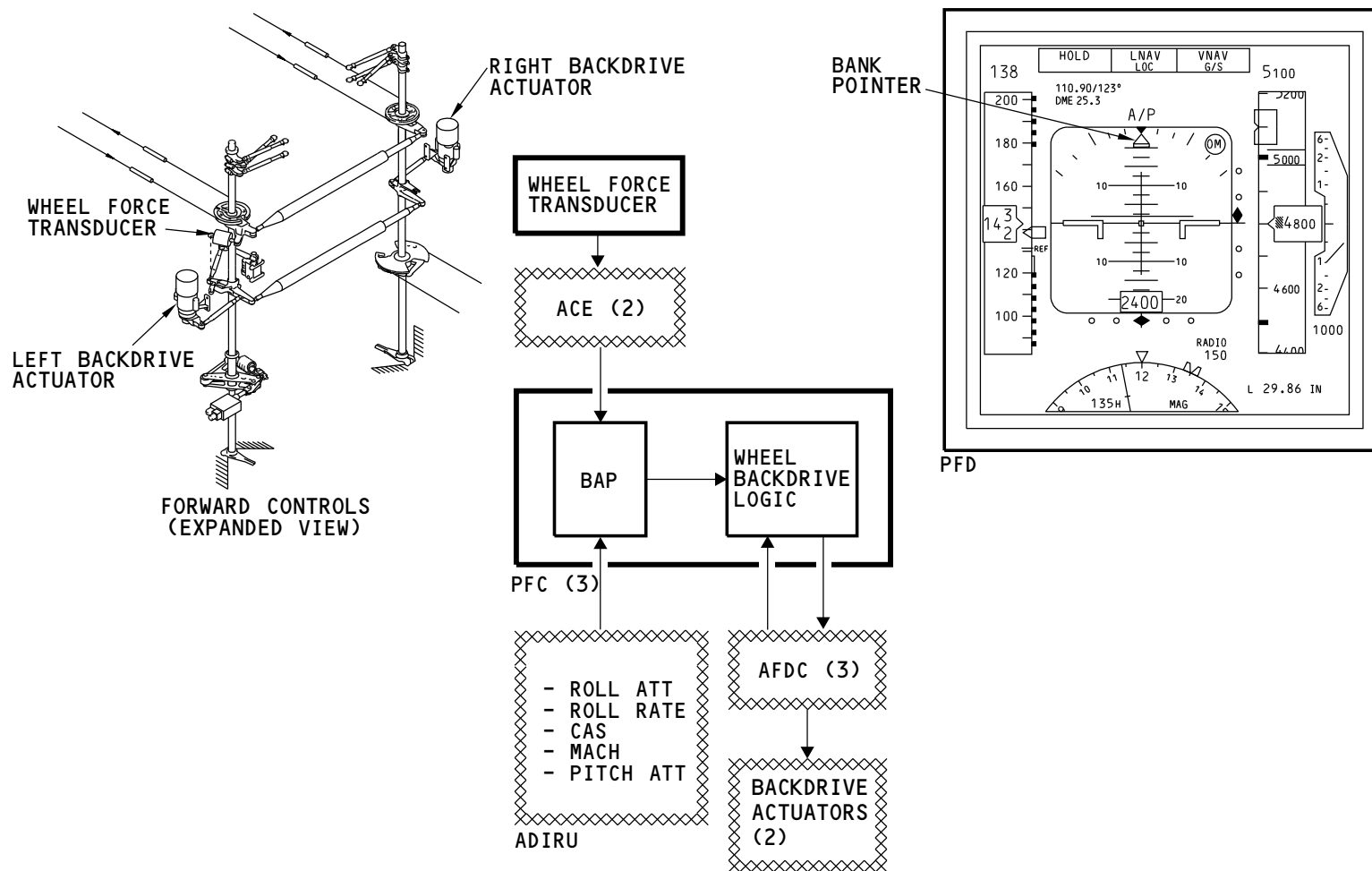


AILERON AND FLAPERON CONTROL - BANK ANGLE PROTECTION

On the PFD, the bank pointer changes to amber when the bank angle is 35 degrees or more.

Page 1 of the flight control maintenance pages has a protection mode activity which shows when BAP is active.

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AILERON AND FLAPERON CONTROL - BANK ANGLE PROTECTION

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RUDDER CONTROL - INTRODUCTION

General

The rudder controls the flight attitude of the airplane about the vertical axis.

The rudder hinges on the rear spar of the vertical stabilizer. A rudder tab increases the effect of the rudder. The rudder tab moves further in the same direction as the rudder.

Yaw Control

The pilots make a manual yaw correction with the rudder pedals. The autopilot does not control the rudder during most phases of flight. When the autopilot is engaged during the approach and landing phases of flight, the autoland function commands the rudder. The backdrive actuators then backdrive the rudder pedals.

Rudder Ratio

During flight, the rudder ratio function reduces the movement of the rudder as the airspeed increases. The primary flight computers (PFCs) command the rudder ratio function of the yaw control.

Yaw Damper

The PFCs control the conventional yaw damper and turn coordination functions of the rudder.

Wheel-Rudder Cross-Tie

The wheel-rudder cross-tie function moves the rudder in response to control wheel inputs when the airspeed is less than 210 knots. This makes roll and yaw control better during one-engine-out operation. It also lets the pilot control yaw caused by an engine failure with the control wheel.

Gust Suppression

A gust suppression function reduces the effects of air gusts on the vertical stabilizer.

Modal Suppression Function

A modal suppression function reduces the forward and aft body lateral movements.

Abbreviations and Acronyms

- ACE - actuator control electronics
- ACMS - airplane condition monitoring system
- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AIMS - airplane information management system
- ARINC - Aeronautical Radio, Inc.
- CAS - computed airspeed
- CMCS - central maintenance computing system
- CPU - central processing unit
- EDIU - engine data interface unit
- EEC - electronic engine control
- EHSV - electrohydraulic servo valve
- EICAS - engine indication and crew alerting system
- FSEU - flap/slat electronics unit
- GSE - ground support equipment
- HLCS - high lift control system
- LRU - line replaceable unit
- LVDT - linear variable differential transformer
- MEC - main equipment center
- MFD - multi-function display
- PCU - power control unit
- PFC - primary flight computer
- PFCS - primary flight control system

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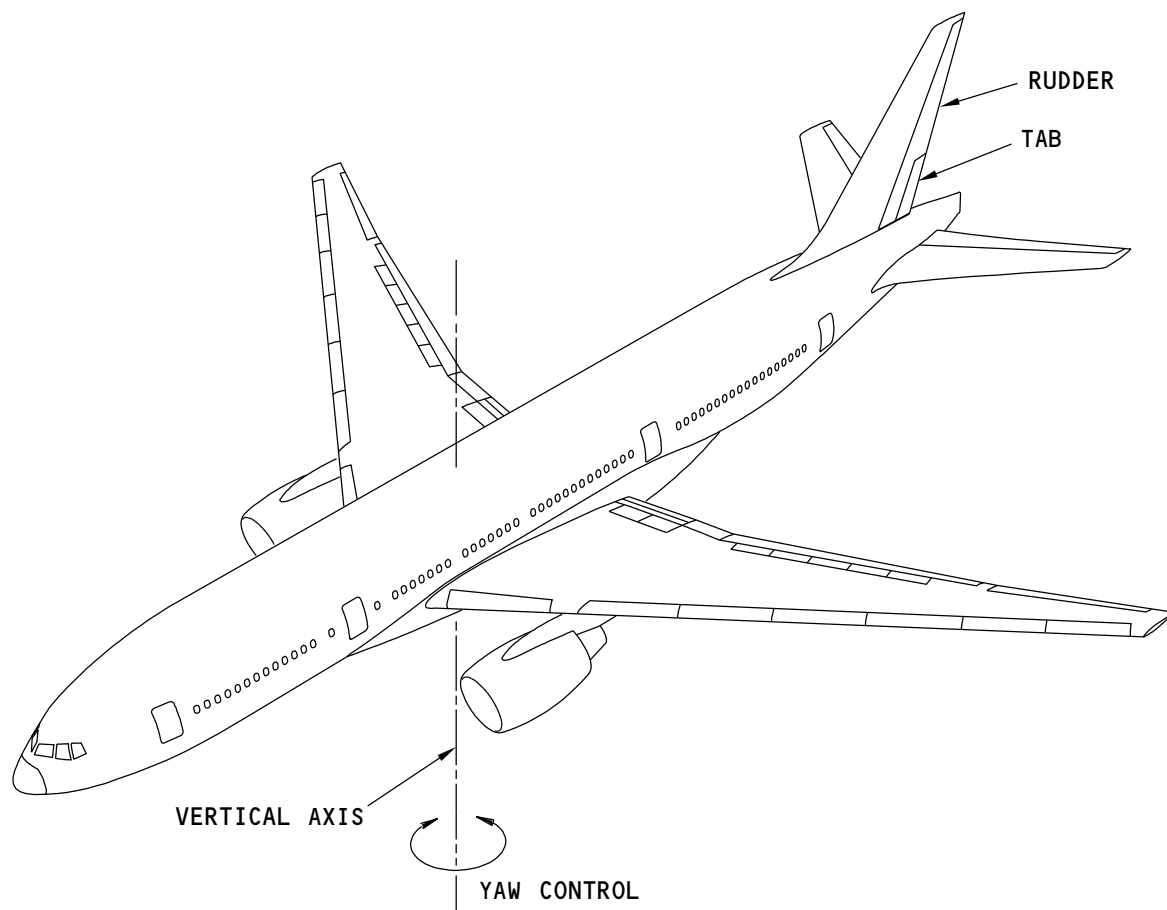
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RUDDER CONTROL - INTRODUCTION

- PFD - primary flight display
- PSAS - pitch stability augmentation system
- PSEU - proximity sensor electronic unit
- RVDT - rotary variable differential transformer
- SAARU - secondary attitude air data reference unit
- TAC - thrust asymmetry compensation
- WEU - warning electronic unit
- WOW - weight-on-wheels



RUDDER CONTROL - INTRODUCTION

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RUDDER CONTROL- GENERAL DESCRIPTION

General

The pilots manually command the rudder; the autopilot automatically commands it.

Manual Operation - Rudder Pedals

The flight crew uses two conventional rudder pedals to control yaw.

Four rudder pedal position transducers change the flight crew rudder pedal commands to analog electrical signals. These signals go to the four actuator control electronics (ACEs). The ACEs change the signals to digital format and send them to the three primary flight computers (PFCs) through the flight controls ARINC 629 buses.

The PFCs use position data from the rudder pedals, data from the air data inertial reference unit (ADIRU) and the airplane information management system (AIMS), to calculate control surface commands. The PFCs send the digital commands to the ACEs, which change them to analog signals. The ACEs send the analog position commands to the power control units (PCUs), which move the rudder. The position transducers on the PCU actuator pistons supply position feedback to the ACEs.

Two gust suppression pressure transducers measure wind gusts on the vertical stabilizer. The transducer signals go to the ACEs and then to the PFCs through the flight controls ARINC 629 buses. The PFCs command the rudder PCUs to move. This movement of the rudder reduces the effect of the side gust.

Two modal accelerometers measure the lateral movement of the aft fuselage. The accelerometer signals go to the ACEs and then to the PFCs through the flight control ARINC 629 buses. The PFCs calculate command signals for the ACEs to move the rudder PCUs to decrease the lateral movement of the forward and aft cabin.

The PFCs operate the yaw damper and rudder ratio functions.

Manual Operation - Rudder Trim

The rudder trim control, on the aisle stand, and the trim actuator let the flight crew trim out unwanted rudder pedal forces. When the pilots move the rudder trim control, the switch sends a signal to the ACEs and the PFCs. The PFCs and the ACEs command the rudder trim actuator to move the rudder pedals and the position transducers through the feel and centering mechanism. The rudder pedal position transducers send a signal to the ACEs and PFCs to move the rudder.

The rudder trim indicator, also on the aisle stand, shows the position of the rudder trim. The rudder trim actuator position transducer sends a feedback signal to the ACEs and the PFCs. The PFCs then command the trim indicator through AIMS.

The rudder manual trim cancel switch, on the aisle stand, sends a signal to the ACEs and the PFCs to command the rudder trim to zero.

When the thrust asymmetry compensation (TAC) switch on the P5 panel is in the AUTO position, the PFCs automatically control the rudder trim. This control is to make allowance for asymmetrical thrust from the engines. The TAC function does not operate when the TAC switch is in the OFF position. The manual trim cancel switch does not remove any rudder trim caused by TAC.

Autopilot Operation

When autoland is active, the autopilot flight director computers (AFDCs) control the yaw attitude of the airplane for crosswind and engine-out conditions. The AFDCs supply yaw commands to the PFCs through the flight controls ARINC 629 buses. The PFCs use these inputs to calculate position commands for the rudder.

The PFCs also calculate rudder pedal backdrive commands. The PFCs send these commands to the AFDCs, which transmit rudder movement commands to the backdrive actuators. The backdrive actuators move the rudder pedals to a position to match the autopilot rudder command.

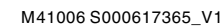
To override the autopilot, the flight crew applies more force on the rudder pedals than the backdrive actuator force. A pilot override disengages the autopilot.

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RUDDER CONTROL- GENERAL DESCRIPTION

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RUDDER CONTROL- COMPONENT LOCATIONS

General

The rudder control components are in three areas:

- The vertical stabilizer
- The flight deck
- Below the flight deck floor.

- Pedal damper
- Friction brake
- Backdrive actuators.

Access to these components is through the forward equipment center.

Tail Components

The rudder control surface and the rudder PCUs are on the vertical stabilizer. The rudder tab is aft of the rudder. Three PCUs directly connect to the rudder. Access to the PCUs is by access panels on the left side of the vertical stabilizer.

The two gust suppression pressure transducers are near the leading edge of the vertical stabilizer at about half span.

The two modal accelerometers are in the aft fuselage.

Flight Deck Components

The rudder pedals, the rudder pedal adjustment cranks, the rudder trim selector and the manual trim cancel switch are in the flight deck. The rudder trim selector and the manual trim cancel switch are on the P8 aft aisle stand. The TAC switch is on the P5 overhead panel.

Components Below the Flight Deck

The rest of the forward controls are below the flight deck floor and above the nose gear wheel well. These are the:

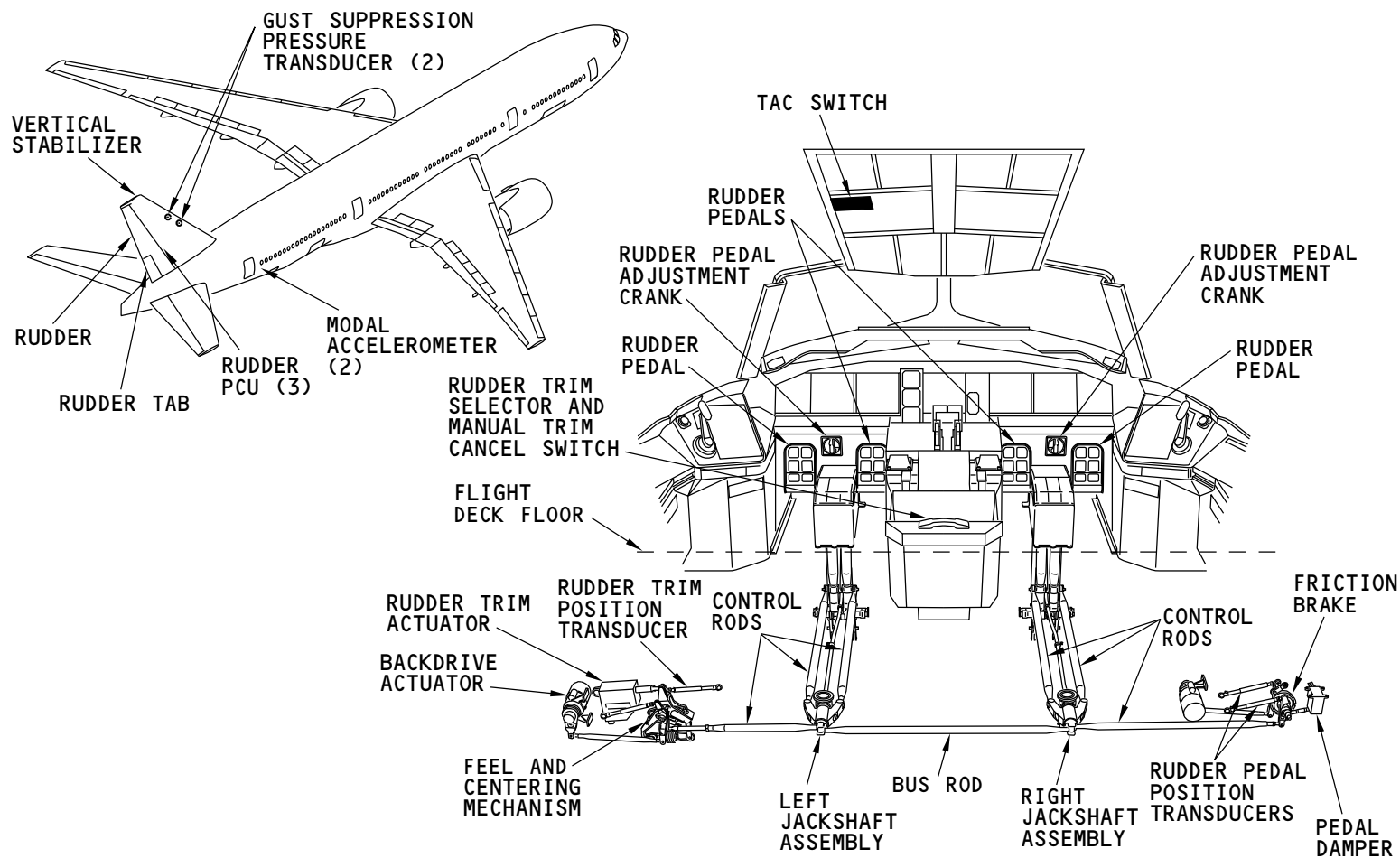
- Control rods
- Left and right jackshaft assemblies
- Bus rod
- Rudder Feel and centering mechanism
- Rudder trim actuator
- Rudder trim position transducer
- Rudder pedal position transducers

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NOTE: CONTROL WHEELS AND CONTROL COLUMNS NOT SHOWN FOR CLARITY.

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RUDDER CONTROL- COMPONENT LOCATIONS

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RUDDER CONTROL - ANALOG AND DISCRETE INTERFACES

General

All of the rudder control electrical interfaces in the PFCS go through the ACEs. The ACEs have interfaces with these components:

- Thrust asymmetry compensation switch
- Rudder pedal position transducers
- Rudder trim selector
- Manual trim cancel switch
- Rudder trim actuator
- Rudder trim position transducer
- Gust suppression pressure transducers
- Modal accelerometers
- Rudder PCUs.

The rudder trim actuator connects mechanically with the rudder pedal control system.

Thrust Asymmetry Compensation Switch

The thrust asymmetry compensation (TAC) switch supplies a discrete signal to the C ACE. When the TAC switch is in the AUTO position, the PFCs automatically control the rudder trim actuator to make allowance for asymmetric thrust. TAC does not operate when the TAC switch is in the OFF position.

Rudder Pedal Position Transducers

There are four rudder pedal position transducers, two for each rudder pedal set. Each transducer is a linear variable differential transformer (LVDT) that sends analog signals to the ACEs. These analog signals are in proportion to the rudder pedal position and their movement.

Rudder Trim Selector, Manual Trim Cancel Switch, Trim Actuator and Position Transducer

The rotary trim selector and the manual trim cancel switch supply discrete signals to the L1 and R ACEs. The ACEs transmit these signals to the PFCs. The PFCs then command through the ACEs the rudder trim actuator to move the rudder pedals and the position transducers. The rudder trim actuator sends a feedback signal to the ACE. The rudder trim position transducer also sends a trim position signal to the ACE.

Gust Suppression Pressure Transducers

Two gust suppression pressure transducers, in the vertical stabilizer, supply analog signals to the L1 and C ACEs. These signals represent the differential pressure across the vertical stabilizer. This is a measure of the aerodynamic force.

Modal Accelerometers

Two modal accelerometers, in the aft body, supply analog signals to the L2 and R ACEs. These signals represent the lateral acceleration of the aft body movement.

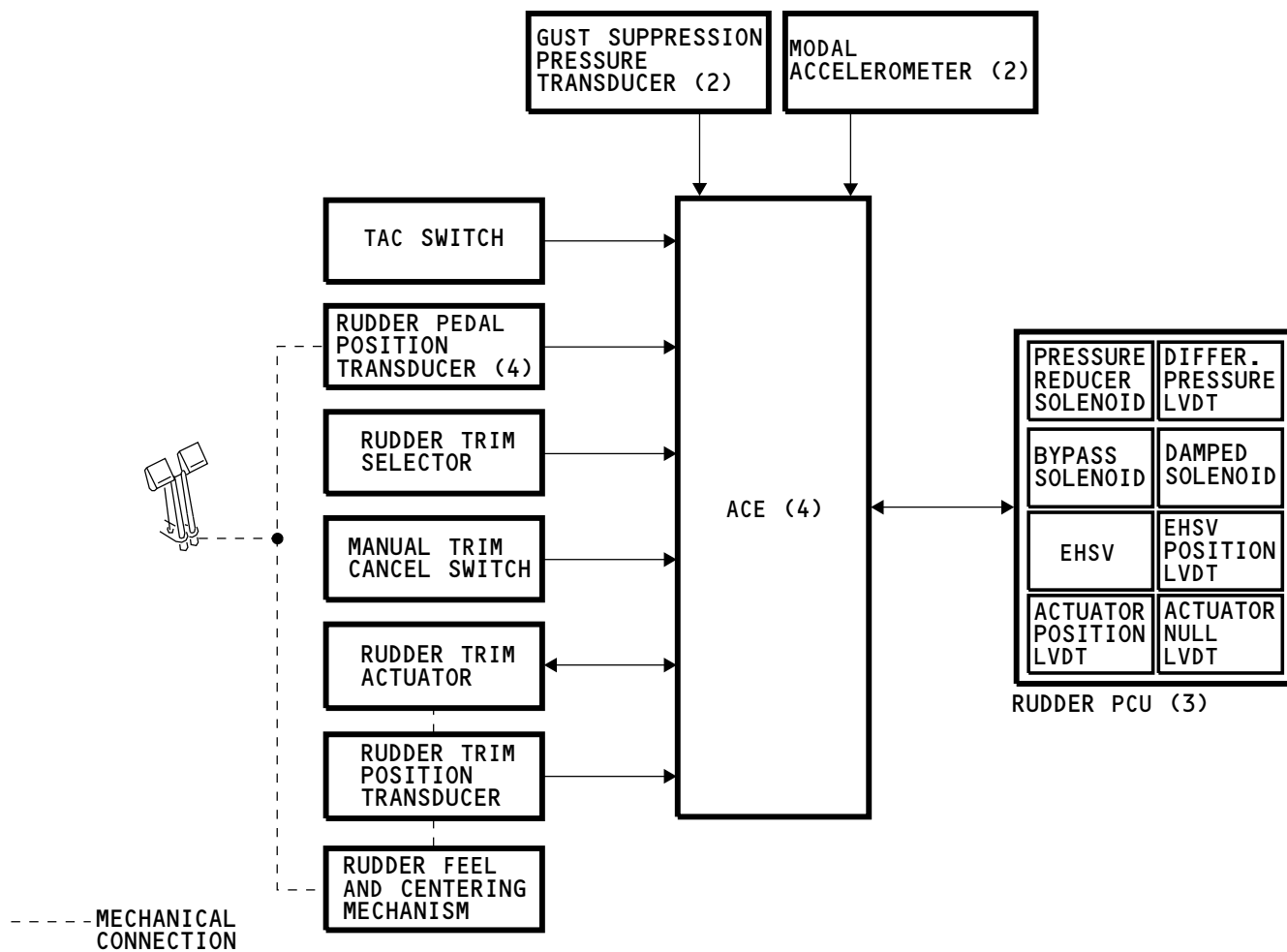
Rudder PCUs

Each of the three rudder PCUs receives analog and discrete electrical signals from the ACEs. The discrete signals go to:

- The pressure reducer solenoid
- The bypass solenoid
- The damped solenoid.

The analog signal goes to the electrohydraulic servo valve (EHSV).

Each of the three rudder PCUs sends analog feedback signals to the ACEs. These signals are from the EHSV position LVDT, the actuator position LVDT, the actuator null LVDT and the differential pressure LVDT.



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RUDDER CONTROL - ANALOG AND DISCRETE INTERFACES

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RUDDER CONTROL - FORWARD CONTROLS

General

The forward controls of the rudder control system include:

- The rudder pedal arms and jackshaft assemblies
- The rudder pedal position transducers
- The backdrive actuators
- The feel and centering mechanism
- The rudder trim actuator
- The friction brake
- The pedal damper
- The connection to the nose wheel steering
- The travel stops.

Rudder Pedal Arms and Jackshaft Assemblies

The rudder pedal arms connect by control rods to the jackshaft assemblies. The two jackshaft assemblies connect with a bus rod. Each jackshaft assembly contains a rudder pedal adjustment mechanism to permit each pilot to adjust the pedals to the most comfortable position.

Each jackshaft assembly connects with control rods and cranks to the left and right shaft assemblies.

There is no jam override mechanism for the rudder pedals. However, the control rods that connect the pedals to the jackshaft assemblies each have a one-way pogo. These supply some relief from jams that may occur as a result of a bird strike through the forward bulkhead.

Rudder Pedal Position Transducers

Four rudder pedal position transducers, installed on the airframe structure, connect to cranks on the left and right shaft assemblies.

Backdrive Actuators

Two backdrive actuators connect to a crank on the left and right shaft assemblies. The backdrive actuators are part of the autopilot system.

See the autopilot flight director system section for more information on the backdrive actuators (SECTION 22-11).

Feel and Centering Mechanism

The feel and centering mechanism is on the left shaft assembly.

Rudder Trim Actuator

The rudder trim actuator connects to the feel and centering mechanism. The rudder trim position transducer connects to the lever of the rudder feel and centering mechanism.

Friction Brake

A friction brake connects with a crank to the right shaft assembly. The friction brake supplies a resistance to the movement of the rudder pedal control mechanism.

Pedal Damper

A pedal damper connects with a crank to the right shaft assembly. The damper absorbs oscillations of the rudder pedal control mechanism.

Connection to Nose Wheel Steering

A crank and a connecting rod, from the right jackshaft assembly, supply the rudder pedal command to the nose wheel steering system. See the nose gear steering system section for more information (SECTION 32-51).

Travel Stops

Travel stops are at the aft end of the left and right shaft assemblies. They keep the movement of the rudder control system to a limit of 3.5 inches of rudder pedal movement in both directions.

Training Information Point

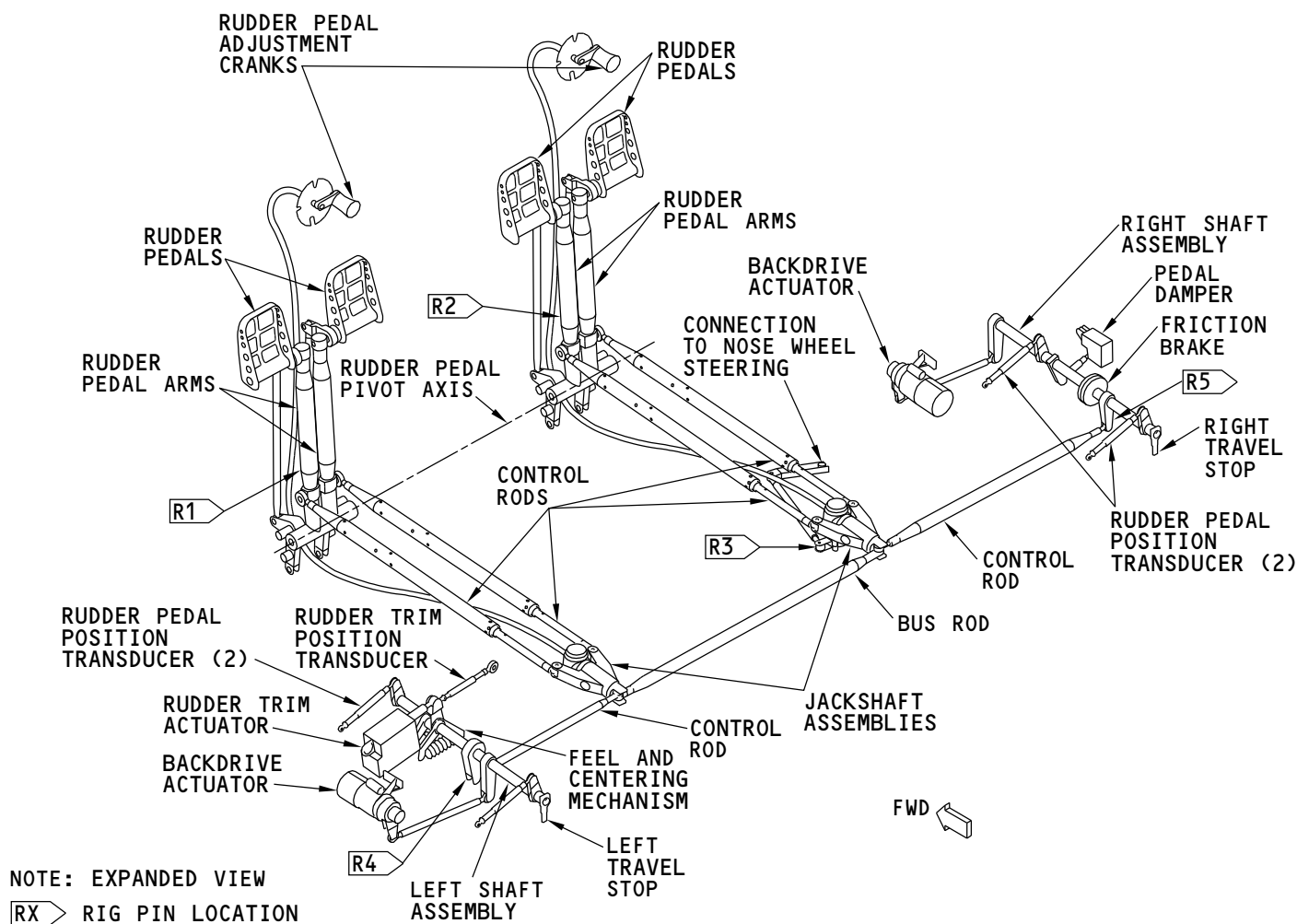
Rig pins lock the rudder forward controls during adjustment of the rudder control system.

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RUDDER CONTROL - FORWARD CONTROLS

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**RUDDER CONTROL - PEDAL ASSEMBLY****Purpose**

The rudder pedals get the pilot commands and transmit them to the rudder control system.

Physical Description

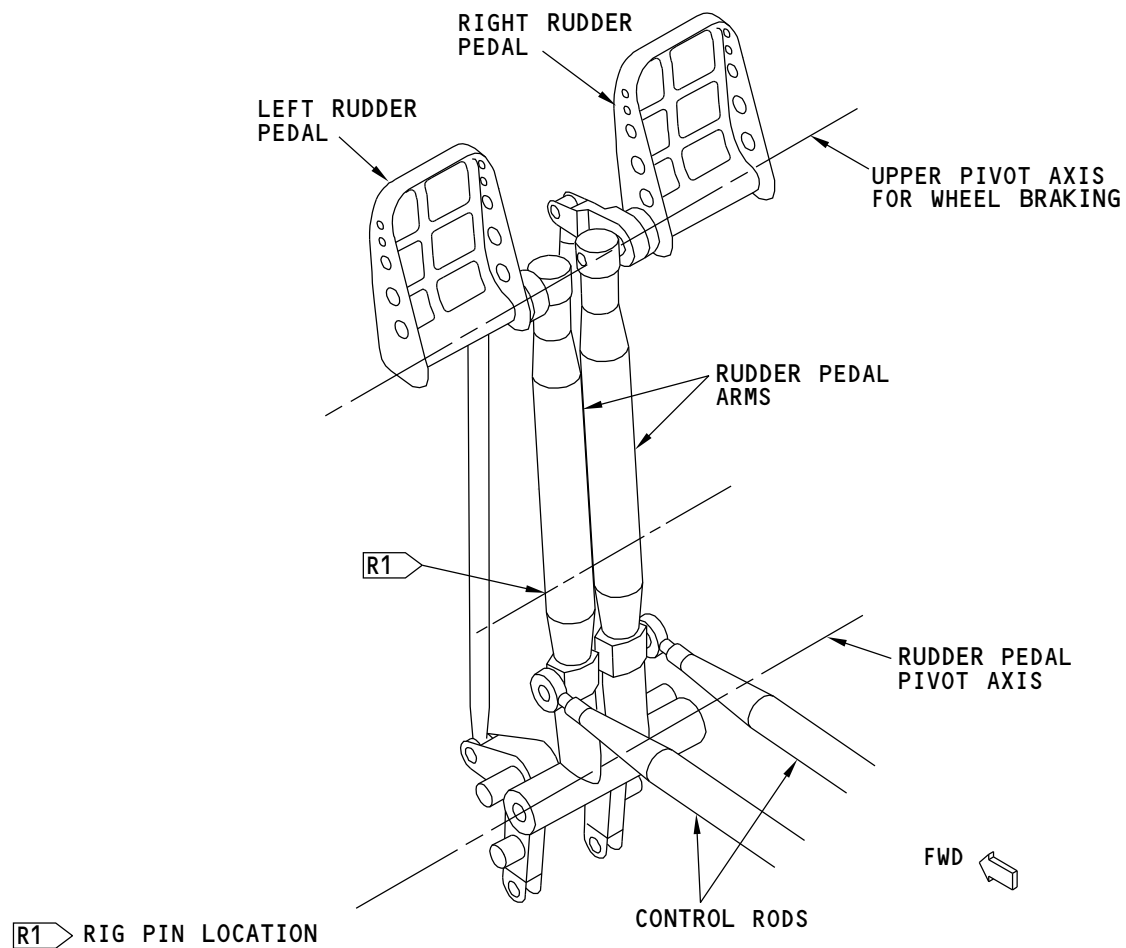
The rudder pedals are conventional in design. Each pilot has two pedals. The pedals of each pair move in opposite direction of each other.

Functional Description

When the pilot moves the rudder pedals, the rudder pedal arms pivot on the rudder pedal pivot axis. Control rods transmit the movement of the rudder pedal arms to the jackshaft assemblies and the yaw control system.

The pilot also uses the rudder pedals to operate the wheel brakes. The pedals then rotate on their upper pivot axis.

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RUDDER CONTROL - PEDAL ASSEMBLY

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RUDDER CONTROL - JACKSHAFT ASSEMBLY

Purpose

The purpose of the jackshaft assemblies is to transmit rudder pedal movement to the left and right shaft assemblies. The bus rod connects the two sets of rudder pedals together. Command of the rudder pedals by one pilot results in the backdrive of the other set of rudder pedals.

The right jackshaft assembly also transmits the movement of the rudder pedals to the nose wheel steering system.

Both jackshaft assemblies have a rudder pedal adjustment. It permits the pilots to adjust the rudder pedals to the most comfortable position.

Jackshaft Assemblies

The jackshaft assemblies have a shaft on which a sleeve yoke slides. The two ends of the yoke attach to the control rods from the rudder pedals. The bus rod connects the two jackshaft assemblies together. A control rod connects each jackshaft assembly to the right and left shafts.

The left and right jackshaft assemblies are the same except for their shaft. The right shaft has a spline at the lower end. The nose wheel steering crank is on the spline. The crank connects to the nose wheel steering mechanism.

Rudder Pedal Adjustment

A rudder pedal adjustment crank is in front of each pilot.

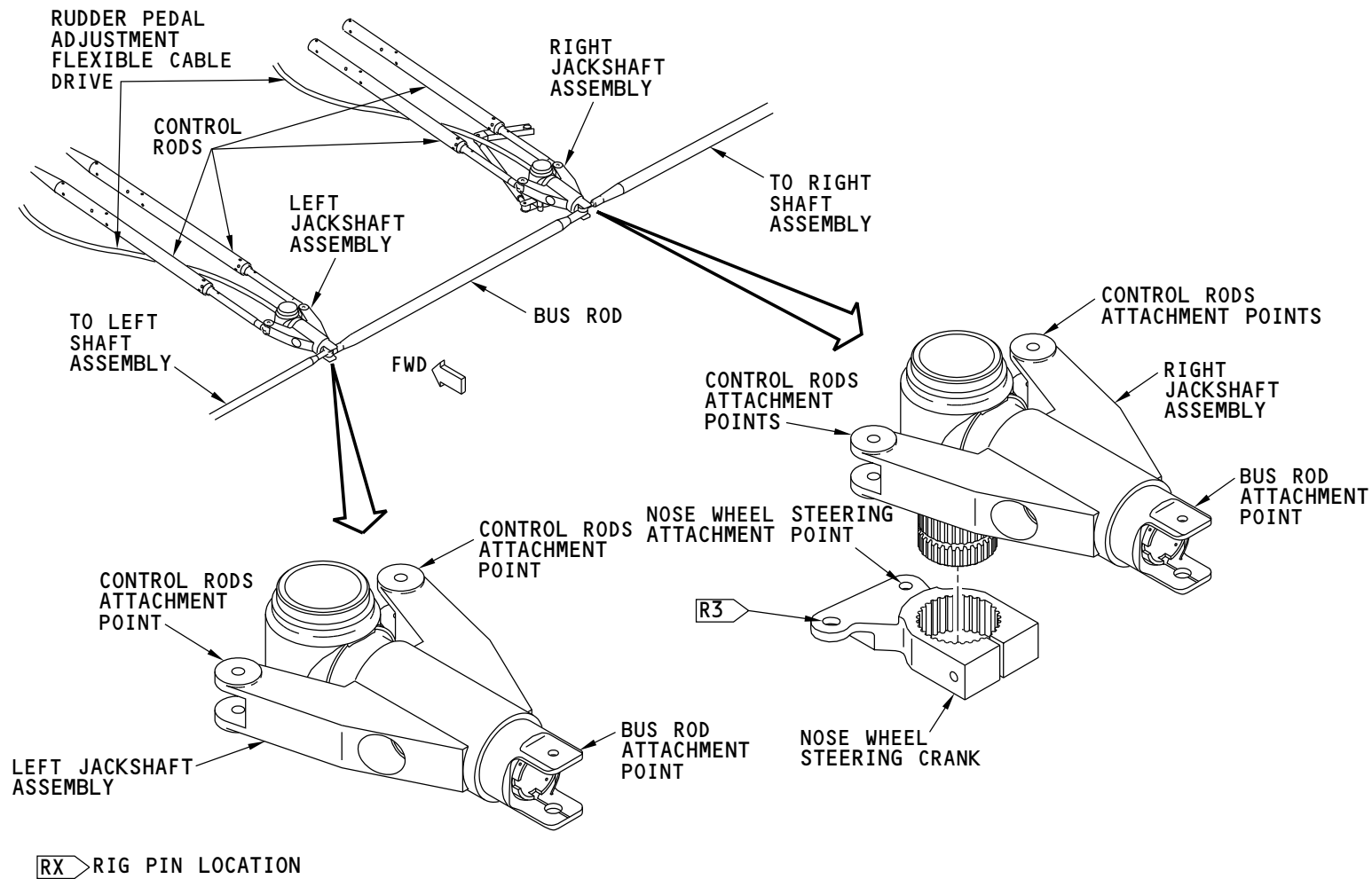
The rudder pedal adjustment crank connects to a flexible cable drive. The flexible cable drive rotates the screw inside the jackshaft assembly. This causes the internal nut and the sleeve yoke to move fore and aft. The control rods connected to the yoke and the rudder pedals cause the rudder pedal arms to move one set of rudder pedals. The pilots adjust each set of rudder pedals independently of the other set without any input to the yaw control system.

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RUDDER CONTROL - JACKSHAFT ASSEMBLY

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**RUDDER CONTROL - CONTROL AND BUS RODS****Purpose**

The control and bus rods transmit movement from the rudder pedals to the yaw control.

The rods include:

- Control rods between the rudder pedals and the jackshaft assemblies
- A bus rod between the two jackshaft assemblies
- Control rods between the jackshaft assemblies and the shaft assemblies.

Control Rods

Four identical control rods connect the rudder pedals to the sleeve yokes of the jackshaft assemblies. These rods have a one-way pogo. The pogo spring permits only compression of the rod. A force of 12 to 15 lb (5.4 to 6.8 kg) at the pedal causes a breakout. The length of these control rods is adjustable.

Two identical control rods connect the jackshaft assemblies to the crank of the shaft assemblies. The length of these control rods is adjustable.

Bus Rod

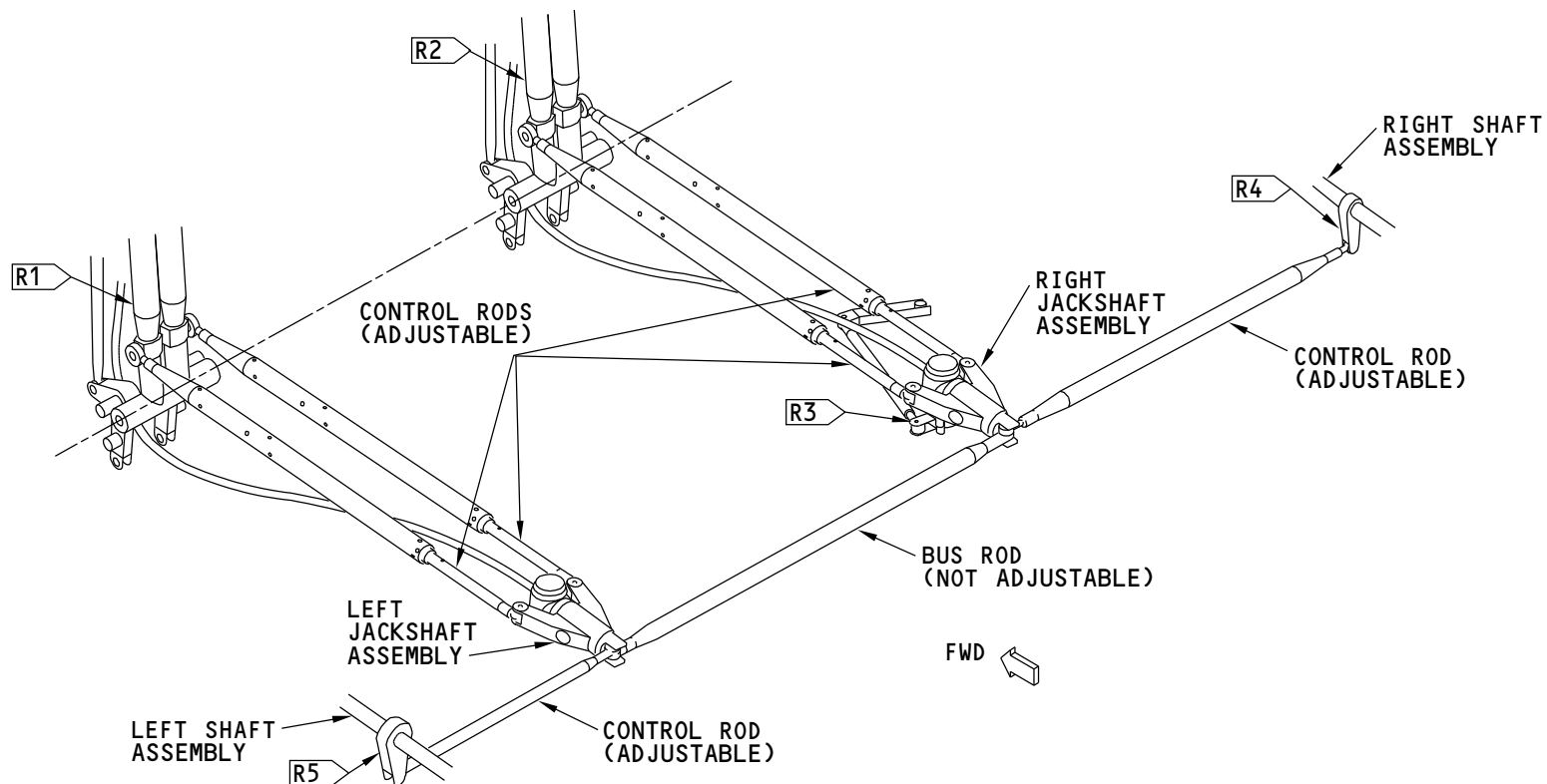
The bus rod connects the two jackshaft assemblies. The length of this bus rod is not adjustable.

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NOTE: EXPANDED VIEW
 [RX] RIG PIN LOCATION

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RUDDER CONTROL - CONTROL AND BUS RODS

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RUDDER CONTROL - FEEL AND CENTERING MECHANISM

Purpose

The rudder feel and centering mechanism supplies feel and centering forces to the yaw control system. The rudder trim actuator supplies rudder trim control. The rudder trim moves the neutral position of the rudder and the rudder pedals.

Physical Description

The feel and centering mechanism has a single cam and roller unit. The cam attaches by a spline to the left shaft assembly and turns with it. The follower assembly has a roller which rolls on the cam surface. An arm supports the follower assembly. The arm pivots on a lever bearing mounted on the left shaft assembly. The lever attaches to the trim actuator rod end. Two springs, between the lever and the arm of the follower assembly, keep the roller on the cam.

The rudder trim actuator attaches to the structure of the left shaft assembly. The rod end of the actuator connects to the lever of the feel and centering mechanism. The rudder trim position transducer also connects to the lever of the feel and centering mechanism.

Location

The feel and centering mechanism is in the mechanism of the left shaft assembly, between the flight deck floor and the nose gear wheel well. Access is through the MEC, then along the left side of the nose gear wheel well.

Functional Description

As the left shaft assembly and the cam turn, the cam follower moves, which extends the two springs. The springs supply a feel force to the rudder pedals. The feel force varies from 19.5 lb (8.8 kg) at breakout to a maximum of 50 lb (22.7 kg) at full displacement of the rudder pedals.

When the pilots release the rudder pedals, the springs force the cam follower back to the cam detent. This returns the system to the neutral trimmed position. The neutral, or zero feel force position, varies with trim input.

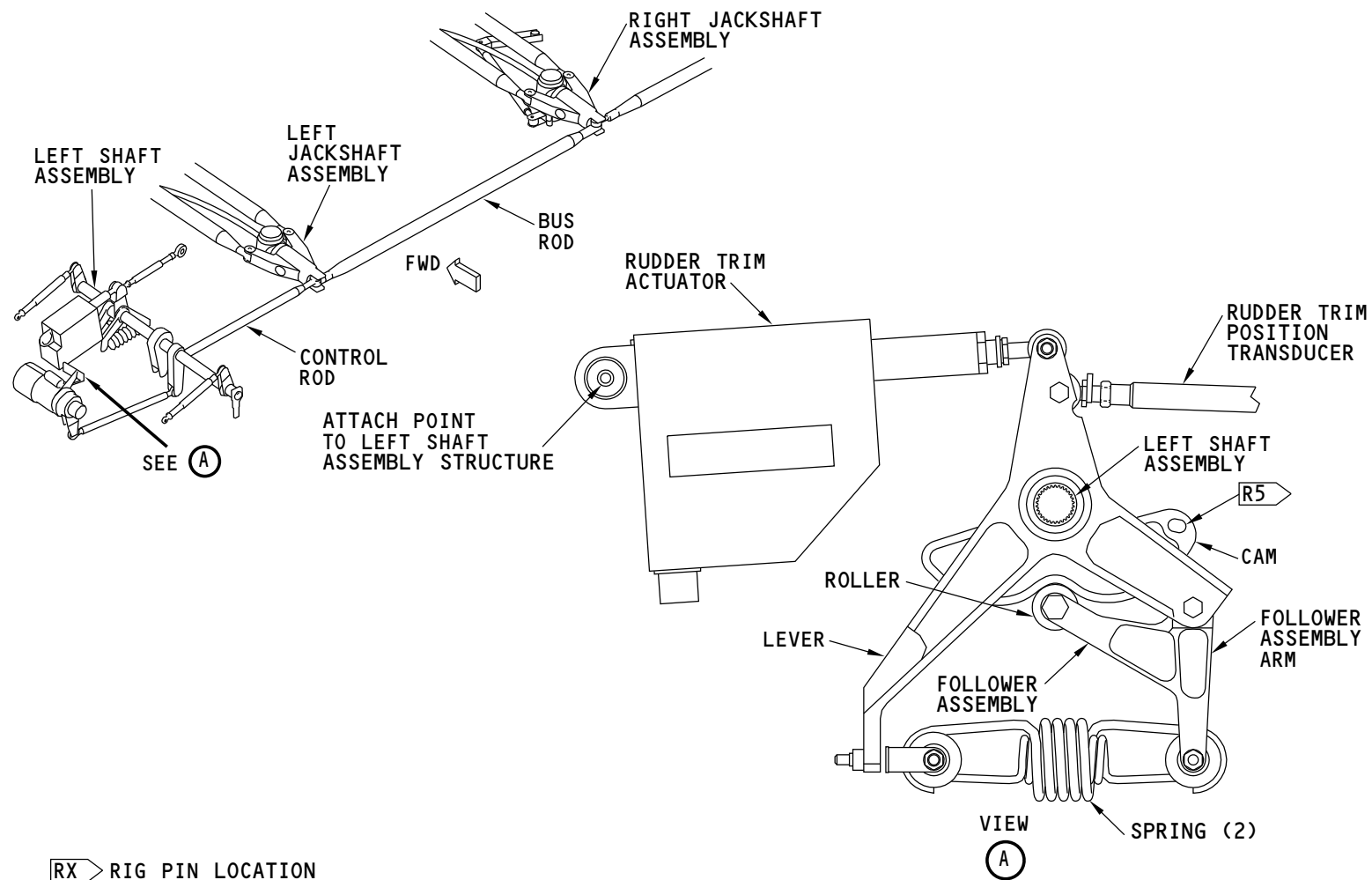
During trim operation, the rudder trim actuator moves the lever and the rudder trim position transducer, which then moves the arm and the cam follower assembly. Since the springs keep the cam follower in the cam detent, the trim actuator causes the cam and the left shaft assembly to turn. This also moves the rudder pedals and the rudder pedal position transducers.

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RUDDER CONTROL - FEEL AND CENTERING MECHANISM

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RUDDER CONTROL - RUDDER TRIM CONTROLS AND TRIM ACTUATOR

Purpose

The pilots use two controls to adjust the trim of the airplane about the vertical axis. The two controls are the rudder trim control and the manual trim cancel switch.

The rudder trim control commands the direction and rate of rudder trim. The manual trim cancel switch commands the rudder to the center position and cancels any rudder trim input by the pilot. The manual trim cancel switch does not remove any rudder trim caused by TAC.

The rudder trim actuator extends and retracts to execute the pilot trim commands.

The rudder trim indicator shows the position of the rudder trim actuator.

Location

The two rudder trim controls are on the aft end of the P8 aft aisle stand. The rudder trim position indicator is in front of the trim switches.

The trim actuator is under the flight deck floor.

Trim Controls Physical Description

The rudder trim selector is a self-centering, dual-torque switch. It supplies the L1 and R ACEs with these electrical signals:

- Arm
- Trim direction (left or right)
- Trim rate.

The manual trim cancel switch is a momentary push button switch. It sends an electrical signal to the R ACE.

Trim Control Operation

When the pilot turns the rudder trim selector less than 25 degrees, the trim actuator does not move. When the pilot turns the trim selector more than 25 degrees, the trim actuator moves at 0.5 unit per second in the direction selected. When the pilot turns the trim selector more than 40 degrees with greater force, the trim actuator moves at 2 units per second in the direction selected.

When the pilot pushes on the manual trim cancel switch, it causes the rudder trim actuator to center the rudder control system at 2 units per second.

Rudder Trim Actuator Physical Description

The rudder trim actuator is a line replaceable unit (LRU). It weighs 4.1 lb (1.9 kg). Electrical commands limit the stroke of the actuator to 3 inches. Mechanical stops limit the actuator stroke to 3.2 inches.

Rudder Trim Position Indicator Physical Description

The rudder trim position indicator is an LRU. It weighs 1.7 lb (0.8 kg).

The rudder trim pointer shows the position of the rudder trim actuator. The indicator scale shows 17 units of actuator trim in both directions. Each unit of pointer movement is equivalent to about 1 degree of rudder movement at low airspeed.

Indications

The warning message CONFIG RUDDER shows on the EICAS display when all of these conditions occur:

- The rudder trim is not within 2 units from center
- Either the left or right engine thrust is more than the takeoff threshold
- The airplane is on the ground.

The status message FLIGHT CONTROL SYS shows on the status display when the rudder trim system is defective.



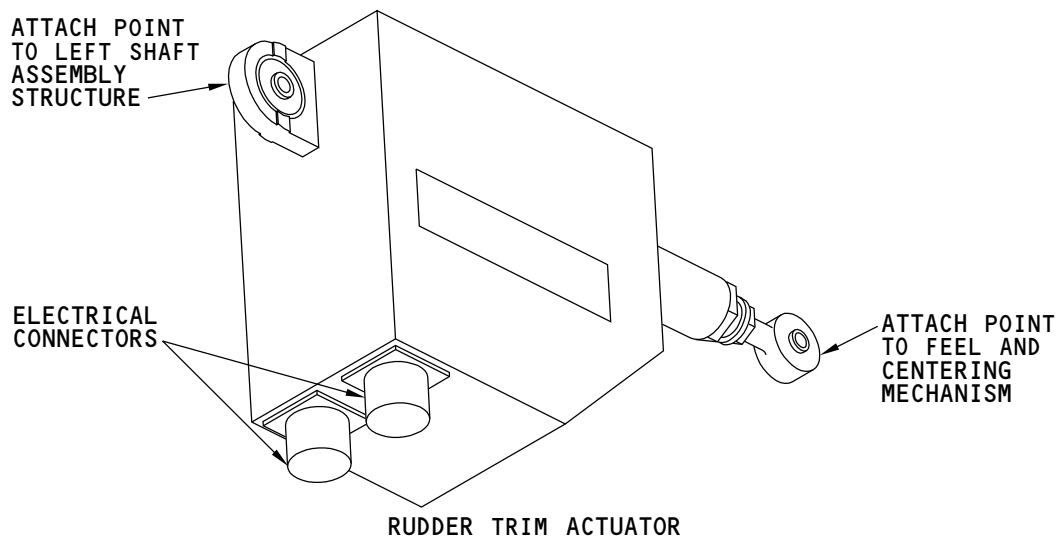
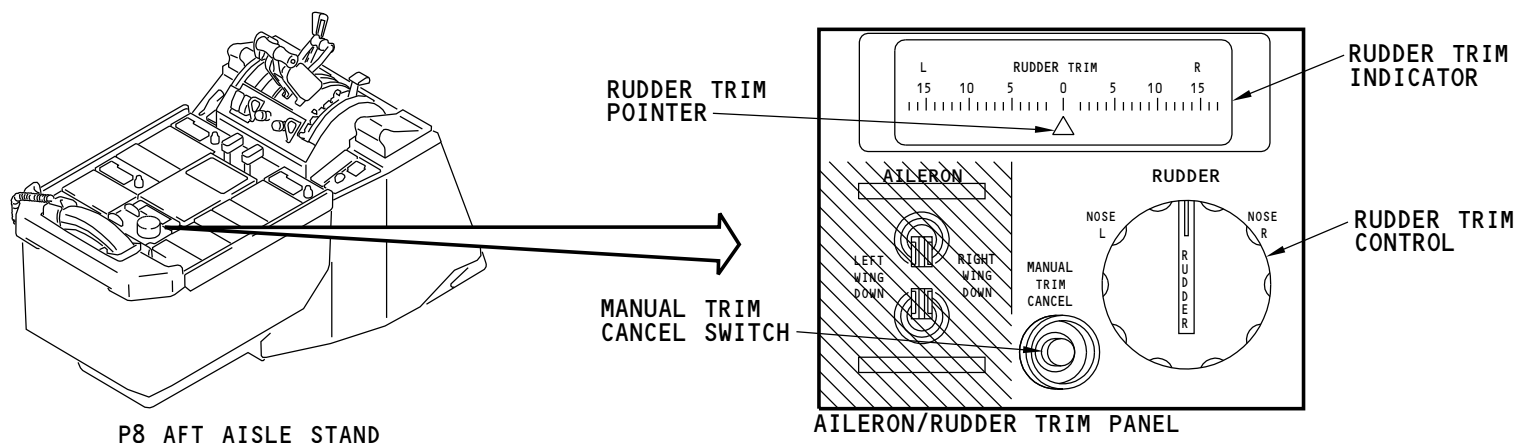
RUDDER CONTROL - RUDDER TRIM CONTROLS AND TRIM ACTUATOR

Training Information Point

In case of a power supply failure to the indicator, the indicator pointer, scale, and nomenclature are not visible. In case of input signal loss, the indicator pointer is not visible but the scale and nomenclature stay visible.

There is an adjustment on the trim actuator rod end. You adjust the rudder trim actuator to make sure that the manual trim cancel switch function moves the trim actuator to the zero trim position.

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RUDDER CONTROL - RUDDER TRIM CONTROLS AND TRIM ACTUATOR

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**RUDDER CONTROL - RUDDER TRIM POSITION TRANSDUCER****Purpose**

The rudder trim position transducer sends a feedback electrical signal to the R ACE. This measures the position of the rudder trim actuator.

Physical Description

The position transducer is an LVDT. The ACE supplies 7v ac, 1800 Hz excitation power.

The rudder trim position transducer is the same as the six wheel position transducers, the six column position transducers, and the four pedal position transducers.

The cable side of the rudder trim position transducer connects to a bracket on the structure of the left shaft assembly mechanism. The adjustable side of the rudder trim actuator connects to the lever of the feel and centering mechanism.

The rudder trim position transducer has an electrical cable which connects to an ACE connector bracket.

Location

The rudder trim position transducer is on the left side, outboard of the nose gear wheel well. Access is through the MEC, along the left side of the nose gear wheel well.

Functional Description

When the rudder trim actuator moves, the movement of the lever of the feel and centering mechanism causes the rudder trim position transducer to extend or retract. The position transducer sends an analog electrical signal to the R ACE.

Indications

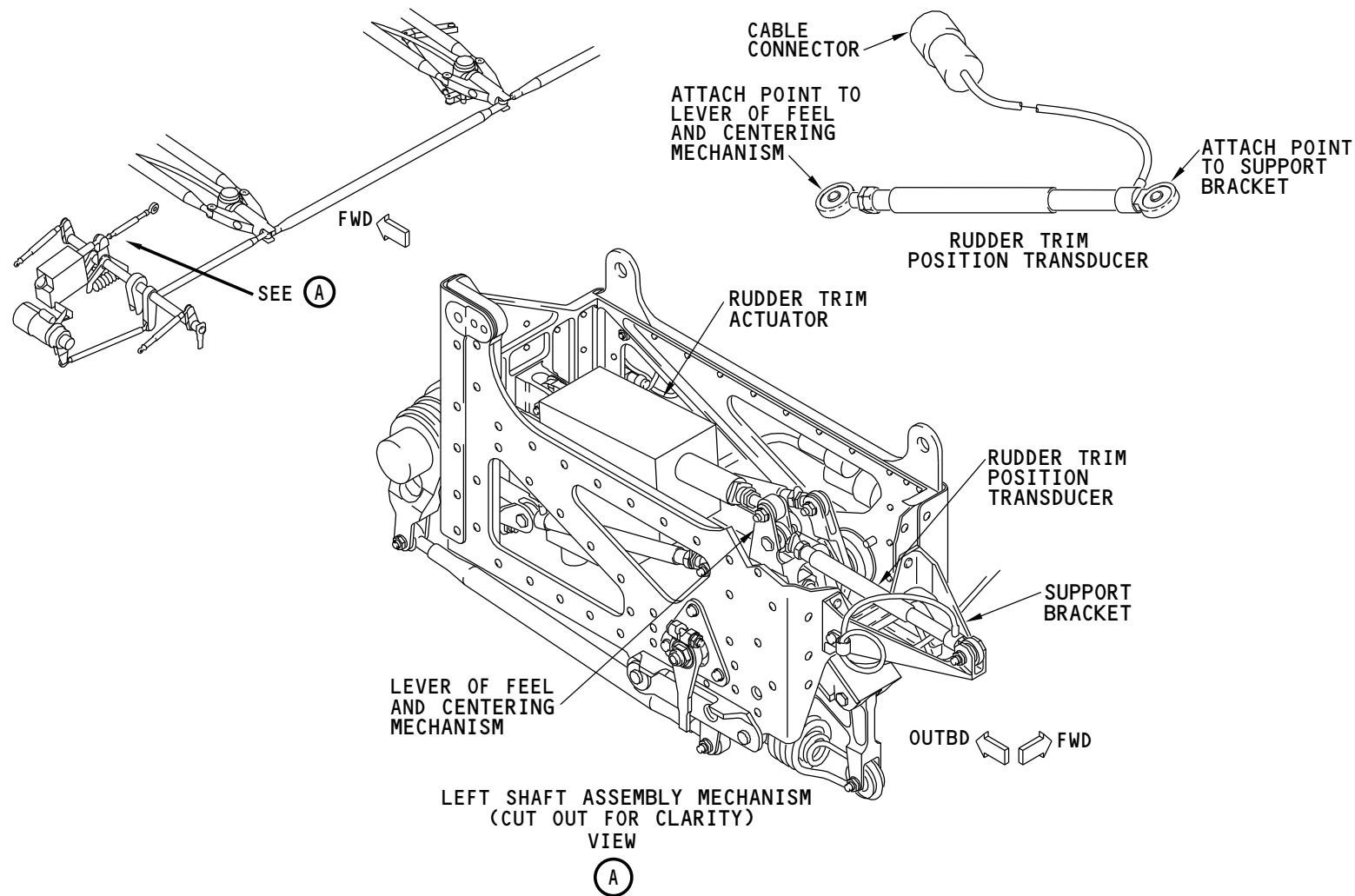
When the rudder trim position transducer is defective, the rudder trim system does not operate. The advisory message THRUST ASYM COMP and the status message FLIGHT CONTROL SYS then show.

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RUDDER CONTROL - RUDDER TRIM POSITION TRANSDUCER

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**RUDDER CONTROL - RUDDER PEDAL POSITION TRANSDUCERS****Purpose**

The four rudder pedal position transducers measure the position of the rudder pedals. The transducers send analog electrical signals to the ACEs.

Physical Description

Each position transducer is an LVDT. The ACEs supply 7v ac, 1800 Hz excitation power.

The four rudder pedal position transducers are identical to the six wheel position transducers, the six column position transducers and the rudder trim position transducer.

Two rudder pedal position transducers are on the right shaft assembly and two are on the left shaft assembly. The position transducers attach at one end to the support structure of the shaft assembly mechanisms. They attach to the transducer crank at the other end.

Each transducer crank attaches to its shaft assembly with a spline. The spline has a missing tooth to help locate the crank on the shaft. Each transducer crank has two shear rivets to allow override of a jammed position transducer.

Each position transducer has an electrical cable which connects to the ACE connector bracket. This bracket has two receptacles, one for each position transducer. The order in which each position transducer connects to the connector bracket determines the transducer-to-ACE relationship.

Location

The four rudder pedal position transducers are outboard of the nose gear wheel well. Access is through the MEC, then along either side of the nose gear wheel well.

Functional Description

When the right and left shaft assemblies rotate in response to a rudder pedal command, the rudder pedal position transducers extend or retract. Each position transducer sends an analog electrical signal to one ACE.

Indications

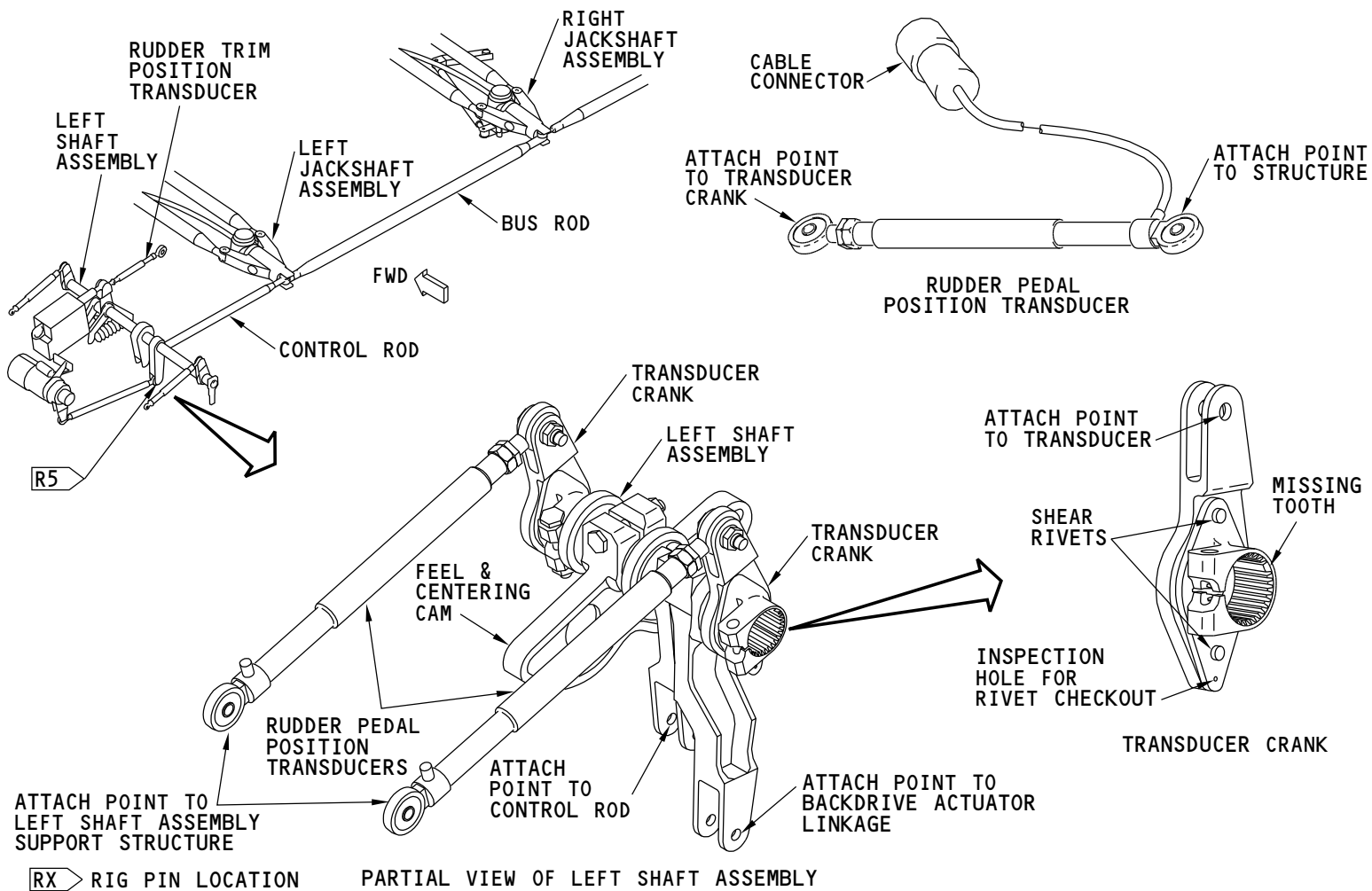
When one or more pedal position transducer is defective, the status message FLIGHT CONTROL SYS shows.

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RUDDER CONTROL - RUDDER PEDAL POSITION TRANSDUCERS

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**RUDDER CONTROL - FRICTION BRAKE****Purpose**

The friction brake supplies a resistive force to the movement of the rudder pedal forward controls. This resistive force is equivalent to the typical resistance of a cable-controlled system.

Physical Description

The friction brake is an LRU and weighs about 2.5 lb (1.1 kg).

The friction brake is in a casing which connects to the structure of the right shaft assembly mechanism. The casing contains a rotor which connects by a spline to the right shaft assembly.

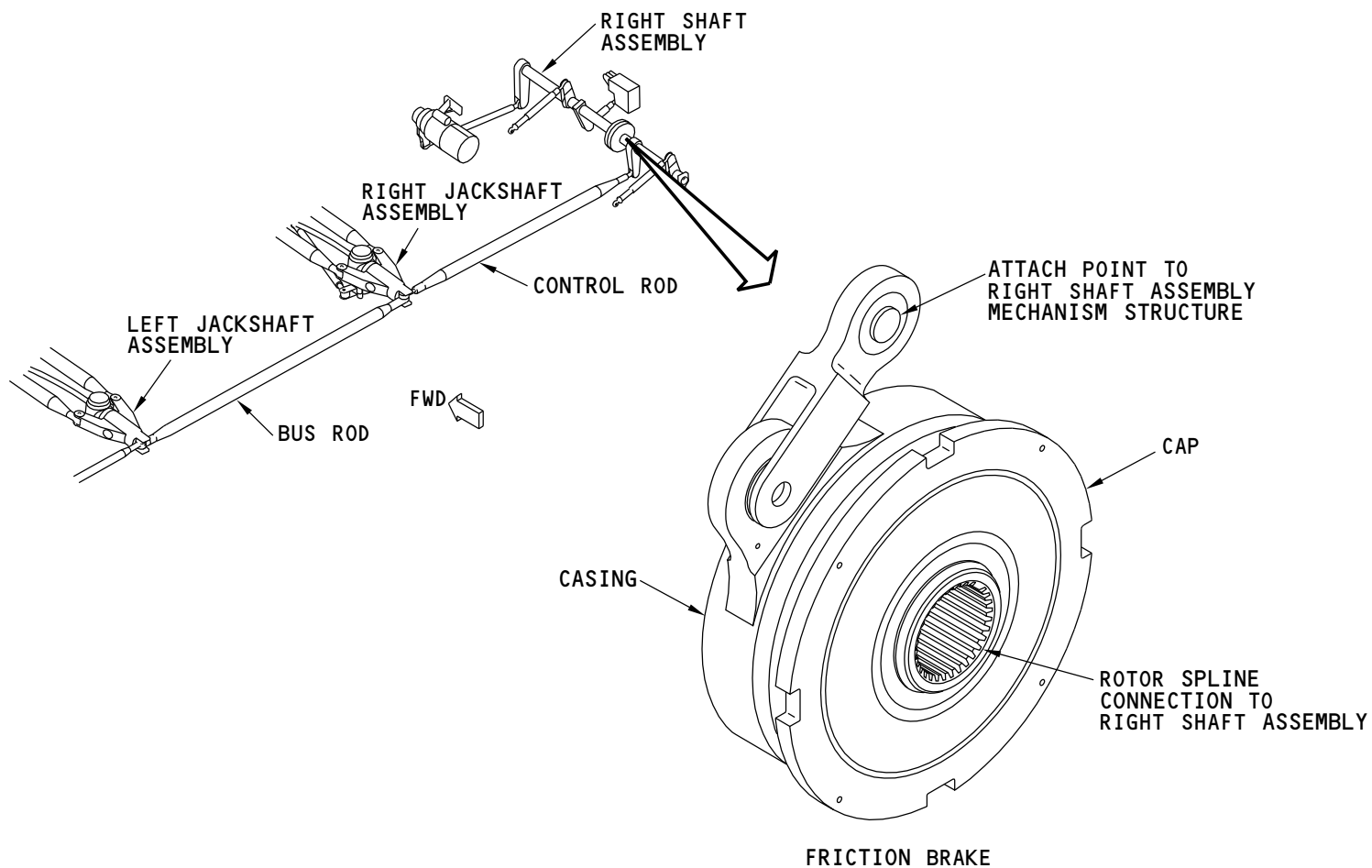
Location

The friction brake is within the mechanism of the right shaft assembly, between the flight deck floor and the right side of the nose gear wheel well. Access is through the MEC, then along the right side of the nose gear wheel well.

Functional Description

As the right shaft assembly turns, the friction brake creates a resistive force of about 2 lb (0.9 kg) at the rudder pedals. This resistive force is in addition to the force of the feel and centering mechanism.

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RUDDER CONTROL - FRICTION BRAKE

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RUDDER CONTROL - PEDAL DAMPER

Purpose

The pedal damper absorbs rudder pedal vibrations and brings the rudder control system to rest with minimum oscillation.

Physical Description

The pedal damper is an LRU and weighs about 1.6 lb (0.7 kg).

The pedal damper is identical to the wheel damper and the two column dampers. There are four of these identical dampers on the airplane.

The damper is on the structure of the right shaft assembly mechanism. A pair of cranks and a control rod connect the damper shaft to the right shaft assembly. The control rod is not adjustable.

The pedal damper has an input shaft. The pedal damper uses fluid to absorb vibrations that go to the shaft. A window on the pedal damper shows the position of the fluid level indicator.

The damper crank, on the damper shaft, has a pair of rivets. These shear out in case of a jam of the damper.

Location

The damper is on the side of the mechanism of the right shaft assembly, between the flight deck floor and the right side of the nose gear wheel well. Access is through the MEC, then along the right side of the nose gear wheel well.

Functional Description

As the right shaft assembly turns, it turns the shaft of the damper which absorbs the vibration of the rudder pedal control system. The damper adds a small force to the rudder pedal control system.

Training Information Point

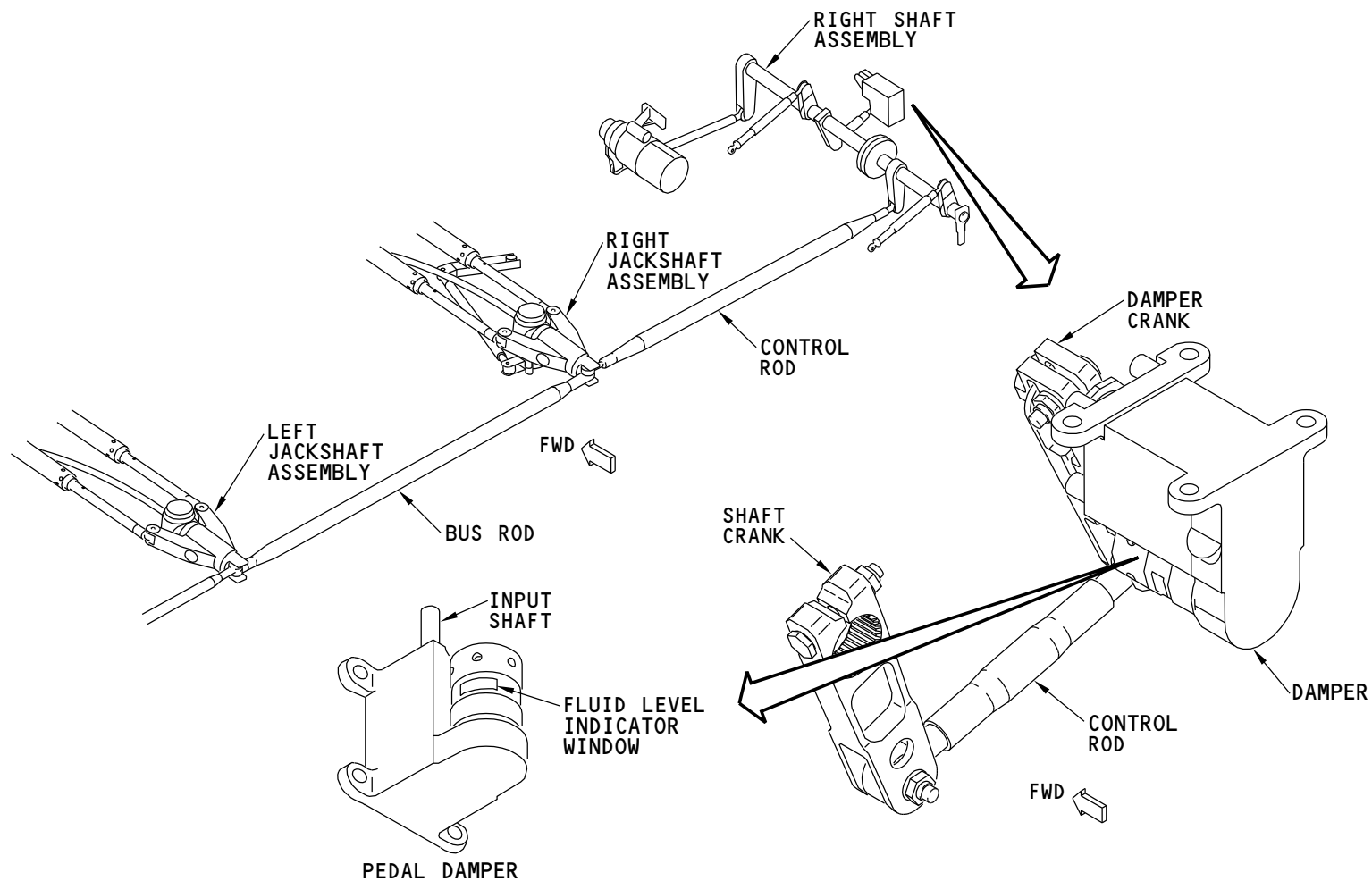
Insert a pin through the inspection hole in the damper crank to check the rivet condition.

If the fluid level indicator shows a green band width of 1/16 inch or less, the fluid level is low. Then it is necessary to replace the pedal damper.

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RUDDER CONTROL - PEDAL DAMPER

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**RUDDER CONTROL - MODAL ACCELEROMETERS****Purpose**

The modal accelerometers measure the lateral acceleration of the aft fuselage. They send an analog signal to the ACEs.

The modal suppression function of the primary flight control system helps improve the quality of passenger ride in the forward and aft sections of the cabin.

Physical Description

There are two identical modal accelerometers. They are LRUs. Each accelerometer weighs about 0.8 lb (0.36 kg).

An electrical cable connects to a connector on each modal accelerometer.

Each modal accelerometer attaches to a support bracket.

Location

The modal accelerometers are on a cabin floor beam of the aft fuselage. One accelerometer is at each outboard side of the beam.

To get access to the modal accelerometers, it is necessary to remove the sidewall liners of the bulk cargo compartment. The modal accelerometers are outboard of the sidewall stanchions of the bulk cargo compartment.

Functional Description

Lateral movement of the aft fuselage causes a change of the analog signal from the modal accelerometer to the ACE.

Indications

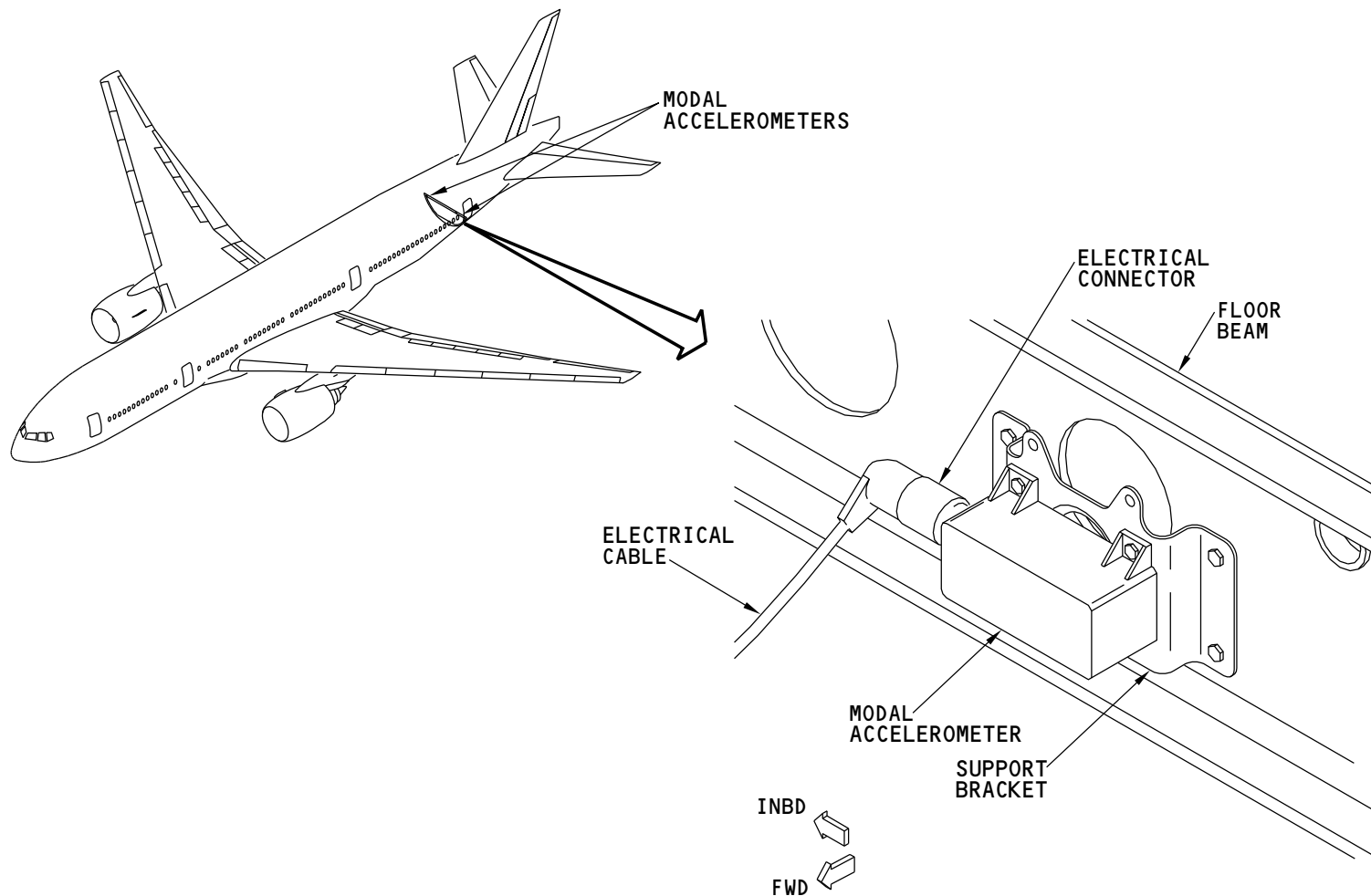
There is no flight deck indication if one or both modal accelerometers are defective.

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RUDDER CONTROL - MODAL ACCELEROMETERS

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**RUDDER CONTROL - GUST SUPPRESSION PRESSURE TRANSDUCERS****Purpose**

The gust suppression pressure transducers measure the pressure difference between both sides of the vertical stabilizer. They also supply an electrical analog signal to the ACEs.

The gust suppression function helps improve the quality of passenger ride in the aft portion of the fuselage.

Physical Description

There are two identical pressure transducers and four identical pressure ports. The transducers and the ports are LRUs. Each transducer weighs about 2 lb (0.9 kg).

Each pressure transducer connects to two pressure ports. The ports are symmetrically positioned, one on each side of the vertical stabilizer. Non metallic hoses connect the ports to the pressure transducers. An electrical cable connects to one connector on the differential pressure transducer.

There is about 6 ft (1.83 m) separation between the two pressure transducers and their associated ports.

Location

The gust suppression pressure transducers are near the vertical stabilizer leading edge, on the aft side of the auxiliary spar. The ports are on the composite skin panels of the vertical stabilizer. The pressure transducers are above the pressure ports to permit drainage of moisture from the tubes and the ports.

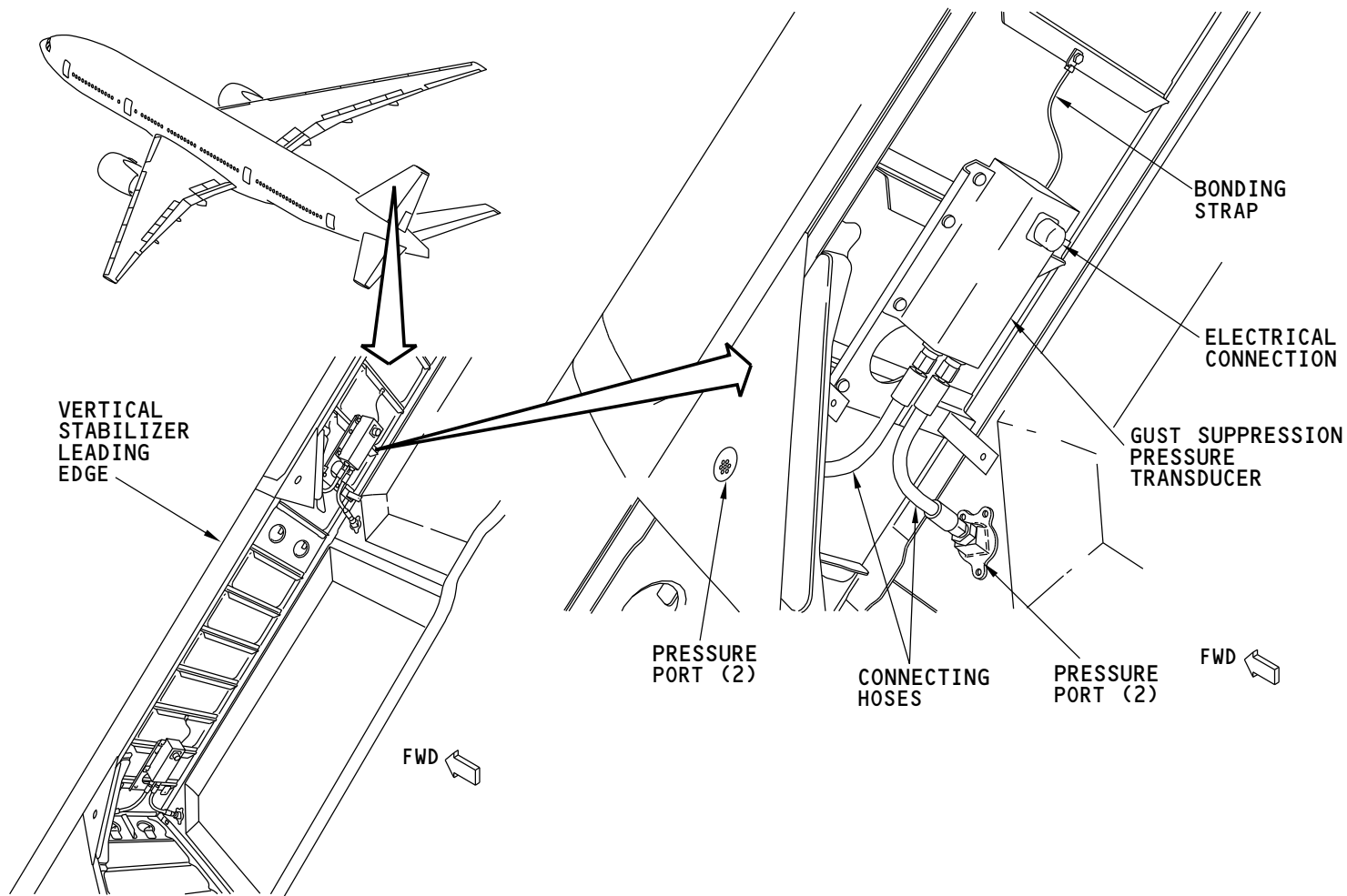
To get access to each transducer, remove a skin panel of approximately 30 in x 48 in (0.76 m x 1.22 m) on the left side of the vertical fin.

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RUDDER CONTROL - GUST SUPPRESSION PRESSURE TRANSDUCERS

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**RUDDER CONTROL - RUDDER PCU - INTRODUCTION****Purpose**

Three rudder PCUs move the rudder. Electrical signals from the ACEs command the rudder PCUs. Each rudder PCU operates with hydraulic power from a different hydraulic system.

Location

The rudder PCUs are on the rear spar of the vertical stabilizer. Remove three panels on the left side of the vertical stabilizer to access the PCUs. Each panel is approximately 20 in x 20 in (0.5 m x 0.5 m).

Physical Description

The kick link connects the PCU to the rear spar fitting. The actuator rod and the reaction link connect to the rudder PCU fitting.

Two electrical connectors of different sizes connect to the lower side of the PCU.

Hydraulic tubing connects to ports on the upper side of the PCU.

The right hydraulic system supplies power to the lower rudder PCU, the left hydraulic system to the middle PCU, and the center hydraulic system to the upper PCU.

A rate fuse is on the center hydraulic system supply line to the upper PCU. A check valve is on the return line from the upper PCU to the center system.

Training Information Point

Remove and install the rudder PCU as one assembly with the reaction link. The rudder PCU disconnects from the kick link which stays on the airplane.

Install a hoist swivel fitting to the hoist attach point of the PCU. Use a ground support equipment (GSE) hoist to support the PCU during removal and installation.

After installation of the rudder PCU, the actuator null LVDT requires adjustment. Remove the null LVDT access cover to adjust the null LVDT.

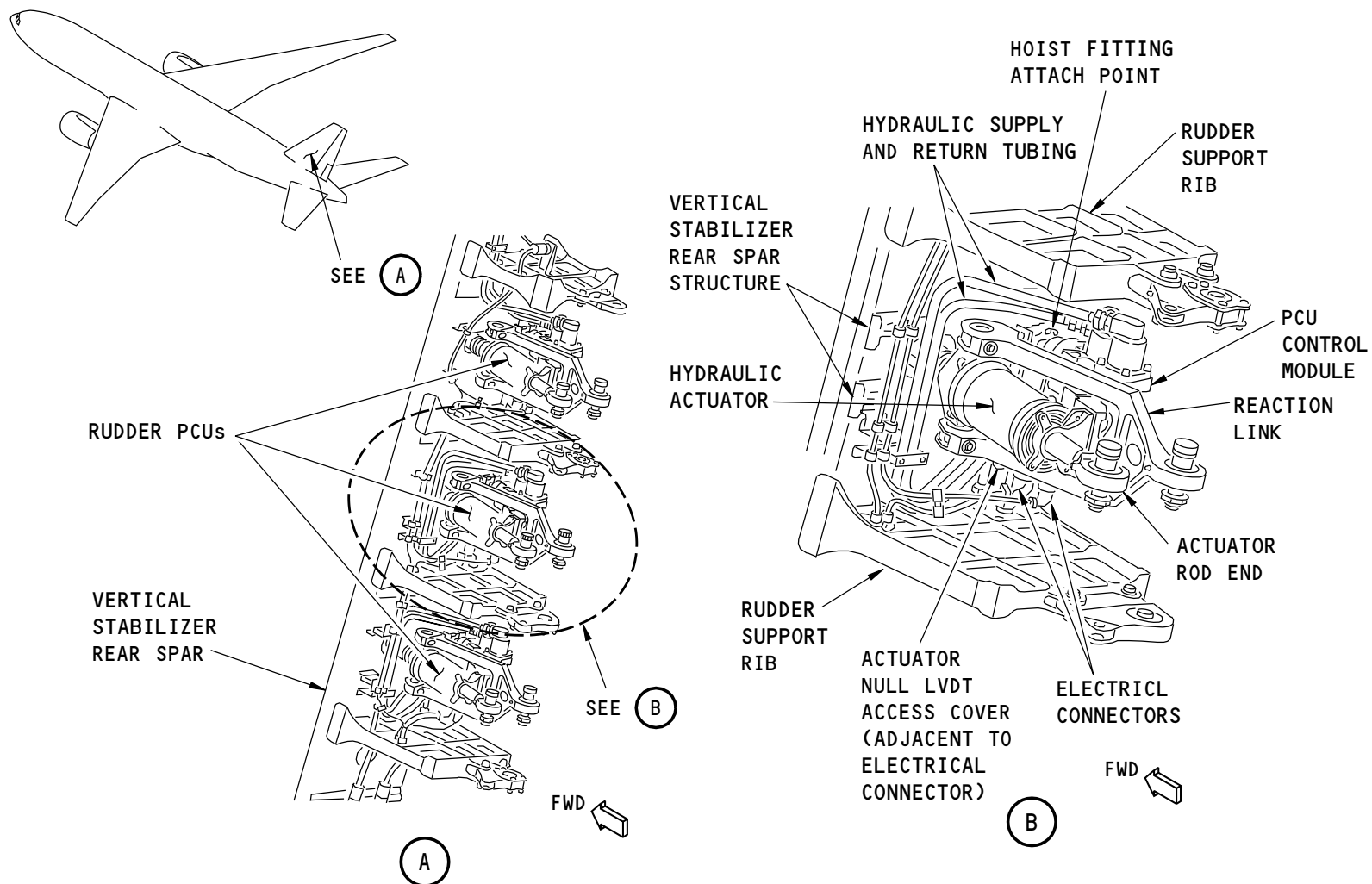
Put the nose gear steering tow lever in the tow position before you move the rudder pedals to operate the rudder system.

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RUDDER CONTROL - RUDDER PCU - INTRODUCTION

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RUDDER CONTROL - RUDDER PCU - PHYSICAL DESCRIPTION**Physical Description**

All three rudder PCUs are identical. Each rudder PCU, with its reaction link, weighs approximately 100.6 lb (45.6 kg).

The rudder PCU contains a hydraulic actuator with a control module. The control module contains:

- An electrohydraulic servo valve (EHSV)
- A pressure reducer solenoid valve
- A bypass solenoid valve
- A damped solenoid valve
- A mode selector valve
- A differential pressure sensor
- Two bypass check valves
- Two relief valves
- A thermal relief valve
- A compensator/relief valve
- Two anti-cavitation check valves
- An inlet check valve
- An inlet filter.

Hydraulic Actuator

The actuator piston has an LVDT that sends actuator position feedback signals to the ACE. The actuator piston also has a null LVDT to adjust the null position of the actuator piston LVDT during installation of the PCU.

EHSV

The EHSV controls the hydraulic power to the extend and retract sides of the actuator. The EHSV has an LVDT that sends EHSV position feedback signals to the ACE.

Pressure Reducer Solenoid Valve

The pressure reducer solenoid valve commands the pressure reducer valve to decrease the hydraulic pressure to 1640 psi. Reduced pressure on the actuator decreases the probability of leak and fatigue loads during normal operation.

If there is a PCU or hydraulic failure, the hydraulic pressure to one or both of the other two PCUs increases to the nominal hydraulic system pressure (3000 psi). The hydraulic pressure also increases to the nominal system pressure on all three PCUs during takeoff and landing.

Bypass Solenoid Valve

The bypass solenoid valve controls the pilot pressure from the hydraulic system to the mode selector valve.

Damped Solenoid Valve

The damped solenoid valve controls the pilot pressure from the actuator to the mode selector valve.

Mode Selector Valve

Pilot pressure from the bypass or the damped solenoid valves commands the mode selector valve in one of three positions:

- Normal
- Bypass
- Damped.

Differential Pressure Sensor

A differential pressure sensor measures the pressure difference between both sides of the actuator piston. The sensor operates an LVDT which sends signals to the ACE.

Bypass Check Valves

The two bypass check valves permit pressure from either side of the actuator to reach the damped solenoid valve.

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**RUDDER CONTROL - RUDDER PCU - PHYSICAL DESCRIPTION****Relief Valves**

The two relief valves protect the actuator in case of high pressure due to a hardover of an adjacent PCU.

Thermal Relief Valve

The thermal relief valve protects the actuator from thermal expansion of the hydraulic fluid.

Compensator/Relief Valve

The compensator/relief valve holds a small quantity of fluid above the hydraulic system return pressure. This fluid is available to the actuator to prevent cavitation.

Anti-cavitation Check Valves

The two anti-cavitation check valves permit return fluid from the compensator to flow to the actuator. This prevents cavitation of the actuator during rapid backdriving of the PCU.

Inlet Check Valve

The inlet check valve keeps the hydraulic fluid in the actuator when the hydraulic system power is lost.

Inlet Filter

The inlet filter protects the actuator from solids in the hydraulic fluid.

Training Information Point

Only the bearings in the actuator rod end and the reaction link, where they attach to the rudder, require lubrication.

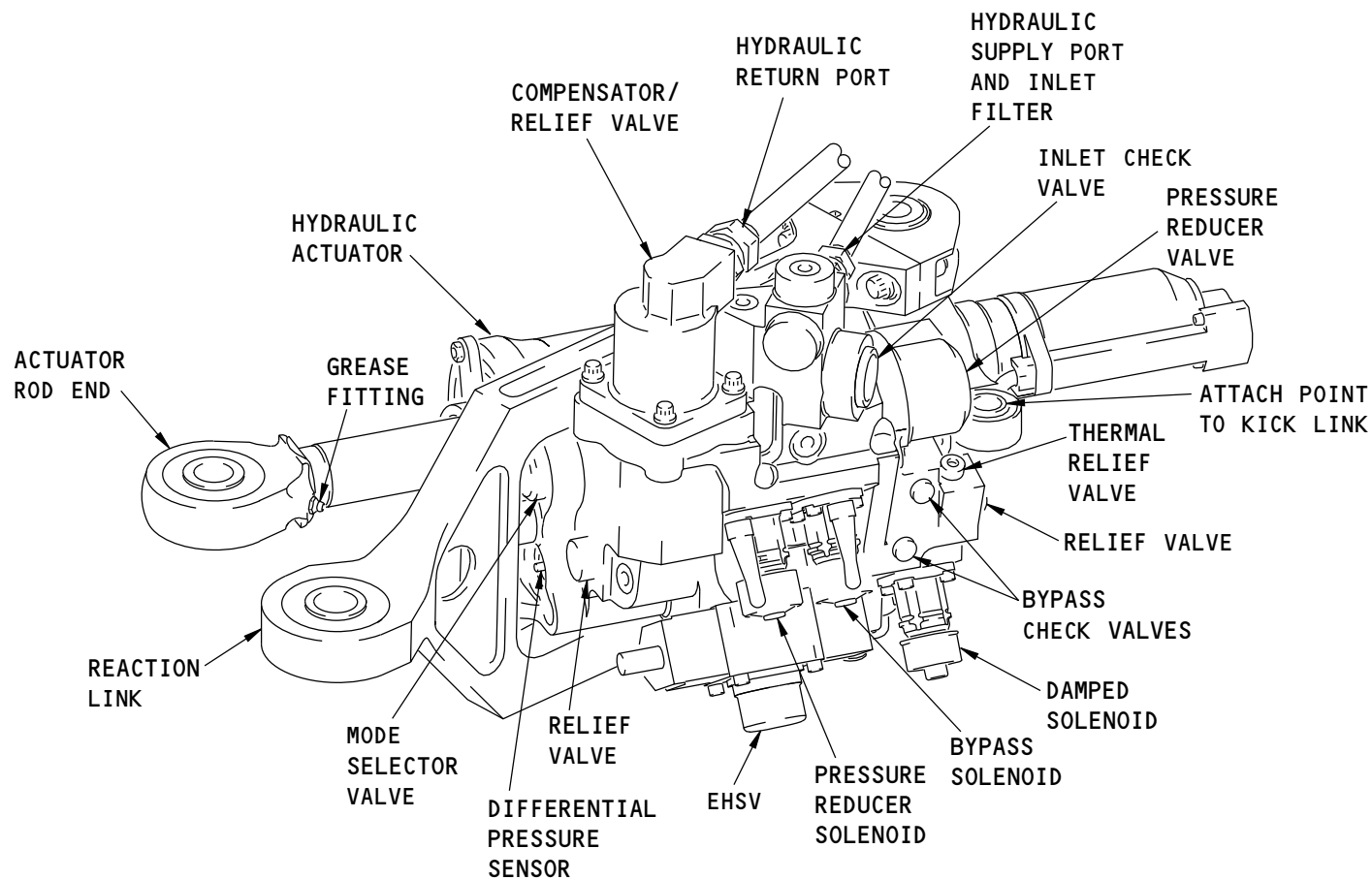
All other bearings on the actuator and reaction link are teflon coated bearings. They do not require lubrication.

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RUDDER CONTROL - RUDDER PCU - PHYSICAL DESCRIPTION

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RUDDER CONTROL - RUDDER PCU - FUNCTIONAL DESCRIPTION

General

The rudder PCU operates in three different modes:

- Normal
- Bypass
- Damped.

In the normal mode, the ACE energizes the bypass solenoid. The pressure reducer and the damped solenoid may or may not be energized.

In the bypass mode, the ACE de-energizes the bypass solenoid. The damped solenoid stays energized. The pressure reducer solenoid may or may not be energized.

In the damped mode, the ACE de-energizes the bypass solenoid and the pressure reducer solenoid. The damped solenoid is also de-energized.

PCU Operational Matrix

The table shows the various conditions of the PCU valve solenoids in the three modes of operation of the PCUs:

SOLENOID CONDITIONS	PCU MODES OF OPERATION		
	NORMAL	BYPASS	DAMPED
PRESSURE REDUCER SOLENOID	E/D*[1]*[2]	E/D*[1]*[2]	D*[2]
BYPASS SOLENOID	E*[1]	D*[2]	D*[2]
DAMPED SOLENOID	E/D*[1]*[2]	E*[1]	D*[2]

*[1] E = ENERGIZED

*[2] D = DE-ENERGIZED

Normal mode

The PCU is in normal mode when the ACE energizes the bypass solenoid. Hydraulic pilot pressure then moves the mode selector valve to the normal position.

For the conditions of the other PCUs, the ACE may or may not energize the pressure reducer solenoid and the damped solenoid. The status of the damped solenoid does not affect the operation in the normal mode.

When the pressure reducer solenoid is energized, the pressure reducer valve regulates the pressure to the EHSV to a lower nominal value. When the pressure reducer solenoid is de-energized, the pressure reducer valve allows full hydraulic system pressure to the EHSV.

Under these conditions, an electrical command to the EHSV results in the actuator extension or retraction.

Bypass Mode

The PCU is in bypass mode when the ACE de-energizes the bypass solenoid. The damped solenoid stays energized. This happens when there is a single hydraulic or electrical failure on the PCU or its ACE.

The bypass solenoid valve then blocks hydraulic pilot pressure to the mode selector valve. However, pressure from the actuator, trapped between the bypass check valves and the thermal relief valve, goes through the damped solenoid valve. This pilot pressure moves the mode selector valve to the bypass position.

Under these conditions, the mode selector valve blocks control pressure from the EHSV to the actuator cylinder. It also connects together both sides of the actuator.

When the PCU is in bypass mode, the other two PCUs backdrive it. These two PCUs then operate at full hydraulic system pressure.

During rapid backdrive of the PCU in bypass mode, the compensator/relief valve supplies fluid to the actuator through the anti-cavitation check valves.

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RUDDER CONTROL - RUDDER PCU - FUNCTIONAL DESCRIPTION**Damped Mode**

The PCU is in damped mode when the ACEs de-energize the bypass, pressure reducer and damped solenoids. This happens when the PCU has no power or there is a double or triple PCU or ACE failure.

In damped mode, there is no hydraulic pilot pressure on the mode selector valve. Its internal spring moves the valve to the damped position. The mode selector valve blocks control pressure from the EHSV to the actuator cylinder. It also connects both sides of the actuator piston through a restriction.

During rudder operation with a double failure, the good PCU moves the rudder very slowly.

Training Information Point

On the ground with no power on the PCUs, all three PCUs are in damped mode. The rudder can move slowly when an outside force pushes on it.

Indications

The EICAS status message ACTUATOR PRESS SNSR shows that the differential pressure sensor on one of the rudder PCUs is defective. The flaperon also uses the same message.

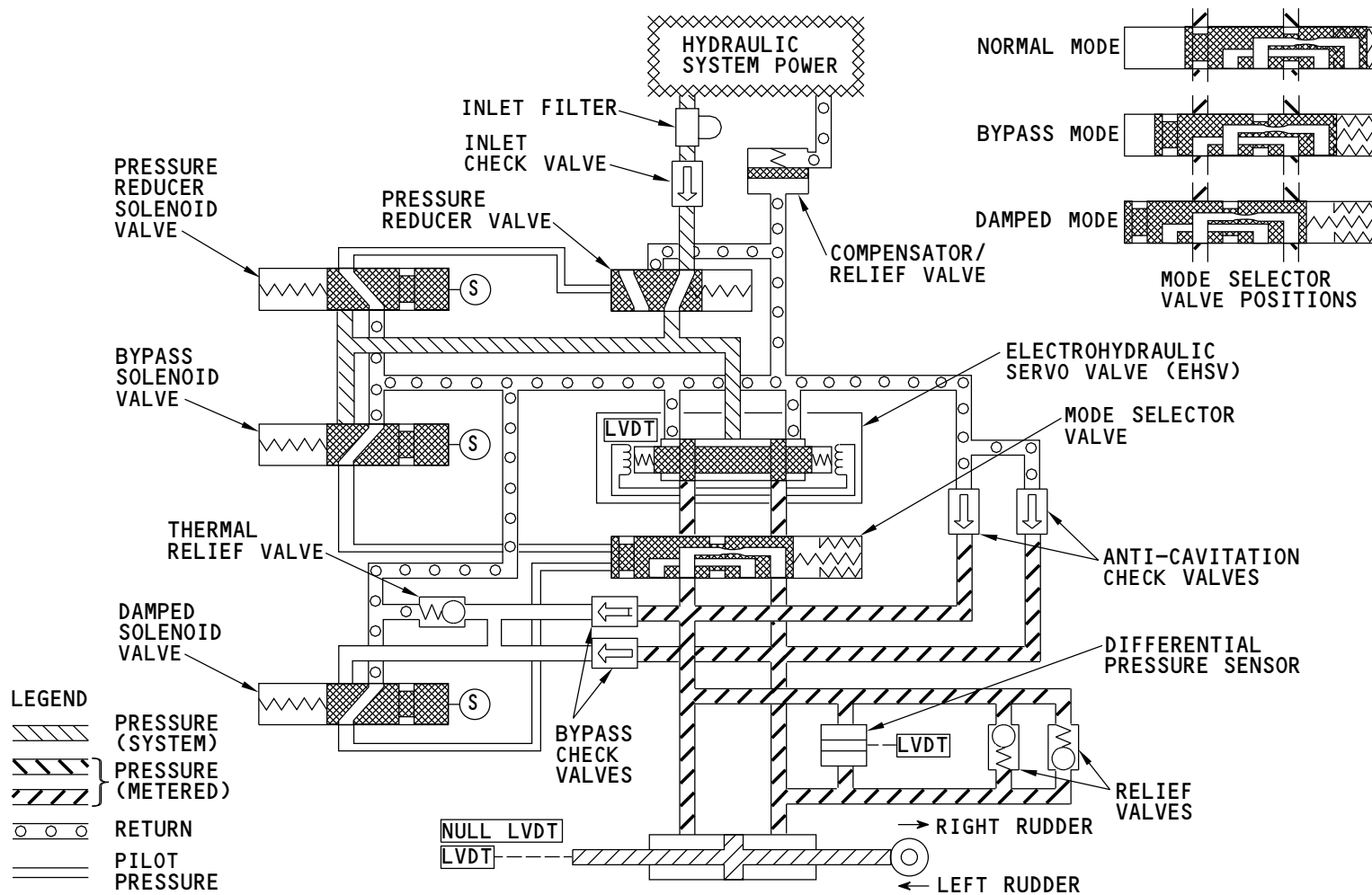
The EICAS status message FLIGHT CONTROL SYS shows that one or more rudder PCU is not operative.

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RUDDER CONTROL - RUDDER PCU - FUNCTIONAL DESCRIPTION

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RUDDER CONTROL - RUDDER PCU - FUNCTIONAL DESCRIPTION - PCU MODES

General

The ACEs control the three modes of operation of the rudder PCUs. Each ACE controls the bypass solenoid of its on-side PCU. It also controls the pressure reducer and damped solenoid of one adjacent PCU.

In normal mode of the PFCS, the PFCs command the ACEs to control the pressure reducer solenoid of all the rudder PCUs. In secondary and direct mode of the PFCS, each ACE controls individually the pressure reducer solenoids.

Normal Mode

A rudder PCU operates in normal mode when there is no failure on the PCU and its on-side ACE.

If the PFCS is in normal mode, the rudder PCU operates with reduced hydraulic pressure during cruise flight and when there is no failure with any rudder PCU or ACE. The PFCs command the PCUs to operate with full system pressure when one of these conditions occurs:

- A failure of one or more PCU
- The airplane is below 500 feet above ground
- The flaps are extended.

If the PFCS is in secondary and direct mode, the ACEs command the PCUs to operate with reduced system pressure when there is no failure of a PCU or ACE.

Bypass Mode

If the PCU has an electrical or hydraulic failure or there is a failure of its ACE, the ACE de-energizes the bypass solenoid. The PCU is then in bypass mode. The ACE also de-energizes the damped solenoid of the adjacent PCU which it also controls.

If the PFCS is in normal mode, the PFCs command all the ACEs to also de-energize the pressure reducer solenoid of all the PCUs. The two PCUs without failure then continue to operate with full hydraulic system pressure.

If the PFCS is in secondary or direct mode, the ACE de-energizes the pressure reducer solenoid of the adjacent PCU which it controls. In this case, one PCU is in bypass mode, one PCU operates in normal mode with full pressure and one PCU is in normal mode with reduced pressure.

Damped Mode

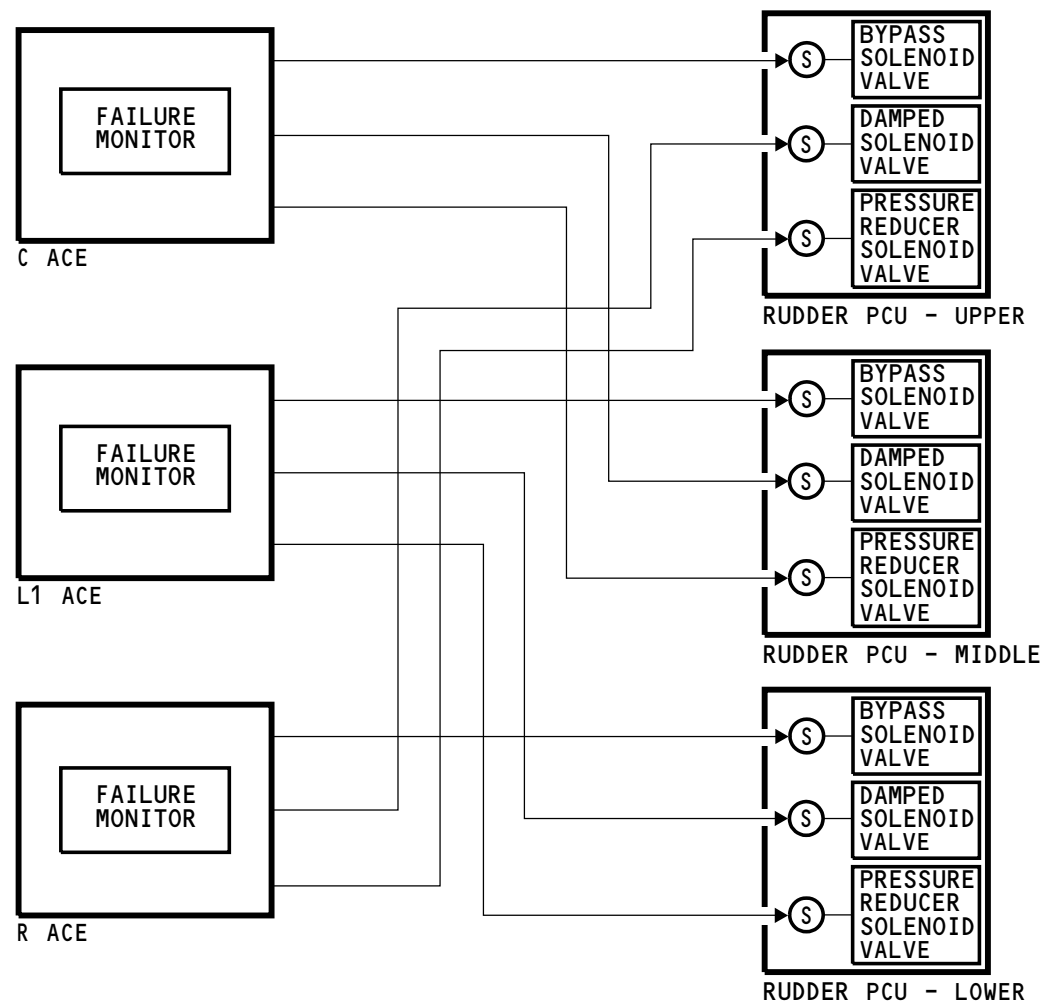
If there is a failure of a second PCU or its ACE, the ACE de-energizes the bypass solenoid of its on-side PCU. The ACE also de-energizes the pressure reducer and damped solenoid of one adjacent PCU. In this case, one PCU is in bypass mode, one PCU is in damped mode and one PCU operates with full hydraulic system pressure.

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RUDDER CONTROL - RUDDER PCU - FUNCTIONAL DESCRIPTION - PCU MODES

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**RUDDER CONTROL - RUDDER ASSEMBLY****Purpose**

The rudder supplies control of the airplane in the yaw direction. The rudder tab pivots on the lower trailing edge of the rudder.

Physical Description

The rudder is a light weight composite material structure. The skin is reinforced graphite/epoxy bonded to a core of Nomex honeycomb. The overall dimensions are approximately 98 in by 442 in (2.5 m by 11.2 m). The rudder weighs approximately 577 lb (262 kg).

A counterbalance at the tip of the rudder prevents flutter.

The rudder attaches to the vertical stabilizer with 10 hinges. Three PCUs attach to the rudder and move it. Jumpers and static dischargers supply electrostatic protection to airplane systems.

Functional Description

The rudder PCUs have internal stops that limit the rudder surface deflection. The rudder has a maximum movement of 27 degrees in both directions at low airspeed under no load conditions.

Under loads, the maximum PFCs and ACEs command signals move the rudder to a nominal position of 25 degrees in both direction at low air speed.

Training Information Point

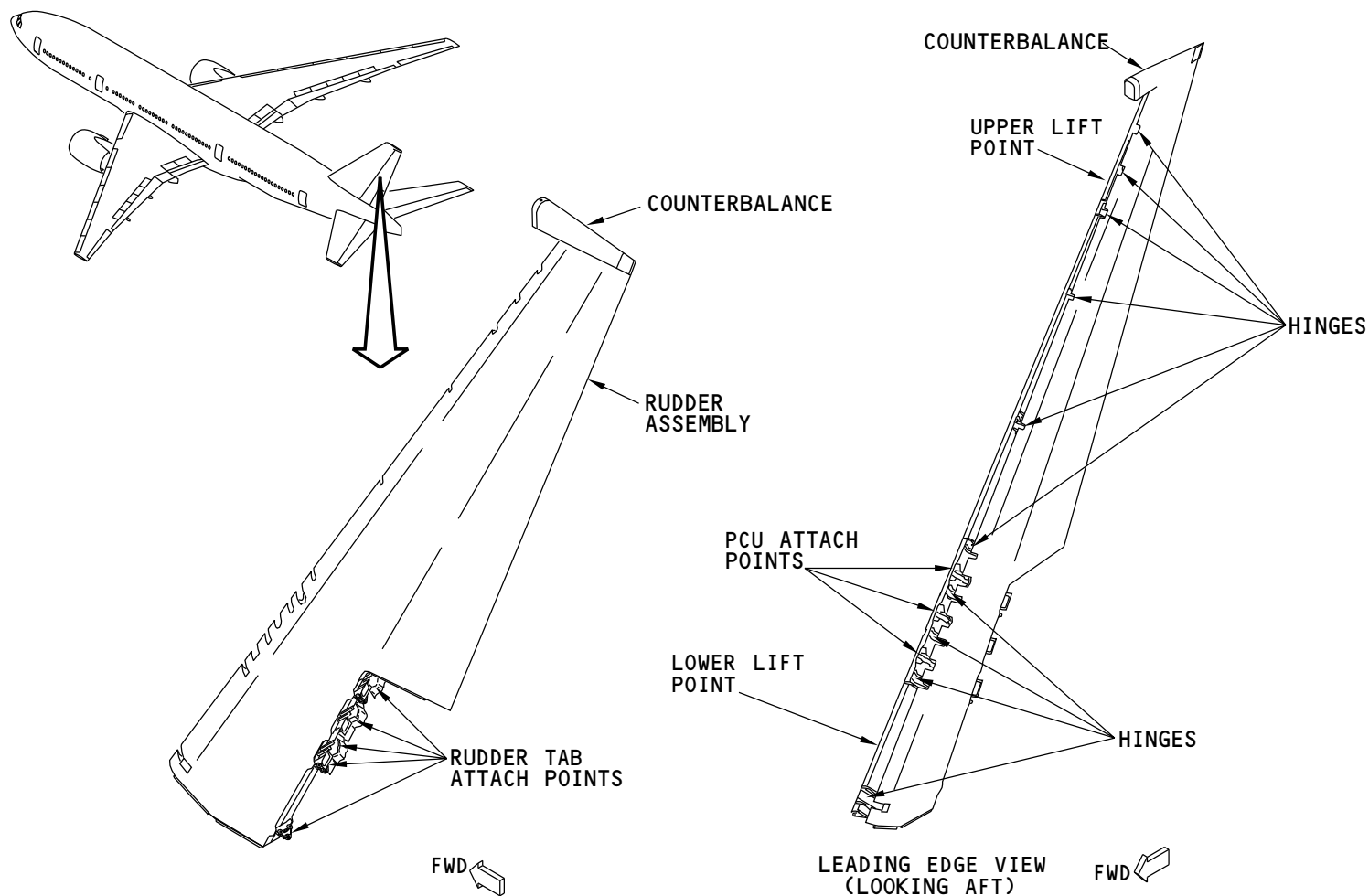
Two hoist attach points are on the rudder. They are near the top and bottom rudder hinges. Remove a small hinge line seal panel to get access to the hoist attach points.

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RUDDER CONTROL - RUDDER ASSEMBLY

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RUDDER CONTROL - RUDDER TAB ASSEMBLY

Purpose

The rudder tab pivots on the lower trailing edge of the rudder. It moves in the same direction of the rudder to increase its effect.

Physical Description

The rudder tab is a light weight composite material structure. The skin is reinforced graphite/epoxy bonded to a core of Nomex honeycomb. The overall dimensions are approximately 50 in by 128 in (1.3 m by 3.2 m). The rudder tab weighs approximately 110 lb (50 kg).

The rudder tab attaches to the rudder by 5 hinges. Three adjustable control rods command the movement of the rudder tab based on the rudder movement. Three fairings cover the control rod connections to the rudder tab.

The rudder index plate, on the upper skin of the tail cone, shows the position of the rudder tab in relation to the airplane centerline.

Functional Description

The rudder tab has a maximum movement of 27 degrees in both directions in relation to the rudder. For each degree of movement of the rudder, the rudder tab also moves one degree.

At full movement of the rudder (27 degrees), the rudder tab moves 27 degrees in relation to the rudder. This results in a 54 degree tab movement in relation to the centerline of the airplane.

Training Information Point

Two hoist attach points are on the rudder tab. They are near the top and bottom tab hinges. Remove a small hinge line seal panel and one fairing to get access to the hoist attach points.

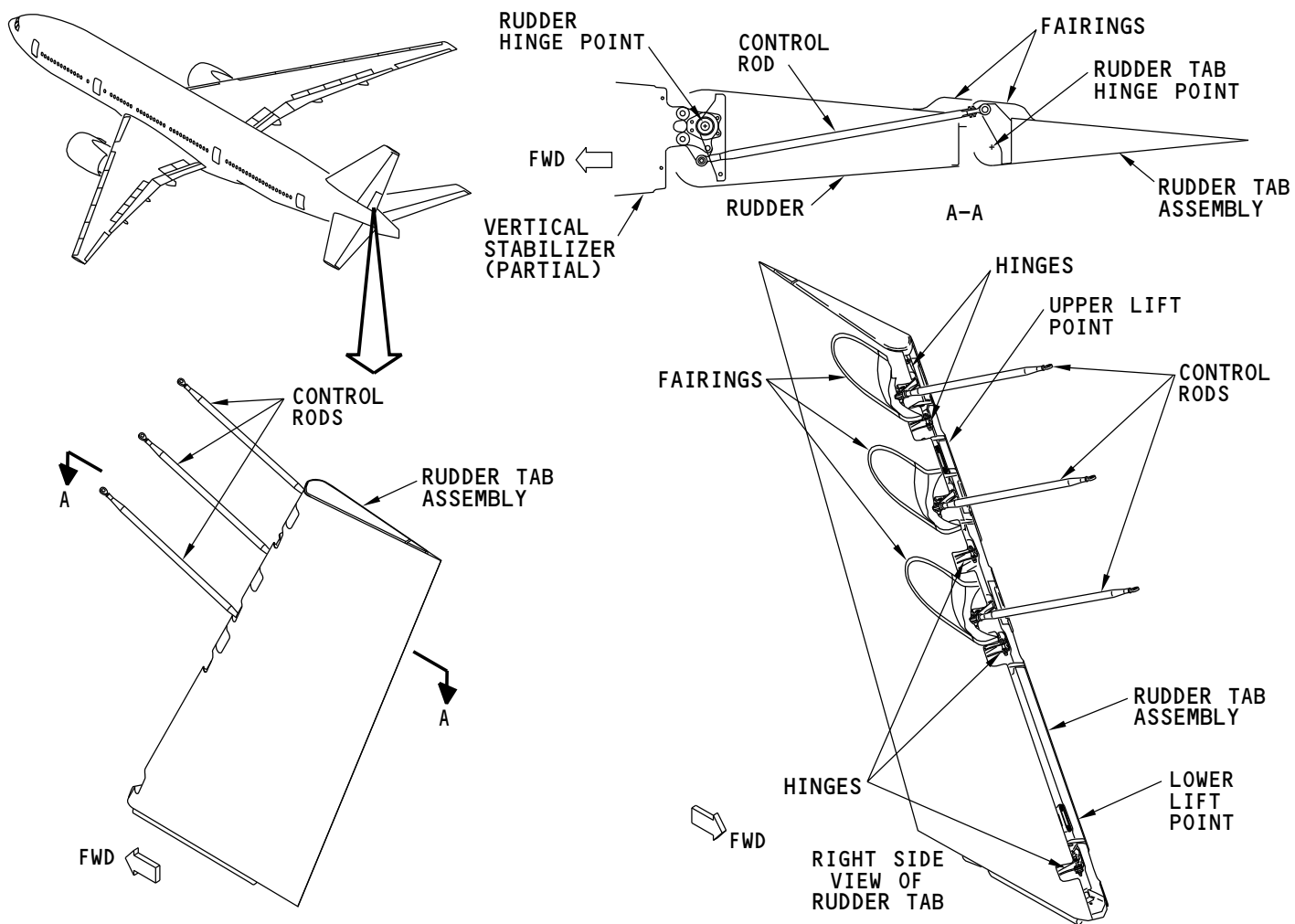
When the airplane is on the ground with the rudder at center, the rudder tab control rods deflect the rudder tab to the left of the airplane centerline. This deflection is necessary for thermal expansion of the rudder tab control rods.

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RUDDER CONTROL - RUDDER TAB ASSEMBLY

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION

General

The rudder control system uses input command signals from the rudder pedal position transducers.

The ACEs receive the input signals and transmit them to the PFCs. The ACEs supply output command signals to the rudder PCUs.

- The actuator piston position LVDT
- The actuator null LVDT
- The differential pressure LVDT.

Rudder Pedal Position Transducers

Each ACE receives the signals from one rudder pedal position transducer. The L1 ACE and C ACE receive signals from the rudder pedal position transducers on the left shaft assembly. The L2 ACE and the R ACE receive signals from the rudder pedal position transducers on the right shaft assembly. After they change the signals to digital format, the ACEs send these signals to the PFCs through the flight controls ARINC 629 buses.

Each PFC receives input signals from all four rudder pedal position transducers. The PFC selects by mid-value selection and averaging which signal to process.

Gust Suppression Pressure Transducers

The C ACE receives signals from the upper gust suppression pressure transducer and the L1 ACE receives signals from the lower one.

Modal Accelerometers

The R ACE receives signals from the right modal accelerometer and the L2 ACE receives signal from the left one.

Rudder PCUs

The L1 ACE, C ACE and R ACE send output command signals to their assigned rudder PCU and one adjacent rudder PCU.

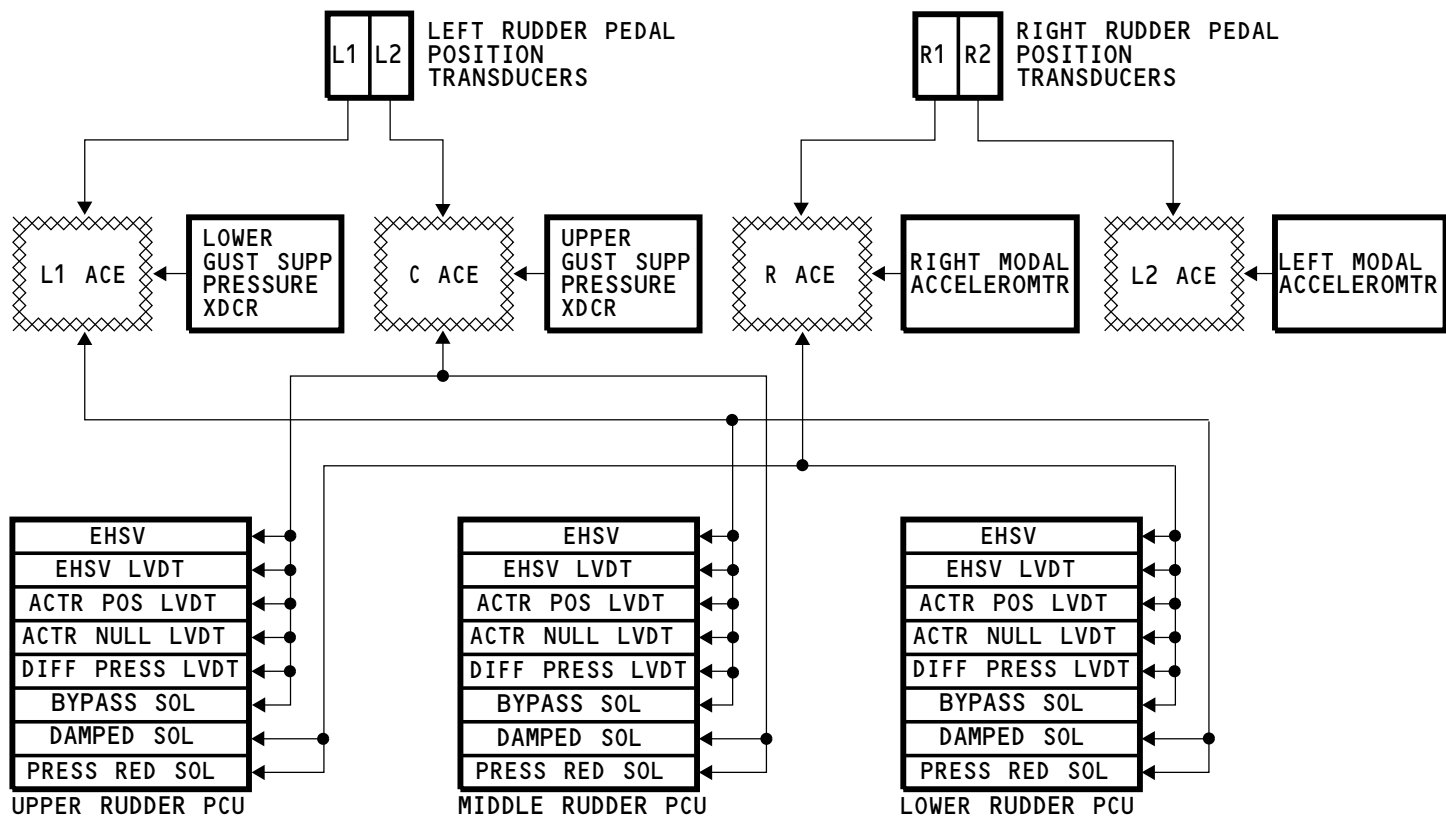
The output command signals go from the ACE to the EHSV and the bypass solenoid of the assigned rudder PCU. The output command signals also go to the damped solenoid and the pressure reducer solenoid of one adjacent rudder PCU. The PCU sends feedback signals to its assigned ACE from:

- The EHSV position LVDT

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP**General**

The ACE contains a servo loop circuit to control the command signals for the PCUs.

In normal and secondary mode, the PFC sends the command signals to the ACE. In direct mode, the ACE calculates the command signals.

Servo Loop Operation

The rudder command signals go through a servo loop in the ACEs. The command signals then go to the EHSV of the PCUs. The ACEs also use the command signals to monitor for failures.

The movement of the EHSV sends hydraulic pressure to extend or retract the actuator.

The EHSV LVDT measures the movement of the EHSV and supplies a feedback signal to the ACEs. The ACEs use this feedback signal to monitor failures.

The actuator position LVDT measures the movement of the actuator and supplies a signal to the actuator null LVDT.

The actuator null LVDT is in series with the actuator position LVDT. The actuator null LVDT modifies the signal from the actuator position LVDT.

The actuator null LVDT supplies a feedback signal to the ACEs to close the servo loop. The ACEs use this feedback signal to monitor for failures. This signal also goes to the PFC.

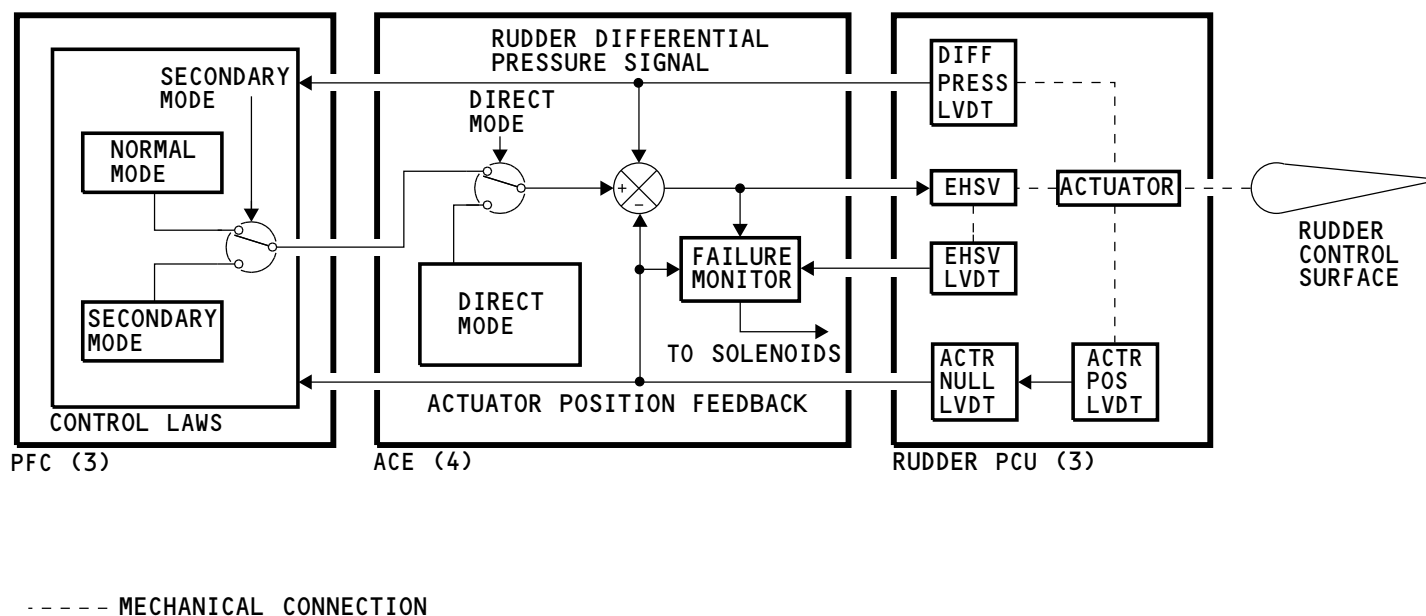
The differential pressure LVDT measures the differential pressure across the actuator. The signal from the differential pressure LVDT goes to the ACEs for the servo loop. The signal also goes to the PFCs for force fight equalization.

Failure Monitor

The ACE has a failure monitor to check the proper operation of the PCU. The monitor uses the ACE command signal and the feedback signals from the EHSV LVDT and the actuator LVDT. When the failure monitor finds a fault with the PCU or the ACE, it de-energizes its own PCU bypass solenoid, and the damped and pressure reducer solenoids of adjacent PCU that it controls.

Training Information Point

During installation of the rudder PCU, the actuator null LVDT requires adjustment. Remove the LVDT access cover to adjust the LVDT.



RUDDER CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP

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**RUDDER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE****General**

In normal mode operation of the PFCS, the PFCs calculate rudder control commands based on:

- Rudder ratio changer schedule
- Thrust asymmetry compensation
- Yaw damper
- Wheel-rudder cross-tie
- Gust suppression
- Modal suppression
- Force fight equalization
- Hydraulic pressure control
- Rudder trim
- Autopilot.

The PFCs also calculate the rudder trim commands. This function is covered separately in this section.

Rudder Ratio Changer Schedule

The PFCs receive commands from the rudder pedal position transducers. The rudder ratio changer schedule calculates rudder commands based on these inputs and calibrated airspeed (CAS) data from ADIRU/SAARU.

Command Limiting Function

The command limiting function receives CAS signals from the ADIRU/SAARU. The limiting function makes sure the sum of the rudder commands does not exceed a limit based on airspeed.

Thrust Asymmetry Compensation

The thrust asymmetry compensation (TAC) function controls the rudder and the rudder trim if there is a thrust asymmetry from the engines. The PFCs use engine thrust data from the engine data interface units (EDIUs) to calculate the yaw correction. The TAC authority limit is 60 percent of available rudder. TAC is available only when the CAS is more than 70 knots and there is no reverse thrust command.

TAC can be disarmed by the TAC switch on the P5 panel or by a fault in the function data sources.

Yaw Damper

The yaw damper function controls the rudder to dampen the dutch roll sensitivity of the airplane. The yaw damper function also controls the turn coordination.

The yaw damper function receives air and inertial data inputs from the ADIRU and SAARU. It also receives air/ground signals from the weight on wheel (WOW) cards. The yaw damper function is available only when the airplane is airborne.

The yaw damper function sends commands to the rudder control summing point.

The PFC limits the yaw damper commands as a function of airspeed to a maximum of six degrees of rudder movement in both directions.

Wheel-Rudder Cross-Tie

The wheel-rudder cross-tie function moves the rudder in response to control wheel inputs. This improves roll and yaw control during one engine-out operation. It also supplies protection against overyaw due to excessive pilot input to the rudder pedals.

The wheel position transducers send data to the wheel-rudder cross-tie function. This data and flap position data are used to calculate rudder commands. The function sends commands to the rudder control summing point.

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

The wheel-rudder cross-tie operates only when the yaw damper function is available. The PFC limits the wheel-rudder cross-tie to move the rudder to a maximum of 10.33 degrees in both directions. The wheel-rudder cross-tie does not operate above 210 knots or when the angle of attack is above the value that triggers the stall warning plus 5 degrees.

Gust Suppression

The gust suppression function improves the passenger ride quality at the aft section of the fuselage.

The gust suppression differential pressure transducers and the yaw and roll rates are inputs to the gust suppression function. The function sends commands to the rudder control summing point.

The PFC limits the gust suppression commands as a function of airspeed to a maximum of six degrees of rudder movement in both directions.

Modal Suppression

The modal suppression function improves the passenger ride at the forward and aft sections of the fuselage. The function reduces the body lateral movements due to excitation of the airplane structural modes.

The two modal accelerometers input to the modal suppression function. The function sends commands to the rudder control summing point.

The PFC limits the modal suppression commands to a maximum of 2 degrees of rudder movement in both directions.

Force Fight Equalization

The rudder commands go to the force fight equalization function. The PFCs use rudder PCU differential pressure data from the ACEs to equalize all the rudder PCU commands before transmission to the ACEs and the EHSV of each rudder PCU. This function minimizes rudder PCU force fight.

Hydraulic Pressure Control

When the airplane is below 500 ft altitude or the flaps are extended, the PFCs de-energize the pressure reducer solenoid of all three PCUs. This causes the PCUs to operate with full hydraulic system pressure.

At altitude above 500 ft and flaps retracted, the PFCs energize the pressure reducer solenoids. This causes the PCUs to operate at the reduced hydraulic pressure of 1850 psi.

Rudder Trim

The rudder trim switches and the TAC function send input signals to the rudder trim to operate the rudder trim actuator.

Autopilot Yaw Commands

During cruise, the autopilot does not provide yaw commands. The rudder pedal backdrive actuators are not engaged and do not control the rudder pedals.

During autoland operation of the autopilot, the PFCs use autopilot yaw commands to move the rudder and calculate backdrive actuator commands. The backdrive actuators move the rudder pedals in relation to the autopilot commands.

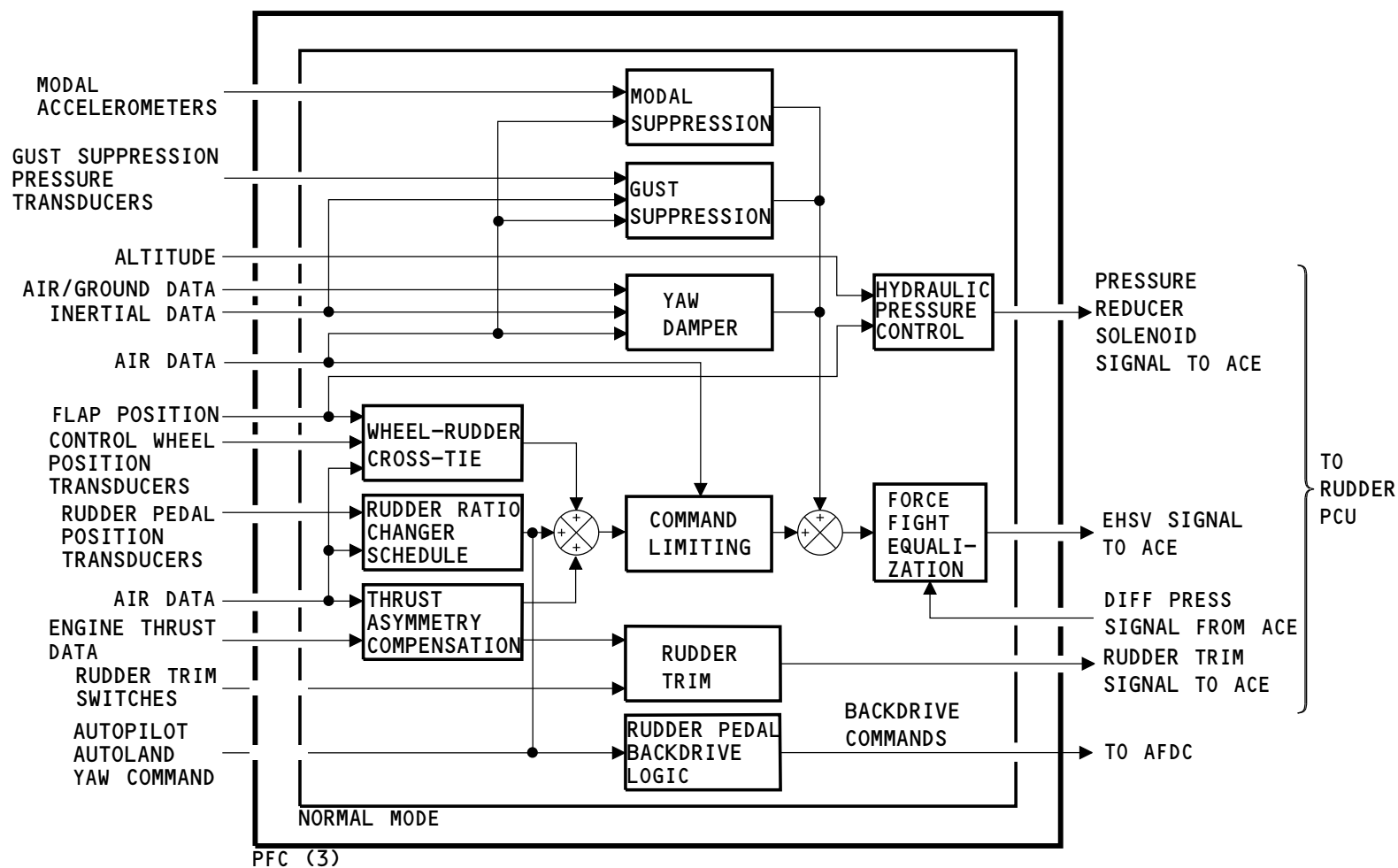
If the pilot moves the rudder pedals while the autopilot autoland function is engaged, the autopilot disengages. To override the backdrive actuators, the pilots need to apply more force than the backdrive actuators. The backdrive actuators then cease to move the rudder pedals.

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE

General

In secondary mode operation of the PFCS, the PFCs calculate rudder control commands for these functions:

- Degraded rudder ratio schedule
- Secondary yaw damper function
- Force fight equalization.

The PFC does not control the pressure reducer solenoid in the secondary mode. The ACE has a hydraulic pressure control which does this function.

No other rudder function is available in secondary mode.

Degraded Rudder Ratio Schedule

The PFCs receive rudder control command signals from the rudder pedal position transducers. The degraded rudder ratio receives the flaps and slats retracted discrete signal from the ACEs. The degraded rudder ratio function calculates the rudder command from the rudder pedal position transducers for two fixed ratios. When the flaps and slats are not retracted, the ratio is high. When the flaps and slats are retracted, the ratio is low.

Secondary Yaw Damper Function

The PFC has a degraded yaw damper function in secondary mode. It uses available air and inertial data to supply rudder commands.

If some of the air or inertial data is not available, the function filters the yaw damper rate and reduces its gain.

Force Fight Equalization

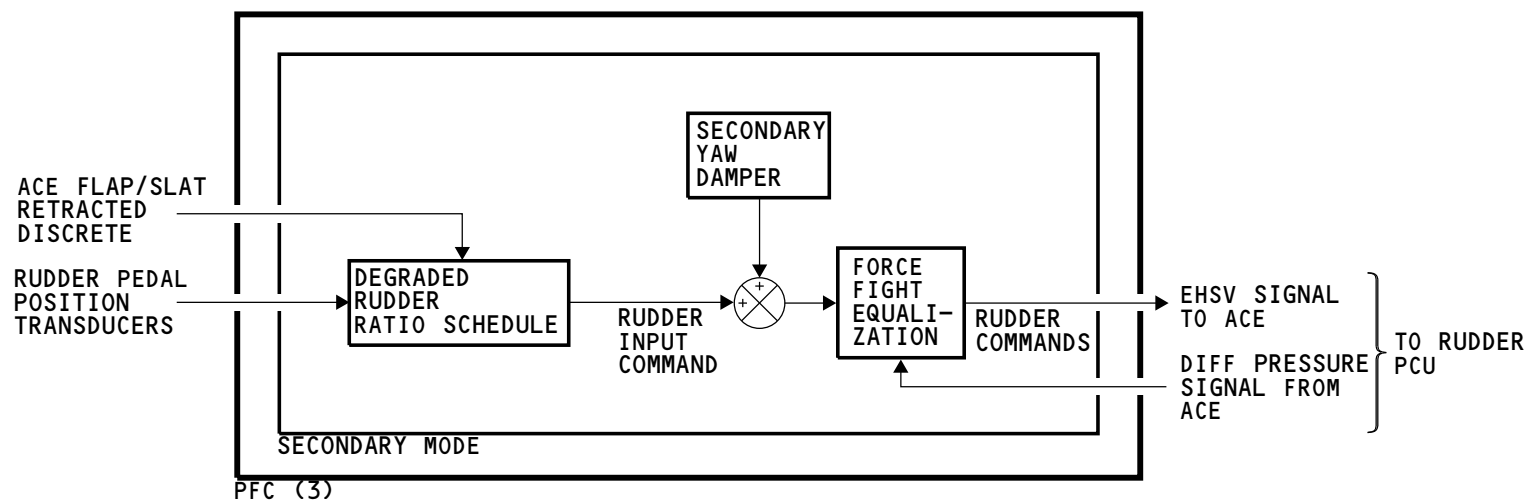
The rudder commands go to the force fight equalization function. The PFCs use rudder PCU differential pressure data from the ACEs to equalize all the rudder PCU commands. This function keeps rudder PCU force fight to a minimum.

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE

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**RUDDER CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE****General**

In direct mode operation of the PFCS, the ACEs calculate rudder control commands based on these inputs:

- Degraded rudder ratio schedule
- Hydraulic pressure control
- Failure monitor.

Degraded Rudder Ratio

The ACEs receive yaw command signals from the rudder pedal position transducers. The degraded rudder ratio receives the flaps and slats retracted discrete signal from the FSEUs. The degraded rudder ratio function calculates the rudder command from the rudder pedal position transducers for two fixed ratios. When the flaps and slats are not retracted, the ratio is high. When the flaps and slats are retracted, the ratio is low.

Hydraulic Pressure Control

When the PFCS is in direct or secondary mode and all ACEs are operational, the ACEs reduce the hydraulic pressure of their assigned PCU.

If there is an electrical power loss to an ACE or failure of an ACE or PCU, the pressure reducer solenoid of the other PCUs de-energize. The other PCUs then operate at high pressure to supply enough force for the control of the rudder.

Failure Monitor

The failure monitor controls the signals to the bypass and the damped solenoids of the applicable PCUs. When it finds a single failure of the ACE or its on-side PCU, the ACE de-energizes the bypass solenoid of its on-side PCU and the damped solenoid of its adjacent PCU.

The ACE failure monitor also controls the pressure reducer solenoid of the adjacent PCU through the hydraulic pressure control function.

The failure monitor operates in all three modes, normal, secondary, and direct. The failure monitor can find faults in these:

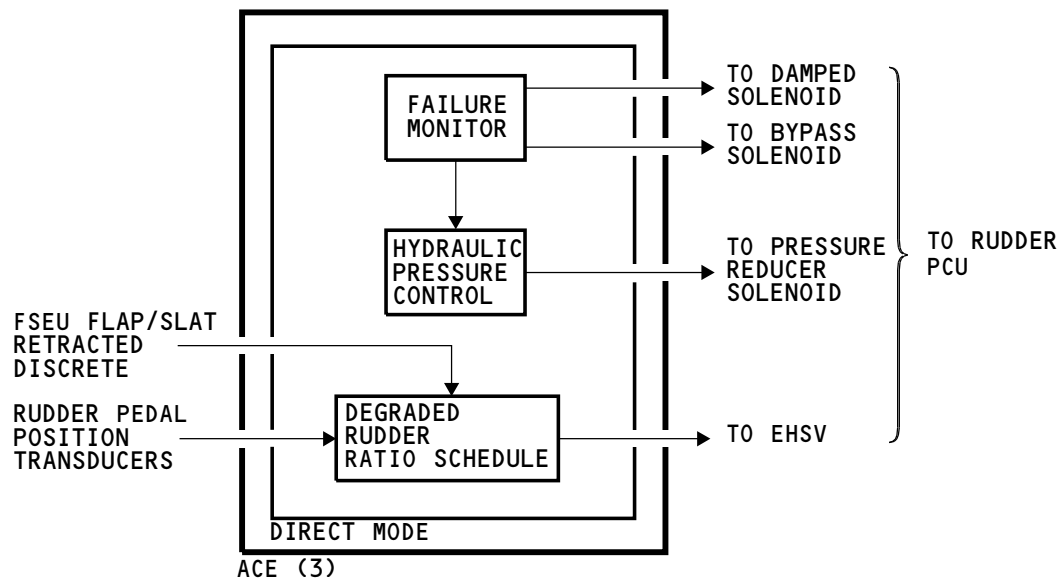
- ACE
- PCUs
- Pedal position transducers
- Interface wiring.

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - RUDDER TRIM

General

The rudder trim selector and the manual trim cancel switch send discrete electrical signal to the L1 ACE. The L1 ACE transmits this signals to the PFCs via the flight controls ARINC 629 buses.

The L1 and R ACEs, and the PFCs operate the rudder trim function as a two channel system. The L1 ACE supplies rudder trim actuator engagement, manual trim cancel, and servo loop control. The R ACE supplies rudder trim actuator engagement, rate discrete, arm, and brake status control.

In normal mode, when the thrust asymmetry compensation (TAC) function is active, the PFCs control the rudder trim actuator through the L1 and R ACEs based on differential engine thrust.

During normal and secondary modes of operation, the PFCs use pilot inputs from the rudder trim selector and the manual trim cancel switch to control the rudder trim actuator at one of two available speeds. The PFCs transmit commands back to the ACEs which then control the rudder trim actuator.

During direct mode of operation, the ACEs use the requests from the rudder trim selector and directly command the rudder trim actuator at a single speed.

The trim range of the rudder is a function of rudder ratio.

Rudder Trim Switches

The rudder trim selector has three pairs of contacts. The 15 degree contacts send an arm status discrete signal directly to the rudder trim actuator. The 25 degree contacts signal the PFCS to operate the rudder trim actuator at low speed in the direction selected. The 40 degree contacts signal the PFCS to operate the rudder trim actuator at high speed.

In normal and secondary modes, the manual trim cancel switch sends a signal to the PFCs through the L1 ACE to remove any pilot commanded trim. The rudder trim actuator moves at high speed.

Rudder Trim Actuator

The rudder trim actuator has these components:

- 28v dc electric motor with variable speed electronic control
- Electromagnetic brake to lock the actuator when the brake is de-energized
- Pseudo-tachometer (derived rate feedback) to supply speed rate feedback signals to the servo loop internal to the actuator
- Actuator position RVDT.

The rudder trim actuator position RVDT sends position signals to the L1 ACE for servo-loop control. The L1 ACE provides rudder trim position to the PFCs for fault monitor. These signals also go to the AIMS cabinets which control the rudder trim position indicator.

Rudder Trim Position Transducer

The rudder trim position transducer sends a position signal to the R ACE, which sends the signal to the PFCs. The PFCs monitor this signal and compare it to the rudder trim actuator position RVDT for fault monitor.

Normal and Secondary Mode Control

During normal and secondary modes of operation of the PFCS, the PFCs control the rudder trim actuator through the L1 and R ACEs.

When the pilot turns the rudder trim selector, command signals from the 15 degree switch contacts go to the rudder trim actuator arm status function and then to the R ACE and on to the PFCs.

When the pilot turns the rudder trim selector to close the 25 degree contacts, a discrete signal goes through the L1 ACE to the PFCs. The PFCs send an engage command through the ACEs to the rudder trim actuator where the electromagnetic brake is released. The brake status goes from the actuator through the R ACE to the PFCs. After they receive the brake released status, the PFCs send a slow rate command to the actuator through the L1 ACE servo command function. The PFCs and ACEs cause the rudder trim actuator to move at a rate of 0.38 units per second.

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - RUDDER TRIM

When the pilot turns the rudder trim selector to close the 40 degree contacts, a discrete goes to the PFCs through the R ACE to command high rate rudder trim. The PFCs send that signal through the L1 ACE servo command function that causes the rudder trim actuator to move at 1.54 units per second.

When the manual trim cancel switch is closed, a discrete signal goes through the L1 ACE To the PFCs. The PFCs send an engage command through the ACEs and when the actuator brake is released, the PFCs send a command to operate the actuator motor at high speed (1.54 units per second).

In normal mode, when TAC is active, the PFCs and the L1 and R ACEs cause the rudder trim actuator to move at a rate as much as 8 units per second.

The signal from the rudder trim actuator position RVDT closes the servo loop in the L1 ACE.

The pseudo-tachometer (derived rate) supplies rate feedback to the speed control in the rudder trim actuator.

On the ground, the PFCs limit the rudder trim actuator movement to 17 units of rudder trim. In flight, the PFCs let the trim actuator move to its mechanical stops. This causes a maximum of 18 units of rudder trim at low airspeed. Because the rudder trim indicator limit is 17 units, the indicator shows 17 units for a trim condition of 17 units or more.

The PFCs compare the signal from the rudder trim actuator RVDT with the signals from the rudder trim position transducer. If the signals do not agree, the PFCs stop the operation of the rudder trim. The PFCs also compare the signal from the rudder trim actuator RVDT with the PFC commanded position. If these signals do not agree, the PFCs stop the operation of the rudder trim.

If the R ACE does not operate, automatic trim by the TAC function does not operate. The pilot can control manual trim with the rudder trim selector. The PFCs then control the rudder trim actuator through the L1 ACE. In this condition, the rudder trim operates at 0.38 units per second. The 40 degree selector position and the manual trim cancel switch do not operate.

If the L1 ACE does not operate, the PFCs stop the operation of the rudder trim.

Direct Mode Control

During direct mode operation, the ACEs directly control the rudder trim actuator.

When the selector is beyond the 25 degree position, the ACEs cause the rudder trim actuator to move the rudder. The trim rate is 1.4 units per second. The trim range of the rudder in direct mode is a function of whether or not the flaps and slats are retracted.

The manual trim cancel switch function does not operate in direct mode.

Indications

The warning message CONFIG RUDDER shows on the EICAS display when all of these conditions occur:

- The rudder trim is not within 2 units from center
- Either the left or right engine thrust is more than the takeoff threshold
- The airplane is on the ground
- TAC is not active.

The advisory message THRUST ASYM COMP shows when the rudder trim system is defective.

The status message FLIGHT CONTROL SYS shows when the rudder trim system has failed.

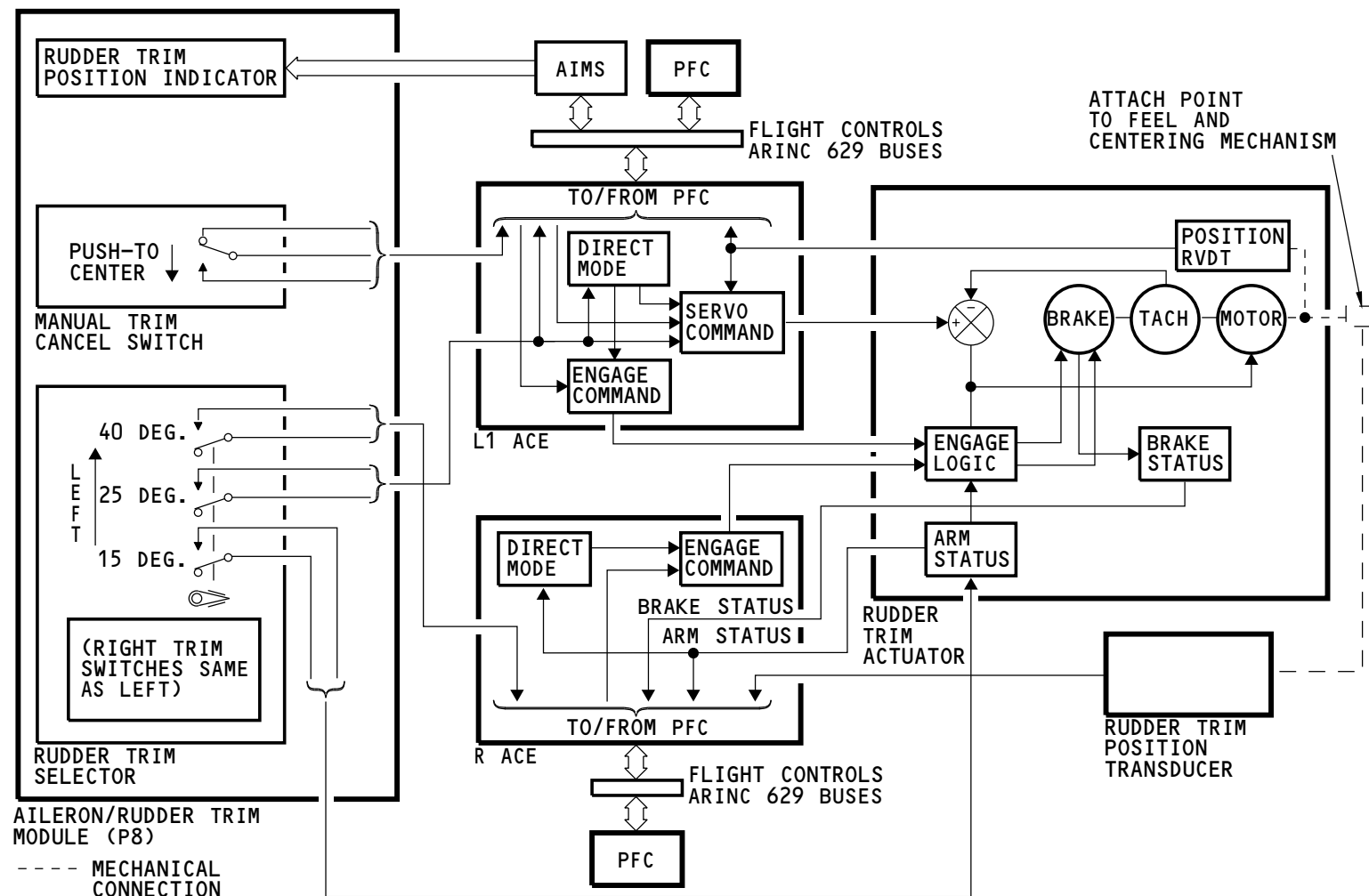
The rudder trim indicator on the center aisle stand is blank when the rudder trim system is defective.

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - RUDDER TRIM

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**RUDDER CONTROL - RUDDER RATIO CHANGER****Purpose**

The rudder ratio changer reduces the travel of the rudder. This keeps the effectiveness of the rudder constant and reduces the air loads on the rudder.

Normal Mode Rudder Ratio

In normal mode, the control laws in the PFCs reduce the rudder input command as the computed airspeed (CAS) increases. The rudder ratio changer schedule is fixed.

At airspeeds below 130 kts, the ratio is 1.00 and full rudder pedal movement causes 27 degrees of rudder movement under no load. As the airspeed increases, the ratio decreases. At airspeeds above 430 kts, full rudder pedal movement causes 2.9 degrees of rudder movement under no load.

At airspeeds below 148 kts, the ratio is 1.00 and full rudder pedal movement causes 27 degrees of rudder movement under no load. As the airspeed increases, the ratio decreases. At airspeeds above 430 kts, full rudder pedal movement causes 3.1 degrees of rudder movement under no load.

Secondary Mode Rudder Ratio

In secondary mode, the PFCs reduce the rudder input command by a fixed ratio based on the flaps and slats position. When the flaps and slats are not retracted, full pedal movement causes 27 degrees of rudder movement under no load.

When the flaps and slats are retracted, full pedal movement causes 10 degrees of rudder movement under no load.

Direct Mode Rudder Ratio

In direct mode, the ACEs reduce the rudder input command by a fixed ratio based on the flaps and slats position. When the flaps and slats are not retracted, full pedal movement causes 23.5 degrees of rudder movement under no load.

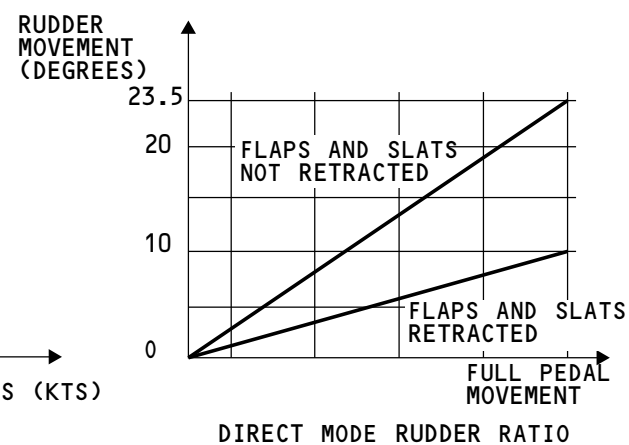
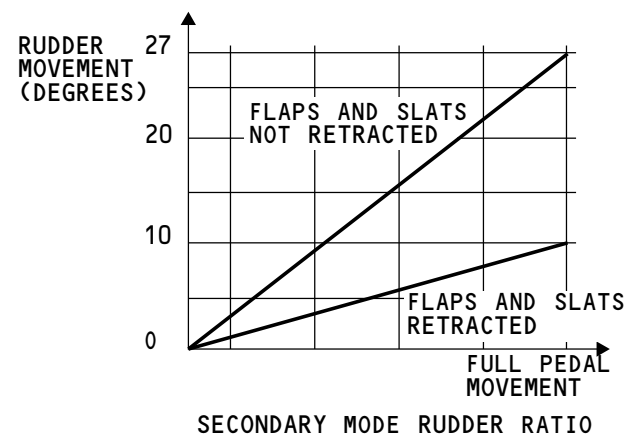
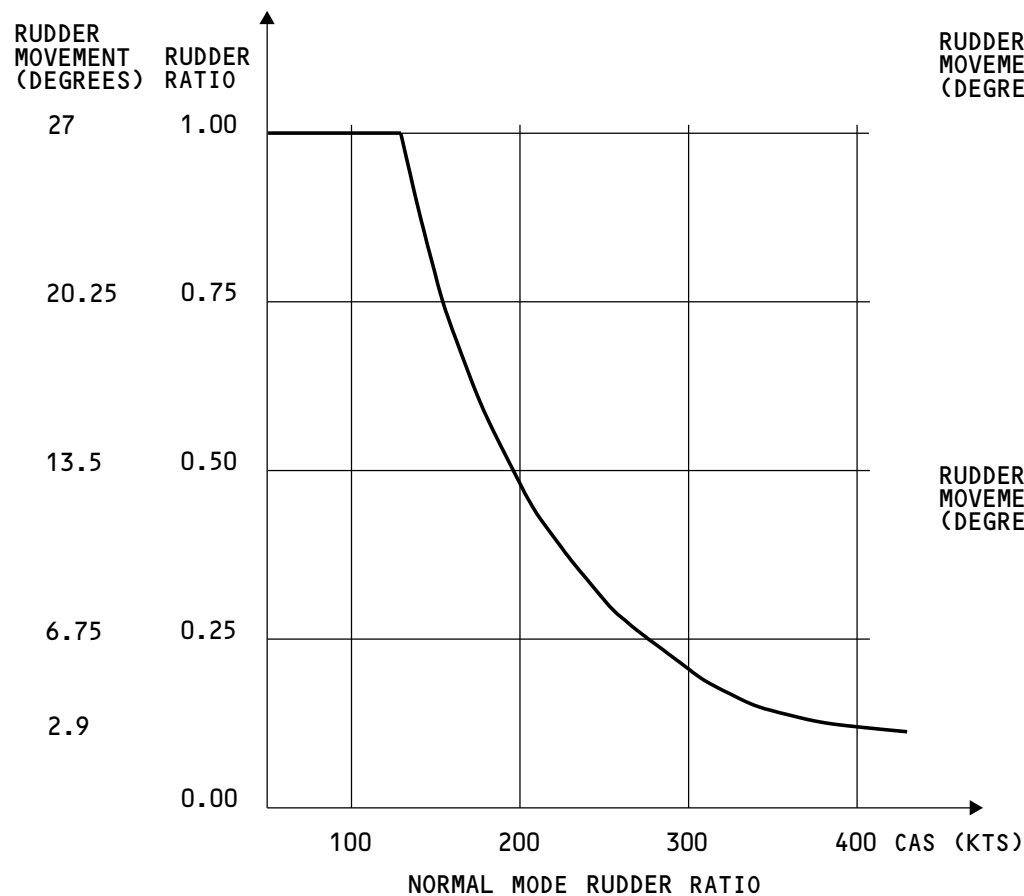
When the flaps and slats are retracted, full pedal movement causes 10 degrees of rudder movement under no load.

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RUDDER CONTROL - RUDDER RATIO CHANGER

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - THRUST ASYMMETRY COMPENSATION

General

The thrust asymmetry compensation (TAC) helps control the airplane during asymmetrical engine thrust conditions. The TAC protection function operates in the PFCS normal mode only.

The pilot can disarm the TAC function with the TAC switch on the P5 panel.

Input Signals

The TAC function receives thrust data for the two engines from the engine data interface units (EDIU). The EDIUs use the N1 rotational speed signals from the electronic engine controls (EECs) to calculate the thrust values. The EECs also send other engine data to the EDIUs to make sure the N1 signal is accurate. The EDIUs send the engine thrust data to the PFCs through the AIMS.

TAC also uses the CAS signal from the ADIRU, flap position from the FSEUs and the TAC switch position from the C ACE.

Functional Description

The TAC function arms manually or automatically. TAC arms manually when you move the TAC switch from OFF to AUTO and all these conditions occur:

- All the signals used by TAC are satisfactory
- The rudder trim can operate
- The PFCS is in normal mode
- The L1 ACE and R ACE are not in direct mode.

When the TAC switch is in the AUTO position, the TAC function arms automatically. The conditions for TAC automatic arm are the manual arm conditions and these conditions:

- The PFCs find that the airplane is on the ground
- CAS is less than 70 knots
- One or both engines are running with the thrust levers at the idle position or the engines are not running.

The TAC function disarms when the TAC switch is in the OFF position. It also disarms for any one of these conditions:

- Any signal used by TAC is not satisfactory
- The rudder trim is defective
- The PFCS is not in normal mode
- The L1 ACE or R ACE is in direct mode
- The L1 ACE or R ACE status signal is not available.

The TAC function is active when it is armed and all of these conditions occur:

- CAS is more than 70 knots
- The thrust reversers do not have a command to deploy
- The thrust difference between the two engines is more than 6000 lbs, about 10 percent of the maximum rated thrust.

When TAC is active, the PFCs use the difference between the thrust signals from the EDIUs to calculate rudder and rudder trim commands. The TAC function initially calculates a high rate rudder command to make allowance for the yaw moment caused by the thrust difference. This command goes to the ACEs to move the rudder PCUs.

The TAC function also sends rudder trim commands to the ACEs. The rudder trim actuator movement then backdrives the rudder pedals and the pedal position transducers. The PFCs make allowance for the input signals from the pedal position transducers to keep a near constant rudder PCU command.

The PFCs limit the TAC authority to 60 percent of available rudder.

If TAC is active when there is a command for thrust reverser deployment during landing or refused takeoff, the PFCs automatically ramp the TAC trim commands to zero trim. The trim actuator ramps to zero at a speed of 6 units per second.

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**RUDDER CONTROL - FUNCTIONAL DESCRIPTION - THRUST ASYMMETRY COMPENSATION**

When TAC is active, the pilot can use the rudder pedals or the rudder trim switches. The PFCs add these command signals to the TAC commands to control the rudder PCUs. If the pilot pushes on the manual trim cancel switch, the PFCs send a command to the rudder trim actuator to remove any input made with the rudder trim selector. The TAC command to the rudder trim actuator is not removed.

If TAC is active during autoland operation of the autopilot, the engine out correction of the autopilot is disabled. This is done so this function of the autopilot does not control during TAC operation. If the pilot moves the pedals, TAC stays active but the autopilot disengages.

The TAC function stops to be active when the thrust difference between the two engines is less than 3 percent of the maximum rated thrust.

If the airspeed data becomes unreliable, the TAC function uses the flap position signal to limit the gain of the rudder and rudder trim command.

Indications

The amber OFF light shows in the TAC switch on the P5 panel and the advisory and status messages THRUST ASYM COMP show when one of these conditions occurs:

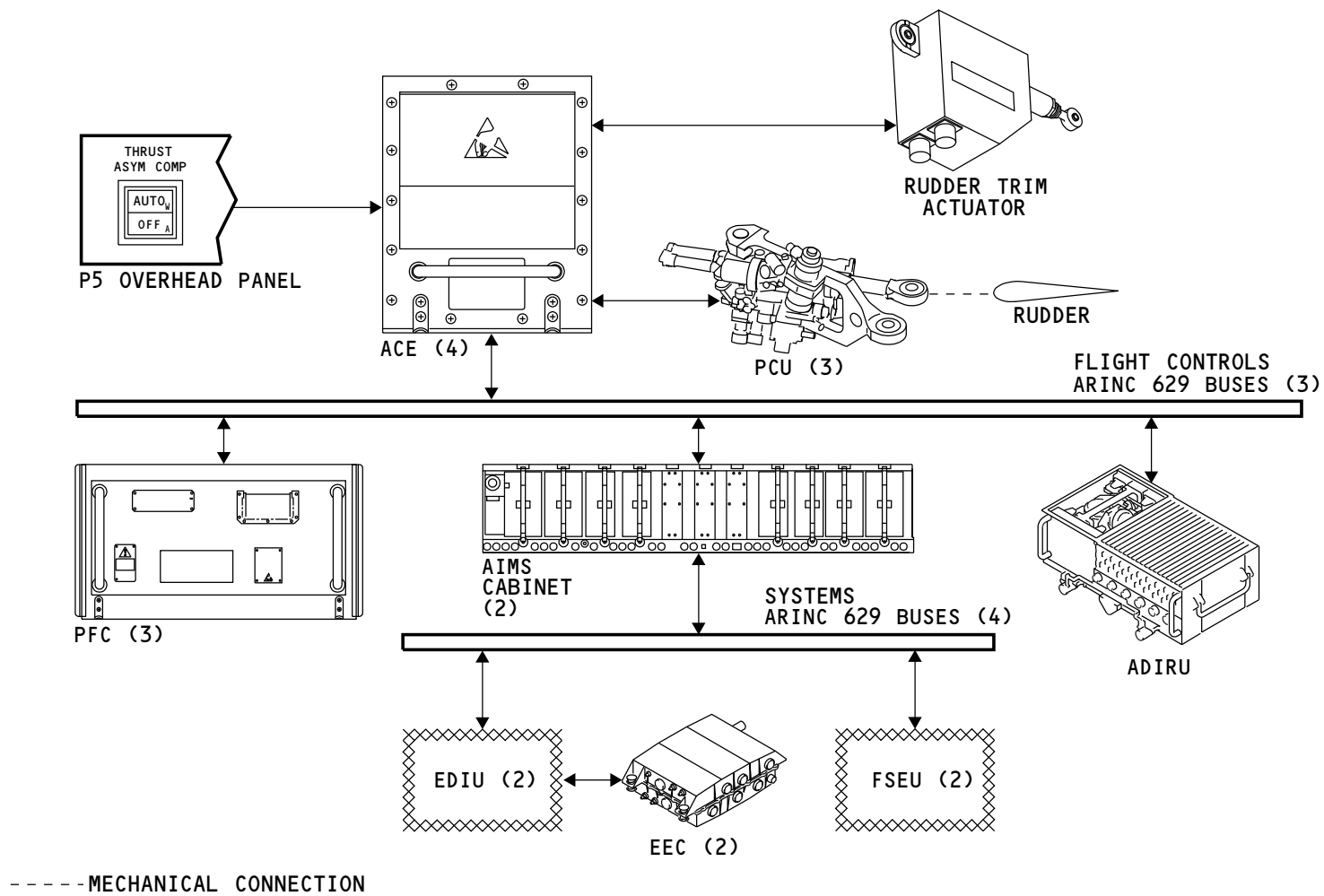
- The rudder trim is defective
- Loss of the thrust data from 2 of 3 channels in one EDIU
- Loss of left and right engine running data
- The two engines are not running in the air
- The R, L1 or C ACE is failed or in direct mode
- The PFCS is not in normal mode
- The TAC switch is in the OFF position
- The TAC switch position signal is lost.

When the TAC function is armed after it was disarmed, the above indications do not show.

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RUDDER CONTROL - FUNCTIONAL DESCRIPTION - THRUST ASYMMETRY COMPENSATION

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ELEVATOR CONTROL - INTRODUCTION

General

The elevators supply short-term correction of the pitch attitude of the airplane. This movement is around the lateral axis of the airplane.

There is one elevator panel on each side of the aft fuselage. Hinges attach the elevator to the rear spar of the horizontal stabilizer. Two hydraulic power units move each elevator panel.

Pitch Control

The pilots manually command pitch correction with forward and aft movement of the control column.

When engaged, the autopilot automatically commands the elevators. During autopilot operation, actuators backdrive the control columns.

Elevator Off-load Function

The elevator off-load function transfers manual and autopilot commanded elevator deflection to the stabilizer. The stabilizer movement allows the elevators to move to the neutral position.

Abbreviations and Acronyms

- ACE - actuator control electronics
- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AIMS - airplane information management system
- AOA - angle of attack
- ARINC - Aeronautical Radio, Incorporated.
- CMCS - central maintenance computing system
- CPU - central processing unit
- EHSV - electrohydraulic servo valve
- EICAS - engine indication and crew alerting system

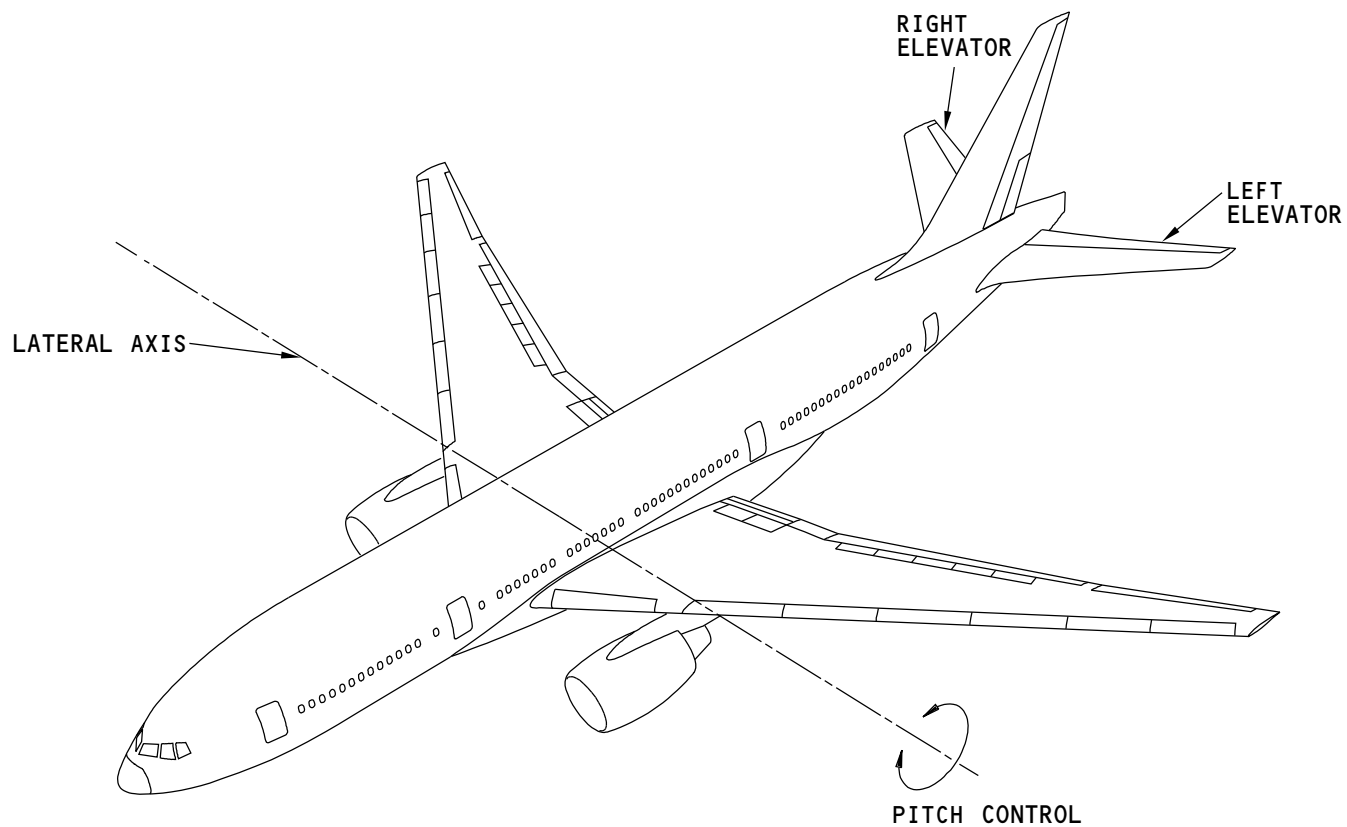
- FSEU - flap/slat electronics unit
- LIB - left inboard
- LOB - left outboard
- LVDT - linear variable differential transformer
- MAT - maintenance access terminal
- MFD - multi-function display
- PCU - power control unit
- PFC - primary flight computer
- PFCS - primary flight control system
- RIB - right inboard
- ROB - right outboard
- SAARU - secondary attitude and air data reference unit
- TED - trailing edge down
- TEU - trailing edge up

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ELEVATOR CONTROL - INTRODUCTION

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ELEVATOR CONTROL - GENERAL DESCRIPTION

General

The pilots manually command the elevators and the autopilot automatically commands them.

Manual Operation

The flight crew uses two conventional control columns to command pitch. They connect to torque tubes joined by a break-out mechanism. This allows one control column to move if the other jams.

The flight crew can make manual commands to the elevator in the normal mode with the pitch trim switches. This is possible only if the airplane is in the air.

Six position transducers change flight crew control column commands to analog electrical signals. Four pitch rate sensors measure the pitch rate. These signals go to the four actuator control electronics (ACEs) that change the signal to digital format. The digital signals go to the primary flight computers (PFCs) through the ARINC 629 buses.

The PFCs use data from these sources to calculate control surface commands:

- Air data inertial reference unit (ADIRU)
- Pitch rate sensor
- Airplane information management system (AIMS).

The PFCs send digital commands to the ACEs, which change them to analog signals. The ACEs then send the analog surface position commands to the power control units (PCUs). The PCUs move the elevators. The position transducers on the PCU hydraulic pistons send actuator position feedback to the PFCs through the ACEs.

The PFCs use data from the ADIRU to calculate elevator feel commands. The feel command goes through the ACE to the left and right feel actuators on the elevator feel units. The feel actuators supply to the column a variable feel based on airspeed.

The ACEs get analog signals from the force transducers and send them to the PFCs. The PFCs use these signals to verify control column null position.

Autopilot Operation

When engaged, the autopilot flight director computers (AFDCs) control airplane pitch. The AFDCs supply pitch commands to the PFCs through the flight controls ARINC 629 buses. The PFCs process these commands to supply position commands for the elevators. These position commands go through the ACEs to the PCUs.

The PFCs also supply column backdrive commands. The PFCs send these commands to the AFDCs, which supply column movement commands to the backdrive actuators. The backdrive actuators move the control columns the same amount as the pilot would move them manually for the same surface movement. This gives the flight crew visual feedback when the AFDS moves the flight control surfaces. The flight crew can override the autopilot with sufficient force on the control column to overcome the backdrive.

Protection Functions

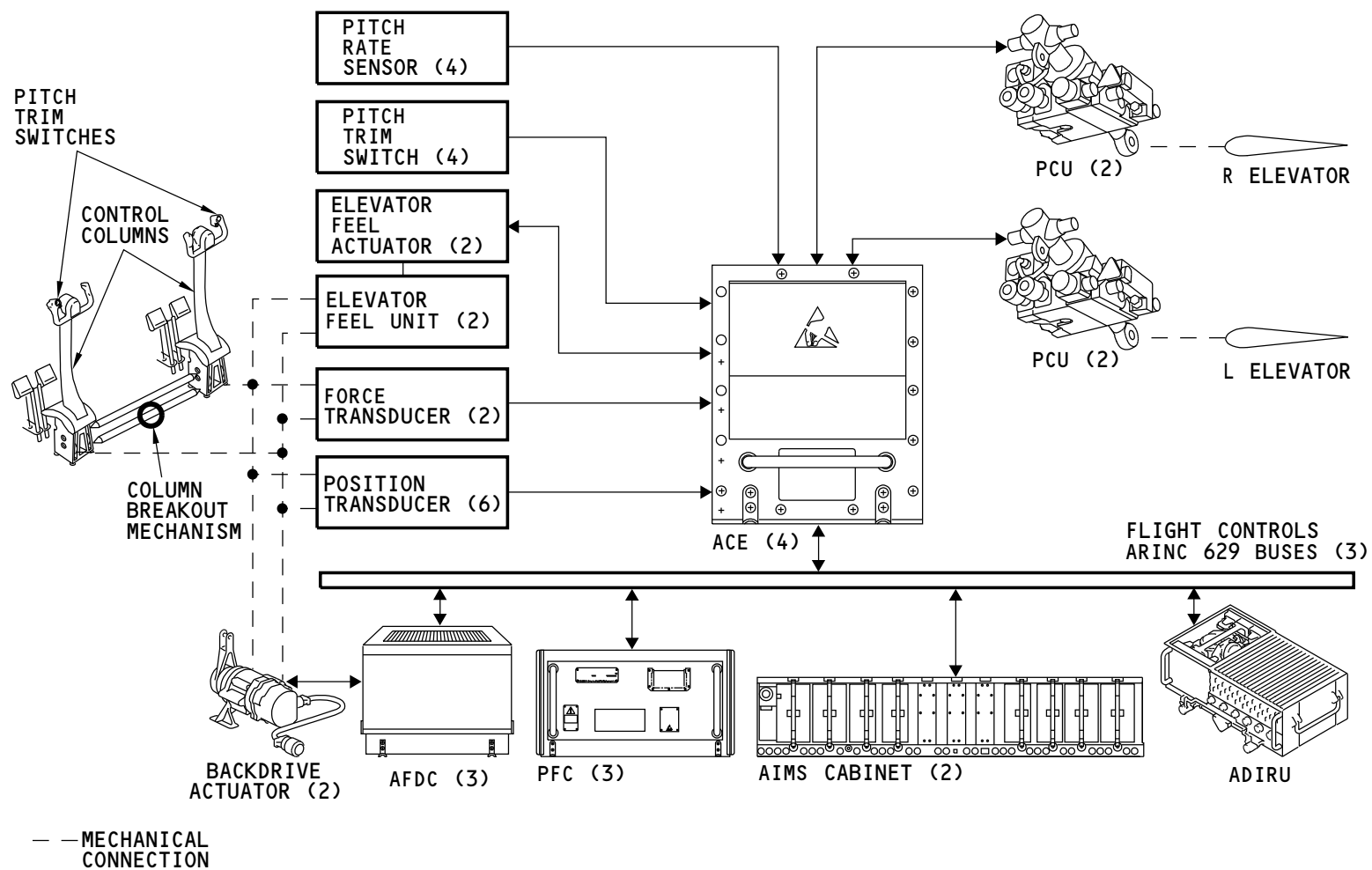
Overspeed and stall protection functions in the PFCs supply flight envelope protection in both manual and autopilot operation. The overspeed protection supplies a pitch-up elevator command. The stall protection supplies a pitch-down elevator command.

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ELEVATOR CONTROL - GENERAL DESCRIPTION

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ELEVATOR CONTROL - COMPONENT LOCATIONS

General

Pitch control components are in these areas:

- The flight deck
- Below the flight deck floor
- The wing front spar
- The tail.

Flight Deck Components

The control columns are in the flight deck.

Components Below the Flight Deck

These forward controls are below the flight deck floor and above the nose gear wheel well:

- Column torque tubes
- Column balance weights
- Column dampers
- Stick shaker actuators
- Column force transducers
- Elevator feel units
- Column backdrive actuators
- Column breakout mechanism.

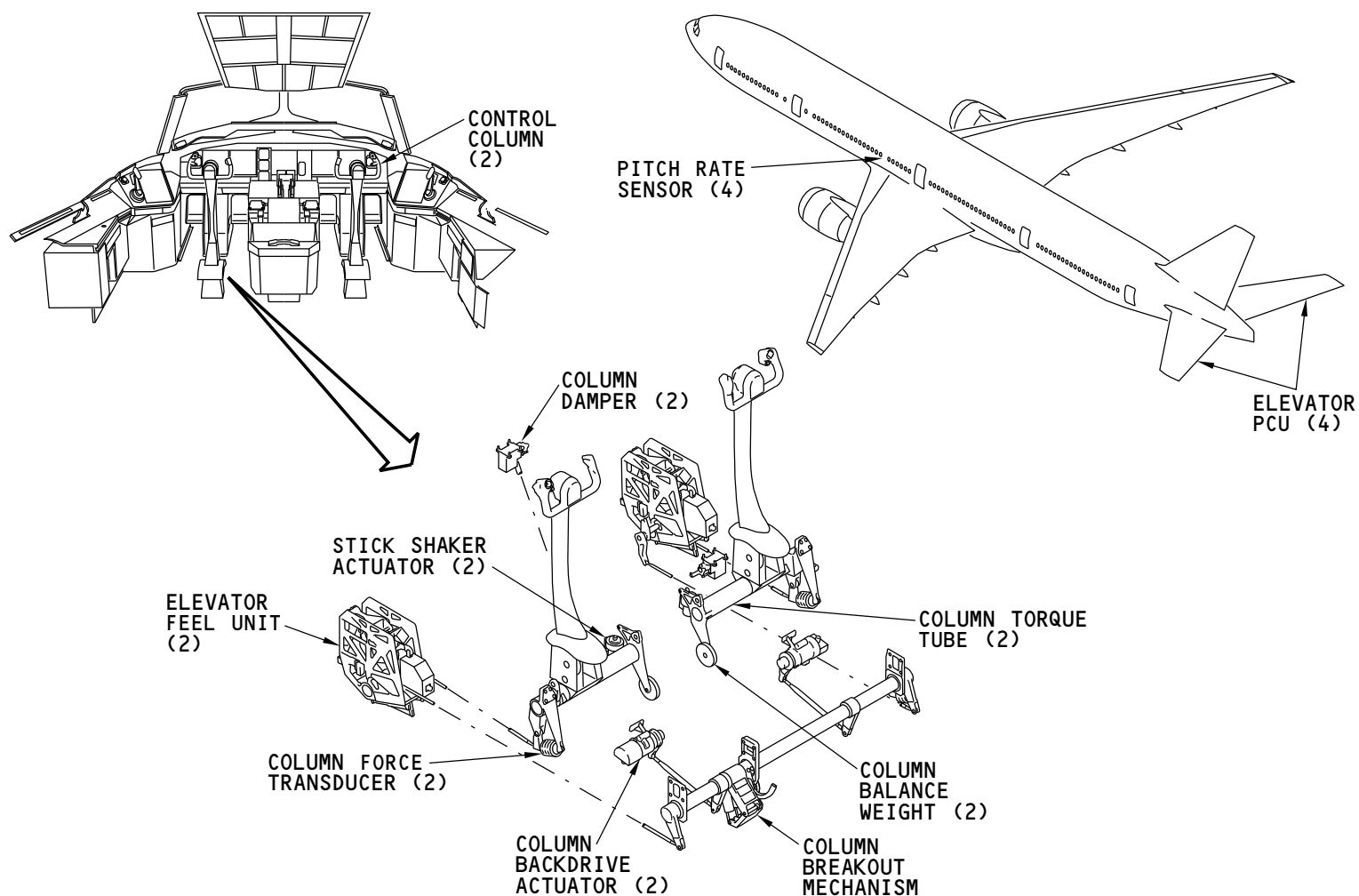
Access to these components is through the forward equipment center door.

Wing Front Spar Components

The pitch rate sensors are on the forward side of the front spar of the wing center section. They are at the aft end of the forward cargo compartment. Access to these sensors is through the forward cargo door.

Tail Components

The elevators and their PCUs are on the rear spar of the horizontal stabilizer. Two PCUs connect to each elevator. Access to the PCUs is by panels under the stabilizer.



ELEVATOR CONTROL - COMPONENT LOCATIONS

M41043 S000617402_V1

ELEVATOR CONTROL - ANALOG AND DISCRETE INTERFACES

General

All pitch control analog interfaces within the PFCS go through the ACEs. Each ACE has interfaces with these components:

- Column position transducers
- Column force transducers
- Elevator feel actuators
- Pitch rate sensors
- Elevator PCUs.

Each of the four elevator PCUs sends these analog feedback signals to the ACEs:

- EHSV position LVDT
- Actuator position LVDT
- Actuator null LVDT
- Differential pressure LVDT.

Column Position Transducers

There are six position transducers, three for each control column. The transducers send control column position and movement data to the ACEs.

Column Force Transducers

Two column force transducers measure the forces applied to the control column. The transducers send this data to the ACEs.

Elevator Feel Actuators

An elevator feel actuator is in each of the elevator feel units. They supply a feel force to the columns through the feel units. The ACEs command the elevator feel actuators. The elevator feel actuators also send position feedback signals to the ACEs.

Pitch Rate Sensors

Four pitch rate sensors measure the pitch rate of the airplane. The sensors send this data to the ACEs.

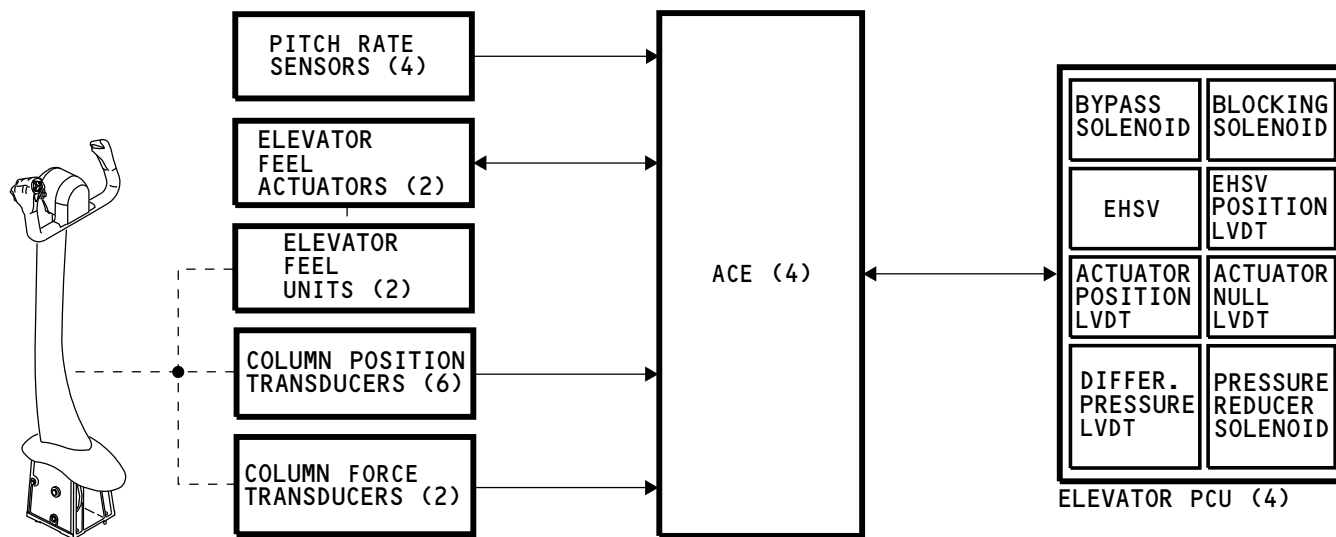
Elevator PCUs

Each of the four elevator PCUs receive analog and discrete electrical signals from the ACEs. The discrete signals are for the bypass, blocking, and pressure reducer solenoids. The analog signal is for the electrohydraulic servo valve (EHSV).

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ELEVATOR CONTROL - ANALOG AND DISCRETE INTERFACES

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ELEVATOR CONTROL - FORWARD CONTROLS

General

These are the forward controls of the pitch control system:

- Control columns
- Column torque tubes
- Column force transducers
- Compliance springs
- Column dampers
- Column balance weights
- Elevator feel units
- Elevator feel actuators
- Column position transducers
- Column breakout mechanism
- Backdrive actuators
- Stick shaker actuators
- Travel stops.

Control Columns

The two control columns are conventional in design and serve as the interface between the pilots and the flight controls. Forward and aft movement of the control columns command the movement of the elevators through flight control system electronics.

Each control column connects to a torque tube.

Column Torque Tubes

Each column torque tube moves when the control column moves. These are the components on the torque tube:

- Force transducer
- Compliance spring
- Column damper
- Column balance weight

- Column stick shaker.

The torque tubes connect to the elevator feel and centering mechanisms with a control rod.

Elevator Feel Units

The two elevator feel units supply feel forces to the pilots and column position data to the ACEs. Each feel unit has a feel and centering mechanism.

The elevator feel actuators on each elevator feel unit change the feel force on the control column.

Each elevator feel unit connects to the column breakout mechanism with a control rod.

Column Position Transducers

Three column position transducers are on each feel unit.

Column Breakout Mechanism

The column breakout mechanism connects the two control column systems together. The mechanism also makes it possible to move one control column should the other jam.

Backdrive Actuators

Two backdrive actuators connect to cranks on the left and right sides of the column breakout mechanism. The backdrive actuators are part of the autopilot system.

See the autopilot flight director system section for more information on the backdrive actuators (SECTION 22-11).

Stick Shaker Actuator

One stick shaker actuator is on each column torque tube.

See the warning electronic system section for more information on the stick shaker actuators and stall warning function (SECTION 31-51).

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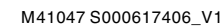


ELEVATOR CONTROL - FORWARD CONTROLS

Travel Stops

Travel stops are on the column torque tubes. They limit control column travel to 9.6 degrees forward and 10.5 degrees aft.

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ELEVATOR CONTROL - FORWARD CONTROLS

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**ELEVATOR CONTROL - CONTROL COLUMNS****Purpose**

Each pilot has a control column to command pitch control.

Physical Description

The control column is a one piece aluminum casting. It is approximately 36 inches (.9 m) long.

The control column extends down through the flight deck floor and attaches to the torque tube with four bolts.

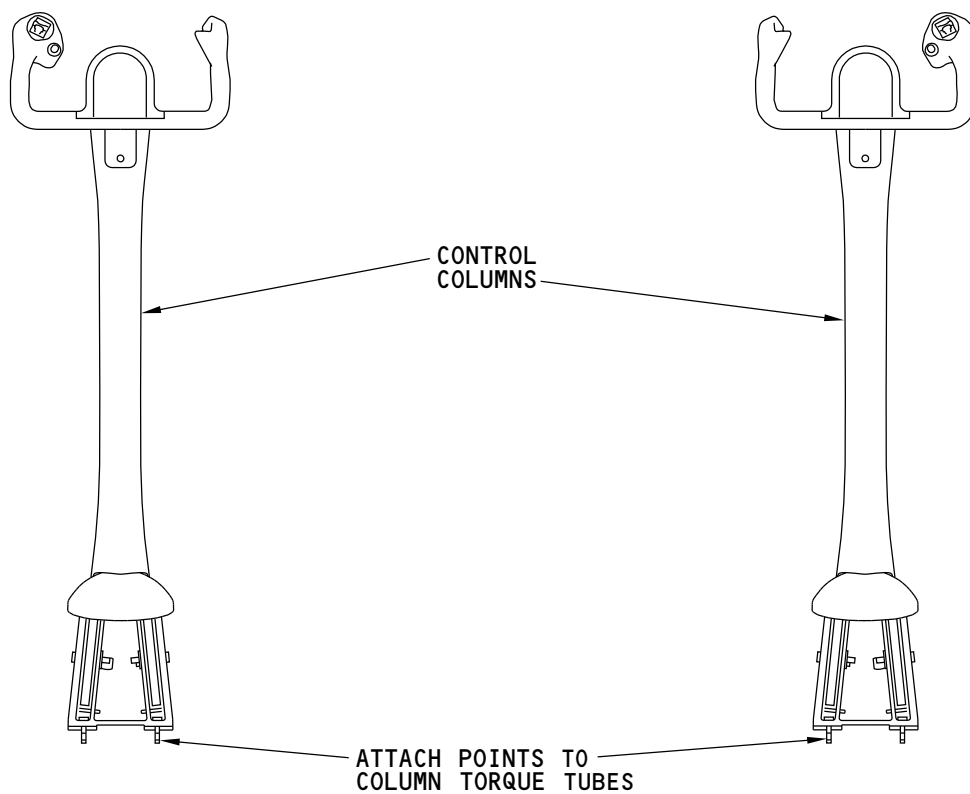
Location

The two control columns are on the flight deck.

Functional Description

Fore and aft movement of the control column operates the pitch control mechanisms below the flight deck.

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ELEVATOR CONTROL - CONTROL COLUMNS

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ELEVATOR CONTROL - COLUMN TORQUE TUBES

Purpose

Each control column attaches to a column torque tube below the flight deck floor. The torque tube also connects to the elevator feel unit with a control rod.

Each column torque tube has these components:

- Stick shaker actuator
- Compliance spring
- Column force transducer
- Lost motion device
- Column balance weight
- Crank for column damper.

Compliance Spring

The compliance spring connects the column torque tube and the column force transducer. The flexibility of the compliance spring simulates the feel of a mechanical system to the pilots.

Lost Motion Device

The lost motion device permits movement in the force transducers. The elevator feel unit supplies resistance to fore and aft movement of the control column. The lost motion device allows some movement of the force transducers as control column force increases. If the column force transducer fails or disconnects, the lost motion device allows control column force to be transmitted to the elevator feel unit. Additionally, the lost motion device permits the force transducer to compress and expand. Lost motion is approximately two degrees at the control column.

Column Balance Weight

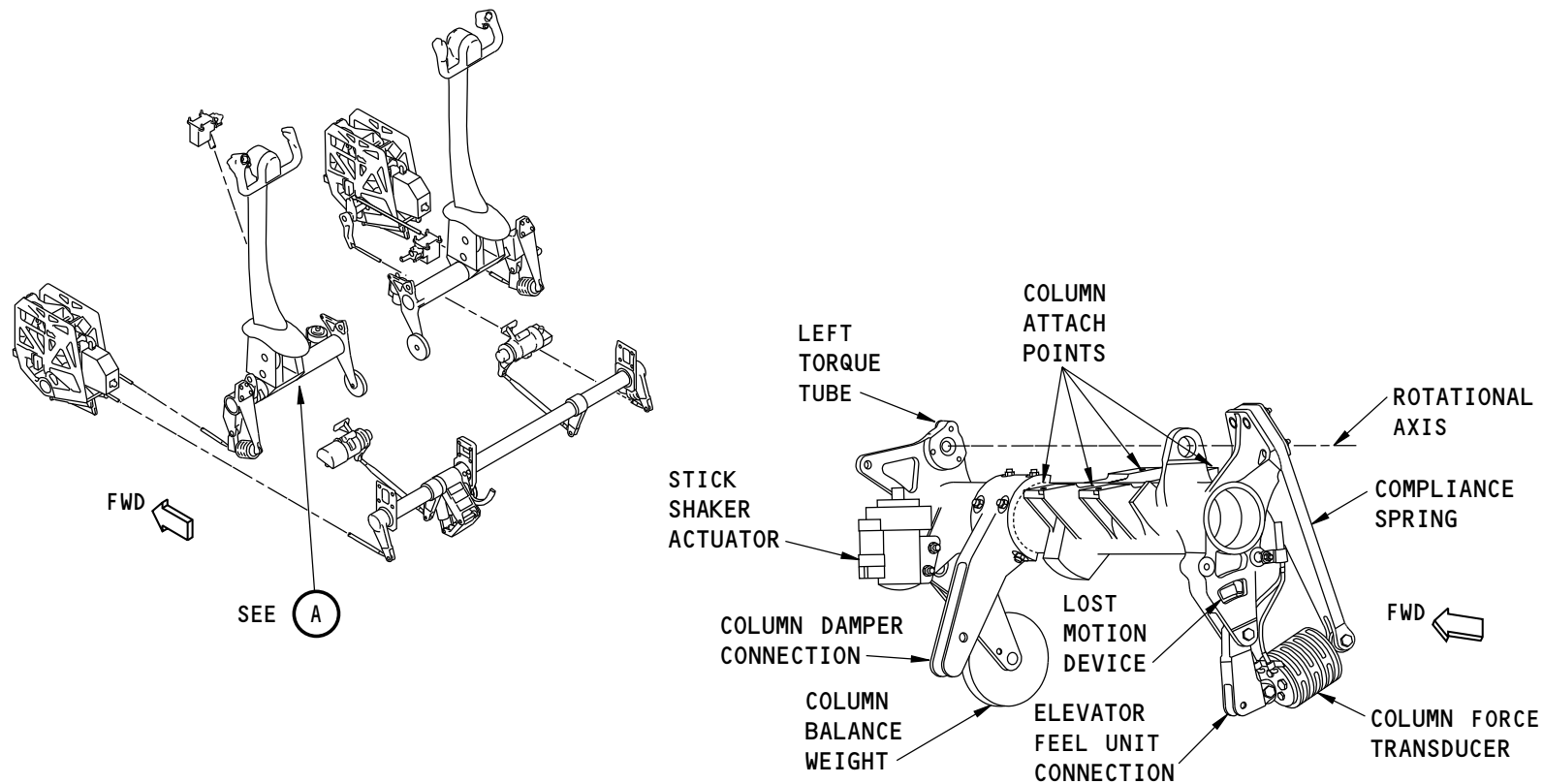
A balance weight attaches to each torque tube. This weight balances the control column about its rotational axis.

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CAPTAIN'S SIDE IS SHOWN
(FIRST OFFICER'S IS OPPOSITE)

(A)

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ELEVATOR CONTROL - COLUMN TORQUE TUBES

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**ELEVATOR CONTROL - STICK SHAKER ACTUATOR****Purpose**

Two stick shaker actuators cause the control columns to vibrate when the aircraft is near a stall condition. This warns the flight crew of a situation that can be dangerous.

Physical Description

The stick shaker actuator is an LRU and weighs approximately 1.6 lb (0.6 kg). It attaches with two bolts to the column torque tube.

A power source connects to the electrical connector on each stick shaker actuator.

Functional Description

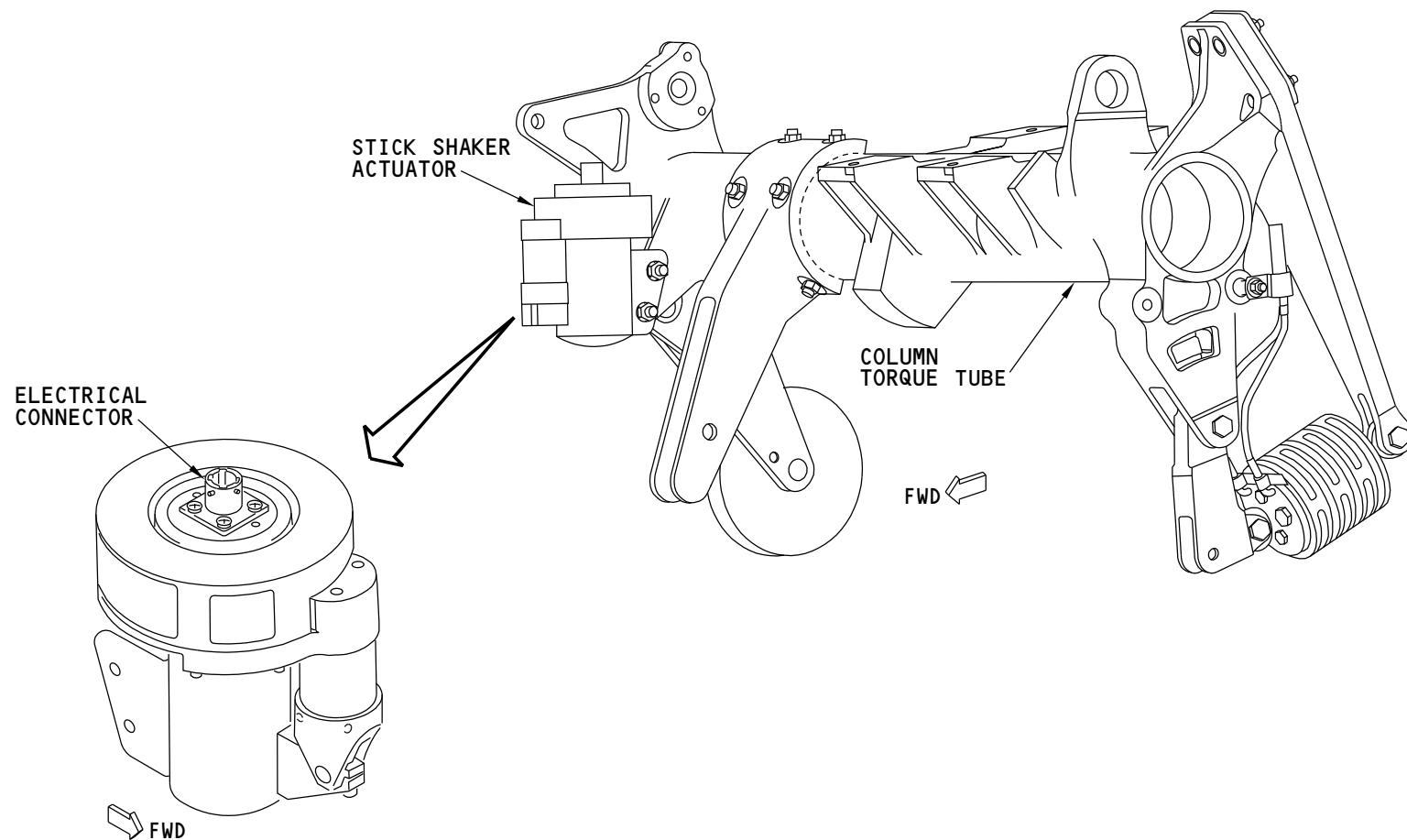
When the airplane gets near a stall condition, the warning electronics system supplies power to the stick shaker actuators. This causes a 28v dc motor in the actuator to rotate a shaft.

On the motor shaft is an eccentric weight that makes the control column vibrate.

This supplies a warning to the pilots that the airplane is near a stall.

Training Information Point

The stick shaker actuators are identical and interchangeable.



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ELEVATOR CONTROL - STICK SHAKER ACTUATOR

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ELEVATOR CONTROL - COLUMN FORCE TRANSDUCER

Purpose

Two column force transducers measure the force that the pilot applies to the control column. The force transducers send analog electrical signals to the ACEs. The PFCs use these signals to know when a pilot applies a force to the control column.

Physical Description

The force transducer is a spring with two electrically isolated LVDTs inside. The ACEs supply 7v ac, 1800 Hz excitation power.

Each LVDT has a separate cable which connects to the ACE connector bracket. This bracket has two receptacles, one for each LVDT of the force transducer. The order in which each LVDT connects to the connector bracket determines the LVDT-to-ACE relationship.

The column force transducers are different from the wheel force transducer.

Location

There is a force transducer on each elevator torque tube. The force transducer attaches to the compliance spring at the aft end, and to the elevator feel unit connecting rod at the forward end. There is a column force transducer installed on the outboard end of each column torque tube.

Functional Description

When a pilot applies a force of 2.5 lb or more to the control column, the force transducers signal the PFC the columns are no longer in the neutral position.

When the force transducers find a force of less than 2.5 pounds, the PFC uses that signal to find that the column is at the neutral position.

Indications

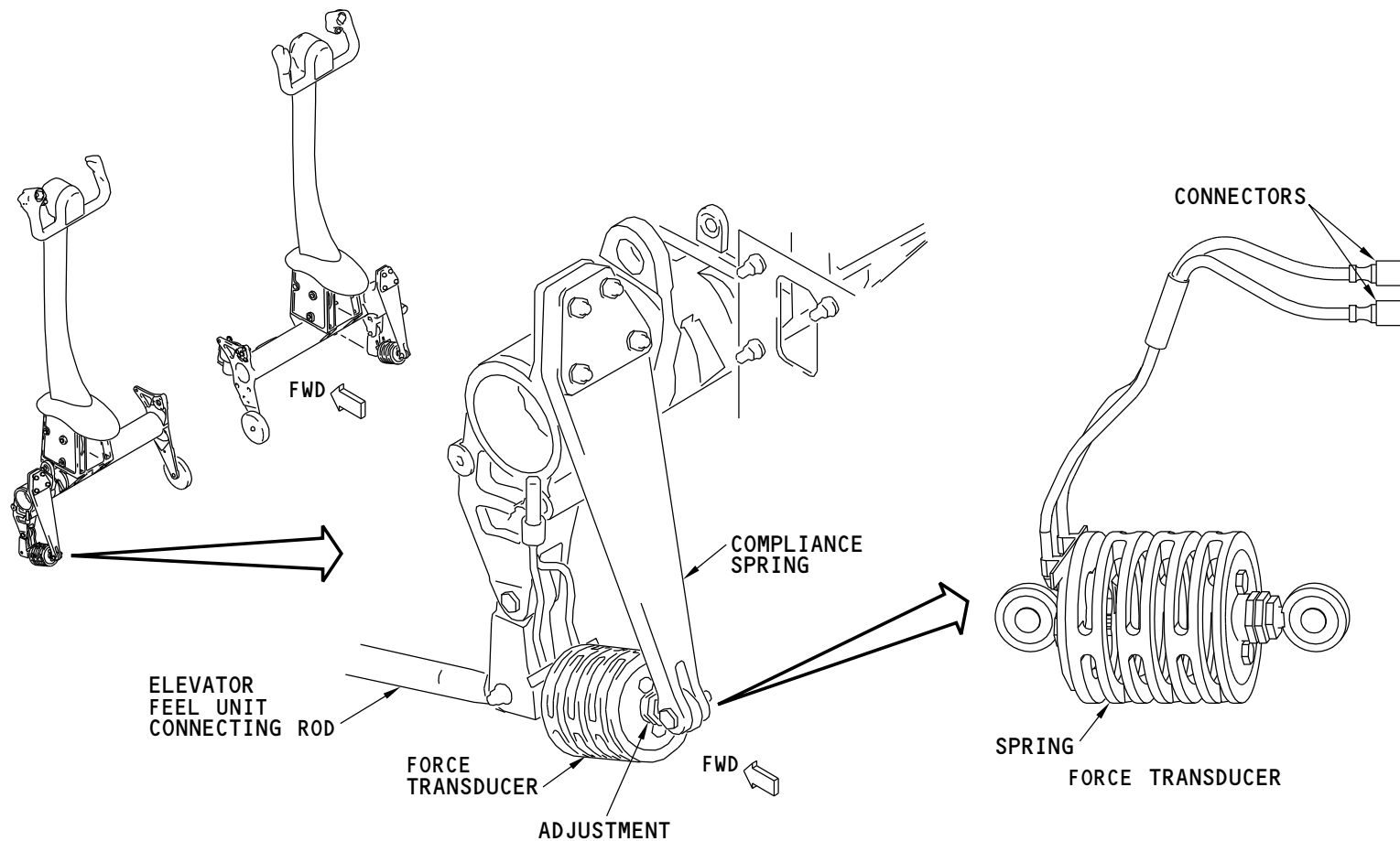
The status message FLIGHT CONTROL SYS shows when one of the force transducers is defective.

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ELEVATOR CONTROL - COLUMN FORCE TRANSDUCER

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ELEVATOR CONTROL - COLUMN DAMPER

Purpose

Two control column dampers supply a resistance to the movement of the control column. This prevents column vibrations and brings the column to rest with minimum oscillation.

Physical Description

The column damper is an LRU and weighs about 1.6 lb (0.7 kg).

The column dampers are identical to the wheel and rudder pedal dampers. There are four of these identical dampers on the airplane.

The dampers are on each of the column torque tubes. Control rods connect from arms on the column torque tubes to splined cranks connecting to the dampers.

The column damper has an input shaft. The column damper uses a fluid to absorb vibrations that go to the shaft. A window on the column damper shows the position of the fluid level indicator.

The damper crank on the damper shaft, has a pair of rivets. These shear out in case of a jam of the column damper.

Location

The column dampers are just forward of each column torque tube.

Functional Description

As the control columns rotate the torque tubes, the connecting rods move the splined cranks on the column dampers. The dampers absorb the vibration in the control columns. The dampers add a small force to control column movement.

Training Information Point

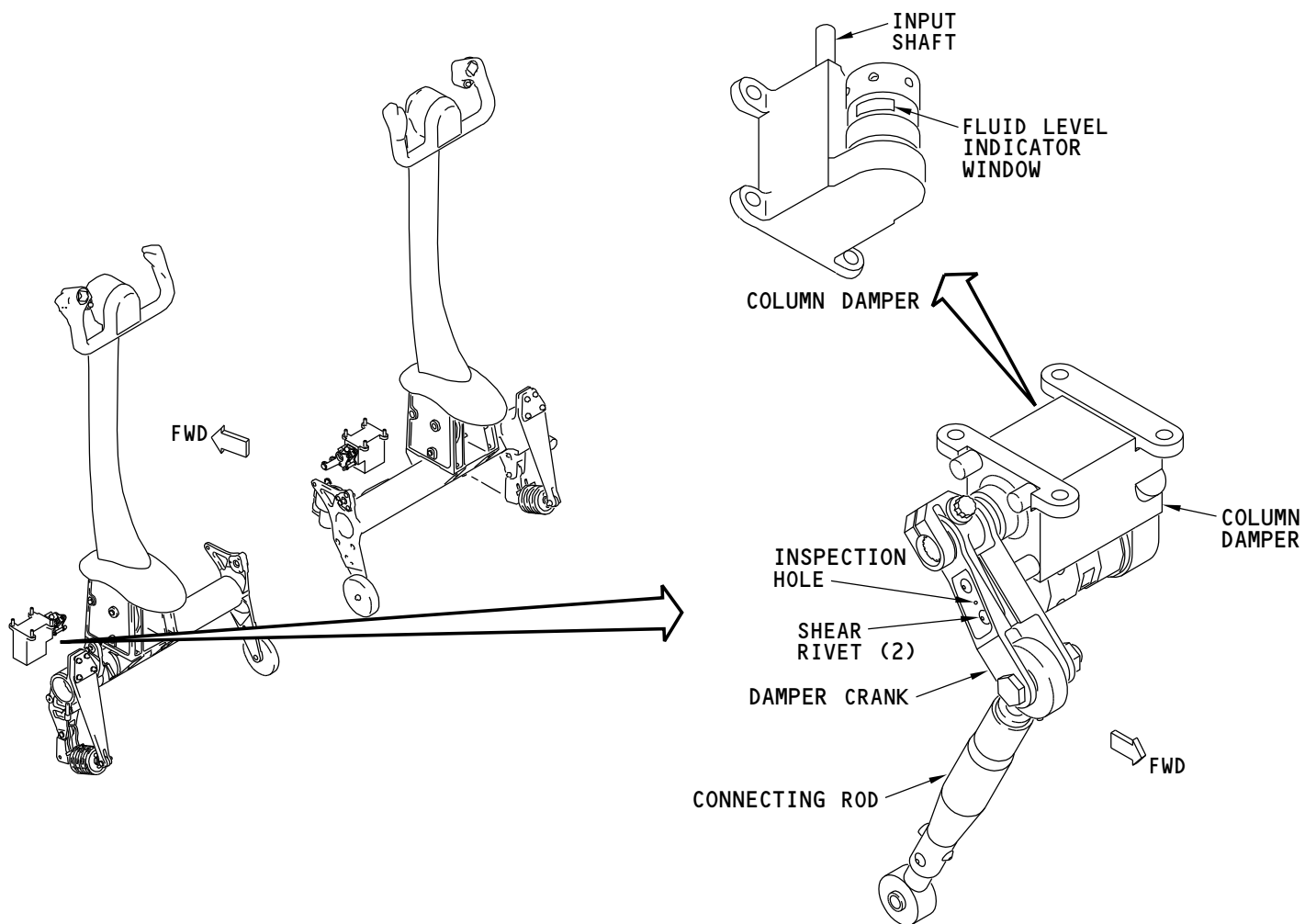
If the fluid level indicator shows a green band width of 1/16 inch or less, the fluid level is low. Then it is necessary to replace the column damper.

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ELEVATOR CONTROL - COLUMN DAMPER

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ELEVATOR CONTROL - ELEVATOR FEEL UNIT

Purpose

Two elevator feel units supply feel forces to the control columns. They also supply a centering function that returns the control column to neutral.

Physical Description

The two elevator feel units are similar but not interchangeable.

Each elevator feel unit has a single cam and roller unit. The cam attaches by a spline to the shaft of the feel unit. The input crank, connected to the column torque tube, turns the shaft and the cam. The follower assembly has a roller which rides on the cam. A centering arm, which pivots on the elevator feel unit structure, supports the follower assembly and attaches to the feel springs. Two feel springs, between the centering arm and the spring arm, keep the roller on the cam. The two feel springs provide the feel force and the centering function. The output crank also attaches to the shaft of the feel unit. The output crank connects to the aft torque tube with a control rod.

An elevator feel actuator and three column position transducers are on each elevator feel unit.

The elevator feel actuator connects to the variable feel mechanism. This mechanism consists of levers and a linkage which connect to the spring arm. A spring connects to the mechanism to take up any play in the mechanism. A bias spring, near the feel actuator, forces the feel actuator to fully retract when it does not operate.

Location

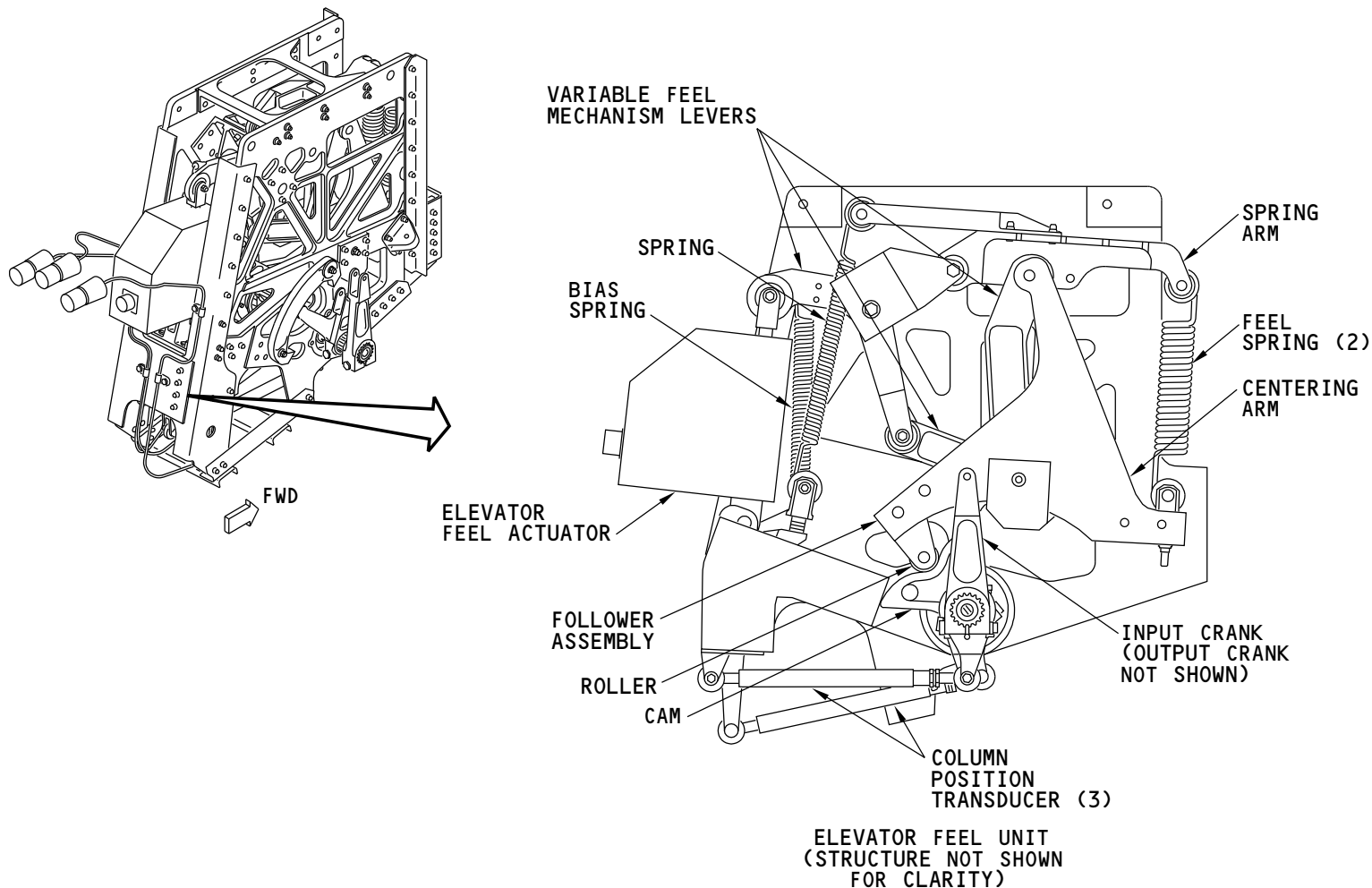
The two elevator feel units are under the flight deck. Access is by the forward equipment door or from the MEC.

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ELEVATOR CONTROL - ELEVATOR FEEL UNIT

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**ELEVATOR CONTROL - ELEVATOR FEEL ACTUATOR****Purpose**

The feel actuators change the geometry of the elevator feel units to change the feel force at the control columns.

Physical Description

The two actuators are identical and interchangeable LRUs.

The feel actuator has a 28v dc reversible electric motor. The actuator extends 2.5 inches (63.5) maximum. Each actuator weighs about 4.27 lb (1.6 kg).

The actuator attaches to the elevator feel unit structure. The actuator rod end attaches to the input lever of the variable feel mechanism.

Location

The elevator feel actuators are on the aft side of the elevator feel units.

Functional Description

When the elevator feel actuator extends, it changes the configuration of the feel mechanism in the feel unit. When the column moves, this causes an increase in the extension of the feel springs. This increases the feel force at the columns.

The rod end of the actuator moves in response to the commands from the ACEs. The L2 ACE sends commands to the left feel actuator and the C ACE sends commands to the right feel actuator. An RVDT in the feel actuator supplies a position feedback signal to the PFCs through the ACE.

Indications

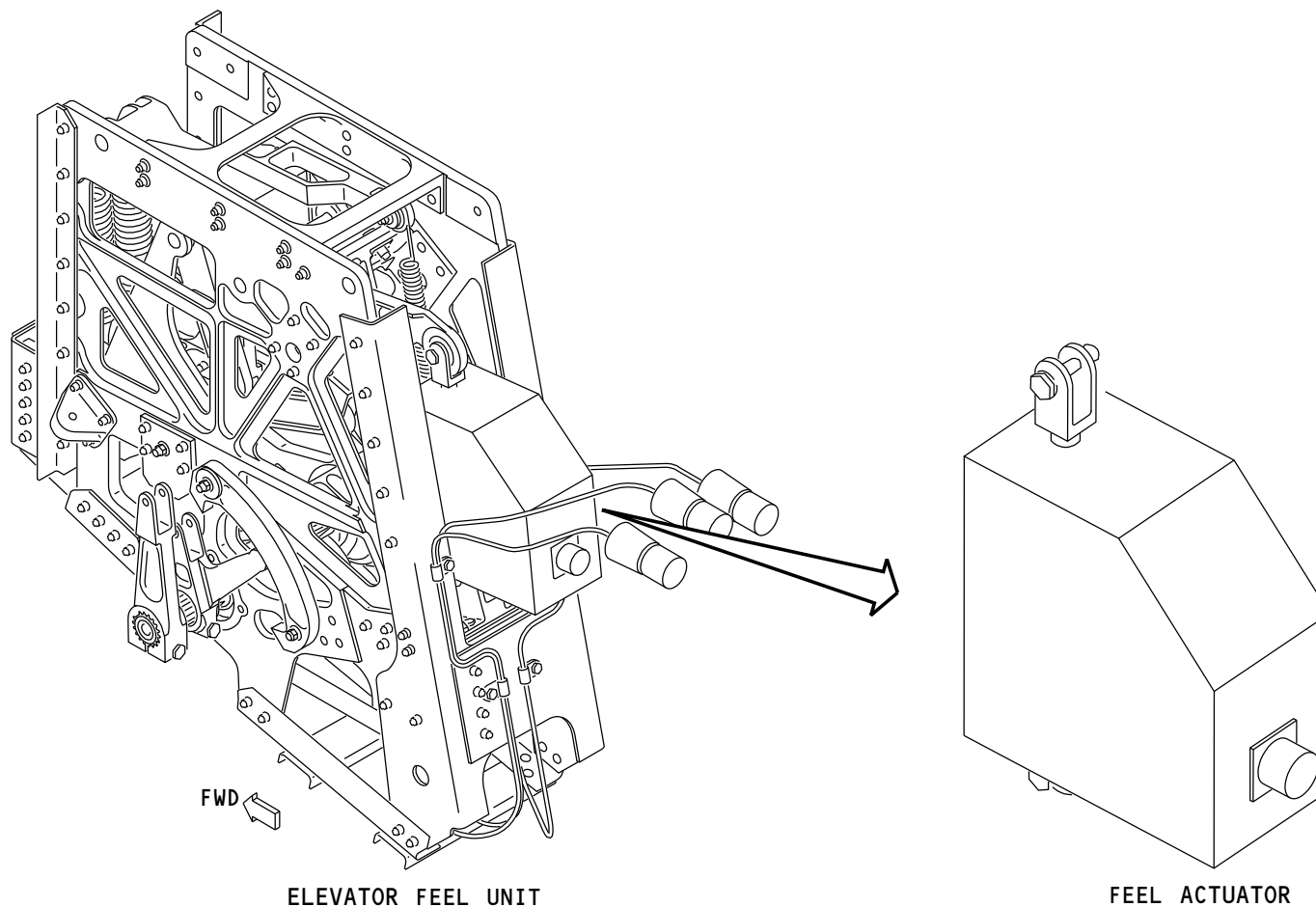
The status message FLIGHT CONTROL SYS shows when one, or more, elevator feel actuator is defective.

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ELEVATOR CONTROL - ELEVATOR FEEL ACTUATOR

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**ELEVATOR CONTROL - ELEVATOR FEEL - FUNCTIONAL DESCRIPTION****General**

The elevator feel unit supplies a feel force to the control columns. The elevator feel actuator changes the feel force. The feel at the control column increases with the amount of column movement and the speed of the airplane.

Feel and Centering

When the pilot moves the control column, the cam in the elevator feel unit rotates. This causes the cam follower to move and the centering arm to extend the feel springs. At low airspeed, the feel force at the control column is from 6.4 lb (2.9 kg) at breakout to a maximum of 43.3 lb (19.6 kg) at column maximum travel.

When the pilot releases the control column, the feel springs force the cam follower back to the cam detent. This returns the elevator control system to the neutral position.

Variable Feel

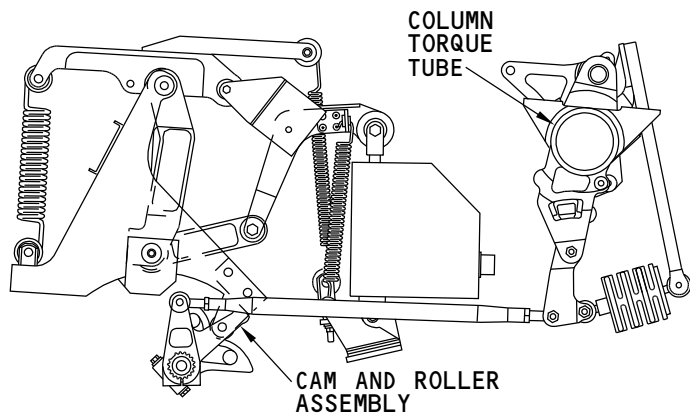
As the speed of the airplane increases, the feel actuator extends gradually. This causes the levers of the variable feel mechanism to move the mechanism pivot point. The feel springs extend further with the mechanism in this position. When the pilot moves the column, the increased spring extension causes an increase of the column feel force.

The feel actuator extends and retracts as the airspeed increases and decreases. This causes the column feel force, at full travel, to change from 43.3 lb (19.6 kg) at low airspeed to approximately 100 lb (45.4 kg) at high airspeed.

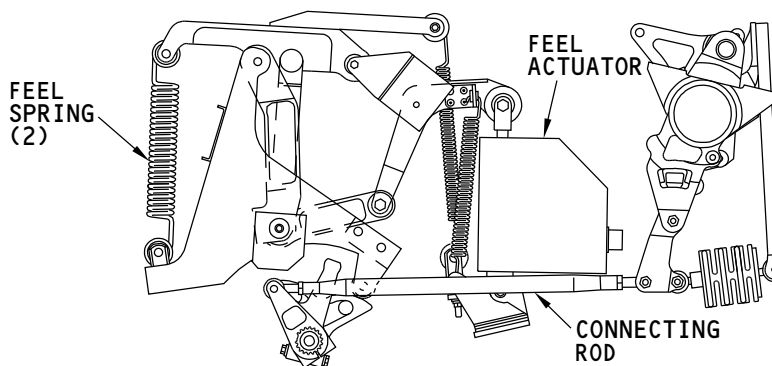
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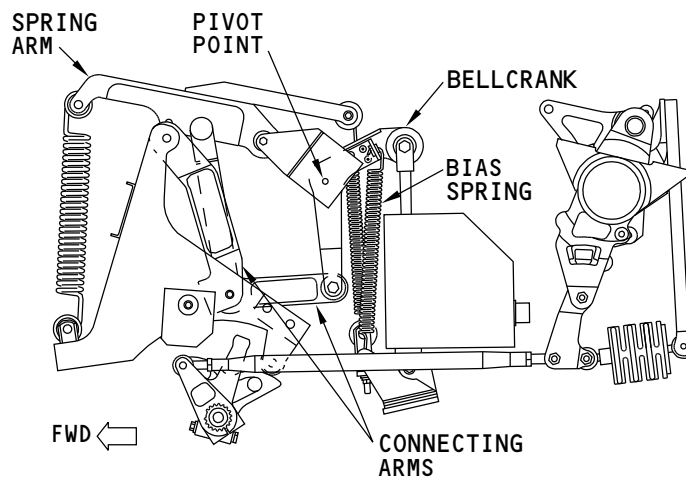
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CONTROL COLUMN-NEUTRAL, FEEL ACTUATOR RETRACTED



CONTROL COLUMN INPUT, FEEL ACTUATOR RETRACTED



CONTROL COLUMN INPUT, FEEL ACTUATOR EXTENDED

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ELEVATOR CONTROL - ELEVATOR FEEL - FUNCTIONAL DESCRIPTION

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ELEVATOR CONTROL - COLUMN POSITION TRANSDUCERS

Purpose

The six column position transducers measure the position of the control columns. The transducers send analog electrical signals to the ACEs.

Physical Description

Each position transducer is an LVDT. The ACEs supply 7v ac, 1800 Hz excitation power.

The aft attach point on each position transducer connects to a fixed point on the elevator feel unit. The forward end attaches to a transducer crank.

Each transducer crank attaches to its shaft assembly with a spline. The spline has a missing tooth to help locate the crank on the shaft. Each transducer crank has two shear rivets to allow override of a jammed position transducer.

Each transducer has an electrical cable which connects to the ACE connector bracket. This bracket has three receptacles, one for each position transducer. The order in which each position transducer connects to the connector bracket determines the transducer-to-ACE relationship.

Location

Three column position transducers are on each elevator feel unit.

Functional Description

When the splined input shaft rotates in response to control column movement, the column position transducers extend or retract. Each position transducer sends an analog electrical signal to one ACE.

Indications

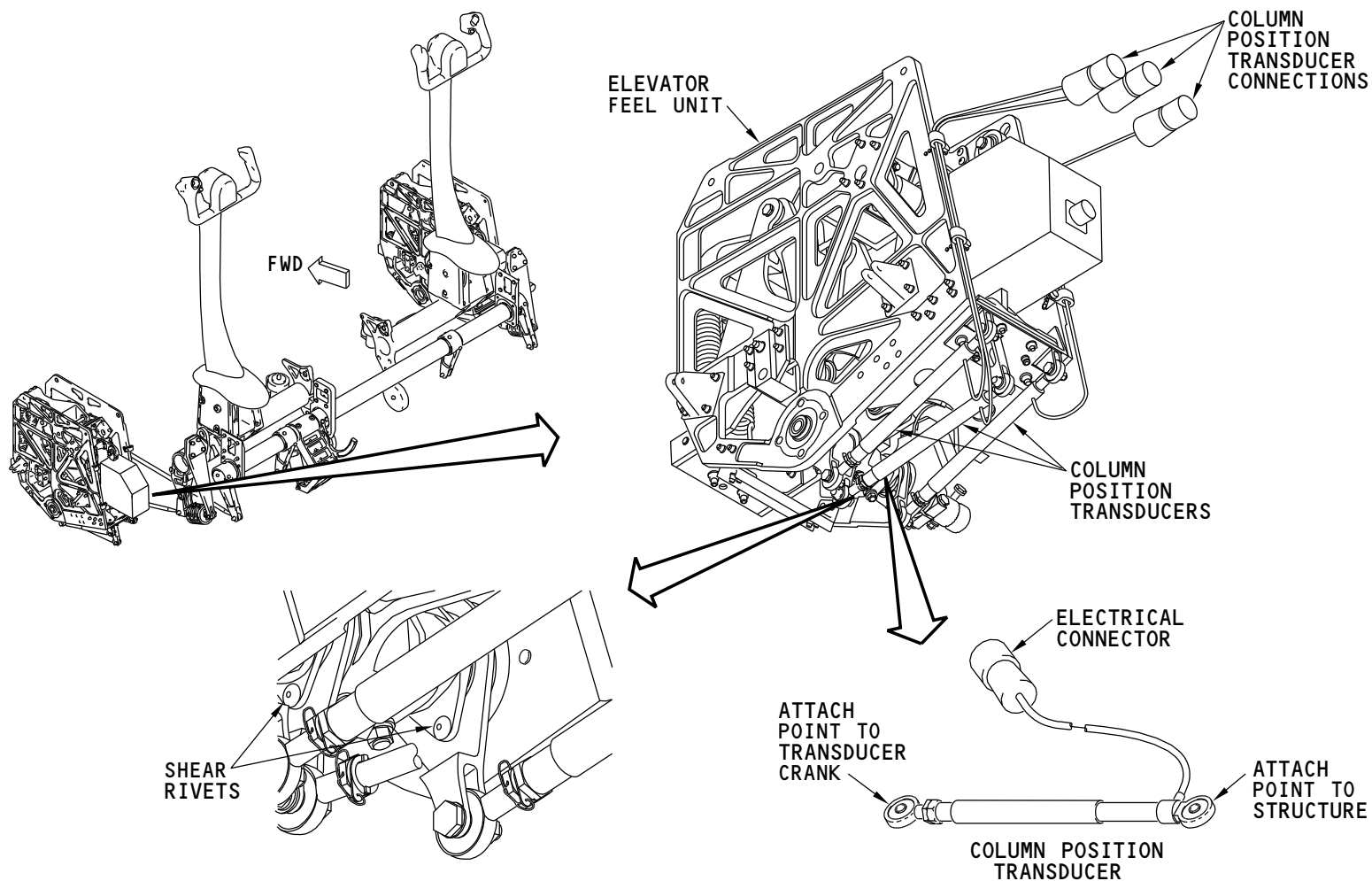
On the status display, the message CONTROL COLUMN XDCR shows that there is a failure in one of six column transducers.

The status message FLIGHT CONTROL SYS shows when two or more column position transducers are failed.

Training Information Point

The six column position transducers are identical to the six wheel position transducers and the four pedal position transducers. There are 17 of these identical position transducers on the airplane.

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ELEVATOR CONTROL - COLUMN POSITION TRANSDUCERS

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ELEVATOR CONTROL - COLUMN BREAKOUT MECHANISM

Purpose

The column breakout mechanism makes it possible to control the elevators if a jam occurs in a control column, the column torque tubes, or an elevator feel unit.

Physical Description

The column breakout mechanism has a cam on the right torque tube. The cam follower assembly roller is on the left torque tube. Two springs keep the roller on the cam. The two torque tubes have connections for the elevator feel unit and backdrive actuator rods.

Location

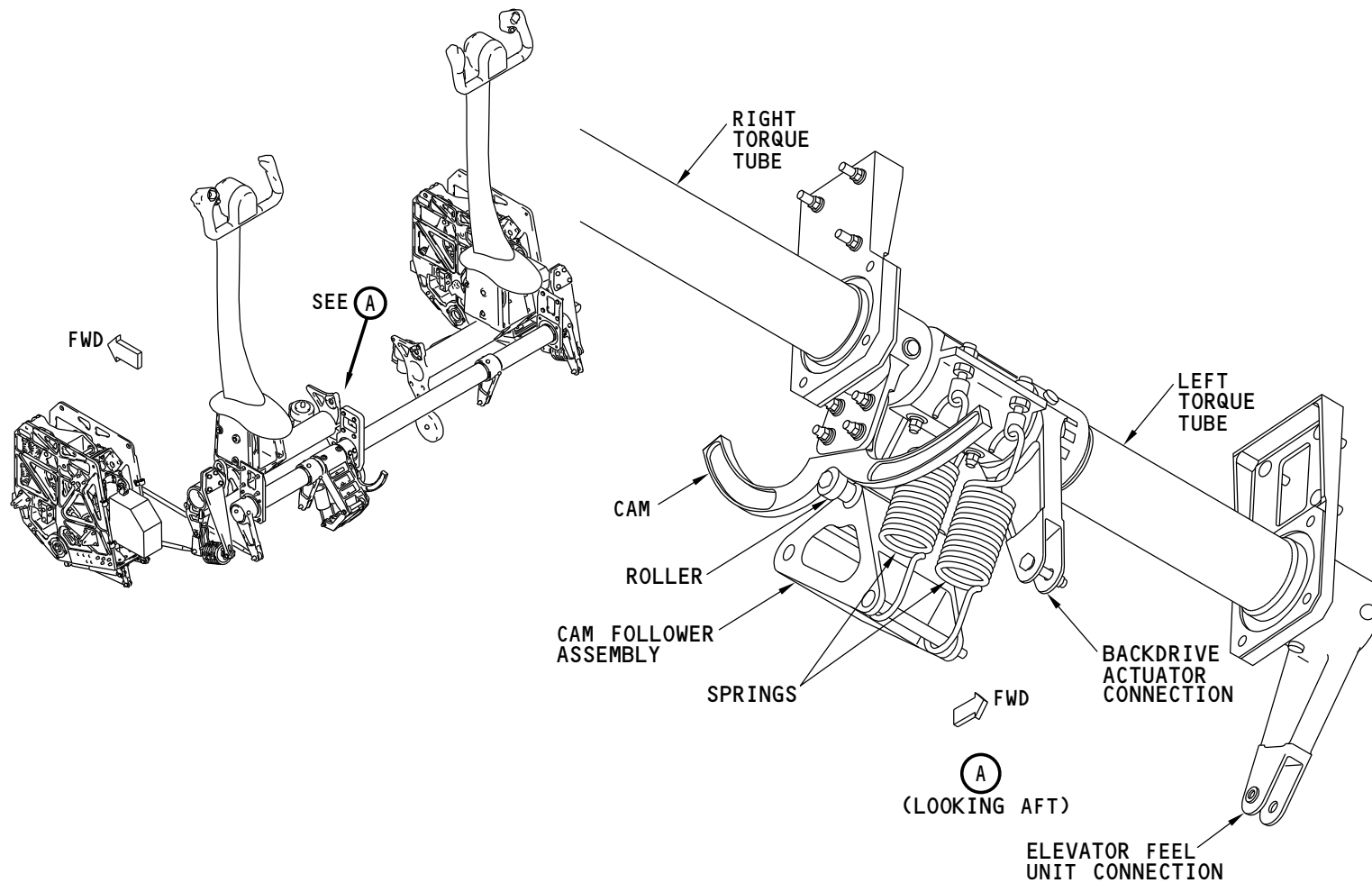
The breakout mechanism is under the flight deck, aft of the column torque tubes. Access is through the forward equipment center door.

Functional Description

During normal operation, the two torque tubes of the column breakout mechanism are held together by the springs of the cam and roller mechanism. This supplies a load path to transfer control column force from one side to the other. During normal operations, movement of one control column will cause approximately the same movement of the other column.

If a jam occurs in the elevator control mechanism on either pilot's side, the other side will be free to move. The roller then moves out of the cam detent which allows control column movement on the side opposite the jam.

A force at the control column of approximately 50 lb (23 kg) is necessary to move the roller out of the detent position.



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ELEVATOR CONTROL - COLUMN BREAKOUT MECHANISM

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ELEVATOR CONTROL - PITCH RATE SENSOR

Purpose

The pitch rate sensors measure the pitch rate of the airplane. The sensors send analog electrical signals to the ACEs. Pitch rate sensor data goes to the PFCs for normal mode pitch command calculations.

Physical Description

There are four identical pitch rate sensors. They are LRUs. Each pitch rate sensor attaches to a support bracket. Each sensor attaches to structure by a bonding strap.

Location

The pitch rate sensors are on the front spar of the wing center section. They are at the aft end of the forward cargo compartment in the environmental control system mix bay area. You get access to the pitch rate sensors through the forward cargo door. You must remove the aft end wall of the forward cargo compartment. The pitch rate sensors are mounted on the aft side of support brackets.

Functional Description

When the pitch attitude of the airplane changes, the pitch rate sensors sense and measure the rotational acceleration of the airplane about the lateral axis. The sensors change the rotational acceleration into analog electrical signals.

Indications

When a single pitch rate sensor fails, the PFCS INTERFACE status message shows.

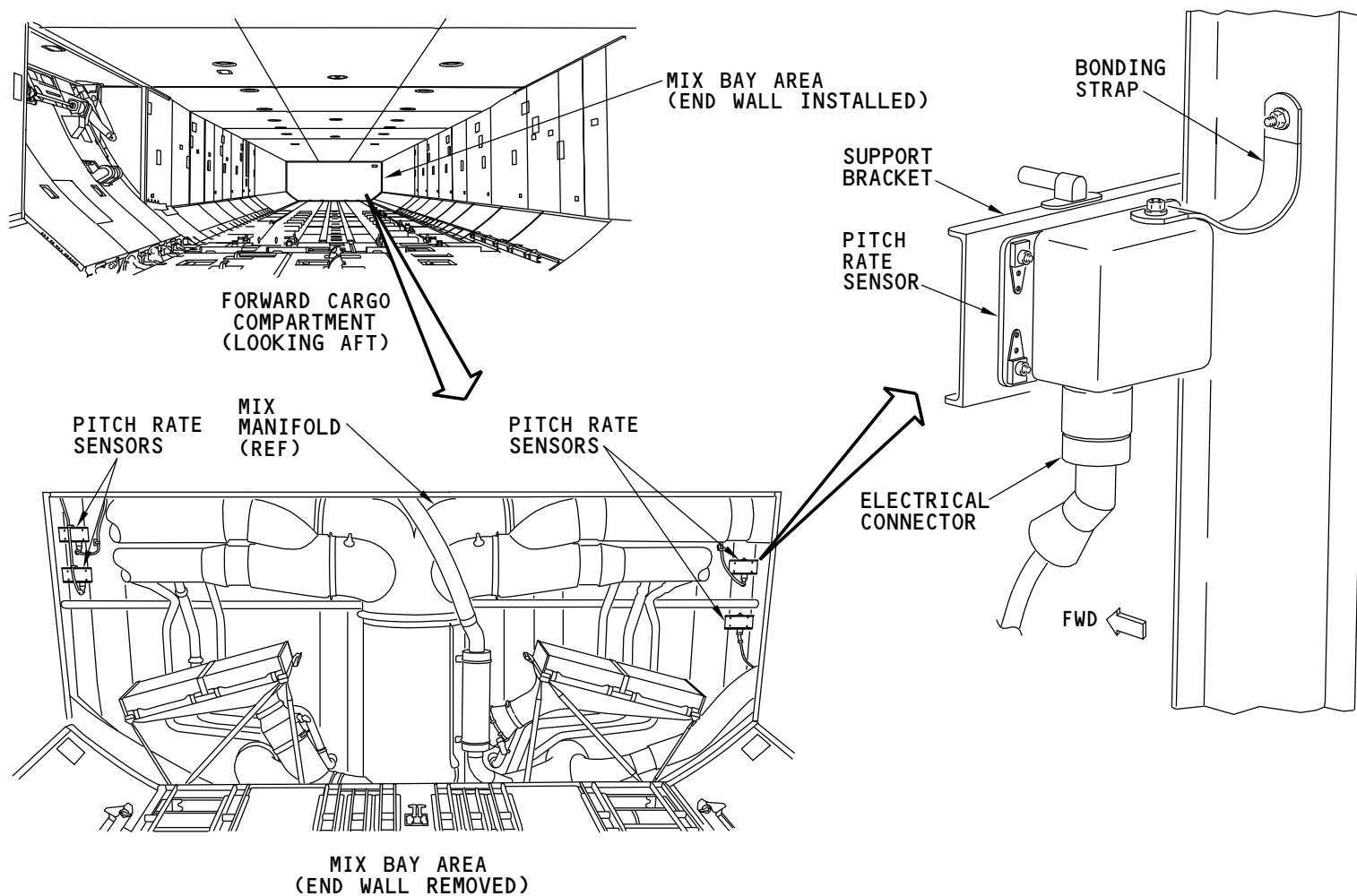
When two or more pitch rate sensors fail, the FLIGHT CONTROL SYS status message shows and the PFCS selects the secondary mode of operation.

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ELEVATOR CONTROL - PITCH RATE SENSOR

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**ELEVATOR CONTROL - ELEVATOR PCU - INTRODUCTION****Purpose**

The elevator PCUs move the elevators. Electrical signals from the ACEs command the elevator PCUs. Each elevator has two PCUs.

Location

The two PCUs are side by side on the rear spar of the horizontal stabilizer. To get access to each PCU, remove a 24 by 24 inch (Approx.) panel on the bottom of the stabilizer.

The kick link connects the PCU to the rear spar fitting. The actuator rod and the reaction link connect to the elevator structure at the PCU fitting.

Two electrical connectors of different sizes connect to the upper side of the PCU.

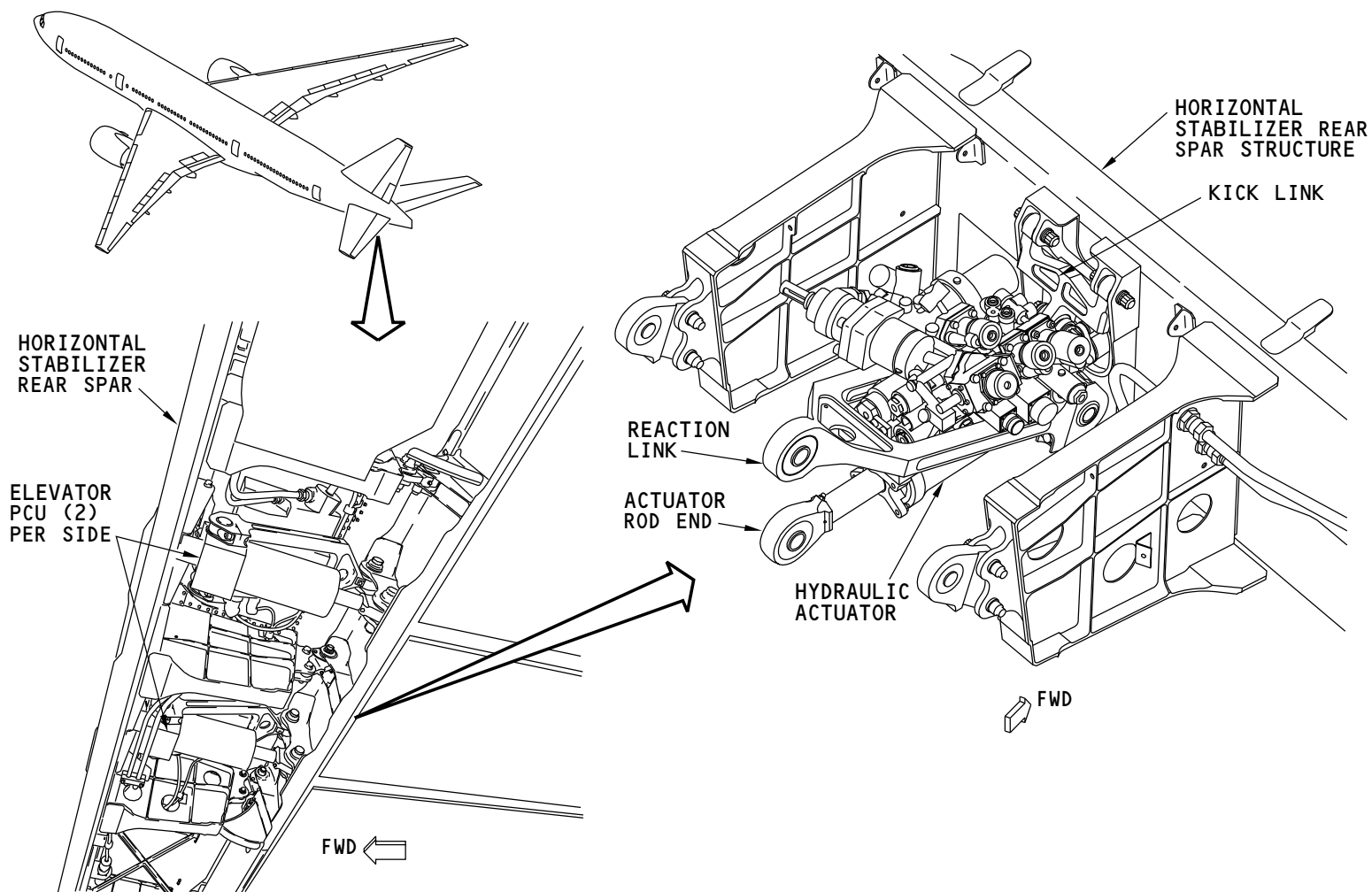
Hydraulic tubing connects to ports on the upper side of the PCU.

Training Information Point

Remove and install the elevator PCU as one assembly with the reaction link. The elevator PCU disconnects from the kick link which stays on the airplane.

Use the cradle hoist ground service equipment (GSE) to support the PCU during removal and installation.

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ELEVATOR CONTROL - ELEVATOR PCU - INTRODUCTION

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ELEVATOR CONTROL - ELEVATOR PCU - PHYSICAL DESCRIPTION

Physical Description

All four elevator PCUs are identical. Each elevator PCU, with its reaction link, weighs about 85 lb (41 kg).

The outboard PCUs are powered by the left hydraulic system. The left inboard is powered by the center system and the right inboard is powered by the right system.

Each elevator PCU contains a hydraulic actuator with a control module. The control module contains:

- Electrohydraulic servo valve (EHSV)
- Pressure reducer solenoid valve which controls the pressure reducer valve
- Bypass solenoid valve
- Pressure sag check valve
- Blocking solenoid valve with two solenoid coils
- Mode selector valve with manual bypass
- Differential pressure sensor
- Bypass check valves with restrictors (2)
- Thermal relief valve
- Compensator/relief valve with quantity indicator
- Manual test valve for the compensator/relief valve
- Anti-cavitation check valves with restrictors (2)
- Inlet check valve
- Inlet filter.

Hydraulic Actuator

The actuator piston has an LVDT that sends actuator position feedback signals to the ACE. The actuator piston also has a null LVDT to adjust the null position of the actuator piston LVDT during installation of the PCU.

EHSV

The EHSV controls the hydraulic power to the extend and retract sides of the actuator. The EHSV has an LVDT that sends EHSV position feedback signals to the ACE.

Pressure Reducer Solenoid Valve

The outboard PCU uses the pressure reducer solenoid valve to operate with reduced hydraulic pressure. The pressure reducer solenoid valve for the inboard PCU is not used. The inboard PCU always operates at nominal hydraulic system pressure of 3000 psi.

The ACE that commands the inboard PCU controls the pressure reducer solenoid valve for the outboard PCU. The pressure reducer solenoid valve commands the pressure reducer valve to decrease the hydraulic pressure to 2140 psi for the outboard PCU. Reduced pressure on the actuator decreases the probability of a leak and decreases fatigue loads during normal operation.

In case of failure of an inboard PCU or its hydraulic source, the hydraulic pressure to the outboard PCU increases to the nominal hydraulic system pressure of 3000 psi. This permits the outboard PCU to increase its capacity.

Bypass Solenoid Valve

The on-side ACE commands the bypass solenoid valve. The bypass solenoid valve controls the pilot pressure from the hydraulic system to the mode selector valve.

Pressure Sag Check Valve

The pressure sag check valve prevents pressure decreases from affecting the position of the mode selector valve.

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ELEVATOR CONTROL - ELEVATOR PCU - PHYSICAL DESCRIPTION

Blocking Solenoid Valve

The on-side ACE controls one coil of the blocking solenoid valve, the ACE commanding the adjacent PCU controls the other coil. The blocking solenoid valve controls the pilot pressure from the actuator to the mode selector valve.

Mode Selector Valve

Pilot pressure from the bypass or the blocking solenoid valves commands the mode selector valve to one of these positions:

- Normal
- Bypass
- Blocking.

Differential Pressure Sensor

A differential pressure sensor measures the pressure difference between both sides of the actuator piston. The sensor operates an LVDT which sends signals to the ACE.

Bypass Check Valves with Restrictors

The two bypass check valves permit pressure from either side of the actuator to reach the blocking solenoid valve. The restrictors prevent pressure fluctuations from affecting the position of the mode selector valve.

Thermal Relief Valve

The thermal relief valve protects the actuator from thermal expansion of the hydraulic fluid.

Compensator/Relief Valve with Quantity Indicator

The compensator/relief valve holds a small quantity of fluid at a pressure slightly above the hydraulic system return pressure. This fluid is available to the actuator to prevent cavitation.

The indicator shows the quantity of fluid in the compensator.

Manual Test Valve

You use the manual test valve to test the proper operation of the compensator/relief valve. With the manual test valve open, the compensator/relief valve pressure decreases. Check that the quantity indicator moves to the empty position.

Anti-Cavitation Check Valves with Restrictors

The two anti-cavitation check valves permit return fluid from the compensator/relief valve to flow to the actuator. This prevents cavitation of the actuator during rapid backdriving of the PCU. The restrictors maintain elevator panel stiffness in case a check valve fails open.

Inlet Check Valve

The inlet check valve keeps the hydraulic fluid in the actuator when the hydraulic system power is lost.

Inlet Filter

The inlet filter protects the actuator from solids in the hydraulic fluid.

Training Information Point

A manual bypass valve permits movement of the PCU manually. Hydraulic power must be off before you use the manual bypass valve.

To move the elevator for maintenance, access the manual bypass valve. Turn the valve on both PCUs with the special tool while moving the elevator. After release of the manual bypass, it closes.

After installation of the elevator PCU, the actuator null LVDT requires adjustment. Remove the null LVDT access cover to adjust the actuator null LVDT.

During periodic inspection, you use the manual test valve to check the proper function of the compensator/relief valve. Remove hydraulic power from the PCU then move the manual test valve to release pressure internal to the compensator/relief valve. Do a check to see that the compensator/relief valve indicator moves all the way to its empty position.

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ELEVATOR CONTROL - ELEVATOR PCU - PHYSICAL DESCRIPTION

The bearings in the actuator rod end and the reaction link require lubrication.

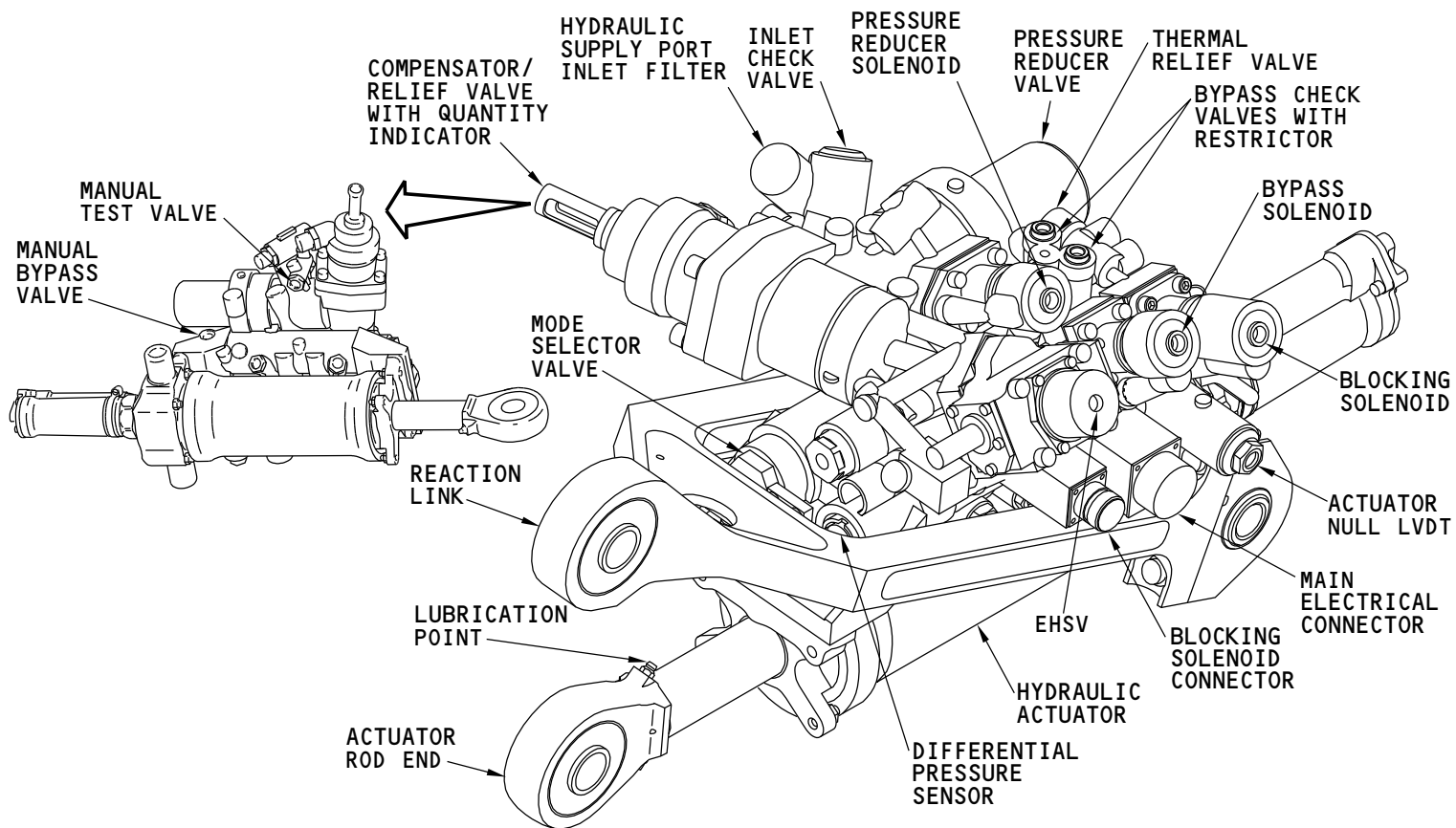
All other bearings on the actuator and the reaction link are teflon coated. They do not require lubrication.

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ELEVATOR CONTROL - ELEVATOR PCU - PHYSICAL DESCRIPTION

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ELEVATOR CONTROL - ELEVATOR PCU - FUNCTIONAL DESCRIPTION

General

The elevator PCU operates in three different modes:

- Normal
- Bypass
- Blocking.

In the normal mode, the ACE energizes the bypass solenoid and at least one of the coils of the blocking solenoid. The ACE energizes or de-energizes the pressure reducer solenoid of the outboard PCU. The pressure reducer solenoid of the inboard PCU is not used and is always de-energized.

In the bypass mode, the ACE de-energizes the bypass solenoid and energizes at least one of the coils of the blocking solenoid. When the outboard PCU is in the bypass mode, the ACE energizes the outboard PCU pressure reducer solenoid.

In the blocking mode, the ACE de-energizes:

- The bypass solenoid
- Both coils of the blocking solenoid
- The pressure reducer solenoid (outboard PCU).

The solenoid of the blocking valve has two coils. When both coils are de-energized, the valve is in its relaxed state. When one or both coils of the solenoid is energized, the valve moves.

PCU Operational Matrix

The table below shows the various conditions of the PCU valve solenoids in the three modes of operation.

SOLENOID CONDITIONS	PCU MODES OF OPERATION		
	NORMAL	BYPASS	BLOCKING
BYPASS SOLENOID	E*[1]	D*[2]	D*[2]

SOLENOID CONDITIONS	PCU MODES OF OPERATION		
	NORMAL	BYPASS	BLOCKING
BLOCKING SOLENOID COIL 1	E*[1]	E/D*[1]*[2]	D*[2]
BLOCKING SOLENOID COIL 2	E/D*[1]*[2]	E*[1]	D*[2]
PRESSURE REDUCER SOLENOID - OB PCU	E/D*[1]*[2]	E*[1]	D*[2]

NOTE: THE PRESSURE REDUCER SOLENOID FOR THE INBOARD PCU IS ALWAYS DE-ENERGIZED.

*[1] E = ENERGIZED

*[2] D = DE-ENERGIZED

Normal mode

The PCU is in the normal mode when the ACE energizes the bypass solenoid and at least one coil of the blocking solenoid. In the normal mode, the ACE energizes the outboard PCU pressure reducer solenoid when there is no failure of the ACE or the PCU. The inboard PCU pressure reducer solenoid valve is not used and the solenoid is always de-energized.

With the bypass and blocking solenoids energized, hydraulic pressure moves the mode selector valve to the normal mode position. An electrical command to the EHSV results in the actuator extension or retraction.

When the ACE energizes the outboard PCU pressure reducer solenoid, the pressure reducer valve reduces the hydraulic pressure to 2140 psi. When there is a failure of the adjacent inboard PCU, the ACE de-energizes the outboard PCU pressure reducer solenoid. The actuator then operates with full hydraulic system pressure (3000 psi).

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ELEVATOR CONTROL - ELEVATOR PCU - FUNCTIONAL DESCRIPTION

Bypass Mode

The PCU is in the bypass mode when the ACE de-energizes the bypass solenoid and energizes one coil of the blocking solenoid.

This happens when there is a failure on the PCU or the ACE in control of the PCU.

Under these conditions, the bypass solenoid valve blocks hydraulic pressure to the mode selector valve. However, pressure trapped between the bypass check valves and the thermal relief valve moves the mode selector valve to the bypass position.

The mode selector valve blocks control pressure from the EHSV to the actuator cylinder. It also connects both sides of the actuator through a restriction.

During rapid backdrive of the failed PCU, the compensator/relief valve supplies fluid to the actuator through the anti-cavitation check valves.

Blocking Mode

The PCU is in the blocking mode when the ACE de-energizes the bypass solenoid and both coils of the blocking solenoid. The ACE also de-energizes the pressure reducer solenoid. This happens when the PCU has no electrical and hydraulic power. Also, the PCU is in the blocking mode when there is a failure of both adjacent PCUs or their ACEs and the elevator is near the faired position.

In the blocking mode, there is no hydraulic pressure on the mode selector valve. Its internal spring moves the valve to the blocking position. The mode selector valve blocks control pressure from the EHSV to the actuator cylinder. It also blocks hydraulic flow between both sides of the actuator piston.

Under these conditions, the actuator cannot move. When both PCUs on an elevator are in blocking mode, they lock the elevator in its position.

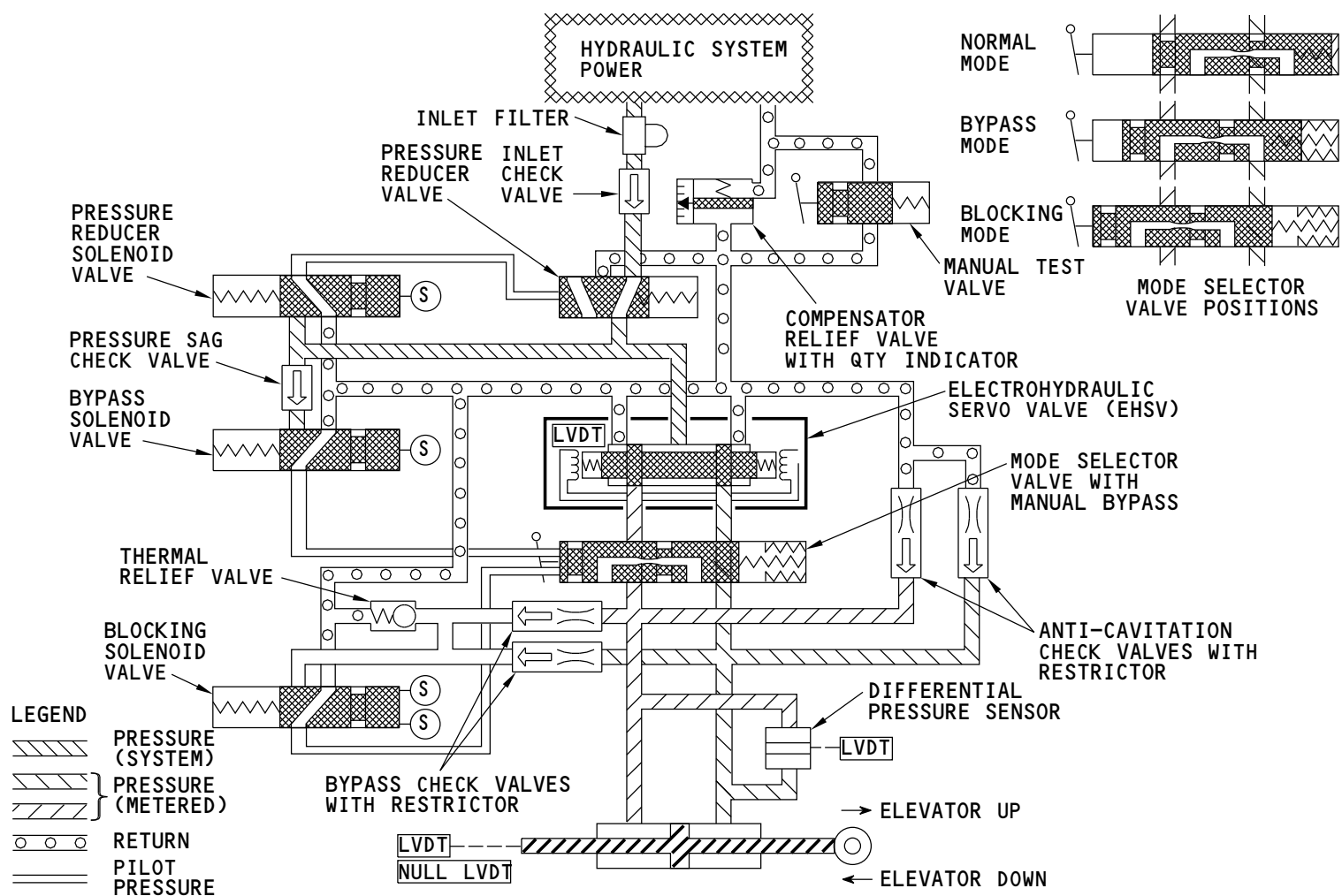
Indications

The status message FLIGHT CONTROL SYS shows when one or more elevator actuator has failed.

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ELEVATOR CONTROL - ELEVATOR PCU - FUNCTIONAL DESCRIPTION

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**ELEVATOR CONTROL - ELEVATOR PCU - FUNCTIONAL DESCRIPTION - PCU MODES****General**

The ACEs control the mode of operation of the elevator PCU.

Normal Mode

An elevator PCU operates in the normal mode when there is no failure on the PCU and there is no failure of its on-side ACE.

If the adjacent PCU is also in normal mode, the ACEs energize both coils of the blocking solenoid. For the outboard PCU, the ACEs energize the pressure reducer solenoid if the inboard PCU is also in the normal mode. When these conditions are true, the outboard PCU operates with reduced hydraulic pressure. The inboard PCU always operates with full hydraulic system pressure because the pressure reducer solenoid is not used.

Bypass Mode

If the PCU has an electrical or hydraulic failure or there is a failure of its ACE, the ACE de-energizes the bypass solenoid. The PCU is then in the bypass mode. If the inboard PCU has the failure, the ACE also de-energizes the pressure reducer solenoid of the outboard PCU. The outboard PCU then operates in normal mode with full hydraulic system pressure.

When the elevator position is less than two degrees from neutral with flaps retracted, or five degrees with flaps extended, it is near to being faired. When the elevator is near to being faired, the ACE also de-energizes one coil of the blocking solenoid on the failed and the adjacent PCU. This prepares the two PCUs to go into the blocking mode should there be a failure on the adjacent PCU or its ACE.

Blocking Mode

If there is a failure with the second PCU or its ACE when the elevator is near to being faired, all PCU solenoids de-energize. When it is not near to faired, the energized blocking solenoids on each PCU stay energized.

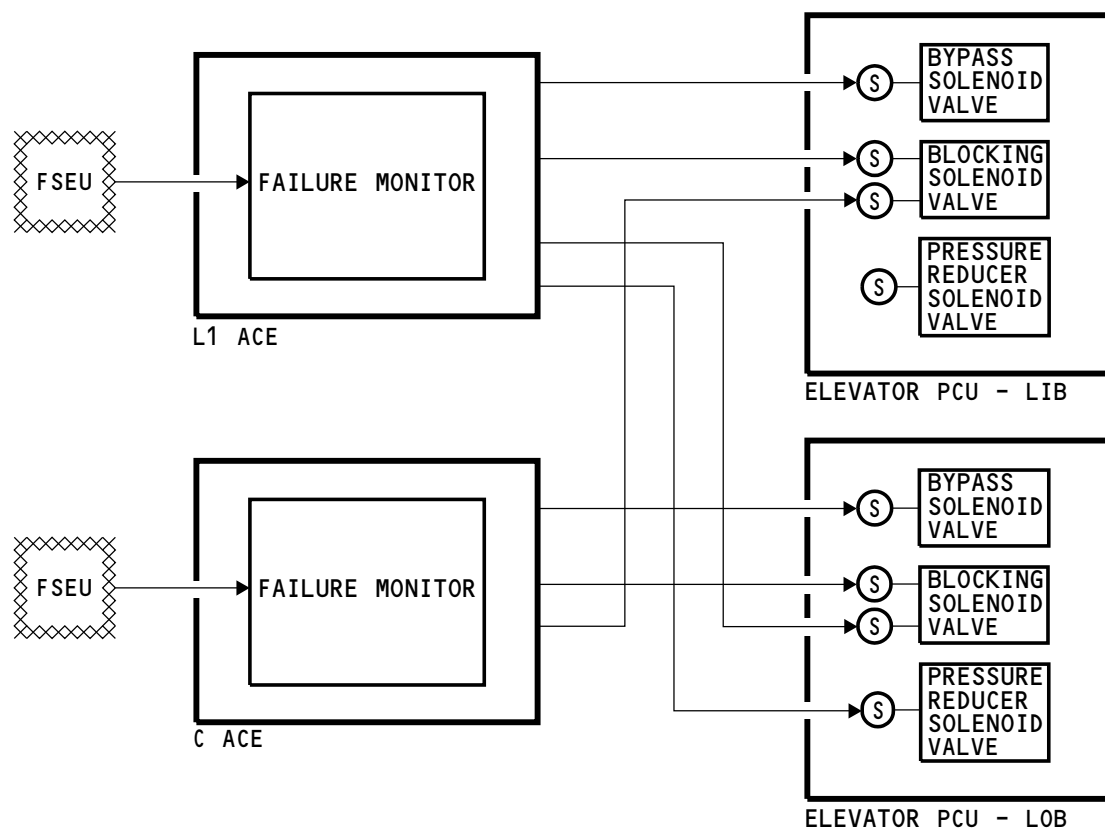
As soon as the airloads move the elevator panel near to faired, both blocking solenoids de-energize. At this time, a hydraulic lock in the PCUs keeps the elevator in the faired position.

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ELEVATOR CONTROL - ELEVATOR PCU - FUNCTIONAL DESCRIPTION - PCU MODES

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**ELEVATOR CONTROL - ELEVATOR ASSEMBLY****Purpose**

The elevators supply short-term pitch control of the airplane.

Physical Description

The elevators are light weight composite material structures. The skin is reinforced graphite/epoxy bonded to a core of Nomex honeycomb. The overall dimensions are approximately 70 inches by 403 inches (1.7 m by 10.2 m). Each elevator panel weighs approximately 327 lb (148 kg).

The elevator attaches to the stabilizer rear spar with seven hinges. There are four PCU attach fittings on each elevator. Jumpers and static dischargers supply electrostatic protection.

Functional Description

The elevator surface deflection limits are at the PCU internal stops. The elevators have a maximum movement of 33 degrees trailing edge up (TEU) and 27 degrees trailing edge down (TED) under no load conditions.

Under load conditions, the maximum PFC and ACE command signals move the elevators to a nominal position between 30 degrees TEU and 25 degrees TED. You adjust the elevator PCUs on the ground with the stabilizer at the neutral position. You adjust the PCUs so the elevator control surfaces are at neutral in reference to an index plate on the tail section of the fuselage.

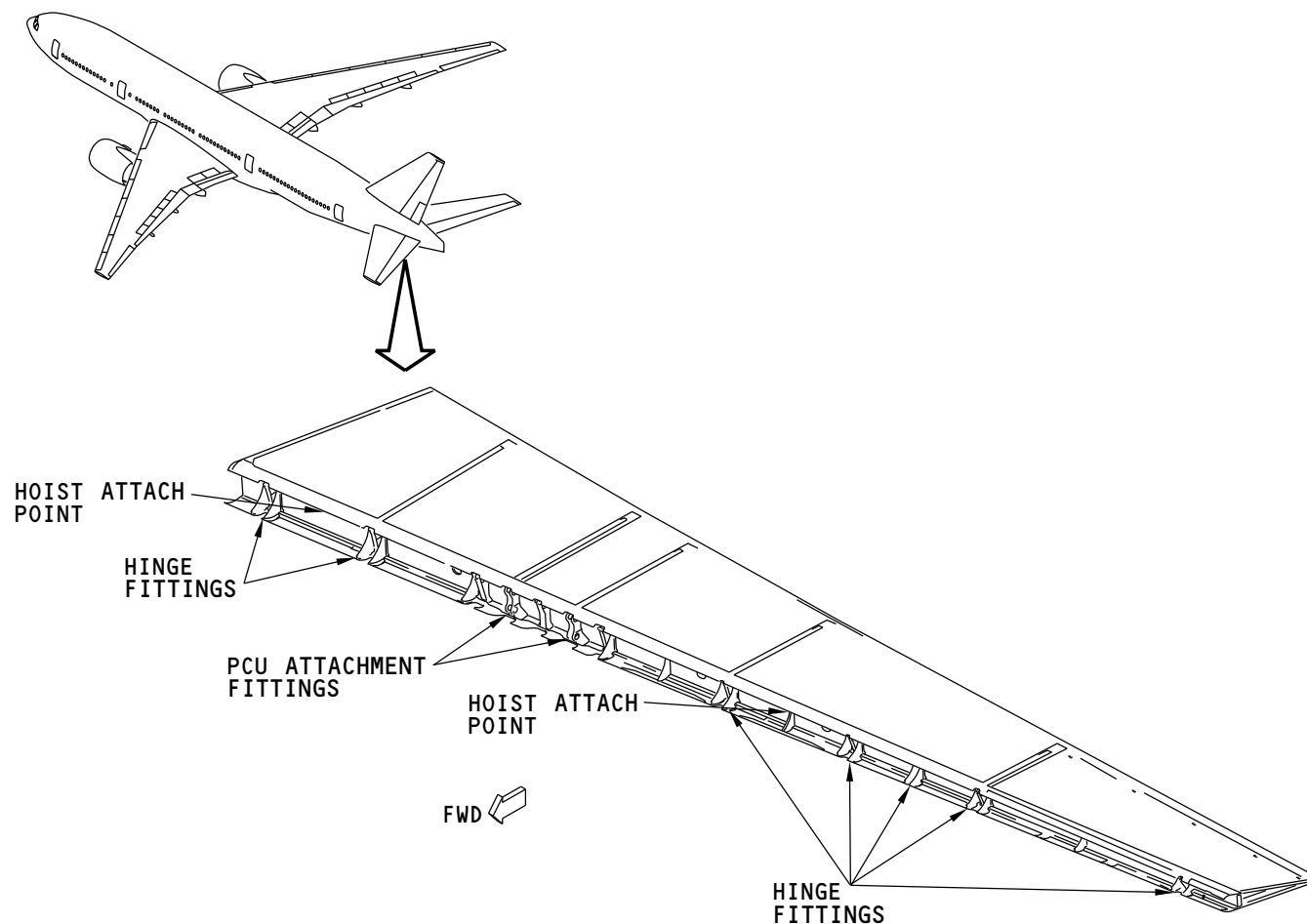
Training Information Point

Two hoist attach points are on each elevator. They are on the upper leading edge spar flange. One is between the inboard hinge fittings. The other is between the hinge fittings outboard of the PCU fittings. Two fasteners at each attach point are removed so the GSE lifting tool may be attached. A clamp on the trailing edge to supplies the third lifting point.

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ELEVATOR CONTROL - ELEVATOR ASSEMBLY

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION

General

The pitch control system for the elevators uses input signals from the control column position transducers, the force transducers, and the pitch rate sensors.

The ACEs receive the input signals and transmit them to the PFCs. The ACEs supply output command signals to the elevator feel actuators and the elevator PCUs.

Control Column Position Transducers

The C and R ACEs each receive signals from two control column position transducers. L1 and L2 ACEs receive signals from only one transducer. After they change the signals to digital format, the ACEs send these signals to the PFCs through the flight controls ARINC 629 buses.

Force Transducers

Each ACE receives one input from the four force transducer LVDTs. The ACEs change and transmit these signals to the PFCs.

Pitch Rate Sensors

Each ACE receives one input from a pitch rate sensor. The ACEs change and transmit these signals to the PFCs.

Elevator Feel Actuators

The L2 ACE controls the left elevator feel actuator and the C ACE controls the right one.

Elevator PCUs

Each ACE sends output commands to the assigned elevator PCU. It also sends control signals to the adjacent PCU on the same elevator. The pitch command goes to the EHSV. A control signal goes to the bypass and number one blocking solenoid. It sends blocking solenoid signals to the adjacent PCU on the same elevator. The C and R ACEs each send a control signal to the pressure reducer solenoid of an outboard PCU. The pressure reducer solenoid of the inboard PCU is not used.

The PCU sends feedback signals to its assigned ACE from:

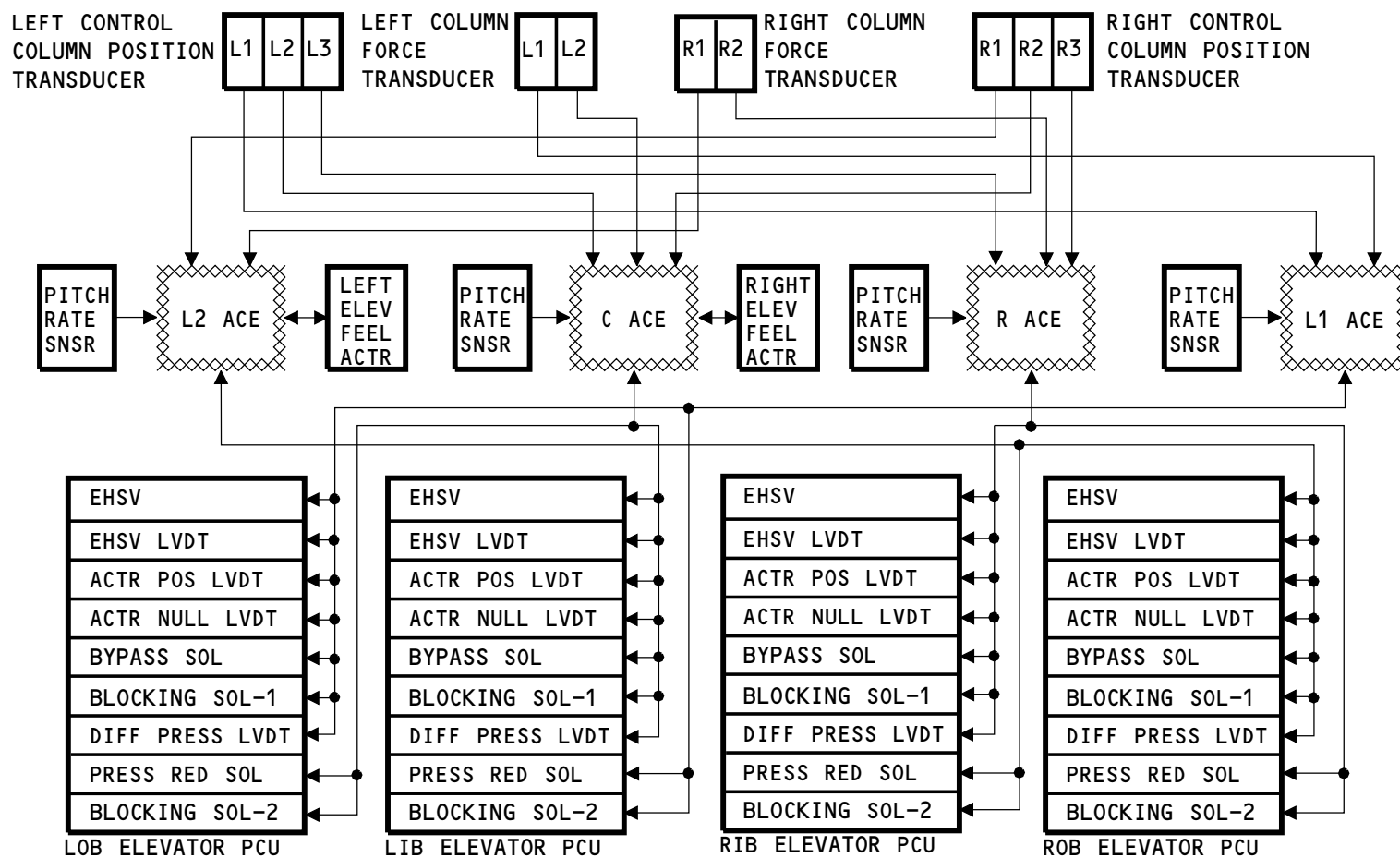
- The EHSV position LVDT
- The actuator piston position LVDT
- The actuator null LVDT
- The differential pressure LVDT.

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION

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**ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP****General**

The ACE contains a servo loop circuit to give the command signals to the PCUs.

In normal and secondary mode, the PFC sends the command signals to the ACE. In direct mode, the ACE calculates the command signals.

Servo Loop Operation

The elevator command signals go through a servo loop in the ACEs. The command signals then go to the EHSV of the PCUs. The ACEs also use the command signals to monitor for failures. The movement of the EHSV sends hydraulic pressure to extend or retract the actuator.

The EHSV LVDT measures the movement of the EHSV and supplies a feedback signal to the ACEs. The ACEs use this feedback signal to monitor failures.

The actuator position LVDT measures the movement of the actuator and supplies a signal to the actuator null LVDT.

The actuator null LVDT is in series with the actuator position LVDT. The actuator null LVDT modifies the signal from the actuator position LVDT.

The actuator null LVDT supplies a feedback signal to the ACEs to close the servo loop. The ACEs use this feedback signal to monitor for failures. This signal also goes to the PFC.

A differential pressure LVDT measures the differential pressure across the actuator. The signal from the differential pressure LVDT goes to the ACEs for the servo loop. The signal also goes to the PFCs for force fight equalization.

Failure Monitor

The ACE has a failure monitor to check the proper operation of the PCU. The monitor uses the ACE command signal and the feedback signals from the EHSV LVDT and the actuator LVDT. When the failure monitor finds a fault with the PCU or the ACE, it de-energizes the PCU bypass, blocking and pressure reducer solenoids.

Training Information Point

During installation of the elevator PCU, it is necessary to adjust the actuator null LVDT. Remove the null LVDT access cover to adjust the null LVDT.

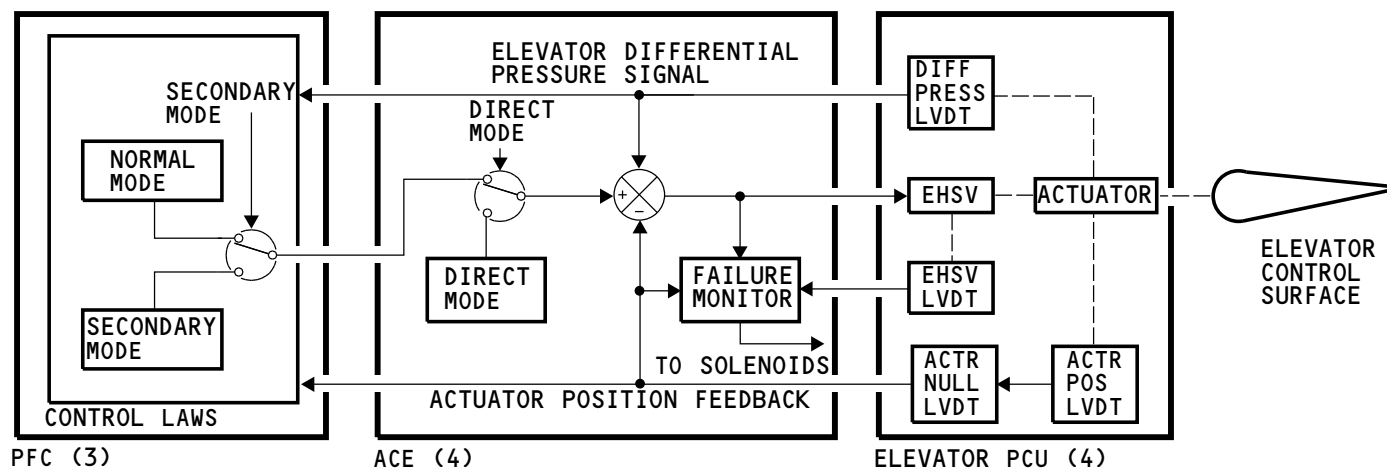
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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

General

In normal mode operation of the PFCS, the PFCs calculate pitch control commands based on this data:

- Column-based command logic
- Elevator column control
- Speed stability function
- Pitch rate
- Flare compensation
- Stall protection function
- Overspeed protection function
- Elevator rig position function
- Elevator command limiting function
- Force fight equalization
- Elevator offload function
- Elevator feel logic
- Autopilot command.

Column-Based Command Logic

The column based command logic receives signals from the column position transducers and the column force transducers. When the pilot applies a force on the control column, the logic function selects the column position transducer signal by mid-value selection and averaging.

When the force on the column is less than 2.5 lb, the column force transducer sends a near zero signal and the PFC logic considers the columns at neutral. The column based command logic then supplies a zero position signal to the elevator column control.

The column based command logic does not function during autopilot operation.

Elevator Column Control

The elevator column control calculates the elevator command as a function of the column position transducer input.

When the force transducers detect that there is no force at the column, the elevator column control function uses the zero position signal. This zero position signal resets the calculation of the control function.

When the autopilot is engaged, the elevator column control uses the autopilot pitch command to calculate the elevator command.

Speed Stability Function

The speed stability function operates only in the air. It does not function during autopilot operation.

The speed stability function receives computed airspeed (CAS) signals from the ADIRU and SAARU. It also receives the pitch trim switch signals from the ACEs and the alternate pitch trim lever switch signals from the AIMS.

The speed stability function controls the elevator to maintain the trim reference speed. The trim reference speed is the speed last selected by the pitch trim switches or the alternate pitch trim lever switches.

When the pilot moves the pitch trim switches, the trim reference speed changes. The speed stability function sends an elevator command so the airplane can reach the new trim reference speed.

When the pilot moves the alternate pitch trim levers, the levers cause a stabilizer movement and the lever switches change the trim reference speed. The new trim reference speed matches the speed reached by the new position of the stabilizer.

The speed stability function supplies automatic elevator commands during these conditions:

- Thrust changes
- Turbulence
- Flap and slat extension and retraction
- Speedbrake operation

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

- Landing gear extension and retraction
- Ground effect
- Banked turns less than 30 degrees.

Pitch Rate

Pitch rate data supplies a feedback signal to the pitch command for pitch damping. The PFCs get pitch rate data from the ADIRU and the pitch rate sensors.

The ADIRU is in the main equipment center. The ADIRU senses airplane pitch, but also senses main equipment center vertical motion due to airplane structural deflection. Airplane structural vibration modes are excited during flight.

The pitch rate sensors are on the wing front spar. They sense pitch, but not the additional movement of the main equipment center.

The pitch rate data from the ADIRU and the pitch rate sensors are blended to supply the feedback signal for pitch damping.

Flare Compensation

The flare compensation function operates when the airplane descends through 50 feet of radio altitude. The flare compensation function supplies a pitch-down command that simulates the natural attitude of the airplane in ground effect.

Stall Protection Function

The stall protection function uses the angle of attack from the ADIRU. It also uses the computed airspeed (CAS) and the mach number. The FSEU supplies the position of the flaps and slats and the WEU supplies stall data.

The stall protection function operates only in the air.

If the airplane approaches a stall condition, the stall protection function sends a signal to the elevator for pitch-down command. The function also increases the column feel force in the column aft direction.

Overspeed Protection Function

The overspeed protection function monitors the CAS and Mach number. If there is an overspeed condition, the function sends a signal to the elevator for a pitch-up command.

Elevator Rig Position Function

The elevator rig position function is active only in the air when the flaps are at the 25 or 30-unit positions. The function monitors the position of the horizontal stabilizer to move the neutral position of the elevator to a maximum of 4 degrees trailing-edge-up. This elevator position increases the down lift of the horizontal stabilizer during landing.

The elevator neutral position moves from 0 to 4 degrees trailing edge up in proportion to the stabilizer movement from 2 degrees leading-edge-up to 2 degrees leading-edge-down. When the stabilizer is from 2 to 11 degrees leading-edge-down, the elevator neutral position stays at 4 degrees trailing-edge-up.

The control column does not move as a result of the elevator rig position function.

Elevator Command Limiting Function

The elevator command limiting function receives the command signals from the summing point. The function limits the rate of elevator movement. It also limits the position of the elevator for structural protection.

Force Fight Equalization

The elevator commands go to the force fight equalization function. The PFCs use elevator PCU differential pressure data from the ACEs to equalize all the elevator PCU commands before transmission to the ACEs and the EHSV of each elevator PCU. This function minimizes elevator PCU force fight.

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

Elevator Feel Logic

The elevator feel logic monitors the CAS. The logic sends a signal to the ACE for the elevator feel actuators. As the airspeed increases and decreases, the feel logic commands the actuators to extend and retract respectively.

When one of the two elevator feel actuators is defective, the elevator feel logic sends a much larger command to the good actuator to compensate for the defective one.

If the airplane approaches a stall condition, the stall protection sends a signal to the elevator feel logic to increase the elevator feel force if the pilot pulls the column. The signal does not change the feel force if the pilot pushes the column.

Elevator Offload Function

The elevator offload function operates only in the air.

It uses the elevator commands to determine when the elevator is not at the neutral position for more than two seconds minimum. The function then commands the horizontal stabilizer to move as a function of airspeed. The movement of the horizontal stabilizer then causes the elevator to move to the neutral position.

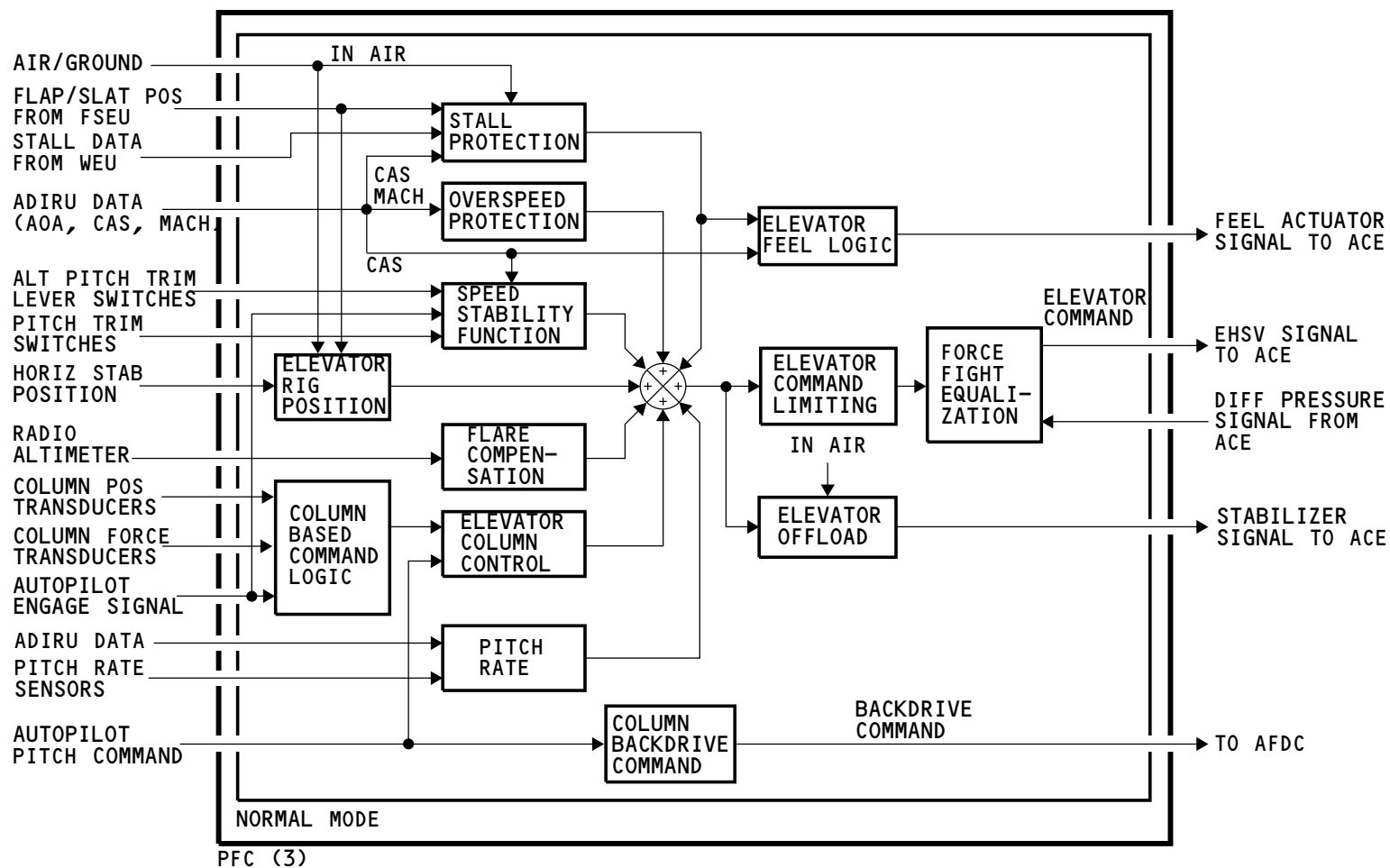
The function is inhibited during these times:

- During flare
- During stabilizer commands
- During alternate trim lever use
- When roll or pitch attitude is more than 30 degrees.

See the horizontal stabilizer control section for more information (SECTION 27-41).

Autopilot Pitch Commands

During autopilot operation, the PFCs use the autopilot pitch commands to calculate the elevator commands. They also calculate the backdrive actuator commands which go the AFDCs. This causes the backdrive actuators to move the control columns in the same relationship to the autopilot commands. When the pilots move a control column while the autopilot is engaged, the autopilot disengages. The backdrive actuators then stop the movement of the control column.



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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE

General

In secondary mode operation of the PFCS, the PFCs calculate elevator commands based on this data:

- Elevator control schedule
- Pitch rate
- Elevator command limiting function
- Force fight equalization
- Elevator feel logic.

Elevator Control Schedule

The PFC calculates the elevator commands as a function of the column position transducers and the flaps and slats position. The commands from the elevator control schedule are higher when the flaps and slats are not retracted.

Pitch Rate

The pitch rate sensor in each ACE supplies a feedback signal to the elevator command for pitch damping.

Elevator Command Limiting Function

The elevator command limiting function limits the rate of the elevator movement and the position of the elevator for structural protection.

Force Fight Equalization

The force fight equalization function uses elevator PCU differential pressure data from the ACEs to equalize all the elevator PCU commands. This function minimizes elevator PCU force fight.

Elevator Feel Logic

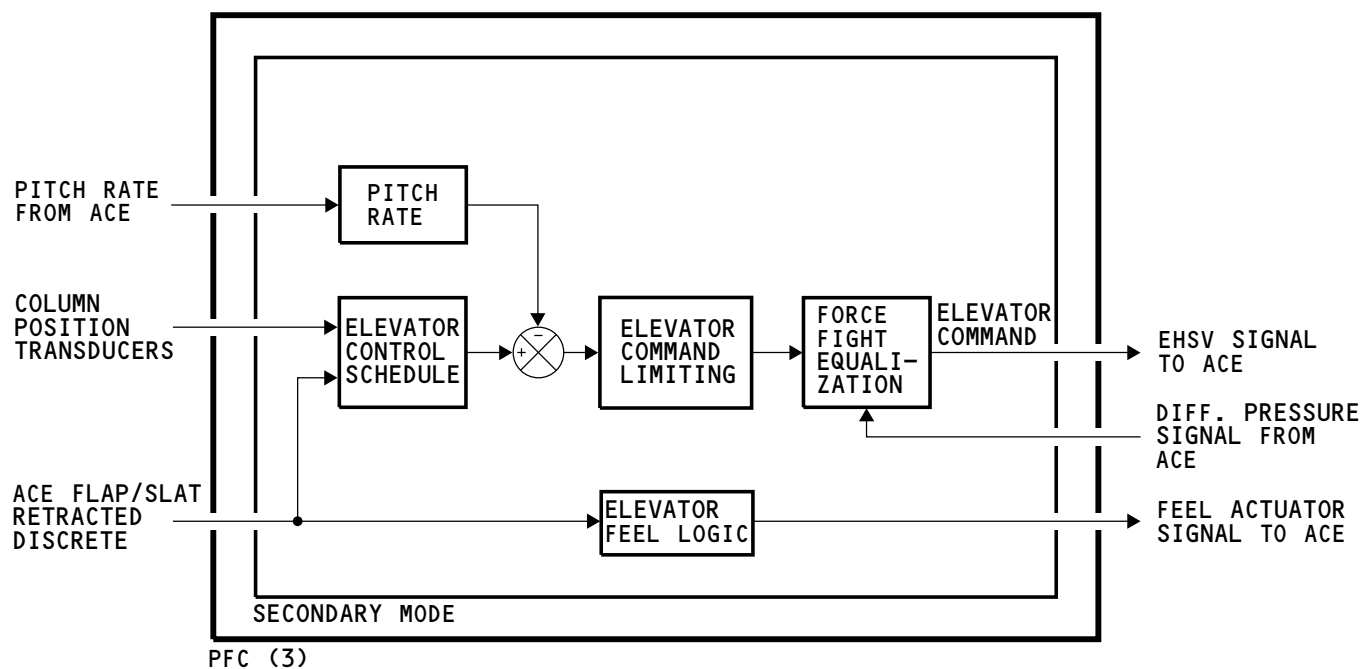
The elevator feel logic operates on the basis of the flaps and slats position. When the flaps and slats are retracted, the logic supplies a high feel signal to the feel actuators. When the flaps and slats are not retracted, the signal is for low feel.

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

General

In direct mode operation of the PFCS, the ACEs calculate pitch control commands based on:

- Elevator control schedule
- Pitch rate sensor
- Elevator feel logic
- Failure monitor.

Elevator Control Schedule

The ACEs calculate the pitch commands from the column position transducers and the position of the flaps and slats. The commands changes per fixed gain schedules for flaps and slats retracted or not retracted.

The elevator displacement is larger with the flaps and slats not retracted and smaller with the flaps and slats retracted. The elevator command goes directly to the EHSV of the elevator PCU.

Pitch Rate Sensor

As in the secondary mode, the pitch rate sensor in each ACE supplies a feedback signal to the elevator command for pitch damping.

Elevator Feel Logic

The elevator feel logic operates on the basis of the flaps and slats position. When the flaps and slats are retracted, the logic supplies a high feel signal to the feel actuators. When the flaps and slats are not retracted, the signal is for low feel.

Failure Monitor

When the ACE failure monitor finds a PCU electrical failure, it removes power from the bypass solenoid, the pressure reducer solenoid and/or the blocking solenoid of the applicable PCU.

If the failure monitor finds a first failure, the ACE de-energizes the bypass solenoid of the on-side PCU. If the failure is of the inboard PCU, the ACE also de-energizes the pressure reducer solenoid of the outboard PCU.

The blocking solenoids are dual-coil solenoids. When the ACE detects the first failure, one of the coils is de-energized on both the on-side and the adjacent PCUs when the elevator is less than two degrees from neutral with flaps retracted or less than five degrees from neutral with flaps extended.

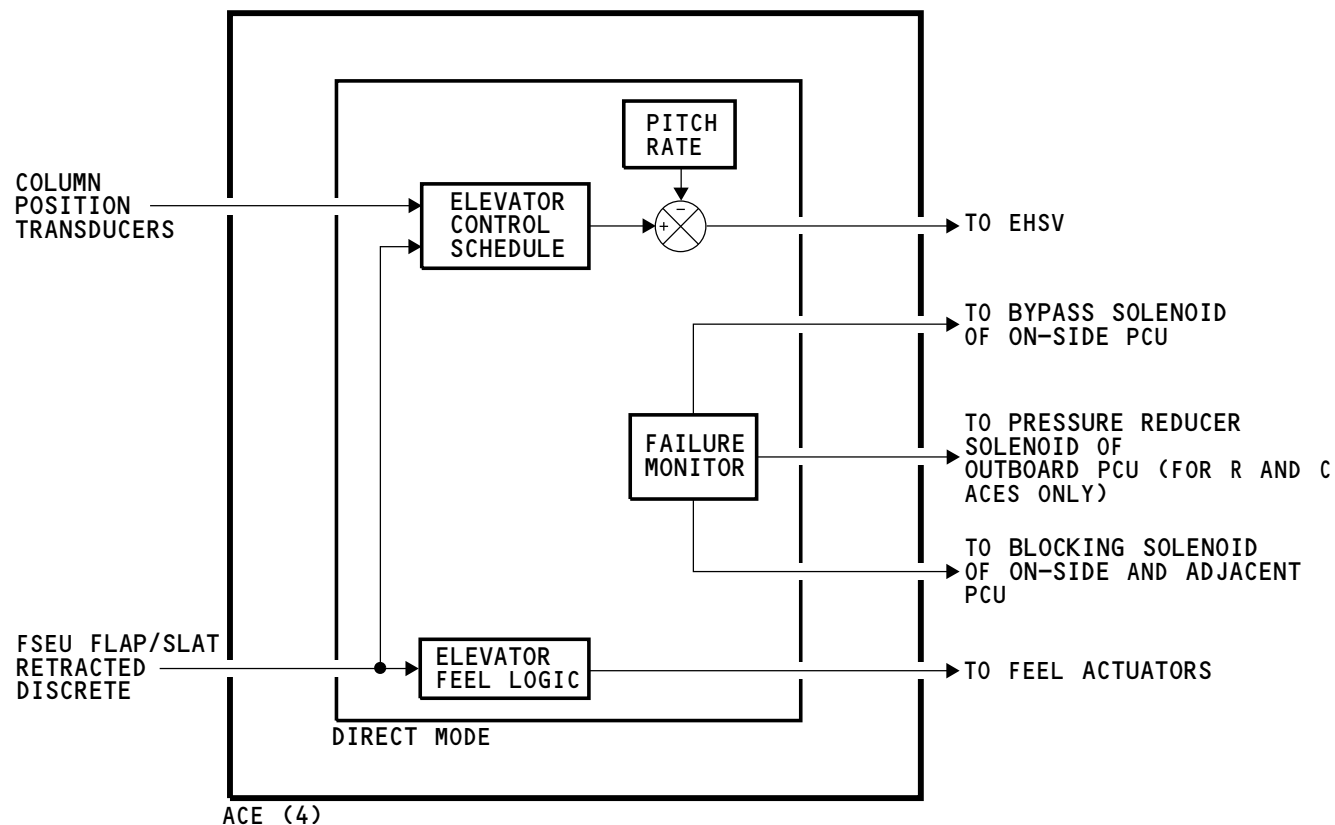
If a second failure occurs, the second coil on both PCUs is de-energized when the elevator is less than two degrees from neutral with flaps retracted or less than five degrees from neutral with flaps extended.

The failure monitor operates in the normal, secondary, and direct modes. The failure monitor can find faults in the ACE, the PCUs, column position transducers and interface wiring.

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - ELEVATOR FEEL

General

The PFCS controls the elevator feel actuators and works with the elevator feel unit to supply resistance to the movement of the control column.

The PFCs control elevator feel in the normal and secondary modes and the L2 and C ACEs control it in the direct mode.

Elevator Feel Actuator

The elevator feel actuator contains a brushless 28v dc reversible motor, and a 7v RVDT to supply an actuator position signal.

Normal Mode

In the normal mode, the PFC calculates elevator feel commands as a function of airspeed. As airspeed increases, it commands the actuator to extend. As airspeed decreases, the PFC commands the actuator to retract. This results in more or less resistance (feel) to movement of the control column. The command goes to the feel actuator through the ACE.

During takeoff, the feel actuators disengage above 40 knots. The feel actuators engage to provide variable feel 5 seconds after the ground-to-air transition. On the ground with airspeed below 40 knots, the feel actuators engage to permit the flight crew to do a check of the feel forces during the freedom of controls check.

Secondary Mode

In the secondary PFCS mode, the PFC calculates feel commands as a function of flaps and slats position. The FSEUs supply through the ACEs a discrete flaps and slats retracted signal. When the flaps and slats are not retracted, a low feel command is made. When the flaps and slats are retracted, a high feel command is made.

Direct Mode

The ACE uses the FSEU discrete flaps and slats retracted signal to calculate feel actuator commands in the direct mode. When the flaps and slats are not retracted, it makes a low feel command. When the flaps and slats are retracted, it makes a high feel command.

Failure Monitor

In normal mode, if the PFC detects a difference between the output and the feed back signals from one of the feel actuators, it shuts off the signal to that actuator. The failed actuator is spring loaded to a zero force input.

The PFC then commands the other actuator with a doubled signal that compensates for the failed actuator. Because of this, the feel force at the control columns remains the same.

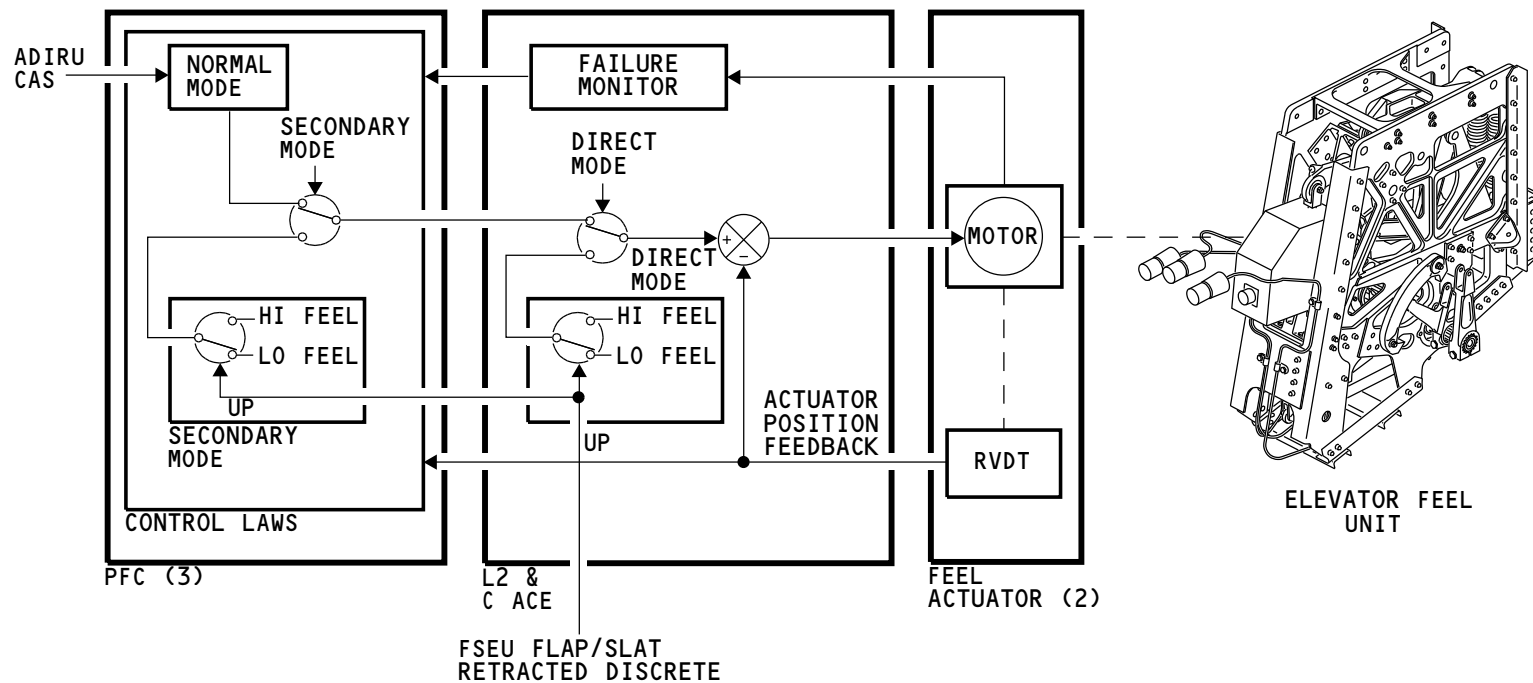
Indications

The status message FLIGHT CONTROL SYS shows that there is a failure in one or more elevator feel actuators.

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ELEVATOR CONTROL - FUNCTIONAL DESCRIPTION - ELEVATOR FEEL

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**ALTERNATE GEAR DOWN DISPATCH SWITCH****Description**

The alternate gear down dispatch switch has two positions.

Operation

When the alternate gear down dispatch switch is in the maximum operating speed (VMO) position, the WEU channels use the switch signals to lower the maximum speed limit to 270 knots and the maximum operating mach (MMO) to mach .73.

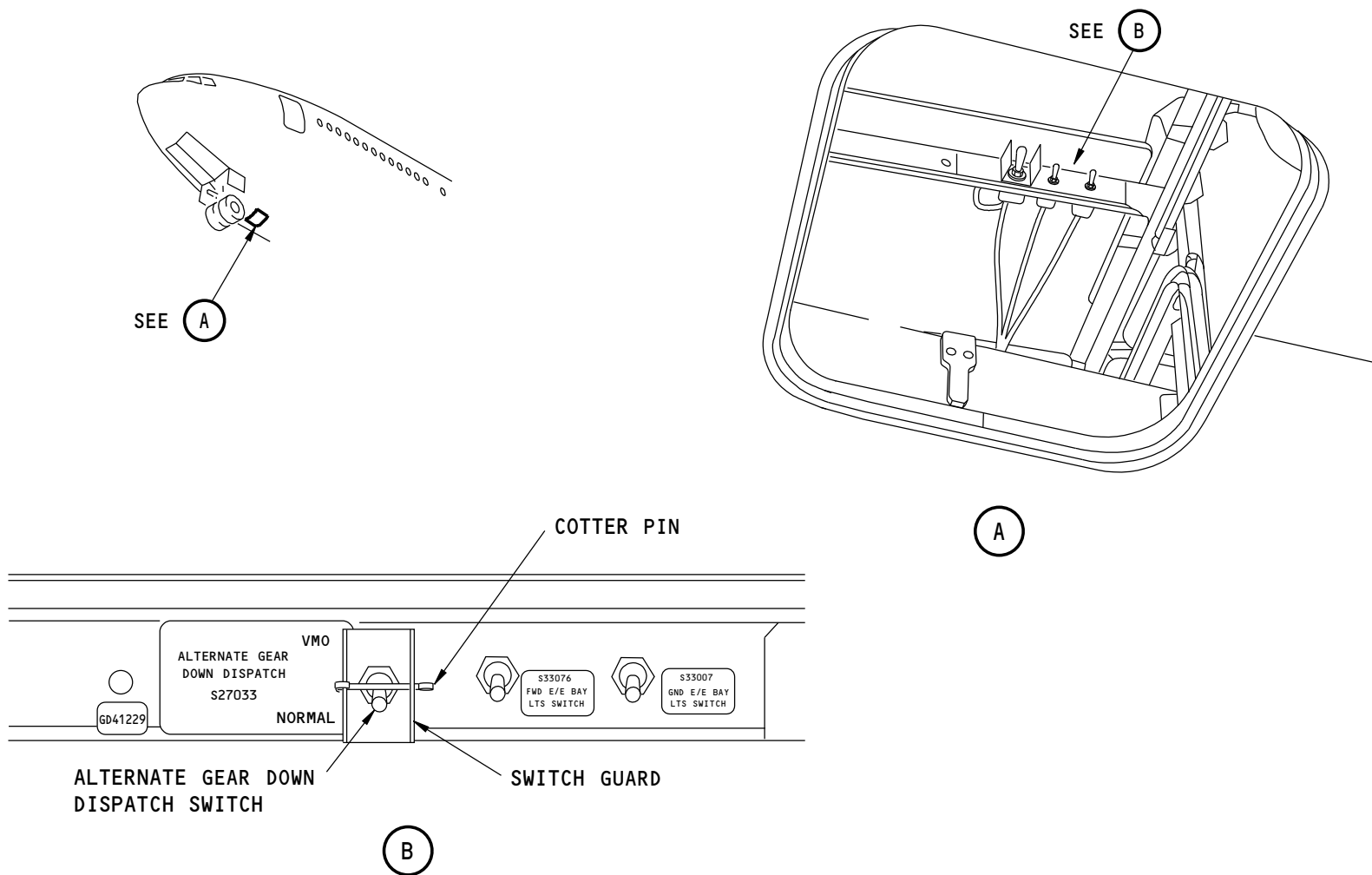
When the alternate gear down dispatch switch is in the normal position, the VMO is 330 knots. The MMO is .87.

A switch guard and cotter pin was added to the alternate gear down dispatch switch to prevent accidental activation of the switch.

Training Information Point

The memo message VMO GEAR DOWN shows on EICAS when you put the switch in the VMO position.

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WES - ALTERNATE GEAR DOWN DISPATCH SWITCH

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HORIZONTAL STABILIZER CONTROL - INTRODUCTION

General

The horizontal stabilizer supplies long-term correction of the pitch attitude of the airplane. This movement is around the lateral axis of the airplane.

Stabilizer Control

The elevator off-load function automatically sets the position of the stabilizer during manual flight or in autoflight. In this mode, the PFCs monitor elevator deflection and transfer pitch changes to the stabilizer. Once the stabilizer goes to its commanded position, the elevator moves to neutral.

The pilots command the stabilizer to move with either the pitch trim switches on the control wheels or the alternate pitch trim levers on the control stand.

The pilots stop unwanted stabilizer movement with the stabilizer cutout switches on the aisle stand.

Stabilizer Operation

Two hydraulic motors with two speeds move the horizontal stabilizer through a jackscrew mechanism. Four rates of horizontal stabilizer movement are available.

Abbreviations and Acronyms

- ACE - actuator control electronics
- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AIMS - airplane information management system
- AOA - angle of attack
- ARINC - Aeronautical Radio, Incorporated.
- CMCS - central maintenance computing system
- CPU - central processing unit
- EHSV - electrohydraulic servo valve
- EICAS - engine indication and crew alerting system

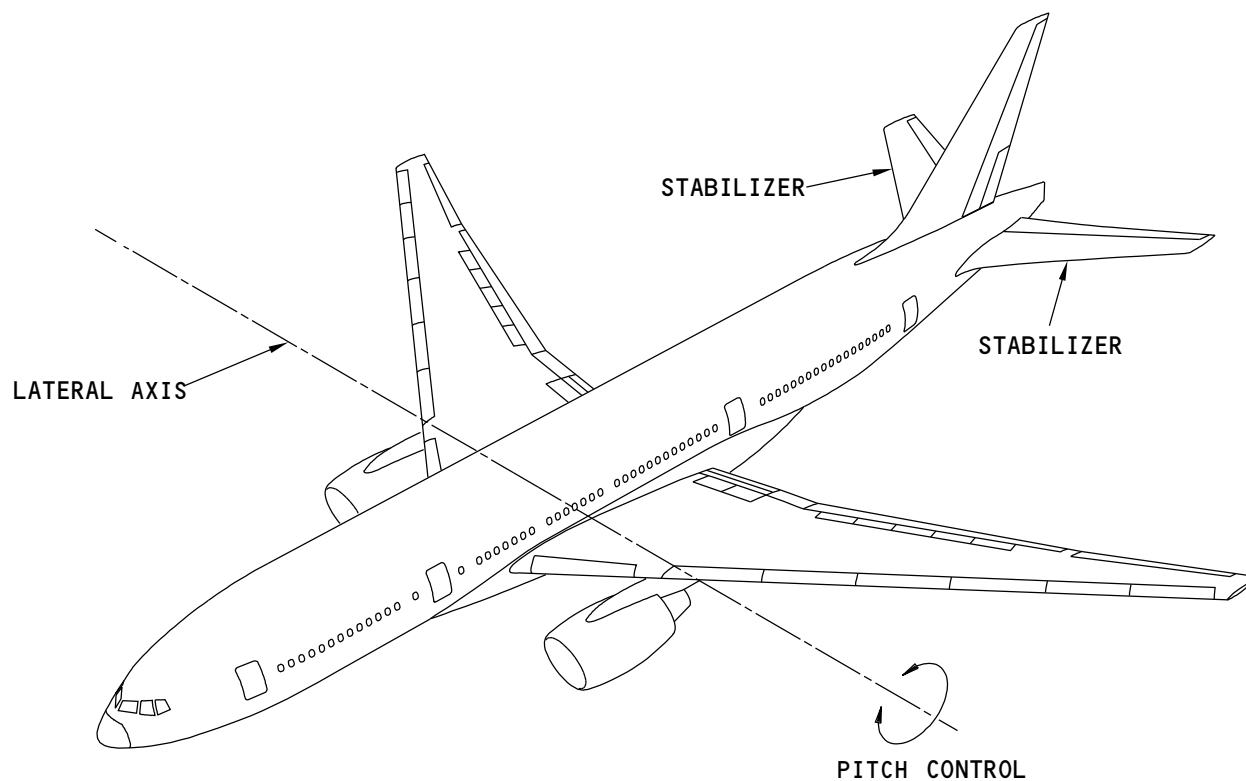
- FMCS - flight management computing system
- LIB - left inboard
- LOB - left outboard
- LTA - left trim arm
- LTC - left trim control
- LVDT - linear variable differential transformer
- MAT - maintenance access terminal
- MFD - multi-function display
- PCU - power control unit
- PFC - primary flight computer
- PFCS - primary flight control system
- PSA - power supply assembly
- RIB - right inboard
- ROB - right outboard
- RTA - right trim arm
- RTC - right trim control
- RVDT - rotary variable differential transformer
- SAARU - secondary attitude air data reference unit
- SPM - stabilizer position module
- STCM - stabilizer trim control unit
- TED - trailing edge down
- TEU - trailing edge up

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HORIZONTAL STABILIZER CONTROL - INTRODUCTION

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HORIZONTAL STABILIZER CONTROL - GENERAL DESCRIPTION

General

The PFCS commands automatic movement of the stabilizer. The pilots manually command the stabilizer to move.

Flight Deck Controls

The pilots operate two pitch trim switches for manual pitch trim control. The switch modules are on the outboard side of each control wheel. They send electrical pitch trim signals to the ACEs.

Two alternate pitch trim levers are on the captain's side of the control stand. These levers mechanically control stabilizer movement.

Two guarded cutout switches on the aisle stand control hydraulic shutoff valves on the stabilizer trim control modules (STCMs). When the pilot moves the switches to the cutout position, hydraulic pressure is shut off to the hydraulic motors.

Two stabilizer position indicators on the control stand show the position of the stabilizer. A green band on the indicator shows the correct stabilizer position for takeoff. See the horizontal stabilizer position indication section for more information (SECTION 27-48).

Stabilizer Controls

Two stabilizer trim control modules (STCMs) receive commands from the ACEs and the alternate pitch trim levers to control the hydraulic pressure to the motors and brakes.

Two hydraulic motors that use different hydraulic system power sources, cause the ballscrew actuator to rotate. Two hydraulic brakes work with the motors and are powered by the same hydraulic systems. The brakes release and the motor runs with hydraulic pressure. With low pressure, the brakes set and the motors do not run. This prevents movement of the stabilizer.

The horizontal stabilizer is a one piece, negative lift airfoil. It pivots at its rear spar. A ballscrew actuator, attached to the front spar, moves the stabilizer leading edge to a maximum of 4 degrees up and 11 degrees down.

Cables transmit the stabilizer movement to three stabilizer position modules (SPMs) in the stabilizer compartment. The SPMs supply stabilizer position data to the ACEs.

Column Cutout

When the pilot moves the control column in the opposite direction of the pitch commanded by the pitch trim switches, the PFCs cut out the pitch command to the STCMs. This stops the stabilizer movement.

Stabilizer Automatic Cutout

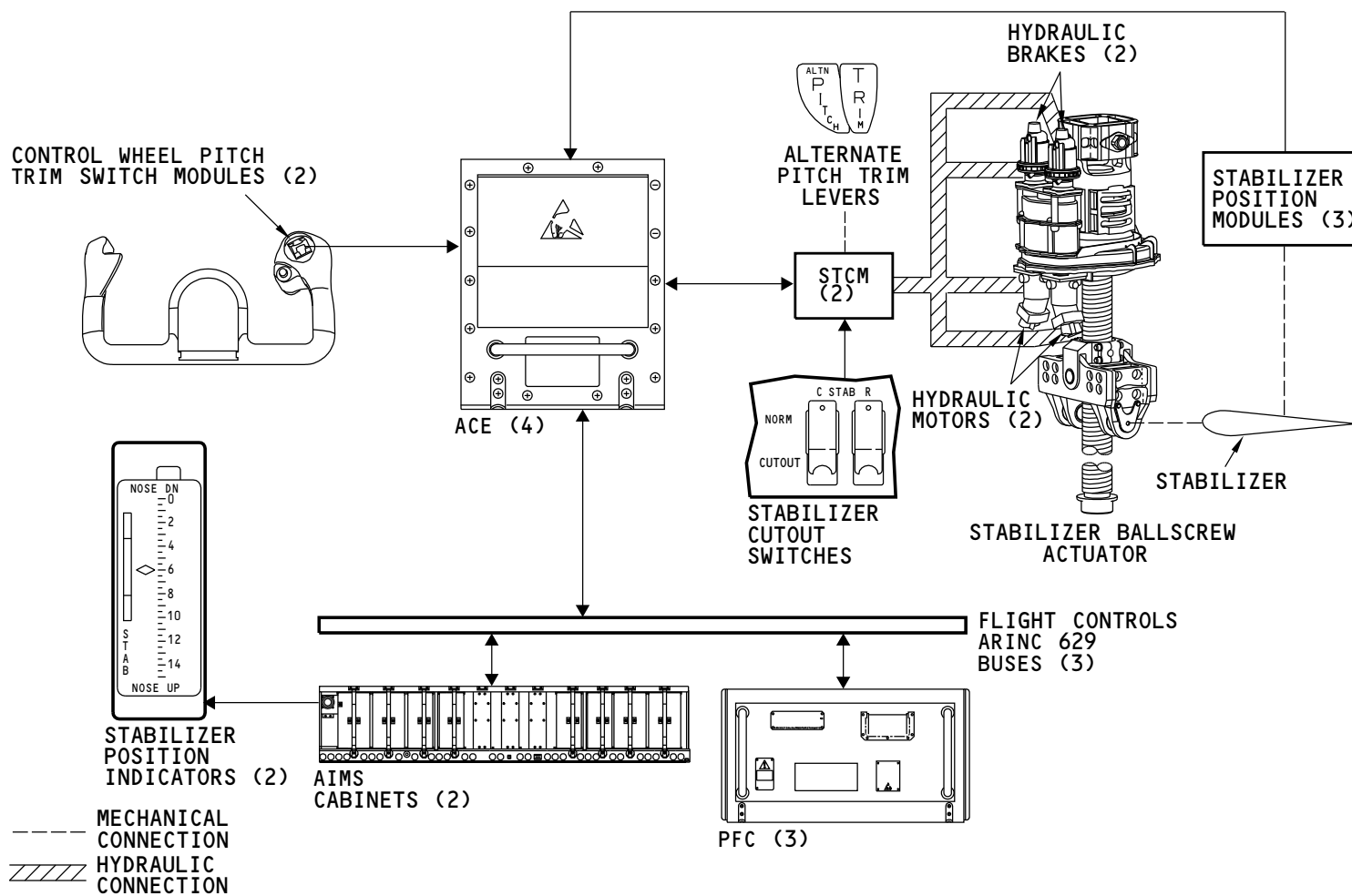
In case of uncommanded pitch trim, the PFCs command the hydraulic shutoff valves on the STCMs to close.

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HORIZONTAL STABILIZER CONTROL - GENERAL DESCRIPTION

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**HORIZONTAL STABILIZER CONTROL - COMPONENT LOCATIONS - FLIGHT DECK AND BELOW****General**

Stabilizer system components are in the flight deck and below the flight deck.

Flight Deck Components

Two pitch trim switches are on the outboard side of each control wheel. The switches have three positions: nose-up, nose-down, and off.

Two alternate pitch trim levers are on the P10 control stand. They connect by cables to mechanical valves on the STCMs.

Two guarded stabilizer cutout switches are on the P10 control stand. Each switch removes hydraulic power from a hydraulic motor and brake when put in the CUTOUT position.

Two stabilizer position indicators are on the P10 control stand. They both have a green band to show when the stabilizer is in the proper position for take-off.

Components Below the Flight Deck

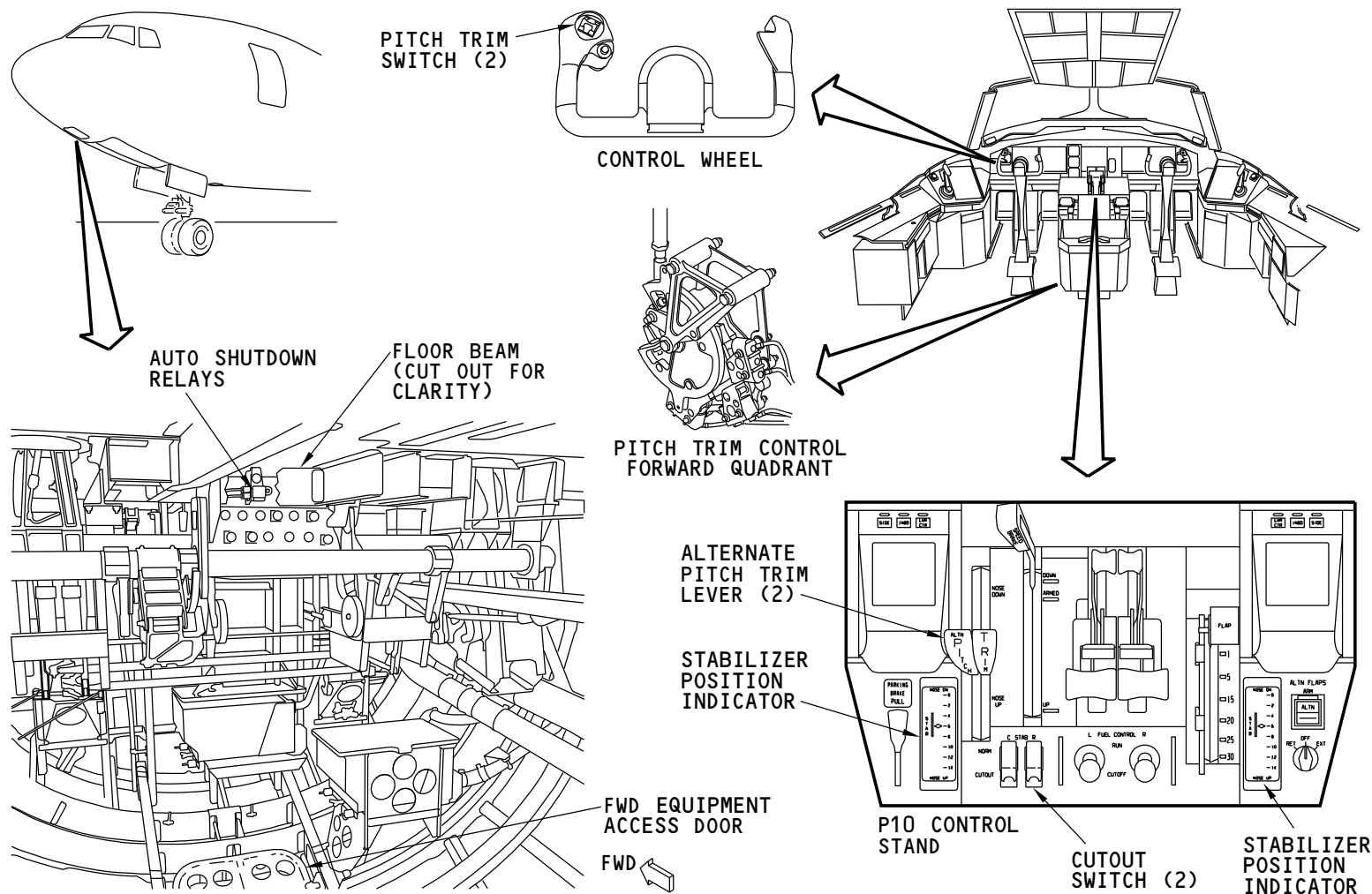
The auto shutdown relays are between flight deck floor beams in the forward equipment center.

The pitch trim control forward quadrants are below the control stand. Access is through the forward equipment center.

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HORIZONTAL STABILIZER CONTROL - COMPONENT LOCATIONS - FLIGHT DECK AND BELOW

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**HORIZONTAL STABILIZER CONTROL - COMPONENT LOCATIONS - TAIL****Tail Components**

The stabilizer is a single unit. It attaches to the aft fuselage by hinges on the stabilizer rear spar. The forward stabilizer structure attaches to a ball nut on the stabilizer ballscrew. The stabilizer ballscrew is on the airplane structure in the stabilizer compartment. Access to this area is by a service access door on the left side of the lower aft fuselage.

Also in the stabilizer compartment are the three stabilizer position modules (SPMs) assemblies and the two stabilizer trim control modules (STCMs).

Cables connect to the forward end of the stabilizer structure and mechanically transmit stabilizer movement to the stabilizer position modules.

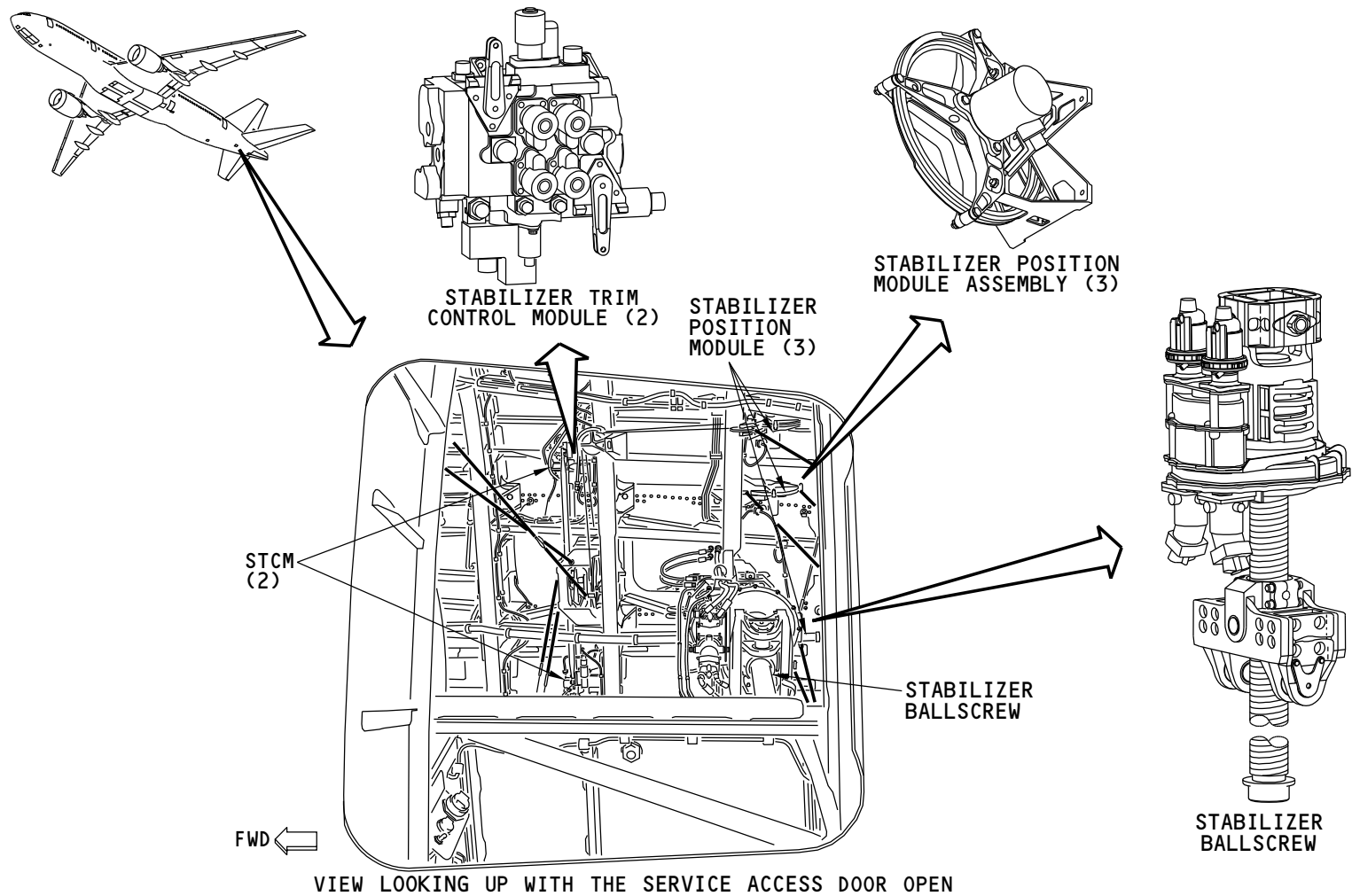
The STCMs are immediately aft of the pressure bulkhead near the ceiling of the stabilizer compartment.

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HORIZONTAL STABILIZER CONTROL - COMPONENT LOCATIONS - TAIL

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HORIZONTAL STABILIZER CONTROL - ANALOG AND DISCRETE INTERFACES

General

All the analog interfaces for the stabilizer pitch control within the PFCS go through the ACEs. Each ACE has interfaces with these components:

- Alternate pitch trim lever switches
- Control wheel pitch trim switches
- Stabilizer position indicators
- Auto shutdown relays
- Stabilizer trim control modules (STCM)
- Stabilizer position modules.

Alternate Pitch Trim Lever Switches

The alternate pitch trim lever switches on the alternate pitch trim forward quadrants send discrete signals to the AIMS. The signals represent pitch up or pitch down commands.

Control Wheel Pitch Trim Switch Modules

The pitch trim switches on each control wheel send pitch up, pitch down or off discrete signals to the ACEs.

Stabilizer Position Indicators

The two stabilizer position indicators receive analog signals from the AIMS that show stabilizer position.

Stabilizer Cutout Switches

Each stabilizer cutout switch controls a motor-operated shutoff valve in an STCM.

Auto Shutdown Relays

The ACEs can send discrete signals to the auto shutdown relays to close the motor-operated shutoff valves in the STCMs.

Stabilizer Trim Control Modules

Each of the two STCMs receive discrete signals from the ACEs and the auto shutdown relays. The discrete signals are for the:

- Control and arm trim solenoids
- Rate control solenoids
- Motor operated shutoff valves.

The pressure switches send discrete signals back to the ACEs.

Stabilizer Position Module

Three stabilizer position modules contain a position RVDT and limit switches.

The RVDTs send an analog signal to the ACEs that represents the stabilizer position.

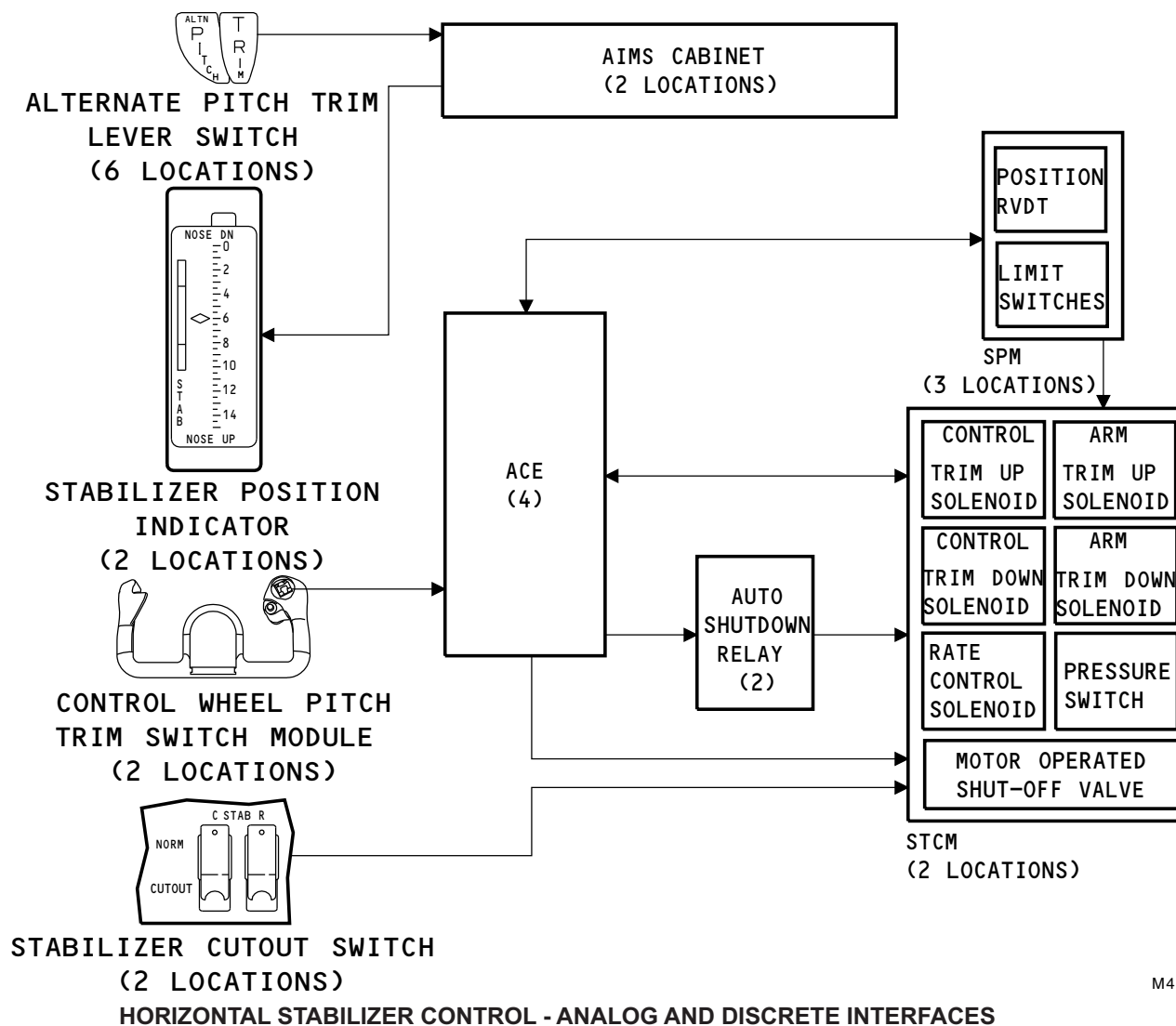
The ACEs send discrete signals through the limit switches to the STCMs.

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**HORIZONTAL STABILIZER CONTROL - PITCH TRIM SWITCHES****Purpose**

The pitch trim switches electrically command stabilizer movement.

Physical Description

Each switch has three positions: pitch up, pitch down, and off. It is spring loaded to the off position.

Location

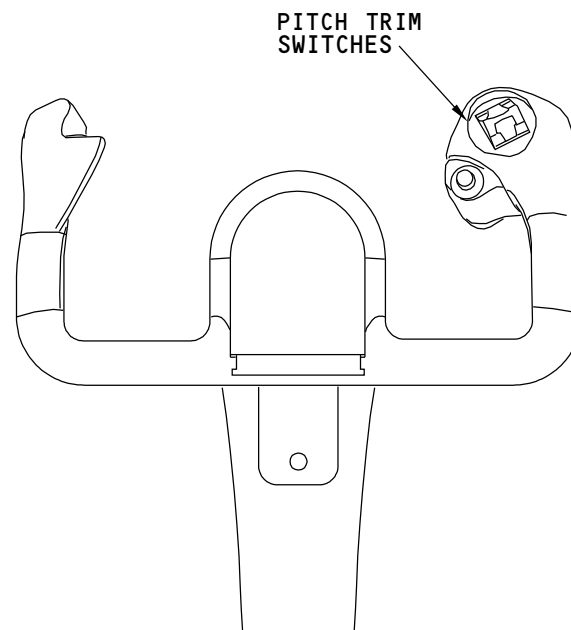
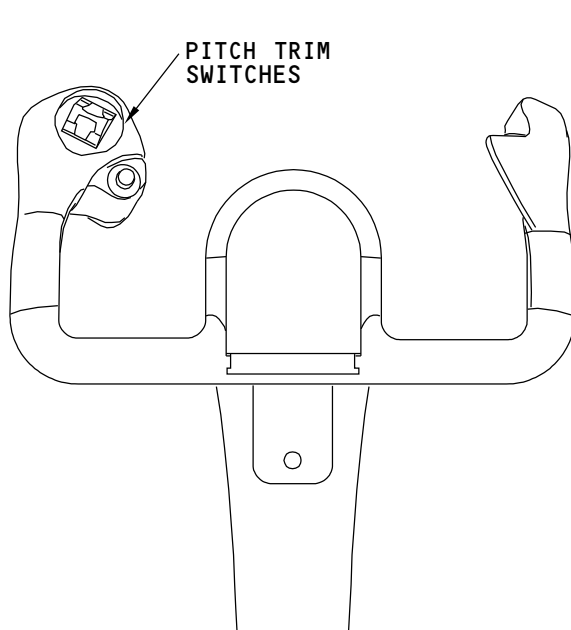
Two pitch trim switch pairs are on the outboard side of each control column.

Functional Description

One switch of the pair sends an arm signal and the other sends a control signal to the ACEs.

The pilot moves both switches in the up position to command nose down trim. In the down position, the switches command nose up trim.

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HORIZONTAL STABILIZER CONTROL - PITCH TRIM SWITCHES

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**HORIZONTAL STABILIZER CONTROL - ALTERNATE PITCH TRIM LEVERS AND FORWARD QUADRANT ASSEMBLY****Purpose**

The alternate pitch trim levers give the pilots mechanical control of pitch trim. The forward quadrant assembly transmits the movement from the levers to the control cables.

Physical Description

Two alternate pitch trim levers supply arm and control mechanical commands to the STCMs. The two levers are independent of each other. Springs move the levers back to the center position. Each lever connects by rod to its own forward quadrant.

Each quadrant has three alternate pitch trim lever switches. Cams on the quadrants operate the switches. A pair of cables connects each quadrant to the aft control module in the stabilizer compartment.

Location

The two alternate pitch trim levers are on the captain's side of the P10 control stand. The forward quadrant assembly is just below the levers in the aisle stand.

Functional Description

To command pitch trim, the pilot moves both alternate pitch trim levers together in the same direction. The pilot moves the levers forward to command nose down trim, aft for nose up trim. Movement of the left lever supplies the control command, the right lever supplies the arm command.

Movement of the alternate pitch trim levers causes rotation of the forward quadrants and movement of the two pairs of cables.

The forward quadrant rotation causes cams to move the three alternate pitch trim lever switches on each quadrant. The switches send these discrete signals to the AIMS:

- Up command
- Down command
- Actuation command.

Training Information Point

There is a rig pin hole in the forward quadrants and on the support structure.

Indications

The status message ALT PITCH TRIM LEV shows when one alternate pitch trim lever switch is defective.

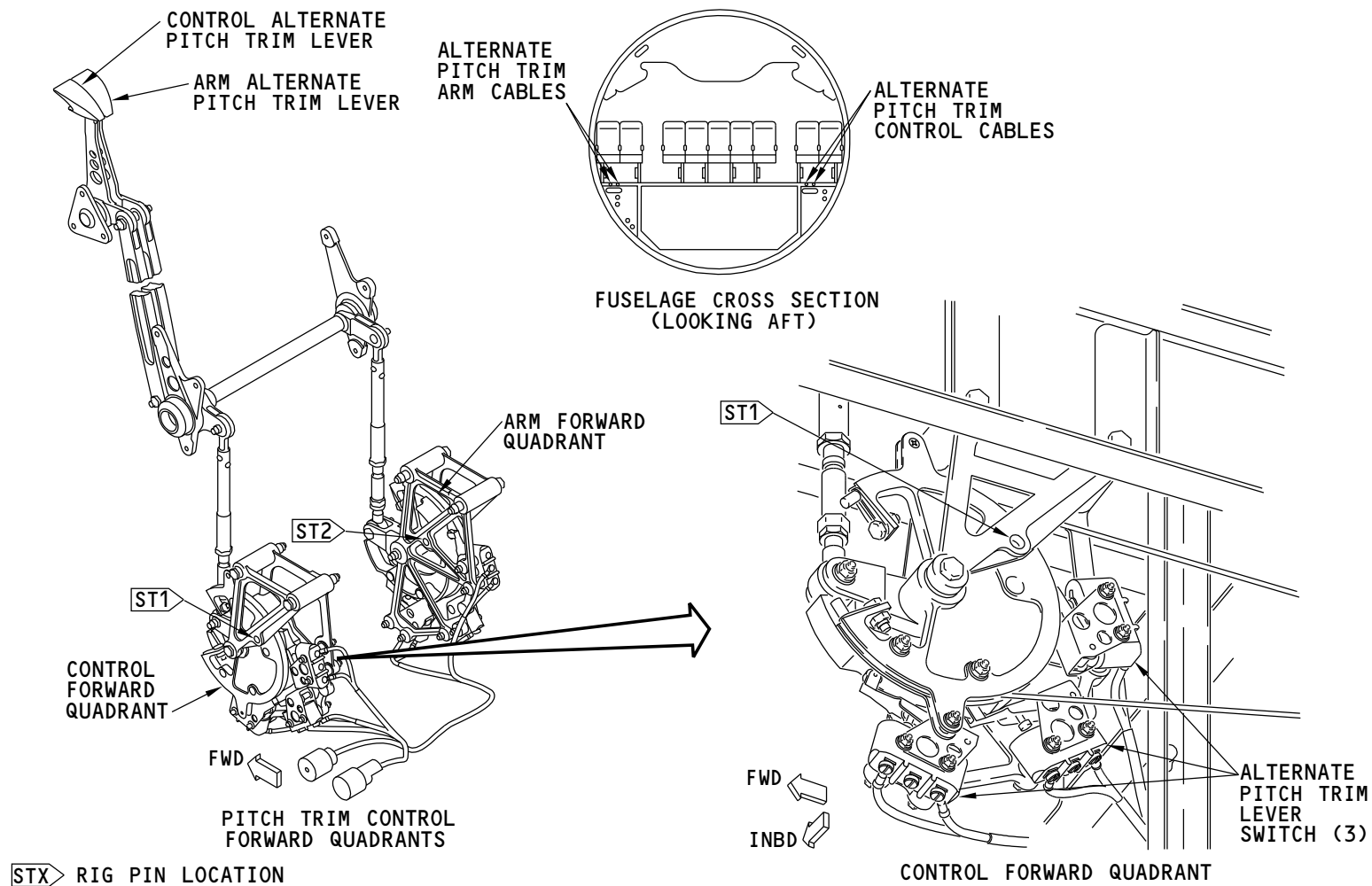
The status message FLIGHT CONTROL SYS shows when two or more alternate pitch trim lever switches are defective.

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HORIZONTAL STABILIZER CONTROL - ALTERNATE PITCH TRIM LEVERS AND FORWARD QUADRANT ASSEMBLY

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HORIZONTAL STABILIZER CONTROL - AFT STABILIZER QUADRANT ASSEMBLY

Purpose

The aft stabilizer quadrant assembly receives control movement from the two pairs of cables from the forward quadrant assembly. The aft stabilizer quadrant assembly transfers this movement to the input cranks on the STCMs.

Physical Description

The aft stabilizer quadrant assembly has an arm and a control quadrant on which the two alternate trim cable pairs attach. The arm quadrant is forward of the aft stabilizer quadrant assembly. The control quadrant is inside the quadrant assembly. Each quadrant connects to its own shaft by a spline which also connects to its output lever.

Control rods connect the output levers of the aft stabilizer quadrant assembly to the input cranks on the STCMs.

A travel limit drum assembly is at the aft of the quadrant assembly. The drum rotates on bearings on the aft quadrant assembly structure. A cable pair connects the drum assembly to the stabilizer structure.

Location

The aft stabilizer quadrant assembly is in the stabilizer compartment, near the ceiling just aft of the pressure bulkhead. The two STCMs are on either side of the quadrant assembly.

Functional Description

As the alternate pitch trim cable pairs move, in response to a movement of the alternate pitch trim levers, the arm and control quadrants rotate. Splined shafts transfer this rotation to the output levers. Control rods transfer the movement to the input cranks on the STCMs.

Training Information Point

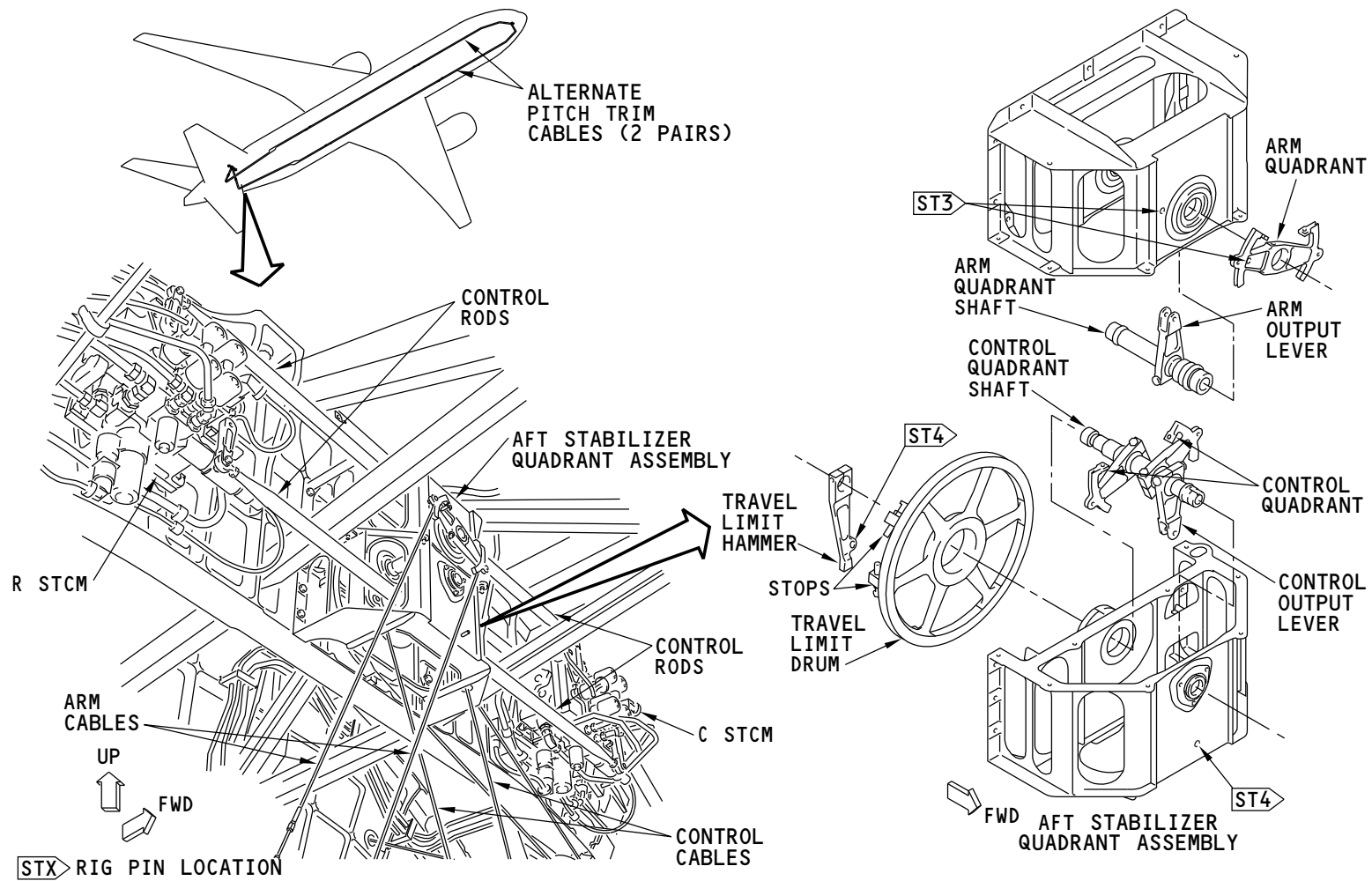
There are rig pin holes in the arm quadrant, the travel limit hammer and aft stabilizer quadrant assembly structure.

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HORIZONTAL STABILIZER CONTROL - AFT STABILIZER QUADRANT ASSEMBLY

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**HORIZONTAL STABILIZER CONTROL - AFT STABILIZER QUADRANT ASSY - TRAVEL LIMIT DRUM ASSEMBLY****Purpose**

When the horizontal stabilizer is operated from the alternate pitch trim levers, the travel limit drum assembly stops the stabilizer at the up and down limits. These limits prevent contact between the stabilizer ballnut and the ballscrew stops.

Physical Description

The travel limit drum turns on bearings on the aft quadrant assembly structure. A cable pair connects the drum assembly to brackets attached on the front spar of the stabilizer. This cable also operates the left stabilizer position module. Stops on the drum assembly contact the travel limit hammer when the stabilizer reaches its travel limits. The travel limit hammer connects by splines to the control quadrant shaft of the aft stabilizer quadrant assembly.

Location

The travel limit drum assembly is at the aft side of the aft stabilizer quadrant assembly.

Functional Description

When you move the alternate pitch trim levers, the control quadrant shaft moves the travel limit hammer from its neutral position. The STCMs command causes the stabilizer to move. The pair of cables connected to the stabilizer front spar also moves. The cable movement causes the rotation of the travel limit drum assembly. As the stabilizer reaches its up or down limit, stops on the drum contact the hammer and move it back to its neutral position. This moves the control lever of the alternate pitch trim levers to the neutral position and stops the stabilizer command.

Training Information Point

There is a rig pin hole in the travel limit hammer.

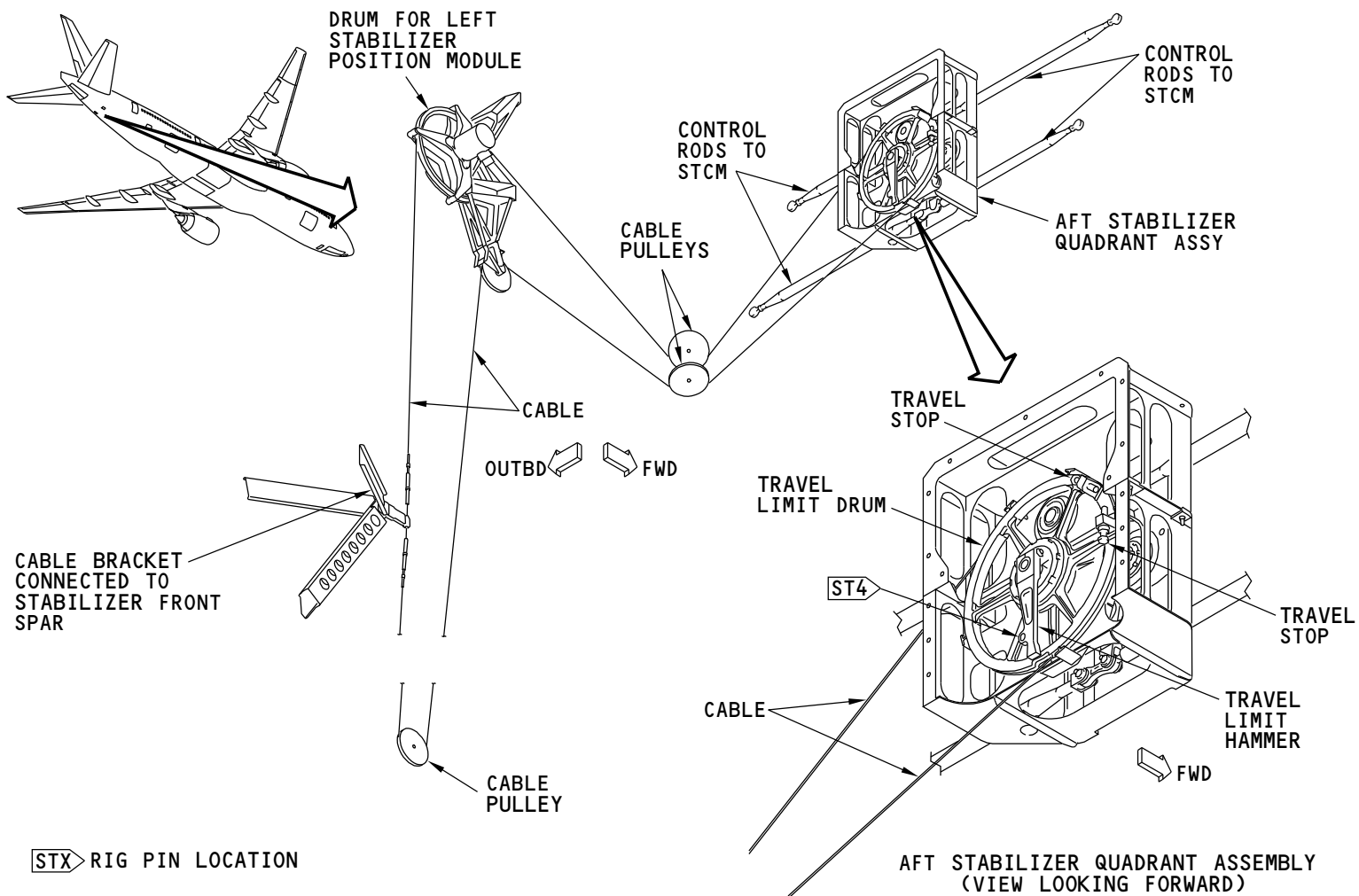
The travel stops on the travel limit drum assembly are adjustable.

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HORIZONTAL STABILIZER CONTROL - AFT STABILIZER QUADRANT ASSY - TRAVEL LIMIT DRUM ASSEMBLY

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HORIZONTAL STABILIZER CONTROL - CUTOUT SWITCHES

Purpose

The two stabilizer cutout switches stop the stabilizer movement when they are in the CUTOUT position. The pilots use these switches in the unlikely event there is uncommanded stabilizer movement. You can move the switches to the CUTOUT position separately to control either the center or right STCM shutoff valves. These valves control hydraulic power to the stabilizer motors and brakes.

Physical Description

The cutout switches are two toggle switches, each guarded with a safety cover. To move the switches to the CUTOUT position, the pilot must raise the safety guards. The guards move the switches back to the NORM position when they are closed.

Location

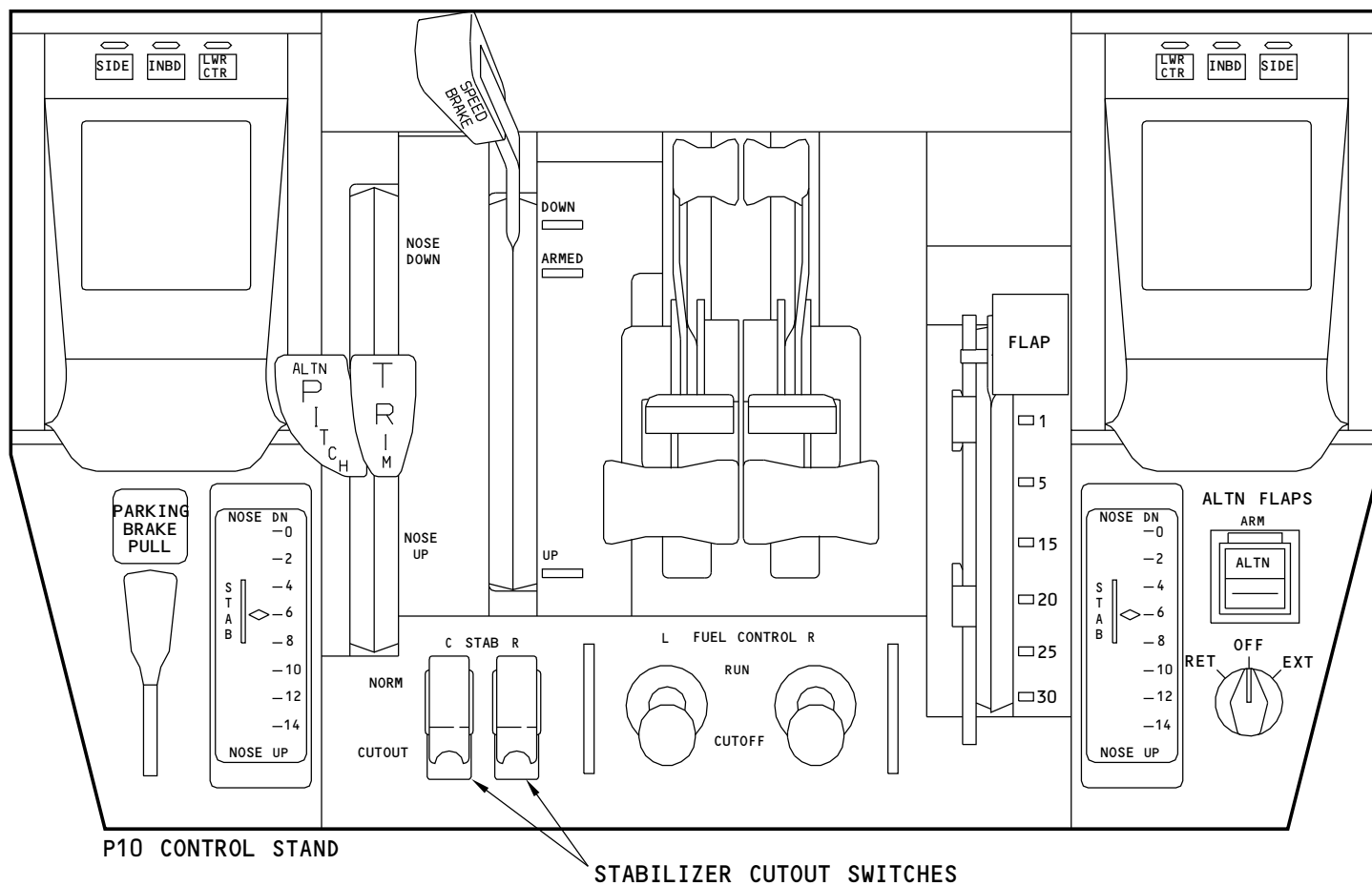
The switches are on the aft, left hand side of the P10 control stand.

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HORIZONTAL STABILIZER CONTROL - CUTOFF SWITCHES

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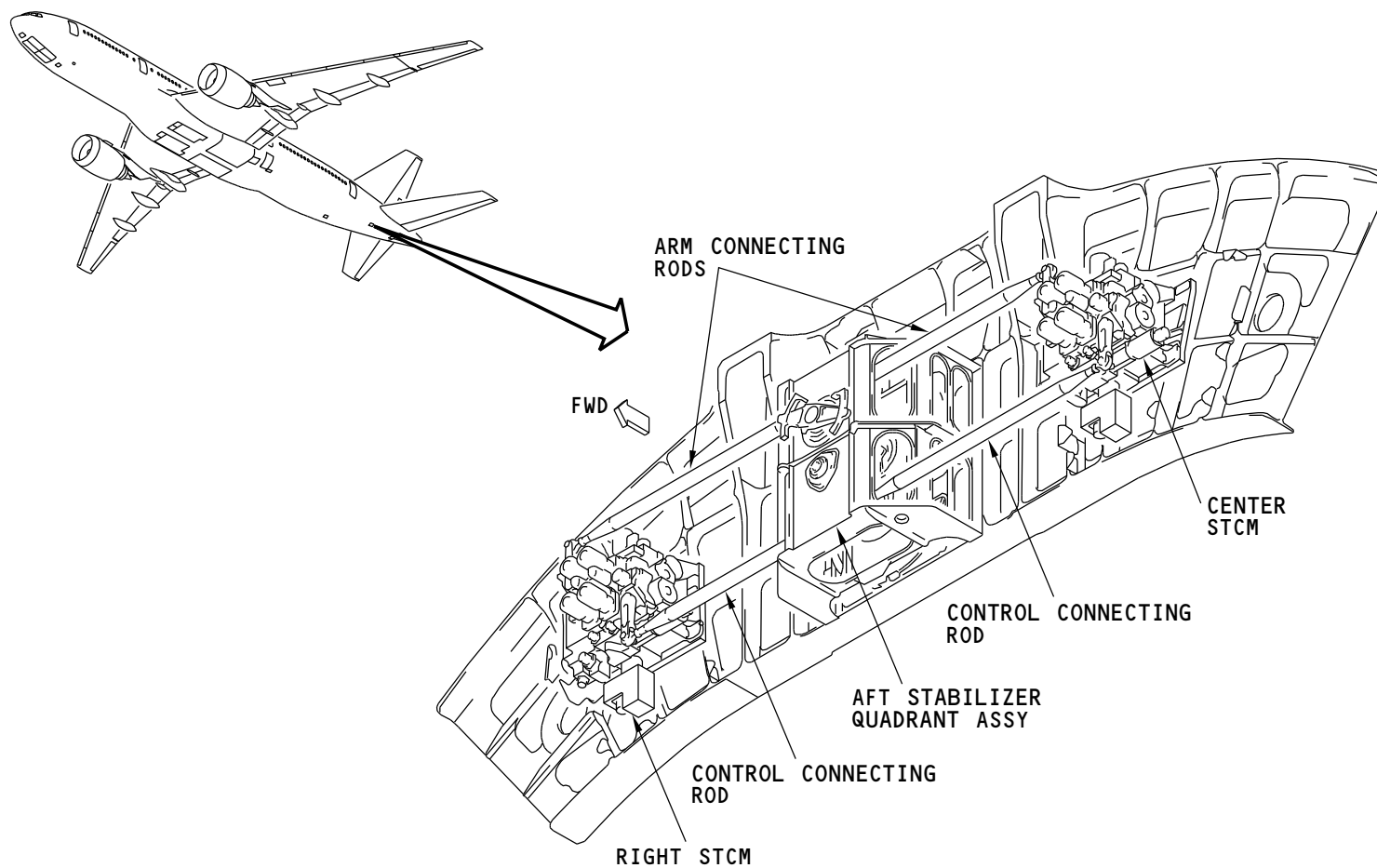
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**HORIZONTAL STABILIZER CONTROL - STCM - INTRODUCTION****Purpose**

There are two stabilizer trim control modules. Each module controls hydraulic pressure to a hydraulic motor and brake. The STCMs receive electrical signal commands from the ACEs and mechanical commands from the alternate pitch trim levers.

Location

The two STCMs are near the ceiling of the stabilizer compartment just aft of the pressure bulkhead. Access to the compartment is by a hatch on the lower left side of the empennage.



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HORIZONTAL STABILIZER CONTROL - STCM - INTRODUCTION

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HORIZONTAL STABILIZER CONTROL - STCM - PHYSICAL DESCRIPTION

General

The two STCMs are on the airplane structure. Between the STCMs is the control module. Control rods transfer movement in the control module to the STCMs.

Electrical connectors of different sizes connect to the STCMs.

Hydraulic tubing connects to STCM input and output ports.

The center hydraulic system supplies power to the center STCM (located on the left side). The right hydraulic system supplies power to the right STCM.

The two STCMs are identical. Each STCM weighs approximately 29 lb (13 kg).

Each STCM contains an arming and control valve which controls hydraulic power to the hydraulic motor and brake. Movement of the two valves allows hydraulic pressure to release the hydraulic brake and to drive the motor in the commanded direction.

These components control the operation of the STCM:

- Motor operated shutoff valve
- Nose down control solenoid
- Nose down arm solenoid
- Arm input crank
- Rate control solenoid
- Nose up arm solenoid
- Nose up control solenoid
- Pressure switch
- Control input crank
- Brake bypass valve.

Motor Operated Shutoff Valve

The motor operated shutoff valve controls hydraulic power to the STCM. The cutout switches on the control stand, and the ACEs control power to the electric motor of the shutoff valve.

The motor operated shutoff valve has a manual override lever which is also a position indicator.

Nose Up and Nose Down, Arm and Control Solenoids

The ACEs control the nose up and nose down, arm and control solenoids. These solenoids operate valves which control hydraulic pilot pressure to move the arming and control valves.

Arm and Control Input Cranks

The arm and control input cranks connect to an arm and control manual valve in the STCM. The manual valves control hydraulic pilot pressure to move the arming and control valves.

Rate Control Solenoid

The ACEs control the trim rate solenoid. The solenoid operates a two position valve. It allows either full or restricted hydraulic flow to the hydraulic motor. This controls the rotation speed of the motor.

Pressure Switch

The pressure switch monitors the hydraulic pressure to the brake. The switch closes when the STCM sends hydraulic pressure to release the brake. The discrete brake release signal goes to the ACE.

Brake Bypass Valve

Maintenance personnel use the brake bypass valve to periodically test the operation of the hydraulic brake. When you push on the brake bypass valve button, the valve shuts off hydraulic pressure to the brake. While you hold the button, you verify that the brake stops and holds the hydraulic motor. When released, a spring moves the brake bypass valve back to the open position.

Training Information Point

These are the LRUs on the STCMs:

- Rate control solenoid

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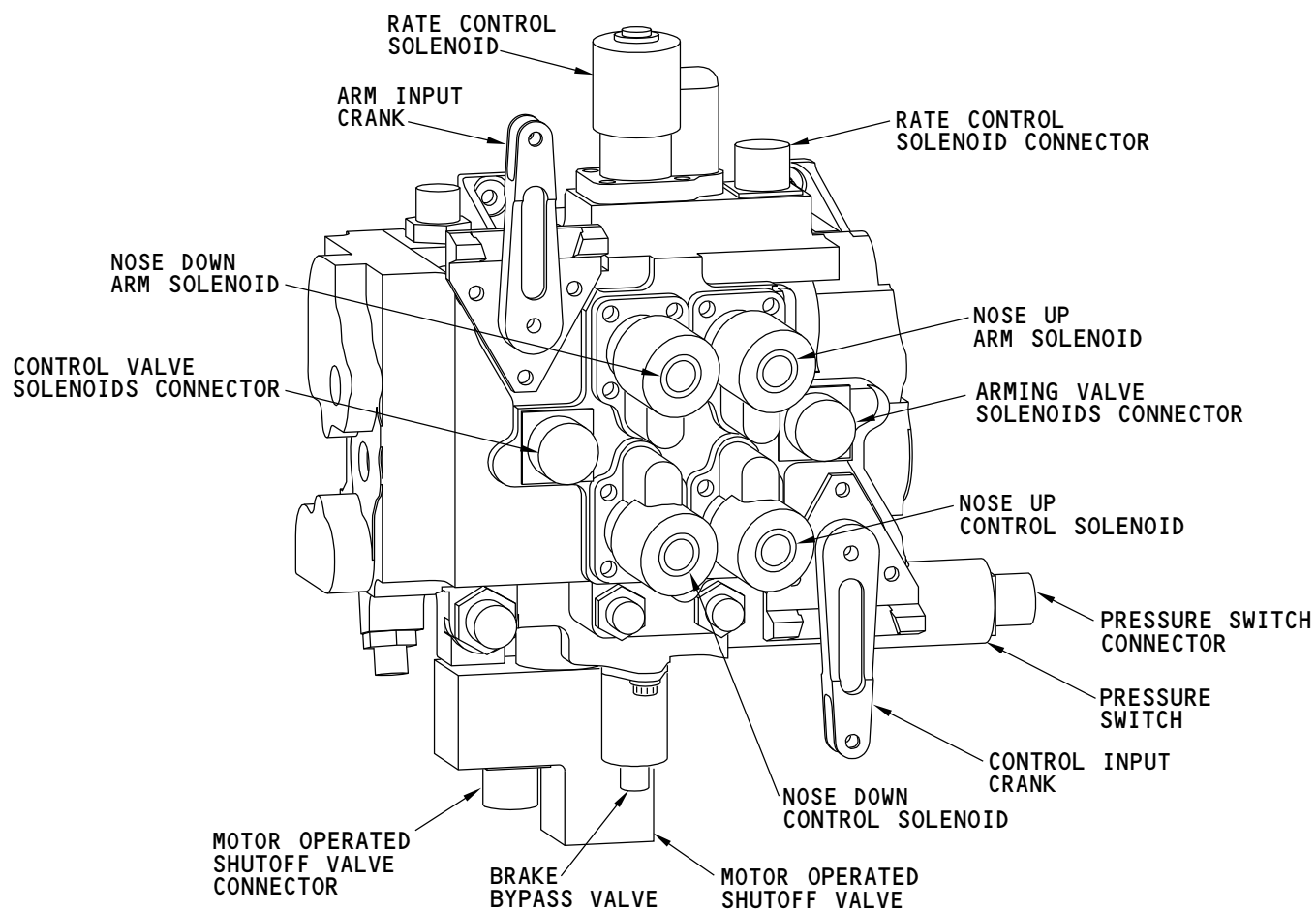
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HORIZONTAL STABILIZER CONTROL - STCM - PHYSICAL DESCRIPTION

- Nose up and down arm solenoids
- Nose up and down control solenoids
- Pressure switch
- Motor operated shutoff valve.



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HORIZONTAL STABILIZER CONTROL - STCM - PHYSICAL DESCRIPTION

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HORIZONTAL STABILIZER CONTROL - STCM - FUNCTIONAL DESCRIPTION

General

The STCM controls hydraulic power to the motor and brake of the stabilizer ballscrew actuator. It operates in two different modes of operation:

- Electrical
- Mechanical.

An inlet filter and check valve are in the hydraulic power supply line to the motor operated shutoff valve. In either mode of operation, the shutoff valve normally controls hydraulic power to the trim rate solenoid valve. The cutout switches on the control stand and the PFCs control the motor operated shutoff valve.

The PFC commands, through the ACE, the trim rate solenoid valve to high or low flow based on airspeed and flap position. A spring returns the trim rate solenoid valve to the high flow position when the solenoid is de-energized.

Arming and Control Valves

The arming and control valves have three positions:

- Null
- Trim up
- Trim down.

Hydraulic pilot pressure controls the position of the arming and control valves. This pilot pressure comes from one or both of these sources:

- The trim up and down, arm and control solenoid valves
- The arm and control manual valves.

Springs in the arming and control valves center and hold them in the null position when there is no hydraulic pressure. With the two valves in the null position, they stop hydraulic pressure to the brake and motor of the stabilizer ballscrew actuator.

The arming and control valves must move together in the same direction to permit hydraulic pressure to the hydraulic brake and motor.

When both arming and control valves move to the trim up position, hydraulic power goes to release the brake and drive the hydraulic motor in the nose up direction.

When both arming and control valves move to the trim down position, hydraulic power goes to release the brake and drive the hydraulic motor in the nose down direction.

Two anti-cavitation check valves supply hydraulic fluid to the motor. They prevent motor cavitation in the unlikely event of brake slip and backdrive of the motor.

Electrical Operation

When the trim up and trim down, arm and control solenoid valves are de-energized, they allow hydraulic pilot pressure on both sides of the arming and control valves. The two valves are in the null position.

When their solenoids are both energized, the trim up arm and control solenoid valves operate. They stop hydraulic pilot pressure to the trim up side of the arming and control valves and port it to the system return line. Both arming and control valves move to the trim up position and permit pressure to the brake and motor.

When the solenoids of the trim down arm and control solenoid valves are both energized, the same process occurs. But in this case, the arming and control valves move to the trim down position and permit hydraulic pressure to the brake and motor.

Mechanical Operation

The arm and control input cranks connect to the arm and control manual valves. These valves control hydraulic pilot pressure to the arming and control valves.

The arm and control manual valves have three positions:

- Null
- Trim up
- Trim down.

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HORIZONTAL STABILIZER CONTROL - STCM - FUNCTIONAL DESCRIPTION

Springs in the arm and control manual valves center them in the null position when there is no force on the input cranks. With the two valves in the null position, they permit hydraulic pilot pressure to both sides of the arming and control valves.

Because they are directly upstream of the arming and control valves, the manual valves have first priority of control over the trim up and down, arm and control solenoid valves. This permits the pilot to manually override any electrical command to the stabilizer.

When the arm and control input cranks move to the trim up position, they command the manual valves to move to the trim up position. The manual valves stop hydraulic pilot pressure to the trim up side of the arming and control valves and port it to the system return line. Both arming and control valves move to the trim up position and permit pressure to the brake and motor.

When the input cranks move to the trim down position, the same process occurs. But in this case, the arming and control valves move to the trim down position and permit hydraulic pressure to the brake and motor.

Brake Bypass Valve

The manually operated brake bypass valve permits maintenance personnel to test the effectiveness of the hydraulic brake. When activated, the valve blocks hydraulic pressure to the brake and ports it to the system return line. This prevents brake release when the hydraulic motor is pressurized.

Pressure Switch

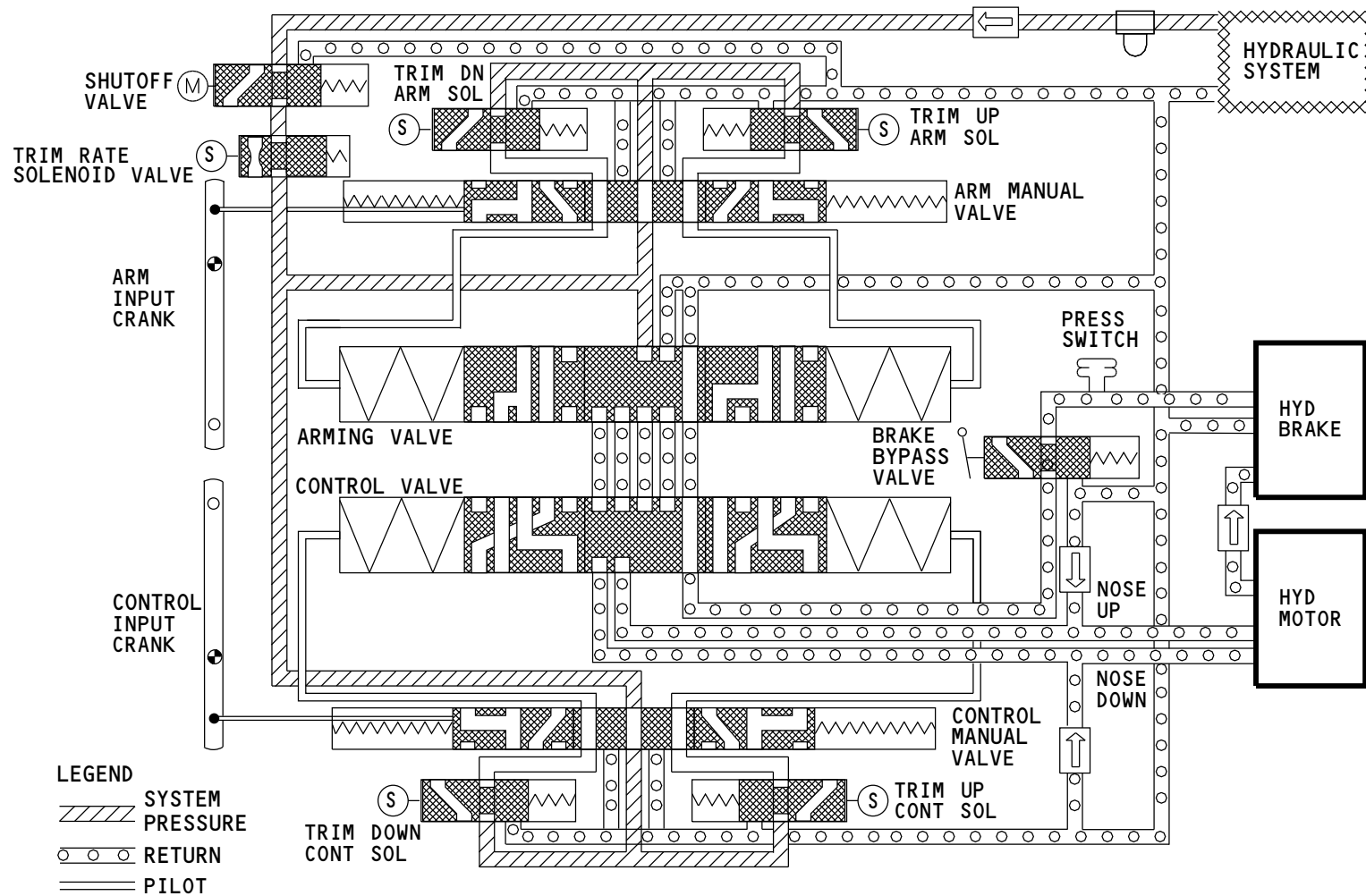
The pressure switch closes at 1000 psi. It sends a discrete signal to the ACEs to indicate the pressure status to the brake.

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HORIZONTAL STABILIZER CONTROL - STCM - FUNCTIONAL DESCRIPTION

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HORIZONTAL STABILIZER CONTROL - STABILIZER BALLSCREW ACTUATOR

Purpose

The stabilizer ballscrew actuator uses the hydraulic pressure from the STCMs to move the horizontal stabilizer assembly.

Physical Description

The stabilizer ballscrew actuator attaches to the aircraft structure with a gimbal. The gimbal is at the top of the actuator. The stabilizer ballscrew actuator includes:

- Two hydraulic motors
- Two hydraulic brakes
- A differential gear box
- A primary brake
- A ballscrew.

Each hydraulic brake is on the same shaft with each hydraulic motor. The two hydraulic motors turn the motor pinions and the motor gears. The two motor gears are part of the differential gearbox. The bull gear pinion of the differential connects with the bull gear and the ballscrew.

The ballscrew also connects to a primary brake. The primary brake has two brakes with brake discs, ratchets, and pawls. The two brakes are similar but each one operates in one direction of rotation.

Location

The stabilizer ballscrew actuator is in the stabilizer compartment, just forward of and below the STCMs.

Functional Description

Hydraulic pressure from the STCMs pressurizes the hydraulic motors and brakes. The hydraulic pressure releases the hydraulic brakes and permits the motors to turn the motor pinions. They move the differential mechanism in the gearbox.

The differential mechanism permits operation with one or two motors at a time. The differential mechanism adds the speed of both hydraulic motors. When one hydraulic motor operates, the speed of the ballscrew is 50 percent of the speed when both hydraulic motors operate. The bull gear pinion of the differential mechanism drives the bull gear and the ballscrew.

The primary brake makes sure airloads on the stabilizer do not backdrive the ballscrew. The primary brake uses the axial load in the ballscrew caused by an airload on the stabilizer. An axial load in the ballscrew sets one brake and its ratchet pawls make sure the ballscrew cannot turn in one direction. An axial load in the opposite direction sets the other brake. If there is no airload when one or both hydraulic motors operate, the primary brake releases and the ballscrew turns freely. If there is an airload on the stabilizer when one or both hydraulic motors operate, it may cause some drag of the ballscrew on one brake.

The ballnut moves vertically on the ballscrew. The direction of movement depends upon the direction of ballscrew rotation.

The front structure of the stabilizer assembly attaches to the gimballed ballnut assembly.

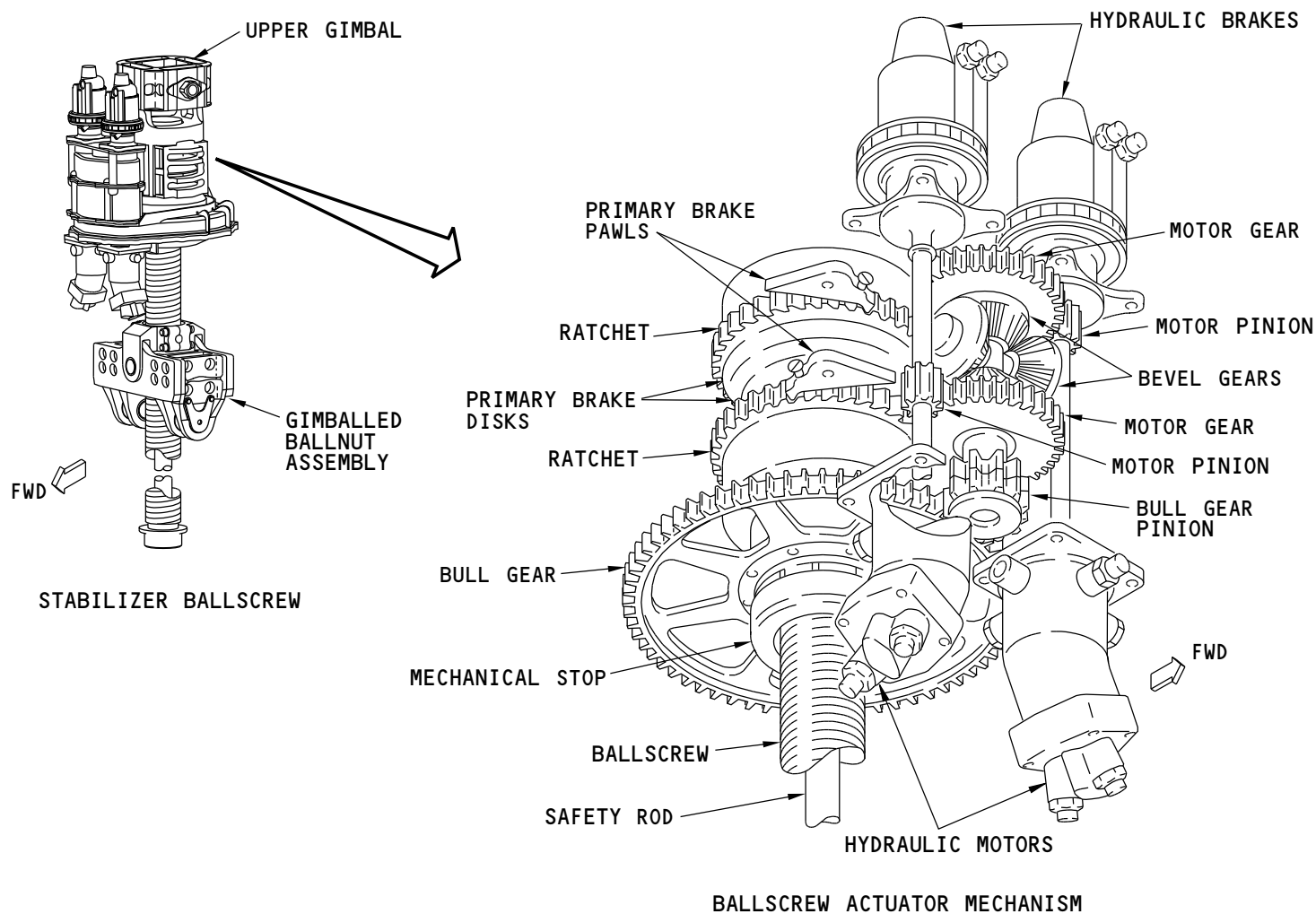
A safety rod inside of the ballscrew holds the ballscrew in case of failure.

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HORIZONTAL STABILIZER CONTROL - STABILIZER BALLSCREW ACTUATOR

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**HORIZONTAL STABILIZER CONTROL - HYDRAULIC MOTOR****Purpose**

The stabilizer hydraulic motors change hydraulic power to rotary motion to move the stabilizer.

Physical Description

The two identical motors are reversible, fixed-angle, constant-displacement, piston-operated hydraulic motors.

The rated speed of the motor is 2320 RPM.

At rated speed with 3000 psi, the motor produces 345 in-lbs of torque.

Each motor uses 8.15 gpm at rated speed.

The motor weighs approximately 10 lb (4.5 kg).

Two drain lines are on the motor. One is a shaft seal drain and the other is a case drain line. Two hydraulic supply lines connect at the lower side of the motor.

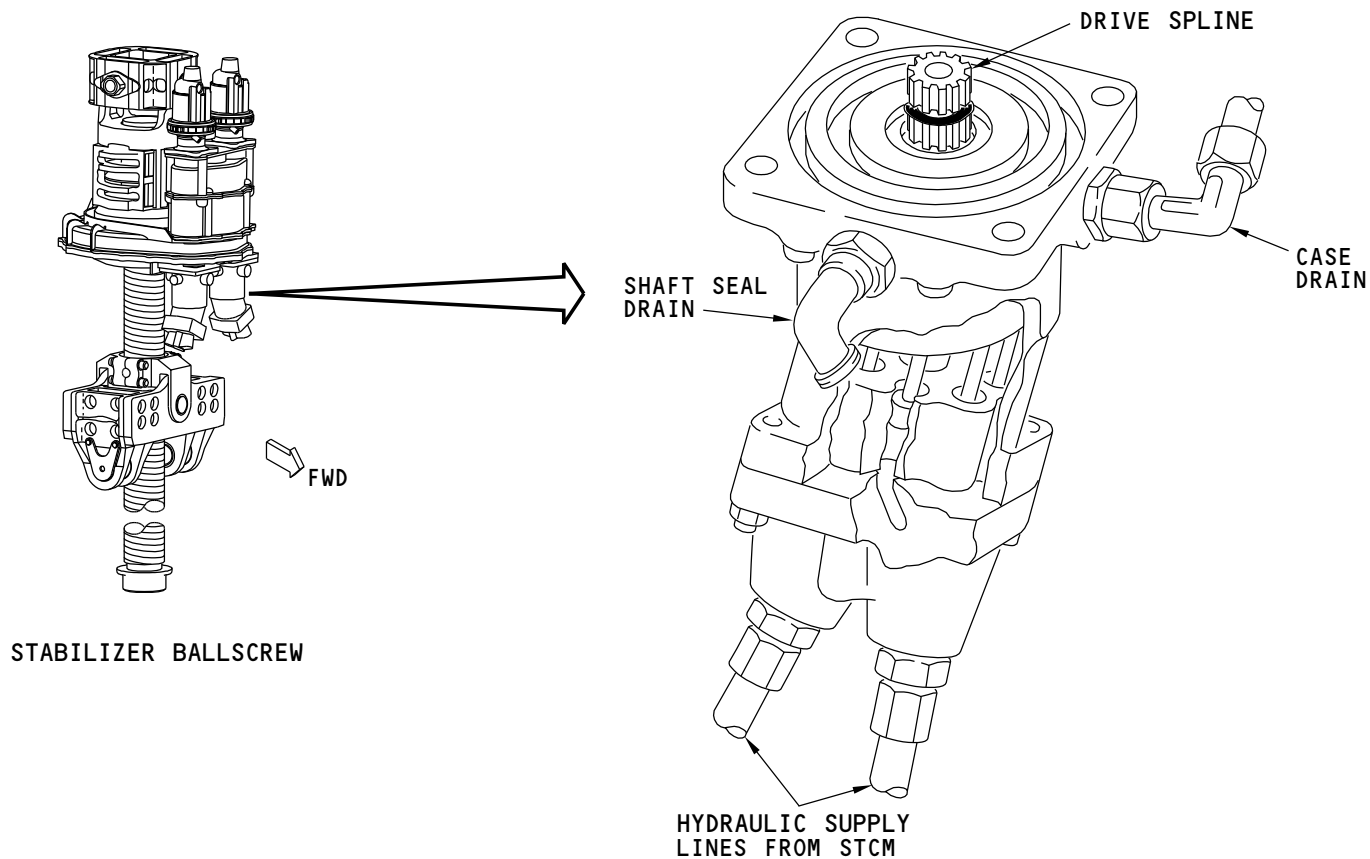
Location

The motors are on the lower, forward area of the stabilizer ballscrew actuator.

Functional Description

The motors receive system hydraulic pressure from the STCMs. The center STCM sends center hydraulic system pressure to the left hydraulic motor. The right STCM sends right system pressure to the right motor.

The STCMs control the speed and direction of motor rotation. The motors input to the ballscrew actuator with a drive spline.



HORIZONTAL STABILIZER CONTROL - HYDRAULIC MOTOR

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**HORIZONTAL STABILIZER CONTROL - HYDRAULIC BRAKE****Purpose**

The stabilizer hydraulic brake prevents rotation of the hydraulic motor when the motor is not commanded to move.

Physical Description

The two identical hydraulic brakes contain rotors and stators. Each hydraulic brake weighs about 7.25 lb (2.7 kg).

A hydraulic pressure line from the STCM connects to the brake. There is a case drain line from the hydraulic motor to the brake. This case drain fluid returns to the STCM from the brake case drain return port.

A drive shaft from the gearbox connects to the brake shaft and the gearbox.

Location

The brakes are on the upper, forward area of the stabilizer ballscrew actuator.

Functional Description

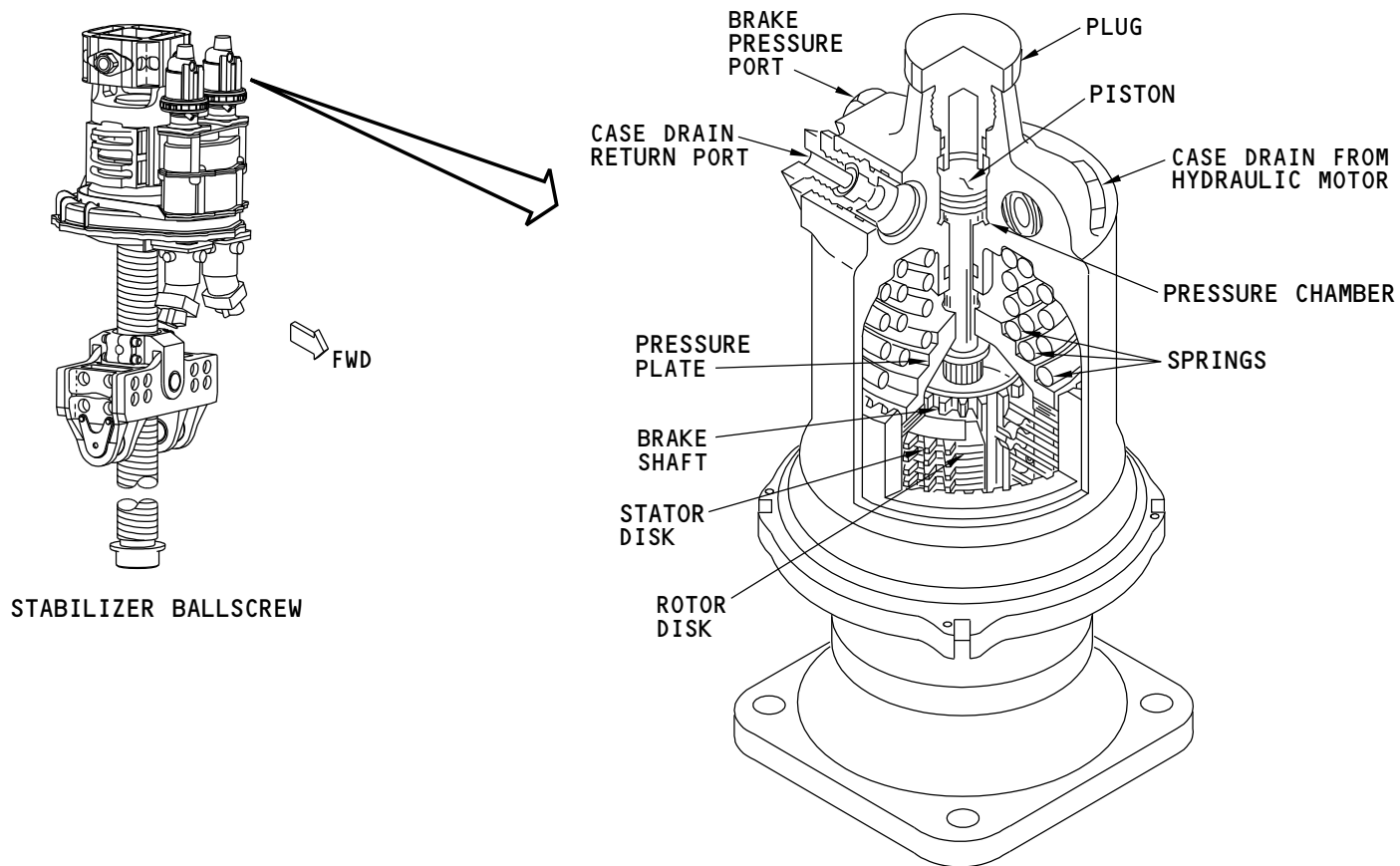
With no hydraulic pressure on the brake, springs apply a force on the pressure plate. This pressure prevents rotor and stator rotation. The brake holds a minimum of 565 in-lb of torque.

When the STCM sends at least 1000 psi pressure to the brake, the piston moves up. As the piston moves up, it pulls the pressure plate up and compresses the springs. Once the pressure releases from the rotors and stators, the hydraulic motor can operate.

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HORIZONTAL STABILIZER CONTROL - HYDRAULIC BRAKE

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HORIZONTAL STABILIZER CONTROL - POSITION MODULES

Purpose

The stabilizer position modules perform two functions. Limit switches within the modules electrically limit the travel of the stabilizer. An RVDT in each module sends an analog signal that represents stabilizer position. This signal goes to the ACEs.

Physical Description

There are three identical stabilizer position modules. The modules are on assemblies which include a pulley bracket base, a cable drum, and the stabilizer position module.

The module weighs approximately 1.6 lb (0.7 kg).

Location

The modules attach to airplane structure near the ceiling in the stabilizer compartment.

Functional Description

Three cables attach to the leading edge of the stabilizer and go around the cable drums. The cables go around pulleys attached to the structure at the bottom of the stabilizer compartment. The cables also attach to the cable drums of the stabilizer position module assemblies. When the stabilizer moves, the cable drums turn the splined shaft in the position module.

Internal gears within the module, cause rotation of an RVDT. It sends a variable analog signal to the ACEs. The signal represents the stabilizer position.

See the horizontal stabilizer position indication section for more information about the stabilizer position modules (SECTION 27-48).

Rotation of the shaft also causes two switches to open and close. As the stabilizer reaches +3.75 degrees nose down, the nose down control switch opens. This removes the control signal to the STCM and stops stabilizer movement.

The nose up control switch opens at -10.75 degrees to stop stabilizer travel in the nose up direction.

Training Information Point

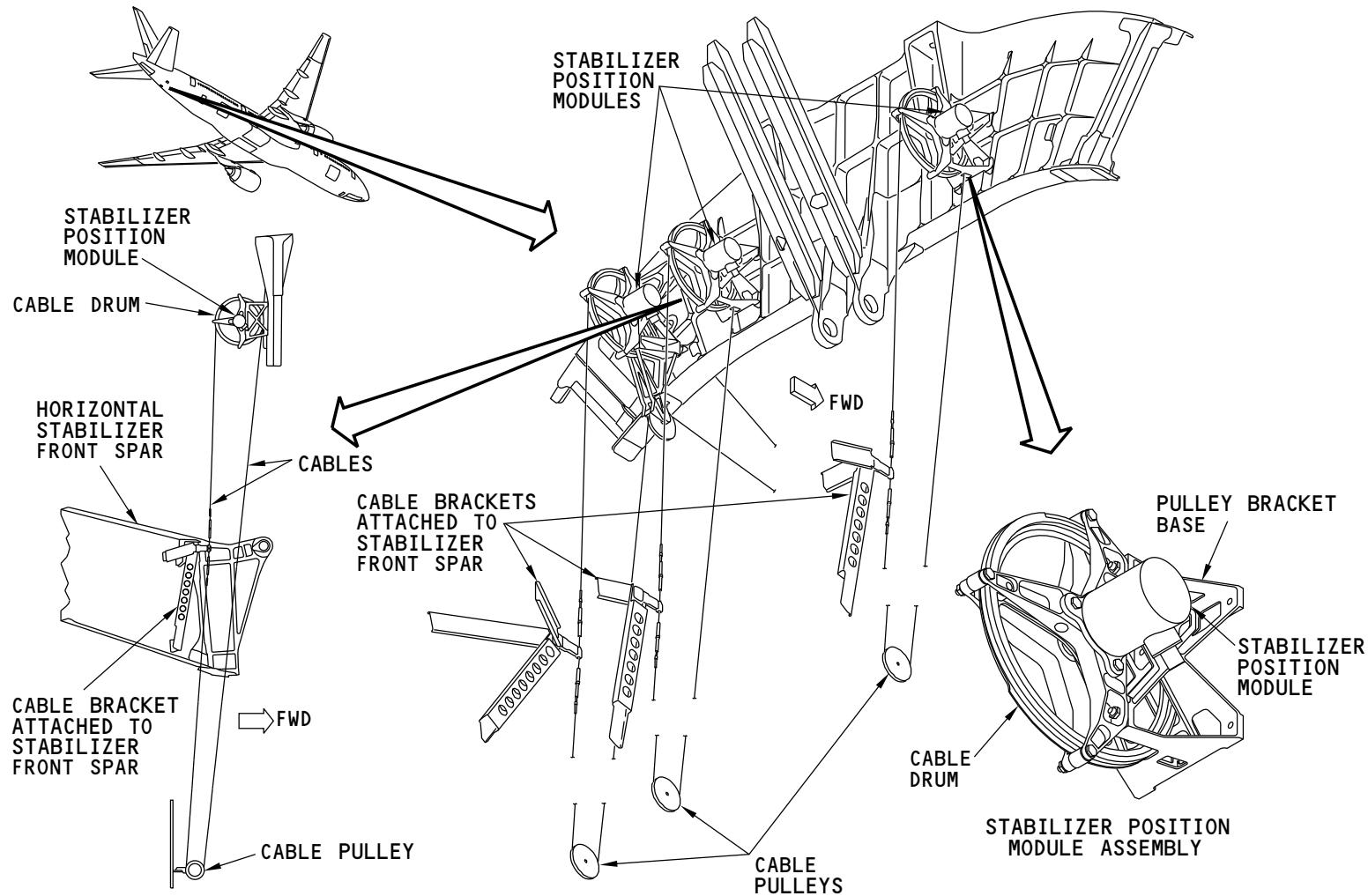
No rigging is necessary for removal and installation of the module.

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HORIZONTAL STABILIZER CONTROL - POSITION MODULES

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**HORIZONTAL STABILIZER CONTROL - STABILIZER ASSEMBLY****Purpose**

The horizontal stabilizer supplies long-term pitch control of the airplane.

Physical Description

The stabilizer is a light-weight composite material structure. The main torque boxes are carbon fiber construction with aluminum trailing edge hinge ribs. Steel hinge plates with fiberglass honeycomb panel fairings attach to the trailing edge of these ribs.

Forward of the main torque boxes are auxiliary boxes formed by aluminum sheet metal ribs that have covers made of fiberglass honeycomb panels.

The leading edges and the tips of the stabilizer are aluminum skinned honeycomb panels.

The horizontal stabilizer assembly weights approximately 6100 lbs (2765 kg). This includes the weight of the elevators and the PCUs. The horizontal stabilizer assembly measures about 71 feet wide by 34 feet long (21.6 meters by 10.4 meters).

There are four hoist points on the upper and lower surfaces on each side of the horizontal stabilizer assembly.

Functional Description

The stabilizer moves 15 degrees:

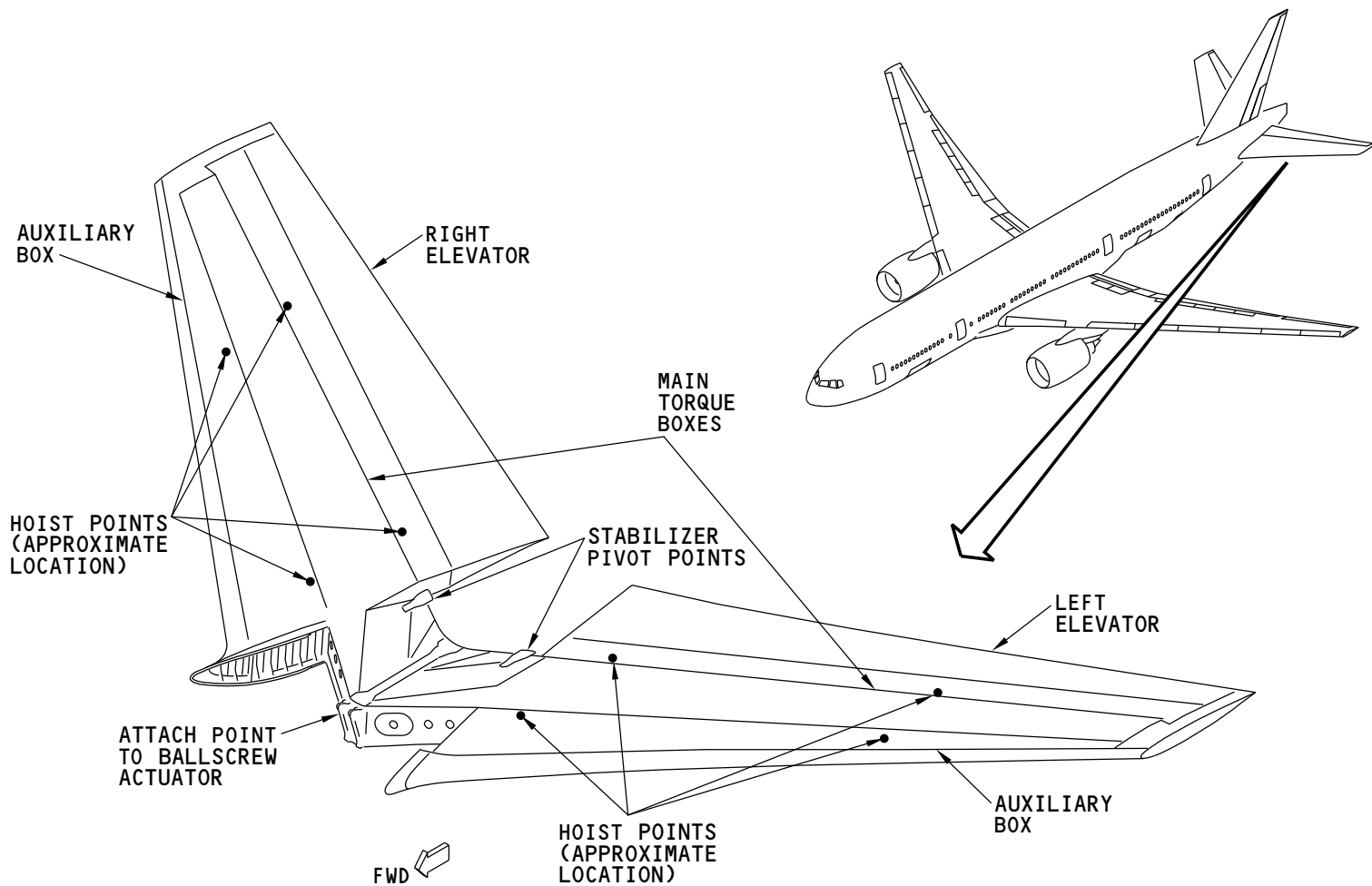
- 4 degrees leading edge up (4 degrees airplane nose down trim) from neutral
- 11 degrees leading edge down (minus 11 degrees airplane nose up) from neutral.

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HORIZONTAL STABILIZER CONTROL - STABILIZER ASSEMBLY

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - INTRODUCTION

General

The stabilizer control system uses input command signals from the captain's and first officer's pitch trim switches.

The ACEs receive the input signals and supply output command signals to the STCMs. The ACEs also receive feedback signals from the SPMs.

The stabilizer cutout switches and the auto shutdown relays send signals to the STCMs to close the motor operated shutoff valves.

The system also operates with mechanical commands from the alternate pitch trim levers directly to the STCMs.

Pitch Trim Switches

Each ACE receives a signal from a pitch trim switch. The L1 ACE receives the arm signal from the captain's arm switch and the L2 ACE from the first officer's arm switch. The C ACE receives the control signal from the captain's control switch and the R ACE from the first officer's control switch.

Stabilizer Cutout Switches and Auto Shutdown Relays

The stabilizer cutout switches directly control power to close the motor operated shutoff valve on the STCMs.

Two ACEs control the auto shutdown relays individually. When commanded, each relay sends power to close a motor operated shutoff valve on an STCM.

Stabilizer Trim Control Modules

The center STCM requires the operation of the C and L1 ACEs.

The C ACE sends command signals through the auto shutdown relay to close the shutoff valve of the center STCM. The shutoff valve also receives command signals directly from the center stabilizer cutout switch. The center STCM also receives from the C ACE the control up or down command signals. These signals initially go through the limit switches of the center SPM before they command the control solenoids.

The center STCM receives arm up or down command signals and the rate solenoid signals from the L1 ACE.

The right STCM requires the operation of the R and L2 ACEs.

The R ACE sends command signals through the auto shutdown relay to close the shutoff valve of the right STCM. The shutoff valve also receives command signals directly from the right stabilizer cutout switch. The right STCM also receives the control up and down command signals from the R ACE. These signals initially go through the limit switches of the right SPM before they command the control solenoids.

The right STCM receives arm up or down command signals and the rate solenoid signals from the L2 ACE.

The brake pressure switch of the center STCM sends a feedback signal to the C ACE, the switch from the right STCM to the R ACE.

The alternate pitch trim levers mechanically operate the arm and control manual valves of both STCMs.

Stabilizer Position Modules

The RVDT of the left SPM sends a stabilizer position feedback signal to the L1 ACE, the RVDT of the center SPM to the C ACE, and the RVDT of the right SPM to the R ACE.

The limit switches in the center SPM control the signal from the C ACE to the center STCM. The limit switches in the right SPM control the signal from the R ACE to the right STCM. The limit switches of the left SPM are not used.

Alternate Pitch Trim Switches

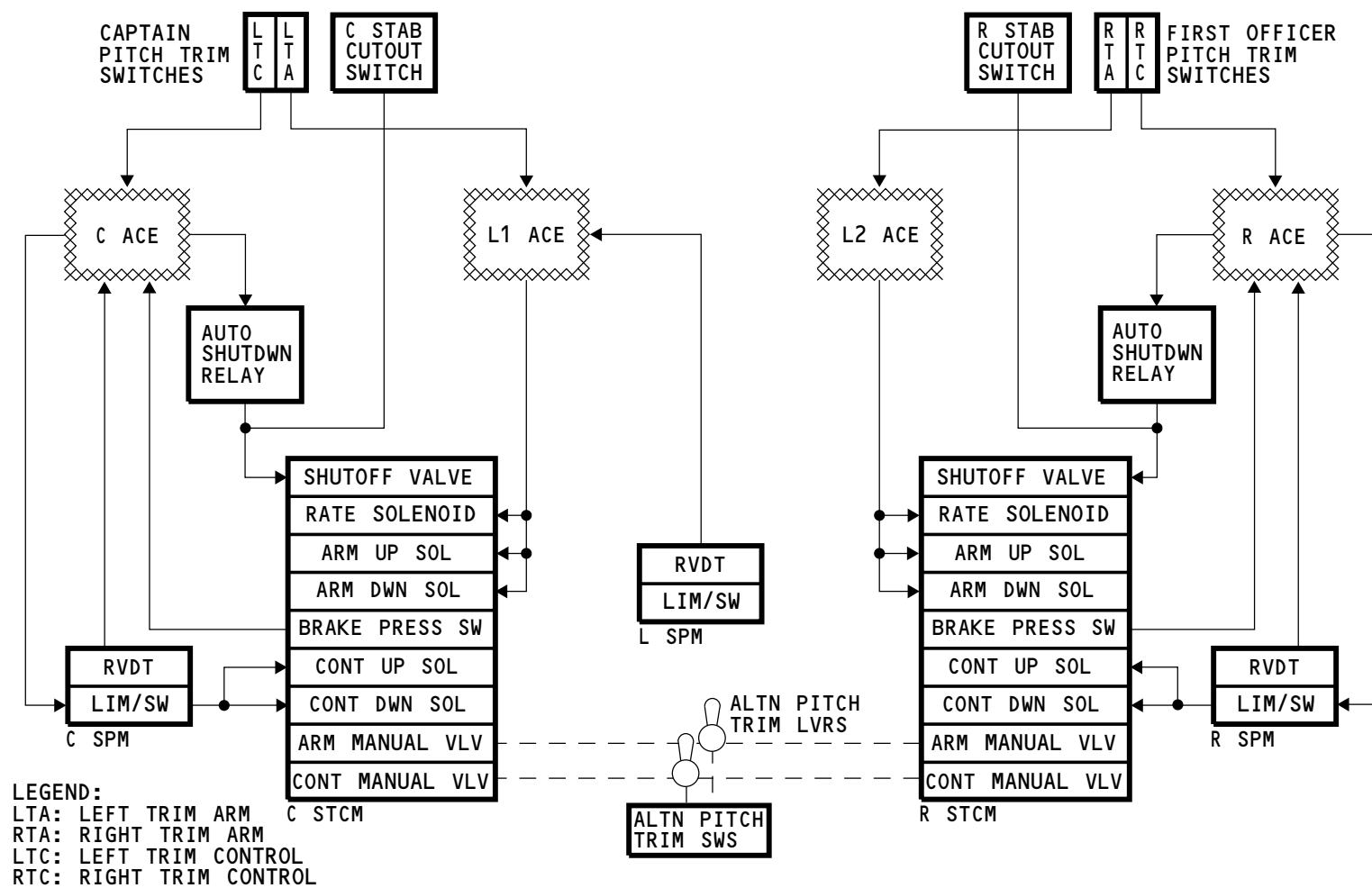
The alternate pitch trim levers move alternate pitch trim switches which send signals to the AIMS cabinets.

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - INTRODUCTION

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**HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - HYDRAULIC CUTOUT AND AUTO SHUTDOWN****General**

The stabilizer cutout switches and auto shutdown relays supply power to the shutoff valves in the STCMs. These valves control hydraulic power to the stabilizer motor and brake.

Cutout Switches

With the cutout switch in the CUTOUT position, 28v dc power goes directly to the close side of the shutoff valve motor. As the valve completes its travel to the closed position, limit switches in the motor assembly move to the ready-to-open position.

With the cutout switch back to the NORM position, power goes through the de-energized shutdown relay to drive the valve back to the open position. The motor limit switches then return to the ready-to-close position.

Auto Shutdown Relays

The PFCs command the ACEs to energize the auto shutdown relays for:

- An uncommanded stabilizer movement
- A no stabilizer motion fault
- An STCM defective response.

The PFCs monitor the left and right STCMs individually for stabilizer operation. If a PFC finds a system malfunction, it commands the ACE to energize the left or right stabilizer auto shutdown relay in relation to the STCM that has a defect. The ACE then latches the auto shutdown relay. The energized auto shutdown relay supplies power to close its shutoff valve.

Indications

Unscheduled stabilizer motion when there is an auto shutdown failure causes a STABILIZER warning message to show.

A FLIGHT CONTROLS caution message shows if both stabilizer channels are defective.

A STABILIZER C or a STABILIZER R advisory message shows if the center or right channel shuts down or if one of the cutout switches is in the CUTOUT position.

The advisory message STABILIZER CUTOUT shows when both cutout switches are in the CUTOUT position.

Training Information Point

Maintenance personnel can use the stabilizer cutout switches to do fault isolation of stabilizer system malfunctions.

A maintenance action is necessary to unlatch the auto shutdown relays. After correction of the fault, the stabilizer system ground test unlatches the PFC auto shutdown commands to the ACEs when the system passes the test.

You can also use the PFC disconnect switch on the P5 panel with the C and R cutout switches to unlatch the auto shutdown relays. Because the ACE latch can be manually reset only in direct mode, the PFC disconnect switch first must be in the DISC position. With the cutout switch of the shutdown STCM in the CUTOUT position, the auto shutdown relay de-energizes. The ACE monitors the power removal from the auto shutdown relay and resets its auto shutdown latch.

When the cutout switch moves back to the NORM position, the auto shutdown relay stays de-energized and permits the STCM shutoff valve to open. This permits the pilot to control the stabilizer in direct mode.

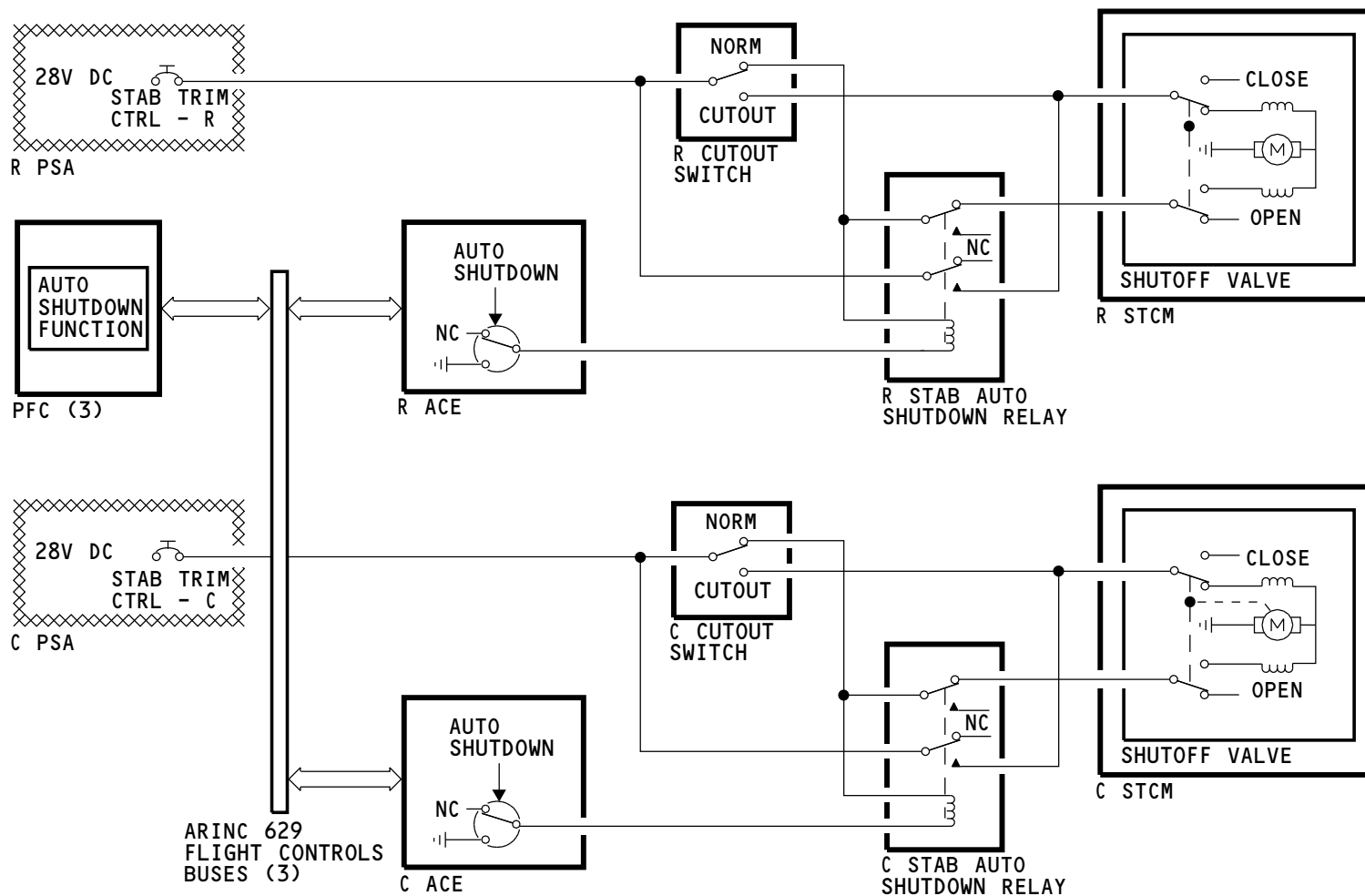
If the stabilizer motion fault continues when the PFC disconnect switch moves back to the NORM position, the PFCs immediately command the ACEs to energize and latch the auto shutdown relays.

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - HYDRAULIC CUTOUT AND AUTO SHUTDOWN

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**HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE****General**

In normal mode operation of the PFCS, the PFCs calculate stabilizer pitch commands based on:

- Trim switches signals
- Column cutout function
- Elevator control schedule
- On ground stabilizer control
- Elevator offload function
- Control path logic
- Rate control
- Stabilizer position limit
- Failure monitor.

The PFCS determines the priority of the stabilizer control. The alternate pitch trim levers always have the highest priority.

In the air, the pitch trim switches, the control columns, and the autopilot send inputs to the PFCs for use in the elevator control schedule. The elevator control schedule sends commands for the elevator control and for the elevator offload function. The elevator offload function controls the operation of the horizontal stabilizer.

On the ground, elevator offload does not operate. The pitch trim switches directly control the stabilizer and the control columns directly control the elevators.

Trim Switches Signals

The trim switches signals function analyzes the input from:

- The alternate pitch trim lever switches
- The pitch trim switches.

Alternate Pitch Trim Lever Switches

The alternate pitch trim levers have priority over any other input command. They mechanically command both STCMs and cause the two hydraulic motors to move the stabilizer at the rate of speed available at the time.

The alternate pitch trim lever switches send discrete signals through the AIMS to the PFCs. These signals cause the PFCs to stop electrical control of the stabilizer, prevent failure indication, and prevent auto shutdown. They also change the trim reference speed in the elevator control schedule.

If the autopilot is engaged when a pilot moves the alternate pitch trim levers, the lever command causes the movement of the stabilizer but the autopilot stays engaged.

Pitch Trim Switches

The pitch trim switch signals operate in pairs. The signals from both the control and arm switches are necessary from the captain or the first officer for the PFC logic to calculate a command signal.

On the ground, the pitch trim switches control the stabilizer. The stabilizer moves at high speed with two hydraulic motors.

In the air, the pitch trim switches send an input signal to the elevator control schedule to change the trim reference speed.

If the autopilot is engaged when a pilot moves the pitch trim switches, the PFCs ignore the pitch trim switch signals and the autopilot stays engaged.

If the captain and first officer pitch trim switches send opposite signals, the PFCs do not use the signals and ignore the input.

If the signal from an arm or control pitch trim switch is not valid due to an ACE or an ARINC 629 bus failure, the PFCs uses a single pitch trim switch to calculate a command signal.

When there is no input from the alternate pitch trim lever switches, the pitch trim switch signals go to the column cutout function.

HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

Column Cutout

The column cutout function uses the signals from the column position transducers. It stops the pitch trim switch commands when the pilot moves the column in the opposite direction of the pitch trim switch command.

Elevator Control Schedule

In the air, commands from the pitch trim switches, the control columns, and the autopilot cause the elevator control schedule to calculate an elevator output command. The pitch trim switches change the trim reference speed in the elevator control schedule. The PFCs then command the ACEs to move the elevator. The elevator command also goes to the elevator offload function. The alternate pitch trim lever switches also change the trim reference speed in the elevator control schedule.

On Ground Stabilizer Control

On the ground, the pitch trim switch signals go directly to the control path logic function. The PFCs then calculate commands to operate the stabilizer with two hydraulic motors at the high rate of speed.

Elevator Offload

The elevator offload function operates in the air. It increases the aerodynamic efficiency of the airplane and keeps the elevator available for full deflection.

The PFC uses amount, direction, and duration of the elevator command to calculate the amount and direction of the elevator offload command to the stabilizer.

There are two elevator actuation levels in the elevator offload function: the lower and the upper level. Small elevator commands may be more than the lower level and larger elevator commands may be more than the upper level. The PFCs calculate these levels as a function of airspeed and roll attitude of the airplane. The levels decrease with increased airspeed and increase with decreased airspeed.

When the elevator command is more than one of the elevator actuation levels and it exists past a time delay, the PFCs then command the stabilizer to move. This transfers the elevator deflection to the stabilizer and the elevator moves back to neutral.

The PFCs calculate the time delay based on the amount of the elevator command. Greater command causes less time delay, and lesser command causes more time delay. The time delay prevents elevator offload during brief elevator commands.

Control Path Logic

The stabilizer control has two paths. Each path has separate electrical control to one STCM. The logic function determines which of the paths operate and whether it is single or dual.

In single path operation, the PFCs command the ACEs to operate one STCM. The STCM then supplies hydraulic power to one motor and brake. The PFCs alternate which path operates.

In dual path operation, the PFCs command the ACEs to operate both STCMs. They supply hydraulic power to the two motors and two brakes.

The PFCs use the elevator actuation levels to determine single or dual path of stabilizer operation. An elevator command that is more than the lower level causes the PFCs to command the single path operation. When the elevator command is more than the upper level, the PFCs command the dual path operation.

Rate Control

The PFC uses air/ground and airspeed data to determine the stabilizer rate of speed. The rate control function controls the rate control solenoid on both STCMs. It energizes the solenoids to operate at low speed rate and de-energizes the solenoid to operate at high speed rate.

When the airplane is on the ground, the PFC commands the stabilizer at high speed.

In flight, during airplane acceleration, the stabilizer moves at high speed when the airspeed is less than 230 knots. More than 230 knots, the stabilizer moves at low speed.

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

In flight, during airplane deceleration, the stabilizer moves at low speed when the airspeed is more than 220 knots. Less than 220 knots, the stabilizer moves at high speed.

Speed of Stabilizer Movement

The paths and the speed controls combine to result in four speeds of stabilizer movement.

When the PFCs command the dual path operation at high speed, the stabilizer moves at 0.5 degree per second. When the PFCs command the single path operation at high speed, the stabilizer moves at 0.25 degree per second.

When the PFCs command a dual path operation at low speed, the stabilizer moves at 0.2 degree per second. When the PFCs command a single path operation at low speed, the stabilizer moves at 0.1 degree per second.

Stabilizer Position Limits

The PFCs limit the movement of the stabilizer as a function of the flap position.

When the flaps are retracted, the PFCs stop the movement of the stabilizer at:

- +2.25 degrees of airplane nose down trim
- -10.25 degrees of airplane nose up trim.

When the flaps are extended, the PFCs stop the stabilizer movement at -10.25 degrees of airplane nose up trim. The PFCs do not limit the nose down trim. The SPM limit switches stop stabilizer movement at +3.75 degrees of nose down trim.

Failure Monitor

The PFCs monitor the operation of the center and right STCMs individually for correct operation.

When it finds a system malfunction, the PFC failure monitor commands the ACE to energize and latch the auto shutdown relay. With the stabilizer cutout switch in the NORM position, the auto shutdown relay supplies power to close the motor operated shutoff valve of the defective STCM.

To command an auto shutdown, the failure monitor needs to detect one of three malfunctions:

- Uncommanded stabilizer motion
- No stabilizer motion
- STCM defective response.

There is an unscheduled stabilizer motion when the stabilizer moves without a valid command. The PFC failure monitor shuts down the STCM that moved the stabilizer when this malfunction occurs.

When there is no stabilizer movement after a valid PFC command, the failure monitor shuts down the defective STCM. In single path operation, the failure monitor shuts down the defective STCM and transfers the operation to the other STCM. In dual path operation, the failure monitor shuts them both down.

There is an STCM defective response when the PFCs find an incorrect command response. If the stabilizer moves at half speed in dual path operation, the PFCs shut down the defective STCM. If the failure monitor detects open or short circuits in the STCM solenoids, or a faulty ACE command to the rate solenoid, the monitor shuts down the defective STCM.

Indications

The warning message STABILIZER shows when there is an unscheduled stabilizer motion and the auto shutdown has failed. The warning message also shows when all of these conditions occur for four seconds:

- Both the right and center stabilizer channels have failures, or the STABILIZER C and the STABILIZER R advisory messages show while the STABILIZER CUTOUT advisory message does not show
- Both elevator surfaces have a minimum of one PCU in operation, or the right and center hydraulic systems have failures.

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**HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE**

The caution message FLIGHT CONTROLS shows for one of these conditions:

- Both stabilizer paths are not operative
- Two elevator PCUs and one stabilizer path are not operative
- Two elevator PCUs are defective on one elevator
- Captain and first officer wheel, column, or pedal position transducers are different by more than 15% with the airplane on the ground
- The elevator force fight equalization function senses a large force fight between the PCUs.

The advisory message STABILIZER C or STABILIZER R shows for one of these conditions:

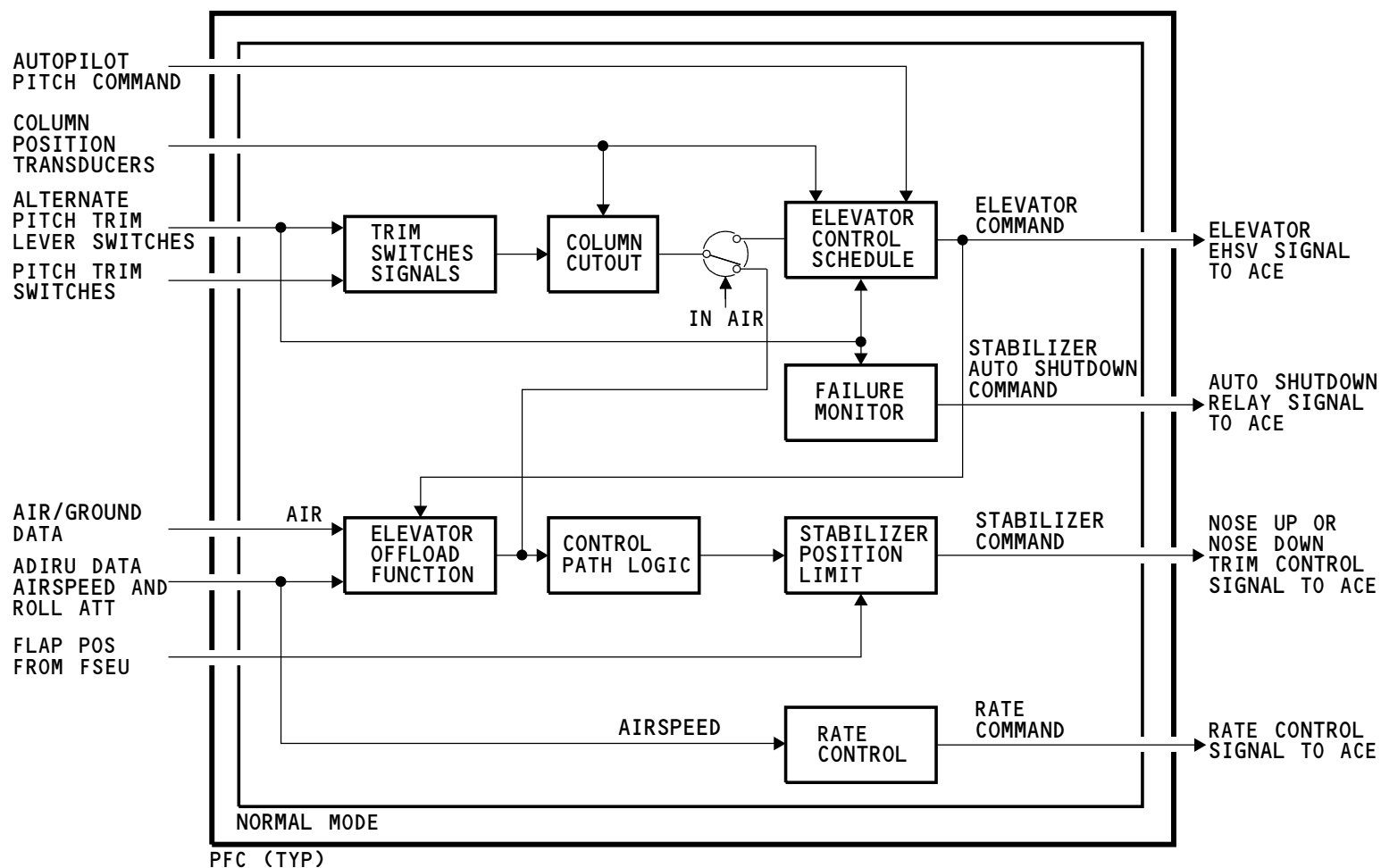
- There is an auto shutdown of the center or right stabilizer channel
- Center or right cutout switch is in the CUTOOUT position
- Captain or the first officer pitch trim switches signals are stopped by the column cutout function for more than 15 seconds.

The advisory message STABILIZER CUTOOUT shows when both the right and center stabilizer cutout switches are in the CUTOOUT position.

The status message FLIGHT CONTROL SYS shows when one or more stabilizer control channel is defective. The message also shows when there is a double fault in one of these:

- Stabilizer position modules
- Rate solenoids on the STCMs
- Pitch trim switches
- Alternate pitch trim lever switches.

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

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**HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE****General**

In secondary mode operation of the PFCS, the PFCs calculate stabilizer pitch commands based on:

- Column cutout function
- Secondary stabilizer control
- Stabilizer position limit
- Failure monitor.

Operational Priority

The alternate pitch trim levers always have the highest priority of stabilizer control. The pitch trim switches have secondary priority.

Alternate Pitch Trim Levers

Except for rate control, the alternate pitch trim lever operation in secondary mode is the same as in normal mode. They supply first priority of stabilizer control.

Because there is no rate control in secondary mode, the hydraulic motors operate at high rate of speed.

Pitch Trim Switches

The only available electrical control in secondary mode is from the captain's and the first officer's pitch trim switches.

Anytime the pilot moves the pitch trim switches, the PFC directly commands one STCM at high rate of speed. The stabilizer then moves with one hydraulic motor at a speed of 0.25 degree per second.

If the captain's and first officer's pitch trim switches send opposite command signals, the PFCs stops the command process.

Column Cutout

The column cutout function stops the pitch trim switch commands when the pilot moves the column in the opposite direction of the switch commands.

Stabilizer Position Limits

PFCs supply the same stabilizer position limits as in the normal mode.

Failure Monitor

With the stabilizer cutout switches in the NORM position, the PFC monitors the commanded STCM for correct stabilizer operation.

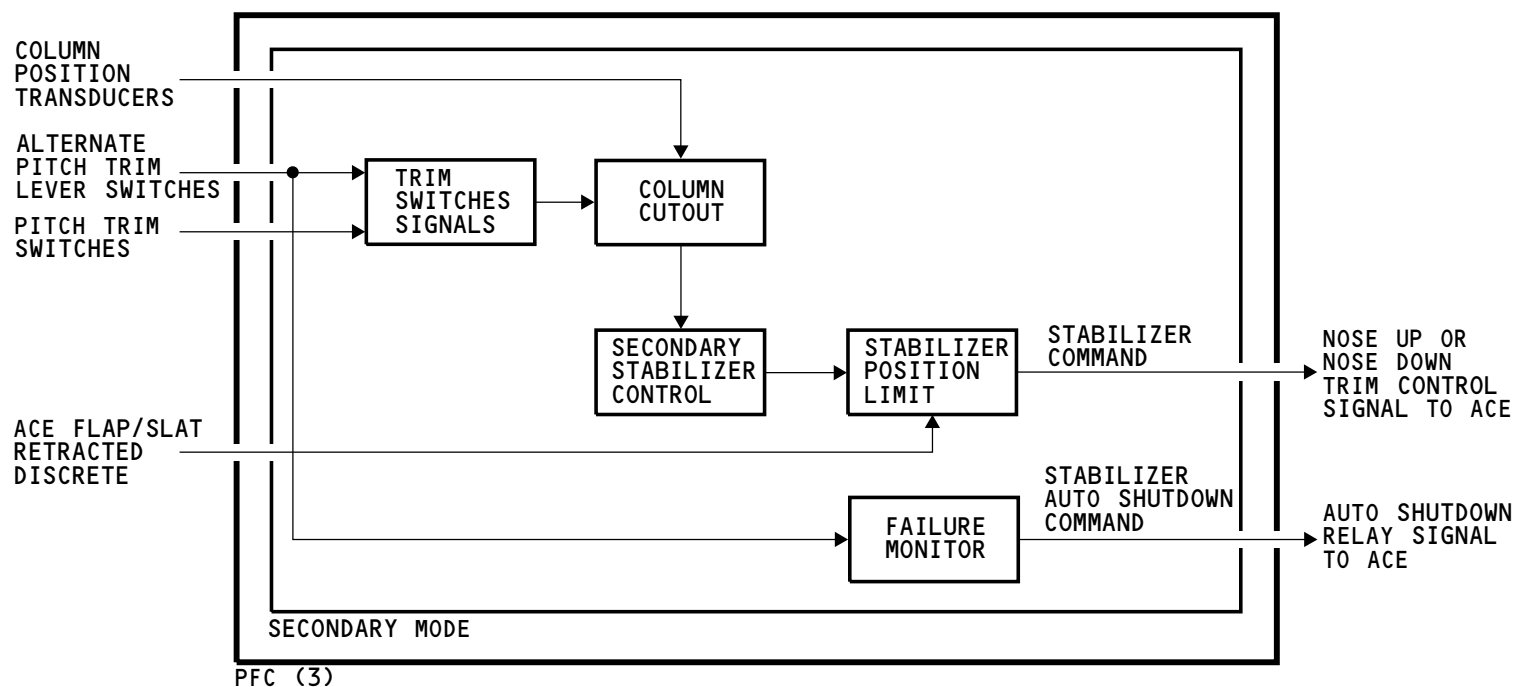
The failure monitor finds the same malfunctions as in the normal mode. When it detects a malfunction, the failure monitor commands the ACE to energize the auto shutdown relay of the commanded STCM.

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE

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**HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE****General**

In direct mode operation of the PFCS, the ACEs directly control the stabilizer pitch commands.

The ACE does not monitor the stabilizer operation for failure. If the PFCS is in direct mode and there is a stabilizer failure, the pilots must manually shut down the STCM with the cutout switches.

Operational Priority

The alternate pitch trim levers always have the highest priority of stabilizer control. The pitch trim switches have secondary priority.

Alternate Pitch Trim Levers

The first priority of stabilizer control in the direct mode is the alternate pitch trim levers. Their operation in direct mode is the same as in secondary mode.

Because there is no rate control in direct mode, the hydraulic motors operate at high rate of speed.

Pitch Trim Switches

The second priority of stabilizer control in the direct mode is the captain's and the first officer's pitch trim switches. They supply the only available electrical control of the STCMs in direct mode.

Anytime the pilot moves the pitch trim switches, the ACE directly commands one STCM at high rate of speed. The stabilizer then moves with one hydraulic motor at a speed of 0.25 degree per second.

Stabilizer Position Limits

The limit switches in the stabilizer position modules limit stabilizer travel in the direct mode. These limits are:

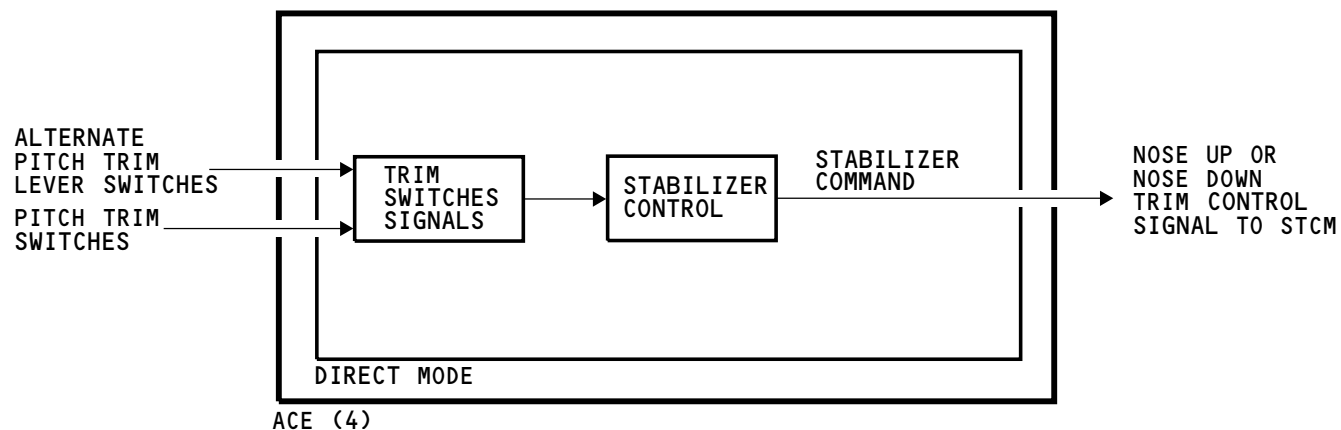
- +3.75 degrees of airplane nose down trim
- -10.75 degrees of airplane nose up trim.

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - STABILIZER ELECTRICAL CONTROL**General**

The ACEs send the electrical commands to control the stabilizer. In normal and secondary modes, the PFC calculate the commands and send them to the ACEs. In the direct mode, the ACEs use the commands from the pitch trim switches.

The STCM must have both an arm and a control signal from its two ACEs to operate the stabilizer ball screw assembly.

Normal Mode

In normal mode, the pitch trim switch signals operate in pairs. The signals from both the control and arm pitch trim switches are necessary from the captain (left) or the first officer (right) for the PFC logic to calculate a command for the ACEs.

In the air, a command from the pitch trim switches causes a command to the elevator. Only the elevator offload function of the PFCs can control the stabilizer while the airplane is in the air. The command can be for single or dual path, low or high rate.

On the ground, an input from the pitch trim switches causes a PFC stabilizer command to the ACEs. This command is for dual path at high rate.

When the flaps are retracted, the PFC logic stops the movement of the stabilizer at:

- +2.25 degrees of airplane nose down trim
- -10.25 degrees of airplane nose up trim.

When the flaps are extended, the SPM limit switches stop the stabilizer at +3.75 degrees of nose down trim. The PFC logic still stops the movement of the stabilizer at -10.25 degrees of airplane nose up trim.

If there is an ACE or an ARINC 629 flight control bus failure, the PFC permits a single pitch trim switch, arm or control, to command pitch trim as long as the signal path from the switch to the PFC is valid.

Secondary Mode

In secondary mode, the pitch trim switch signals also operate in pairs. Both arm and control signals are necessary for the PFC logic to calculate a command.

An input by the pitch trim switches always causes a stabilizer command for single path at high rate. The PFCs alternate which stabilizer path operates.

The stabilizer limits are the same as in the normal mode.

Direct Mode

In direct mode, the pitch trim switch signals operate individually through the ACE to which they connect. Pitch trim switch arm and control signals are necessary to the two ACEs that connect to the STCM. The captain's input causes a command to the C STCM while the first officer's input causes a command to the R STCM. The command is always at high rate.

The limit switches in the SPM that connect the ACE and the STCM stop the movement of the stabilizer at:

- +3.75 degrees of airplane nose down trim
- -10.75 degrees of airplane nose up trim.

If both pilots make a pitch trim switch command at the same time and in the same direction, the ACEs send commands in dual path. The two STCMs operate both motors and brakes. The stabilizer then moves at full speed.

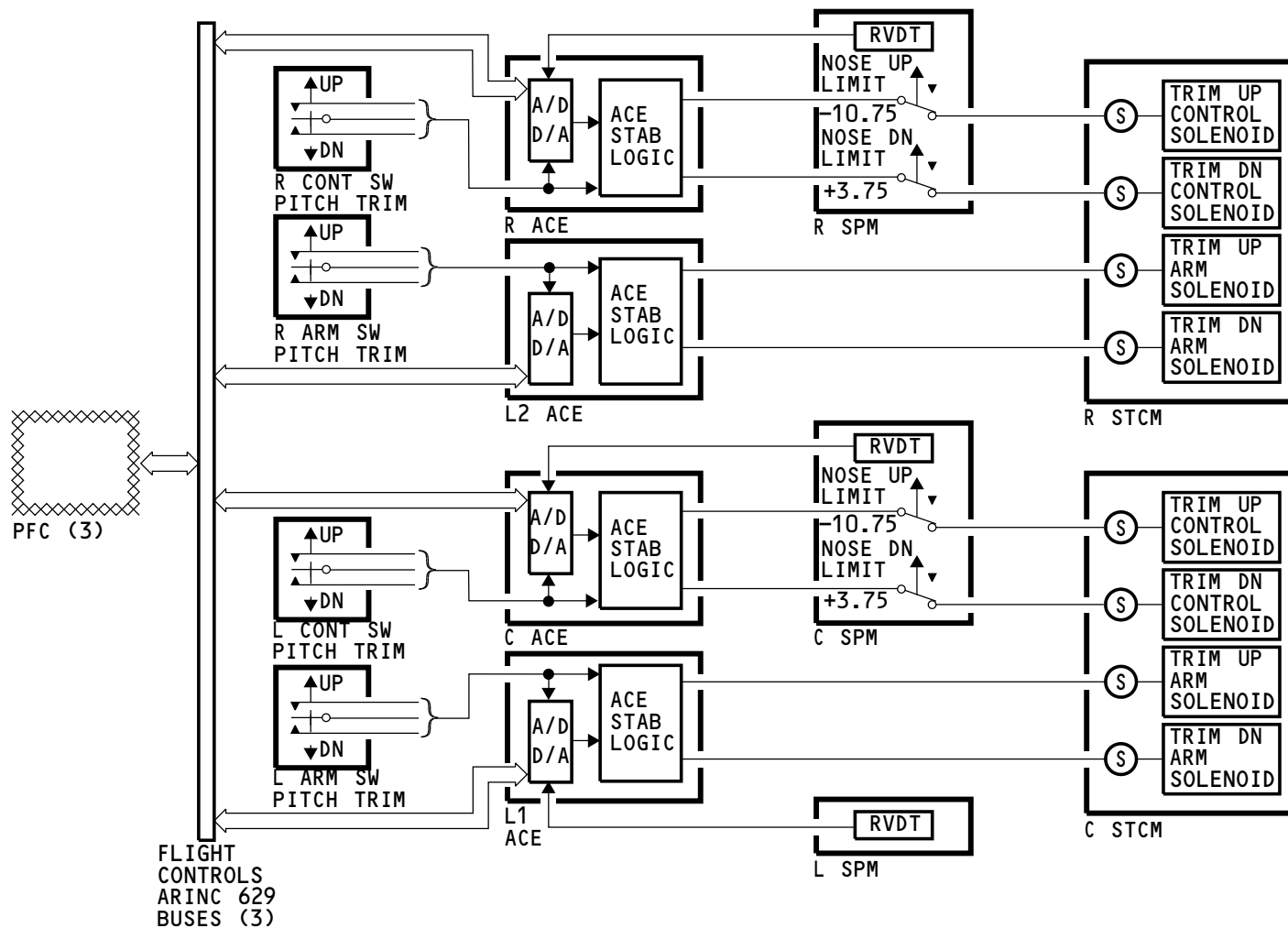
If both pilots make a pitch trim switch command at the same time but in opposite direction, the ACEs send commands in dual path in opposite rotation. The two STCMs operate both motors and brakes. The stabilizer then does not move, or may move slowly if one motor turns faster than the other.

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HORIZONTAL STABILIZER CONTROL - FUNCTIONAL DESCRIPTION - STABILIZER ELECTRICAL CONTROL

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HORIZONTAL STABILIZER CONTROL - TRIM LIMITS

General

Structural stops and the travel limiter limit stabilizer movement mechanically. Electrical limit switches and the stabilizer position limit function in the PFCs limit stabilizer movement electrically.

Structural Stops

On the upper and lower portions of the stabilizer ball screw are structural stops that limit stabilizer travel to +4 degrees airplane nose down trim and -11 degrees airplane nose up trim.

Travel Limiter

Within the aft stabilizer quadrant assembly of the alternate stabilizer trim mechanism there are hammer and stops that keep stabilizer travel to a limit.

The mechanism forces the control lever of the alternate pitch trim levers back to the null position when the stabilizer reaches its travel limits.

The travel limits for operation with the alternate pitch trim levers are: +3.88 degrees airplane nose down trim and -10.88 degrees airplane nose up trim.

Limit Switches

In each of the three stabilizer position modules are two limit switches. One switch opens to stop stabilizer movement in the airplane nose up trim direction and the other stops stabilizer movement in the airplane nose down trim direction.

In the normal mode of operation, the limit switches restrict nose down trim if the flaps are not retracted. The PFCs control airplane nose down trim when the flaps are retracted.

The limit switch trim limits are +3.75 degrees nose down and -10.75 degrees nose up.

PFC Limits

In the normal and secondary mode the PFCs supply limits to stabilizer movement.

With flaps retracted the PFCs limit stabilizer travel to +2.25 degrees airplane nose down to -10.25 degrees airplane nose up.

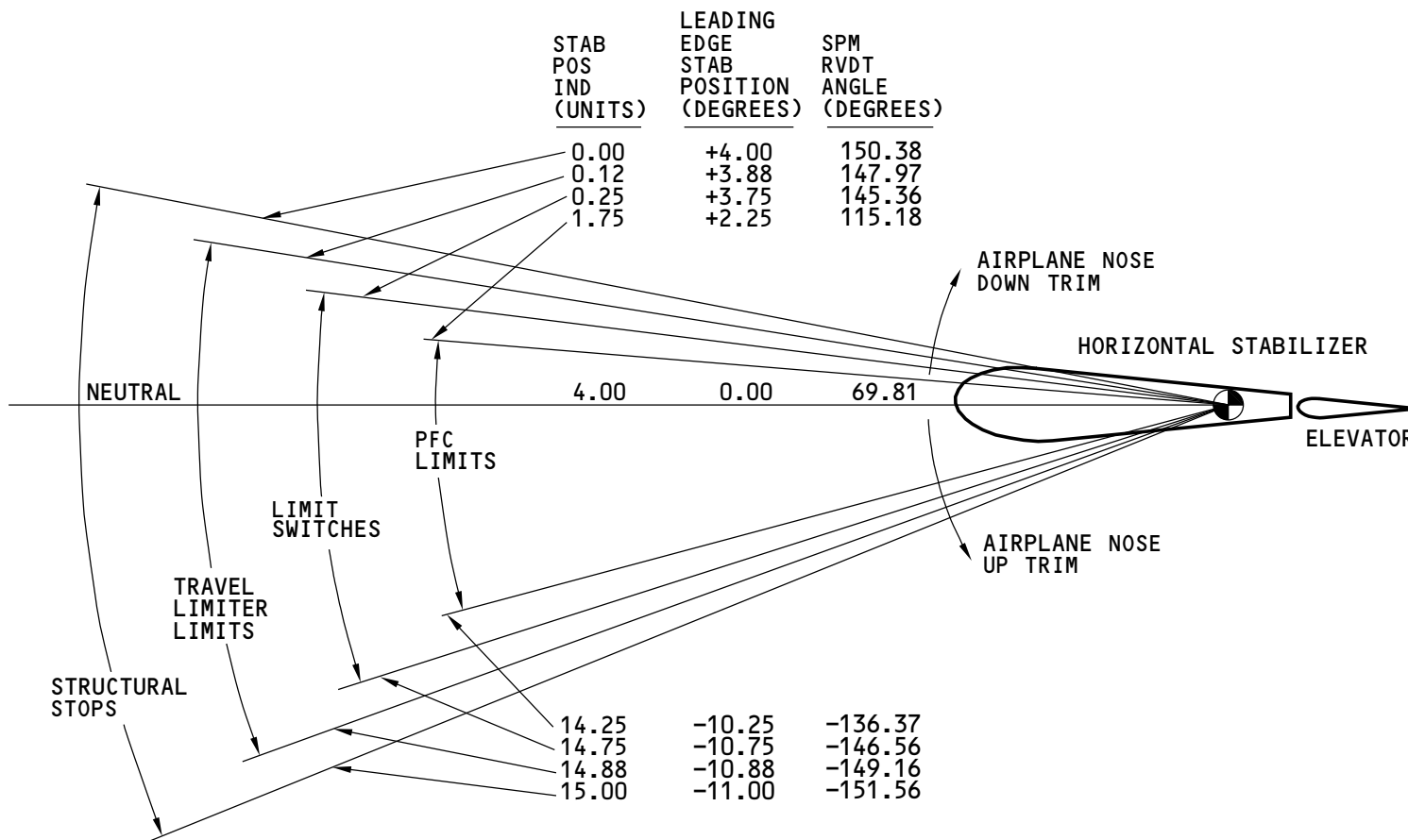
If the flaps are not retracted, the nose up PFC limitation remains at -10.25 degrees. The limit switches control the nose down limit at +3.75 degrees.

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NOTE: THE SPM RVDt ANGLES IN DEGREES ARE NOMINAL VALUES. THEY ARE SHOWN FOR REFERENCE ONLY.

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HORIZONTAL STABILIZER CONTROL - TRIM LIMITS

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**HORIZONTAL STABILIZER POSITION INDICATION - GENERAL DESCRIPTION****Purpose**

The stabilizer position indication system measures the position of the stabilizer and sends this information to the ACEs. The ACEs send the information to the PFCs for stabilizer position calculation and control. The PFCs send the stabilizer position signals to the AIMS which controls the position indicators.

Stabilizer Position Indication

The three stabilizer position modules send signals to three ACEs. The ACEs change the signals from analog to digital and send them to the PFCs.

The PFCs use the position module signals to control the stabilizer position. The PFCs then send the stabilizer position signals to the AIMS. The AIMS sends them through the ARINC 429 bus to the stabilizer position indicators.

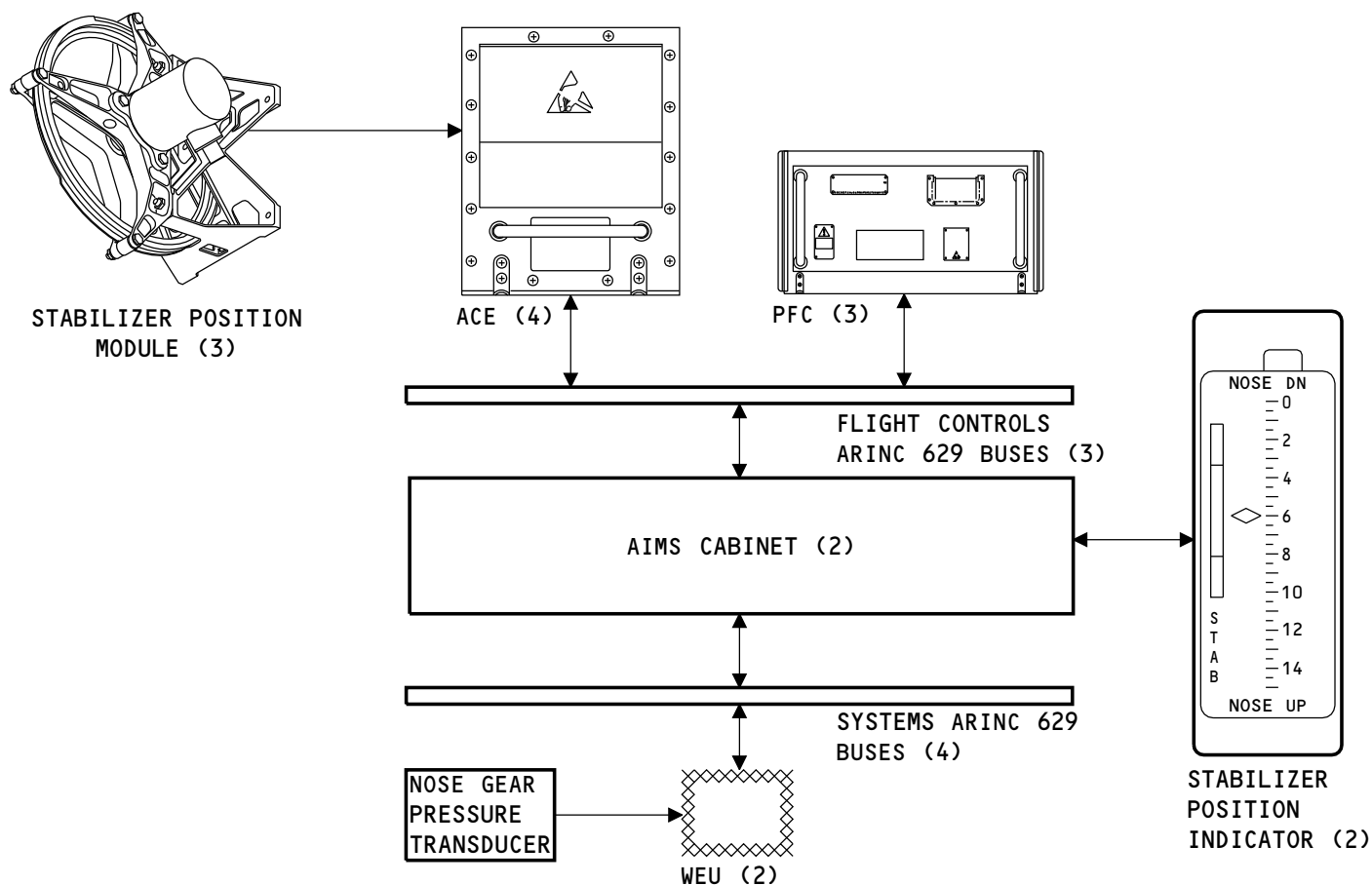
The AIMS also sets the green band display on each position indicator. The WEUs calculate which of the three green band segments to show on the position indicators. The WEUs use airplane weight, center of gravity position and engine thrust rating to calculate the green band display. The WEUs use an output from the nose gear pressure transducer to verify the green band calculation. The calculated signals then go from the WEUs to the AIMS which selects and shows the green band on the stabilizer position indicators.

The stabilizer position indicating system operates in normal, secondary, and direct modes.

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HORIZONTAL STABILIZER POSITION INDICATION - GENERAL DESCRIPTION

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**HORIZONTAL STABILIZER POSITION INDICATION - STABILIZER POSITION MODULE AND INDICATOR****Purpose**

The stabilizer position modules send stabilizer position signals to the ACEs. From the ACEs, the digital signals then go to the PFCs. The PFCs use this data for two functions, stabilizer position indication and stabilizer control. The PFCs then send the stabilizer position indication to the AIMS.

The two identical stabilizer position indicators show the position of the stabilizer.

Functional Description

A cable transfers stabilizer movement to the cable drum on the three identical position module assemblies. Rotation of the cable drum causes rotation of an RVDT within the stabilizer position modules. The RVDTs send signals to the ACEs and the AIMS for stabilizer position.

Location

The stabilizer position modules are in the stabilizer compartment. They are near the ceiling on the aft side of a bulkhead above the stabilizer ballscrew assembly.

The stabilizer position indicators are on the aft end of the P10 control stand.

Physical Description

The stabilizer position module attaches to the position module assembly with three bolts. The module spline has a missing tooth and an alignment mark so removal and installation can be done without rigging.

Each stabilizer position module has an RVDT and two limit switches. The limit switches keep stabilizer movement to a limit.

See the horizontal stabilizer control section for more information about the position modules (SECTION 27-41).

The position indicators have a pointer that shows the stabilizer position. The indicator scale has 15 units. Each unit of pointer movement is equivalent to approximately one degree of stabilizer movement.

Also on the indicator is a green band that shows the safe takeoff range. These are the three green band displays that AIMS can select:

- Upper and middle segments
- Lower and middle segments
- Middle segment only.

Failure Indication

Loss of signal or invalid signals causes the pointer and green band to go out of view.

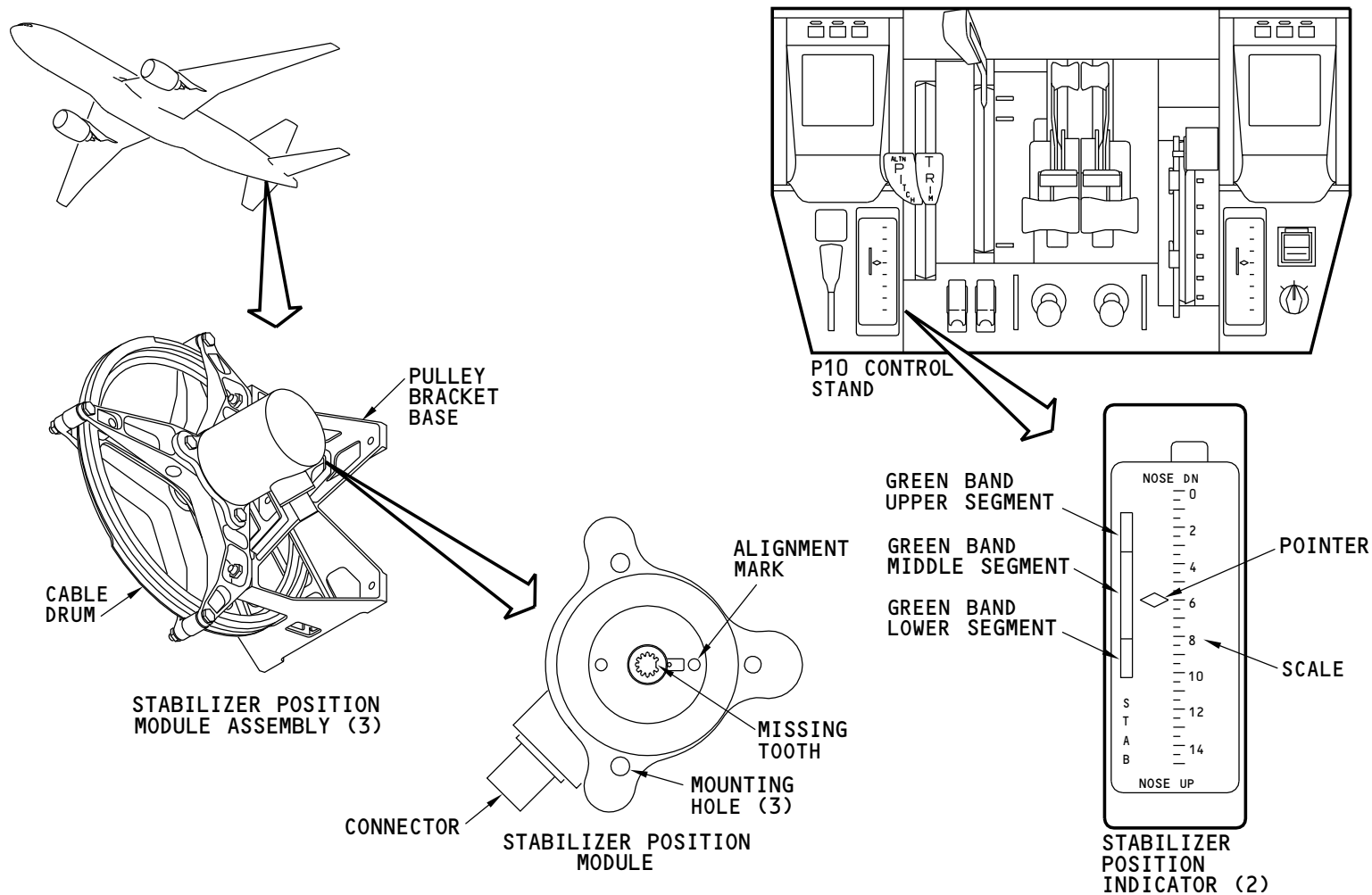
Loss of power causes all of the display to go out of view.

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HORIZONTAL STABILIZER POSITION INDICATION - STABILIZER POSITION MODULE AND INDICATOR

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**HORIZONTAL STABILIZER POSITION INDICATION - NOSE GEAR PRESSURE TRANSDUCER****Purpose**

The WEUs use a variable output from the nose gear pressure transducer to make sure the stabilizer indicator green band calculation is correct.

Physical Description

The transducer sends a variable signal to the WEUs for processing.

Location

The nose gear pressure transducer is on the top of the nose gear strut but it measures the strut oil pressure which is ported from the middle of the strut.

Functional Description

The pressure transducer receives oil pressure from the nose landing gear strut and sends a variable signal to the WEUs. If the center of gravity of the airplane is forward, the pressure in the nose landing gear strut increases which the transducer measures and sends to the WEU for processing.

If the center of gravity of the airplane is aft, the pressure in the nose landing gear strut decreases and the transducer sends this reading to the WEU for processing.

The WEUs calculate the green band display for the stabilizer trim indicators to show the safe range of stabilizer trim for take-off. The WEUs use the signal from the pressure transducer to verify the green band calculation.

Indications

Disagreement between the green band calculation and the pressure transducer reading causes the STAB GREENBAND advisory message to show.

Training Information Point

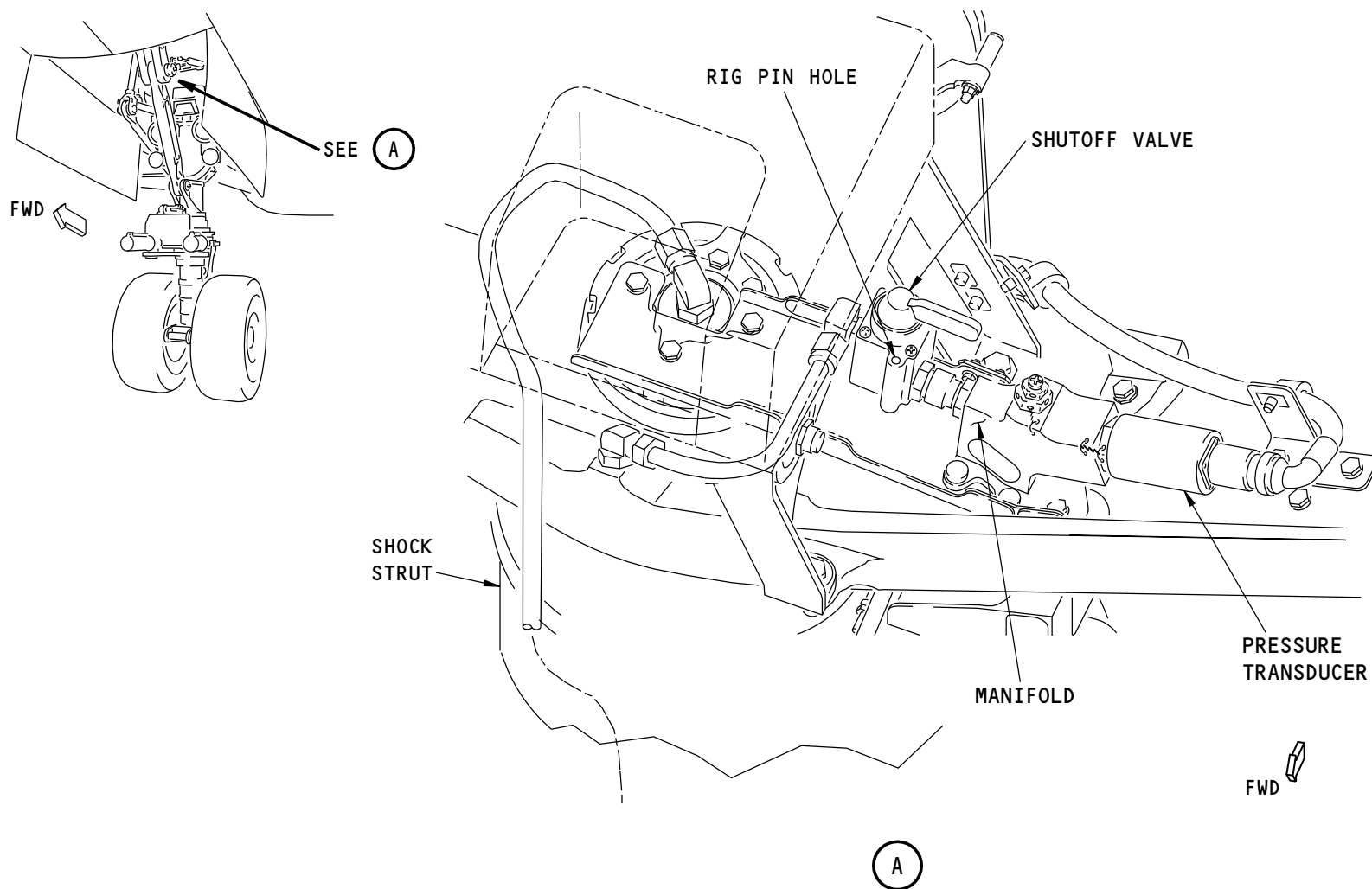
To remove the pressure transducer, move the shutoff valve to the closed position and lock it with a rig pin. This isolates the transducer from the strut oil pressure.

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HORIZONTAL STABILIZER POSITION INDICATION - NOSE GEAR PRESSURE TRANSDUCER

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HORIZONTAL STABILIZER POSITION INDICATION - FUNCTIONAL DESCRIPTION

General

The stabilizer position module RVDTs send analog signals to the ACEs. The ACEs change the signals to digital format and send them to the three PFCs. The PFCs calculate the stabilizer position signals and send them to the two AIMS which command the stabilizer position indicators to show the stabilizer position.

The flight management computing function (FMCF) of AIMS sends airplane data to the WEUs for green band computation. The WEUs also use the nose gear pressure transducer signal to verify the green band calculation. The WEUs then send the green band signals to AIMS which commands the indicators to show the safe takeoff range.

Functional Description

The three stabilizer position module RVDTs send individual analog signals to the L1, C and R ACEs. The ACEs change the signals to digital and put them on the flight controls ARINC 629 busses where they are sent to the three PFCs.

The PFCs calculate the stabilizer position from the ACE signals and send the data to AIMS. AIMS changes the data and sends them through ARINC 429 buses to the stabilizer position indicators. The indicators show the stabilizer position with a pointer that moves adjacent to the indicator scale.

The WEUs calculate the green band position based on FMCF data in AIMS. The pilot manually enters the airplane weight, the position of the center of gravity, and the engine thrust rating into the FMCF. The WEUs use these data to calculate the length of the greenband. The WEUs also use the nose gear pressure transducer signal to verify the green band calculation. The WEUs then send the green band data to the AIMS. The AIMS uses this data to show the green band on the stabilizer position indicators.

Indications

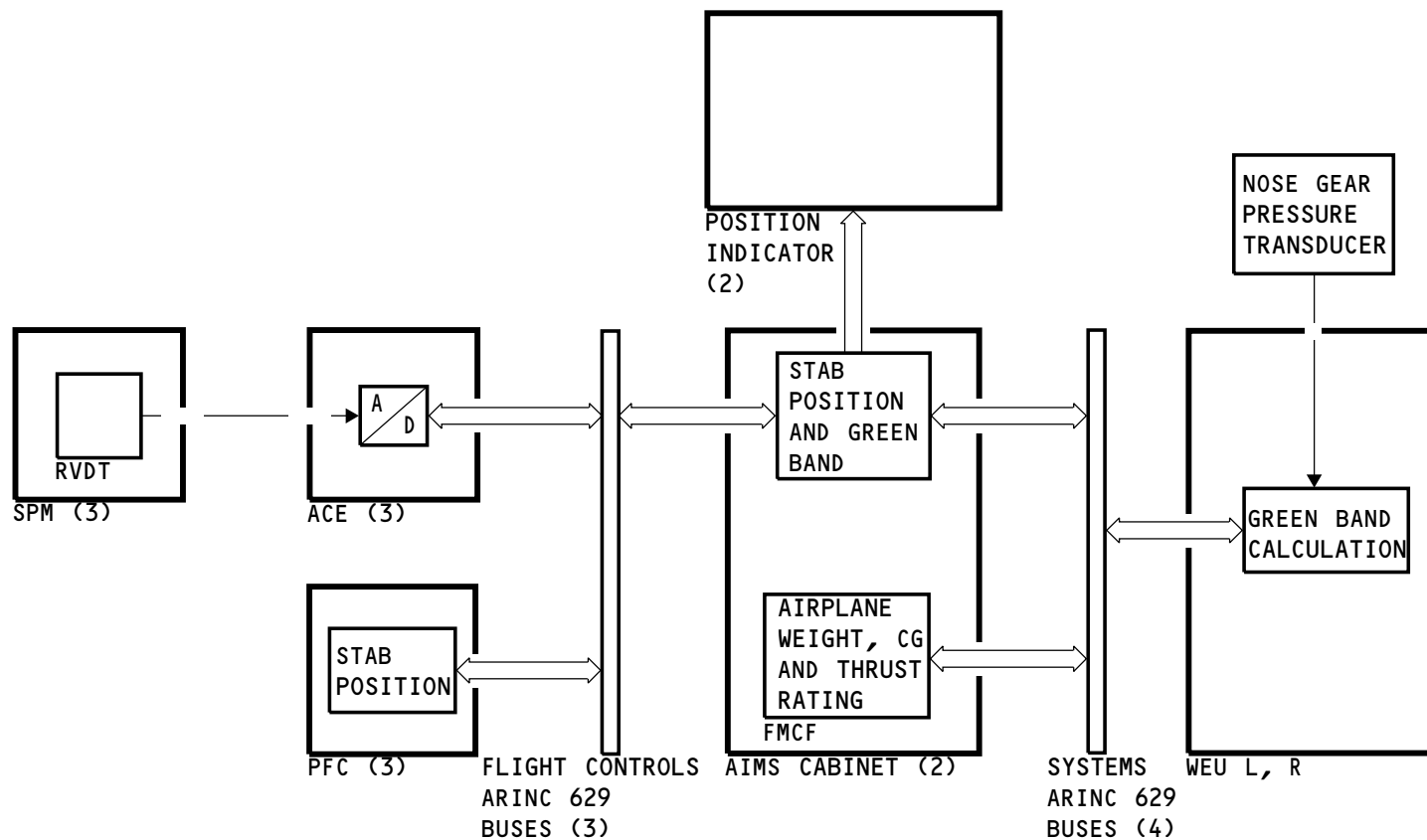
If there is a disagreement between the green band calculation and the weight on the nose gear, the STAB GREENBAND advisory message shows.

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HORIZONTAL STABILIZER POSITION INDICATION - FUNCTIONAL DESCRIPTION

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TRAILING EDGE FLAPS - INTRODUCTION

General

The trailing edge (TE) flaps improve the takeoff and landing performance of the airplane. When the flaps extend, they increase the lift of the wing. They also help to decrease the airspeed during landings and approaches.

The flaps are part of the high lift control system (HLCS). The HLCS electrically controls the flaps with a fly-by-wire system.

During takeoff and landing, the pilots use the flap lever to command the flaps to move to an extended position. During cruise, the pilots command the flaps to retract to the up position.

Each wing has an inboard flap and an outboard flap. The inboard flap is double-slotted and has a main flap and an aft flap. The outboard flap is single-slotted and is one piece.

Flap Operation

The flaps operate in sequence with the slats. At cruise speed and altitude, flap extension is inhibited.

The load relief function retracts the flaps to prevent structural damage to the flaps at high airspeeds.

The flaps are monitored for skew or asymmetry. When the system detects a skew or asymmetry, the flap drive shuts down.

Abbreviations and Acronyms

- AIMS - airplane information management system
- altn - alternate
- ARINC - Aeronautical Radio, Inc.
- EICAS - engine indication and crew alerting system
- EXT - extend
- FSEU - flap/slat electronics unit
- HLCS - high lift control system
- LVDT - linear variable differential transformer
- MAT - maintenance access terminal

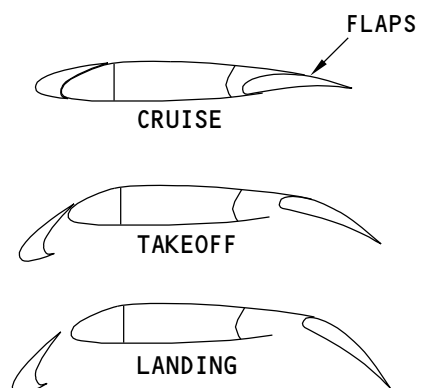
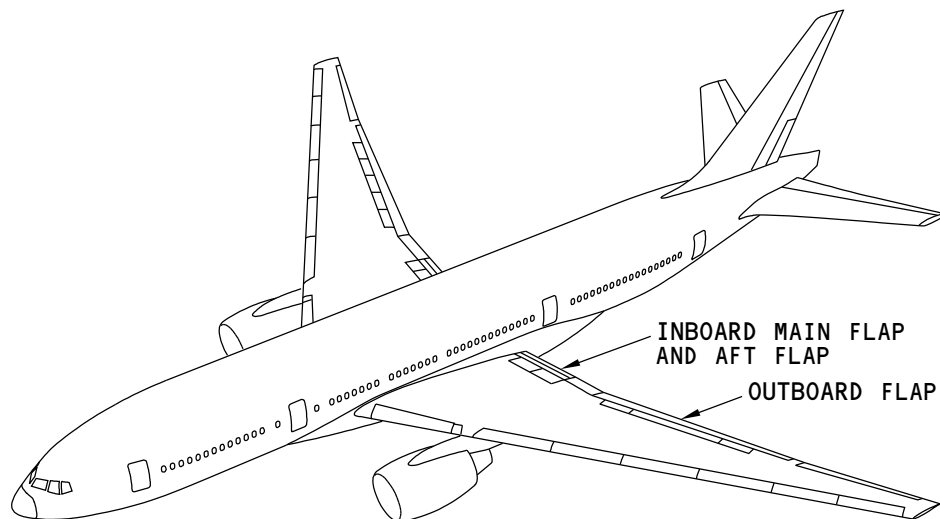
- PDU - power drive unit
- retr - retract
- RVDT - rotary variable differential transformer
- sec - secondary
- TE - trailing edge

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TRAILING EDGE FLAPS - INTRODUCTION

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TRAILING EDGE FLAPS - GENERAL DESCRIPTION

General

The flaps operate in one of three modes:

- Primary mode
- Secondary mode
- Alternate mode.

The primary mode uses hydraulic power to operate the flaps. The secondary and alternate modes use electrical power to operate the flaps.

Primary Mode

The primary mode has a closed-loop control system. The pilot commands the flaps with the flap lever. The flap lever position sensor sends input signals to the FSEUs. The FSEUs use the flap lever position to calculate the flap commands. The FSEUs also receive data from the systems ARINC 629 buses.

The FSEUs send the flap commands to the flap primary control valve. This valve supplies hydraulic power to the flap power drive unit (PDU). The hydraulic motor on the PDU then moves the flap mechanisms.

The flap/slat priority valve controls the amount of hydraulic flow to the flap primary control valve. The flap/slat priority valve gives priority of hydraulic power to the primary flight control system (PFCS) over the HLCS.

As the flaps move, the flap position sensors send feedback signals to the FSEUs. The FSEUs stop the flap commands when the feedback signals equal the commanded position.

The FSEUs use the flap skew sensors to shutdown the primary mode (and the secondary mode) if there is a flap skew or asymmetry.

Secondary Mode

The FSEUs use the secondary mode when the primary mode disengages. The secondary mode is only available in the air or during special maintenance functions.

The secondary mode also has a closed-loop control system. The pilot commands the flaps with the flap lever. The FSEUs use the flap lever position to calculate the flap commands. The FSEUs then energize the secondary/alternate control relays. One relay energizes the bypass solenoid in the flap primary control valve and the clutch in the electric motor unit. This stops hydraulic power to the hydraulic motor and lets free flow through it. The electric motor clutch connects the motor shaft to the PDU gearbox. The other relays control electrical power to the flap electric motor on the flap PDU. The electric motor then moves the flap mechanisms.

As the flaps move, the flap position sensors send feedback signals to the FSEUs. The FSEUs command the relays to stop the electric motor when the flaps are at the commanded position.

The FSEUs use the flap skew sensors to shutdown the secondary mode if there is a flap skew or asymmetry.

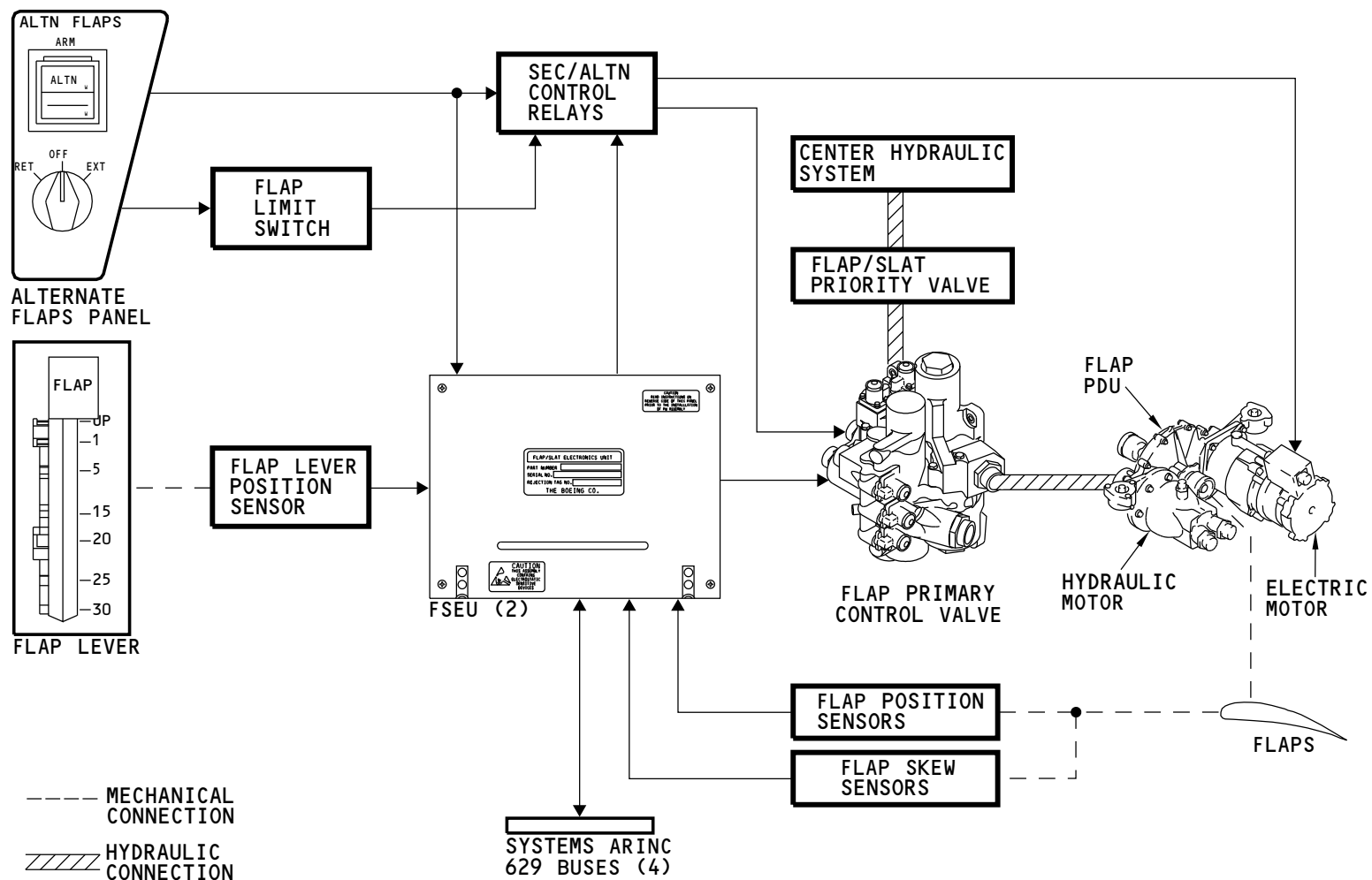
Alternate Mode

The alternate mode has an open-loop control system. The pilot uses the switches on the alternate flaps panel to command the flaps. An arm switch sends a discrete signal to the FSEUs to disengage the primary and secondary modes. This switch also energizes one of the secondary/alternate control relays. This relay energizes the bypass solenoid in the flap primary control valve and the clutch in the electric motor unit. This stops hydraulic power to the hydraulic motor and lets free flow through it. The electric motor clutch connects the motor shaft to the PDU gearbox.

The alternate flaps selector sends commands through the flap limit switch to energize the other secondary/alternate control relays. These relays control electrical power to the flap electric motor in the PDU. The electric motor then moves the flap mechanisms.

The flaps move until the pilot moves the alternate flaps selector to the OFF position or the flap limit switch stops the motor when the flaps are at the limit.

There is no automatic shutdown of the alternate mode if there is a flap skew or asymmetry.



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TRAILING EDGE FLAPS - GENERAL DESCRIPTION

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TRAILING EDGE FLAPS - GENERAL DESCRIPTION - FLAP DRIVE SYSTEM

General

These are the components of the flap drive system:

- Flap PDU
- Torque tubes
- Torque tube supports
- Position sensor gearboxes
- Angle gearboxes
- Transmission assemblies
- No-back brakes.

Flap PDU

The flap PDU receives hydraulic power through the primary control valve and electric power through the flap extend/retract relays. Hydraulic and electric motors on the PDU move the flap drive system.

Torque Tubes

The torque tubes transmit power from the PDU to the transmission assemblies.

Torque Tube Supports

The torque tube supports hold the torque tubes.

Position Sensor Gearboxes

The position sensor gearboxes contain the flap position sensors and limit switch. The sensors send flap position signals to the FSEUs. The limit switch removes electrical power from the electric motor when the flaps move to their limit during operation in the alternate mode.

Angle Gearboxes

The angle gearboxes connect torque tubes that are at different angles to each other.

Transmission Assemblies

The transmission assemblies receive power from the torque tube to move the flap surfaces. There are two transmissions for each flap surface.

No-back Brakes

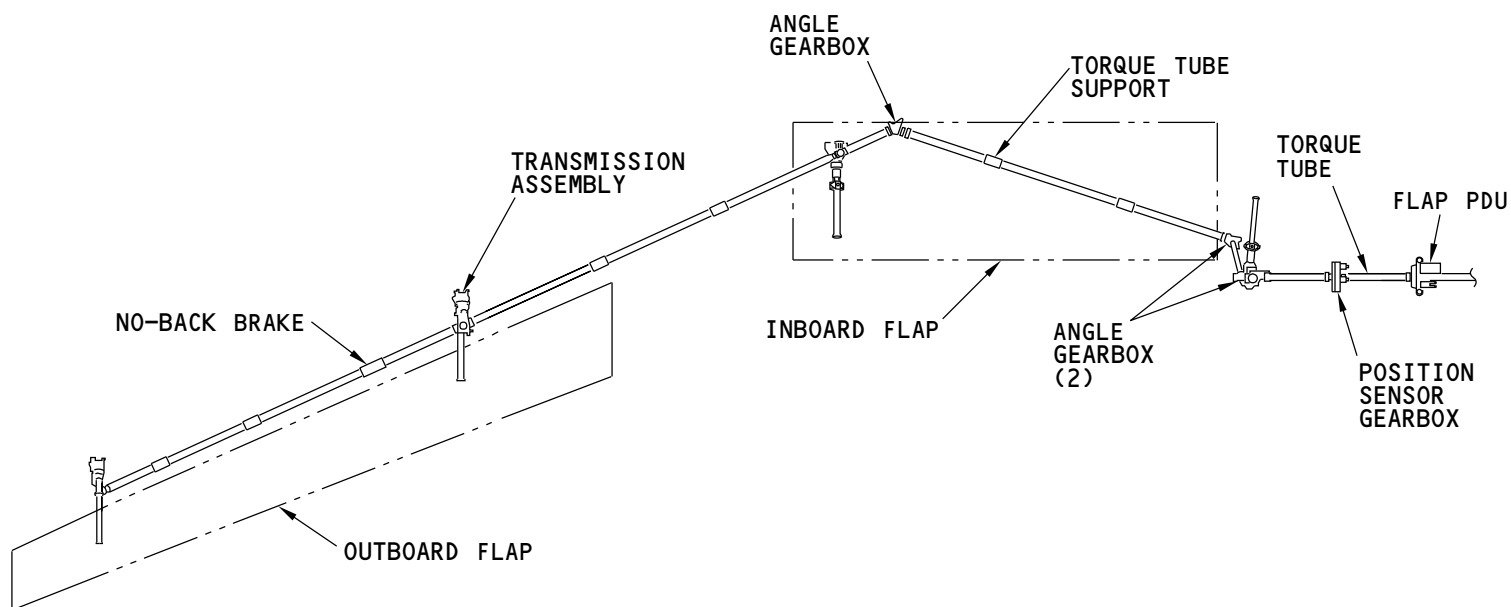
The no-back brakes prevent air loads from backdriving the flap mechanisms. There is one no-back brake on each wing. The no-back brakes attach to the torque tubes between the two transmission assemblies for the outboard flaps.

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NOTE: LEFT FLAPS ARE SHOWN
(RIGHT FLAPS ARE SIMILAR)

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TRAILING EDGE FLAPS - GENERAL DESCRIPTION - FLAP DRIVE SYSTEM

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TRAILING EDGE FLAPS - COMPONENT LOCATIONS - 1

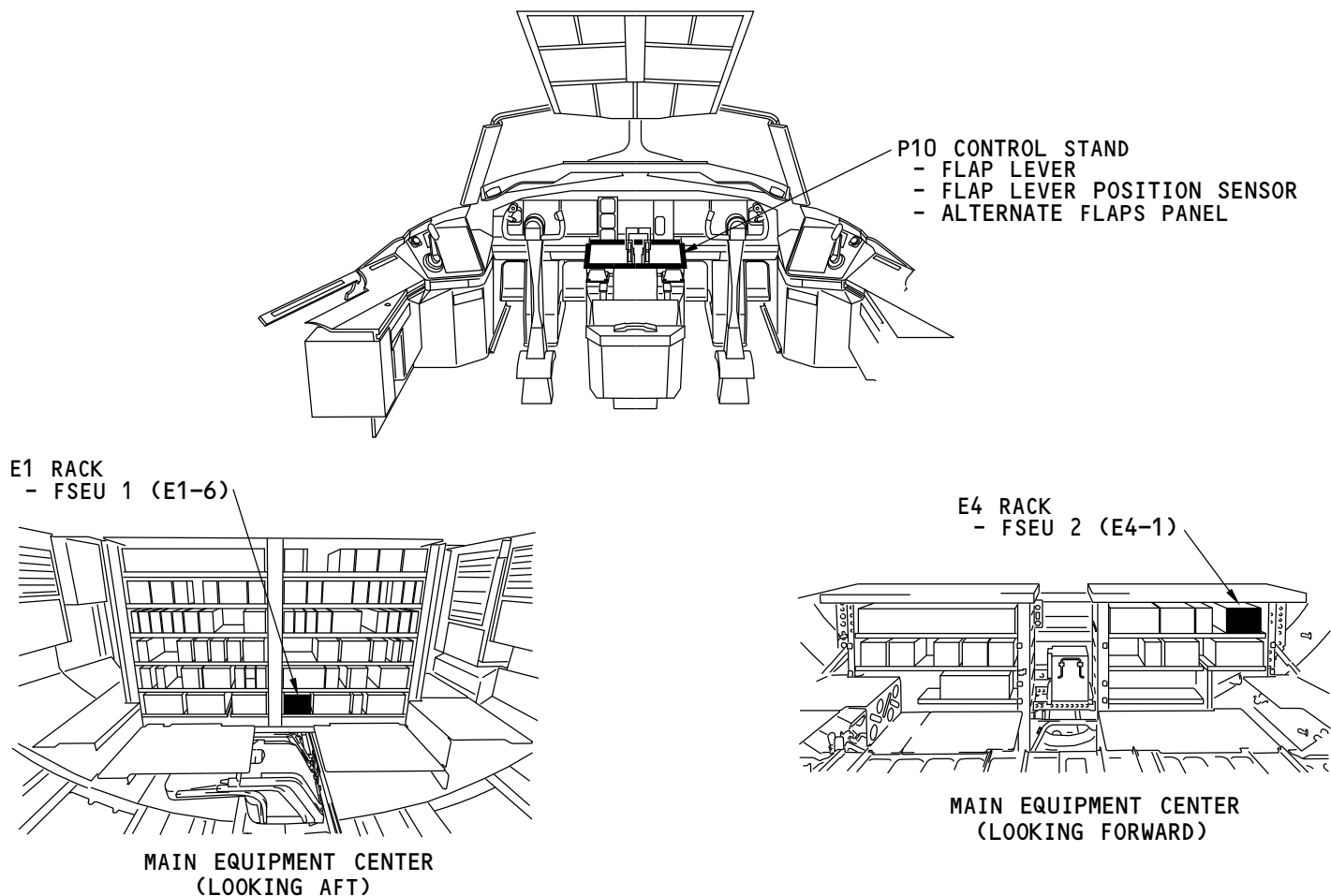
Flight Deck Controls

The flap lever and the alternate flaps panel are on the P10 control stand.
The flap lever position sensor is inside the control stand.

Main Equipment Center

The FSEU 1 is on the E1-6 shelf. The FSEU 2 is on the E4-1 shelf.

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TRAILING EDGE FLAPS - COMPONENT LOCATIONS - 1

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TRAILING EDGE FLAPS - COMPONENT LOCATIONS - 2

General

The flap components are in these areas:

- The main landing gear wheel wells
- The wings.

Main Landing Gear Wheel Well Components

The flap primary control valve and the flap/slat priority valve attach to the keel beam in the right wheel well.

The flap PDU attaches to the top of the keel beam. Access to the flap PDU is through the left or right wheel well.

The flap position sensor gearboxes attach to brackets on the floor beams. One of these gearboxes is in the right wheel well and the other is in the left wheel well.

The inboard flap inboard transmissions, side-of-body angle gearboxes, and some of the torque tubes are also in the wheel wells.

Wing Components

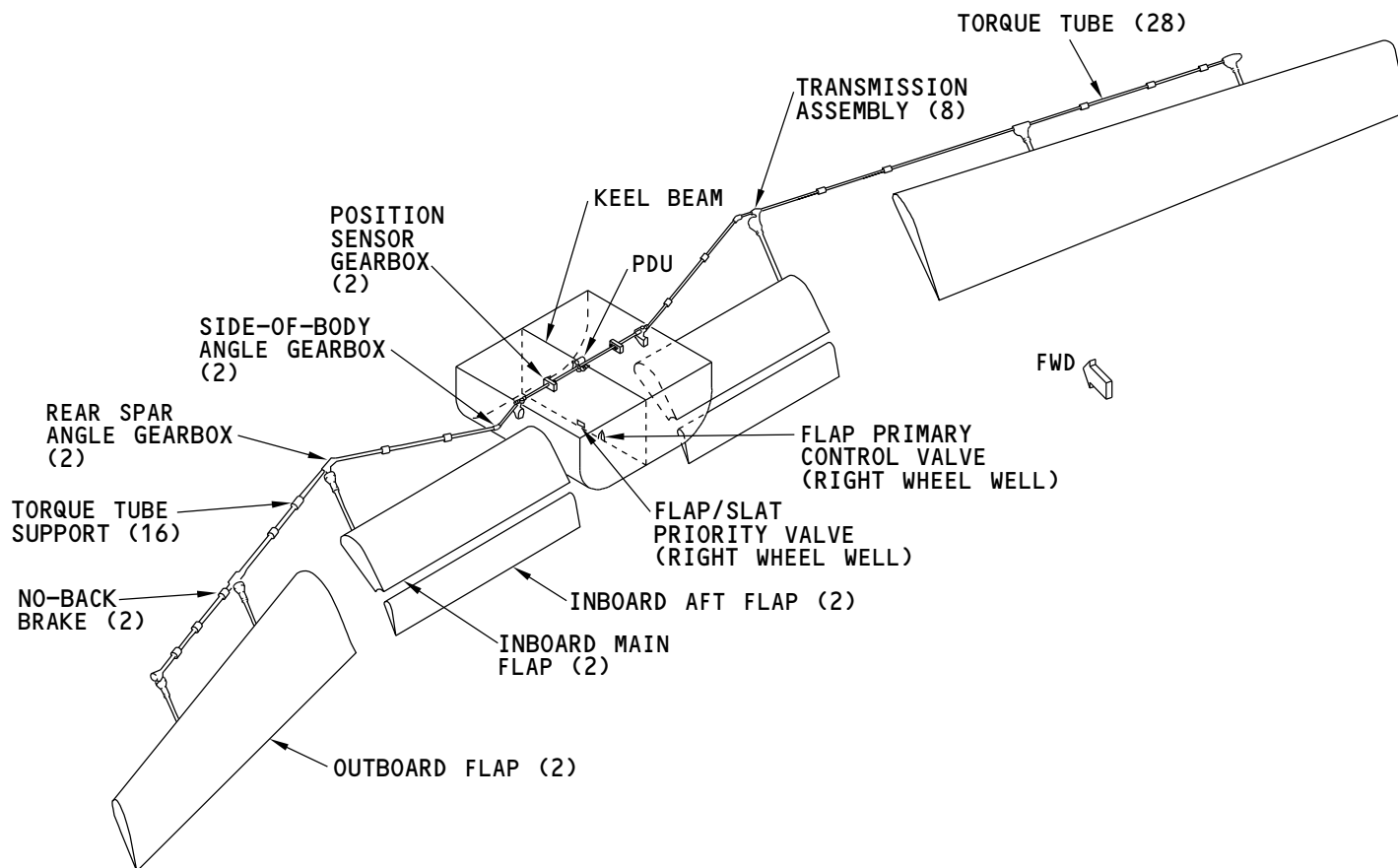
The outboard flaps, inboard main flaps, and inboard aft flaps are on the wings. Most of the flap transmissions and ballscrews are under the wings. Remove the flap support fairings under the wing or extend the flaps to get access to the transmissions and ballscrews.

The rear spar angle gearboxes, the no-back brakes, and some of the torque tubes attach to the rear spar of the wings. Access to the gearboxes is through panels under the wings. Extend the flaps to get access to the torque tubes and the no-back brakes.

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TRAILING EDGE FLAPS - COMPONENT LOCATIONS - 2

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**TRAILING EDGE FLAPS - FLAP LEVER AND FLAP LEVER POSITION SENSOR****Purpose**

The pilots use the flap lever to control the position of the flaps and slats in the primary and secondary modes. The flap lever position sensor sends input position signals to the FSEUs.

Physical Description

The flap lever has detent positions at UP, 1, 5, 15, 20, 25, and 30. Gates at detents 1 and 20 help the flight crew to identify these positions during climb-out and go-around.

The flap lever connects with a crank and a control rod to the brake mechanism. The flap lever position sensor attaches to the brake mechanism. The position sensor has a splined shaft with a missing tooth to help align the position sensor with the brake mechanism.

The flap lever position sensor has four internal rotary variable differential transformers (RVDTs). The assembly is an LRU, but the RVDTs are not LRUs.

Location

The flap lever is on the right side of the P10 control stand. The brake mechanism and the flap lever position sensor are in the control stand.

Functional Description

When the pilots move the flap lever, the control rod turns the spline in the brake mechanism. The spline then drives the position sensor. If the control rod disconnects, the brake mechanism prevents movement of the RVDTs.

Training Information Point

After you install the flap lever position sensor, do the LRU replacement test. To do this test, move the flap lever to each detent and check the value of each RVDT on the high lift maintenance page.

During installation of the brake mechanism, adjust the control rod to align the index tooth with the index bolt hole.

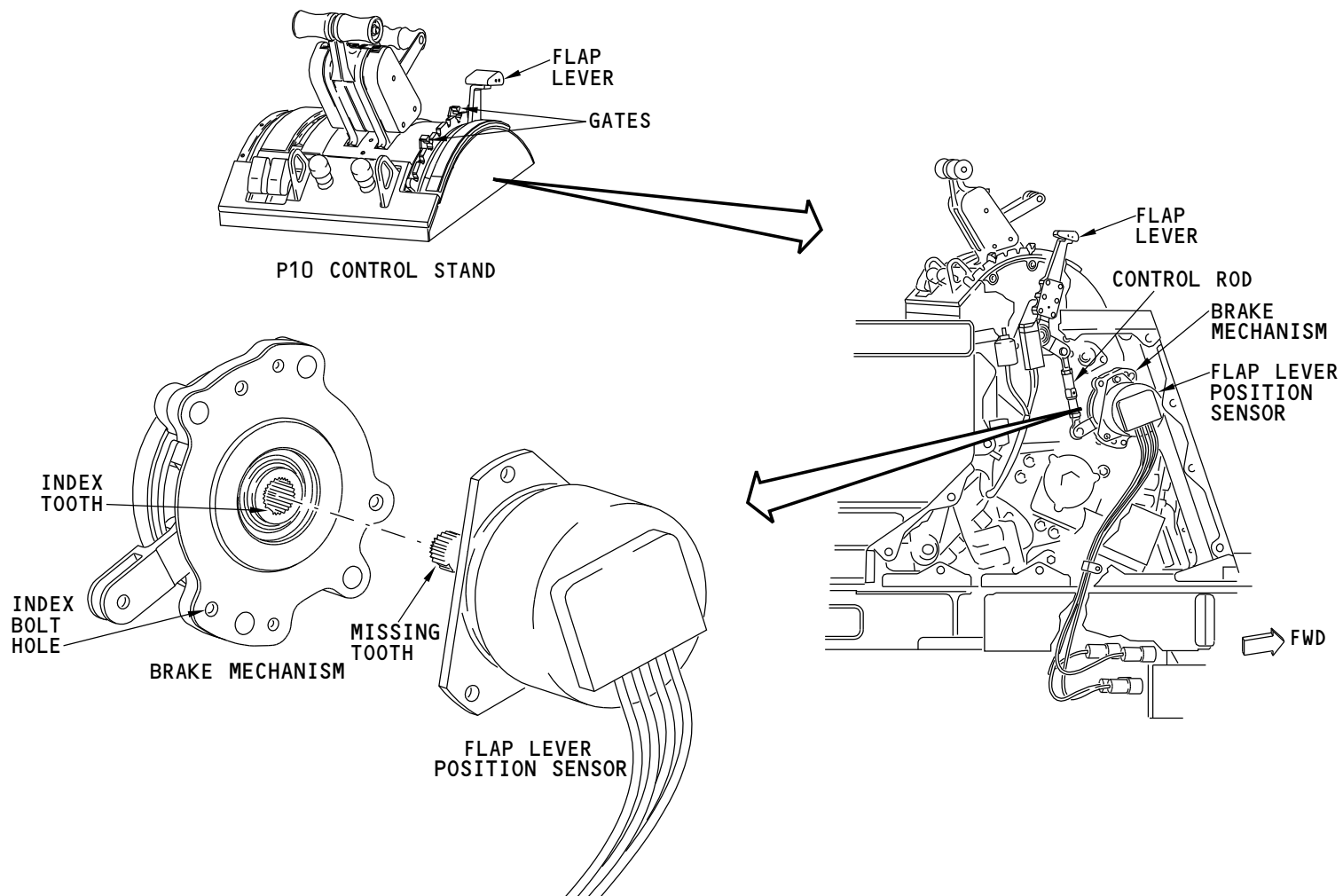
If you replace only the flap lever position sensor without removal of the brake mechanism, it is not necessary to adjust the control rod.

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TRAILING EDGE FLAPS - FLAP LEVER AND FLAP LEVER POSITION SENSOR

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TRAILING EDGE FLAPS - ALTERNATE FLAPS PANEL

Purpose

The two switches on the alternate flaps panel are:

- The alternate flaps arm switch
- The alternate flaps selector.

These switches control the flaps and slats in the alternate mode.

Physical Description

The alternate flaps arm switch is a guarded, alternate action switch. When you push the switch, ALTN shows.

The alternate flaps selector has these detents

- OFF
- RET
- EXT.

Location

The alternate flaps panel is on the right side of the P10 control stand.

Operation

To engage the alternate mode, push the alternate flaps arm switch. To extend the flaps and slats in the alternate mode, turn the alternate flaps selector to the EXT position. Turn the selector to the OFF position to stop the movement of the flaps and slats. To retract the flaps and slats, turn the selector to the RET position.

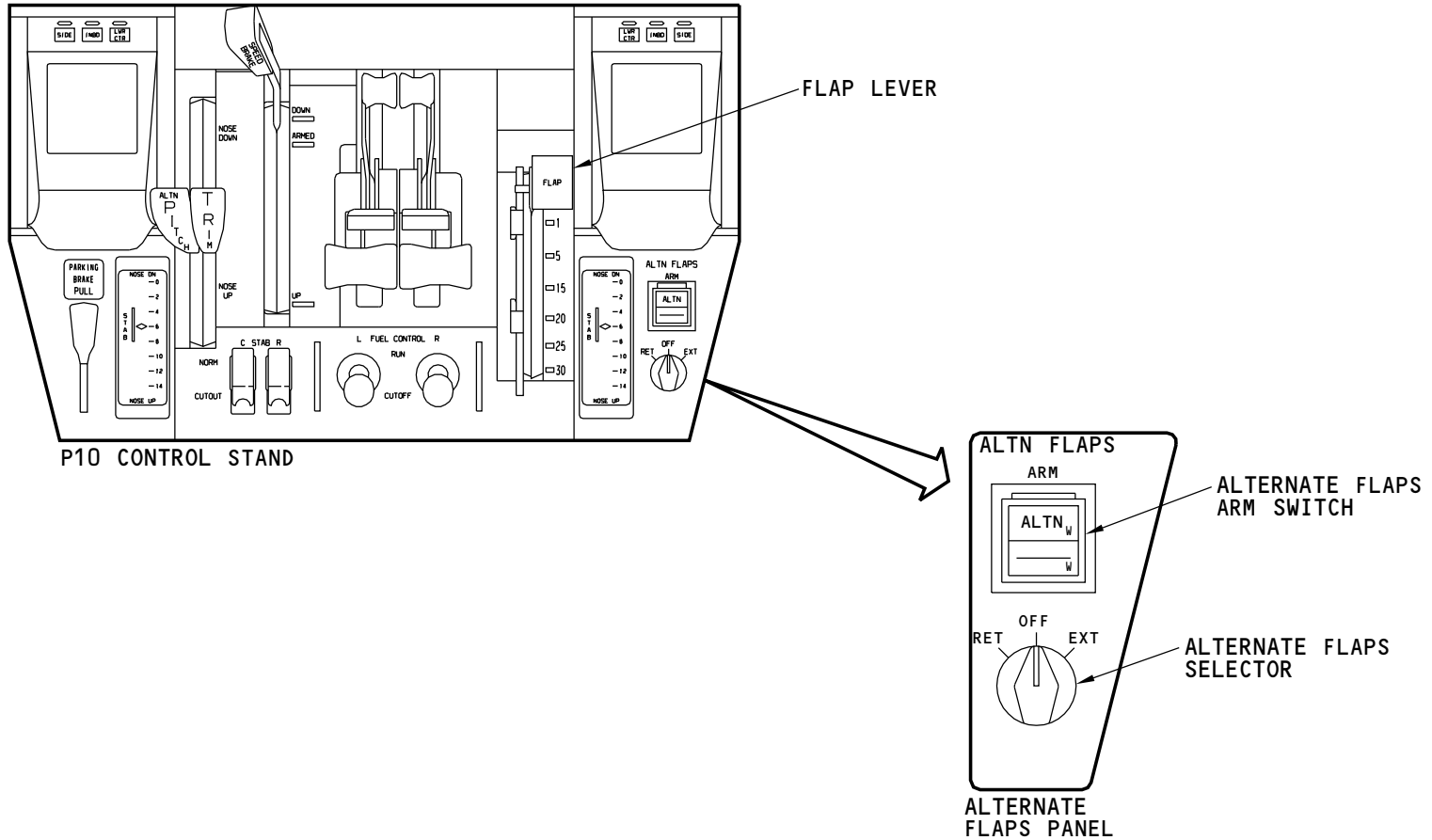
To disengage the alternate mode, push the alternate flaps arm switch again.

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TRAILING EDGE FLAPS - ALTERNATE FLAPS PANEL

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TRAILING EDGE FLAPS - FLAP/SLAT ELECTRONICS UNIT (FSEU)

General

The two flap/slat electronics units (FSEUs) control the flaps and slats in the primary and secondary modes. Only one FSEU is in control of the flaps and slats at a time. The other FSEU does not send commands to the flaps and slats. The FSEUs automatically transfer control to the other FSEU after a post-flight self-test of the FSEUs or after disengagement from the alternate mode. There is also an automatic transfer after a fault in the FSEU in control.

Physical Description

The two FSEUs are the same and interchangeable. Each FSEU contains two independent channels: the control channel and the monitor channel. The two channels have different microprocessors, made by different manufacturers. The microprocessors have different part numbers. The two channels have the same capabilities and operate with the same software.

Program pins on each FSEU supply information on FSEU location and software. Cooling for both FSEUs is passive.

Channel Functions

The control channel and the monitor channel of each FSEU has:

- A set of HLCS sensor inputs
- An analog to digital (A/D) converter
- A set of control laws
- A failure monitor
- A cross-channel monitor
- A lane monitor
- Separate interfaces with the ARINC 629 buses.

HLCS Sensor Inputs

Each channel receives inputs from the HLCS sensors. Failure of a sensor can cause the control to change to the other FSEU.

A/D Converter

The FSEU changes the analog inputs to digital format before using them in the control laws.

Control Laws

The FSEUs use control laws to calculate the commands for the flaps and slats in the primary and secondary modes. Each channel sends the commands to output drivers. Both channels must agree on the commands to permit the FSEU to supply a ground for the flap and slat solenoids or relays.

Failure Monitor

Each channel monitors the HLCS for these conditions:

- Flap position failure
- Slat position failure
- Slat loss.

If the FSEU detects one of these conditions, the FSEU stops the commands to the failed surface.

Cross-Channel Monitor

The cross-channel monitor compares the commands from the control and monitor channels. The output command signals to control the flaps and slats go to the opposite channel for comparison. If the commands disagree, then the FSEU stops all commands. Control then changes to the other FSEU.

The alternate arm switch position signals to the FSEU directly disable the output commands. If this switch is in the ARMED position, the FSEU stops all commands.

Lane Monitor

The lane monitor compares the input signals to both channels in each FSEU. The lane monitor receives the inputs from the other FSEU in two ways.

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**TRAILING EDGE FLAPS - FLAP/SLAT ELECTRONICS UNIT (FSEU)**

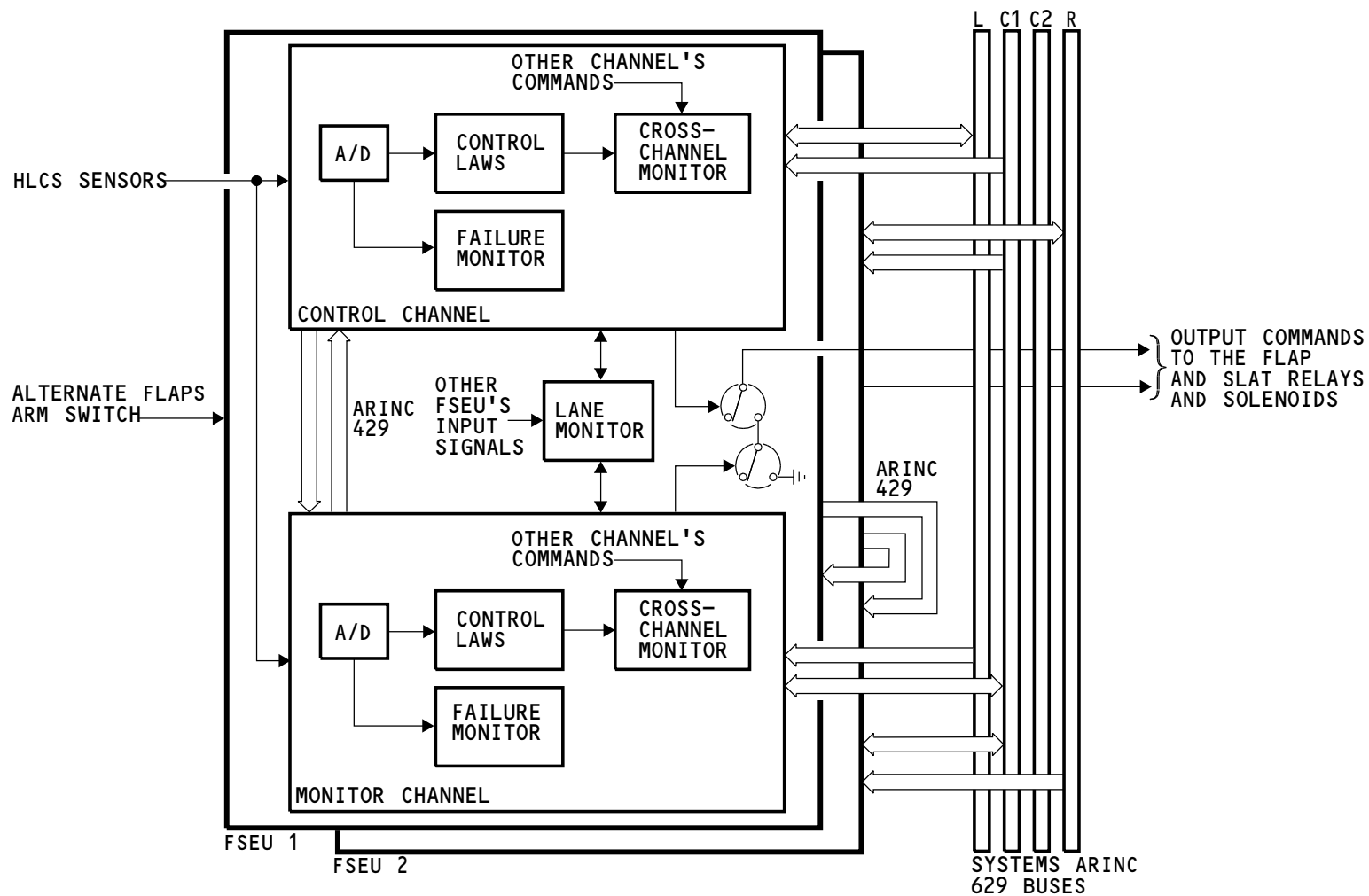
One way is through the cross-lane ARINC 429 buses. The other way is through the systems ARINC 629 buses. If the input signals to the FSEU in control fails, then the control changes to the other FSEU.

ARINC 629 Buses

Each channel transmits and receives data from the systems ARINC 629 buses. Each channel transmits its own commands, and receives commands from the other channel and from the other FSEU. Each channel receives data from two of the systems buses for redundancy.

Training Information Point

Use the maintenance access terminal (MAT) to load the software for the FSEUs. After you load the software, push the alternate flaps arm switch to the ARMED then NOT ARMED position. This removes any EICAS messages for the HLCS.



TRAILING EDGE FLAPS - FLAP/SLAT ELECTRONICS UNIT (FSEU)

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TRAILING EDGE FLAPS - FLAP PRIMARY CONTROL VALVE

Purpose

The flap primary control valve controls hydraulic power to the hydraulic motor. In the primary mode, this valve controls the direction and speed of movement of the flap drive system. In the secondary and alternate modes, this valve prevents hydraulic power to the hydraulic motor.

Physical Description

The primary control valve is an LRU. These components on the primary control valve are LRUs:

- The shutoff solenoid
- The extend solenoid
- The retract solenoid
- The low-speed solenoid
- The bypass solenoid.

The low-speed solenoid is different than the other solenoids, but it is interchangeable with the low-speed solenoid on the slat primary control valve. All the other solenoids are interchangeable and they are interchangeable with the other solenoids on the slat primary control valve. The flap primary control valve is similar to, but not interchangeable with, the slat primary control valve.

Location

The flap primary control valve attaches to the keel beam in the right wheel well.

Training Information Point

There is a small difference in the location of the mounting holes for the flap and slat primary control valves. This helps prevent the slat primary control valve from being installed where the flap primary valve should be. The reverse is also true.

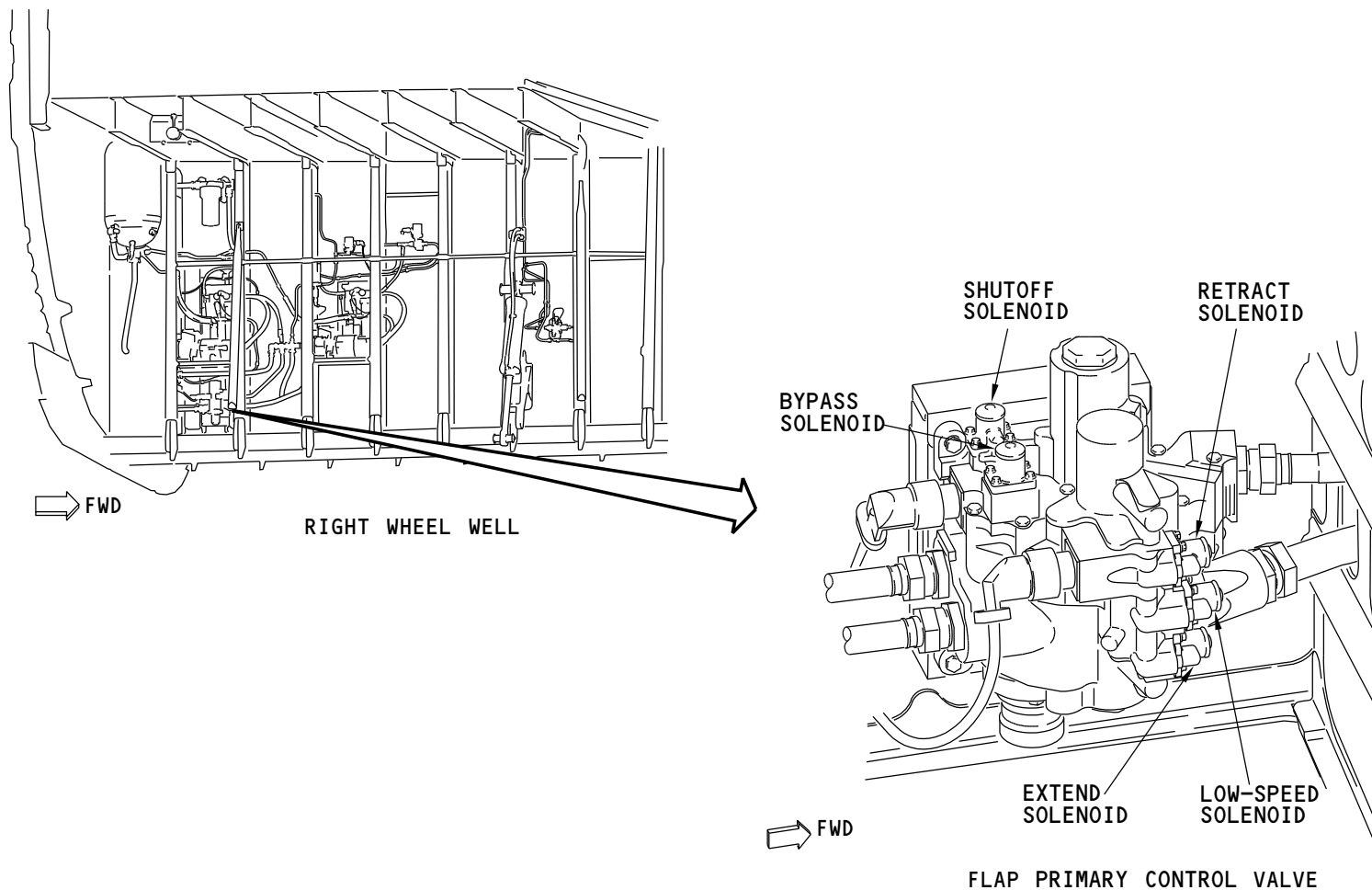
The low-speed solenoid has a longer valve and different mounting hole locations. This helps prevent the low-speed solenoid from being installed where a different type of solenoid should be. This also helps prevent a different solenoid from being installed where the low-speed solenoid should be.

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TRAILING EDGE FLAPS - FLAP PRIMARY CONTROL VALVE

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TRAILING EDGE FLAPS - PRIMARY CONTROL VALVE - FUNCTIONAL DESCRIPTION

General

The primary control valve has these components:

- Shutoff valve
- Shutoff solenoid valve
- Low-speed solenoid valve
- Low speed piston
- Flow regulator
- Retract solenoid valve
- Extend solenoid valve
- Selector valve
- Bypass solenoid valve
- Bypass valve.

The FSEUs electrically control the solenoid valves in the primary control valve. All the solenoid valves are normally de-energized.

Shutoff Valve and Shutoff Solenoid Valve

The shutoff valve supplies hydraulic pressure and hydraulic flow to the selector valve.

The shutoff valve has three positions: closed, open, and low-speed. The shutoff valve is spring-loaded and hydraulically controlled to the closed position. It moves to the open or low-speed positions when the shutoff solenoid valve removes pressure from one side of the valve.

The shutoff solenoid valve controls the pilot pressure to the shutoff valve. The shutoff valve solenoid has two coils. When both coils are de-energized, the shutoff solenoid valve lets pilot pressure close the shutoff valve. When either coil is energized, the shutoff solenoid valve removes pilot pressure from the shutoff valve. Hydraulic system pressure then lets the shutoff valve open.

When the shutoff valve is closed, it removes hydraulic pressure from the selector valve. When the shutoff valve is open, hydraulic system pressure goes to the selector valve to move the flaps at their normal rate. When the shutoff valve is in the low-speed position, the hydraulic flow to the selector valve is restricted.

Low-Speed Solenoid Valve, Low Speed Piston, and Flow Regulator

The low-speed solenoid valve, the low speed piston, and the flow regulator help to decrease the speed of the flap drive system.

The low-speed solenoid valve has two coils. It controls hydraulic pressure to the low speed piston. The low speed piston is a hydraulic piston that is spring-loaded to the retracted position.

When the FSEUs energize the low-speed solenoid valve, the low speed piston extends. This limits the position of the shutoff valve to the low-speed position.

When the FSEUs de-energize the low-speed solenoid valve, the pressure in the low speed piston decreases. An internal spring then forces the low speed piston to retract. This lets the shutoff valve move to the open position.

The flow regulator limits the flow of hydraulic fluid to 25 gpm at high speed, and 5 gpm at low speed.

Selector Valve

The selector valve controls the direction of operation of the hydraulic motor.

The selector valve is spring-loaded and hydraulically balanced to the center position and normally has pressure on both sides of the valve. The selector valve moves to the extend position when the extend solenoid valve removes pilot pressure from the extend side of the selector valve. The selector valve moves to the retract position when the retract solenoid valve removes pilot pressure from the retract side of the selector valve.

Bypass Valve and Bypass Solenoid Valve

The bypass valve isolates the hydraulic motor from hydraulic system pressure. The bypass valve also prevents a hydraulic lock and permits backdrive of the hydraulic motor.

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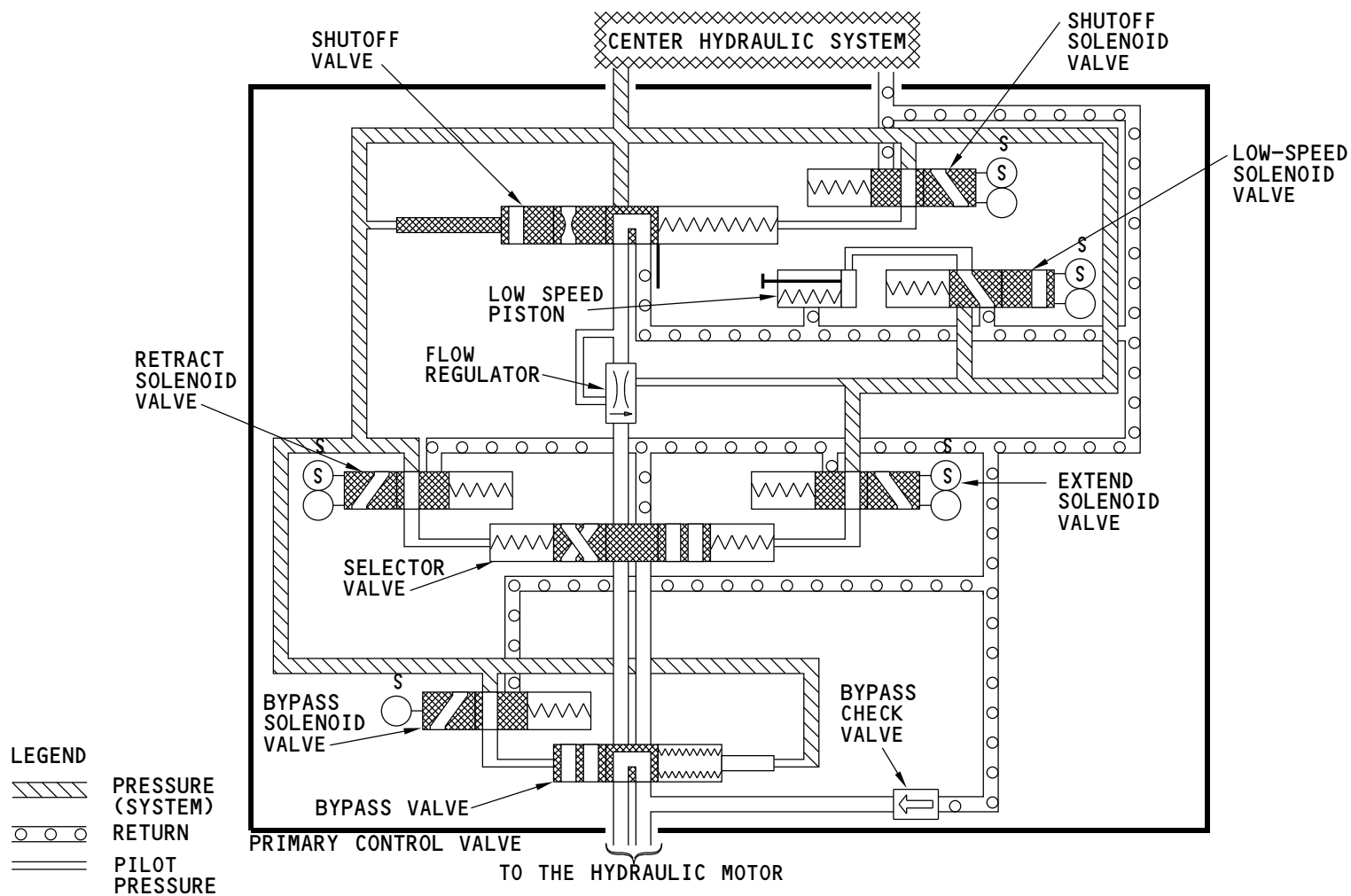
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**TRAILING EDGE FLAPS - PRIMARY CONTROL VALVE - FUNCTIONAL DESCRIPTION**

A dual-coil bypass solenoid valve controls pilot pressure to the bypass valve, but only one coil of the solenoid is used. When the FSEUs energize the bypass solenoid valve, it removes pilot pressure from the open side of the bypass valve. This closes the bypass valve, which connects the hydraulic lines to both sides of the hydraulic motor.

The bypass valve is spring-loaded and hydraulically controlled to the closed position. The open side of the valve has a larger surface area for the pilot pressure than the close side of the valve. When the center hydraulic system pressure is low, springs automatically force the bypass valve to close. When the center hydraulic system pressure is high, the bypass valve opens.

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TRAILING EDGE FLAPS - PRIMARY CONTROL VALVE - FUNCTIONAL DESCRIPTION

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**TRAILING EDGE FLAPS - FLAP/SLAT PRIORITY VALVE****Purpose**

The flap/slat priority valve gives priority of hydraulic power to the primary flight controls over the flaps and slats. This priority valve makes sure that the primary flight control PCUs receive sufficient hydraulic power when both air driven pumps (ADPs) are not operating.

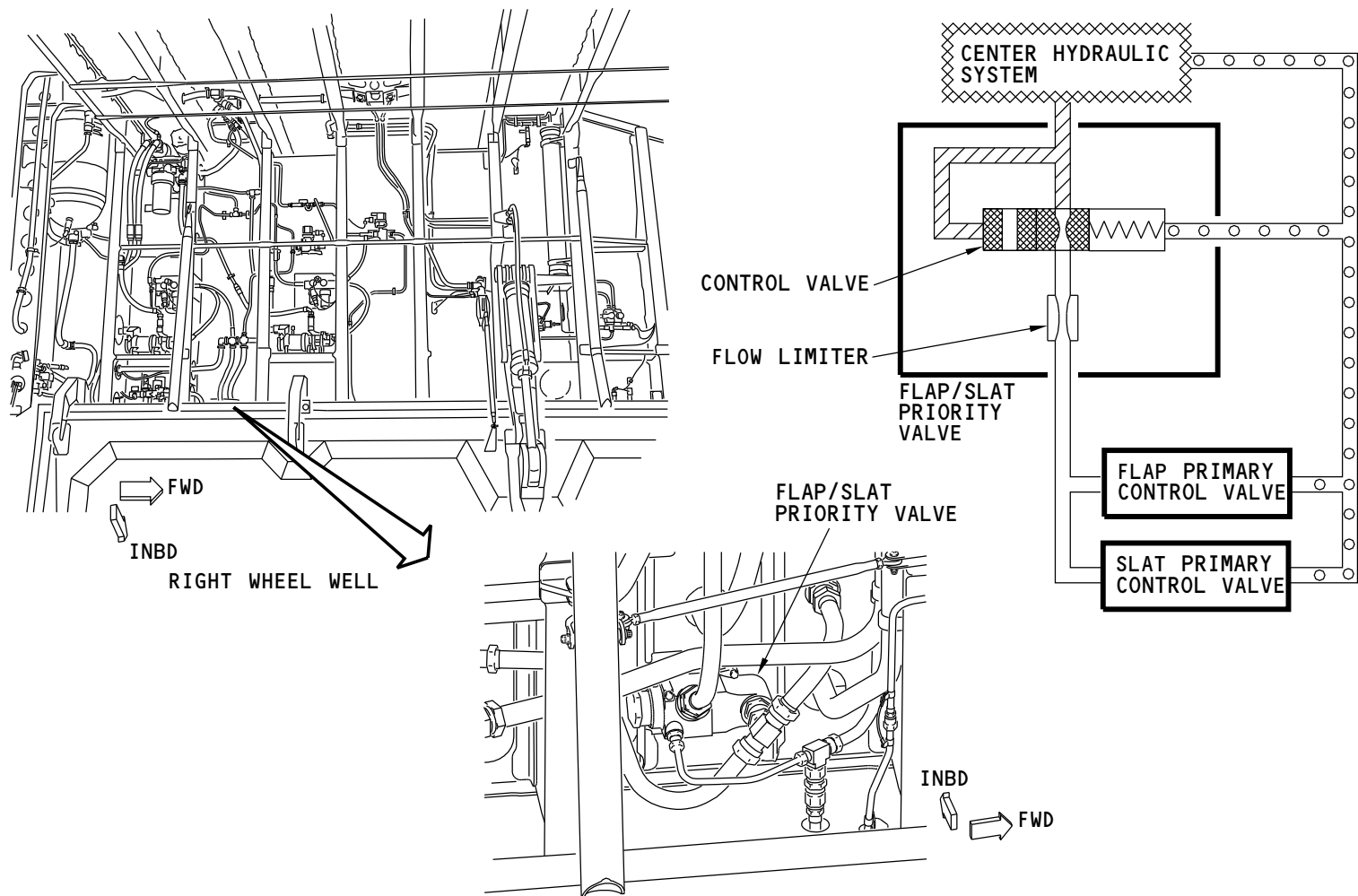
Location

The flap/slat priority valve is at the bottom of the keel beam in the right wheel well.

Physical Description

The flap/slat priority valve has a flow limiter and a control valve. When the pressure in the center hydraulic system is high, the control valve fully opens. The maximum flow through the flow limiter is then 43 gpm.

When the system pressure decreases, the control valve restricts the flow to the flap and slat primary control valves. In the fully restricted position, the control valve limits the flow to 0.4 gpm. Restriction of the flap/slat flow permits the control valve to modulate the system pressure to 1750 psi during high demand conditions.



TRAILING EDGE FLAPS - FLAP/SLAT PRIORITY VALVE

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TRAILING EDGE FLAPS - FLAP POWER DRIVE UNIT (PDU)

Purpose

The flap PDU turns the flap torque tubes during operation in all three modes. The flap PDU has these LRUs:

- A hydraulic motor
- An electric motor
- A gearbox.

Information on the hydraulic motor and the electric motor is shown later.

Location

The flap PDU is above the keel beam in the main landing gear wheel wells. Access to the hydraulic and electric motors is through the right wheel well. Access to the gearbox is through the left wheel well.

Gearbox

The gearbox transmits the power from the hydraulic or electric motors to the torque tubes.

The hydraulic motor or the electric motor rotates gears in the gearbox. These gears increase the torque from the motors. The gearbox turns the torque tube couplings on both sides of the PDU. These couplings turn the torque tubes.

During high-speed operation in the primary mode, the gearbox turns the torque tubes at 550 rpm. During low-speed operation, the gearbox turns the torque tubes at 110 rpm.

During operation in the secondary and alternate modes, the gearbox turns the torque tubes at 74 rpm.

Training Information Point

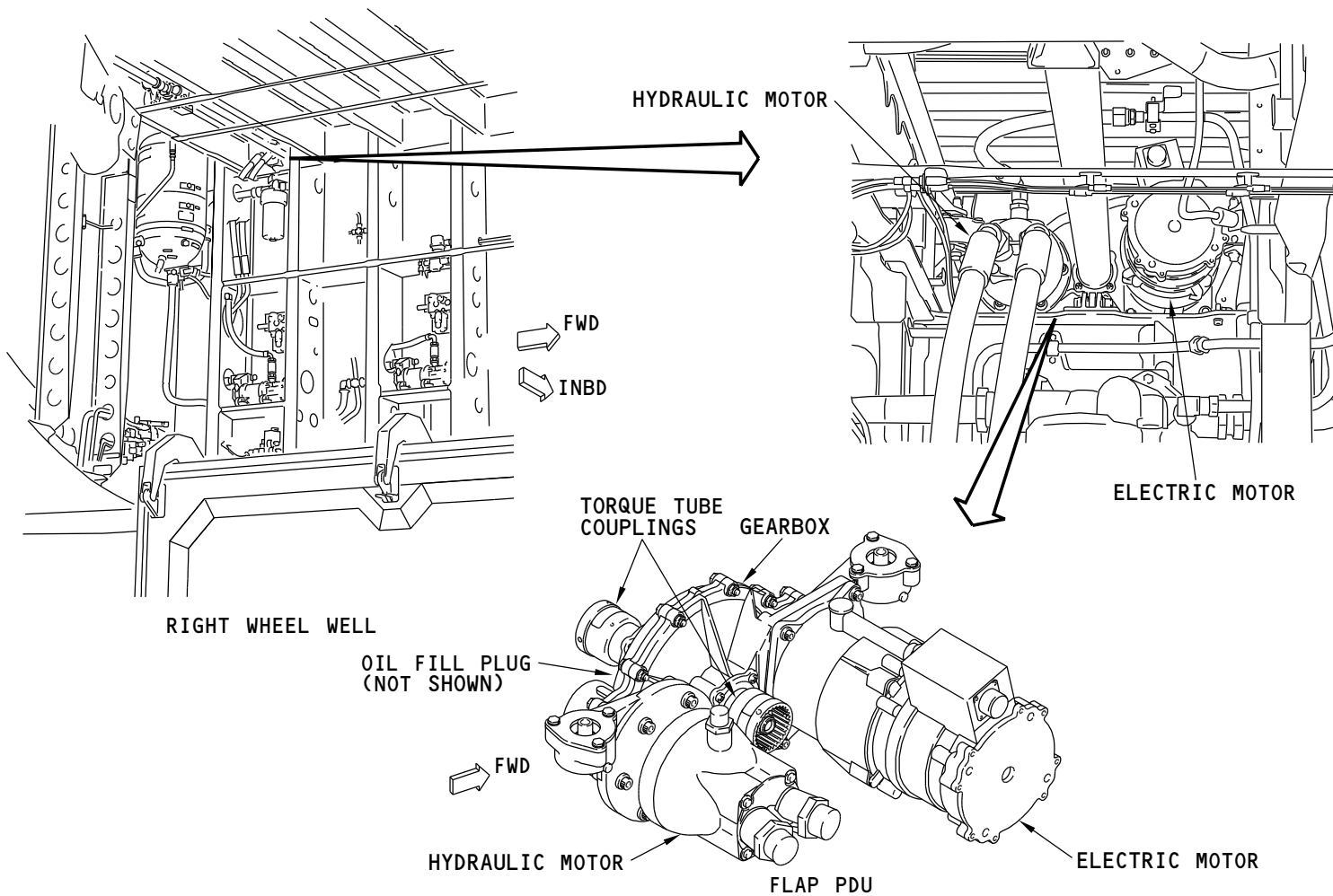
The gearbox contains oil and it is necessary to do servicing at specified times. You get access to the oil fill plug through the left wheel well.

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TRAILING EDGE FLAPS - FLAP POWER DRIVE UNIT (PDU)

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**TRAILING EDGE FLAPS - PDU HYDRAULIC AND ELECTRIC MOTORS****Purpose**

The PDU hydraulic and electric motors supply power to turn the gearbox and the torque tubes.

Location

The motors are on the flap PDU and connect to the gearbox.

Hydraulic Motor

The hydraulic motor operates in the primary mode. It receives hydraulic pressure from the flap primary control valve. During secondary and alternate mode operation, the primary control valve blocks hydraulic power to the motor. It also permits the hydraulic motor to be backdriven.

The hydraulic motor is a reversible, constant displacement, piston-type motor. The hydraulic motor has two hydraulic connections for pressure and return to the flap primary control valve. It also has one connection for case drain to the return line of the center hydraulic system. The hydraulic motor weighs 16 lb (7 kg). It is identical and interchangeable with the slat hydraulic motor.

Electric Motor

The electric motor operates in the secondary or alternate modes. Relays supply electrical power to the electric motor. During primary mode operation, a clutch disengages the electric motor from the gearbox.

The electric motor is a reversible motor and receives 3-phase 115v ac power. It weighs approximately 42 lb (19 kg). An electrically actuated clutch and a torque limiter are in the motor assembly. The clutch engages the motor with the gearbox in the secondary or alternate modes. The torque limiter prevents too much load on the flap mechanisms. An internal brake engages when the motor is not energized.

Training Information Point

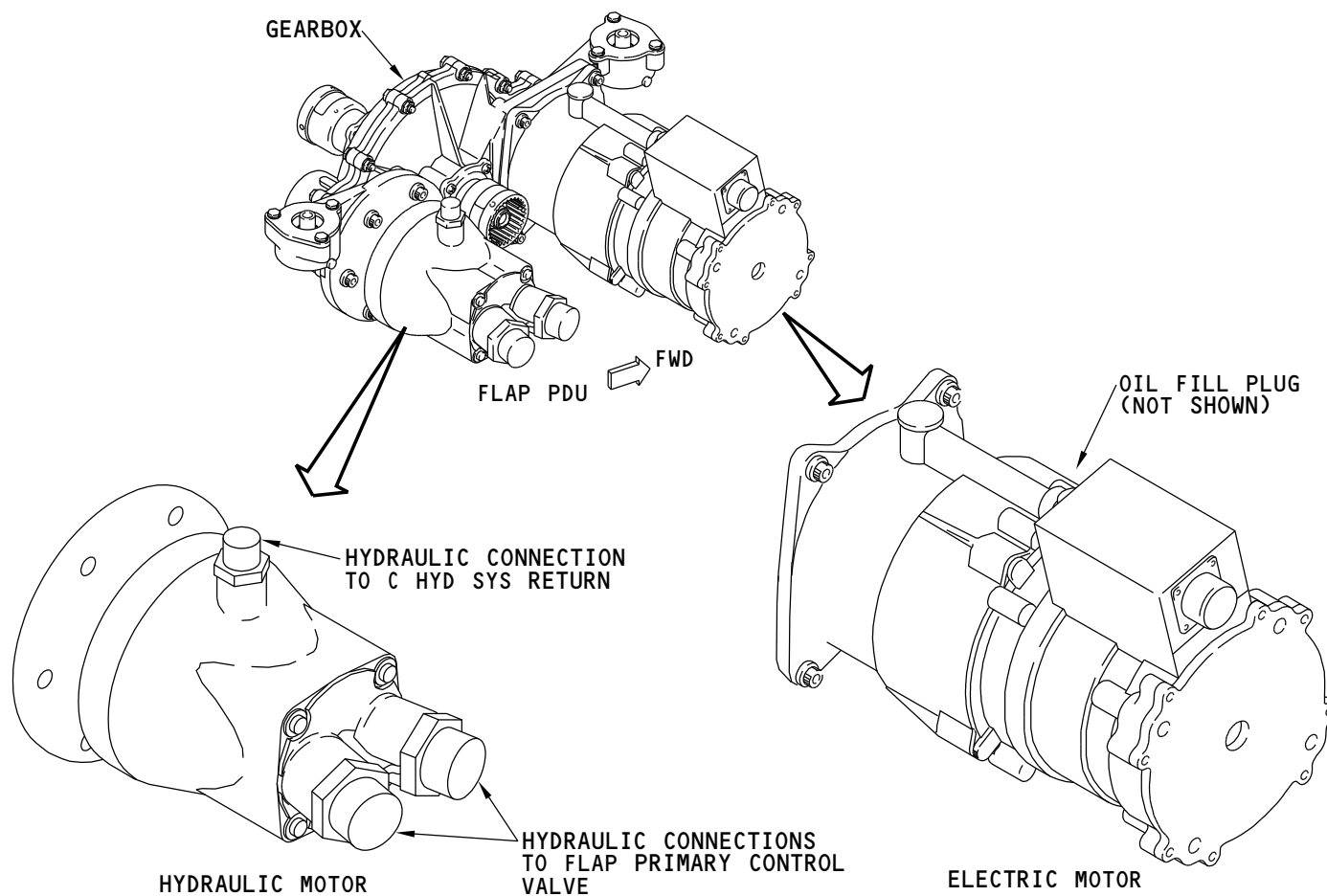
The electric motor contains oil and it is necessary to do servicing. Use the oil fill plug on the side of the motor.

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TRAILING EDGE FLAPS - PDU HYDRAULIC AND ELECTRIC MOTORS

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TRAILING EDGE FLAPS - FLAP LIMIT SWITCH

Purpose

The flap limit switch limits the position of the flaps during alternate mode operation. The flap limit switch also prevents retraction of the slats in the alternate mode until the flaps are fully retracted.

Location

The flap limit switch is on the right flap position sensor gearbox in the right wheel well.

Functional Description

The limit switch is one LRU. It has two internal switches, up and 20.

The up switch controls the sequence of flap and slat retraction in the alternate mode. To do this, the up switch controls the electrical power to the flap and slat electric motors.

During retraction, the up switch permits retraction of the flaps but removes electrical power from the slat electric motor. When the flaps retract to the up position, the up switch removes power from the flap electric motor and permits retraction of the slats.

When the flaps extend to the 20 position, the 20 switch removes electrical power from the flap electric motor.

Training Information Point

The flap limit switch is interchangeable with the slat limit switch.

You install the flap limit switch with the trailing edge flaps in the retracted position. The limit switch rig indicator has a fixed scribe mark and an indicator needle. The indicator needle moves up or down in relation to the scribe mark as the shaft of the limit switch turns. Make sure you align the center of the indicator needle in the rig indicator with the scribe mark when you install the limit switch.

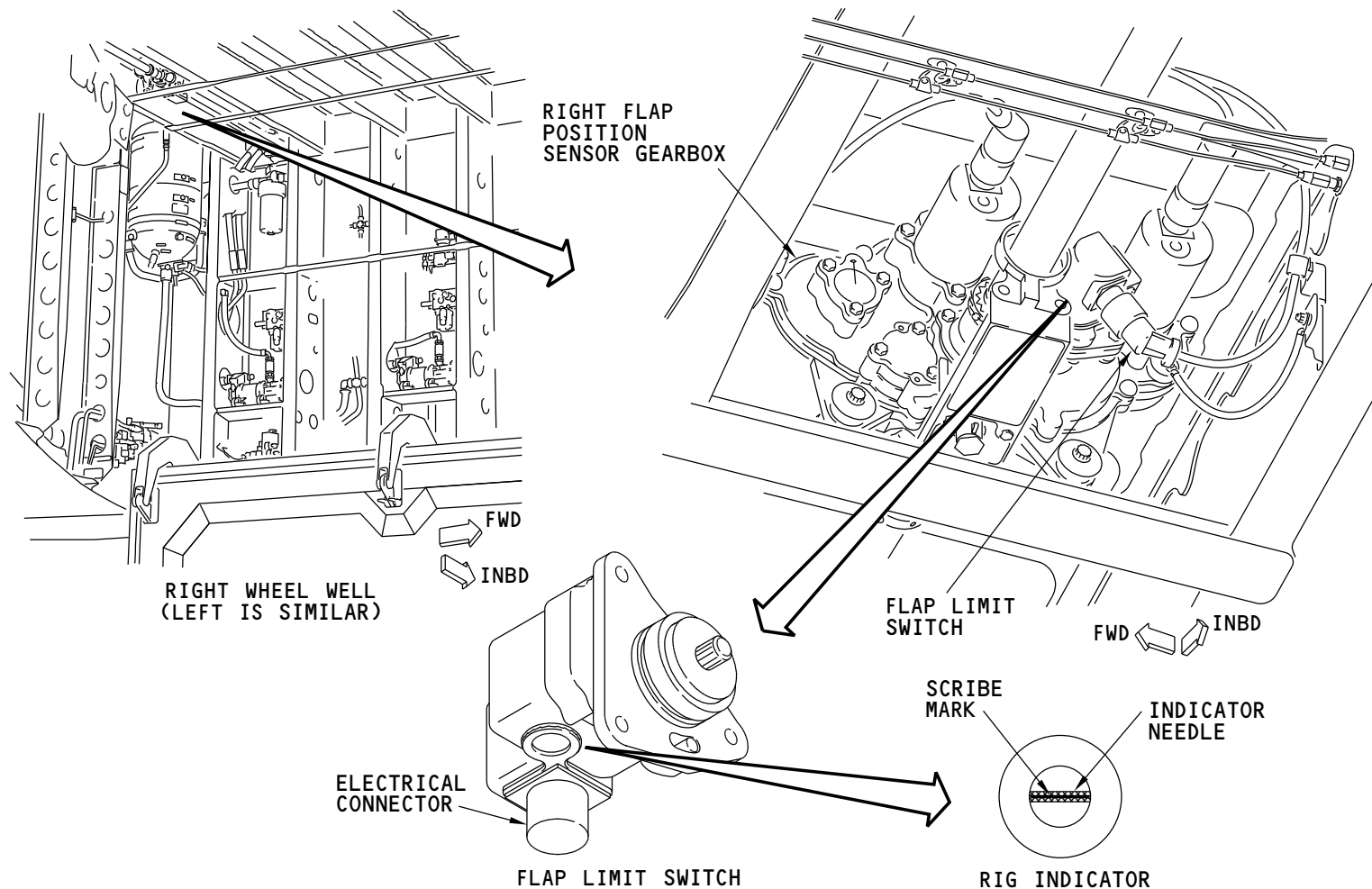
To retract the slats with the flaps extended and disabled, you must install a jumper wire on the electrical connector for the flap limit switch. This permits the slats to fully retract with the flaps extended.

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TRAILING EDGE FLAPS - FLAP LIMIT SWITCH

27-51-00

27-51-00-013

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	D633W101-ARO



TRAILING EDGE FLAPS - TORQUE TUBES AND TORQUE TUBE SUPPORTS

Purpose

The flap torque tubes transmit power from the flap PDU, through angle gearboxes, to the flap transmissions. The torque tube supports hold the torque tubes in place.

Location

There are 28 torque tubes of different lengths for the flap drive system. These torque tubes are in the left and right wheel wells, along the main landing gear beams, and along the rear spar of both wings. Access is through the wheel wells, hinged panels under the landing gear beams, and by extending the flaps.

There are 14 torque tube supports. These supports are along the main landing gear beams, and along the rear spar of both wings. Access is the same as for the torque tubes except for two locations in each wing. The locations in the wings require the removal of a lower skin panel. These locations are at the flaperon support structure and at the main landing gear beam.

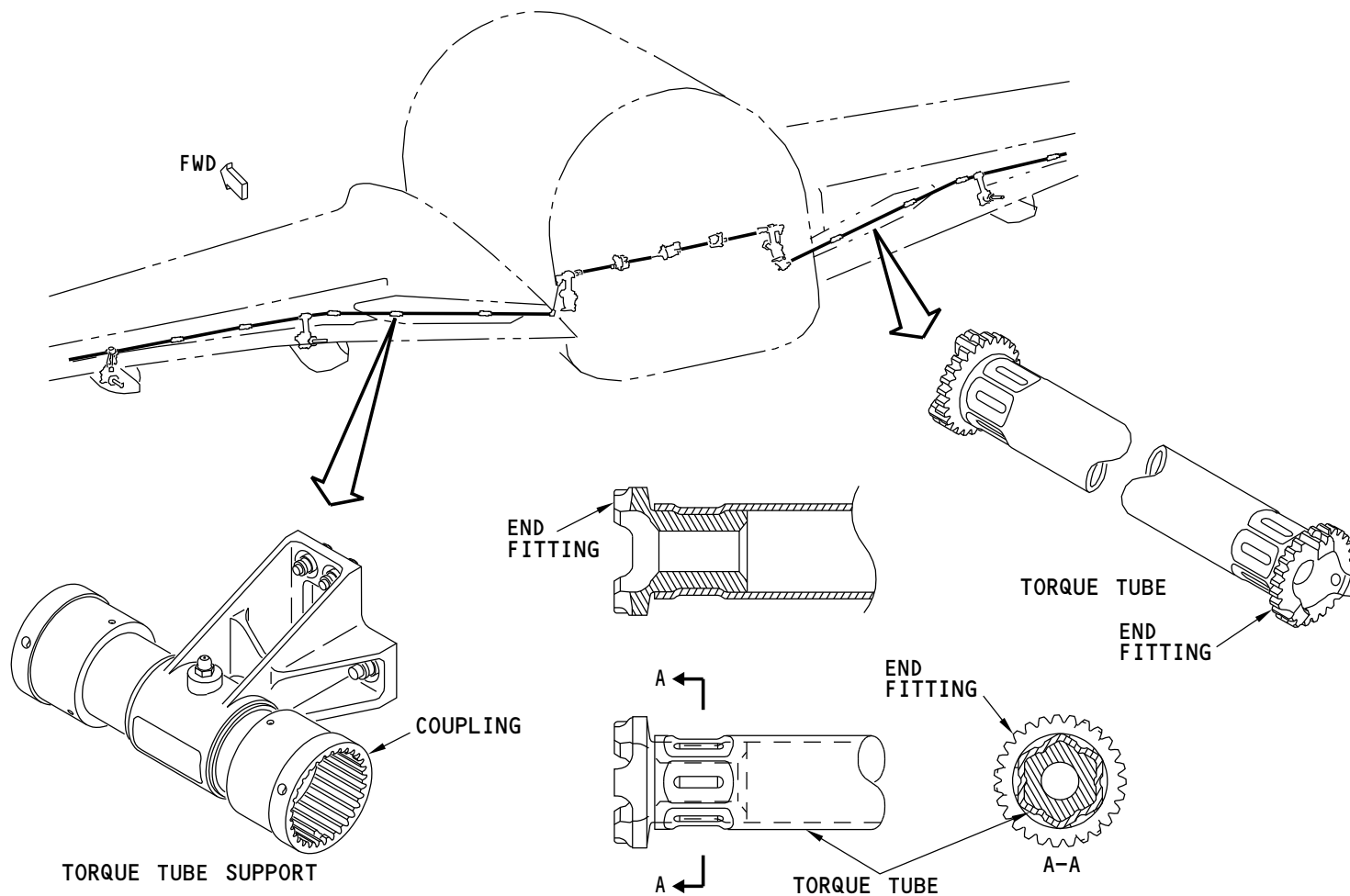
Torque Tubes

The aluminum torque tubes are magneformed to steel end fittings. The magneforming process forms the end of the torque tubes around the fittings electro-magnetically.

Torque Tube Supports

The torque tube supports are filled with grease.

ARO ALL	EFFECTIVITY



TRAILING EDGE FLAPS - TORQUE TUBES AND TORQUE TUBE SUPPORTS

M41119 S000617477_V1

27-51-00

27-51-00-014

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TRAILING EDGE FLAPS - ANGLE GEARBOXES

Purpose

The angle gearboxes connect torque tubes that are at different angles to each other. There are six angle gearboxes:

- Two side-of-body angle gearboxes
- Two rear spar angle gearboxes
- Angle gearboxes on the output of the inboard transmissions for the inboard flap (transmissions 4 and 5).

Location

The side-of-body angle gearboxes are on the inboard flap support assemblies in the main landing gear wheel wells. Access is through the wheel wells.

The rear spar angle gearboxes are on the rear spar of each wing, near the main landing gear beam. Access is through removable panels under the wings.

The other two angle gearboxes are on the output side of the inboard flap inboard transmissions (4 and 5).

Physical Description

The angle gearboxes are filled with grease and sealed.

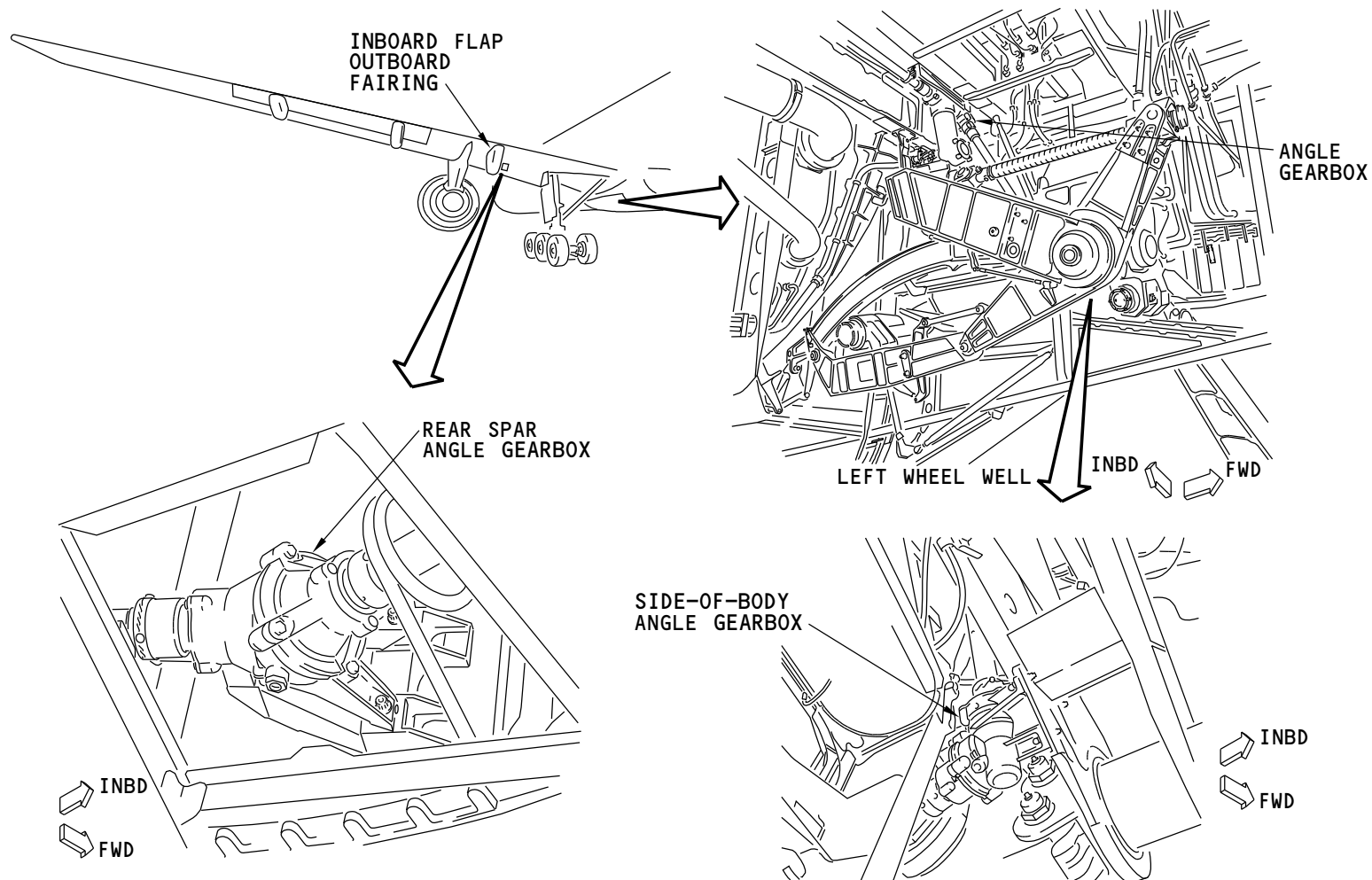
The side-of-body angle gearbox weighs 10 lb (4.5 kg). The rear spar angle gearbox weighs 11 lb (5 kg). The angle gearboxes on transmissions 4 and 5 each weigh about 12.5 lb (5.7 kg).

27-51-00

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M41121 S000617479_V1

TRAILING EDGE FLAPS - ANGLE GEARBOXES

27-51-00

27-51-00-015

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TRAILING EDGE FLAPS - INBOARD FLAP INBOARD TRANSMISSION ASSEMBLY

Purpose

There are two transmission assemblies for each flap surface, an inboard transmission assembly and an outboard transmission assembly.

The inboard flap inboard transmission assembly receives power from the torque tubes to move the inboard flap. This assembly has these components:

- A transmission
- A ballscrew
- A gimbal.

The transmission assembly weighs approximately 95 lb (43 kg).

Location

There is one inboard flap inboard transmission assembly in each main landing gear wheel well.

Transmission

The transmission connects to the torque tubes. Gears in the transmission transmit the power from the torque tubes to the U-joint. The U-joint then turns the ballscrew.

The transmission has a torque brake and a no-back brake. The torque brake prevents excessive loads on the ballscrew if the flap does not move freely. The torque brake is a ball ramp type brake with a torque trip indicator. The trip indicator must be manually reset if it activates.

The no-back brake is a skewed roller type brake. It engages by compression load in the ballscrew caused by airloads on the flap. It prevents flap movement if the PDU or torque tubes fail.

Ballscrew

The transmission turns the ballscrew through a U-joint. The ballscrew has a ballscrew nut which connects to the gimbal. As the ballscrew turns, the ballscrew nut moves the gimbal.

The ballscrew has stops at both ends. The ballscrew nut does not touch the stops during normal operation of the flaps.

Gimbal

The gimbal moves the flap surface. The gimbal connects to the ballscrew nut, and moves as the ballscrew turns.

Training Information Point

If you disconnect the ballscrew from the transmission at the U-joint, make sure that the ballscrew nut stays on the ballscrew.

The transmission contains oil and it is necessary to do servicing. Use the oil fill plug.

When manually operating the flap drive system, observe this caution:



CAUTION

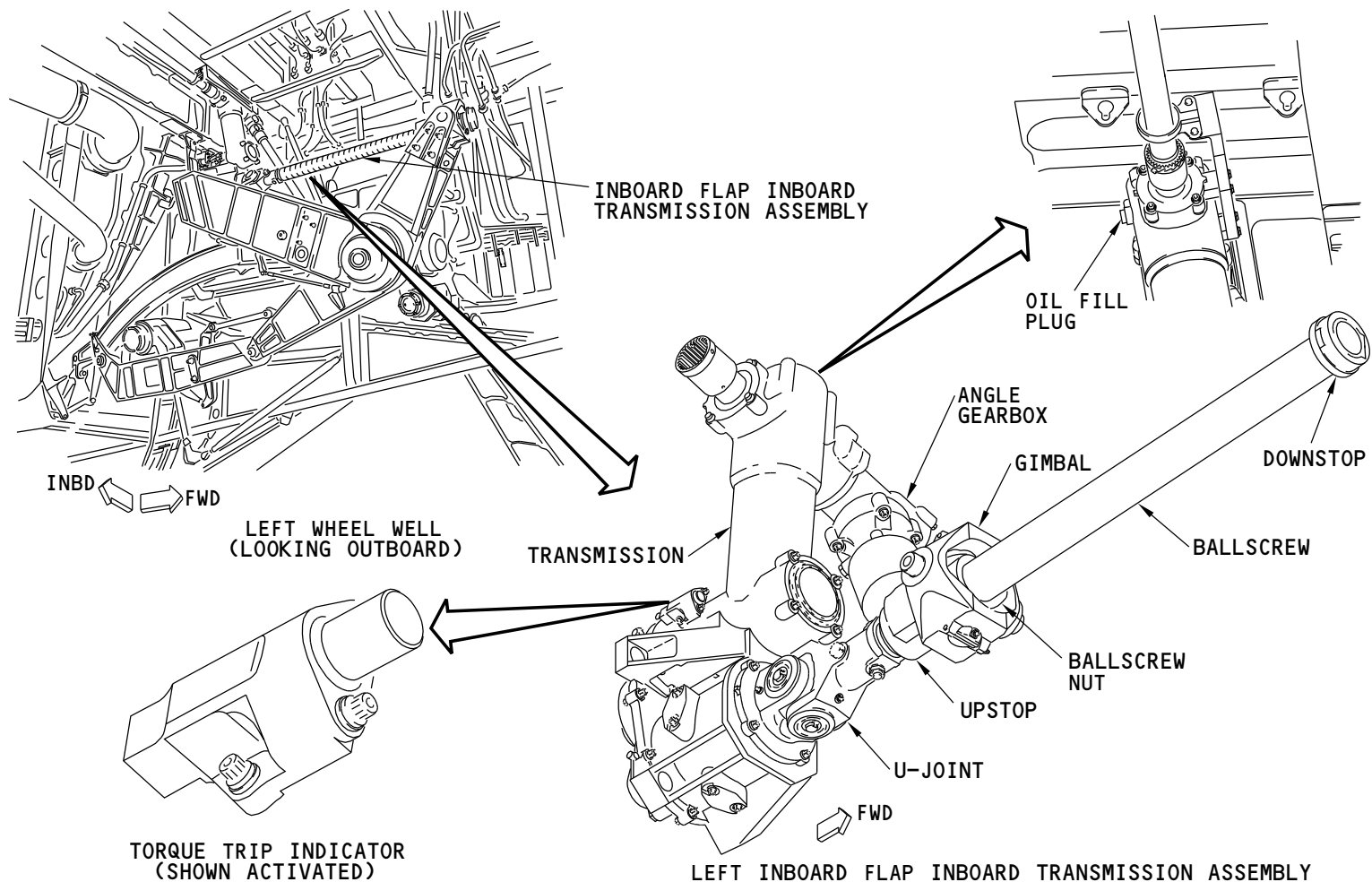
DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

27-51-00

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M41123 S000617481_V1

TRAILING EDGE FLAPS - INBOARD FLAP INBOARD TRANSMISSION ASSEMBLY

27-51-00

27-51-00-017

ARO ALL	EFFECTIVITY
	D633W101-ARO

TRAILING EDGE FLAPS - INBOARD FLAP INBOARD SUPPORT MECHANISM**Purpose**

The flap transmission, ballscrew, and gimbal use the flap support mechanism to extend and retract the inboard flap and aft flap.

Location

There is one inboard flap inboard support mechanism in each main landing gear wheel well.

Functional Description

During extension, the gimbal turns the drive arm about its fixed point. The drive arm moves the flap carrier beam. This beam attaches to the main flap support which attaches to the main flap. As the carrier beam moves, the main flap extends. The main flap roller and track control the position of the main flap as it extends.

The drive arm also moves the aft flap pushrods to extend the aft flap. Rollers and a track control the rotation of the aft flap as it extends. The aft flap extends beyond the trailing edge of the main flap only at flap positions greater than 20.

Retraction is the opposite of extension.

Training Information Point

When manually operating the flap drive system, observe this caution:



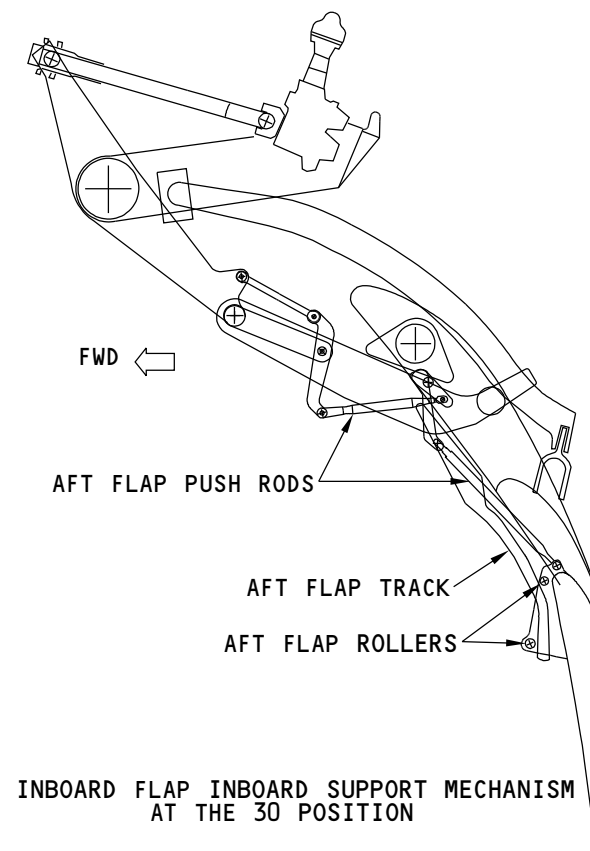
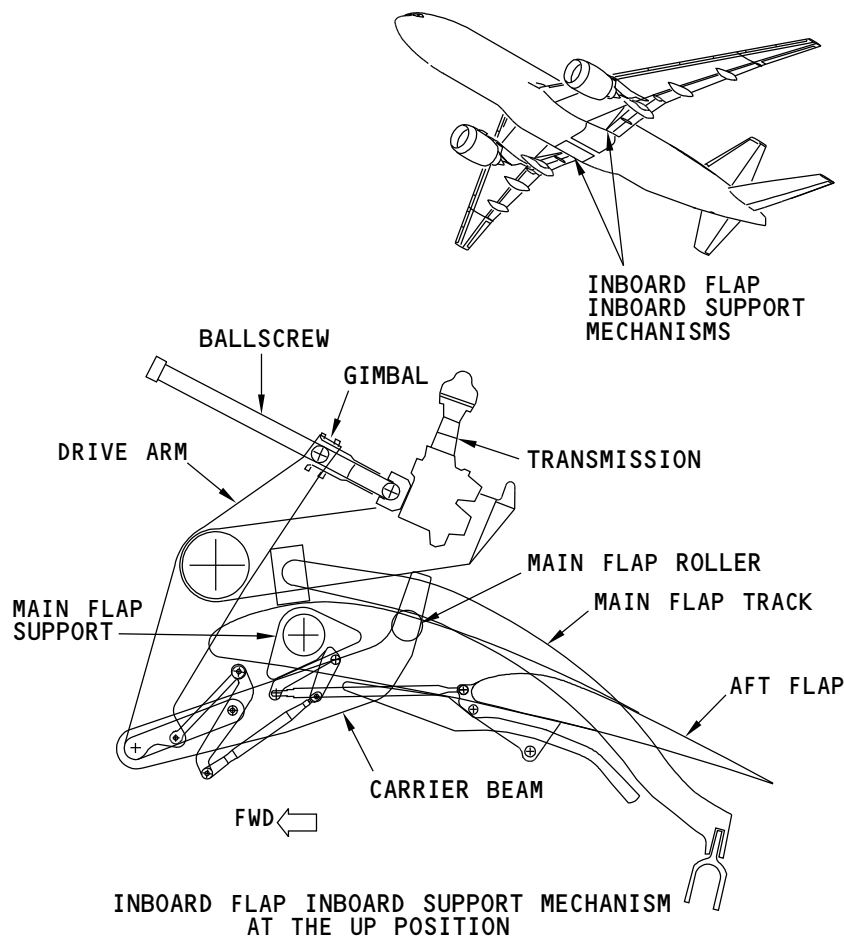
DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

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M41124 S000617482_V1

TRAILING EDGE FLAPS - INBOARD FLAP INBOARD SUPPORT MECHANISM

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TRAILING EDGE FLAPS - INBOARD FLAP OUTBOARD TRANSMISSION ASSEMBLY

Purpose

The inboard flap outboard transmission assembly receives power from the torque tubes to move the inboard flap.

Location

The inboard flap outboard transmission assembly is just inboard of the engines. Access to the assembly is through the fixed and moveable flap support fairings.

Physical Description

The transmission assembly is similar to the inboard flap inboard transmission assembly, but they are not interchangeable.

The transmission assembly weighs approximately 98 lb (45 kg).

Functional Description

The inboard flap outboard transmission assembly operation is similar to the inboard flap inboard transmission assembly.

Training Information Point

The transmission contains oil and it is necessary to do servicing at specified times. Use the oil fill plug.

When manually operating the flap drive system, observe this caution:

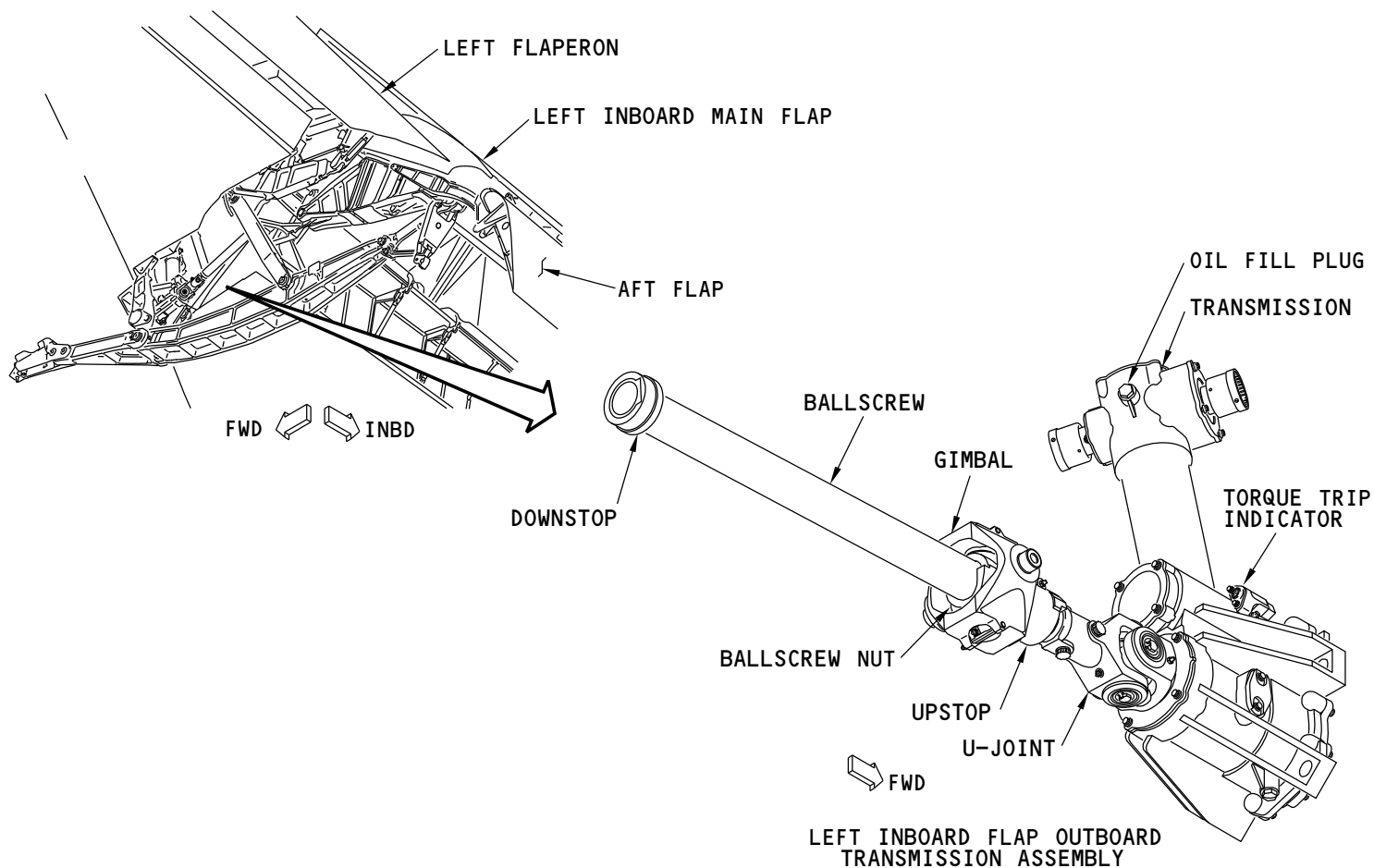


DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

27-51-00EFFECTIVITY
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M41125 S000617483_V1

TRAILING EDGE FLAPS - INBOARD FLAP OUTBOARD TRANSMISSION ASSEMBLY

27-51-00

27-51-00-019

ARO ALL	EFFECTIVITY
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TRAILING EDGE FLAPS - INBOARD FLAP OUTBOARD SUPPORT MECHANISM**Purpose**

The flap transmission, ballscrew, and gimbal use the flap support mechanism to extend and retract the inboard flap and the aft flap.

Location

The inboard flap outboard support mechanism is inboard of the engines. Access requires the removal of the fixed and moveable flap support fairings.

Functional Description

During extension, the gimbal turns the drive arm about its fixed point. The drive arm moves the flap carrier to extend the main flap. The drive arm also moves the compression strut. This strut rotates the aft tension beam which uses the pivot link to control the rotation of the main flap.

The drive arm also moves the aft flap pushrods to extend the aft flap. Rollers and a track control the rotation of the aft flap as it extends. The aft flap extends beyond the trailing edge of the main flap only at flap positions greater than 20.

Retraction is the opposite of extension.

Training Information Point

When manually operating the flap drive system, observe this caution:



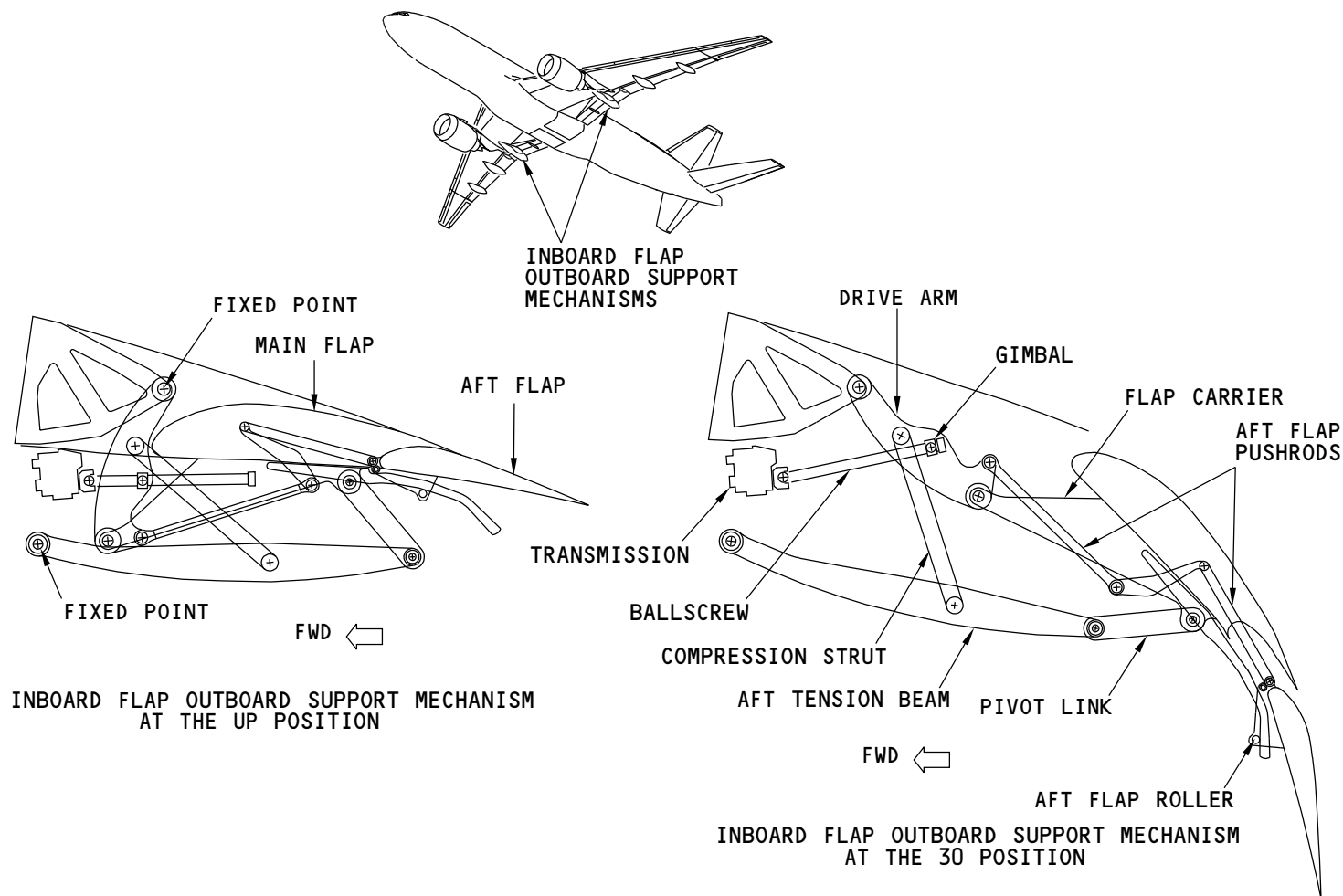
DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

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M41126 S000617484_V1

TRAILING EDGE FLAPS - INBOARD FLAP OUTBOARD SUPPORT MECHANISM

27-51-00

27-51-00-020

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TRAILING EDGE FLAPS - OUTBOARD FLAP INBOARD TRANSMISSION ASSEMBLY**Purpose**

The outboard flap inboard transmission assembly receives power from the torque tubes to move the outboard flap.

Location

The outboard flap inboard transmission assembly is just outboard of the engines. Access to the assembly is through the fixed and moveable flap support fairings.

Physical Description

The transmission assembly is similar to the inboard flap inboard transmission assembly, but they are not interchangeable.

The transmission assembly weighs about 80 lb (36 kg).

Functional Description

The outboard flap inboard transmission assembly operation is similar to the assemblies for the inboard flap.

Training Information Point

The transmission contains oil and it is necessary to do servicing. Use the oil fill plug.

Before you remove the transmission assembly, remove the flap skew sensors to prevent damage to them.

When manually operating the flap drive system, observe this caution:



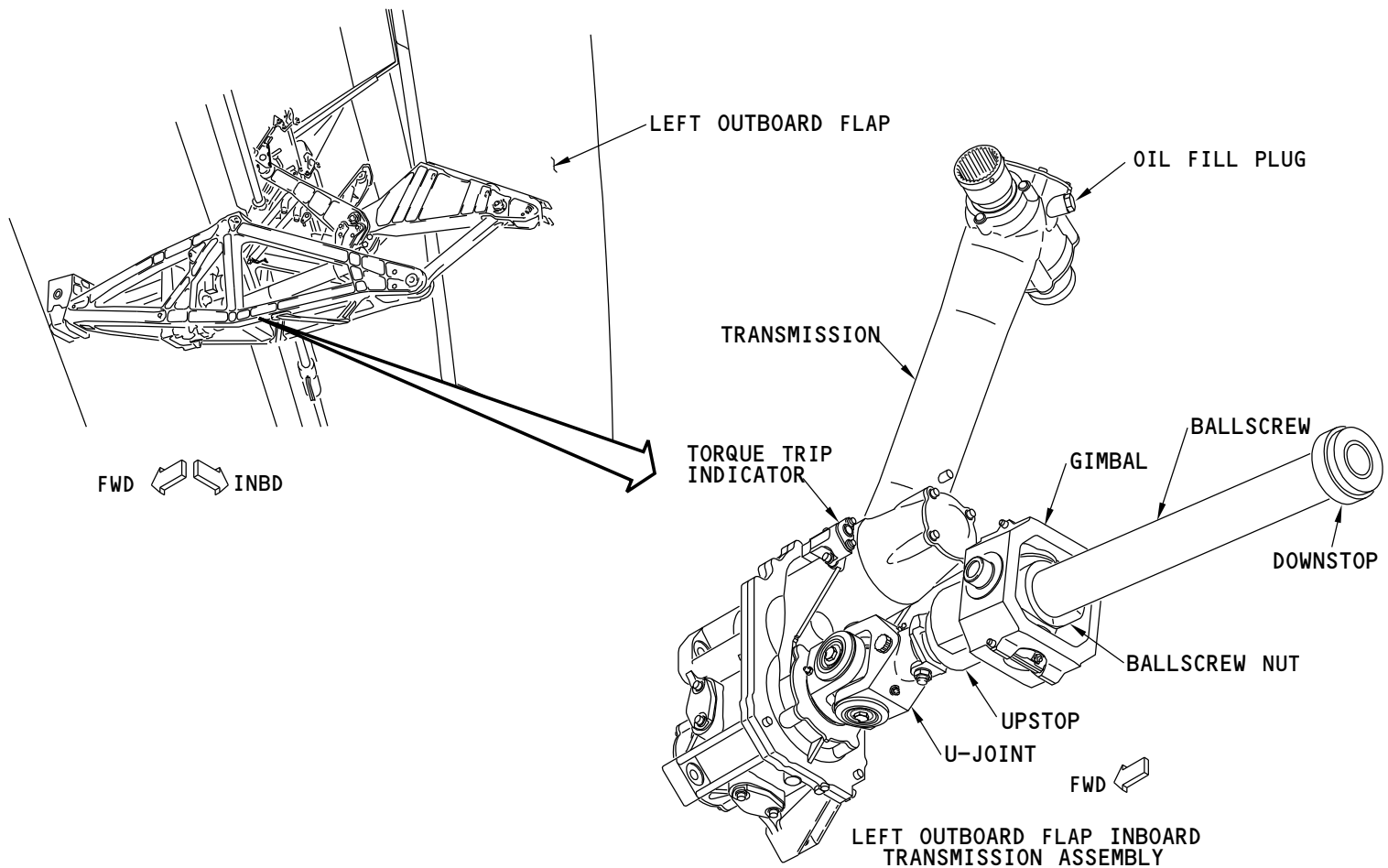
DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

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M41127 S000617485_V1

TRAILING EDGE FLAPS - OUTBOARD FLAP INBOARD TRANSMISSION ASSEMBLY

27-51-00

27-51-00-021

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TRAILING EDGE FLAPS - OUTBOARD FLAP OUTBOARD TRANSMISSION ASSEMBLY**Purpose**

The outboard flap outboard transmission assembly gets power from the torque tubes to move the outboard flap.

Location

The outboard flap outboard transmission assembly is near the outboard end of the outboard flap. Access to the assembly is through the fixed and moveable flap support fairings.

Physical Description

The transmission assembly is similar to the inboard flap inboard transmission assembly, but they are not interchangeable.

The transmission assembly weighs approximately 65 lb (30 kg).

Functional Description

The outboard flap outboard transmission assembly operation is similar to the assemblies for the inboard flap.

Training Information Point

The transmission contains oil and it is necessary to do servicing at specified times. Use the oil fill plug.

Before removing the transmission assembly, remove the flap skew sensors to prevent damage to them.

When manually operating the flap drive system, observe this caution:



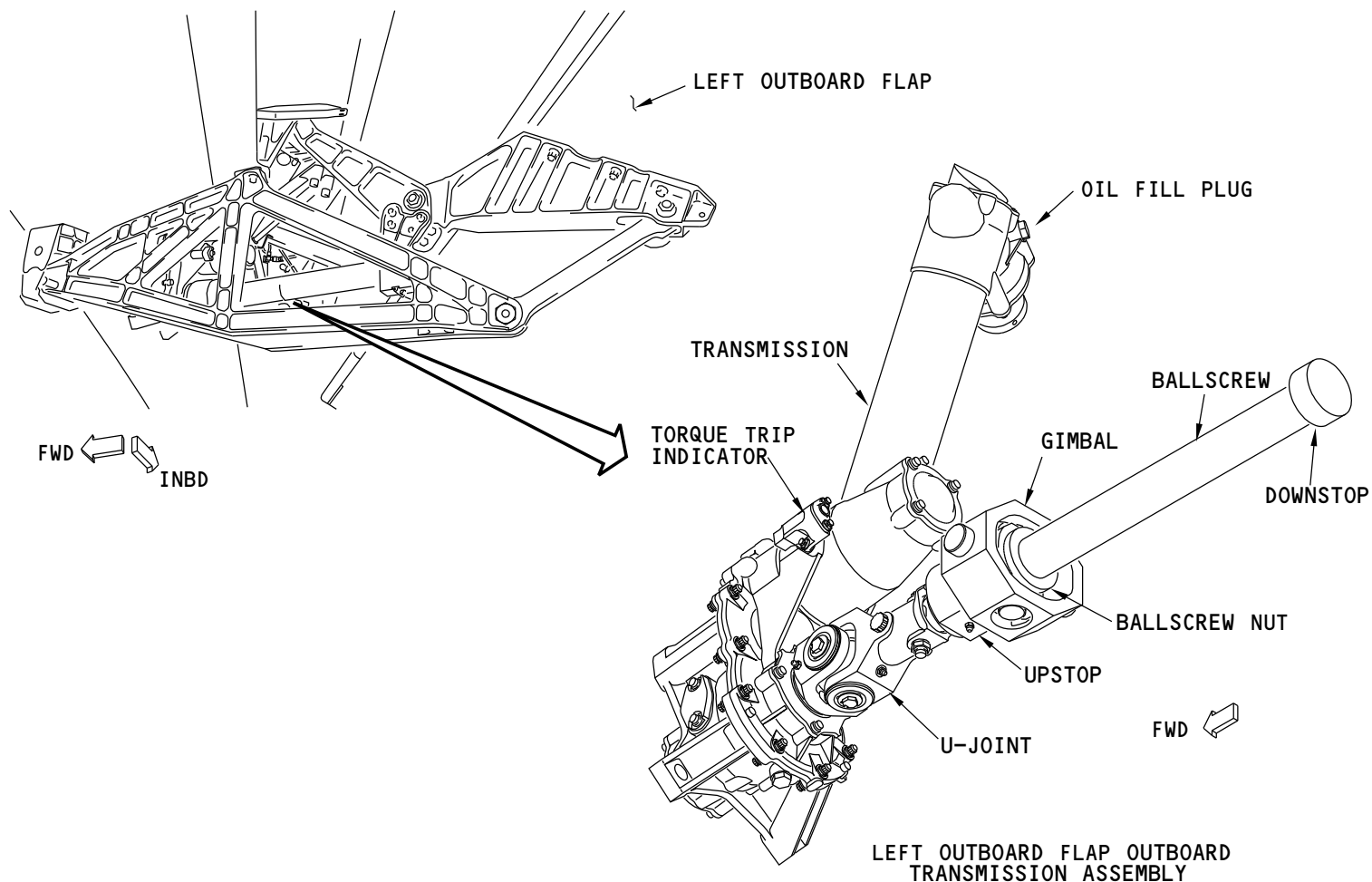
DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

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TRAILING EDGE FLAPS - OUTBOARD FLAP OUTBOARD TRANSMISSION ASSEMBLY

27-51-00

27-51-00-022

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TRAILING EDGE FLAPS - OUTBOARD FLAP SUPPORT MECHANISMS

Purpose

The flap transmission, ballscrew, and gimbal use the flap support mechanism to extend and retract the outboard flap.

Location

The outboard flap support mechanisms are near the ends of the outboard flap. To get access to the assemblies, remove the fixed and moveable flap support fairings.

Functional Description

During extension, the gimbal turns the drive arm about the fixed point. The drive arm moves the flap carrier to extend the outboard flap. The pivot link controls the rotation of the flap.

Retraction is the opposite of extension.

Training Information Point

When manually operating the flap drive system, observe this caution:



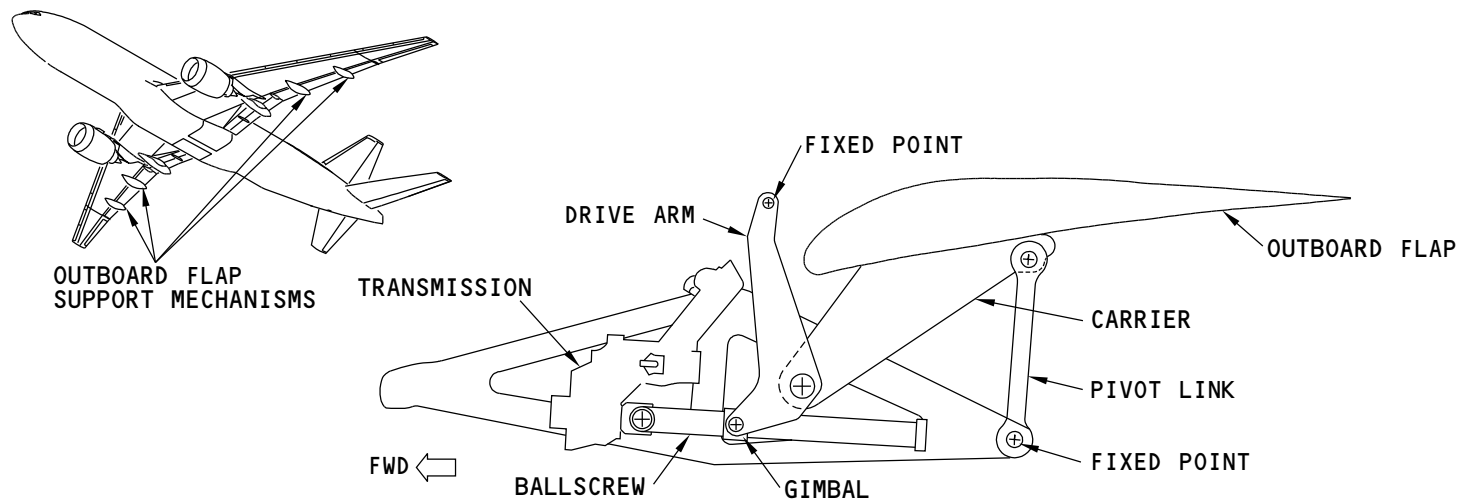
DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

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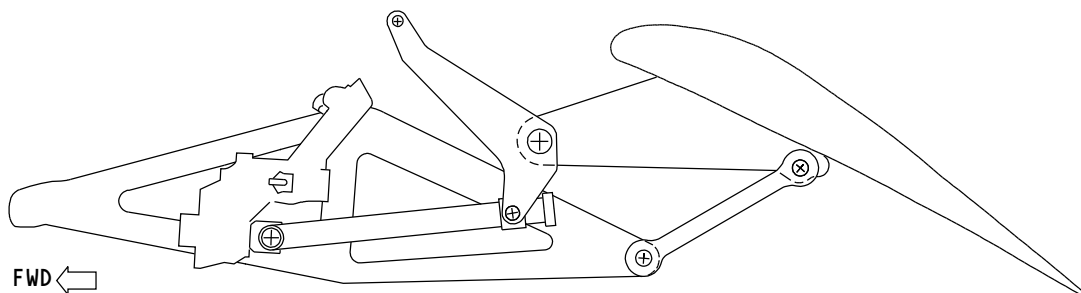
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OUTBOARD FLAP SUPPORT MECHANISM
AT THE UP POSITION



OUTBOARD FLAP SUPPORT MECHANISM
AT THE 30 POSITION

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TRAILING EDGE FLAPS - OUTBOARD FLAP SUPPORT MECHANISMS

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**TRAILING EDGE FLAPS - OUTBOARD FLAP AUXILIARY SUPPORTS****Purpose**

The outboard flap auxiliary supports make sure that the outboard flap deflection is similar to the wing deflection. When the flaps are extended, the outboard flap auxiliary supports prevent the ends of the flap from deflecting above the wing. When the flaps are retracted, the outboard flap auxiliary supports keep the flaps aligned with the wing.

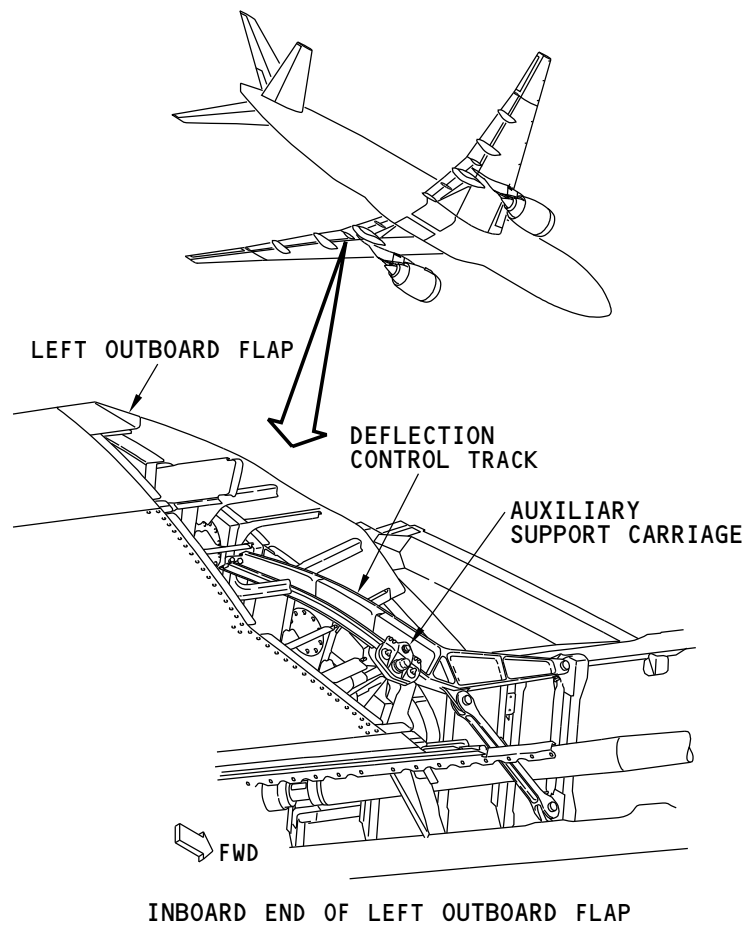
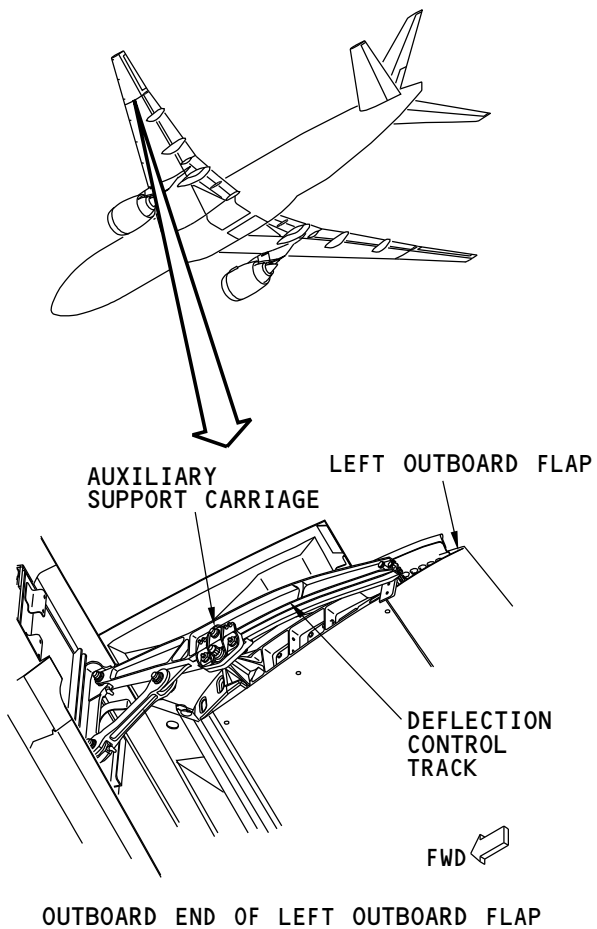
Location

There is one support at each end of the outboard flap. Access to the supports is through access panels under the wing.

Physical Description

Each outboard flap auxiliary support has a deflection control track and a carriage. The carriage attaches to the flap structure. Rollers in the carriage move along the track.

ARO ALL	EFFECTIVITY



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TRAILING EDGE FLAPS - OUTBOARD FLAP AUXILIARY SUPPORTS

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TRAILING EDGE FLAPS - INBOARD FLAP AND AFT FLAP

Purpose

The inboard main flap and aft flap increase the lift of the wing during takeoff and climbout. They also increase the lift and drag during approach and landing. During cruise, they stay in the retracted position.

Physical Description

The inboard main flap and aft flap are made of lightweight composite materials. The skin is reinforced graphite/epoxy bonded to a core of Nomex honeycomb. The dimensions of the inboard main flap are approximately 216 inches by 100 inches (5.5 m by 2.5 m). The dimensions of the aft flap are approximately 192 inches by 46 inches (4.9 m by 1.2 m). The inboard main flap weighs approximately 577 lb (262 kg) and the aft flap weighs approximately 208 lb (95 kg).

Location

The inboard main flap is between the engine and the fuselage, along the trailing edge of the wing. The aft flap attaches to the aft flap tracks along the trailing edge of the main flap.

Functional Description

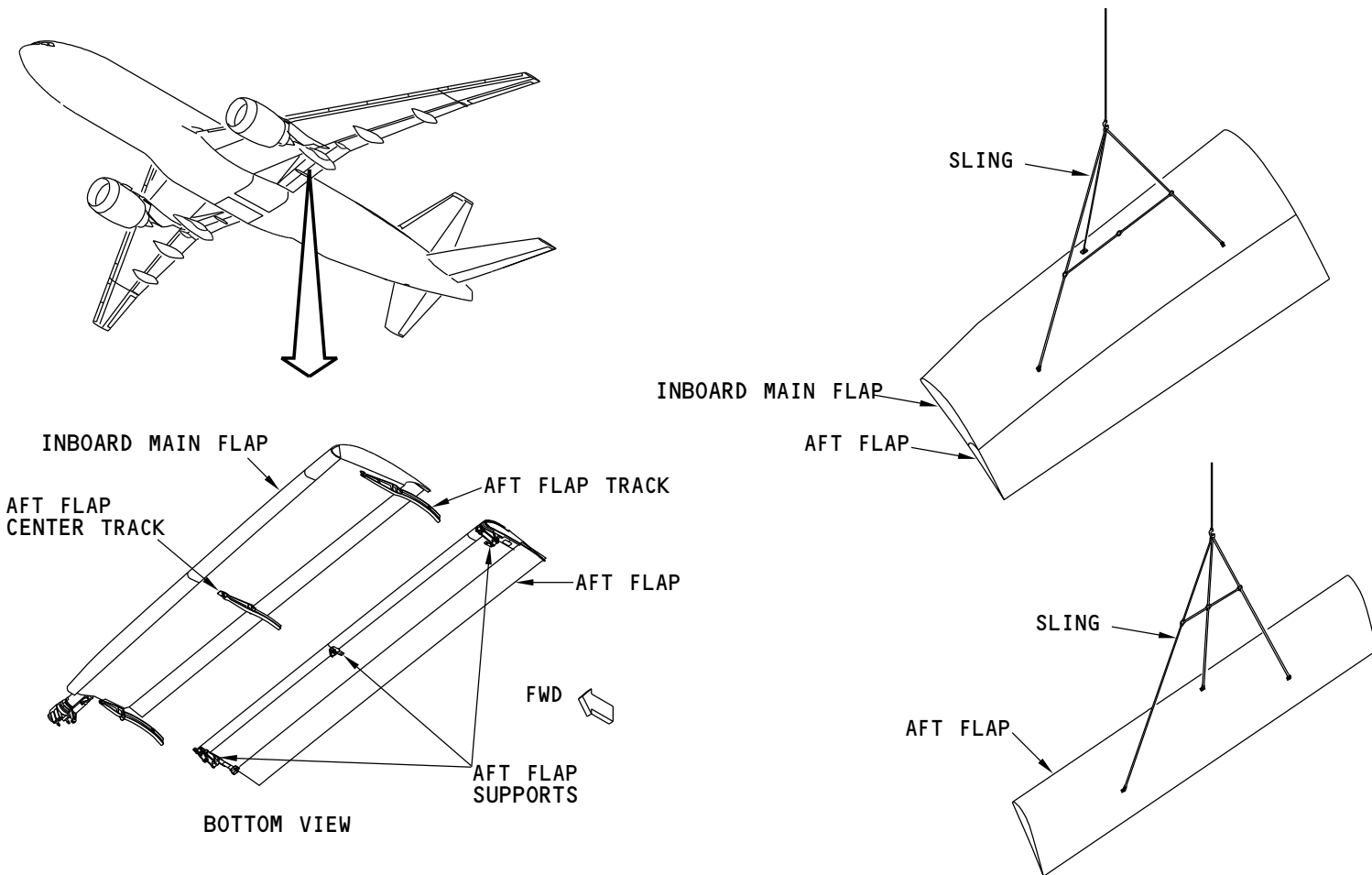
The maximum deflection of the inboard main flap is at flap position 30. The aft flap rotates with the inboard main flap from flap position UP to 20. At flap positions 25 and 30, the aft flap extends and rotates more than the inboard main flap.

Training Information Point

There are three hoist points on both the inboard main flap and the aft flap. A spreader bar is not necessary to lift the flaps.



MAKE SURE THE ADP ACCESS DOOR IS FULLY OPEN OR FULLY CLOSED WHEN YOU MOVE THE TRAILING EDGE FLAPS. THE FLAPS CAN HIT THE DOOR IF IT IS NOT FULLY OPEN OR CLOSED. THIS CAN CAUSE DAMAGE TO EQUIPMENT.



M41131 S000617489_V1

TRAILING EDGE FLAPS - INBOARD FLAP AND AFT FLAP

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TRAILING EDGE FLAPS - INBOARD FLAP SUPPORT FAIRINGS

Purpose

The inboard flap support fairings cover the flap support mechanisms which are outside of the wing to body fairing and below the wing. The fairings supply an aerodynamic enclosure.

Physical Description

All the fairings are composite materials. They attach to their support structure by bearing points and by linkages.

The fairings have access panels to permit access to the components inside the fairings.

Location

The inboard flap has two flap support fairings on each wing. One is inboard near the wing to body fairing and one is outboard. There is also a center track fairing for the inboard aft flap.

Functional Description

The inboard support fairing has a forward fairing attached to the inboard main flap and an aft fairing attached to the inboard aft flap. The forward and aft fairings move with the main and aft flaps.

The center track fairing has a forward fairing attached to the inboard main flap and an aft fairing attached to the aft flap. The forward and aft fairings move with the main and aft flaps.

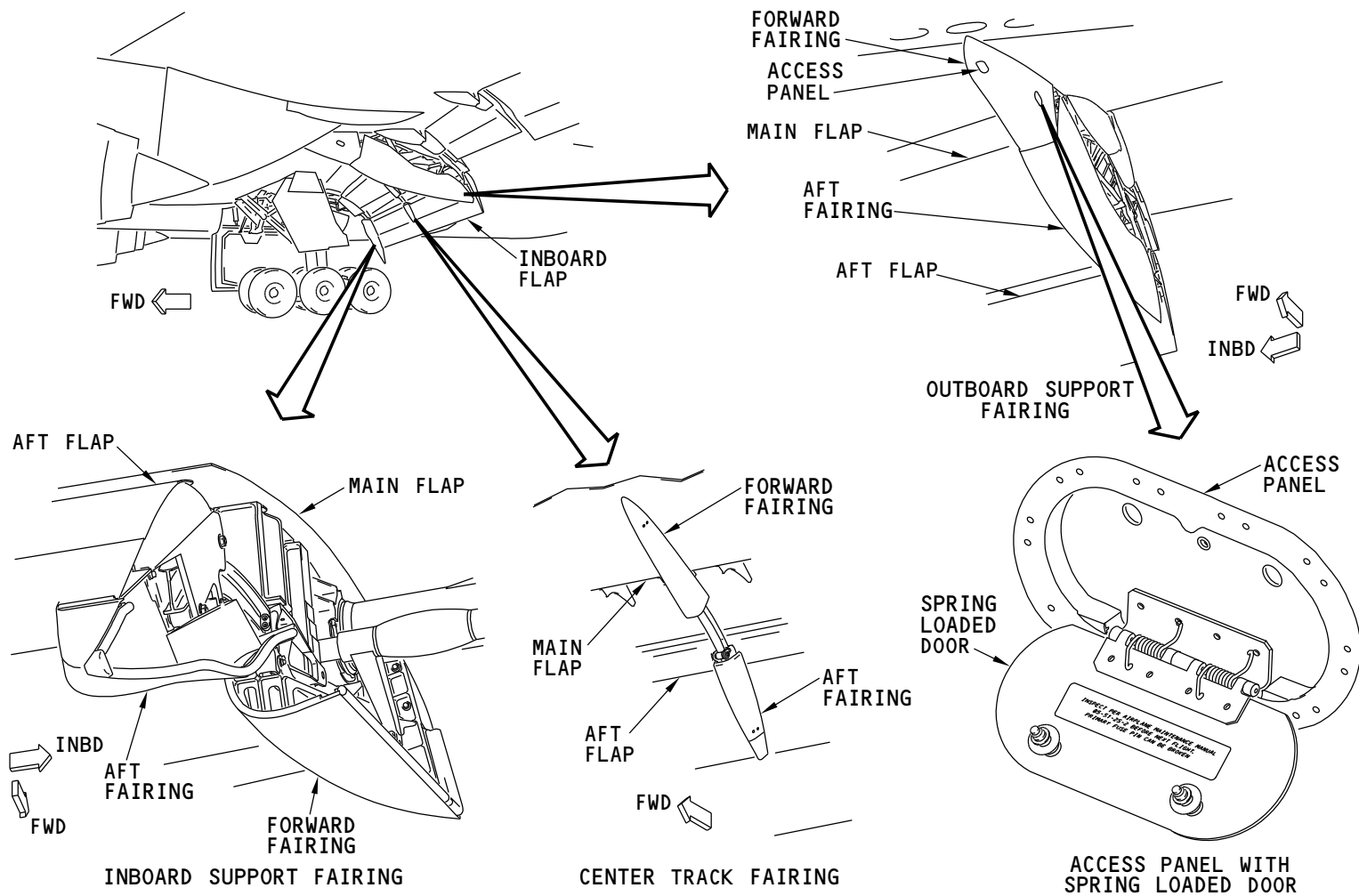
The outboard support fairing has a forward fairing attached to the wing lower surface and an aft fairing attached to the outboard flap support mechanism. The outboard support fairing moves down during the inboard flap extension to supply the clearance for the main and aft flap movement.

Training Information Point

There is a spring loaded door on the access panel on the outboard side of the outboard forward fairing for the inboard flap. This door is not for access to any components. It opens automatically to show that the primary fuse pin has sheared. The primary fuse pin connects the outboard support structure of the inboard flap to the wing. When the primary fuse pin shears, the load transfers to the secondary fuse pin. This causes the flap structure to move and to operate a mechanism that releases the door latch. Springs open the door and keep it open.

If you see this door open on the outboard forward fairing for the inboard flap, it is necessary to make an inspection of the fuse pins and make applicable corrections.

EFFECTIVITY	
ARO ALL	



M41139 S000617498_V1

TRAILING EDGE FLAPS - INBOARD FLAP SUPPORT FAIRINGS

27-51-00

27-51-00-034

ARO ALL	EFFECTIVITY
	D633W101-ARO

**TRAILING EDGE FLAPS - OUTBOARD FLAP****Purpose**

The outboard flaps increase the lift of the wing during takeoff and climbout. They also increase the lift and drag during approach and landing. They are retracted during cruise.

Physical Description

The outboard flap is made of lightweight composite materials. The skin is reinforced graphite/epoxy bonded to a core of Nomex honeycomb. The dimensions of the outboard flap are approximately 528 inches by 76 inches (13.4 m by 1.9 m). The outboard flap weighs about 616 lb (280 kg).

Location

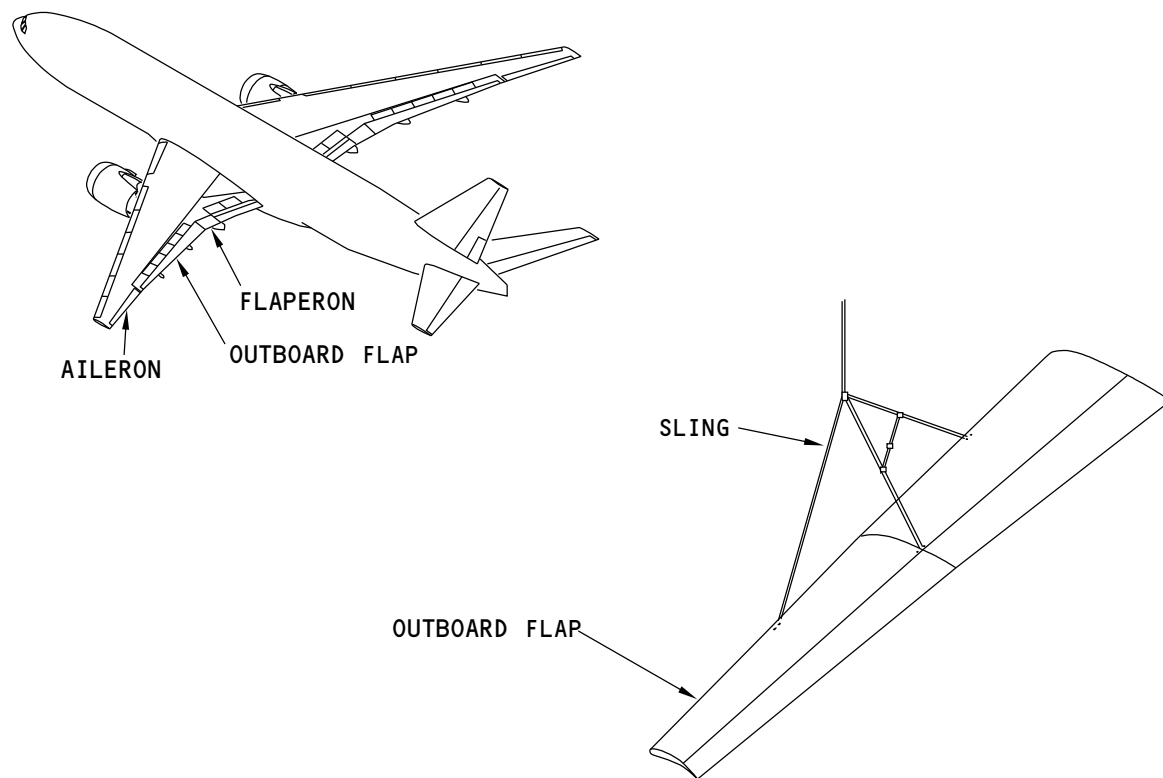
The outboard flap is between the flaperon and the aileron, along the trailing edge of the wing.

Functional Description

The maximum deflection of the outboard flap is 36 degrees at flap lever position 30.

Training Information Point

There are three hoist points on the outboard flap. A spreader bar is not necessary to lift the flaps.



TRAILING EDGE FLAPS - OUTBOARD FLAP

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**TRAILING EDGE FLAPS - OUTBOARD FLAP SUPPORT FAIRINGS****Purpose**

The outboard flap support fairings cover the flap support mechanisms which are below the wing. The fairings supply a streamlined and aerodynamic enclosure.

Physical Description

All the fairings are composite materials. They attach to their support structure by bearing points and by linkages.

Location

The outboard flap has two flap support fairings on each wing. One is inboard and one is outboard.

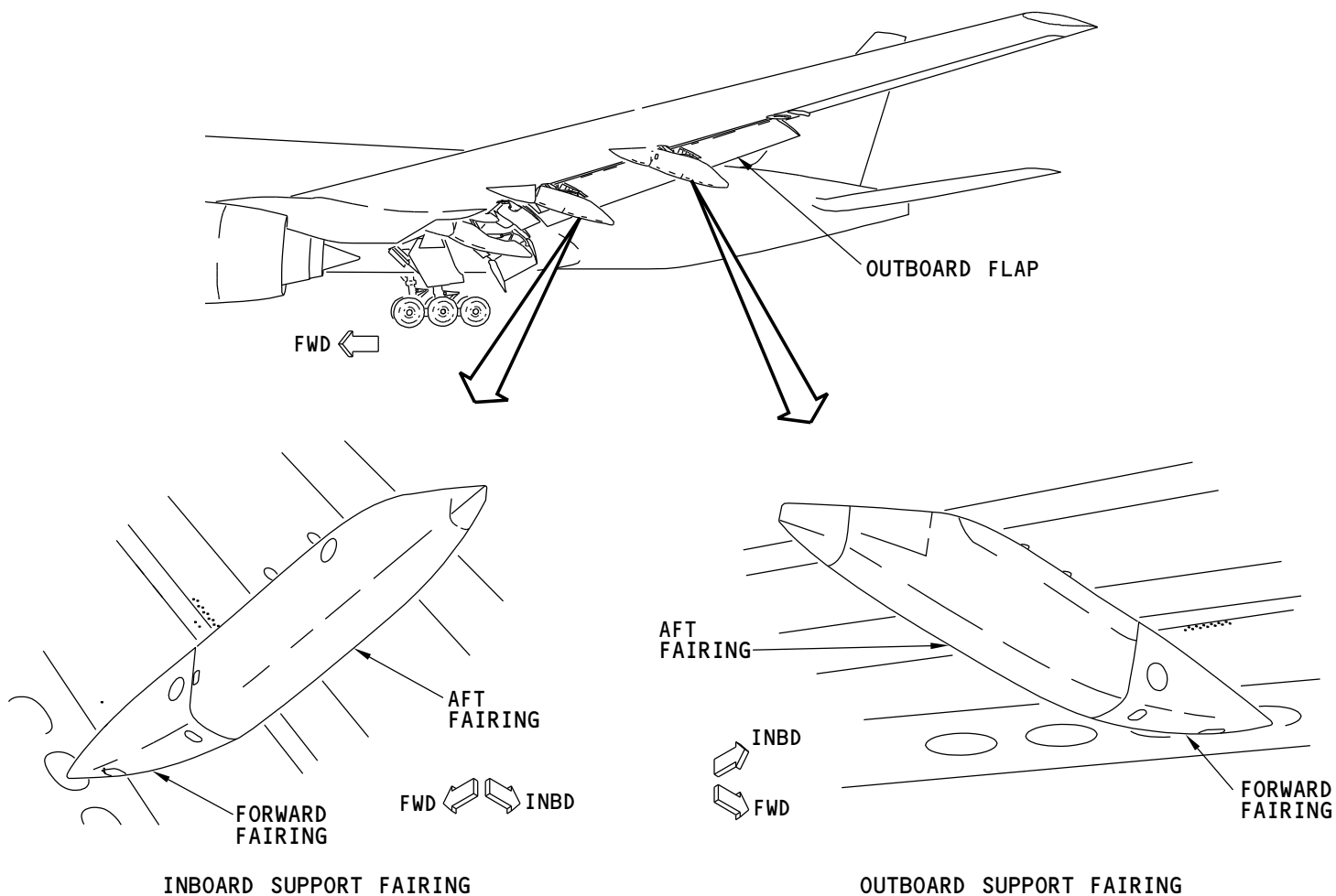
Functional Description

The inboard and outboard support fairings for the outboard flap each have a forward fairing attached to the wing lower surface and an aft fairing attached to the flap support mechanism. The aft fairings move down during the outboard flap extension to provide the clearance for the flap movement.

ARO ALL	EFFECTIVITY

27-51-00

D633W101-ARO



M41140 S000617499_V1

TRAILING EDGE FLAPS - OUTBOARD FLAP SUPPORT FAIRINGS

27-51-00

27-51-00-035

ARO ALL	EFFECTIVITY
	D633W101-ARO

TRAILING EDGE FLAPS - FUNCTIONAL DESCRIPTION - PRIMARY MODE CONTROL

General

Only one FSEU commands the flaps in the primary mode.

In the primary mode, the FSEU controls:

- Flap retraction and extension
- Flap/slat sequence
- Cruise inhibit
- Flap load relief
- Low-speed control
- Shutoff control.

For redundancy, both channels in the FSEU must agree on the flap command. Each channel controls switches that are connected in series. Both channels must send the same command to the switches for the FSEU to energize the commanded solenoid.

The two coils in each solenoid of the primary control valve get electrical power from different power sources. Each FSEU controls the ground for one of the coils in each solenoid.

Flap Retraction and Extension

The FSEU compares the flap lever position to the flap position. The flaps retract if the flap lever position is less than the flap position. The flaps extend if the flap lever position is greater than the flap position.

Flap/Slat Sequence

This function controls the sequence of the retraction and extension of the flaps and slats. See the high lift control section for more information about the primary mode flap and slat sequence (SECTION 27-03).

Cruise Inhibit

This function prevents flap extension during cruise. This happens when the airspeed is more than 275 knots or the altitude is above 20,300 feet.

Flap Load Relief

This function commands the flaps to retract if the airspeed increases above the flap load relief limit.

Low-Speed Control

This function reduces the speed of flap movement as the flaps approach the commanded position. The FSEU energizes the low-speed solenoid when the flaps are less than approximately seven torque tube turns from the commanded position.

Shutoff Control

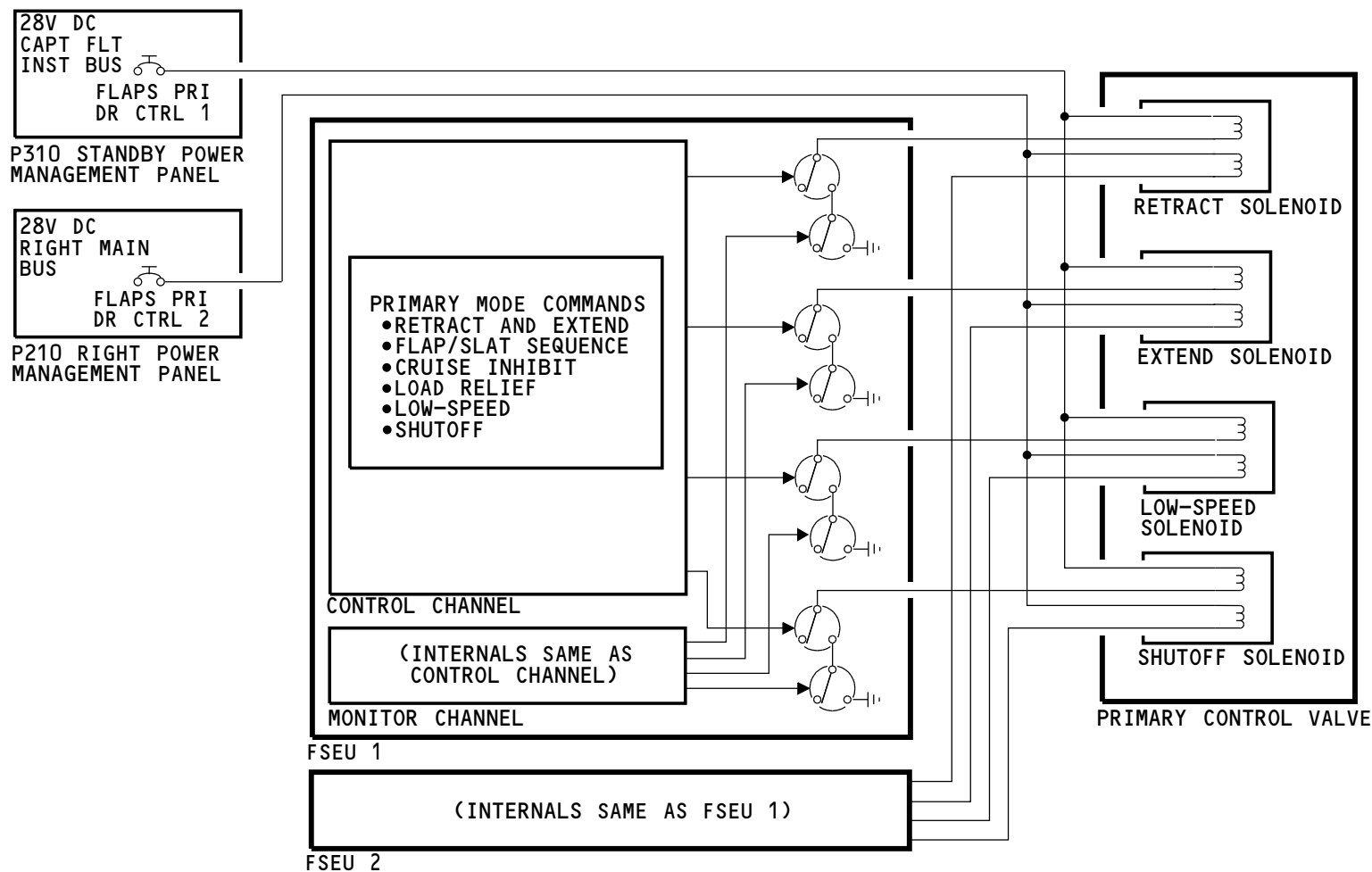
The FSEU energizes the shutoff solenoid valve to open when there is a retract or extend command.

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M41133 S000617491_V1

TRAILING EDGE FLAPS - FUNCTIONAL DESCRIPTION - PRIMARY MODE CONTROL

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Sep 05/2016



TRAILING EDGE FLAPS - LOAD RELIEF - FUNCTIONAL DESCRIPTION

General

The flap load relief function prevents damage to the flaps and their support structures from large aerodynamic forces.

Flap load relief limits the position of the flaps as a function of airspeed. This function initiates when the airspeed is more than one knot more than the flap placard speeds.

Flap load relief operates only in the primary mode. It compares the flap lever command position to the airspeed.

Load relief is active if the airspeed increases above the load relief limit for more than one half second. Load relief then retracts the flaps or prevents the flaps from extending to the commanded position. Flap load relief retracts the flaps to these positions:

- 25
- 20
- 15
- 5.

The flap load relief command resets when the airspeed decreases below a set value. The load relief command also resets when the pilot moves the flap lever to or below the flap load relief position.

Load Relief - 25

Load relief retracts the flaps to 25 if the flap lever is at 30 and the airspeed is more than 181 knots. The load relief command resets if the airspeed decreases to less than 175 knots.

Load Relief - 20

Load relief retracts the flaps to 20 if the flap lever is at 30 or 25 and the airspeed is more than 201 knots. The load relief command resets if the airspeed decreases to less than 195 knots.

Load Relief - 15

Load relief retracts the flaps to 15 if the flap lever is at 30, 25, or 20 and the airspeed is more than 226 knots. The load relief command resets if the airspeed decreases to less than 220 knots.

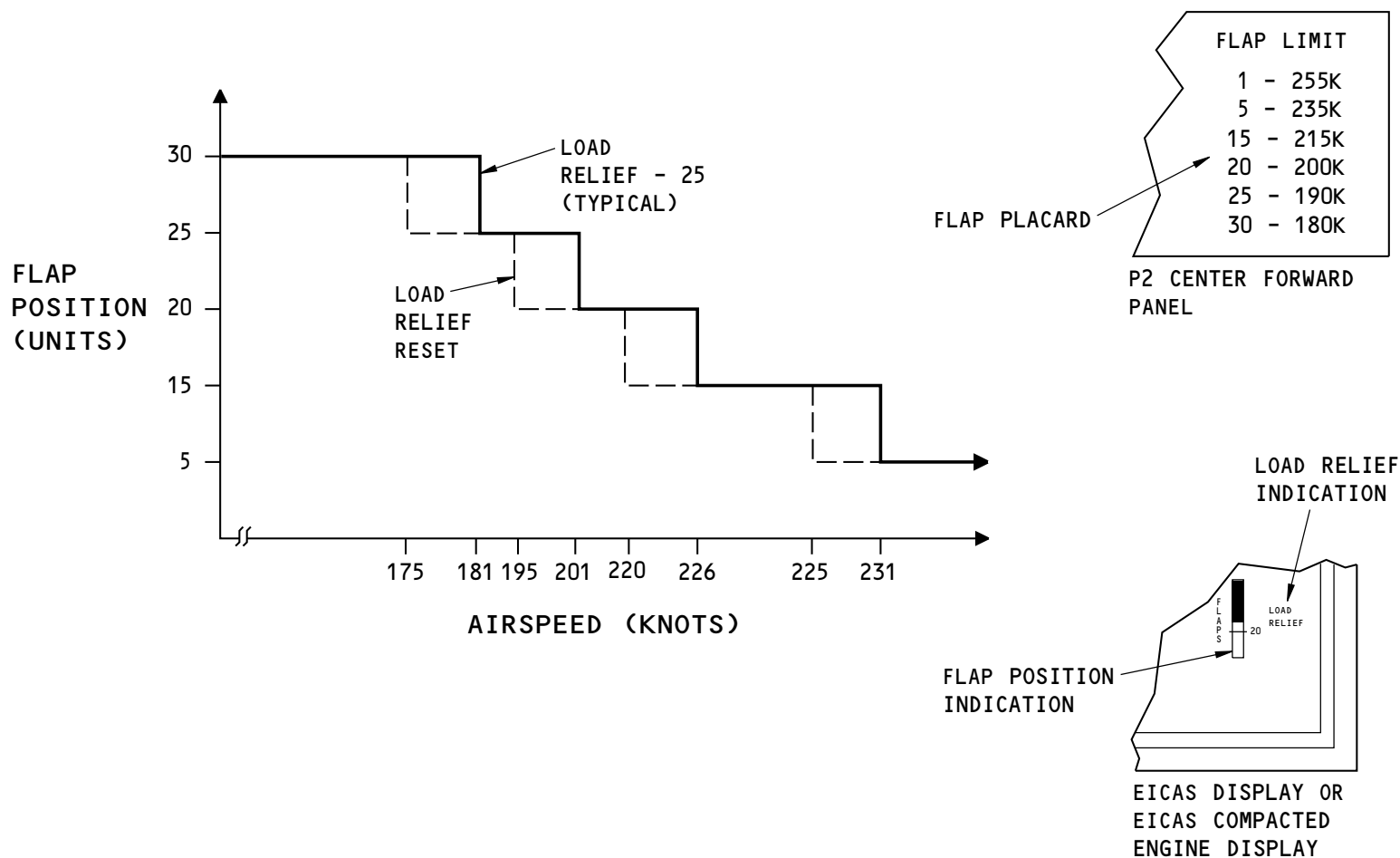
Load Relief - 5

Load relief retracts the flaps to 5 if the flap lever is at 30, 25, 20, or 15 and the airspeed is more than 231 knots. The load relief command resets if the airspeed decreases to less than 225 knots.

Indication

When flap load relief is active, the LOAD RELIEF message shows on the EICAS display or on the EICAS compacted engine display.

The flap position indication shows the position of the flaps. During load relief, the command bar and detent number change to magenta and do not agree with the flap position.



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TRAILING EDGE FLAPS - LOAD RELIEF - FUNCTIONAL DESCRIPTION

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TRAILING EDGE FLAPS - FUNCTIONAL DESCRIPTION - SECONDARY MODE CONTROL

General

Only one FSEU commands the flaps in the secondary mode.

The FSEU controls:

- Secondary mode engage
- Retraction and extension
- Flap/slat sequence
- Cruise Inhibit
- Secondary mode auto test.

For redundancy, both channels in the FSEU must agree on the flap command.

In the secondary mode, the FSEUs energize relays. The relays control the electrical power to the electric motor, clutch, and bypass solenoid. The alternate mode operation also uses these relays.

Secondary Mode Engage

When the FSEU engages the secondary mode, it energizes the bypass/clutch relay.

See the high lift control section for more information about the mode selection (SECTION 27-03).

This relay has three functions. First, the bypass/clutch relay supplies power to the bypass solenoid in the primary control valve. This prevents hydraulic operation in the primary mode.

Second, this relay supplies power to the clutch in the electric motor. This permits the electric motor to move the flap drive system.

Third, the bypass/clutch relay supplies power to the extend and retract relays. These relays do not energize until the FSEUs supply the grounds for them.

Retraction and Extension

The FSEU compares the flap lever position to the flap position. The flaps retract if the flap lever position is less than the flap position. The flaps extend if the flap lever position is greater than the flap position.

Either FSEU can energize the extend and retract relays to move the flaps. These relays supply 115v ac power to the electric motor.

Flap/Slat Sequence

This function controls the sequence of the retraction and extension of the flaps and slats. See the high lift control section for more information about the secondary mode flap and slat sequence (SECTION 27-03).

Cruise Inhibit

This function prevents flap extension during cruise. This happens when the airspeed is more than 275 knots or the altitude is above 20,300 feet.

Secondary Mode Auto Test

The secondary mode auto test checks the operation of the secondary mode. After 100 flight cycles, the FSEUs begin the test when the flaps are commanded to extend. The test does the following:

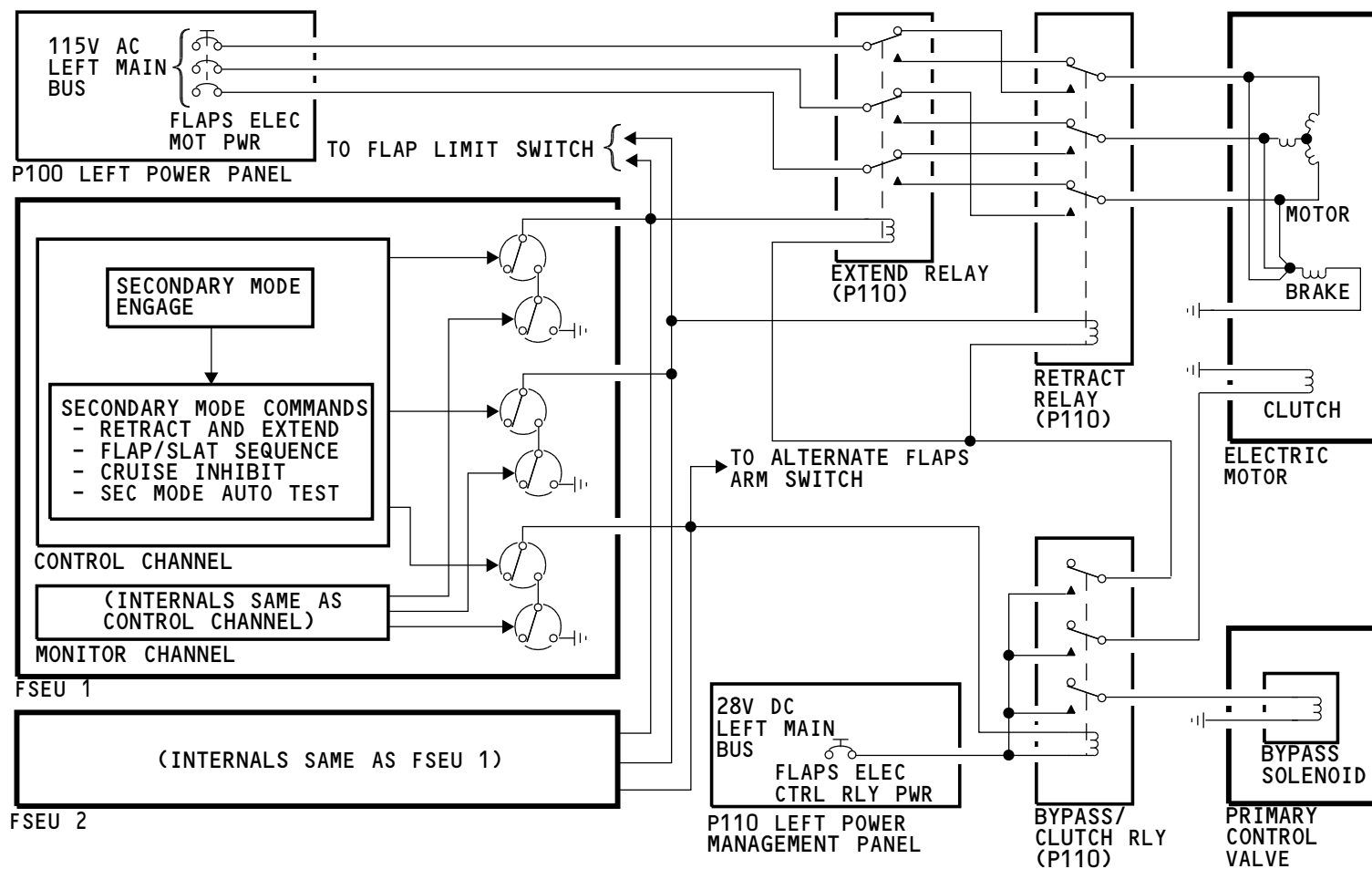
- Disengages the primary mode
- Engages the electric motor clutch
- Extends the flaps for two seconds using the electric motor.

One flight cycle is when all of these conditions occur for two seconds:

- Airplane not on the ground
- Airspeed is greater than 70 knots
- Flap lever is at up
- Flaps are at up.

If the flaps fail to extend during the secondary mode auto test, the FLAPS SECONDARY FAIL status message shows.

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TRAILING EDGE FLAPS - FUNCTIONAL DESCRIPTION - SECONDARY MODE CONTROL

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TRAILING EDGE FLAPS - FUNCTIONAL DESCRIPTION - ALTERNATE MODE CONTROL**General**

The alternate mode operation of the flaps is almost the same as the alternate mode operation of the slats.

See the leading edge slats section for more information about the slats alternate mode control (SECTION 27-81).

In the alternate mode, the alternate flap/slat switches energize relays. The relays control the electrical power to the electric motor, clutch, and bypass solenoid.

In the alternate mode, these functions occur:

- Primary and secondary mode disengage
- Extend and retract control
- Flap/slat sequence.

Primary and Secondary Mode Disengage

When you push the alternate flaps arm switch, the FSEUs receive an alternate arm discrete. The FSEUs use this discrete to disengage the primary and secondary modes.

The alternate flaps arm switch also supplies a ground for the bypass/clutch relay. The operation of the bypass/clutch relay in the alternate mode is the same as in the secondary mode.

Extend and Retract Control

When the alternate flaps selector is in the extend (EXT) position, it supplies a ground for the extend relay to extend the flaps. When this relay energizes, it supplies 115v ac power to the electric motor. The flap limit switch de-energizes this relay when the flaps move to their extend limit. In the alternate mode, this limit is at the flap 20 position.

When the alternate flaps selector is in the retract (RET) position, it supplies a ground for the retract relay to retract the flaps. When this relay energizes, it supplies 115v ac power to the electric motor. The flap limit switch de-energizes this relay when the flaps move to the up position.

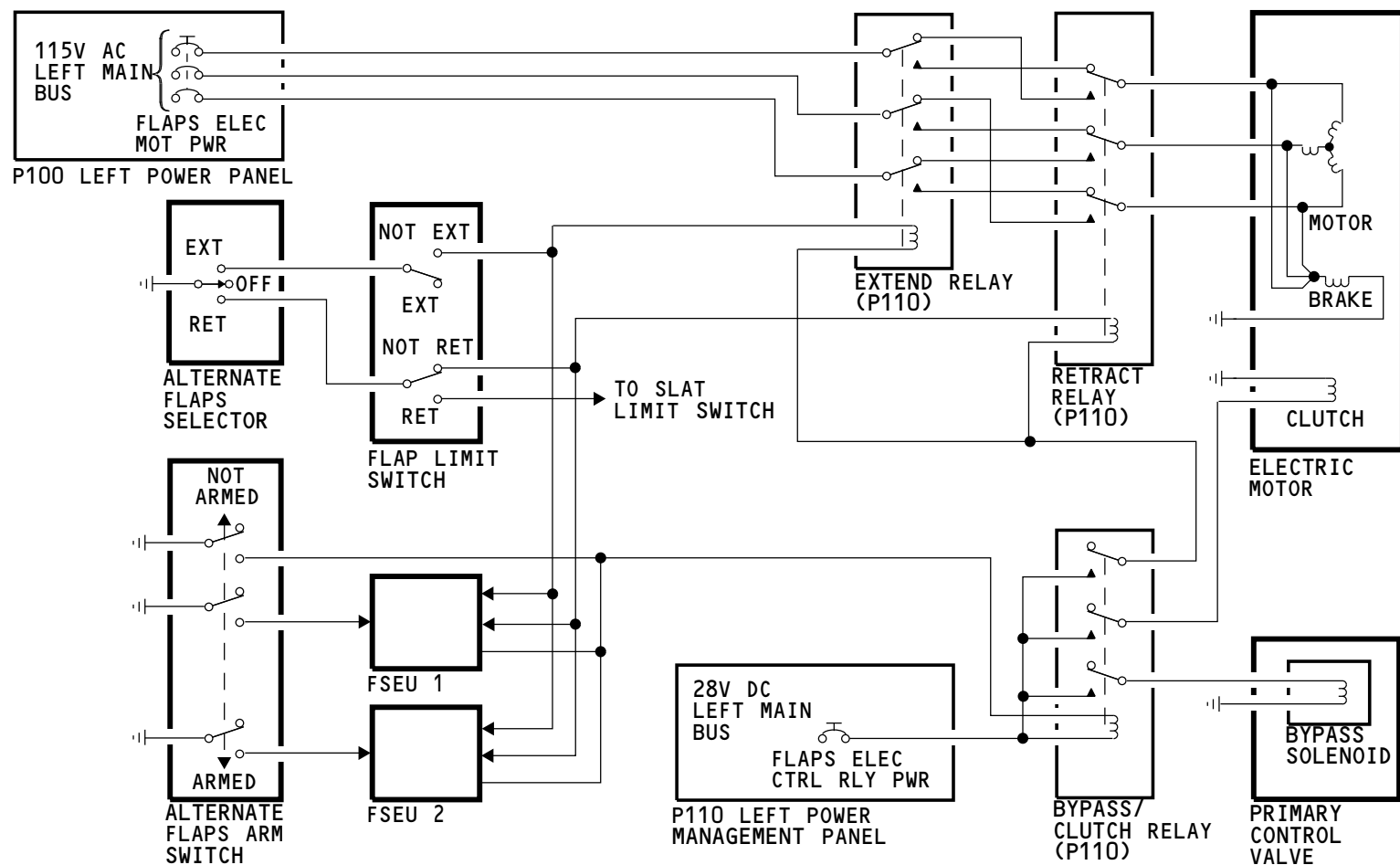
When the alternate flaps selector is in the off position, the grounds for the extend and retract relays is removed. This de-energizes the relays and stops the flap movement.

Flap/Slat Sequence

During extension, both the flaps and slats extend at the same time.

During retraction, the flap limit switch prevents retraction of the slats until the flaps are fully retracted.

See the high lift control section for more information about the alternate mode flap and slat sequence (SECTION 27-03).



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TRAILING EDGE FLAPS - FUNCTIONAL DESCRIPTION - ALTERNATE MODE CONTROL

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FLAP POSITION INDICATION - GENERAL DESCRIPTION

Purpose

The flap position indication system measures the position of the flaps and sends this data to the FSEUs. The FSEUs use this data for:

- Flap control
- Flap/slat position indication
- Failure detection.

Flap Control

The FSEUs use the flap position data during the flap operation in the primary and secondary modes. These modes have closed loop control of the flaps. Closed-loop control stops the flap command when the flap position equals the command.

Flap/Slat Position Indication

The FSEUs send the flap position data to the airplane information management system (AIMS). The AIMS uses this data to show the flap/slat position indication on the EICAS display or the EICAS compacted engine display.

The FSEUs send the flap position data to the AIMS when the data is valid. This permits flap/slat position indication in all three HLCS modes. The three flap/slat position indications are:

- The primary mode display
- The secondary mode display
- The alternate mode display.

Failure Detection

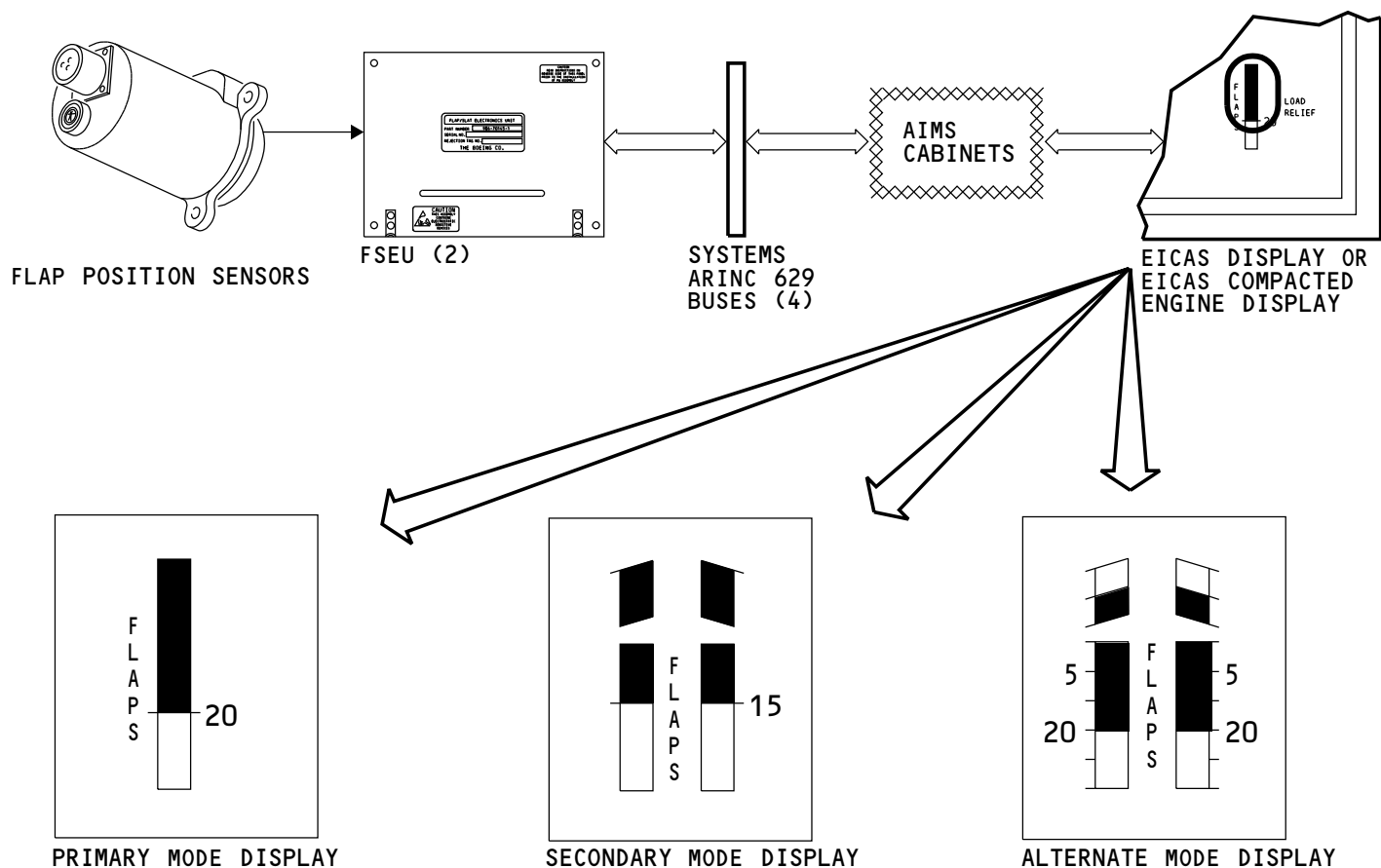
Monitors in the FSEUs compare the flap position data to the flap commands. These monitors find failures in the HLCS and the flap drive system.

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FLAP POSITION INDICATION - GENERAL DESCRIPTION

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FLAP POSITION INDICATION - FLAP POSITION SENSORS AND GEARBOX

Purpose

The flap position sensor gearboxes transmit the flap torque tube position to the flap position sensors. The flap position sensors supply flap position data to the FSEUs for flap control, flap position indication, and failure detection.

Location

The flap position sensor gearboxes attach to the floor beams in the left and right main gear wheel wells. The gearboxes are between the flap PDU and the inboard flap inboard transmissions. The flap position sensors are on the flap position sensor gearboxes. The gearbox in the right wheel well also has the flap limit switch.

Physical Description

The flap position sensor gearboxes have a rig indicator that shows when the flaps are at the UP position. The indicator has a mark that turns with the flap drive. When the mark aligns with the fixed index, the flap drive is at the UP position.

There is a manual drive connection on each gearbox that permits you to manually drive the flaps. The manual drive input shaft has a shearout feature. Remove the manual drive cover to get access to the manual drive input shaft.

The flap position sensors are resolvers and they each have a rig indicator. The rig indicator has two marks that turn when the position sensor shaft turns. The two marks are in line when the flap drive line is at the UP position. All of these sensors are interchangeable with each other and with the slat position sensors.

Training Information Point

Install the flap position sensor gearboxes with the flaps at the UP position. Make sure the index mark for the rig indicator aligns with the fixed index.

Install the flap position sensor with the flap drive line in the UP position. Make sure that the index marks on the position sensor are aligned when you install the sensor. If the index marks on the position sensor are not aligned, you must push the shaft lock pin to turn the shaft. The shaft lock pin is next to the shaft.

When you manually operate the flap drive system, observe these cautions:



CAUTION

DO NOT TURN THE MANUAL DRIVE WITH MORE THAN 1200 POUND-INCHES TORQUE OR FASTER THAN 400 RPM. YOU CAN CAUSE DAMAGE TO THE POSITION SENSOR GEARBOX AND THE TORQUE TUBES.



CAUTION

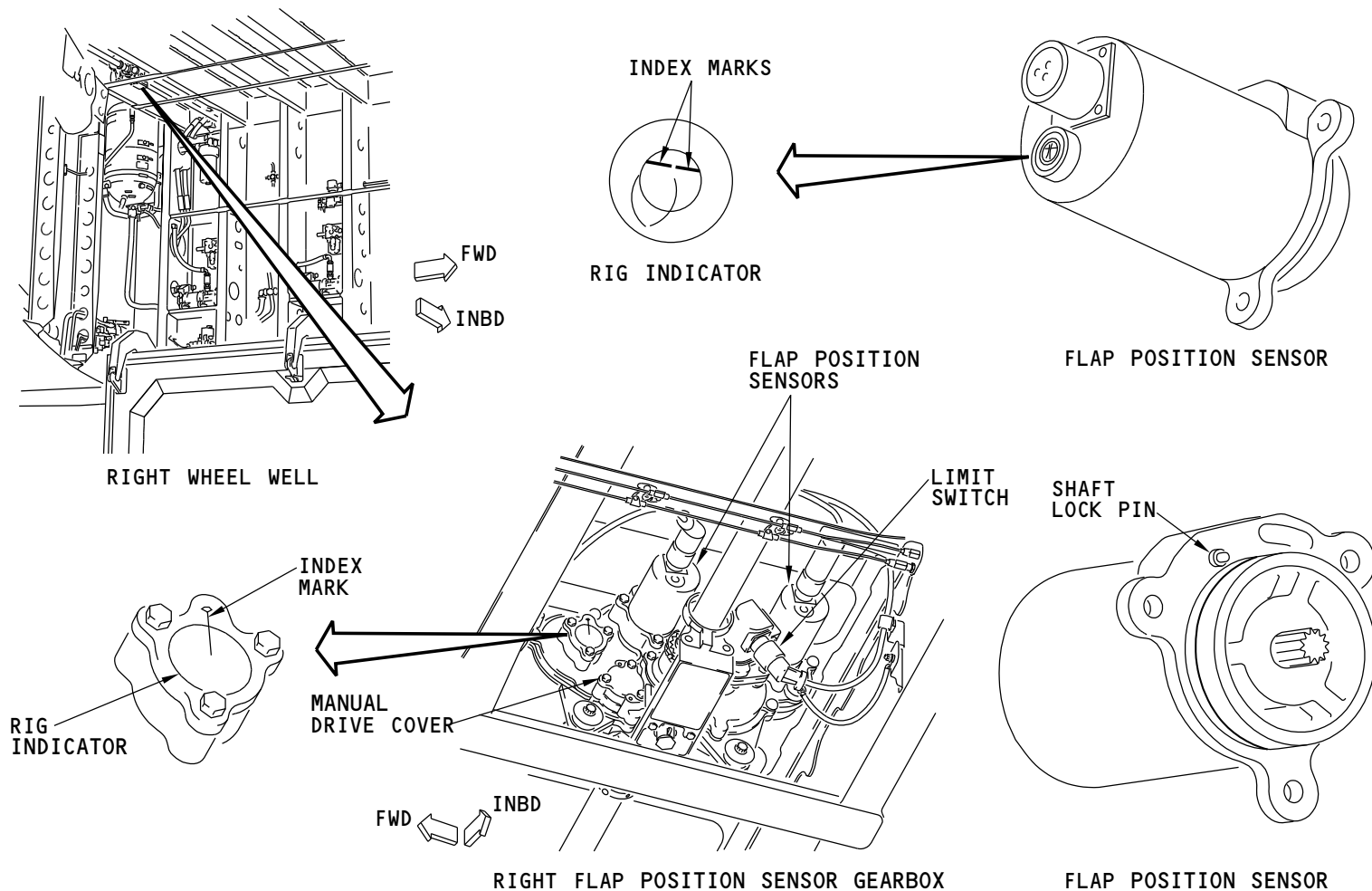
DO NOT LET THE BALLSCREW NUTS HIT THE UPSTOPS OR THE DOWNSTOPS. YOU CAN CAUSE DAMAGE TO THE SHEAROUT IN THE POSITION SENSOR GEARBOX.

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FLAP POSITION INDICATION - FLAP POSITION SENSORS AND GEARBOX

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**FLAP POSITION INDICATION - FUNCTIONAL DESCRIPTION****General**

There are four flap position sensors, two for the right wing flaps and two for the left wing flaps. Each FSEU interfaces with one sensor for the left flaps and one sensor for the right flaps. Separate power sources supply electrical power to the sensors.

Functional Description

The flap position sensors send flap position data to both the control and monitor channels. Both of these channels use this data for:

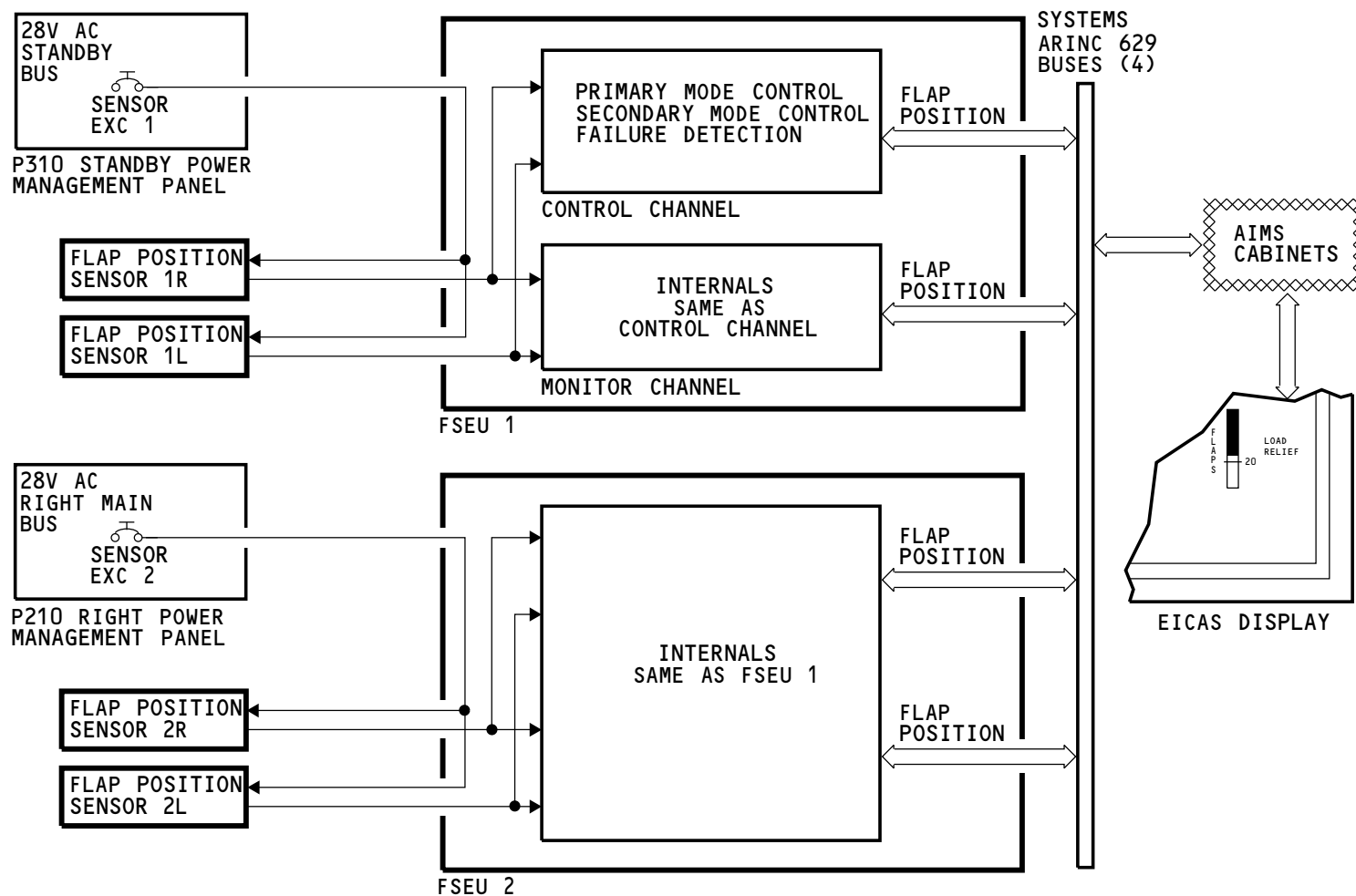
- Flap position indication
- Primary mode control
- Secondary mode control
- Failure detection.

See the high lift control section for more information about the indications (SECTION 27-03).

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FLAP POSITION INDICATION - FUNCTIONAL DESCRIPTION

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**FLAP SKEW DETECTION - GENERAL DESCRIPTION****Purpose**

The flap skew detection system monitors the position of the flaps. The FSEUs stop the primary and secondary mode flap operation if there is a skew, an asymmetry or a secondary mode disagree condition.

The flaps are in a skew condition if the inboard end of a flap does not align with its outboard end.

The flaps are in an asymmetry condition if the left flaps do not align with the right flaps.

There is a secondary mode disagree if the flaps do not move or move too slowly after a command to move in secondary mode.

There is no automatic shutdown of the alternate mode if there is a flap skew, asymmetry, or secondary mode disagree.

Interface

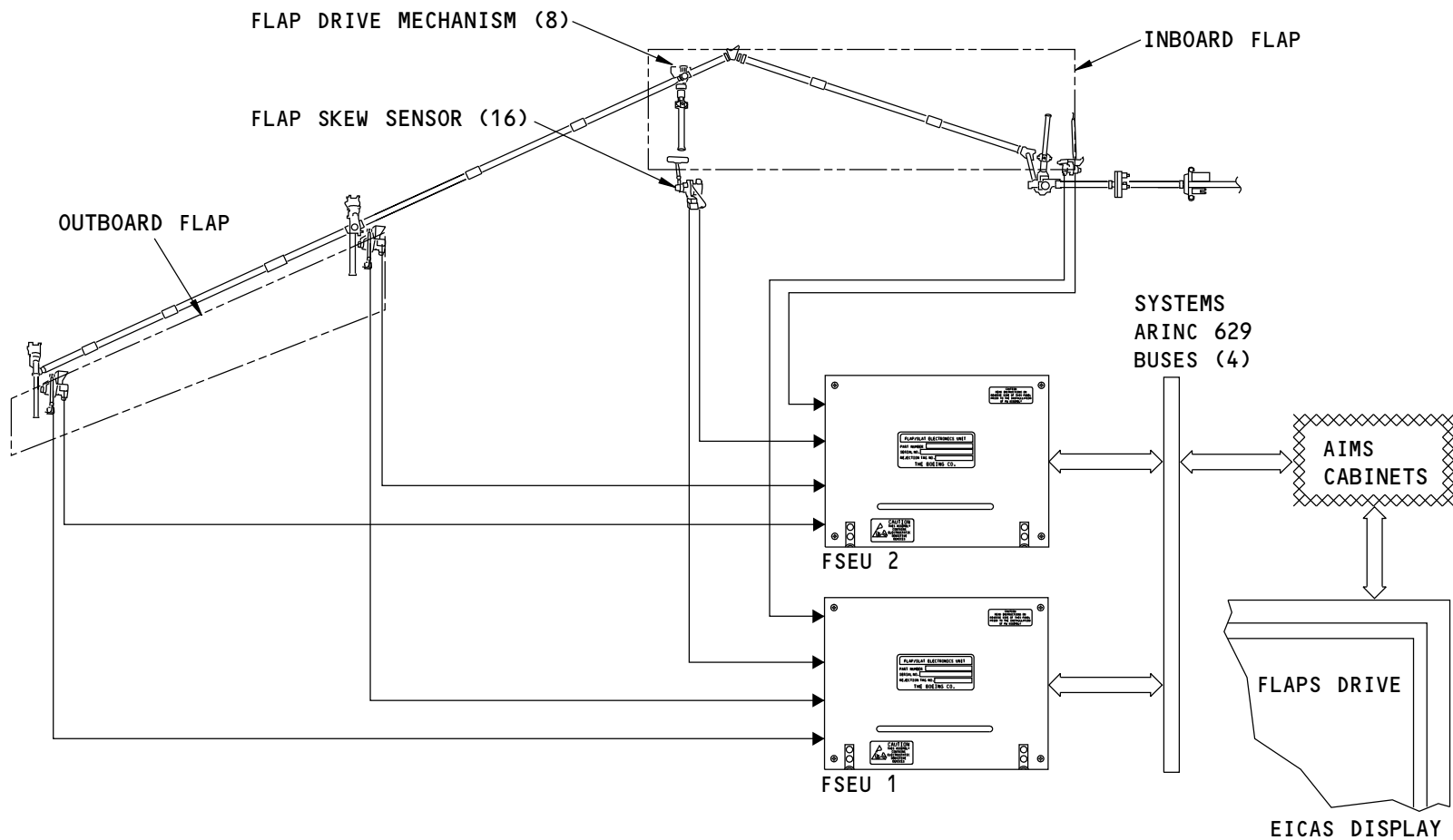
There are 16 flap skew sensors. Each FSEU has interfaces with one sensor at each flap drive mechanism.

If the flaps are in a skew, an asymmetry or a secondary mode disagree condition, the FSEUs stop the flap drive in primary and secondary modes. The FSEUs also send a signal to the AIMS to show the FLAPS DRIVE caution EICAS message. If this happens, the flap position display on EICAS changes to the secondary mode display and the flap position indication shows in amber.

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FLAP SKEW DETECTION - GENERAL DESCRIPTION

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**FLAP SKEW DETECTION - FLAP SKEW SENSORS****Purpose**

The flap skew sensors monitor the position of the flaps at each flap drive mechanism.

Location

The flap skew sensors attach to the flap drive arm and the flap drive mechanism support. Access to these sensors is by extending the flaps to 30. Access to the sensors on the inboard flap inboard drive mechanism is through the main gear wheel wells.

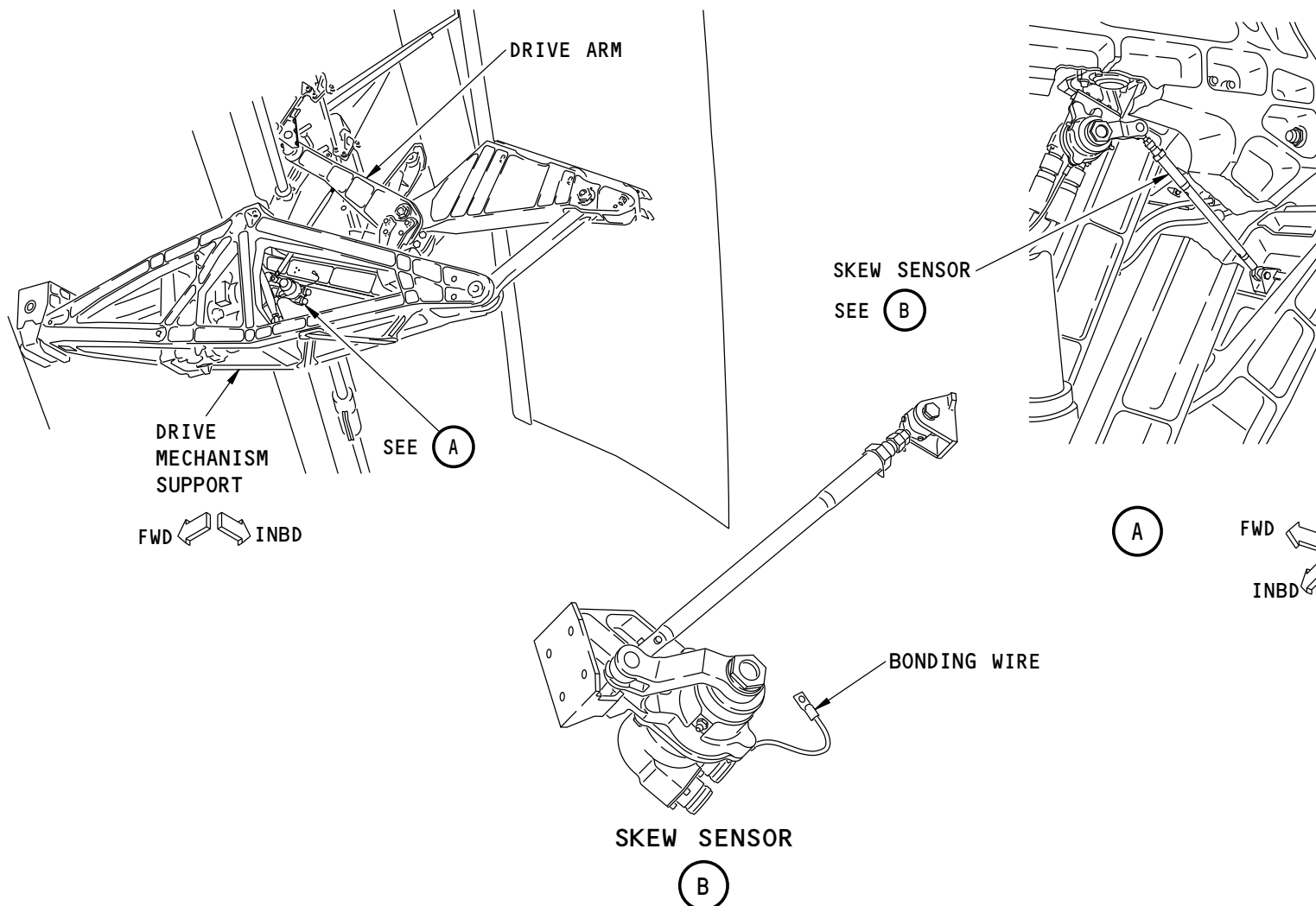
Physical Description

The flap skew sensors are rotary variable differential transformers (RVDTs). Each sensor is a separate LRU.

Training Information Point

The flap skew sensors are rigged after installation by adjusting the length of the control rod assembly.

The electrical connectors for the outboard sensors on flap drive mechanisms 1, 2, 3, 6, 7, and 8 have a 45 degree bend. The connectors can be damaged if you install them on the wrong sensor.



FLAP SKEW DETECTION - FLAP SKEW SENSORS

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FLAP SKEW DETECTION - FUNCTIONAL DESCRIPTION

General

There are 16 flap skew sensors. Each FSEU receives data from one of the skew sensors at each flap drive mechanism.

Both channels in the FSEUs use the flap skew data for failure detection. The FSEUs monitor for flap position failures and for sensor failures.

Flap Drive Shutdown

When both FSEUs find a failure, they stop the flap drive. There is a flap drive shutdown for any one of these conditions:

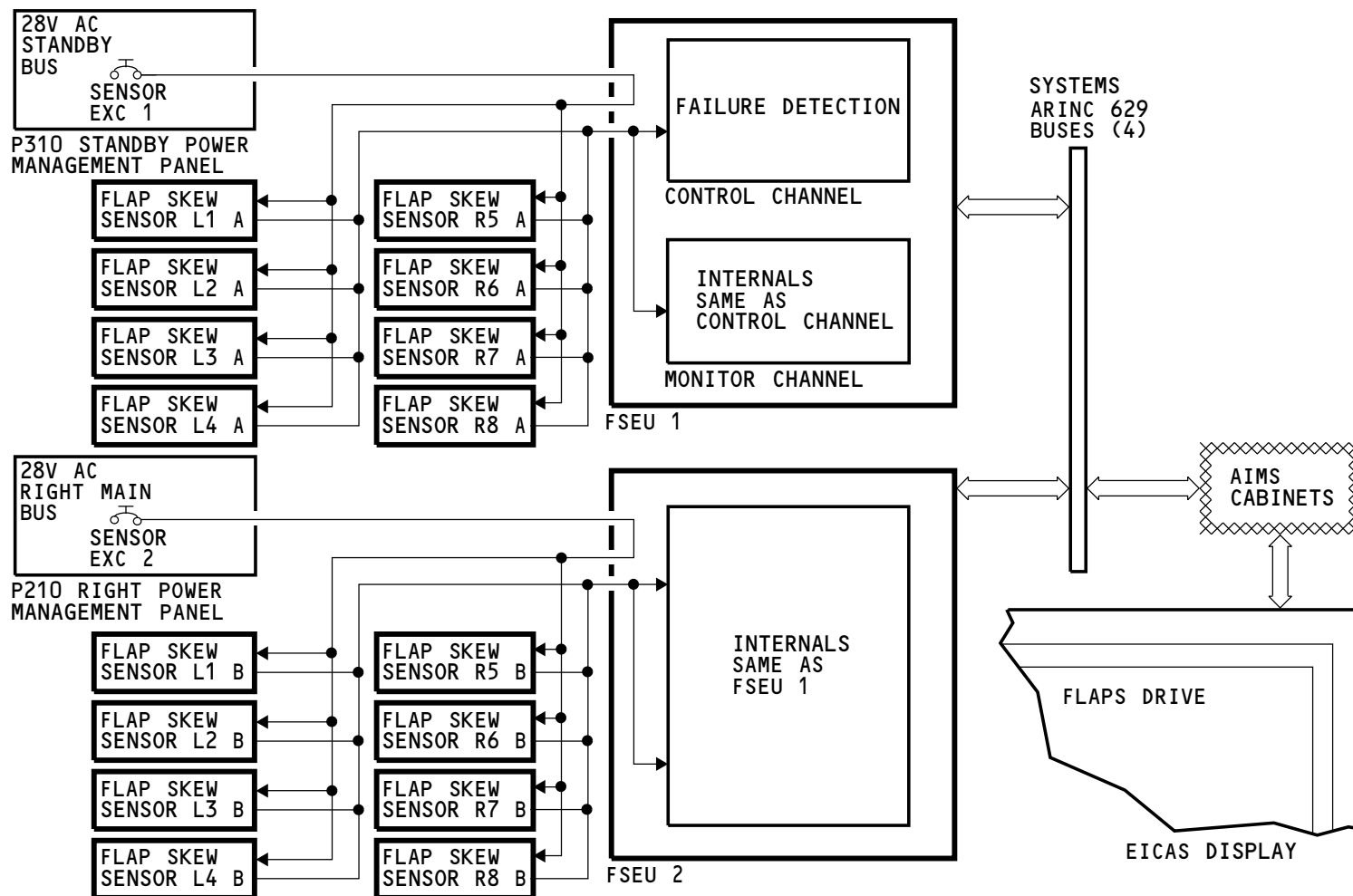
- Skew sensors on symmetrical flap drive mechanisms do not agree (asymmetry or skew)
- The left and right flap position sensors do not agree (asymmetry)
- The flaps do not move within 10 seconds after a flap command in the secondary mode or the flaps move too slowly (secondary mode disagree).

If there is a flap skew, asymmetry, or secondary mode disagree, the FSEUs latch the shutdown of the primary and secondary modes. The FSEUs also send signals to AIMS to show the FLAPS DRIVE caution message. The flap position display changes to the secondary mode display and the flap position indication shows in amber.

To reset the latch, cycle the alternate flaps arm switch or do the primary system test on the MAT.

Skew Sensor Failure

If one of the flap skew sensors fail, the FSEUs send a signal to the AIMS to show the FLAP/SLAT SKEW SNSRS status message.



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FLAP SKEW DETECTION - FUNCTIONAL DESCRIPTION

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SPOILER AND SPEEDBRAKE CONTROL - INTRODUCTION

General

The spoilers help the ailerons and flaperons control airplane roll about the longitudinal axis. They also supply speedbrake control to reduce lift and increase drag for descent and landing.

There are seven spoilers on each wing. The five outboard spoilers are forward of the outboard flap. The two inboard spoilers are forward of the inboard flap.

Each spoiler has an assigned number, from left to right, of 1 through 14. Each spoiler is part of a symmetrical pair, for example, spoiler pair 4 and 11. One ACE and one hydraulic source control a pair.

Roll Control

During roll control, the spoilers on one wing move up and the spoilers on the other wing stay down.

The pilots manually control roll with the rotation of the control wheels. When engaged, the autopilot automatically commands the spoilers. During autopilot operation, the backdrive actuators backdrive the control wheels.

In roll control, all spoilers except for 4 and 11, are fly-by-wire. Spoilers 4 and 11 receive mechanical signals for roll control.

Spoiler Lockout

Symmetrical spoiler pairs fail and lock out if one actuator in the pair fails. Spoilers 5 and 10 fail and lock out as a function of altitude and airspeed.

Speedbrake Control

During speedbrake control, the spoilers on both wings move symmetrically.

The pilots manually command speed brake control with a conventional speedbrake lever on the aisle stand. The autopilot does not control the speedbrake function.

In speedbrake control, all spoilers are fly-by-wire, including spoilers 4 and 11.

Auto Speedbrake Control

The auto speedbrake system supplies automatic extension or retraction of the speedbrakes during landings and refused takeoffs.

To arm the system, the pilots must either place the speedbrake lever in the armed position or command reverse thrust.

See the auto speedbrake control section for more information (SECTION 27-62).

Spoiler Auxiliary Retract Devices

The spoiler auxiliary retract devices (SARDs) automatically retract spoilers 7 and 8 when the offwing slide escape system operates. An offwing slide escape system operates when an overwing passenger door opens with the door set in the auto mode. When the left or the right overwing door opens in the auto mode, door switches make inputs to operate the SARD on the same side. The SARD pressurizes and supplies hydraulic fluid to retract the spoiler.

See the Offwing Slide Escape System section for more information on offwing slide escape system operation (SECTION 25-65).

Abbreviations and Acronyms

- ACE - actuator control electronics
- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AIMS - airplane information management system
- ARINC - Aeronautical Radio, Inc.
- BAP - bank angle protection
- B/D - backdrive
- CAS - computed airspeed
- CMCS - central maintenance computing system
- EHSV - electrohydraulic servo valve

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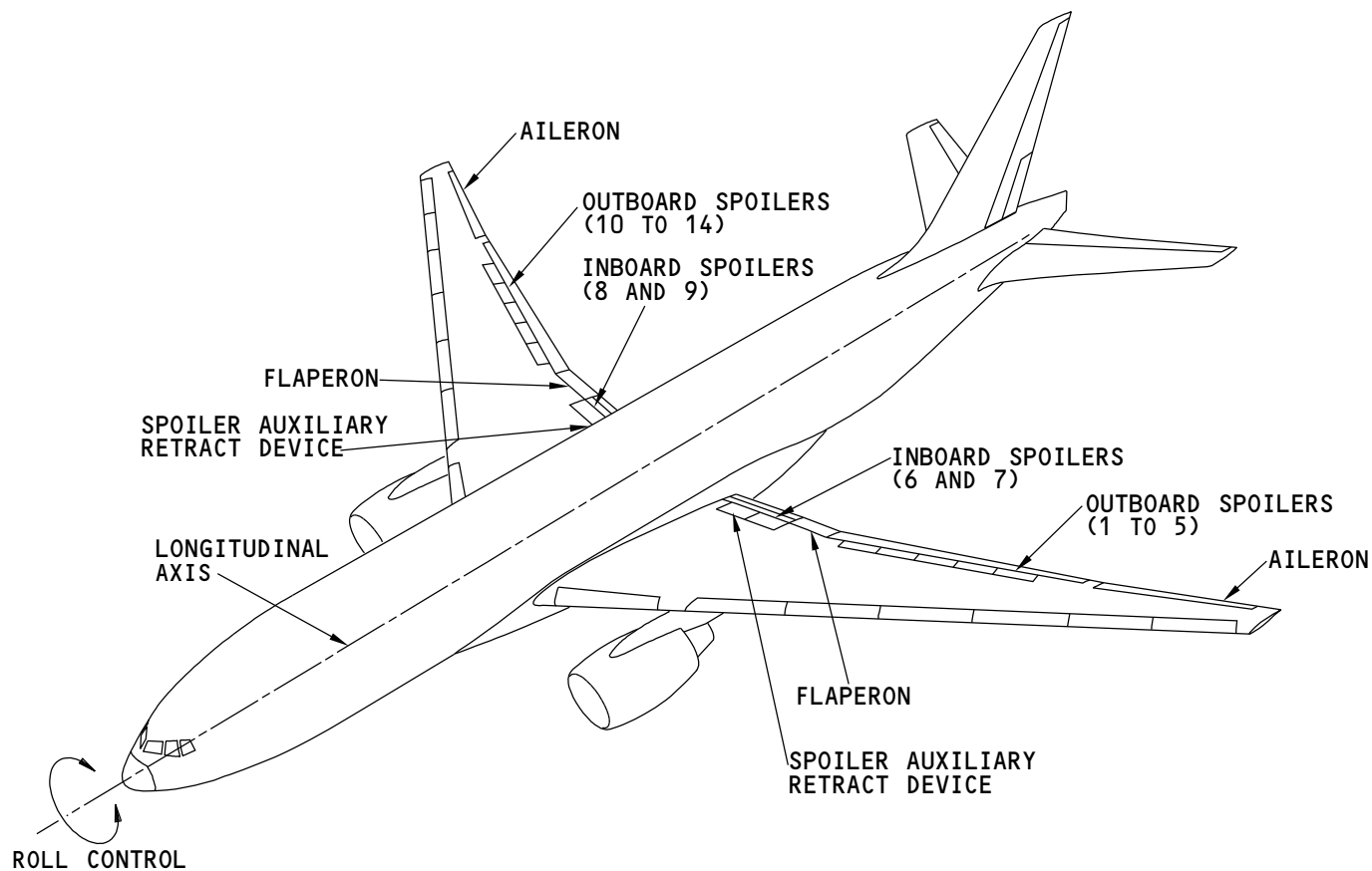
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SPOILER AND SPEEDBRAKE CONTROL - INTRODUCTION

- EICAS - engine indication and crew alerting system
- FMCS - flight management computer system
- FSEU - flap/slat electronics unit
- IB - inboard
- LIB - left inboard
- LOB - left outboard
- LRU - line replaceable unit
- LVDT - linear variable differential transformer
- MCP - mode control panel
- MEC - main equipment center
- MFD - multi-function display
- OB - outboard
- PCU - power control unit
- PFC - primary flight computer
- PFCS - primary flight control system
- PFD - primary flight display
- RBL - right buttock line
- RIB - right inboard
- ROB - right outboard
- RTO - refused takeoff
- RVDT - rotary variable differential transformer
- SOV - shutoff valve
- SARD - spoiler auxiliary retract device
- TEU - trailing edge up



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SPOILER AND SPEEDBRAKE CONTROL - INTRODUCTION

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SPOILER AND SPEEDBRAKE CONTROL - GENERAL DESCRIPTION

General

In roll control, the pilots manually command the spoilers and the autopilot automatically commands them. In speedbrake control, the pilots manually command the spoilers.

Roll Control - Manual Operation

The flight crew uses two conventional control wheels to control roll. All spoilers, except 4 and 11, have an electrical command path. Spoilers 4 and 11 have a mechanical command path in roll control.

Electrical Command Path

Six wheel position transducers change the flight crew control wheel commands to analog electrical signals. These signals go to the four actuator control electronics (ACEs). The ACEs change the signals to digital format and send them to the three primary flight computers (PFCs) through the flight controls ARINC 629 buses.

The PFCs use the control wheel position data, with data from the ADIRU and AIMS, to calculate control surface commands. The PFCs send the digital commands to the ACEs, which change them to analog signals. The ACEs send the analog position commands to the power control units (PCUs) which move the spoilers. The position transducers on the actuator pistons supply position feedback to the ACEs.

Mechanical Control Path

For spoilers 4 and 11, a cable system connects the control wheels to the spoiler PCUs. Cable movement supplies a mechanical input to the PCUs which move the spoilers. The movement of the PCU housing supplies mechanical position feedback.

Roll Control - Autopilot Operation

When engaged, the autopilot flight director computers (AFDCs) control the roll rate and attitude of the airplane. They supply roll commands to the PFCs through the flight controls ARINC 629 buses. The PFCs use these inputs to calculate position commands for the spoilers.

The PFCs also calculate wheel backdrive commands. The PFCs send these commands to the AFDCs, which calculate control wheel movement commands for the backdrive actuator. The backdrive actuator moves the control wheels the same amount as the pilot would move them manually for the same surface movement. This supplies the mechanical signal to move spoilers 4 and 11.

To override the autopilot, the flight crew applies more force on the control wheel than the backdrive actuator force.

Speedbrake Control

The speedbrake lever transducers change the speedbrake lever movements to analog electrical signals.

These signals go to the four ACEs. The ACEs change the signals to digital format and send them to the three PFCs through the flight controls ARINC 629 buses.

The PFCs use the speedbrake lever position along with data from the ADIRU and AIMS, to calculate speedbrake commands. The PFCs mix these speedbrake commands with the spoiler roll commands. The PFCs send the mixed digital commands to the ACEs, which change them to analog signals. Except for spoilers 4 and 11, the ACEs send the analog position commands to the spoiler PCUs. The position transducers on the actuator pistons supply position feedback to the ACEs.

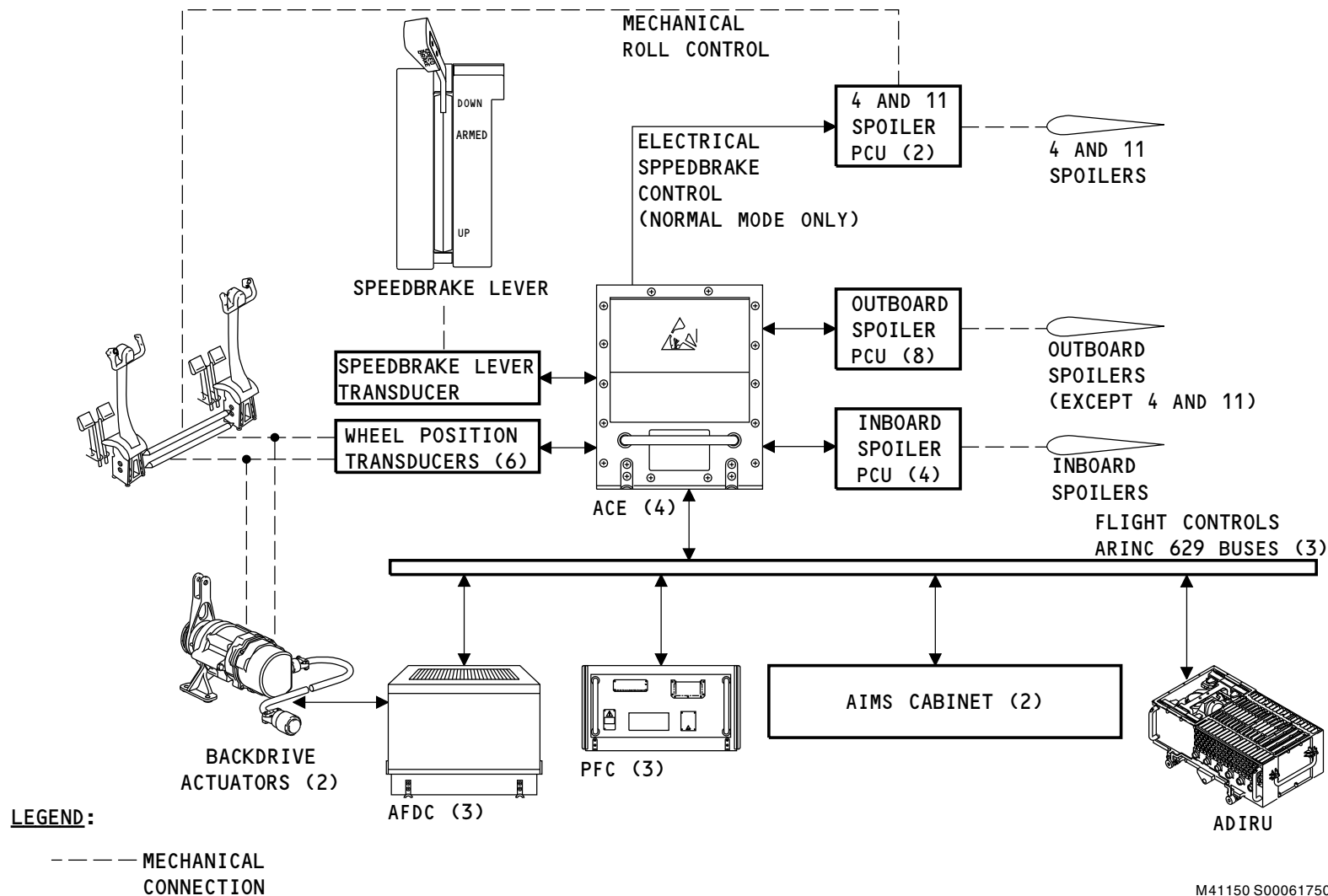
For spoilers 4 and 11, speedbrake control is only available in normal mode. When the pilot moves the speedbrake lever more than 54 degrees, the PFC commands the ACE to send an ON/OFF electrical signal to the two spoiler PCUs.

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SPOILER AND SPEEDBRAKE CONTROL - GENERAL DESCRIPTION

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**SPOILER AND SPEEDBRAKE CONTROL - FLIGHT DECK COMPONENT LOCATIONS****General**

Many spoiler and speedbrake control components are in the flight deck and below the flight deck floor.

Flight Deck Components

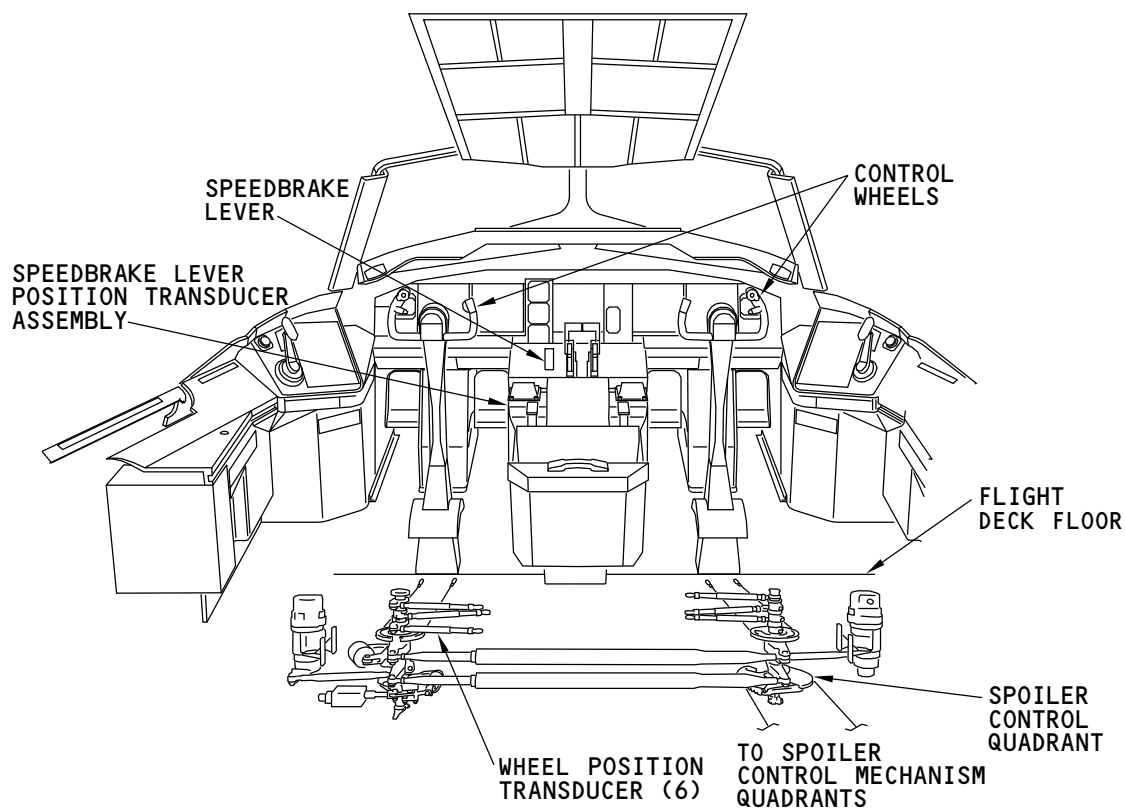
The control wheels and speedbrake lever are in the flight deck. The speedbrake lever is on the captain's side of the control stand. The speedbrake lever transducer is in the control stand.

Components Below the Flight Deck

The spoiler forward controls are below the flight deck floor and above the nose gear wheel well. These include the wheel position transducers and the spoiler control quadrant.

Access to these components is by panels in the flight deck floor. Access is also through the main equipment center (MEC), and then forward along the nose gear wheel well.

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SPOILER AND SPEEDBRAKE CONTROL - FLIGHT DECK COMPONENT LOCATIONS

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**SPOILER AND SPEEDBRAKE CONTROL - WING CENTER SECTION AND WING COMPONENT LOCATIONS****General**

Several spoiler and speedbrake control components are in the wing center section and in the wings.

Wing Center Section Components

The control cables for spoilers 4 and 11 connect the forward quadrant to the spoiler control mechanism quadrants and to the spoiler PCU quadrants. The cables go below the flight deck and passenger compartment floor, along RBL 21, to the wing center section.

The spoiler control mechanism quadrants are in the wing center section of the airplane, above the slant pressure deck and below the passenger floor. The cables go from the control mechanism quadrants through the overwing floor beams, and out along the wing rear spar to the spoiler PCU quadrants.

To get access to the control mechanism quadrants, you remove the floor panels in the passenger compartment.

Wing Components

The spoiler control surfaces and their PCUs are on the wings. One PCU connects to each surface.

The spoiler PCU quadrants for spoilers 4 and 11 are next to the PCUs.

The spoiler auxiliary retract devices (SARDs) for spoilers 7 and 8 are adjacent to the PCUs.

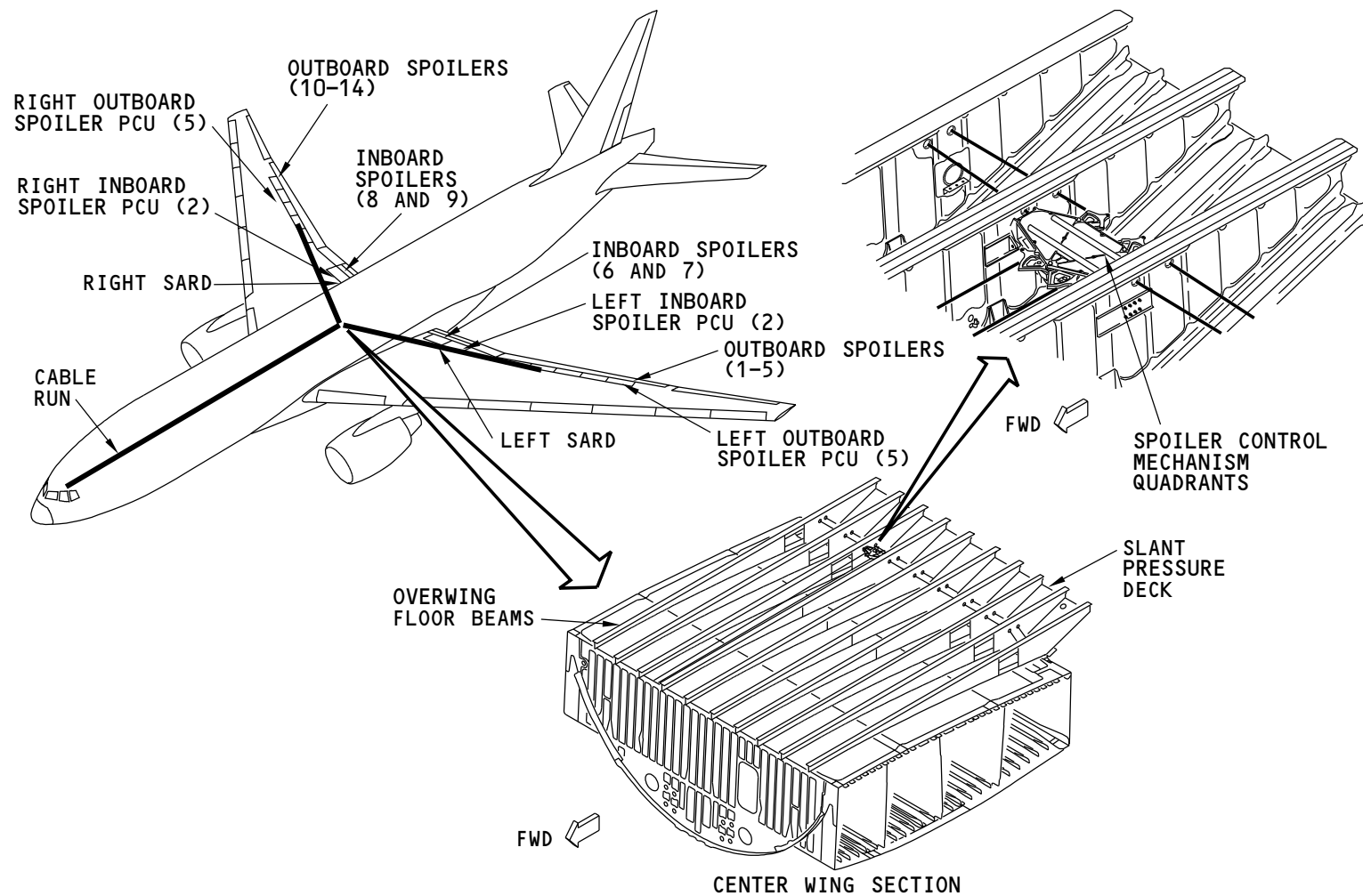
To get access to the PCUs, quadrants, and SARDs, there are access panels on the lower wing.

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SPOILER AND SPEEDBRAKE CONTROL - WING CENTER SECTION AND WING COMPONENT LOCATIONS

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SPOILER AND SPEEDBRAKE CONTROL - ELECTRICAL INTERFACES

General

All of the roll and speedbrake control electrical interfaces with the PFCS go through the ACEs. The ACEs have interfaces with these components:

- Wheel position transducers
- Speedbrake lever transducer
- Inboard spoiler PCUs
- Outboard spoiler PCUs
- Door open and mode select switches (overwing passenger doors).

Wheel Position Transducers

There are six position transducers, three for each control wheel. Each transducer is a linear variable differential transformer (LVDT) that sends analog signals to the ACEs. These analog signals represent the control wheel position and its movement.

See the aileron and flap control section for more information about the wheel position transducers (SECTION 27-11).

Speedbrake Lever Transducers

The speedbrake lever transducer contains four rotary variable differential transformers (RVDTs). These RVDTs send analog signals of the speedbrake lever position to the ACEs.

Inboard Spoiler PCUs

Each of the four inboard spoiler PCUs receives analog electrical signals from the ACEs. The analog signal goes to the electrohydraulic servo valve (EHSV).

Each of these PCUs sends an analog feedback signal to the ACEs from the actuator position LVDT.

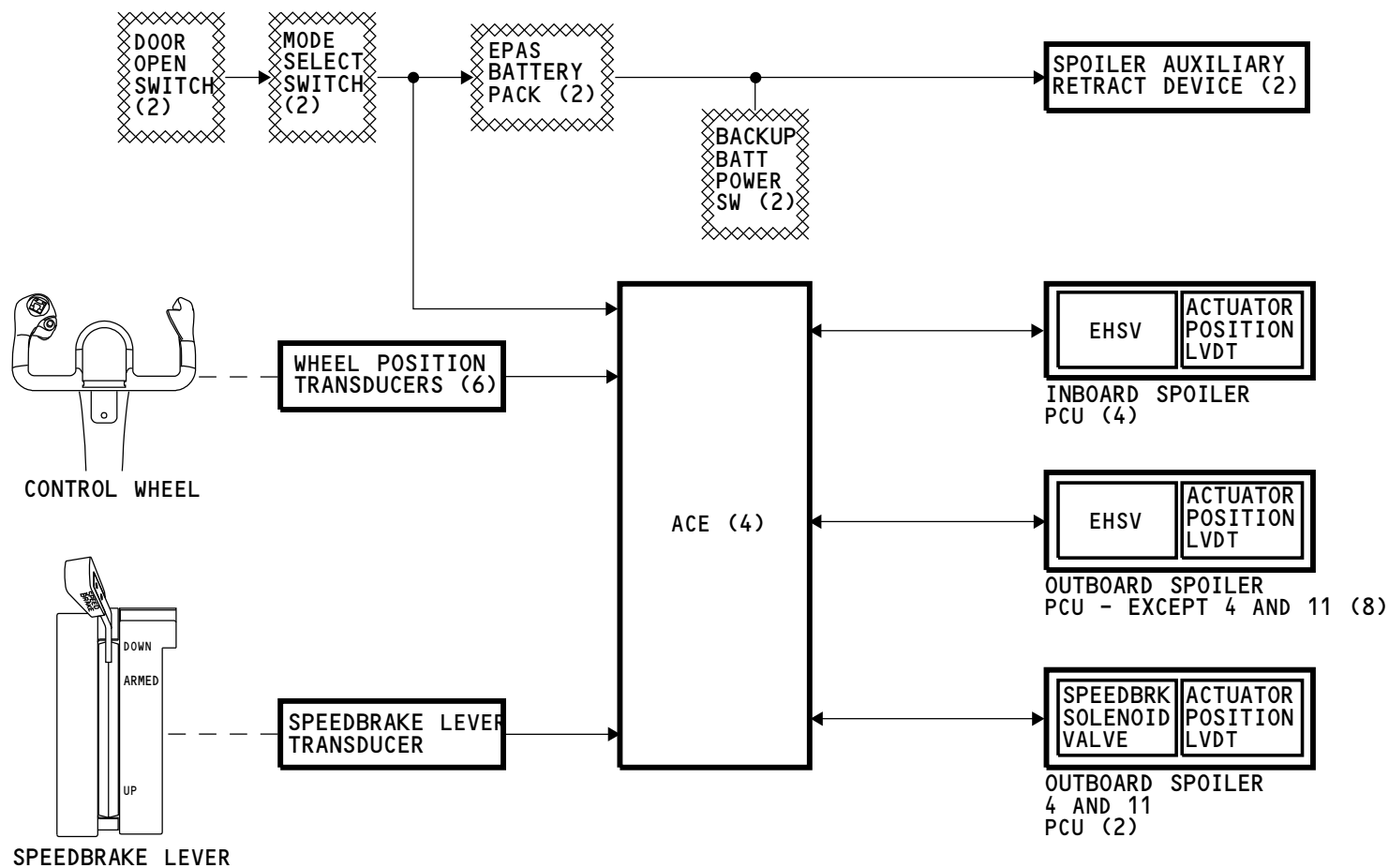
Outboard Spoiler PCUs

Each outboard spoiler PCU receives analog electrical signals from the ACEs. For the outboard spoiler PCUs other than 4 and 11, the electrical signal is for the EHSV. For the spoiler 4 and 11 PCUs, the signal goes to the speedbrake solenoid valve.

All ten of the outboard spoiler PCUs send analog feedback signals to the ACEs. These signals are from the actuator position LVDTs.

Spoiler Auxiliary Retraction

The EPAS battery pack and ACEs receive input signals from the overwing passenger door mode select switch and door open switch. Each spoiler auxiliary retract device (SARD) can receive power from the same side overwing passenger door emergency power assist system (EPAS) battery pack or through the backup battery power switch.



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SPOILER AND SPEEDBRAKE CONTROL - ELECTRICAL INTERFACES

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SPOILER AND SPEEDBRAKE CONTROL - MECHANICAL INTERFACES

General

The roll control mechanical interface for spoilers 4 and 11 is a cable system. The cable goes from the control wheels to the spoiler PCUs through these components:

- Forward spoiler quadrant
- Spoiler control mechanism quadrants
- Spoiler PCU quadrant.

Forward Spoiler Quadrant

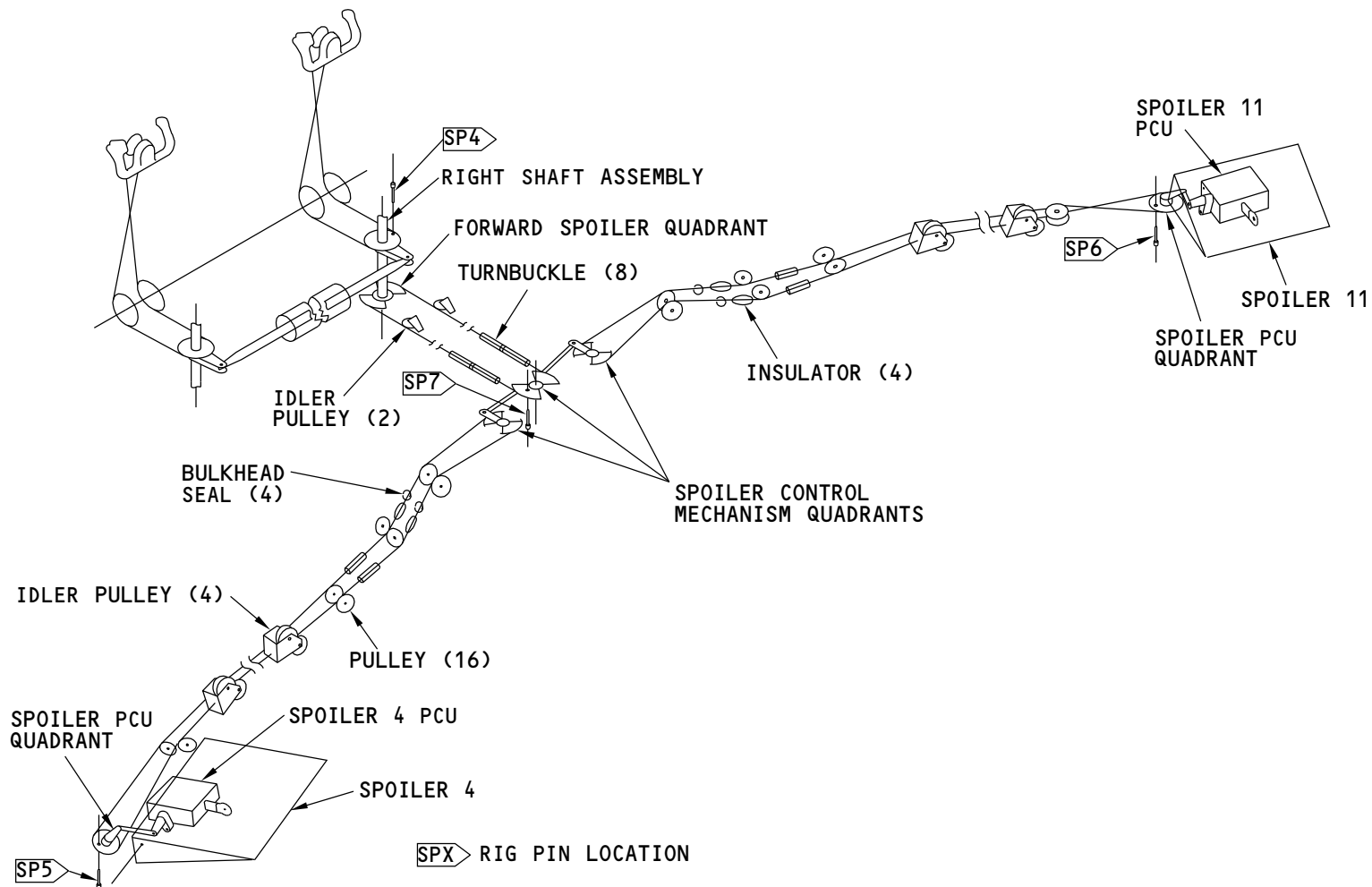
The forward spoiler quadrant connects to the lower end of the right control wheel shaft assembly. Cables connect the forward quadrant to the spoiler control mechanism quadrants through a series of idler pulleys and turnbuckles.

Spoiler Control Mechanism Quadrants

The three spoiler control mechanism quadrants link together to form a travel mechanism assembly. The central mechanism quadrant connects to the cables from the forward spoiler quadrant. The left and right mechanism quadrants connect to the central quadrant with two control rods. Cables go from the left and right quadrants out to the spoiler PCU quadrant on each wing. Pulleys and idler pulleys supply protection to the cables from wing bending. Insulators supply protection from lightning strikes.

Spoiler PCU Quadrants

The spoiler PCU quadrants connect to the PCUs with a mechanical input rod. The rod controls the position of the PCU main control valve.



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SPOILER AND SPEEDBRAKE CONTROL - MECHANICAL INTERFACES

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SPOILER AND SPEEDBRAKE CONTROL - INSULATORS

Purpose

The insulators help protect the airplane from electrical current caused by lightning strikes. The insulators stop the movement of electrical current through the mechanical spoiler control cables.

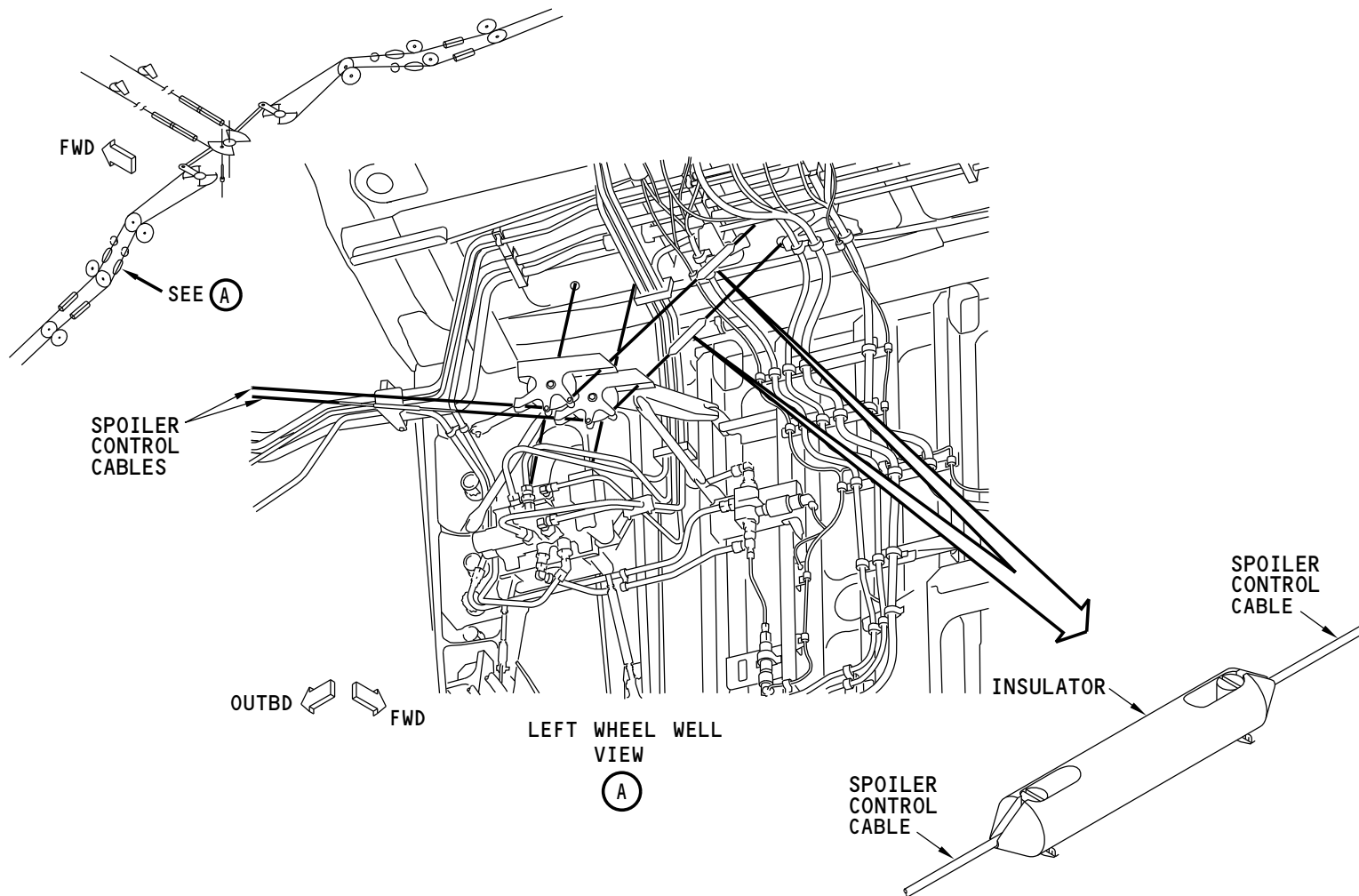
Physical Description

The insulator is made of an electrically insulated material. The mechanical spoiler control cables attach at both ends of the insulator.

Location

Two insulators are in the left wheel well and two are in the right wheel well. They are near the ceiling and near the outboard side of the forward bulkhead.

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SPOILER AND SPEEDBRAKE CONTROL - INSULATORS

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**SPOILER AND SPEEDBRAKE CONTROL - SPOILER FORWARD QUADRANT****Purpose**

The spoiler forward quadrant transmits the control wheel and shaft assembly motion to the mechanical spoiler cable system.

See the aileron and flaperon control section for more information about the forward controls (SECTION 27-11).

Physical Description

The spoiler forward quadrant attaches to the quadrant hub with a bearing mount and an override mechanism. The hub attaches to the right shaft assembly with a spline. The spline has a missing tooth to locate the hub on the shaft. The hub has a cam to operate the override mechanism.

The quadrant has an override mechanism to allow override of a jammed quadrant. The override mechanism includes a roller mounted on an arm. A spring pulls on the arm and keeps the roller on the cam.

Location

The spoiler forward quadrant attaches to the lower end of the right shaft assembly. It is between the flight deck floor and the nose gear wheel well. Access to the quadrant is through the MEC, alongside the nose gear wheel well, or through the flight deck floor access panels.

Functional Description

When the pilots move the control wheels, the right shaft assembly turns the spoiler forward quadrant. The quadrant attaches to cables which go to the spoiler control mechanism quadrants in the wing center section.

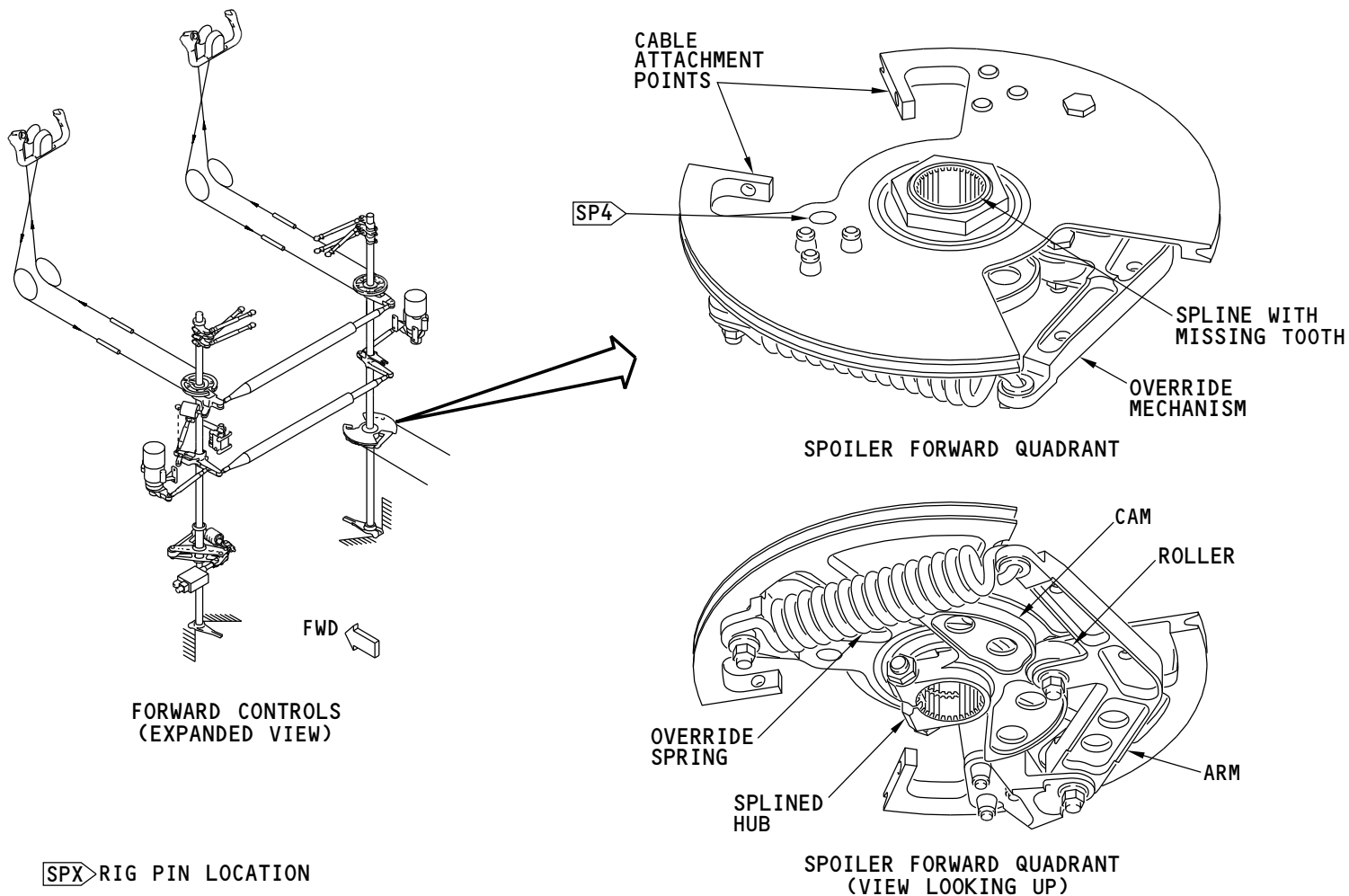
If there is a jam at the quadrant or of the cables downstream of the quadrant, the pilot can override the jam with a force of 19 lb (8.6 kg) at the control wheel.

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SPOILER AND SPEEDBRAKE CONTROL - SPOILER FORWARD QUADRANT

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SPOILER AND SPEEDBRAKE CONTROL - SPOILER CONTROL MECHANISM QUADRANTS

Purpose

The spoiler control mechanism quadrants transmit the forward quadrant and cable motion to the spoiler PCU quadrant in each wing.

Physical Description

The three spoiler control mechanism quadrants are part of the spoiler travel mechanism assembly. Each quadrant attaches to the travel mechanism housing with a bearing mount. The housing attaches to the overwing beam structure with two swing links. A bracket beneath the housing supplies a structural reference point.

The central spoiler mechanism quadrant attaches to the cables from the spoiler forward quadrant. The outer two mechanism quadrants are similar, and attach to the cables that go to the spoiler PCU quadrants in each wing. Two control rods link the three quadrants together.

Location

The spoiler control mechanism quadrants are above and slightly forward of the main wheel well at STA 1245, RBL 21. The spoiler travel mechanism assembly attaches to the overwing beams. Since the quadrants are above the slant pressure deck and below the passenger compartment floor, you get access to them through the passenger compartment floor panels.

Functional Description

When the pilots move the control wheels, the right shaft assembly turns the forward spoiler quadrant. The quadrant attaches to cables which go to the center spoiler control mechanism quadrant. When the center quadrant turns, the two outer quadrants move the cables which attach to the spoiler PCU quadrants.

Training Information Point

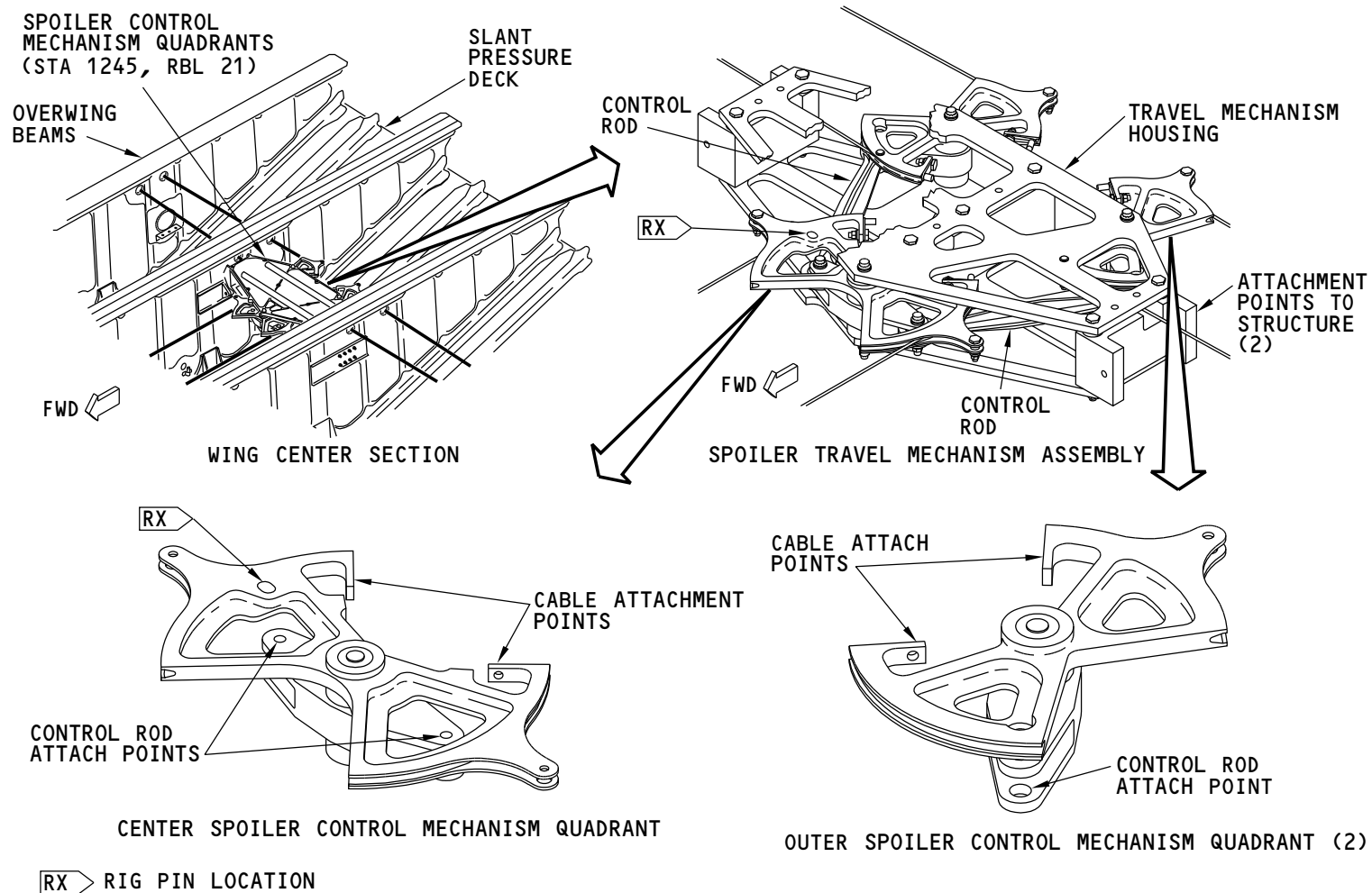
The center spoiler control mechanism quadrant has a rig pin slot.

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SPOILER AND SPEEDBRAKE CONTROL - SPOILER CONTROL MECHANISM QUADRANTS

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SPOILER AND SPEEDBRAKE CONTROL - SPEEDBRAKE LEVER AND SPEEDBRAKE LEVER TRANSDUCER

General

Pilots use the speedbrake lever to command the spoilers in speedbrake operation during descent and landing.

The speedbrake components in the control stand are the speedbrake lever, and the speedbrake lever position transducers. See the auto speedbrake control section for more information about the speedbrake components in the control stand (SECTION 27-62).

Physical Description

The speedbrake lever has a DOWN detent, an ARMED position for auto speedbrake control, and an UP position for full spoiler deflection.

The speedbrake lever transducer has four individual RVDTs with a common rotor input. The rotor attaches to the clutch output shaft with a spline. Each RVDT has a separate cable and connector. The ACEs supply 7v ac, 1800 Hz excitation power.

Location

The speedbrake lever is on the captain's side of the control stand. The speedbrake lever transducers are in an assembly inside the control stand on the captain's side. Access is through a panel on the left side of the control stand.

Functional Description

When the pilots lift the speedbrake lever out of its detent position, and then pull the lever aft, it moves a rod and crank assembly in the control stand. This movement turns the clutch and the input rotor of the transducers. The four RVDTs measure the rotor movement and supply an analog electrical signal to the four ACEs.

Indications

The EICAS warning message CONFIG SPOILERS indicates that the speedbrake lever is not in its down detent when either the left or right engine thrust exceeds the takeoff threshold and the airplane is on the ground.

The EICAS caution message SPEEDBRAKE EXTENDED indicates that the speedbrake lever is more than the armed position with the airplane above 15 feet of radio altitude and one of these conditions:

- Airplane below 800 feet radio altitude
- Flaps at landing position
- Either thrust lever is more than 5 degrees above the idle stop.

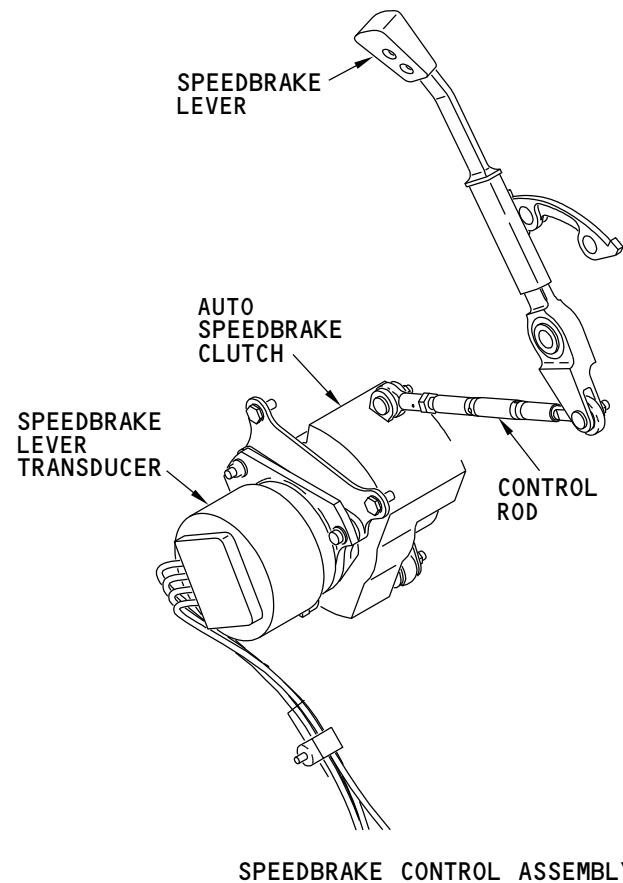
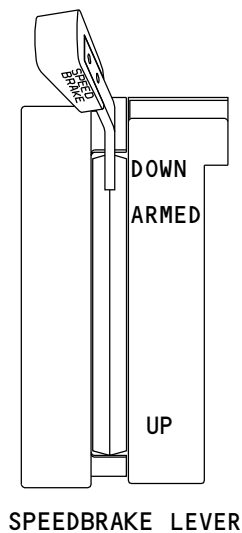
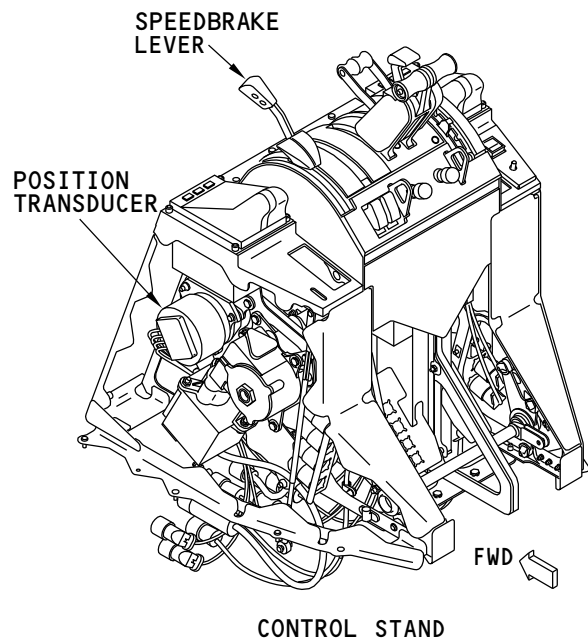
The EICAS memo message SPEEDBRAKE ARMED indicates that the speedbrakes are armed.

On the MFD status display, the message SPEEDBRAKE LEVER XDCR shows when one of the four speedbrake lever transducers has failed.

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SPOILER AND SPEEDBRAKE CONTROL - SPEEDBRAKE LEVER AND SPEEDBRAKE LEVER TRANSDUCER

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**SPOILER AND SPEEDBRAKE CONTROL - SPOILER PCU QUADRANT****Purpose**

The spoiler PCU quadrants supply mechanical input for roll control to the spoiler 4 and 11 PCUs. The quadrants receive this input from the cable system.

Physical Description

The spoiler PCU quadrants attach to the wing rear spar structure with a bracket. The quadrants attach to the PCU mechanical input shafts with a rod and crank assembly. Cables connect the quadrants to the travel mechanism assembly.

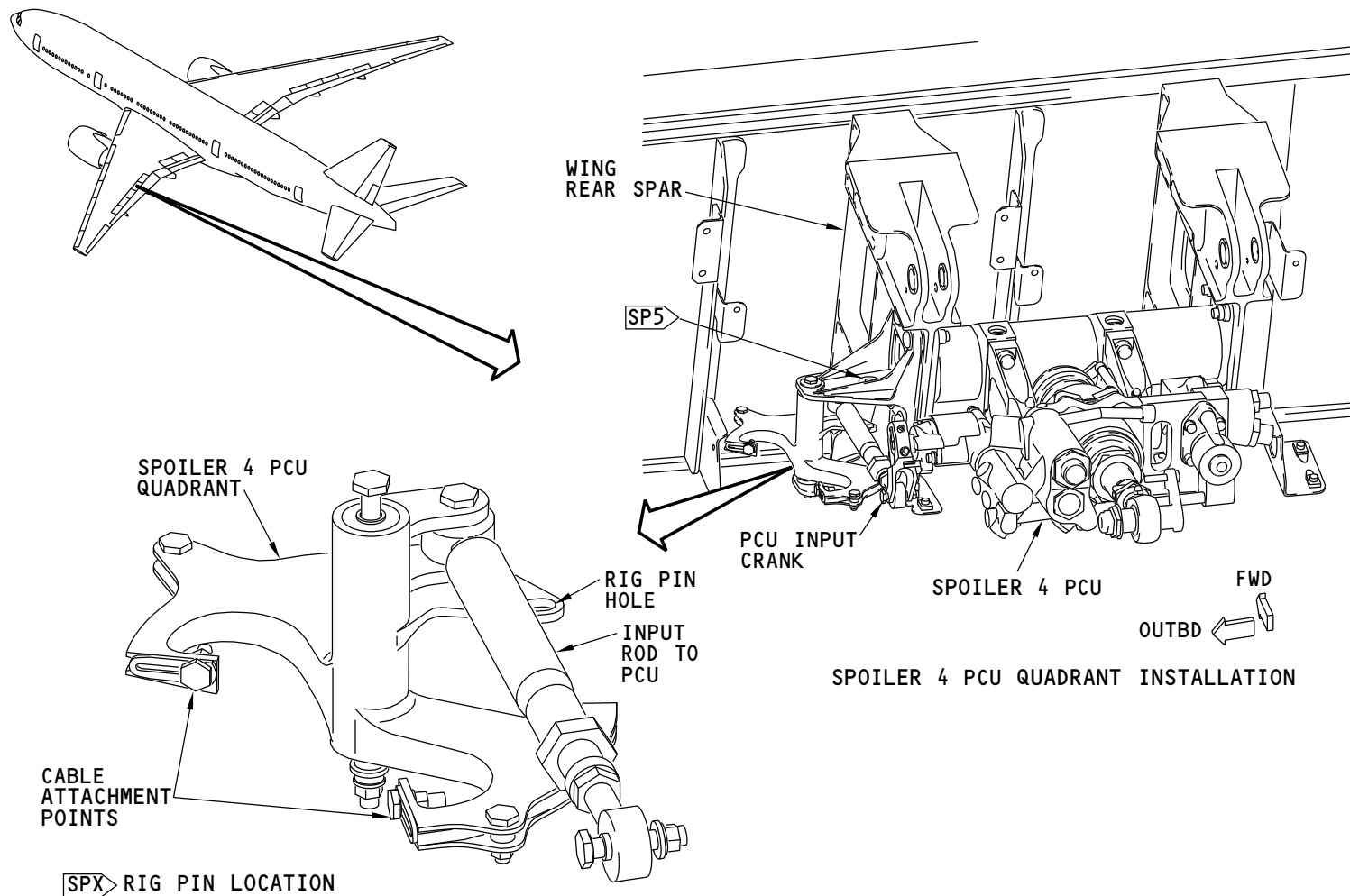
Location

The spoiler PCU quadrants are on the forward, left side of the spoiler 4 and 11 PCUs. Access to the quadrants is through hinged panels on the lower wing.

Functional Description

When the pilot moves the control wheel, the cable system moves the spoiler PCU quadrants. The quadrant movement pushes the input rod forward or aft. The input rod turns the PCU input crank, which attaches to the end of the PCU input shaft with a spline. Rotation of this shaft supplies the mechanical input to the PCU.

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SPOILER AND SPEEDBRAKE CONTROL - SPOILER PCU QUADRANT

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**SPOILER AND SPEEDBRAKE CONTROL - CABLE-CONTROLLED SPOILER PCU - PHYSICAL DESCRIPTION****General**

The cable-controlled PCUs move the outboard spoilers 4 and 11 in roll and speedbrake control. Mechanical command signals from the control wheels, and electrical command signals from the speedbrake lever control the PCUs. Each spoiler has one PCU.

Location

The cable-controlled PCUs are on the rear spar of the inboard wing. Access to the PCUs is through two hinged panels on the lower wing.

Trunnion pillow blocks connect the PCUs to the rear spar structural fitting. Each PCU actuator rod connects to its spoiler actuator fitting.

An electrical connector is near the cap end of the PCU. Hydraulic tubing connect to two ports next to the electrical connector.

Physical Description

The two cable-controlled spoiler PCUs are identical. Each weighs approximately 20 lb (9 kg).

The PCUs contain an unbalanced hydraulic actuator with a control module. The control module contains:

- A main control valve
- A speedbrake solenoid valve
- A speedbrake mode valve
- An extension check and relief valve with manual bypass
- An inlet filter.

The actuator piston has an LVDT that sends position feedback signals to the ACE.

Training Information Point

Use the manual bypass to extend the PCU for maintenance.

Install a spoiler PCU lock when the panel is in the up position.

Use the spoiler PCU rod end adjustment to rig the PCU.

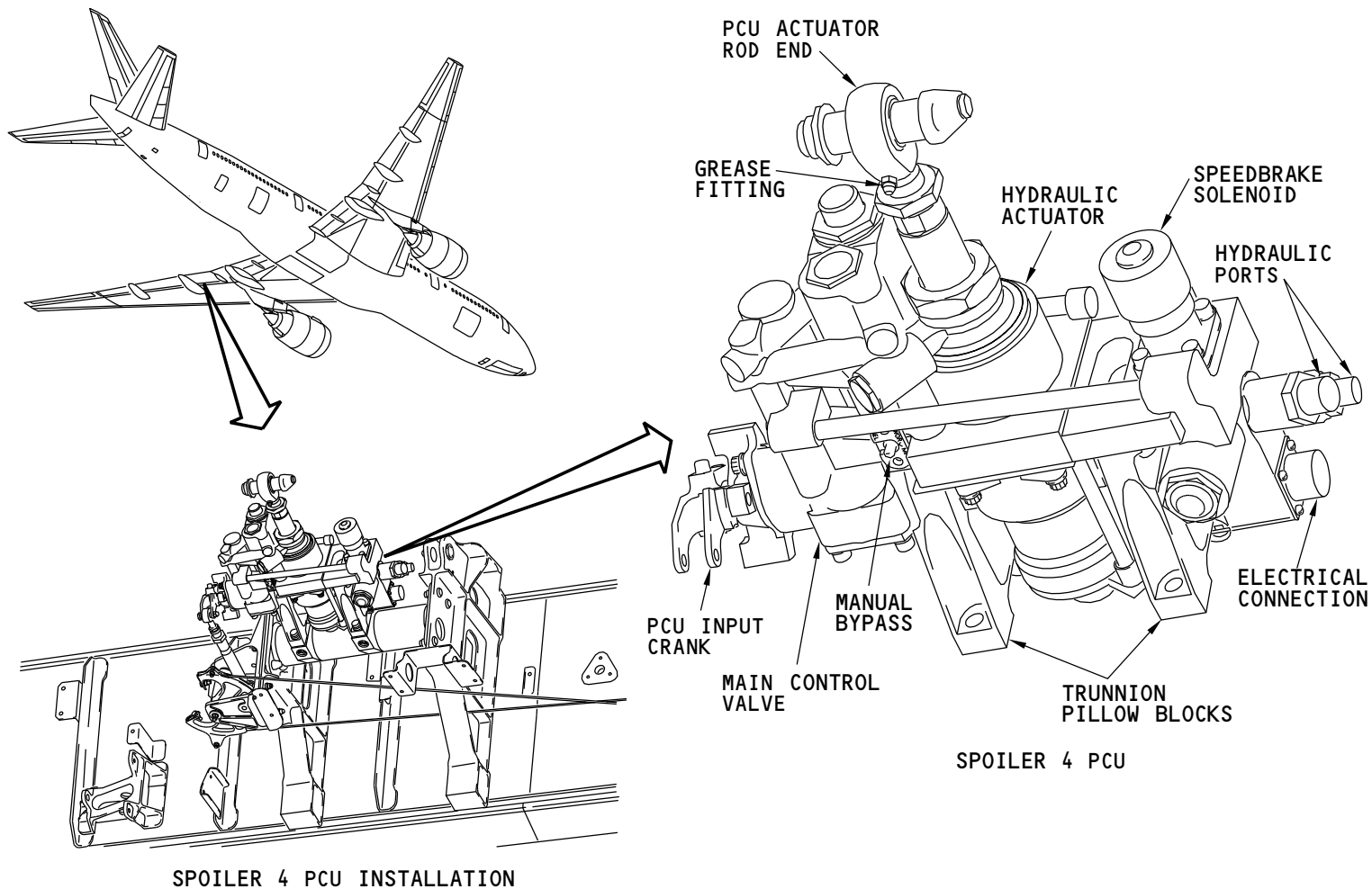
The rod end of the actuator has a grease fitting.

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SPOILER AND SPEEDBRAKE CONTROL - CABLE-CONTROLLED SPOILER PCU - PHYSICAL DESCRIPTION

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SPOILER AND SPEEDBRAKE CONTROL - CABLE-CONTROLLED SPOILER PCU - FUNCTIONAL DESCRIPTION**General**

The cable-controlled spoiler PCU operates in two different modes:

- Roll control
- Speedbrake control.

In roll control mode, the cable system supplies a mechanical input to the main control valve.

In speedbrake control mode, speedbrake lever movement causes the ACEs to energize the speedbrake solenoid. This bypasses the main control valve and sends a hardover command to the actuator.

The actuator LVDT supplies a position feedback signal to the ACEs.

Roll Control Mode

The PCU is in roll control mode when the ACE does not energize the speedbrake solenoid valve.

When there is no roll or speedbrake command, a spring forces the main control valve to the fully retracted position. Hydraulic fluid pressurizes the actuator to retract. The extension check valve stays closed. Its internal check valve permits the retract pressure to the actuator.

When the pilot turns the control wheel, the spoiler PCU quadrant moves the main control valve. This sends hydraulic system pressure through the speedbrake mode valve to the actuator, and results in the actuator extension or retraction. When the command is to extend, the extension check valve opens and permits flow to return. When the command is to retract, the hydraulic pressure flow goes through the closed extension check valve. The angular output movement of the PCU about the trunnion supplies mechanical loop feedback to the main control valve.

Speedbrake Control Mode

The PCU is in speedbrake control mode when the ACE energizes the speedbrake solenoid.

When the pilot moves the speedbrake lever more than 54 degrees, the ACE energizes the speedbrake solenoid. This moves the solenoid valve. Hydraulic pressure then moves the speedbrake mode valve to the speedbrake position. Under these conditions, hydraulic pressure goes directly through the speedbrake mode valve to the actuator. The extension check valve opens and permits flow to return. This results in full actuator extension.

When the pilot moves the speedbrake lever to less than 45 degrees, the ACE de-energizes the speedbrake solenoid. With no electrical input, internal springs force the speedbrake solenoid valve and the speedbrake mode valve to the closed position. This puts the PCU in the roll control mode of operation. If there is no roll command, the main control valve pressurizes the actuator to retract. Hydraulic pressure flows through the closed extension check valve.

Operation Without Hydraulic Pressure

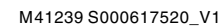
Without hydraulic pressure to the PCU, the extension check valve closes and prevents extension of the PCU actuator.

If the spoiler panel is raised at the time of hydraulic power loss, the airload on the spoiler causes hydraulic fluid to flow through the speedbrake mode valve and the main control valve. This permits the actuator to retract.

The thermal relief valve cracks open at about 3700 psid and closes at approximately 3100 psid.

Manual Operation

You can open the extension check valve with the manual bypass. With the extension check valve open, you can raise the spoiler without hydraulic power. You can lower the spoiler panel with the extension check valve closed.



SPOILER AND SPEEDBRAKE CONTROL - CABLE-CONTROLLED SPOILER PCU - FUNCTIONAL DESCRIPTION

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SPOILER AND SPEEDBRAKE CONTROL - INBOARD AND OUTBOARD SPOILER PCU - PHYSICAL DESCRIPTION**General**

Except for spoilers 4 and 11, the inboard and outboard spoiler PCUs move their spoiler panel with electrical command signals from the ACEs. Each spoiler has one PCU.

Location - Inboard Spoiler PCUs

The inboard spoiler PCUs are on the inboard wing spoiler beams. Access to the PCUs is by hinged panels on the lower wings.

Trunnion pillow blocks connect the PCUs to the spoiler beam structure. Each PCU actuator rod connects to its spoiler panel clevis fitting.

An electrical connector attaches forward and left of the cap end of the PCU.

Two hydraulic tubes connect to ports at the cap end of the PCU.

Location - Outboard Spoiler PCUs

The outboard spoiler PCUs are on the outboard wing rear spars. Access to the PCUs is by hinged panels on the lower wings.

Trunnion pillow blocks connect the PCUs to the rear spar structures. Each PCU actuator rod connects to its spoiler panel clevis fitting.

An electrical connector and two hydraulic tubes attach at the forward, left end of the PCU.

Physical Description

The inboard spoiler PCUs weighs about 25.2 lb (11 kg) each. The outboard spoiler PCUs weigh about 14.5 lb (6.4 kg) each. The electrically-controlled inboard and outboard spoilers PCUs are functionally identical.

The spoiler PCUs contains a hydraulic actuator with a control module. The inboard PCUs have a balanced actuator. The outboard PCUs have an unbalanced actuator. The control module contains:

- An electrohydraulic servo valve (EHSV)
- An extension check and relief valve with manual bypass
- An inlet filter.

The actuator piston has an LVDT that sends position feedback signals to the ACE.

Training Information Point

Use the manual bypass to extend the PCU for maintenance.

Install a spoiler PCU lock when the panel is in the up position.

Use the spoiler PCU rod end adjustment to rig the PCU.

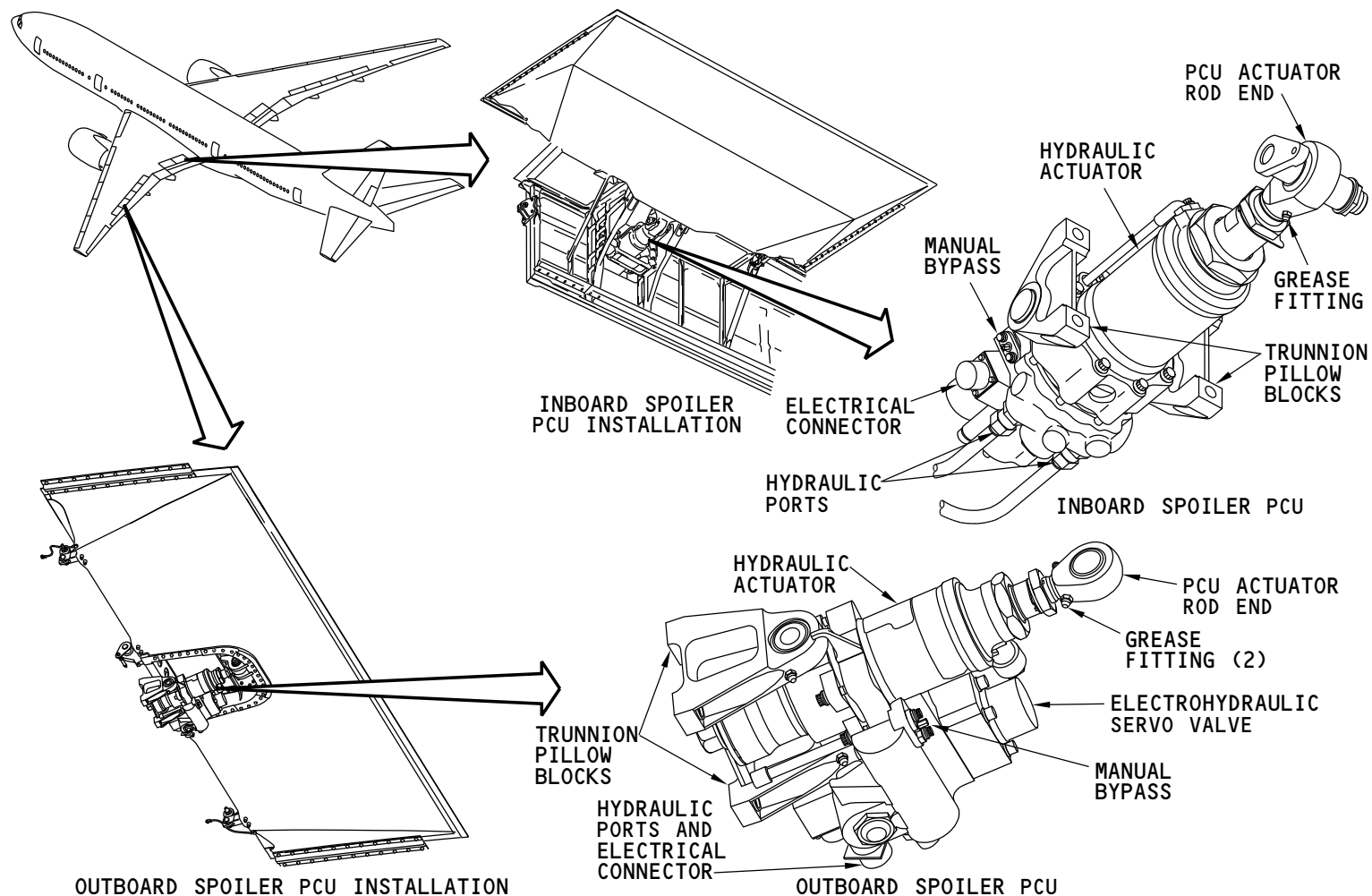
The rod end of the actuator has a grease fitting.

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SPOILER AND SPEEDBRAKE CONTROL - INBOARD AND OUTBOARD SPOILER PCU - PHYSICAL DESCRIPTION

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**SPOILER AND SPEEDBRAKE CONTROL - INBOARD AND OUTBOARD SPOILER PCU - FUNCTIONAL DESCRIPTION****General**

The inboard and outboard spoiler PCUs, except for spoilers 4 and 11, have only one mode of operation.

Normal Operation

When the ACE energizes the EHSV to the extend or retract position, hydraulic system pressure moves the actuator. During a retraction command, the extension check valve stays closed and permits retract pressure to the actuator. During an extension command, the extension check valve opens and permits flow to return. The actuator LVDT supplies a position feedback signal to the ACEs. The ACEs use this signal to adjust the extend command current.

A spring forces the EHSV to the fully retracted position when there is no electrical signal. This permits hydraulic pressure through the closed extension check valve to keep the actuator retracted.

Operation Without Hydraulic Pressure

Without hydraulic pressure to the PCU, the closed extension check valve prevents extension of the PCU.

If the spoiler panel is up at the time of hydraulic power loss, the airload on the spoiler causes hydraulic fluid to flow through the extension check valve and the EHSV. This permits the actuator to retract.

The thermal relief valve cracks open at about 3700 psid and closes at about 3100 psid.

Manual Operation

You can open the extension check valve with the manual bypass. With the extension check valve open, you can raise the spoiler without hydraulic power. You can lower the spoiler panel with the extension check valve closed.

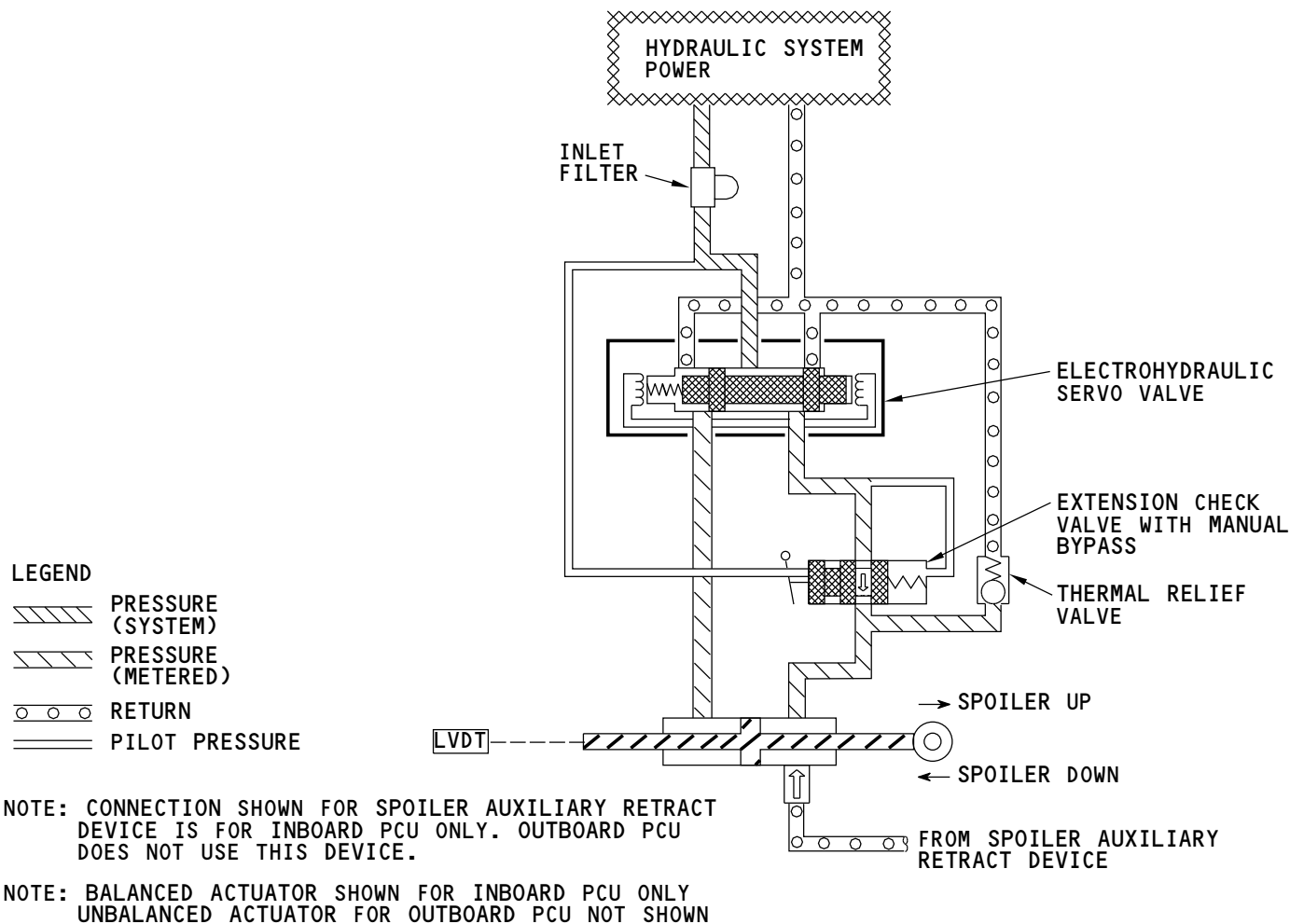
Spoiler Auxiliary Retraction

When the offwing slide escape system operates, the spoiler auxiliary retract devices (SARDs) supply hydraulic pressure to the retract side of the actuator. A check valve connected to the PCU prevents flow out of the actuator to the SARD.

Indications

The advisory message SPOILERS shows when one or more pair of spoilers is shut down.

The status message SPOILER ACTUATOR shows when one or more spoiler actuator fails. If two or more spoiler actuators that are not part of the same symmetrical pair fail, the status message FLIGHT CONTROL SYS will show (spoiler pairs 1/14, 2/13, 3/12, 5/10, 6/9, and 7/8).



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SPOILER AND SPEEDBRAKE CONTROL - INBOARD AND OUTBOARD SPOILER PCU - FUNCTIONAL DESCRIPTION

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SPOILER AND SPEEDBRAKE CONTROL - SPOILER AUXILIARY RETRACT DEVICE

Purpose

The spoiler auxiliary retract devices (SARDs) make sure spoilers 7 and 8 retract when the offwing slide escape system operates.

Location

Brackets attach the SARDs to the forward side of each wing spoiler beam. Access to the SARDs is by a removable lower wing skin panel below each SARD.

Physical Description

The two spoiler auxiliary retract devices are identical. Each device has these components:

- Pyrotechnic cartridge
- Transfer cylinder.

The pyrotechnic cartridge attaches to the bottom of the transfer cylinder. The cartridge has a squib. The squib is an electrically operated explosive device. An electrical connector is on the cartridge on the bottom of the SARD.

The transfer cylinder contains hydraulic system return fluid. The transfer cylinder has a floating piston that separates the hydraulic fluid from the cartridge.

A hydraulic line supplies the hydraulic system return fluid to the transfer cylinder. A flexible hose connects the transfer cylinder to the inboard spoiler PCU.

Functional Description

Offwing slide operation fires the squib. The high pressure gas from the combustion pushes on the floating piston of the SARD. The floating piston pushes hydraulic fluid to the retract side of the PCU actuator.

Training Information Point

When you do maintenance on the SARDs, you must remove the electrical connector and install a shorting cap on the cartridge. You do this to prevent accidental firing of the squib. The shorting cap is in a pouch attached to the spoiler beam near the SARD.



WARNING

MAKE SURE TO REMOVE THE ELECTRICAL CABLE AND INSTALL SHORTING CAP ON THE CARTRIDGE BEFORE YOU DO MAINTENANCE ON THE SPOILER AUXILIARY RETRACT DEVICE OR SPOILER PCU. THIS WILL PREVENT INJURY TO PERSONS AND DAMAGE TO EQUIPMENT.

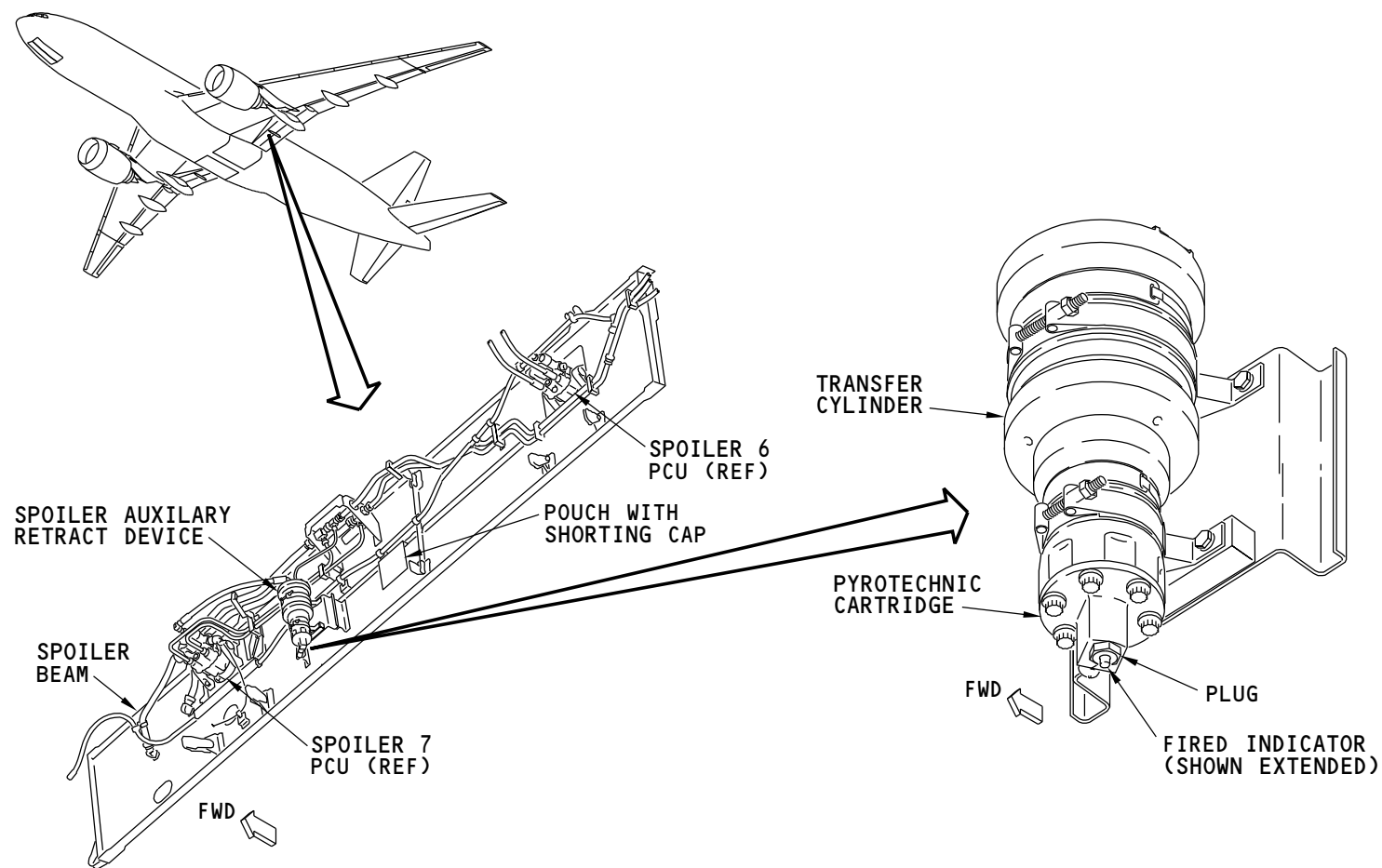
A red fired indicator extends from the bottom of the cartridge when the squib is fired. You then must replace the cartridge.

Before you remove the cartridge, you must unscrew the plug which contains the fired indicator. When you unscrew the plug part of the way, you release the gas pressure from the cartridge.



WARNING

MAKE SURE TO UNSCREW THE INDICATOR PLUG PART OF THE WAY BEFORE YOU REMOVE THE CARTRIDGE. DO NOT UNSCREW THE INDICATOR PLUG MORE THAN IT IS NECESSARY TO RELEASE GAS FROM THE CARTRIDGE. PRESSURE FROM THE CARTRIDGE CAN CAUSE THE INDICATOR PLUG OR THE CARTRIDGE TO QUICKLY RELEASE. THIS CAN CAUSE INJURY TO PERSONS AND DAMAGE TO EQUIPMENT.



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SPOILER AND SPEEDBRAKE CONTROL - SPOILER AUXILIARY RETRACT DEVICE

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**SPOILER AND SPEEDBRAKE CONTROL - SPOILER SURFACES****Purpose**

The spoilers supply roll control in flight and speedbrake control during descent and landing.

Physical Description

The four inboard and ten outboard spoilers are light- weight composite materials structures. The skin is reinforced graphite/epoxy bonded to a core of Nomex honeycomb.

The inboard spoilers weigh about 47 lb (21 kg) each. The outboard spoilers weigh about 30 lb (14 kg) each.

The overall dimensions of the inboard spoiler are approximately 42 in by 80 in (1.1 m x 2.0 m). Each spoiler attaches to the outboard rear spar with two outer hinge fittings, and one center hinge. The PCU actuator rod end connects to the actuator fitting.

The overall dimensions of the outboard spoiler are approximately 28 in by 78 in (0.7 m x 2.0 m). Each spoiler attaches to the spoiler beam with two outer hinge fittings, and one center hinge. The PCU actuator rod end connects to the actuator fitting.

Rubber bulb aroseeals attach to the inboard and outboard edges of all spoiler panels.

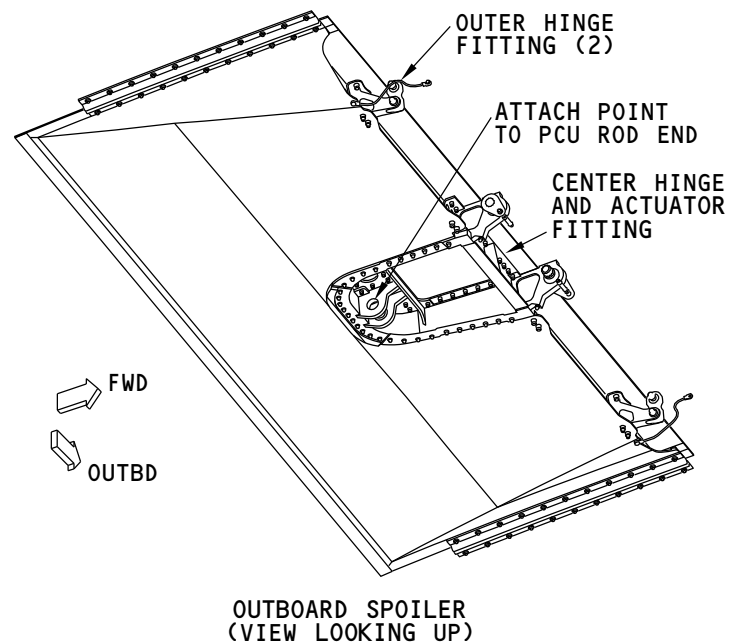
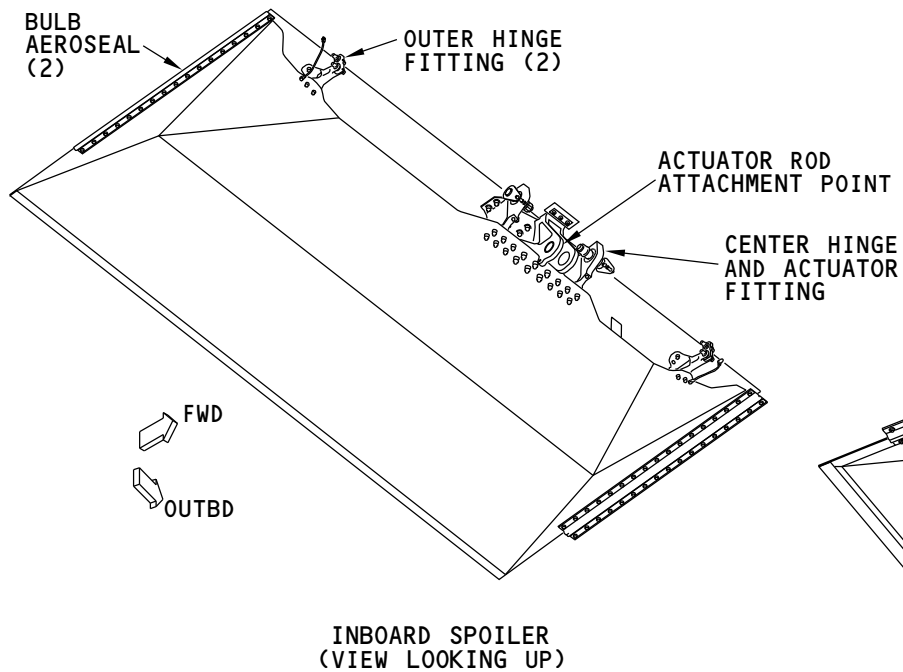
Functional Description

The inboard and outboard spoilers have a maximum movement of 60 degrees trailing edge up (TEU), except for spoilers 4 and 11 which are limited to 45 degrees TEU.

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SPOILER AND SPEEDBRAKE CONTROL - SPOILER SURFACES

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION

General

The roll and speedbrake control system for the inboard and outboard spoilers uses input command signals from the:

- Wheel position transducers
- Force transducer
- Speedbrake lever transducer assembly.

The ACEs receive the input signals and transmit them to the PFCs. The ACEs supply output command signals to the spoiler PCUs.

The roll control system for the cable-controlled spoilers uses input commands from the cable system. The speedbrake control system for these spoilers uses electrical command signals from the ACEs.

Wheel Position Transducers

The C ACE and R ACE each receive signals from two wheel position transducers. The L1 ACE and L2 ACE each receive signals from one wheel position transducer. After they change the signals to digital format, the ACEs send these signals to the PFCs through the flight controls ARINC 629 buses.

Each PFC receives input signals from all six wheel position transducers. Each PFC selects which signal to use by mid-value selection and averaging.

Force Transducer

The two LVDTs of the force transducer send signals to the L2 ACE and the C ACE. The ACEs transmit these signals to the PFCs.

Speedbrake Lever Transducer

The four speedbrake lever transducer RVDTs send signals to the four ACEs. The ACEs transmit these signals to the PFCs.

Electrically-Controlled PCUs

Each ACE sends command signals to the EHSV of the assigned spoiler PCUs. The PCU sends feedback signals to its assigned ACE from the actuator piston position LVDT.

Cable-Controlled PCUs

The L2 ACE sends speedbrake control command signals to the PCUs of spoilers 4 and 11. The speedbrake command signal goes to the speedbrake solenoid valve. The PCU sends feedback signals to its assigned ACE from the actuator piston position LVDT.

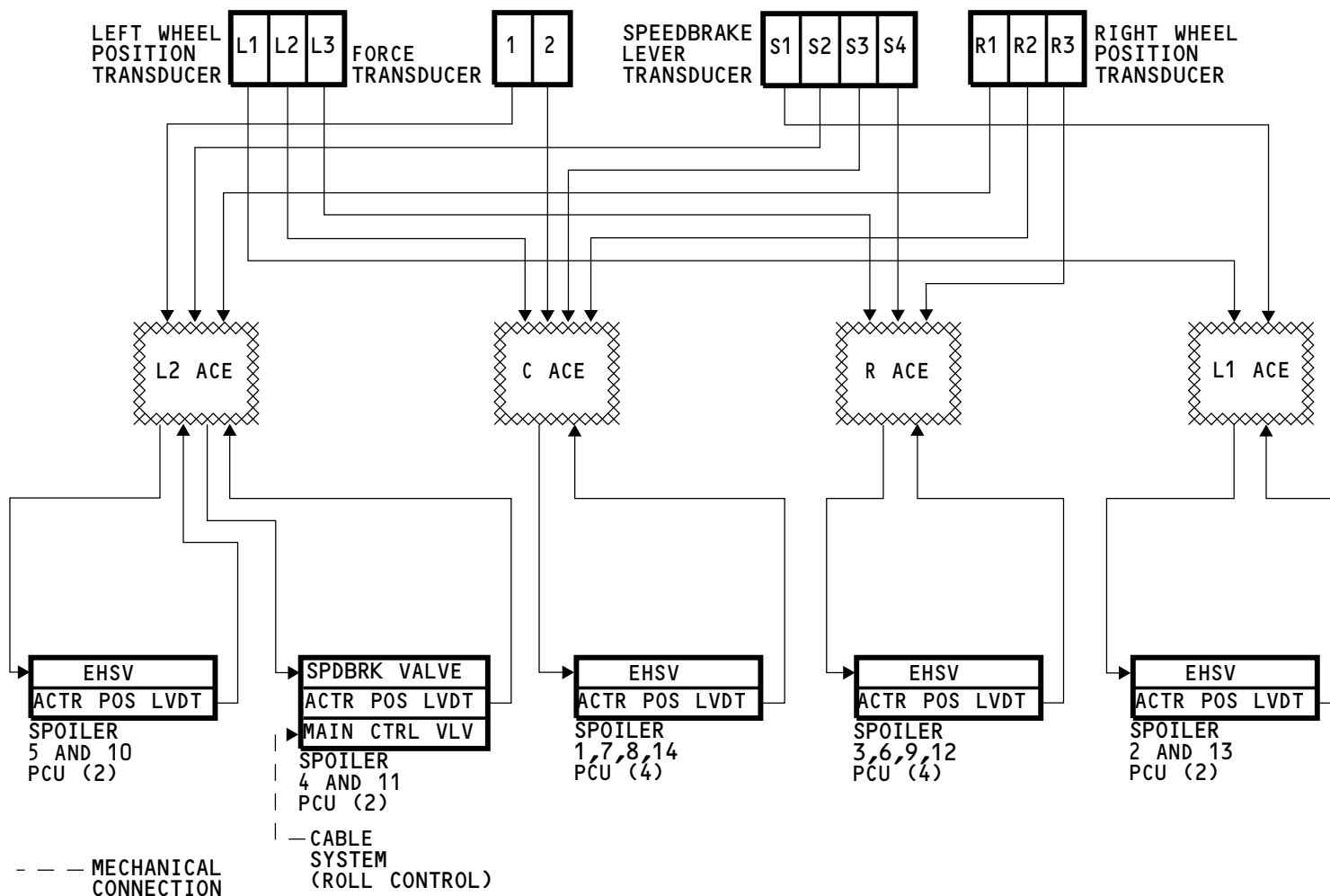
The cable system supplies mechanical roll command input to the main control valve of spoiler 4 and 11 PCUs.

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP**General**

The ACE contains a control servo loop circuit for all the electrically-controlled PCUs. This control servo loop circuit is also for the cable-controlled PCUs in speedbrake operation.

In normal and secondary modes of operation of the PFCS, the PFC sends mixed roll and speedbrake command signals to the ACE for the electrically-controlled PCUs. In direct mode, the ACE calculates the mixed command signals to these PCUs.

In normal mode of operation of the PFCS, the PFC sends speedbrake command signals to the cable-controlled PCUs (spoiler 4 and 11). In secondary and direct modes, there is no speedbrake command signal from the PFCs and ACEs to these PCUs.

Servo Loop Operation

The ACEs send the command signals to the EHSV of the electrically-controlled PCUs. In normal mode, they also go to the speedbrake solenoid valves of the cable-controlled PCUs. The ACEs monitor the PCU command signals for failures.

The actuator position LVDT measures the movement of the actuator and supplies a feedback signal to the ACEs to close the servo loop, and to monitor faults. This signal also goes to the PFC.

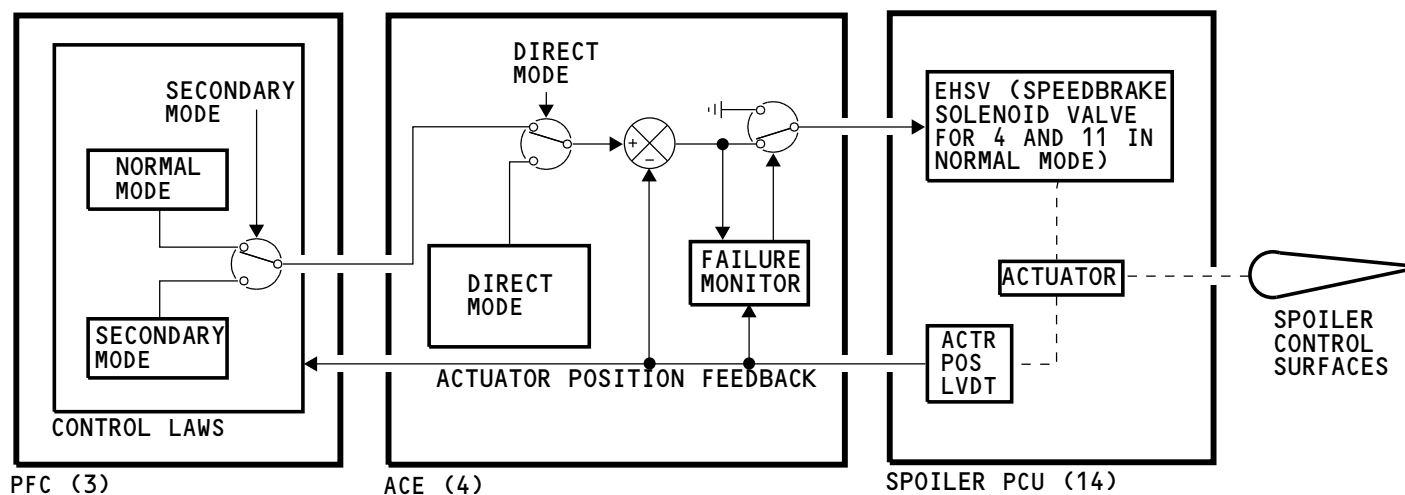
Failure Monitor

The ACE has a failure monitor to do a check of the correct operation of the PCU. The monitor uses the ACE command signal and the feedback signal from the actuator position LVDT.

If the ACE finds a failed spoiler PCU, it connects to ground the EHSV of both PCUs of the spoiler pair. The EHSV of each PCU has a mechanical and magnetic bias to command the actuator to retract when there is no electrical command to the EHSV.

Indications

The EICAS advisory message SPOILERS shows when one or more pair of spoilers does not operate. This condition causes the message to show in normal, secondary, and direct modes.



----- MECHANICAL CONNECTION

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - ACE SERVO LOOP

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

General

In the normal mode operation of the PFCS, the PFCs calculate spoiler commands from this information:

- Spoiler roll schedules
- Spoiler lockout logic
- Spoiler speedbrake schedules
- Mechanical speedbrake logic
- Speedbrake inhibit logic
- Spoiler mixing
- Autopilot roll commands.

Spoiler Roll Schedules

The PFCs receive roll control command signals from the wheel position transducers and from the autopilot. The spoiler roll schedules calculate the roll commands for the inboard and outboard spoilers. There are three different schedules. To select the applicable schedule, the PFCs use this information:

- Spoiler number (1 to 14)
- Flap position
- Spoiler lockout logic.

In roll control, the PFCs command the inboard spoilers to a maximum of 20 degrees and the outboard spoilers to a maximum of 45 degrees.

The cable-controlled system and linkages supply fixed roll schedule for spoilers 4 and 11 to move to a maximum of 45 degrees.

Spoiler Lockout Logic

The spoiler lockout logic affects the roll commands of spoilers 5 and 10. The PFCs use computed airspeed (CAS) and altitude data from the ADIRUs to calculate when to lockout these spoilers. The PFC commands cause spoilers 5 and 10 to fair to the wing surface and to lock out at cruise speed. The PFCs use the same lockout logic for aileron lockout.

Spoiler Speedbrake Schedules

The PFCs receive speedbrake control command signals from the speedbrake lever position transducers. The PFCs use spoiler speedbrake schedules to calculate the speedbrake commands for all spoilers, except 4 and 11. There are four different schedules. To select the applicable schedule, the PFCs use the spoiler number (1 to 14) and the main landing gear (MLG) on ground status.

During speedbrake control in flight, the PFCs command the inboard spoilers to a maximum of 15 degrees and the outboard spoilers to 45 degrees, except for spoilers 4, 5, 10, and 11. Spoilers 5 and 10 do not operate as speedbrakes in flight. Spoilers 4 and 11 operation is described in the paragraph below about mechanical speedbrake logic.

During speedbrake control on the ground, the PFCs command all the spoilers, except spoilers 4 and 11, to move to a maximum of 60 degrees.

Speedbrake Inhibit Function

The speedbrake inhibit function has an effect on the ground spoiler speedbrake commands. The function receives main landing gear on the ground signal from the PSEU and the pitch attitude from the ADIRU. The function also monitors the position of the speedbrake lever.

The speedbrake inhibit function operates when the pitch attitude is more than 2 degrees with the airplane on the ground or during the first 1.25 seconds after a main landing gear air to ground transition. When there is a speedbrake lever command, the outboard spoilers 2, 5, 10 and 13 do not deploy. The PFCs limit the inboard spoilers 6, 7, 8, and 9 to 20 degrees until the speedbrake inhibit function is no longer active.

Mechanical Speedbrake Logic

The mechanical speedbrake logic affects spoilers 4 and 11. The PFCs do not use speedbrake schedules for these spoilers. When the speedbrake lever position transducers indicate a command greater than 54 degrees, the PFCs cause the PCU speedbrake solenoid to energize. The PCUs for spoilers 4 and 11 then extend to move the spoilers to 45 degrees.

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE**Spoiler Mixing**

The PFC spoiler mixing function combines the roll and speedbrake commands into one mixed command for each electrically-controlled spoiler. This combines the roll commands from the control wheels with the speedbrake commands from the speedbrake lever.

For spoilers 4 and 11, there is no mixing of roll and speedbrake commands. Roll commands go through the cable-controlled system. The PFCs send only the speedbrake commands. The speedbrake function has priority over the roll function for spoilers 4 and 11. No matter what the roll command is, the PFCs extend spoilers 4 and 11 to 45 degrees TEU when the pilots move the speedbrake lever past 54 degrees.

Spoiler Auxiliary Retraction

The spoiler auxiliary retraction function gets signals from these overwing passenger door switches:

- Left door mode select switch
- Left door open switch
- Right door mode select switch
- Right door open switch.

The spoiler auxiliary retract function operates when the ADIRU ground speed is less than 40 knots and either door opens with the mode select switch in the auto position. The PFCs send commands to fully retract the inboard spoilers 6, 7, 8, and 9. The retract commands go to the ACEs and then from the ACEs to the EHSV of the inboard spoiler PCUs.

The PFCs remove the retract command to permit roll and speedbrake PCU operation when the overwing passenger doors close and hydraulic pressure for any main hydraulic system goes from low to high. The PFCs also remove the retract command if the ground speed is more than 40 knots.

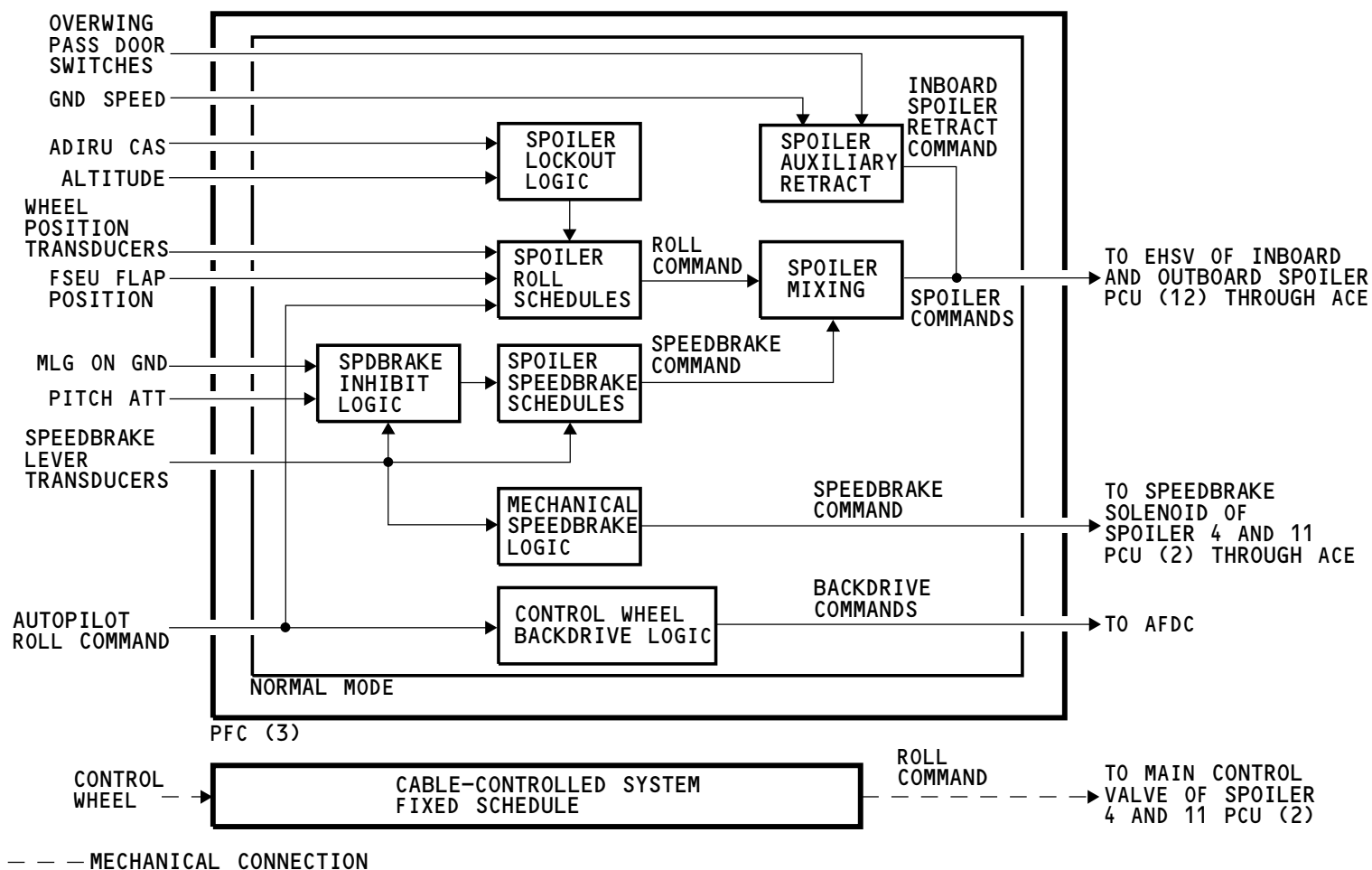
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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - NORMAL MODE

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**SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE****General**

In secondary mode operation of the PFCS, the PFCs calculate roll and speedbrake control commands for the electrically-controlled spoilers based on this data:

- Secondary roll spoiler schedule
- Secondary speedbrake spoiler schedule
- Spoiler lockout.

The PFCs do not control spoilers 4 and 11 in the secondary mode. These spoilers only receive roll commands from the cable-controlled system.

Secondary Roll Spoiler Schedule

The PFCs receive roll control command signals from the wheel position transducers. The secondary roll spoiler schedule determines the spoiler roll commands for all spoilers except 4 and 11. This schedule supplies a fixed, nonlinear relationship between the control wheel command and the spoiler commands. The PFCs invert the commands for the left wing in relation to the commands for the right wing.

During roll control in flight and on the ground, the PFCs command the inboard spoilers to a maximum of 20 degrees and the outboard spoilers to a maximum of 45 degrees, except spoilers 5 and 10. Spoilers 5 and 10 do not operate for roll control in secondary mode.

The cable-controlled system and linkages supply fixed, roll schedules for spoilers 4 and 11.

Secondary Speedbrake Spoiler Schedule

The PFCs receive speedbrake command signals from the speedbrake lever position transducer. The secondary speedbrake spoiler schedule determines the spoiler speedbrake commands for all spoilers except 4, 5, 10, and 11.

During speedbrake control in flight and on the ground, the PFCs command the inboard spoilers to a maximum of 20 degrees and the outboard spoilers to a maximum of 45 degrees, except for spoilers 4, 5, 10, and 11. Spoilers 4, 5, 10, and 11 do not operate as speedbrakes in secondary mode.

Combined Spoiler Commands

The PFCs combine the speedbrake and roll commands to calculate the inboard and outboard spoiler commands for the electrically-controlled spoilers.

Spoiler Lockout

Spoilers 5 and 10 are locked out at all times during roll and speedbrake commands in secondary mode of the PFCS.

Spoiler Auxiliary Retraction

The spoiler auxiliary retraction function gets signals from these overwing passenger door switches:

- Left door mode select switch
- Left door open switch
- Right door mode select switch
- Right door open switch.

The spoiler auxiliary retract function operates when the ADIRU ground speed is less than 40 knots and either overwing passenger door opens with the mode select switch in the auto position. The PFCs then send commands to fully retract the inboard spoilers 6, 7, 8, and 9. The retract commands go to the ACEs and then from the ACEs to the EHSV of the inboard spoiler PCUs.

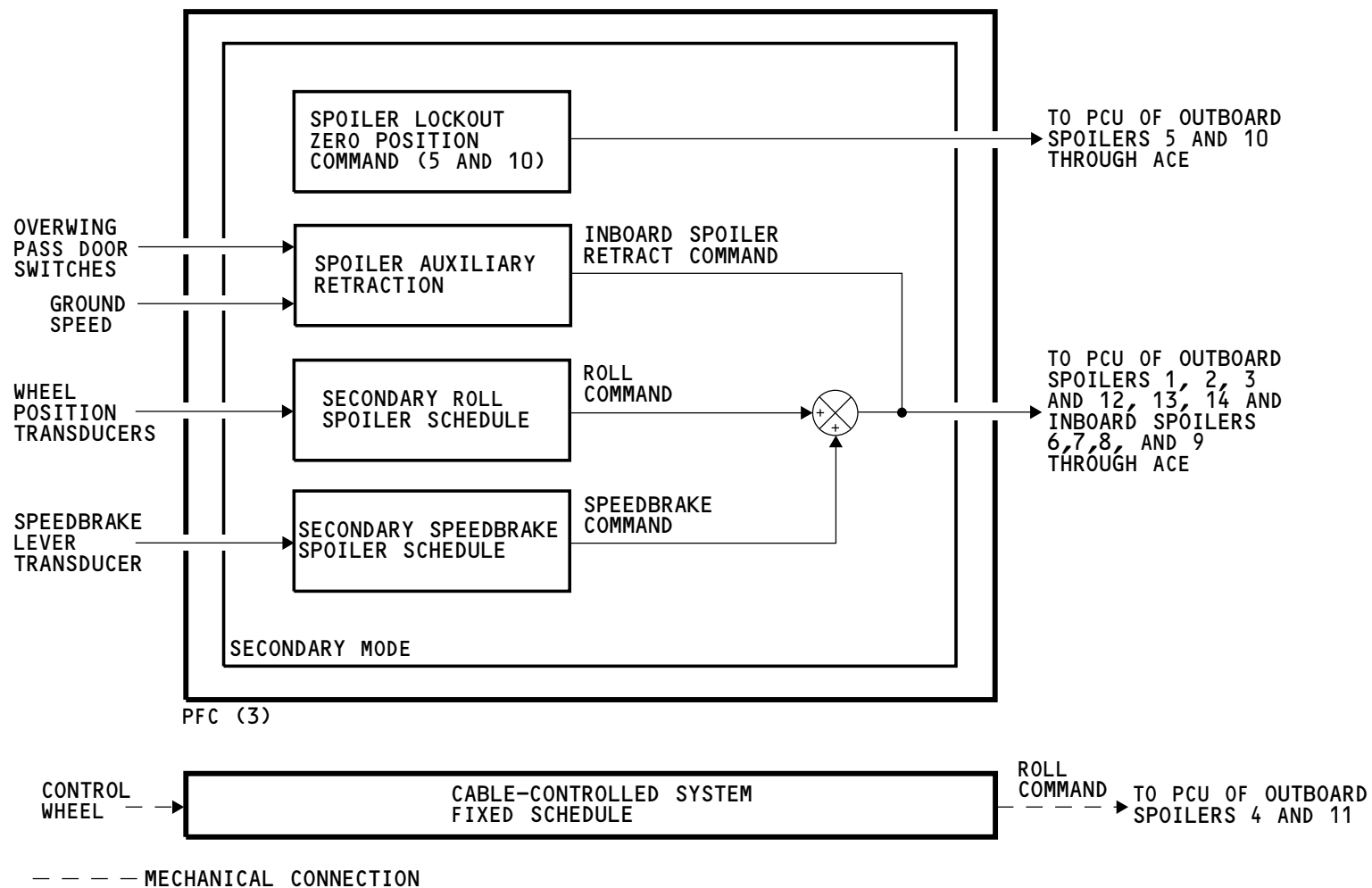
The PFCs remove the retract command to permit spoiler and speedbrake PCU operation when the overwing passenger doors close and hydraulic pressure for any main hydraulic system goes from low to high. The PFCs also remove the retract command if the ground speed is more than 40 knots.

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - SECONDARY MODE

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

General

In the direct mode operation of the PFCS, the ACEs calculate roll and speedbrake commands for the electrically-controlled spoilers based on these inputs:

- Direct roll spoiler schedules
- Direct speedbrake spoiler schedules
- Spoiler lockout.

The ACEs do not control spoilers 4 and 11 in the direct mode. These spoilers only receive roll commands from the cable-controlled system.

Direct Roll Spoiler Schedules

The ACEs receive roll command signals from the wheel position transducers. The ACEs use the direct roll spoiler schedules to calculate the roll commands for the inboard and outboard spoiler PCUs. These schedules supply a fixed nonlinear relationship between the control wheel command and the spoiler command. The ACEs invert the commands for the left wing in relation to the commands for the right wing.

In roll control in flight and on the ground, the ACEs command the inboard spoilers to a maximum of 20 degrees and the outboard spoilers to a maximum of 45 degrees.

The mechanical cable system and linkages supply fixed roll schedules for spoilers 4 and 11.

Direct Speedbrake Spoiler Schedules

The ACEs receive speedbrake command signals from the speedbrake lever transducer. The ACEs use the direct speedbrake spoiler schedules to determine the speedbrake commands for the inboard and outboard spoilers excepts 4, 5, 10 and 11. These schedules supply a fixed nonlinear relationship between the speedbrake lever command and the spoiler command.

In speedbrake control in flight and on the ground, the ACEs command the inboard spoilers to a maximum of 20 degrees and the outboard spoilers to a maximum of 45 degrees except for spoilers 4, 5, 10 and 11. Spoilers 4 and 11 do not operate as speedbrakes in direct mode.

Combined Spoiler Commands

The ACEs combine the speedbrake and the roll commands to calculate the inboard and outboard spoiler commands for the electrically-controlled spoilers.

Spoiler Lockout

Spoilers 5 and 10 are locked out at all times during roll and speedbrake commands in direct mode of the PFCS.

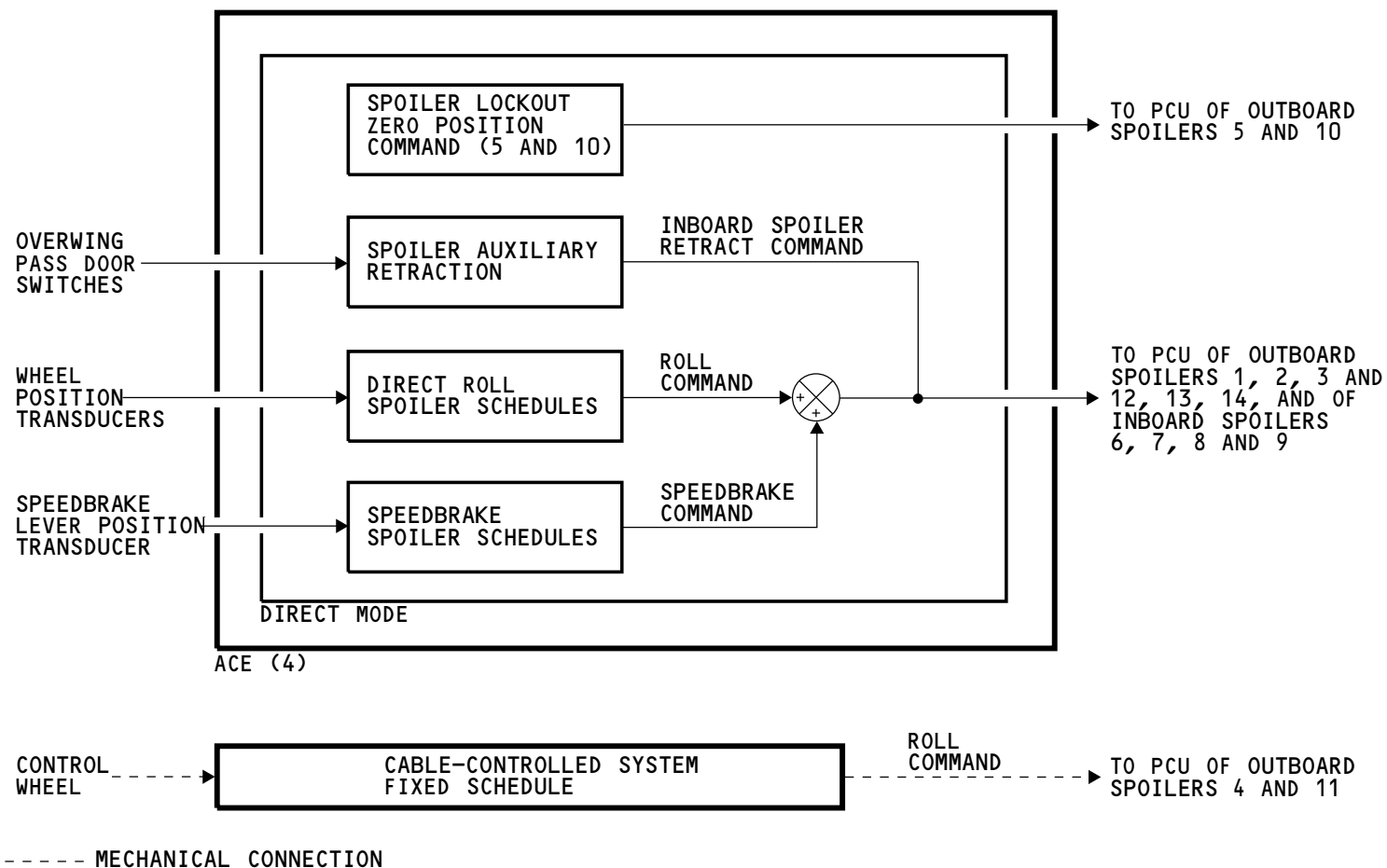
Spoiler Auxiliary Retraction

The C ACE and R ACE get signals from these overwing passenger door switches:

- Left door mode select switch
- Left door open switch
- Right door mode select switch
- Right door open switch.

The spoiler auxiliary retract function operates when either overwing passenger door opens if the mode select switch is in the auto position. The C ACE sends commands to fully retract inboard spoilers 7 and 8. The R ACE sends commands to fully retract inboard spoilers 6 and 9. The retract commands go to the EHSV of the PCUs.

The ACEs remove the retract commands to permit roll and speedbrake PCU operation when the overwing passenger doors close and hydraulic pressure for the PCU goes from low to high.



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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - DIRECT MODE

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**SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - SPOILER LOCKOUT****Purpose**

To prevent tail buffet at cruise speed, spoilers 5 and 10 fair to the wing surface and lock out during cruise.

Functional Description

The PFCs and the ACEs command spoilers 5 and 10 to lock out based on altitude and computed airspeed (CAS).

Spoiler lockout is available in normal, secondary, and direct modes.

Normal Mode

In normal mode, the PFCs control the lockout of spoilers 5 and 10 based on airspeed and altitude. For high airspeeds and altitudes, the spoiler panels are locked out. For low airspeeds and low altitudes, the spoiler panels are commanded to move.

There is a range of reduced authority as the airspeed increases. The PFCs use airspeed input to decrease the amount of spoiler pick-up from full authority to lock out.

Secondary and Direct Modes

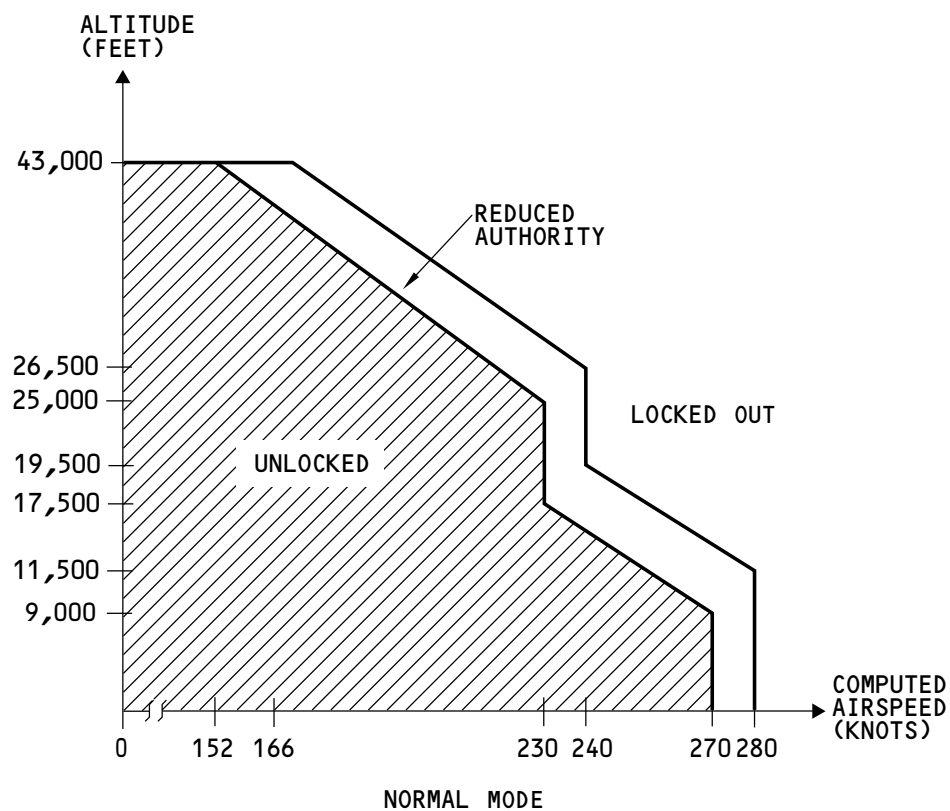
In secondary and direct mode, the PFCs and ACEs lockout spoilers 5 and 10 at all times.

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SPOILER AND SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION - SPOILER LOCKOUT

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**SPOILER AND SPEEDBRAKE CONTROL - SPOILER AUXILIARY RETRACTION - FUNCTIONAL DESCRIPTION****General**

The R ACE and C ACE send signals to the PFCs when an overwing passenger door opens in the auto mode. In the PFCS normal and secondary modes, the PFCs send command signals to fully retract all inboard spoiler PCUs when either door opens in the auto mode. In the PFCS direct mode, the R ACE and C ACE send the command signals.

The SARDs make sure that spoilers 7 and 8 retract even if the PFCS commands fail to cause retraction.

Functional Description

The SARD function uses these passenger door components:

- EPAS battery pack
- Backup battery
- Mode select switch
- Door open switch.

The mode select switch moves to the auto position when the passenger door is armed. The door open switch moves to the open position when the door handle moves to the door open position.

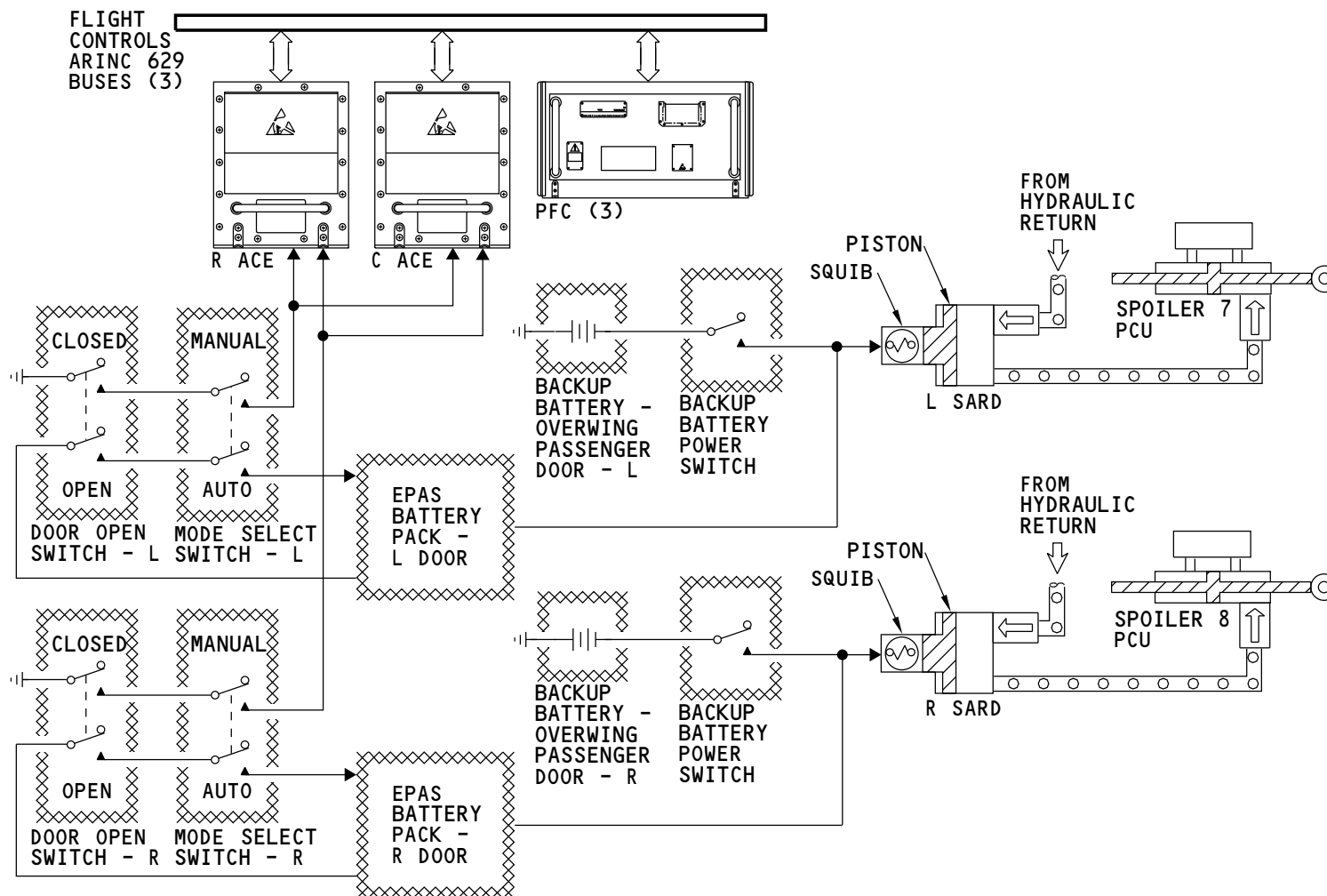
When the door open switch is in the open position and the mode select switch is in the auto position, an electrical signal goes to the:

- EPAS battery pack
- R ACE
- C ACE.

The EPAS battery sends power to fire the SARD squib. High pressure gas from the squib combustion pushes on the floating piston in the SARD transfer cylinder. Return hydraulic fluid inside the transfer cylinder goes through a hydraulic line to the retract side of the spoiler PCU actuator. A check valve prevents the flow of hydraulic fluid back to the hydraulic system return. The spoiler PCU then moves to the fully retracted position.

Backup Operation

An open overwing door gives access to a handle to close the backup battery power switch. A flight attendant will pull on the handle if the EPAS operation has not made the offwing slide deploy and spoiler retract. When the switch closes, power will go from the backup battery to the squib.



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SPOILER AND SPEEDBRAKE CONTROL - SPOILER AUXILIARY RETRACTION - FUNCTIONAL DESCRIPTION

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**AUTO SPEEDBRAKE CONTROL - GENERAL DESCRIPTION****General**

The auto speedbrake controls the automatic movement of the speedbrake lever during airplane operation on the ground. The pilots use the auto speedbrake during landing and refused takeoff (RTO). Extension of the auto speedbrake causes all spoilers to deploy to their maximum position.

Auto Speedbrake Control

The PFCs control the automatic extension and retraction of the speedbrake lever. The PFC logic requires that a series of conditions be met to command the auto speedbrake actuator to operate.

When the pilot moves the speedbrake lever out of its DOWN detent to the ARM position, the speedbrake lever transducer supplies a signal to the PFCs through the ACEs. When the pilot operates the engine thrust reverser, the auto speedbrake thrust reverse switch supplies a signal to the PFCs through the AIMS cabinets.

The main landing gear truck tilt sensors supply signals to the proximity sensor electronic units (PSEUs). The electronic engine controls (EECs) supply signals through the engine data interface units (EDIUs) to show the position and validity of the thrust resolver angles. The hydraulic interface module (HYDIM) cards supply signals about the hydraulic pressure status of the truck tilt actuators. The weight-on-wheels (WOW) cards supply signals that the airplane is on the ground. The radio altimeters supply the airplane altitude near the ground. All these signals go through the AIMS to the PFCs.

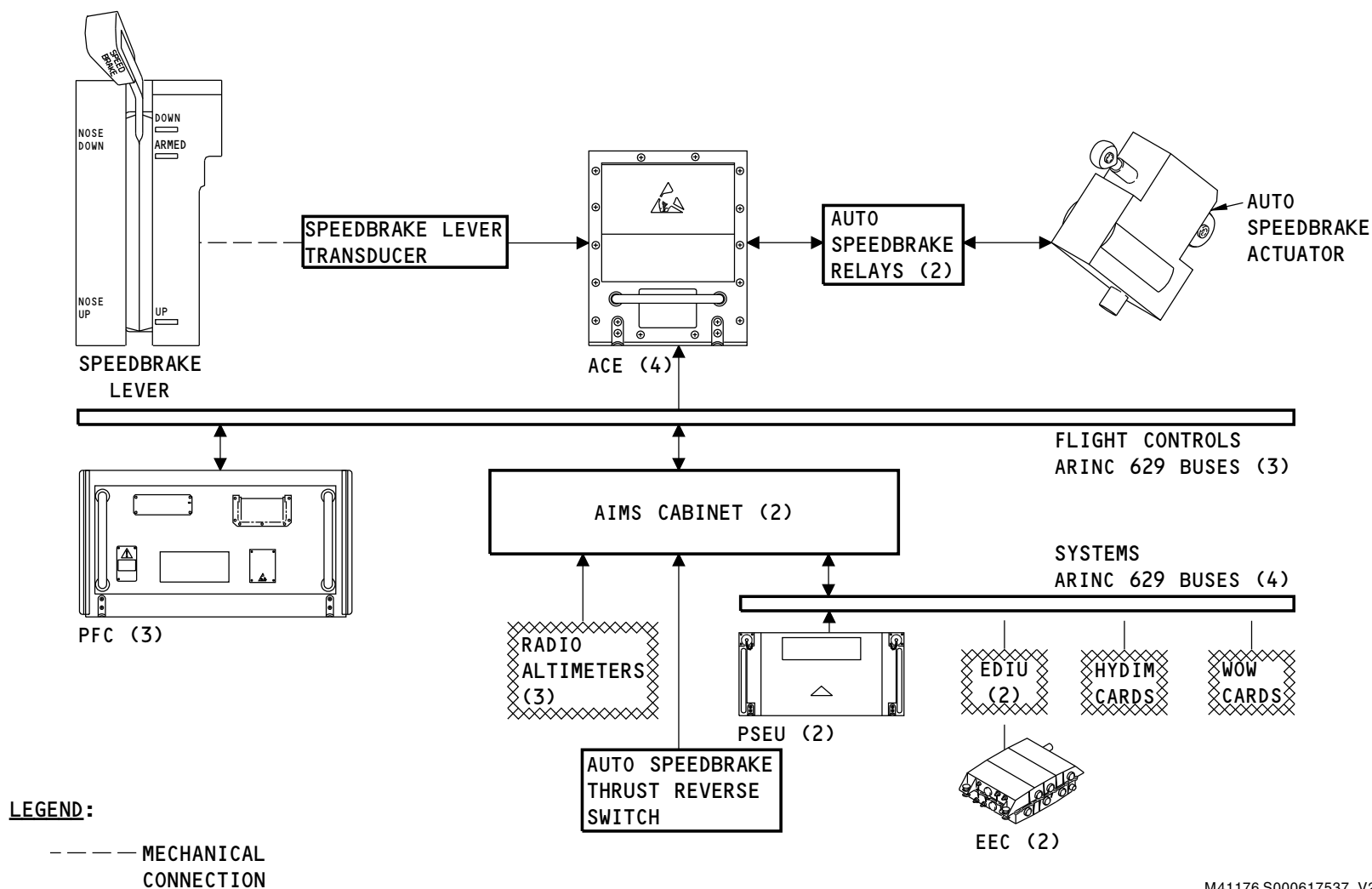
When the extension or retraction conditions are met, the PFCs send command signals to the ACEs. The ACEs then control the auto speedbrake relays which control power to the auto speedbrake actuator. This causes the auto speedbrake actuator to extend or retract.

The auto speedbrake clutch transmits the movement from either the speedbrake lever or the auto speedbrake actuator to the speedbrake lever transducer. The auto speedbrake clutch permits the pilot to move the speedbrake lever and override the commands of the auto speedbrake actuator at anytime.

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AUTO SPEEDBRAKE CONTROL - GENERAL DESCRIPTION

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**AUTO SPEEDBRAKE CONTROL - COMPONENT LOCATIONS****General**

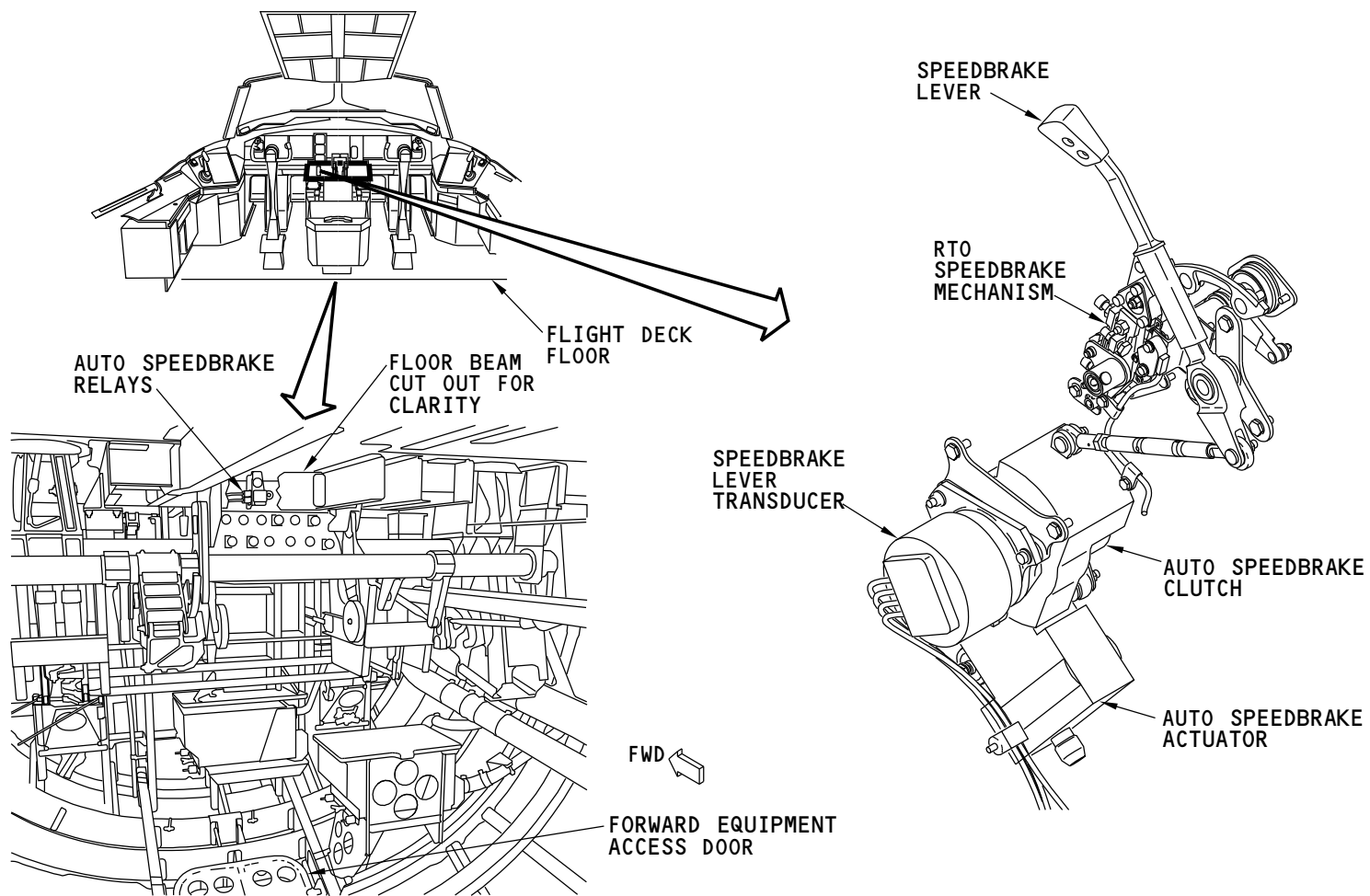
The auto speedbrake components are on the left side of the control stand in the flight deck. These components include:

- The auto speedbrake clutch
- The auto speedbrake actuator
- The RTO speedbrake mechanism.

Remove the left panel of the control stand to access the auto speedbrake components.

The two auto speedbrake relays are on a bracket below the control stand. Access to the relays is through the forward equipment access door.

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AUTO SPEEDBRAKE CONTROL - COMPONENT LOCATIONS

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AUTO SPEEDBRAKE CONTROL - INTERFACES

General

The electrical interfaces with the PFCS for the auto speedbrake go through the ACEs. The ACEs have interfaces with these components:

- The speedbrake lever transducer
- The auto speedbrake thrust reverse switch
- The auto speedbrake actuator
- The auto speedbrake relays.

When both auto speedbrake relays are de-energized, they supply electrical power to retract the auto speedbrake actuator. Retraction of the actuator causes the speedbrake lever to move from the UP position to the DOWN position.

Speedbrake Lever Transducer

The speedbrake lever transducer supplies a signal that the speedbrake lever is in the ARMED position or beyond.

See the spoiler and speedbrake control section for more information about the speedbrake lever transducer (SECTION 27-61).

Auto Speedbrake Thrust Reverse Switch

The auto speedbrake thrust reverse switch supplies an electrical signal to the ACEs when there is movement of one or both thrust reverser levers. The signal goes from the auto speedbrake thrust reverse switch to the AIMS cabinets which transmit it to the ACEs through the flight controls ARINC 629 buses.

Auto Speedbrake Actuator

The auto speedbrake actuator receives electrical power through the auto speedbrake relays. Switches in the auto speedbrake actuator supply the actuator position feedback to the L1 and R ACEs.

Auto Speedbrake Relays

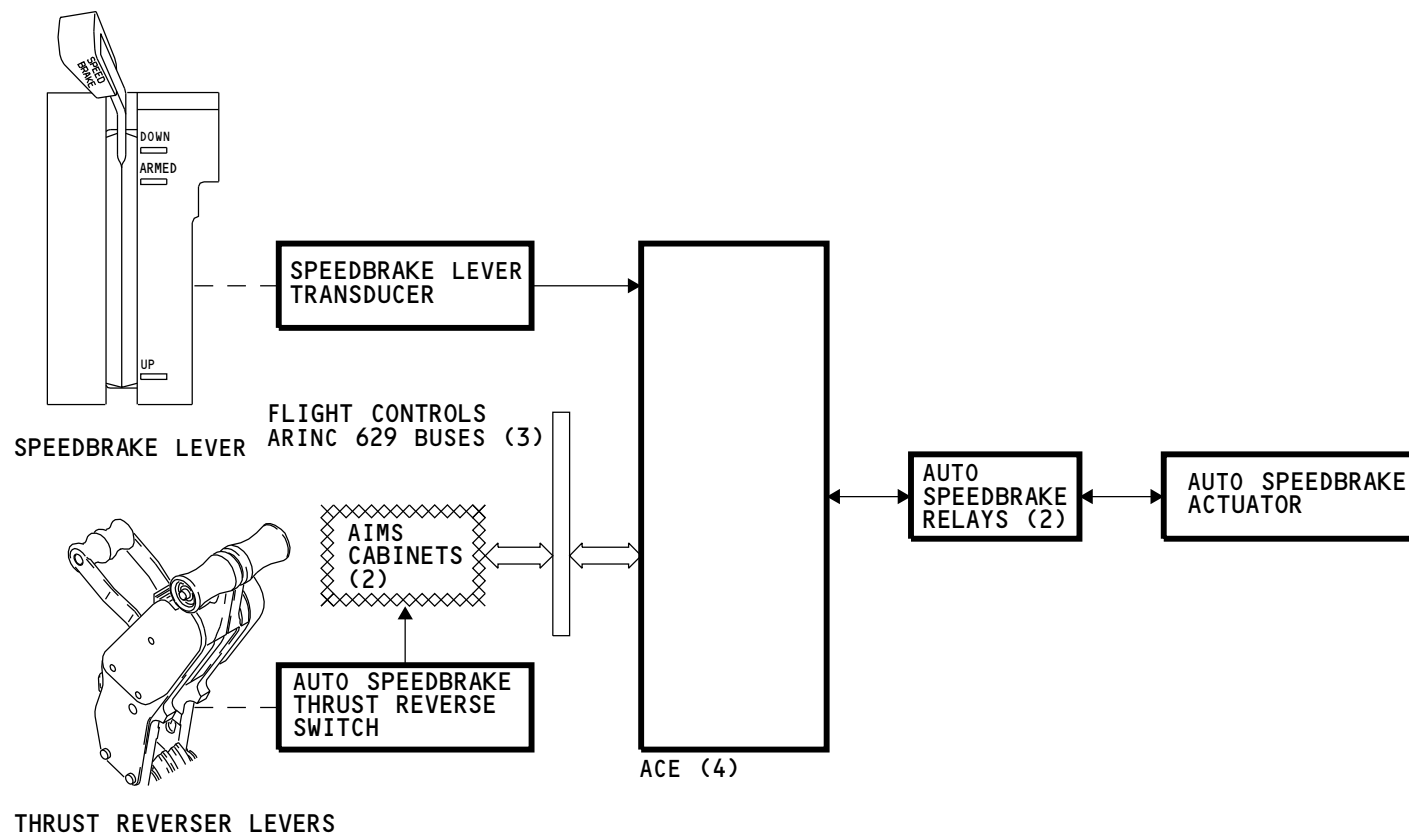
The auto speedbrake relays receive the command signals from the L1 and R ACEs. When both relays are energized, they supply electrical power to extend the auto speedbrake actuator. Extension of the actuator rod causes the speedbrake lever to move from the ARMED position to the UP position.

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AUTO SPEEDBRAKE CONTROL - INTERFACES

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**AUTO SPEEDBRAKE CONTROL - AUTO SPEEDBRAKE CLUTCH****Purpose**

The auto speedbrake clutch transmits the movement of the speedbrake lever or the auto speedbrake actuator to the speedbrake lever transducer. The auto speedbrake clutch prevents movement of the speedbrake lever without an input from the pilot or the auto speedbrake actuator.

The auto speedbrake clutch supplies friction for pilot feel. It also has a detent when the speedbrake lever reaches the ARMED position. The auto speedbrake clutch permits the pilot to move the speedbrake lever and to override the auto speedbrake actuator at anytime.

Physical Description

The auto speedbrake clutch attaches to the left support frame of the control stand. The speedbrake lever control rod attaches to the top lever of the auto speedbrake clutch. The auto speedbrake actuator attaches to the lower aft lever of the auto speedbrake clutch. The output shaft of the auto speedbrake clutch has a spline which connects to the shaft of the speedbrake lever transducer.

The auto speedbrake clutch is an LRU. It is not necessary to adjust the clutch. The clutch weighs about 2 lb (1.8 kg).

Location

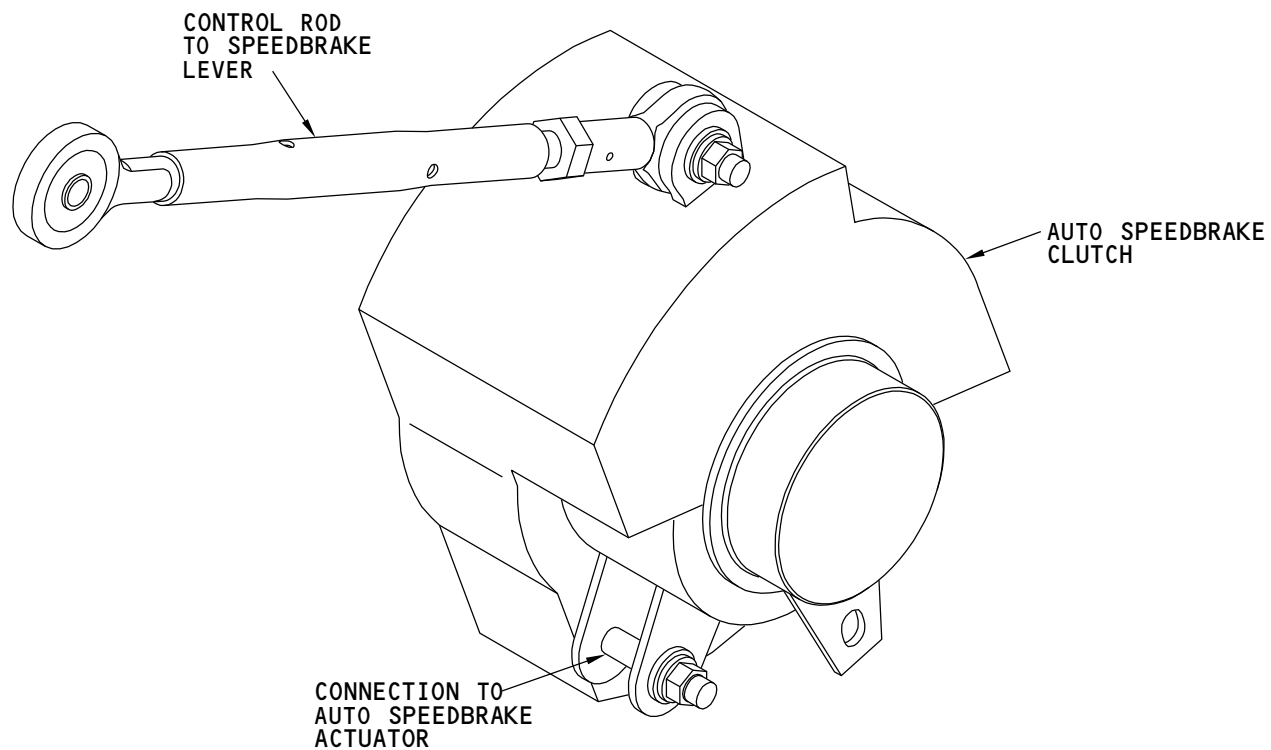
The auto speedbrake clutch is on the left side of the control stand in the flight deck. Remove the left panel of the control stand to get access to the auto speedbrake clutch.

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AUTO SPEEDBRAKE CONTROL - AUTO SPEEDBRAKE CLUTCH

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AUTO SPEEDBRAKE CONTROL - AUTO SPEEDBRAKE ACTUATOR**Purpose**

The auto speedbrake actuator extends and retracts to move the speedbrake lever and the speedbrake lever transducer. The auto speedbrake clutch transmits the movement from the auto speedbrake actuator.

Physical Description

The auto speedbrake actuator is a self-contained unit which contains these components:

- A reversible electric motor
- A gearbox
- Limit switches

The limit switches control electrical power to the reversible motor and supply a feedback position signal to the L1 ACE.

The auto speedbrake actuator operates with 28v dc current. It has a stroke of 1.6 inch (40.64 mm).

The auto speedbrake actuator is an LRU. It is not necessary to adjust the actuator. The actuator weighs about 2.8lb (1.3 kg).

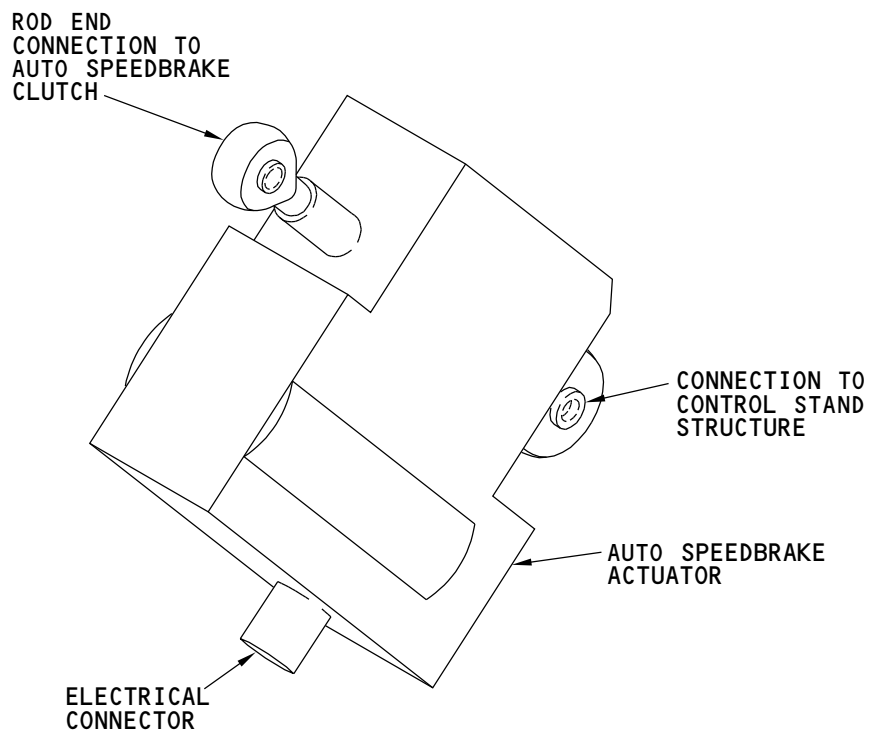
Location

The auto speedbrake actuator is on the left side of the control stand in the flight deck. Remove the left panel of the control stand to get access to the auto speedbrake actuator.

Functional Description

When the actuator gets electrical power, the current direction causes it to move to the full extended or retracted position.

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AUTO SPEEDBRAKE CONTROL - AUTO SPEEDBRAKE ACTUATOR

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**AUTO SPEEDBRAKE CONTROL - RTO SPEEDBRAKE MECHANISM****Purpose**

When the pilot commands reverse thrust, the RTO speedbrake mechanism lifts the speedbrake lever out of the DOWN detent and actuates the auto speedbrake thrust reverse switch. The PFC uses the auto speedbrake thrust reverse switch signal to command the auto speedbrake actuator to move the speedbrake lever to the UP position.

Physical Description

The RTO speedbrake mechanism consists of a pair of cam followers, each actuated by a thrust lever cam. Either cam follower turns the speedbrake lever lifter drive segment. The lifter drive segment connects with the speedbrake lever lifter assembly. A return spring returns the lifter to the down position when the thrust reverser lever moves to the idle position.

A switch adjust screw at the rear of the lifter assembly operates the auto speedbrake thrust reverse switch.

Location

The RTO speedbrake mechanism is on the left frame of the thrust lever assembly in the control stand. Remove the left access panel of the control stand to access the RTO speedbrake mechanism.

Functional Description

When the pilot moves either or both thrust reverser levers, one or both thrust lever cams cause the cam followers to turn. This also turns the speedbrake lever lifter drive segment and causes the speedbrake lever lifter assembly to move. As the speedbrake lever lifter assembly turns, it lifts the speedbrake lever out of the DOWN detent. The switch adjust screw at the rear of the lifter assembly then contacts and actuates the auto speedbrake thrust reverse switch.

Training Information Point

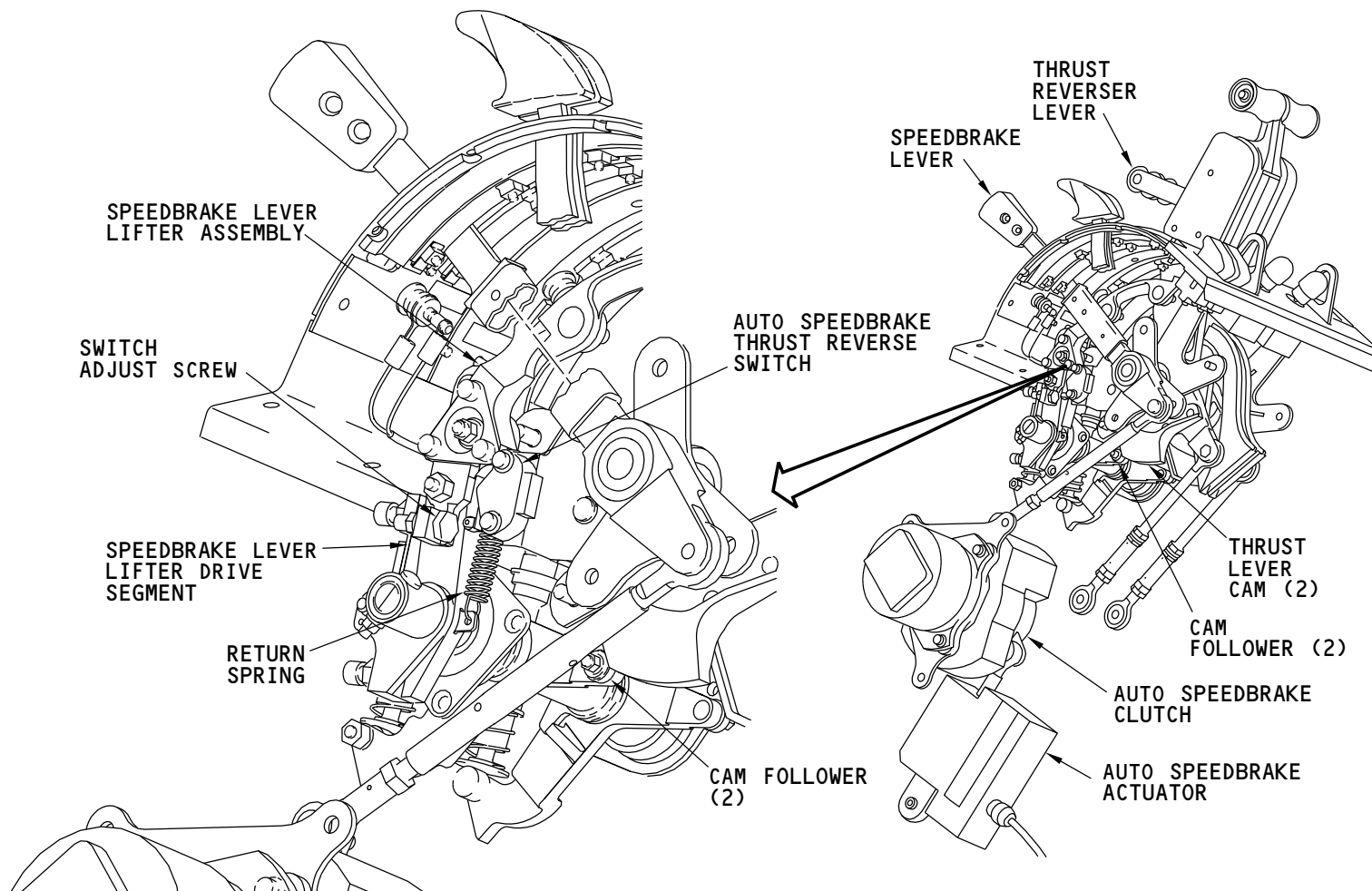
The switch adjust screw at the back of the speedbrake lever lifter assembly is adjustable.

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AUTO SPEEDBRAKE CONTROL - RTO SPEEDBRAKE MECHANISM

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AUTO SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION

General

The PFCs control the extension and retraction of the auto speedbrake actuator. The auto speedbrake operates only when the PFCs are in normal mode. The PFCs send extend command signals to the L1 and R ACEs. These ACEs control two auto speedbrake relays.

The L1 ACE energizes the auto speedbrake control relay and the R ACE energizes the auto speedbrake arm relay. Both relays need to be energized to command the auto speedbrake actuator to extend. Both relays need to be de-energized to command the auto speedbrake actuator to retract.

If one relay is energized while the other is de-energized, the auto speedbrake actuator stops.

Training Information Point

If you move a fuel control switch to RUN or an electronic engine control (EEC) maintenance switch to TEST, airplane power will be supplied to the EEC. The EEC supplies power to the related thrust lever angle resolver, which provides a valid TRA signal to the PFCs. With no engines running, the auto speedbrake logic only requires one valid TRA signal. If the speedbrake lever is not in the down position, the auto speedbrake actuator may extend or retract causing the speedbrake lever and spoilers to move.

Auto Speedbrake Actuator

Two sets of limit switches control electrical power to the motor. The actuator position controls the limit switches. As the actuator starts to extend, the fully retracted switch operates. The fully extended switch operates only when the actuator has fully extended. The reverse happens during retraction.

The fully retracted switch has contacts that supply the L1 ACE and PFCs with the actuator status.

Auto Speedbrake Operation During Landing

During landing, the auto speedbrake operates when all these conditions occur:

- The main landing gear is on the ground

- The speedbrake lever is in the ARMED position
- Both left and right thrust resolver angles are not at the takeoff position
- Both thrust resolver angle signals are valid.

Before landing, the pilots arm the speedbrake lever. During the flare, the pilots move both thrust levers to idle. At touch down, the auto speedbrake actuator fully extends the speedbrake lever. This commands all spoilers to fully deploy.

The auto speedbrake retracts to the DOWN position if any of the above conditions changes after the auto speedbrake has fully extended.

The auto speedbrake retracts to the ARMED position if any of the above conditions changes when the auto speedbrake has partially extended.

Auto Speedbrake Operation During RTO

The auto speedbrake operates during RTO when all these conditions occur:

- Main landing gear is on the ground
- Auto speedbrake thrust reverser switch is closed
- Auto speedbrake thrust reverser switch signal is valid
- No disagreement fault between the auto speedbrake thrust reverser switch and the thrust resolver angle signal.

During a refused takeoff (RTO), the auto speedbrake also operates when all these conditions occur:

- Main landing gear is on the ground
- Either engine thrust reverser is operated
- Thrust resolver angle signal that is operated is valid.

During a RTO, when the pilot moves at least one of the thrust reverser levers, the auto speedbrake extends the speedbrake lever. This commands all spoilers to fully deploy. When the thrust reverser levers are returned to the normal position, the speedbrake lever stays in the UP position as long as the logic for autospeedbrake operation during landing is valid.

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AUTO SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION

Main Landing Gear On Ground

One of the conditions for the auto speedbrake actuator to extend is that the main landing gear is on the ground.

The PFCs determine that the main landing gear is on the ground from a combination of signals received through the AIMS.

During approach, the main landing gear is extended and the main gear trucks tilted by hydraulic pressure. At touch down, the main landing gear is on the ground when the main gear trucks are not tilted with hydraulic pressure on the truck tilt actuators. The radio altimeter signals verify that the main landing gear is on the ground.

The weight-on-wheel cards supply signals when the airplane is on the ground. These signals verify that the main landing gear is on the ground during RTO.

Indications

The EICAS advisory and status messages AUTO SPEEDBRAKE indicate that the auto speedbrake is defective and does not operate normally. This happens when one of these conditions is present:

- Truck tilt pressure is low with the main landing gear down and locked and the center hydraulic system pressure is high
- Radio altitude data is not valid
- An air/ground validity fault is active
- An auto speedbrake power circuit breaker is open
- PFCS is not in normal mode.

Although the operation of the auto speedbrake is available only in normal mode, these conditions cause the message to show in the normal, secondary, and direct modes.

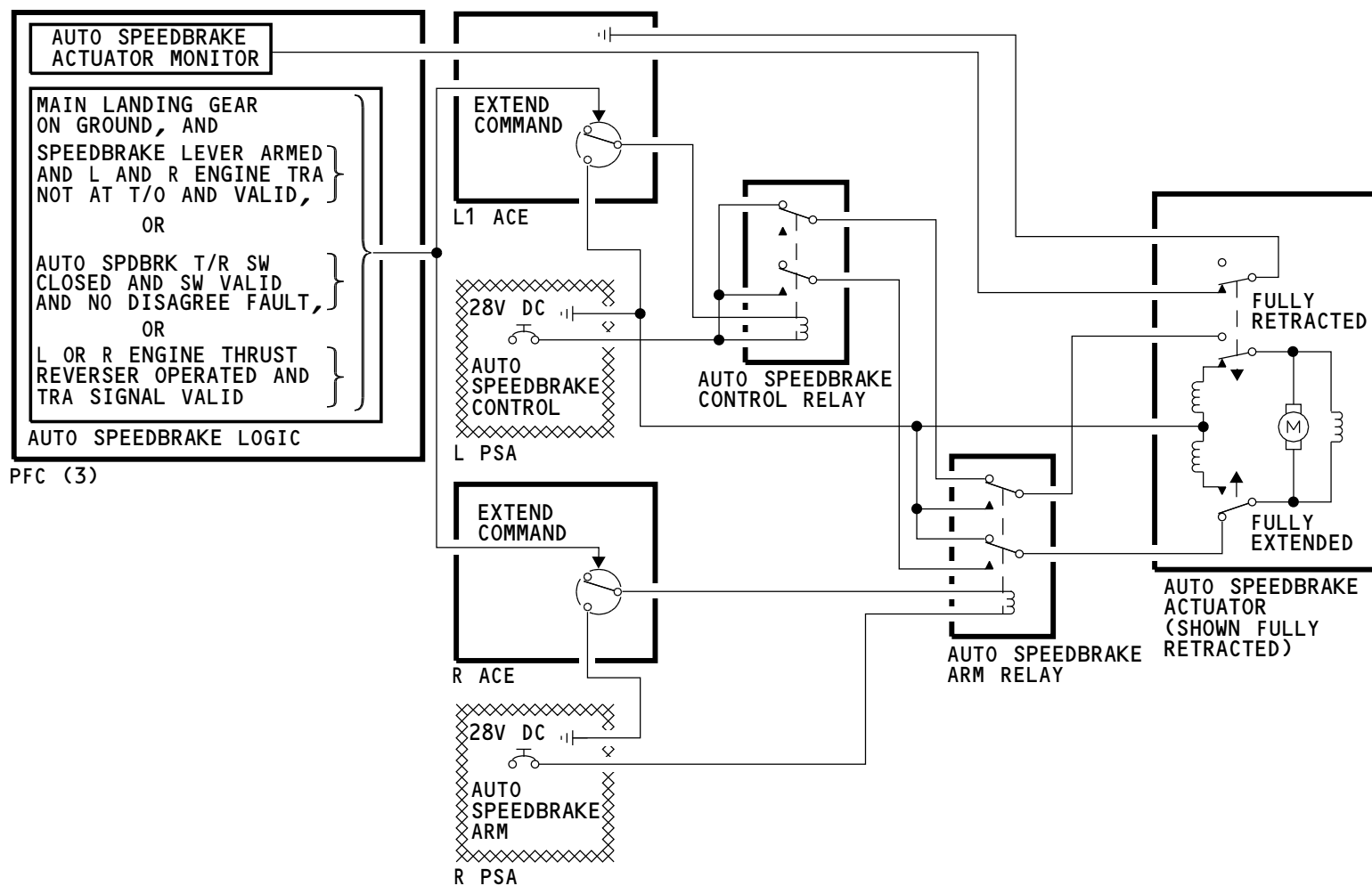
- Either L1 ACE or R ACE is defective
- Auto speedbrake actuator does not retract within 3 seconds after removal of a command to extend
- Auto speedbrake actuator stays retracted for more than 3 seconds after a command to extend
- Loss of data from one thrust resolver angle, in the air with the related engine running, or on the ground with both engines running
- Loss of data from both thrust resolver angles in the air, or on the ground with both engines running
- Loss of valid data of the truck tilt pressure transducers from both the L and R HYDIM cards
- Loss of valid truck tilt position data from either PSEU 1 or PSEU 2
- Center hydraulic system is failed

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AUTO SPEEDBRAKE CONTROL - FUNCTIONAL DESCRIPTION

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LEADING EDGE SLATS - INTRODUCTION

General

The leading edge (LE) slats improve the takeoff and landing performance of the airplane. When the slats extend, they increase the lift of the wing. They also increase the angle of attack (AOA) at which the wing stalls.

The slats are part of the high lift control system (HLCS). The HLCS electrically controls the slats with a fly-by-wire system.

During takeoff and landing, the pilots use the flap lever to command the slats to extend to the sealed or gapped positions. After takeoff, the pilots use the flap lever to command the slats to retract to the up position.

Each wing has an inboard slat, a krueger flap, and six outboard slats.

Slat Operation

The slats operate in sequence with the flaps. At cruise speed and altitude, slat extension is inhibited.

During secondary mode operation, the load relief function retracts the slats at high airspeed.

The autoslat function extends the slats to improve the airplane stall performance near stall conditions.

The slats are monitored for skew or asymmetry. When there is a skew or asymmetry, the slat drive shuts down.

Abbreviations and Acronyms

- ADP - air driven pump
- AIMS - airplane information management system
- altn - alternate
- AOA - angle of attack
- ARINC - Aeronautical Radio, Inc.
- ASCPC - air supply and cabin pressure controller
- EICAS - engine indication and crew alerting system
- EXT - extend
- FSEU - flap/slat electronics unit

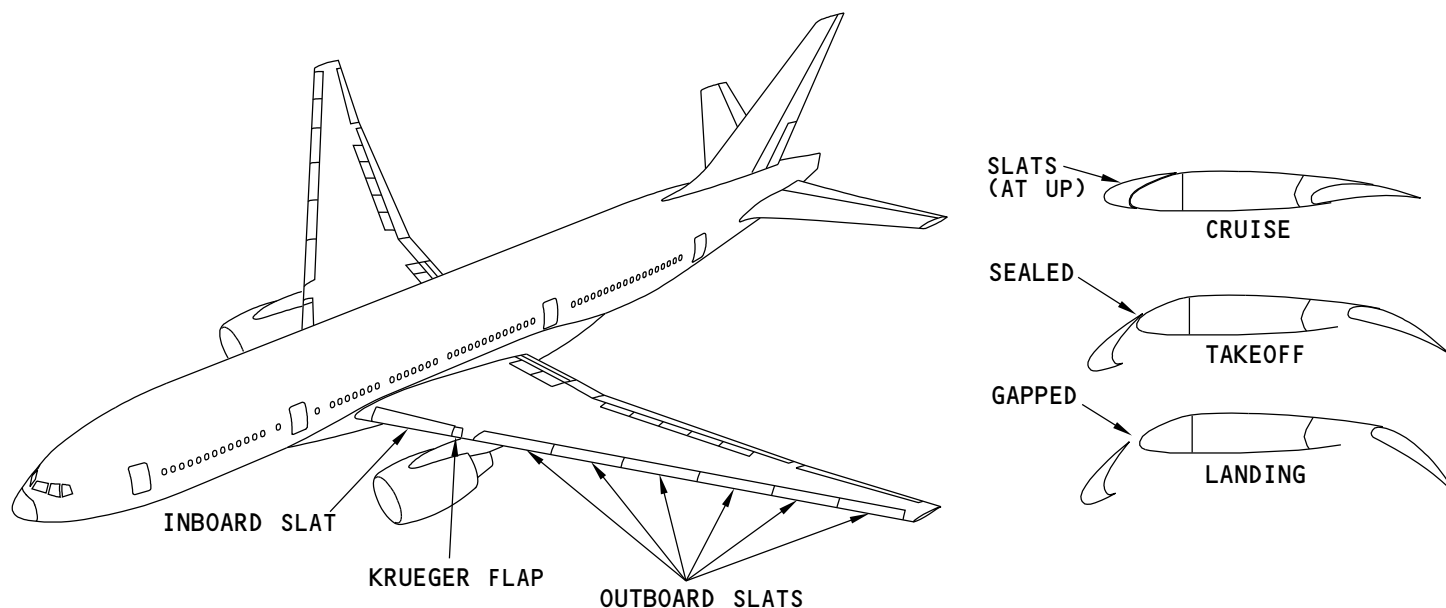
- HYDIM - hydraulic interface module
- HLCS - high lift control system
- LE - leading edge
- LVDT - linear variable differential transformer
- MAT - maintenance access terminal
- PDU - power drive unit
- retr - retract
- sec - secondary
- WEU - warning electronic unit

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LEADING EDGE SLATS - INTRODUCTION

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LEADING EDGE SLATS - GENERAL DESCRIPTION

General

The LE slats and krueger flaps operate in one of these three modes:

- Primary mode
- Secondary mode
- Alternate mode.

The primary mode uses hydraulic power to operate the slats. The secondary and alternate modes use electrical power to operate the slats.

Primary Mode

The primary mode has a closed-loop control system. The pilot commands the slats with the flap lever. The flap lever position sensor sends input signals to the FSEUs. The FSEUs use the flap lever position to calculate the slat commands. The FSEUs also receive data from the systems ARINC 629 buses.

The FSEUs send the slat commands to the slat primary control valve. This valve supplies hydraulic power to the slat power drive unit (PDU). The hydraulic motor on the PDU then moves the slat mechanisms.

The flap/slat priority valve controls the amount of hydraulic flow to the slat primary control valve. The flap/slat priority valve gives priority of hydraulic power to the primary flight control system (PFCS) over the HLCS.

As the slats move, the slat position sensors send feedback signals to the FSEUs. The FSEUs stop the slat commands when the feedback signals equal the commanded position.

The FSEUs use data from the systems ARINC 629 buses for the autoslat function. This function commands the autoslat priority valve to limit the flow of hydraulic fluid to the main landing gear system. This gives priority of the hydraulic power to the slats during autoslat operation. The autoslat priority valve also gives priority of hydraulic power to the HLCS over the main landing gear system during normal operations.

The FSEUs use the slat skew sensors to detect a slat skew and the position sensors to detect a slat asymmetry. In either condition, the FSEUs stop the slat drive.

Secondary Mode

The FSEUs use the secondary mode when the primary mode disengages. The secondary mode is only available in the air or during special maintenance functions.

The secondary mode also has a closed-loop control system. The pilot commands the slats with the flap lever. The FSEUs use the flap lever position to calculate the slat commands. The FSEUs then energize the secondary/alternate control relays. One relay energizes the bypass solenoid in the slat primary control valve and the clutch in the electric motor unit. This stops hydraulic power to the hydraulic motor and lets free flow through it. The electric motor clutch connects the motor shaft to the PDU gearbox. The other relays control electrical power to the slat electric motor on the slat PDU. The electric motor then moves the slat mechanisms.

As the slats move, the slat position sensors send feedback signals to the FSEUs. The FSEUs command the relays to stop the electric motor when the slats are at the commanded position.

The FSEUs use the slat skew sensors to detect a slat skew and the position sensors to detect an asymmetry or disagreement. In either condition, the FSEUs stop the slat drive.

Alternate Mode

The alternate mode has an open-loop control system. The pilot uses the switches on the alternate flaps panel to command the slats. An arm switch sends a discrete signal to the FSEUs to disengage the primary and secondary modes. The switch also energizes one of the secondary/alternate control relays. This relay energizes the bypass solenoid in the slat primary control valve and the clutch in the electric motor. This stops hydraulic power to the hydraulic motor and lets free flow through it. The electric motor clutch connects the motor shaft to the PDU gearbox.

The alternate flaps selector sends commands through the slat and flap limit switches to energize the other secondary/alternate control relays. The relays control electrical power to the slat electric motor in the PDU. The electric motor then moves the slat mechanisms.

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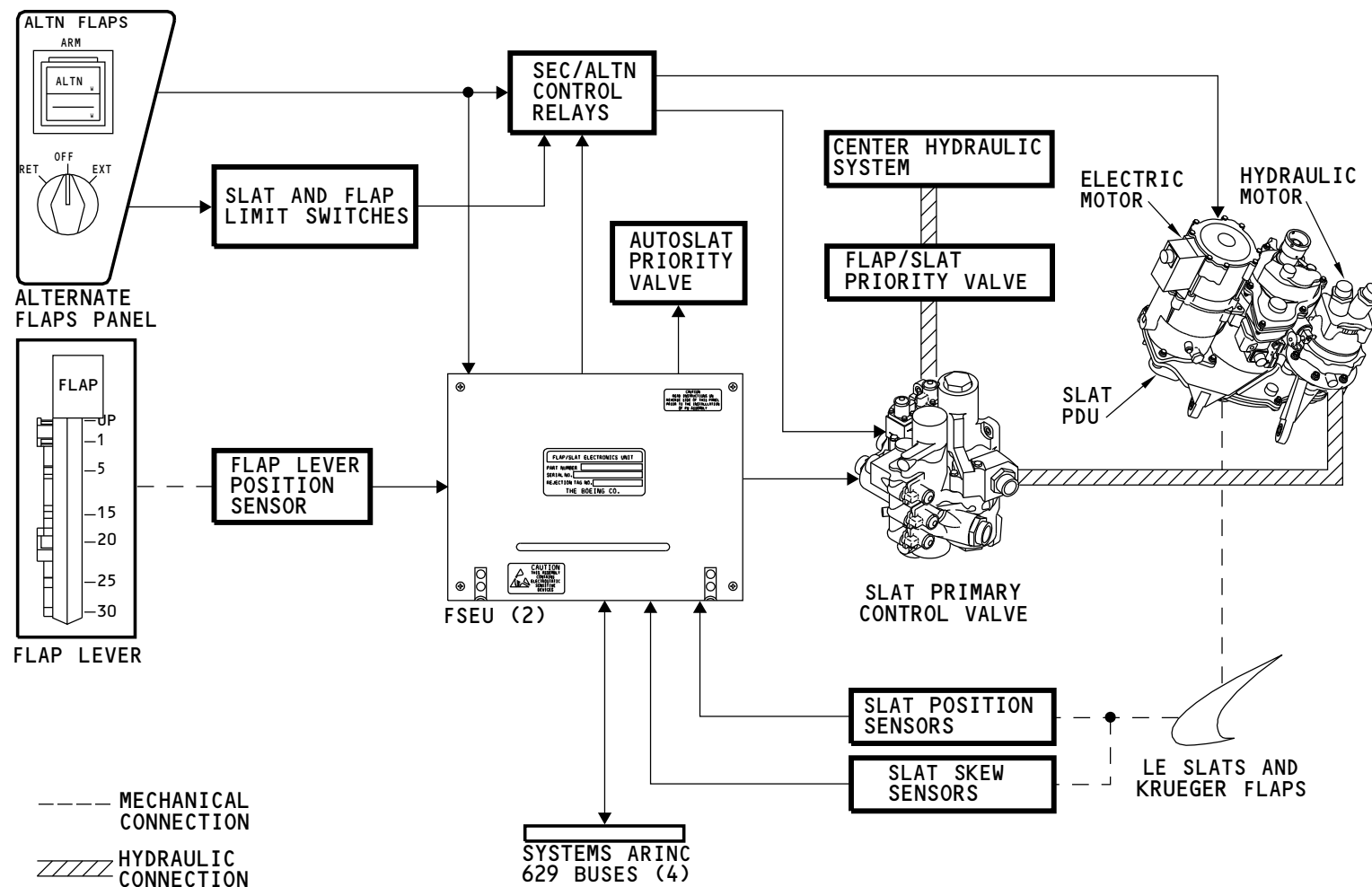
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**LEADING EDGE SLATS - GENERAL DESCRIPTION**

The slats move until the pilot moves the alternate flaps selector to the OFF position or the slat limit switch stops the motor when the slats are at their limits.

There is no automatic shutdown of the alternate mode if there is a slat skew or asymmetry.

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LEADING EDGE SLATS - GENERAL DESCRIPTION

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LEADING EDGE SLATS - GENERAL DESCRIPTION - SLAT DRIVE SYSTEM

General

There are six outboard slats, one inboard slat, and one krueger flap on each wing. The slats are numbered 1 through 14, left outboard to right outboard.

These are the components of the slat drive system:

- Slat PDU
- Torque tubes
- Torque tube supports
- Angle gearboxes
- Driveline offset gearboxes
- No-back brake offset gearboxes
- Krueger flap offset gearboxes
- Rotary actuators
- Slat main tracks.

Slat PDU

The slat PDU gets hydraulic power through the primary control valve and electric power through the slat extend/retract relays. Hydraulic and electric motors on the PDU move the slat drive system. The slat PDU also contains the slat limit switch. The switch removes electrical power from the electric motor when the slats move to their limit during operation in the alternate mode.

Torque Tubes

The torque tubes transmit power from the PDU to the slat actuation assemblies.

Torque Tube Supports

The torque tube supports hold the torque tubes in place.

Angle Gearboxes

The angle gearboxes connect torque tubes that are at different angles to each other.

Offset Gearboxes

The driveline offset gearboxes connect torque tubes that are offset from each other.

The no-back brake offset gearboxes transfer power from the torque tubes to the slat rotary actuators. These gearboxes also help prevent airloads from retracting the slats.

The krueger flap offset gearboxes transfer power from the torque tubes to the krueger flap rotary actuators.

Rotary Actuators

The slat rotary actuators move the slat main tracks. The krueger flap rotary actuators move the krueger flap.

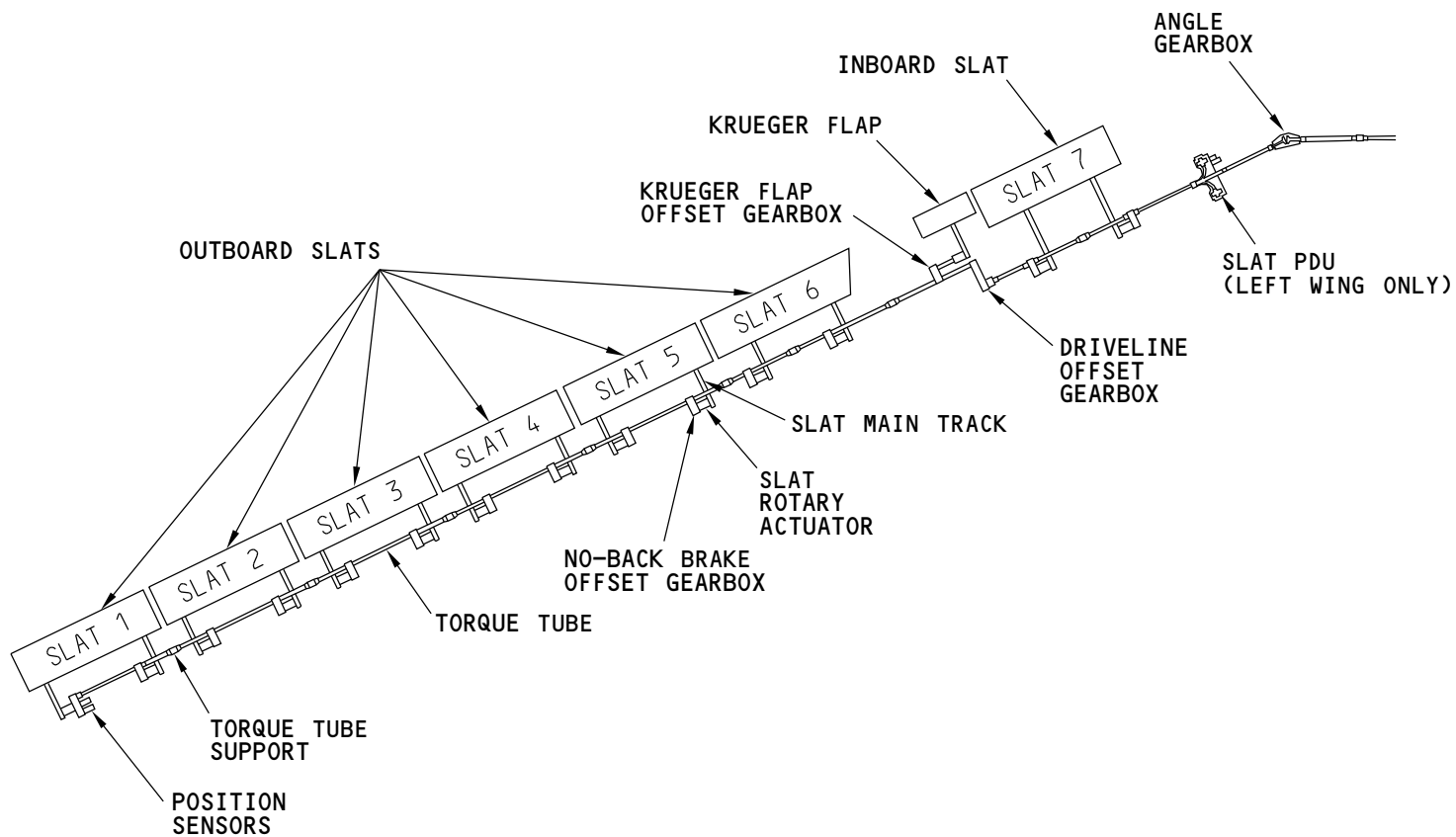
Slat Main Tracks

As the slat rotary actuators turn, the slat main tracks move the slats.

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NOTE: THE LEFT SLATS ARE SHOWN
(THE RIGHT SLATS ARE SIMILAR)

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LEADING EDGE SLATS - GENERAL DESCRIPTION - SLAT DRIVE SYSTEM

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LEADING EDGE SLATS - COMPONENT LOCATIONS

General

The slat components are in these areas:

- The main landing gear wheel wells
- The forward cargo compartment
- The wings.

The inboard slats, krueger flaps, and outboard slats are on the leading edge of the wings. The krueger flap is between the inboard slat and the engine strut.

Main Landing Gear Wheel Well Components

The slat primary control valve is on the keel beam in the left main landing gear wheel well. The autoslat priority valve is on the ceiling in the right main landing gear wheel well.

Forward Cargo Compartment Components

The floor angle gearboxes and some of the torque tubes are above and to the sides of the aft section of the forward cargo compartment. Remove the cargo lining in the aft section of the forward cargo compartment to get access.

Wing Components

The slat PDU and one of the strakelet angle gearboxes are in the left wing root. The other strakelet angle gearbox is in the right wing root. Remove the access panels under the wings to get access to these components.

In the fixed leading edge of the wings are the following components:

- No-back brake offset gearboxes
- Rotary actuators
- Slat main tracks
- Some of the torque tube supports
- Driveline offset gearboxes.

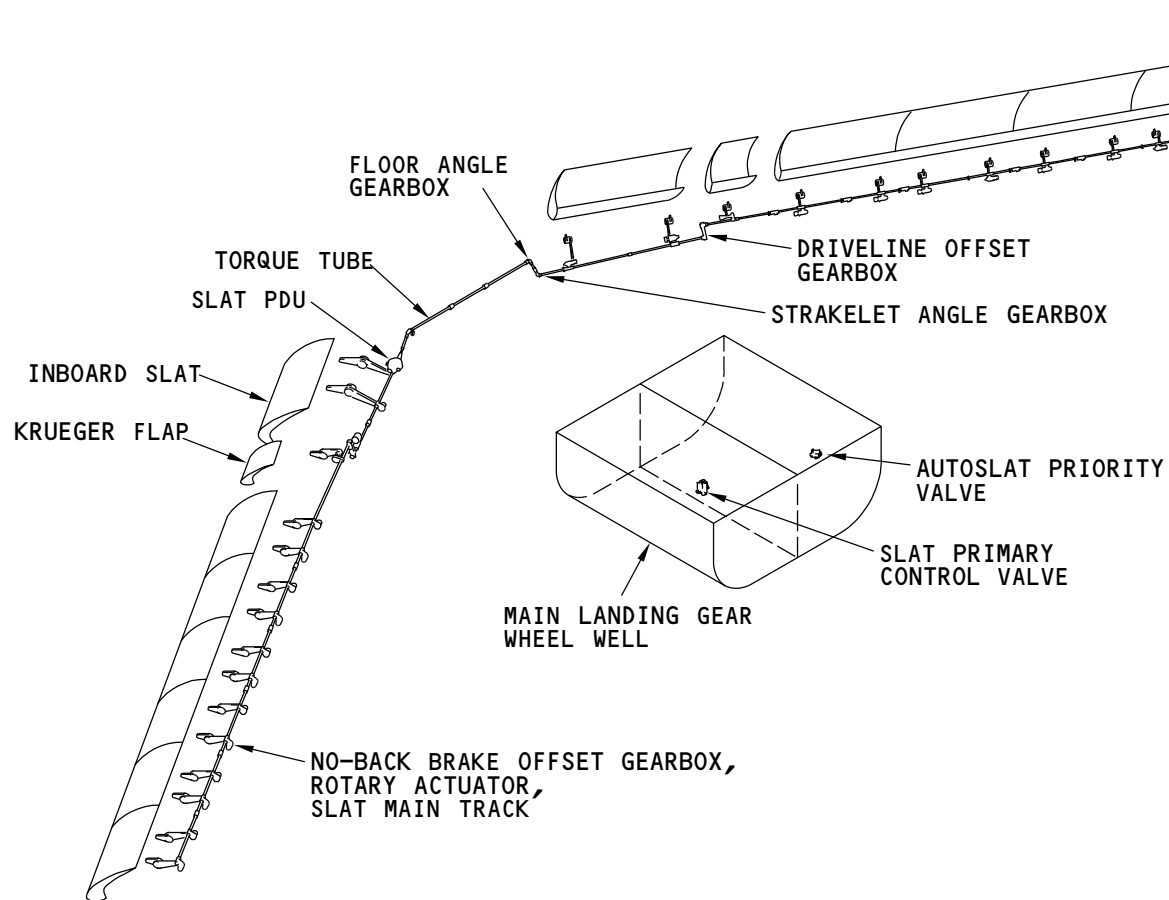
Remove the access panels under the wings to get access to these components.

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LEADING EDGE SLATS - COMPONENT LOCATIONS

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LEADING EDGE SLATS - SLAT PRIMARY CONTROL VALVE

Purpose

The slat primary control valve controls hydraulic power to the hydraulic motor. In the primary mode, this valve controls the direction and speed of movement of the slat drive system. In the secondary and alternate modes, this valve prevents hydraulic power to the hydraulic motor.

Physical Description

The primary control valve is an LRU. These components on the primary control valve are LRUs:

- The shutoff solenoid
- The extend solenoid
- The retract solenoid
- The low-speed solenoid
- The bypass solenoid.

The low-speed solenoid is different than the other solenoids, but it is interchangeable with the low-speed solenoid on the flap primary control valve. All the other solenoids are interchangeable and they are interchangeable with the other solenoids on the flap primary control valve. The slat primary control valve is similar to, but not interchangeable with, the flap primary control valve.

Location

The slat primary control valve attaches to the keel beam in the left main landing gear wheel well.

Training Information Point

There is a small difference in the location of the mounting holes for the flap and slat primary control valves. This helps prevent the slat primary control valve from being installed where the flap primary valve should be. The reverse is also true.

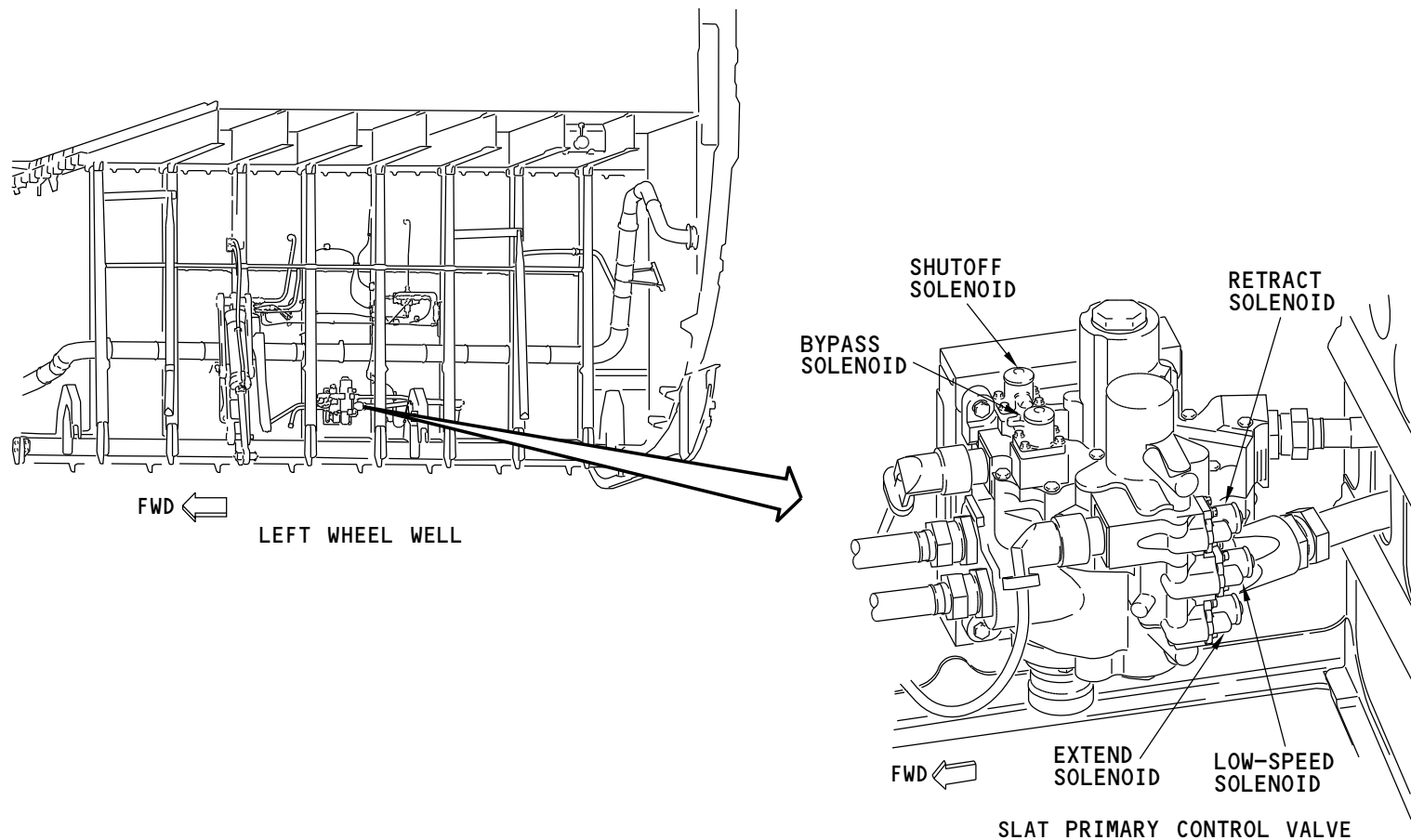
The low-speed solenoid has a longer valve and different mounting hole locations. This helps prevent the low-speed solenoid from being installed where a different type of solenoid should be. This also helps prevent a different solenoid from being installed where the low-speed solenoid should be.

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LEADING EDGE SLATS - SLAT PRIMARY CONTROL VALVE

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LEADING EDGE SLATS - PRIMARY CONTROL VALVE - FUNCTIONAL DESCRIPTION

General

The primary control valve has these components:

- Shutoff valve
- Shutoff solenoid valve
- Low-speed solenoid valve
- Low-speed piston
- Flow regulator
- Retract solenoid valve
- Extend solenoid valve
- Selector valve
- Bypass solenoid valve
- Bypass valve.

The FSEUs electrically control the solenoid valves in the primary control valve. All the solenoid valves are normally de-energized.

Shutoff Valve and Shutoff Solenoid Valve

The shutoff valve supplies hydraulic pressure and hydraulic flow to the selector valve.

The shutoff valve has three positions: closed, open, and low-speed. The shutoff valve is spring-loaded and hydraulically controlled to the closed position. It moves to the open or low-speed positions when the shutoff solenoid valve removes pressure from one side of the valve.

The shutoff solenoid valve controls the pilot pressure to the shutoff valve. The shutoff valve solenoid has two coils. When both coils are de-energized, the shutoff solenoid valve lets pilot pressure close the shutoff valve. When either coil is energized, the shutoff solenoid valve removes pilot pressure from the shutoff valve. Hydraulic system pressure then lets the shutoff valve open.

When the shutoff valve is closed, it removes hydraulic pressure from the selector valve. When the shutoff valve is open, hydraulic system pressure goes to the selector valve to move the slats at their normal rate. When the shutoff valve is in the low-speed position, the hydraulic flow to the selector valve is restricted.

Low-Speed Solenoid Valve, Low-Speed Piston, and Flow Regulator

The low-speed solenoid valve, the low-speed piston, and the flow regulator help to decrease the speed of the slat drive system.

The low-speed solenoid valve is a dual-coil solenoid valve that controls hydraulic pressure to the low-speed piston. The low-speed piston is a hydraulic piston that is spring-loaded to the retracted position.

When the FSEUs energize the low-speed solenoid valve, the low-speed piston extends. This limits the position of the shutoff valve to the low-speed position.

When the FSEUs de-energize the low-speed solenoid valve, the pressure in the low-speed piston decreases. An internal spring then forces the low-speed piston to retract. This lets the shutoff valve move to the open position.

The flow regulator limits the flow of hydraulic fluid to 35 gpm at high speed, and 7 gpm at low-speed.

Selector Valve

The selector valve controls the direction of operation of the hydraulic motor.

The selector valve is spring-loaded and hydraulically balanced to the center position and normally has pressure on both sides of the valve. The selector valve moves to the extend position when the extend solenoid valve removes pilot pressure from the extend side of the selector valve. The selector valve moves to the retract position when the retract solenoid valve removes pilot pressure from the retract side of the selector valve.

**LEADING EDGE SLATS - PRIMARY CONTROL VALVE - FUNCTIONAL DESCRIPTION****Bypass Valve and Bypass Solenoid Valve**

The bypass valve isolates the hydraulic motor from hydraulic system pressure. The bypass valve also prevents a hydraulic lock and permits backdrive of the hydraulic motor.

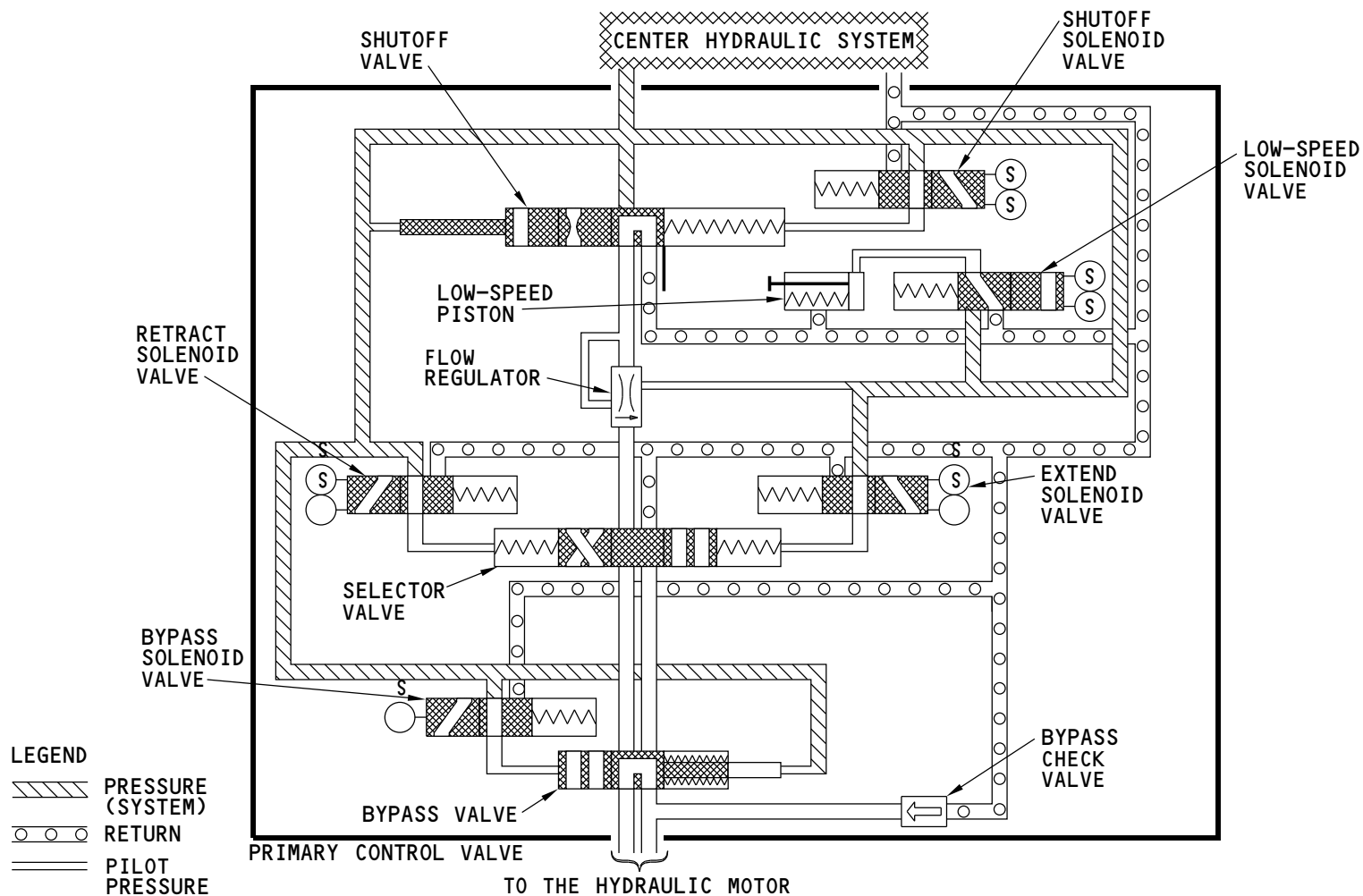
A dual-coil bypass solenoid valve controls pilot pressure to the bypass valve, but only one coil of the solenoid is used. When the FSEUs energize the bypass solenoid valve, it removes pilot pressure from the open side of the bypass valve. This closes the bypass valve, which connects the hydraulic lines to both sides of the hydraulic motor.

The bypass valve is spring-loaded and hydraulically controlled to the closed position. The open side of the valve has a larger surface area for the pilot pressure than the close side of the valve. When the center hydraulic system pressure is low, springs automatically force the bypass valve to close. When the center hydraulic system pressure is high, the bypass valve opens.

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LEADING EDGE SLATS - PRIMARY CONTROL VALVE - FUNCTIONAL DESCRIPTION

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LEADING EDGE SLATS - SLAT POWER DRIVE UNIT (PDU)

Purpose

The slat PDU turns the slat torque tubes during operation in all three modes. The slat PDU has these LRUs:

- A hydraulic motor
- An electric motor
- A limit switch
- A gearbox.

Information on the hydraulic motor, the electric motor, and the limit switch is shown later.

Location

The slat PDU is in the left wing root. Remove the access panel or open the small access panel under the wing to get access.

Gearbox

The gearbox transmits the power from the hydraulic or electric motors to the torque tubes.

The hydraulic motor or the electric motor rotates gears in the gearbox. These gears increase the torque from the motors. The gearbox turns the torque tube couplings on both sides of the PDU. These couplings turn the torque tubes.

The gearbox contains a ball ramp torque brake to limit the output torque from either side of the PDU. When the torque brake activates, a torque trip indicator shows. There is a separate torque trip indicator for the PDU output to the left wing slats and to the right wing slats. The torque trip indicators have the labels LEFT WING and RIGHT WING. The indicators are reset manually.

The slat PDU has a rig pin that locks the PDU gearbox in the slats UP position. A ground lockpin next to the rig pin locks the rig pin in the rig position.

The gearbox also contains a stroke control mechanism to stop the PDU output if one of the motors on the PDU fails to stop. The stroke control mechanism stalls the hydraulic or electric motors within two torque tube rotations of the maximum normal slat positions.

During high-speed operation in the primary mode, the gearbox turns the torque tubes at 640 rpm. During low-speed operation, the gearbox turns the torque tubes at 128 rpm.

During operation in the secondary and alternate modes, the gearbox turns the torque tubes at 85 rpm.

Training Information Point

Wrench flats on the torque tube between the PDU and slat 7 let you manually rotate the slat system.

To install the rig pin in the slat PDU, retract the slats to the UP position. See that the alignment mark on the output shaft aligns with the fixed index mark on the PDU. If the alignment mark does not align with the index mark, use the wrench flats on the torque tube to turn the PDU in the extend direction, then in the retract direction until the marks align. Push the rig pin in the PDU and hold it while you lock it with the ground lockpin.

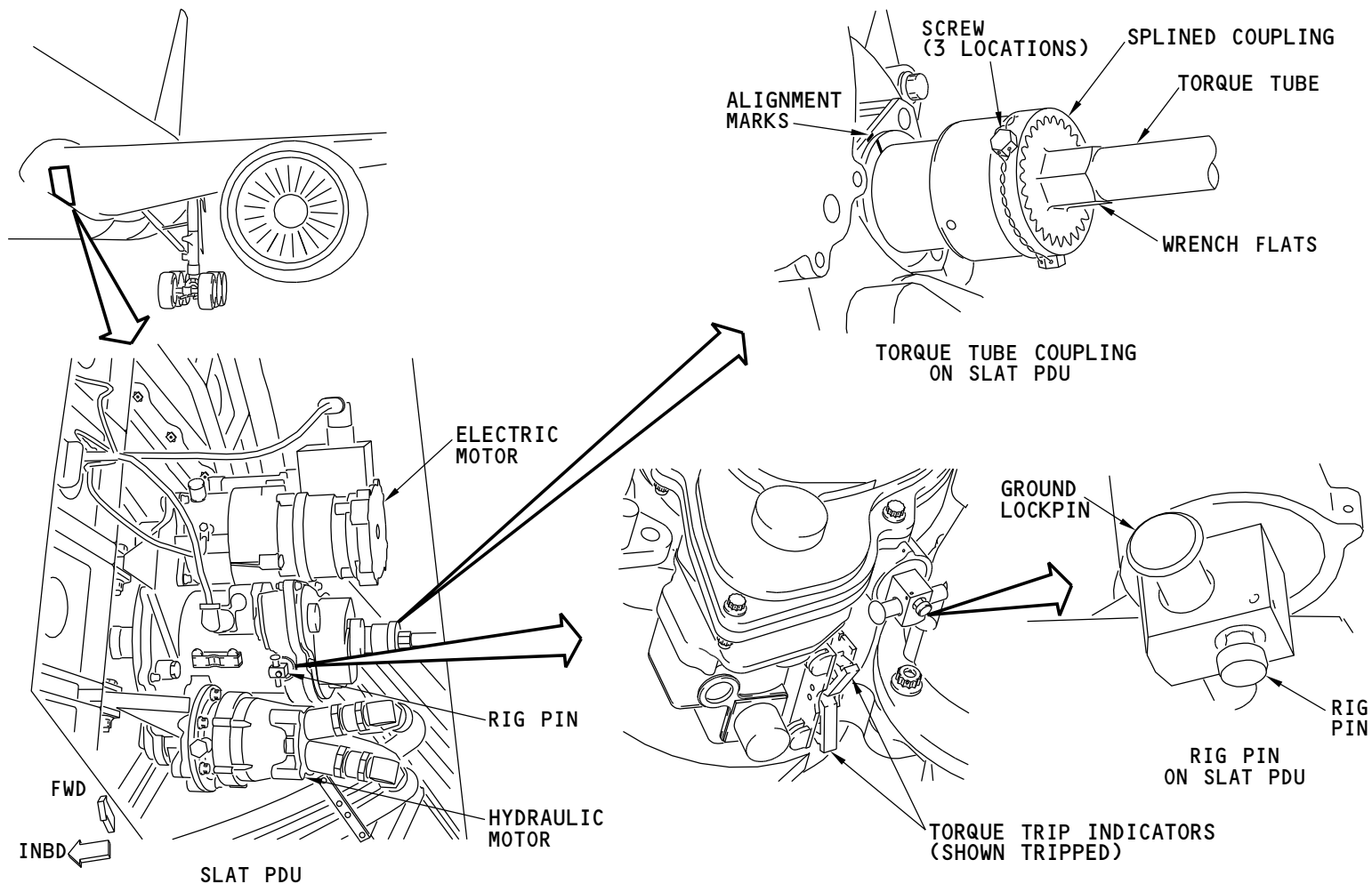
The gearbox contains oil and it is necessary to do servicing at specified times. Use the oil fill plug.

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LEADING EDGE SLATS - SLAT POWER DRIVE UNIT (PDU)

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LEADING EDGE SLATS - PDU HYDRAULIC AND ELECTRIC MOTORS

Purpose

The PDU hydraulic and electric motors supply power to turn the gearbox and the torque tubes.

Location

The motors are on the slat PDU and connect to the gearbox.

Hydraulic Motor

The hydraulic motor operates in the primary mode. It receives hydraulic pressure from the slat primary control valve. During secondary and alternate mode operation, the primary control valve blocks hydraulic power to the motor. It also permits the hydraulic motor to be backdriven.

The hydraulic motor is a reversible, constant displacement, piston-type motor. The hydraulic motor has two hydraulic connections for pressure and return to the slat primary control valve. It also has one connection for case drain to the return line of the center hydraulic system. The hydraulic motor weighs 16 lb (7 kg). It is identical and interchangeable with the flap hydraulic motor.

Electric Motor

The electric motor operates in the secondary and alternate modes. Relays supply electrical power to the electric motor. During primary mode operation, a clutch disengages the electric motor from the gearbox.

The 115v ac, 3-phase, reversible electric motor weighs approximately 42 lb (19 kg). An electrically actuated clutch and a torque limiter are inside the motor assembly. The clutch engages the motor with the gearbox in the secondary or alternate modes. The torque limiter prevents too much load on the slat drive mechanisms. The electric motor has a brake that engages when the motor is not energized.

Training Information Point

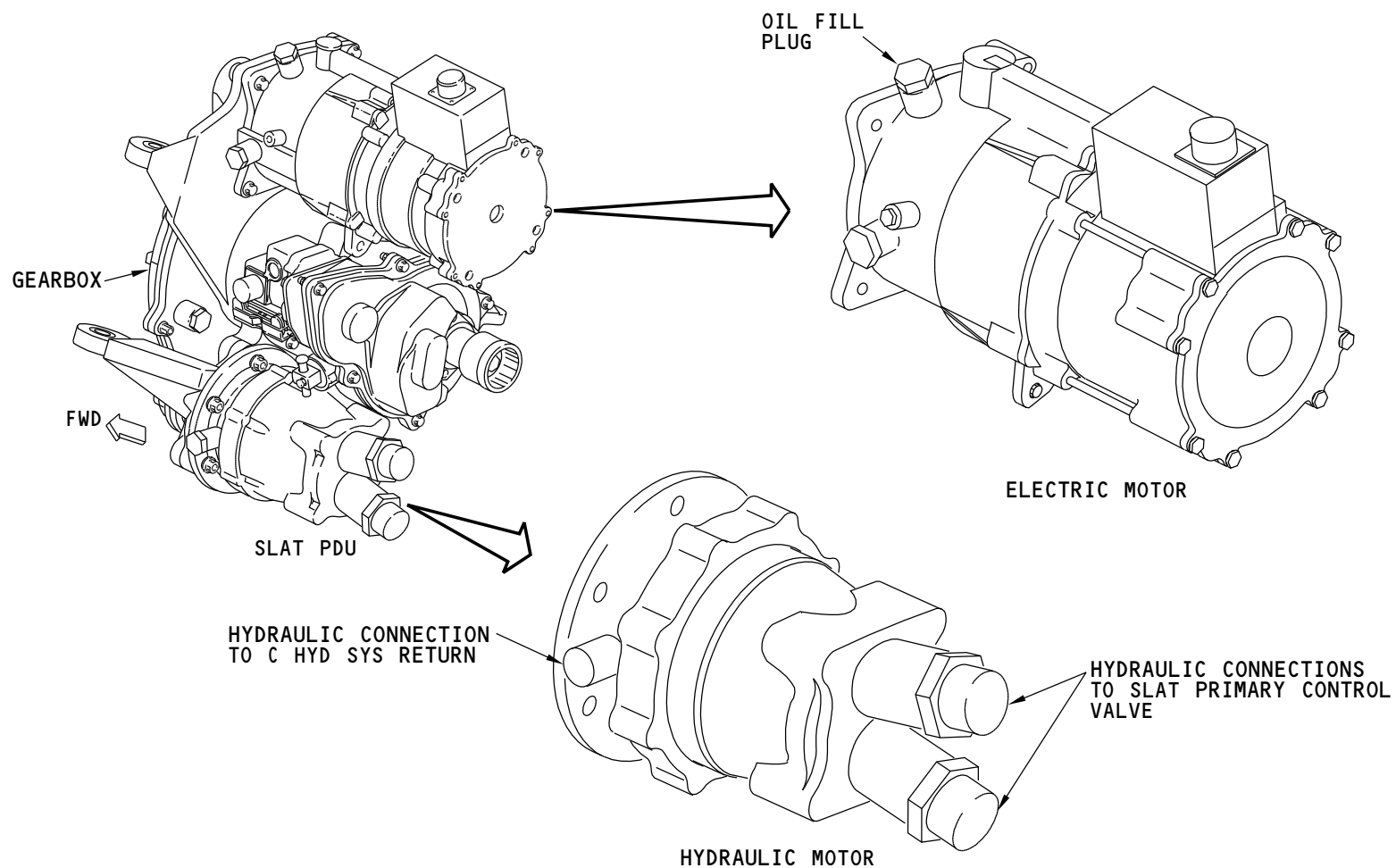
The electric motor contains oil and it is necessary to do servicing at specified times. Use the oil fill plug on the side of the motor.

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LEADING EDGE SLATS - PDU HYDRAULIC AND ELECTRIC MOTORS

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LEADING EDGE SLATS - SLAT LIMIT SWITCH

Purpose

The slat limit switch limits the position of the slats during alternate mode operation.

Location

The limit switch is on the slat PDU.

Physical Description

The limit switch is one LRU. It has two internal switches, retracted and extended.

Functional Description

When the slats retract to the up position, the retracted switch removes electrical power from the slat electric motor.

When the slats extend to the sealed position, the extended switch removes electrical power from the slat electric motor.

Training Information Point

The slat limit switch is interchangeable with the flap limit switch.

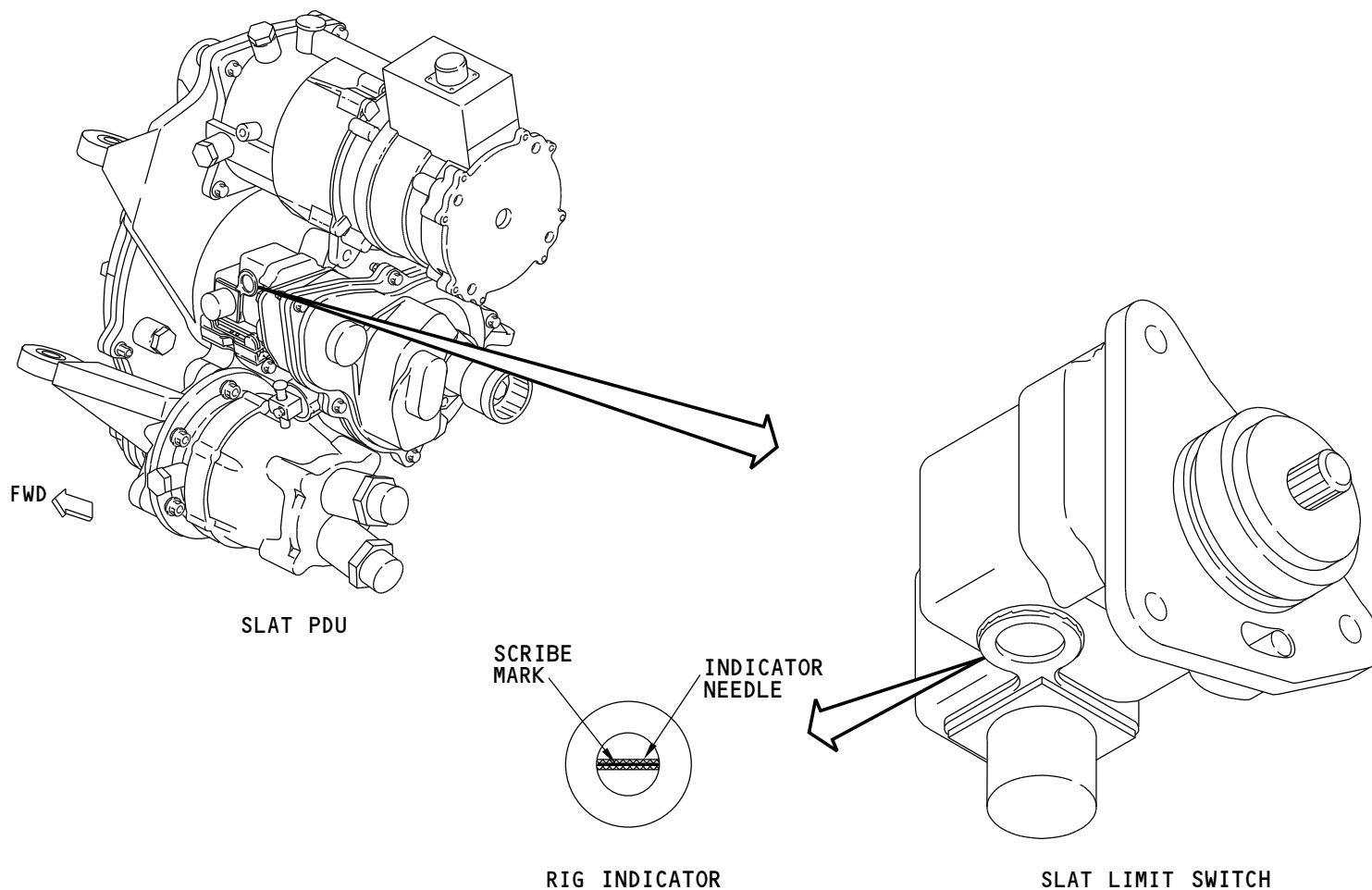
Install the slat limit switch with the slat PDU in the rigged position. The limit switch rig indicator has a fixed scribe mark and an indicator needle. The indicator needle moves up or down in relation to the scribe mark as the shaft of the limit switch turns. Make sure the center of the indicator needle in the rig indicator aligns with the scribe mark when you install the limit switch.

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**LEADING EDGE SLATS - AUTOSLAT PRIORITY VALVE****Purpose**

The autoslat priority valve controls the flow of hydraulic fluid to the main landing gear (MLG) system. This valve gives priority of center hydraulic system power to the slats during autoslat operation and to the flaps and slats during landing gear operation.

Location

The autoslat priority valve is on the ceiling of the right MLG wheel well.

Physical Description

The autoslat priority valve includes a solenoid valve and a control valve.

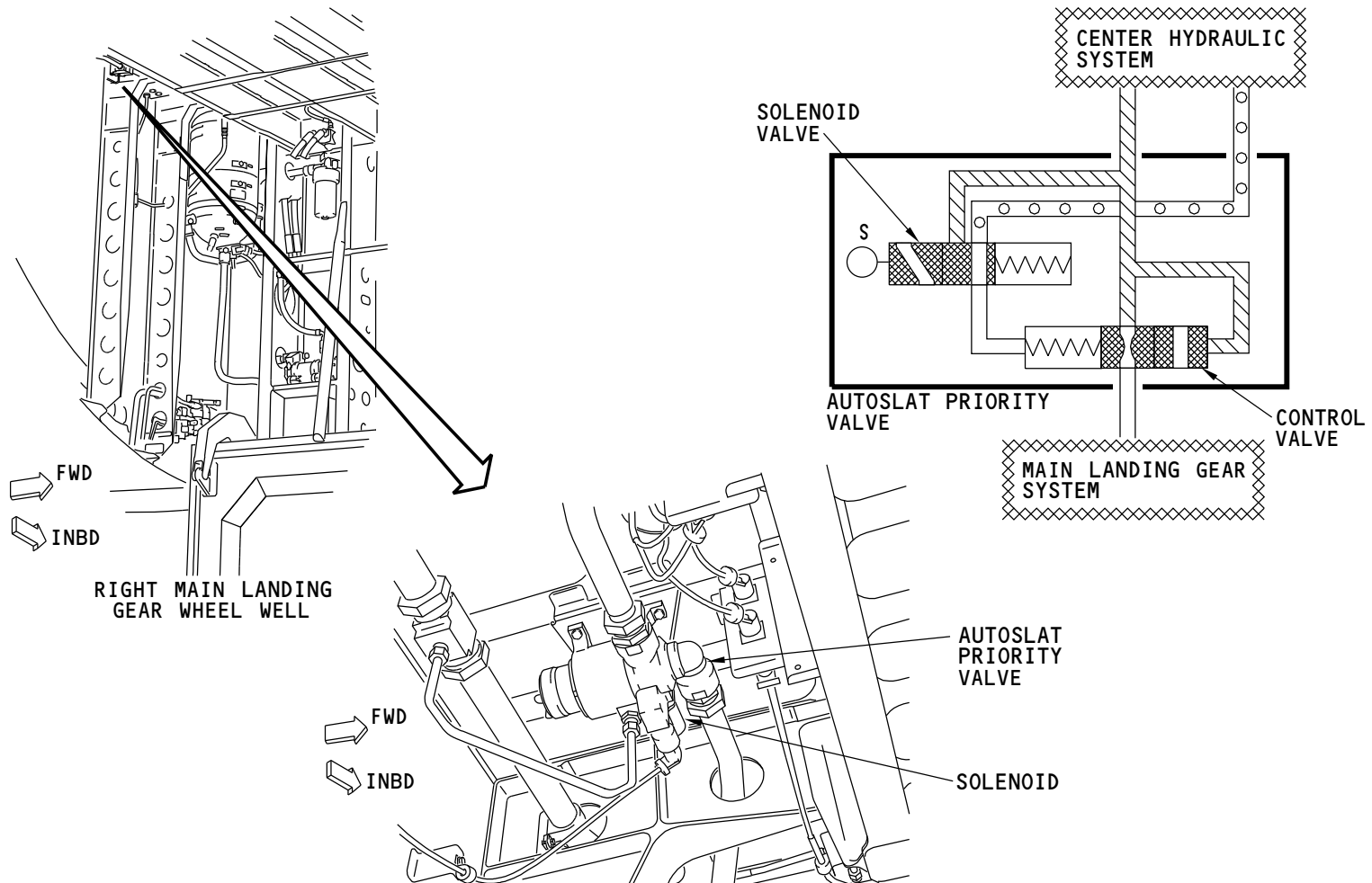
Functional Description

The control valve receives pilot pressure from the solenoid valve and from the center hydraulic system. When the solenoid valve de-energizes, the control valve permits full hydraulic flow to the MLG system.

During autoslat operation, the solenoid valve energizes. This moves the control valve to the reduced flow position. This reduces the hydraulic flow to the MLG system and gives priority of the hydraulic power to the slats.

If the center hydraulic system pressure is less than approximately 2550 psi, springs force the control valve to the reduced flow position. This reduces the hydraulic flow to the MLG system and gives priority of the hydraulic power to the flaps and slats.

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LEADING EDGE SLATS - AUTOSLAT PRIORITY VALVE

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LEADING EDGE SLATS - TORQUE TUBES AND TORQUE TUBE SUPPORTS

Purpose

The slat torque tubes transmit power from the slat PDU, through gearboxes, to the slat rotary actuators. The torque tube supports hold the torque tubes in place.

Location

There are 60 torque tubes of different lengths for the slat drive system. These torque tubes are above the ceiling in the aft section of the forward cargo compartment and along the front spar of both wings. Remove the cargo lining in the aft section of the forward cargo compartment or remove the access panels under the wings to get access. To get access to the torque tubes for the krueger flaps, remove the access panels above the wings.

There are 22 torque tube supports. These supports are just aft of the forward cargo compartment and along the front spar of both wings. Access is the same as for the torque tubes.

Torque Tubes

The torque tubes are made of either aluminum or steel and are hollow tubes with steel end fittings. These are the four different types of torque tubes:

- Electro-magnetically formed (EMF)
- Riveted
- Bolted
- Machined.

Most of the torque tubes are EMF torque tubes. For these torque tubes, the end of the aluminum tubes are formed around the end fittings electro-magnetically.

One torque tube on each wing has end fittings riveted to the aluminum tube. Four torque tubes on each wing have end fittings bolted to the steel tubes. Six torque tubes on the airplane are machined. For the machined torque tubes, the steel tube and the end fittings are made from one piece of material.

Torque Tube Supports

There are three different types of torque tube supports. They differ in how they attach to structure. Also, one type of torque tube support has a pressure seal.

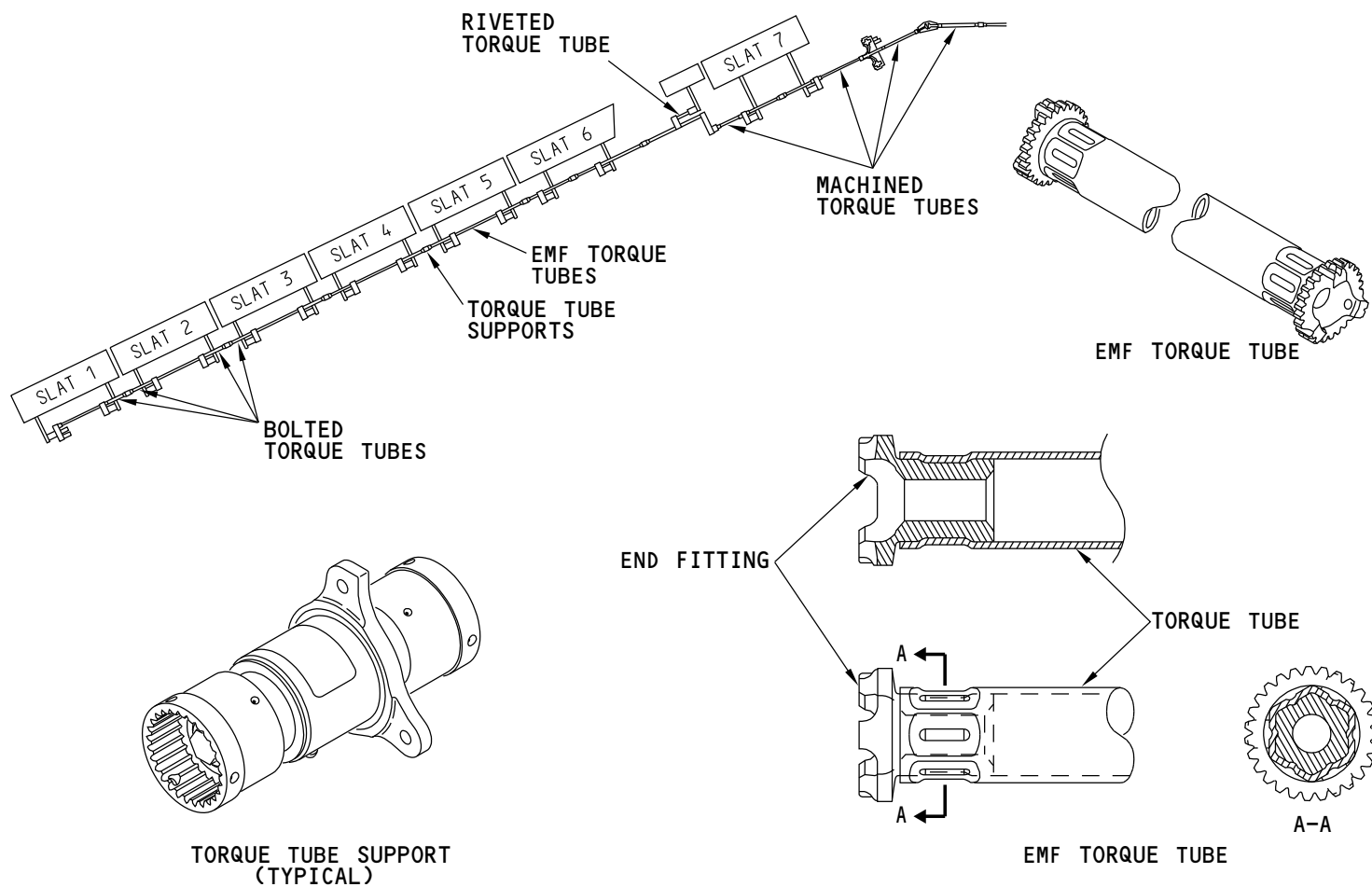
The torque tube supports are filled with grease.

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LEADING EDGE SLATS - TORQUE TUBES AND TORQUE TUBE SUPPORTS

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LEADING EDGE SLATS - ANGLE GEARBOXES

Purpose

The angle gearboxes connect torque tubes that are at different angles to each other. There are four separate angle gearboxes:

- Two floor angle gearboxes
- Two strakelet angle gearboxes.

Location

The floor angle gearboxes are just aft and outboard of the forward cargo compartment. Remove the cargo lining in the aft section of the forward cargo compartment to get access.

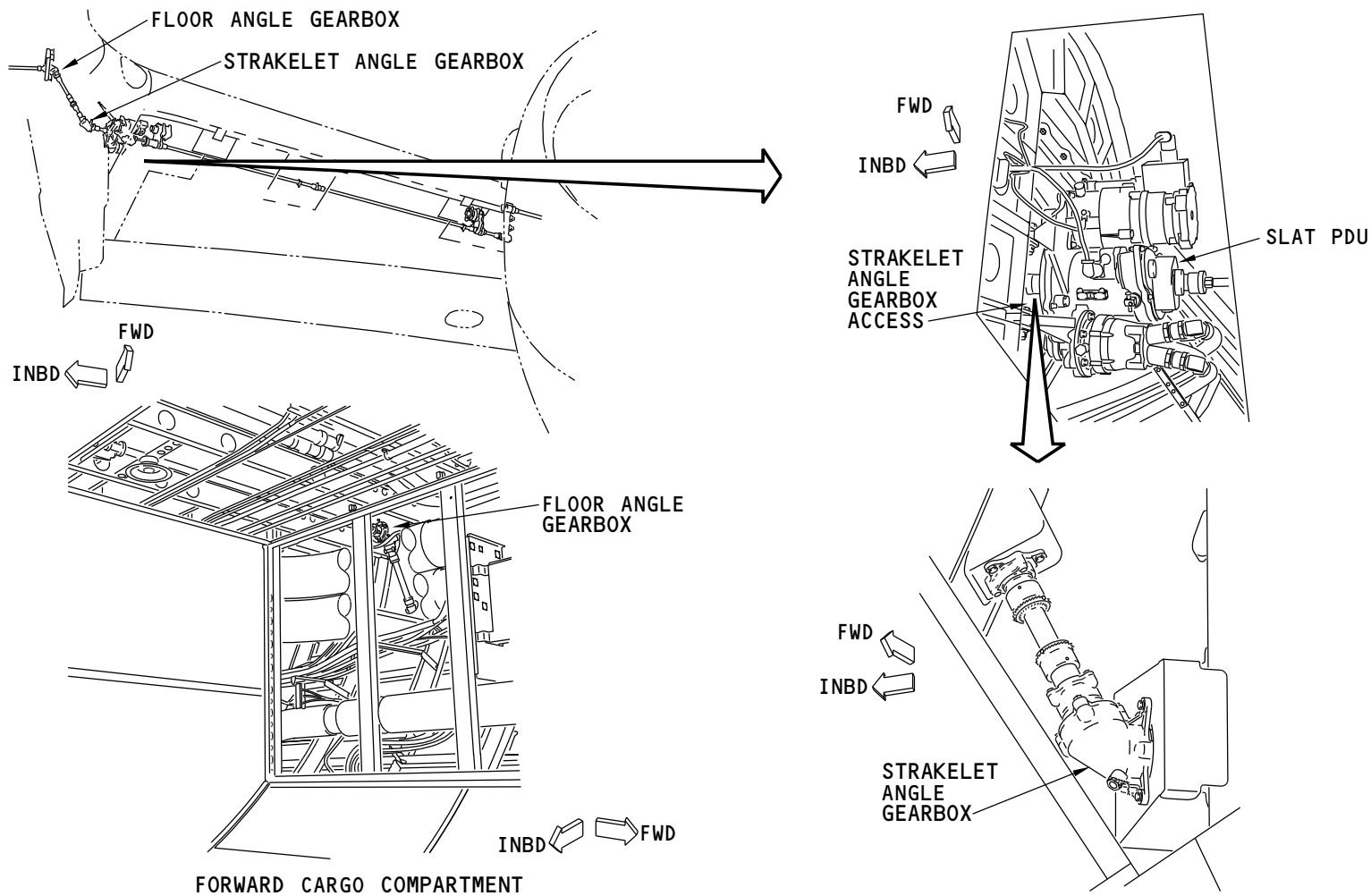
The strakelet angle gearboxes are on the inboard side of the first rib in the fixed leading edge of the wings. Remove the access panel under the inboard end of the wing to get access.

Physical Description

The angle gearboxes are filled with grease and sealed.

Both of the floor angle gearboxes are identical and both of the strakelet angle gearboxes are identical. Each gearbox weighs approximately 12 lb (5.5 kg).

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LEADING EDGE SLATS - ANGLE GEARBOXES

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**LEADING EDGE SLATS - DRIVELINE OFFSET GEARBOXES****Purpose**

The two driveline offset gearboxes connect torque tubes that are offset from each other.

Location

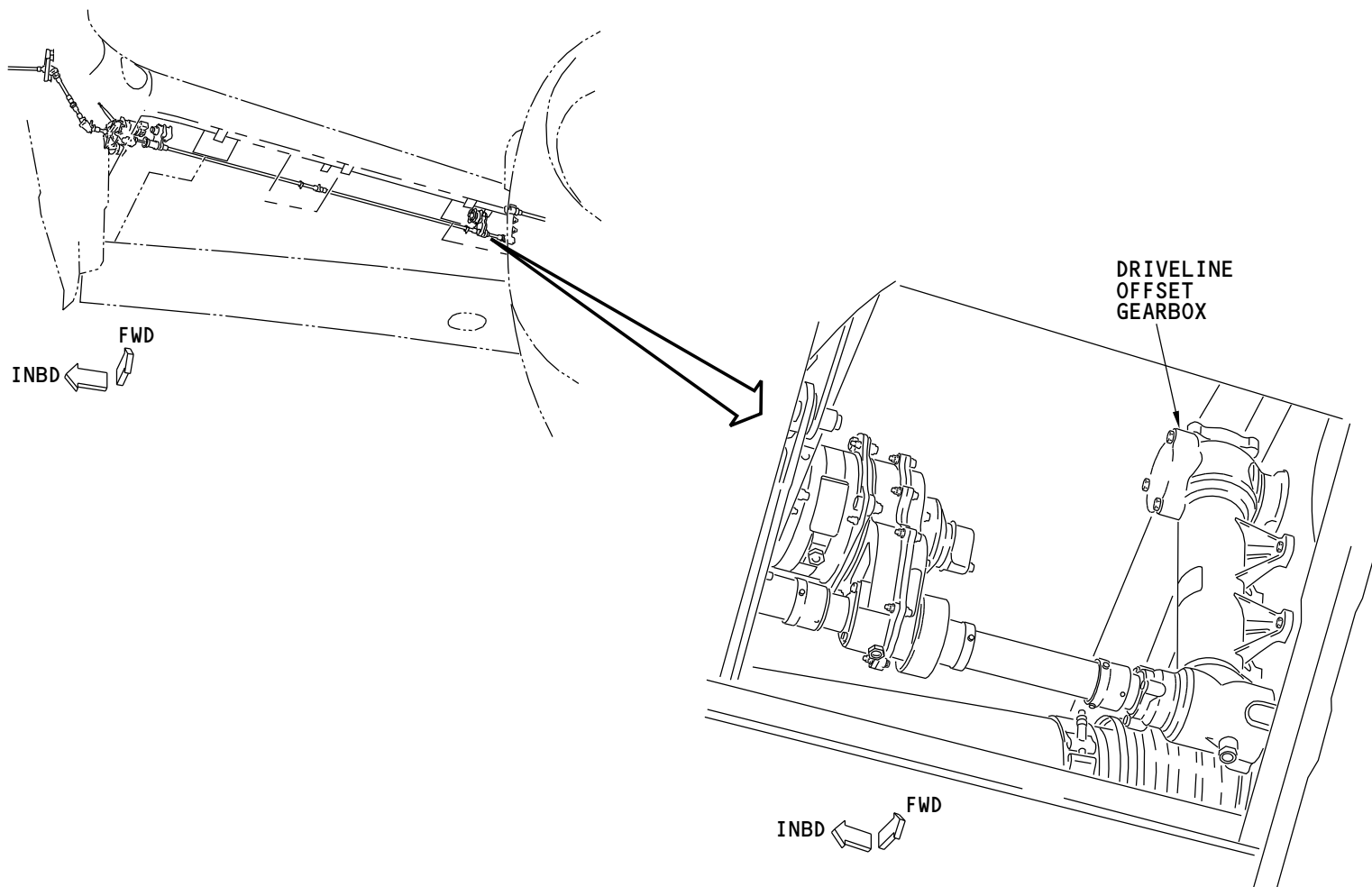
There is one driveline offset gearbox in the fixed leading edge of each wing, between the inboard slat and the krueger flap. Remove the access panel under the wings to get access.

Physical Description

The gearboxes are filled with grease and sealed.

Both of the driveline offset gearboxes are identical. Each gearbox weighs approximately 28 lb (12.7 kg).

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LEADING EDGE SLATS - DRIVELINE OFFSET GEARBOXES

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LEADING EDGE SLATS - NO-BACK BRAKE OFFSET GEARBOXES

Purpose

The no-back brake offset gearboxes get power from the torque tubes to operate the rotary actuators.

Location

The no-back brake offset gearboxes are in the fixed leading edge of the wings. Remove the access panels under the leading edge of the wings to get access.

Physical Description

There are two no-back brake offset gearboxes for each slat. The gearboxes for the inboard slats are similar to the gearboxes for the outboard slats. The gearboxes at the outboard end of the wings are different than the other gearboxes and contain the slat position sensors.

The no-back brake offset gearbox has a no-back brake to help prevent slat retraction if the PDU or a torque tube fails. The no-back brake offset gearbox also has a shearout to prevent excessive loads on the pinion gear if the slat does not move freely.

The no-back brake offset gearboxes are filled with oil and sealed.

The no-back brake offset gearboxes for the inboard slats weigh approximately 16 lb (7 kg). The no-back brake offset gearboxes for the outboard slats weigh approximately 11 lb (5 kg).

Training Information Point

To do a check of the no-back brake in the no-back brake offset gearbox, manually apply a backdrive torque to the gearbox. To do this, remove the no-back brake cover and connect a manual drive.

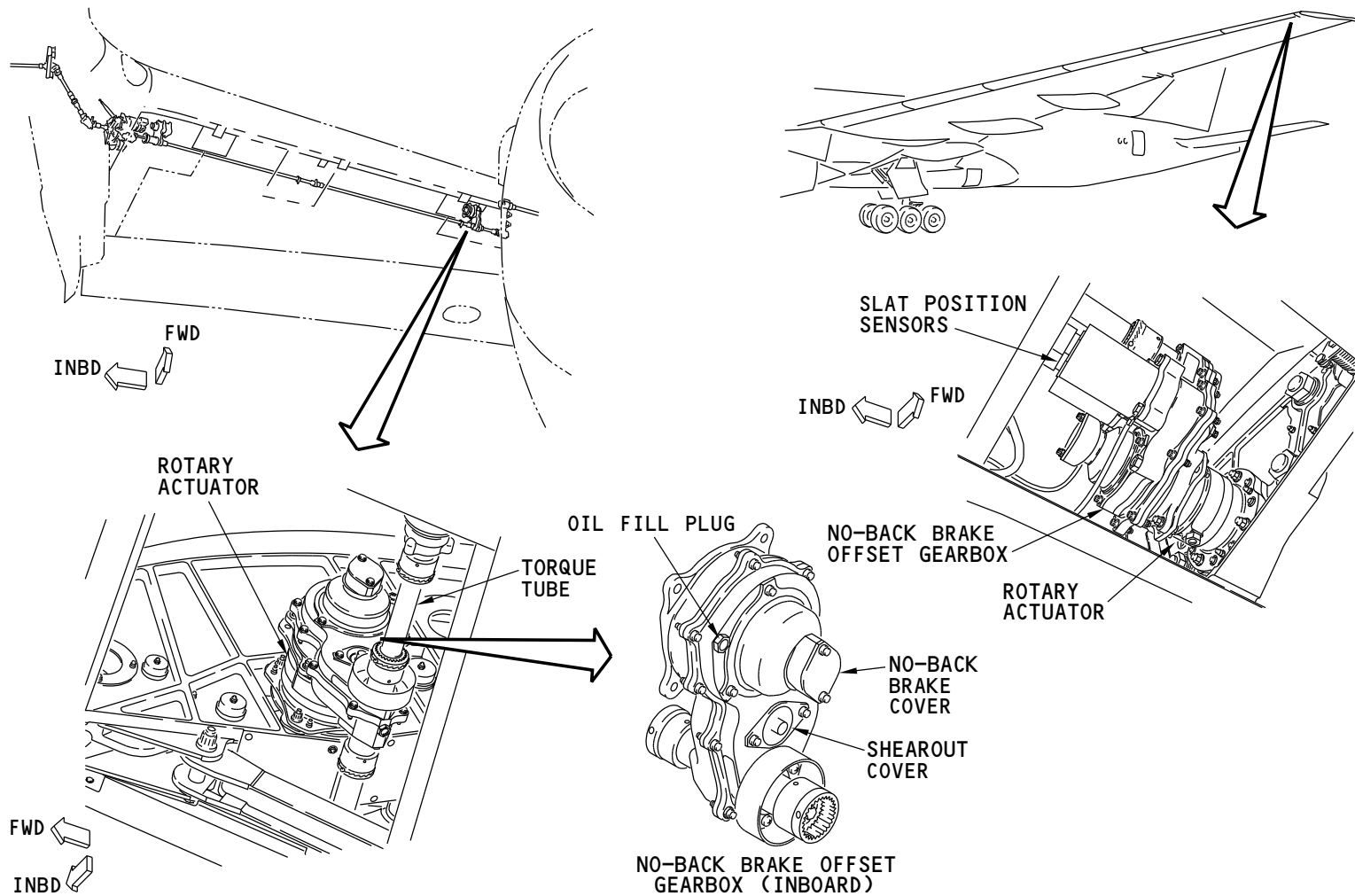


CAUTION

DO NOT REMOVE THE OFFSET GEARBOX IF IT HAS A BROKEN SHEAROUT UNTIL YOU REPLACE THE SHEAROUT. THE NO-BACK BRAKE CAN HOLD A HIGH TORQUE AFTER THE FAILURE OF THE SHEAROUT. YOU CAN CAUSE DAMAGE TO THE ROTARY ACTUATOR AND OFFSET GEARBOX.

If you do a check or replace the shearout in the no-back brake offset gearbox, you must drain all the oil in the gearbox. Then remove the shearout cover to gain access to the shearout.

The no-back brake offset gearbox contains oil and it is necessary to do servicing at specified times. Use the oil fill plug.



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LEADING EDGE SLATS - NO-BACK BRAKE OFFSET GEARBOXES

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**LEADING EDGE SLATS - ROTARY ACTUATORS****Purpose**

The rotary actuators get power from the no-back brake offset gearboxes to turn the pinion gears.

Location

The rotary actuators are in the fixed leading edge of the wings. Remove the access panels under the leading edge of the wings to get access.

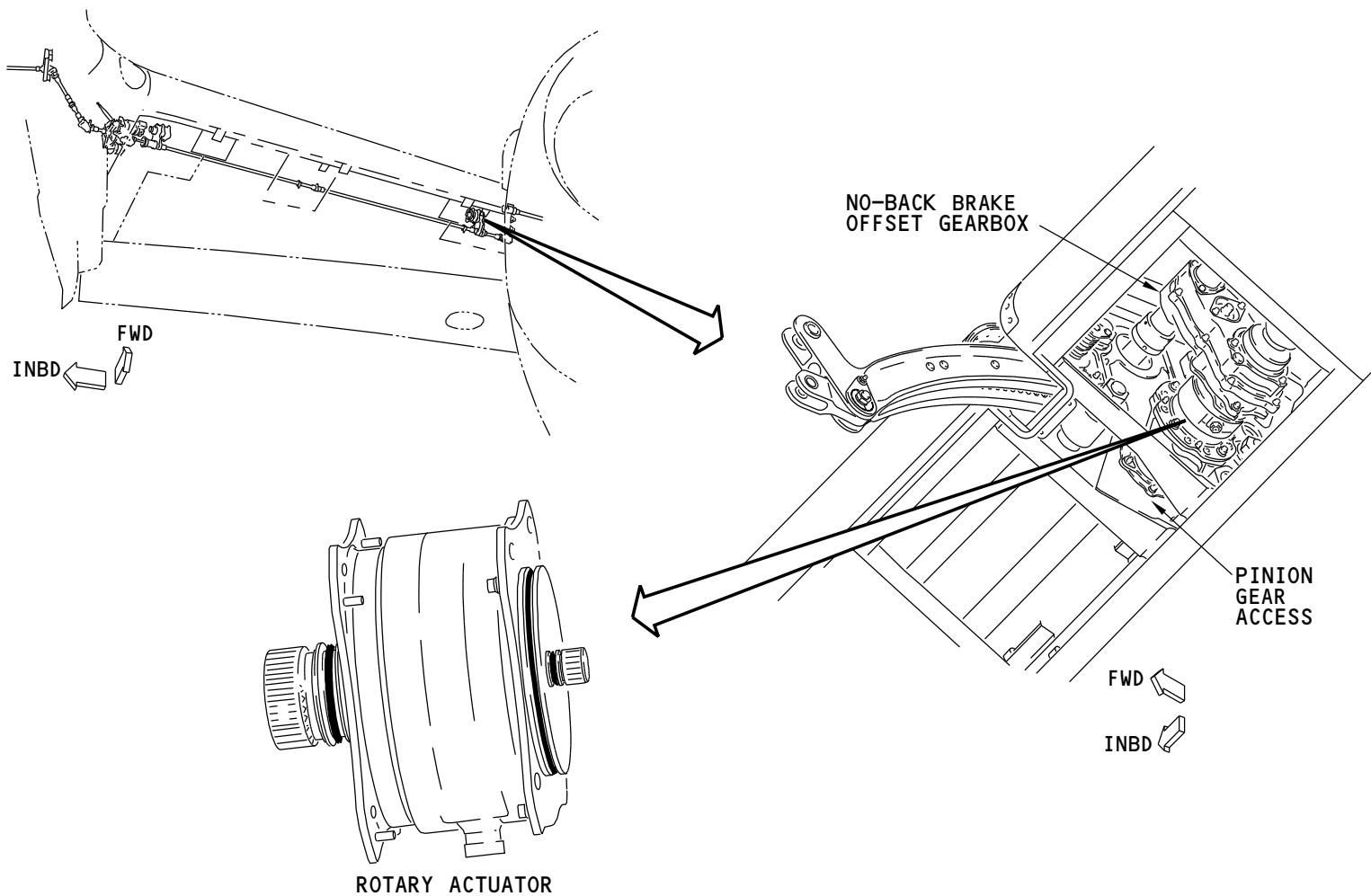
Physical Description

There are two rotary actuators for each slat. The rotary actuators for the inboard slats are similar to the rotary actuators for the outboard slats.

The rotary actuators are filled with grease and sealed.

The rotary actuators for the inboard slats weigh approximately 14 lb (6 kg).
The rotary actuators for the outboard slats weigh approximately 6.8 lb (3 kg).

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LEADING EDGE SLATS - ROTARY ACTUATORS

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LEADING EDGE SLATS - PINION GEARS AND SLAT MAIN TRACKS

Purpose

The pinion gears receive power from the rotary actuators to move the slat main track. The slat main tracks move the slats.

Location

The pinion gears and main tracks are in the fixed leading edge of the wings. Remove the access panel under the leading edge of the wings to get access.

Pinion Gears

There are two pinion gears for each slat surface. The pinion gears for the inboard slats are different than the pinion gears for the outboard slats.

The pinion gears weigh approximately 4 lb (2 kg) for the outboard slats and 11 lb (5 kg) for the inboard slats.

Slat Main Track



DO NOT LET OBJECTS GET IN THE HOUSING ASSEMBLY OF THE SLAT TRACK. THIS WILL HELP PREVENT A PUNCTURE OF THE HOUSING ASSEMBLY THAT COULD CAUSE A FUEL LEAK. THE FUEL LEAK COULD CAUSE A FIRE AND POSSIBLE DEATH OR INJURY TO PERSONNEL.

There are three slat main tracks (only two are driven by rotary actuators) for each inboard slat and two slat main tracks for each outboard slat. The slat main tracks for the inboard slats are different than the slat main tracks for the outboard slats. There is a restoration seal door installed on the wing fixed leading edge at every outboard main track location. The restoration seal door permits air to flow smoothly over the wing when the slats are extended. Removal of the restoration seal door may be needed in order to complete the removal/installation task of the outboard slat main track.

The slat main tracks have stops at both ends to prevent over-travel of the slat surface. During normal slat operation, the main track does not touch the stops.

Training Information Point

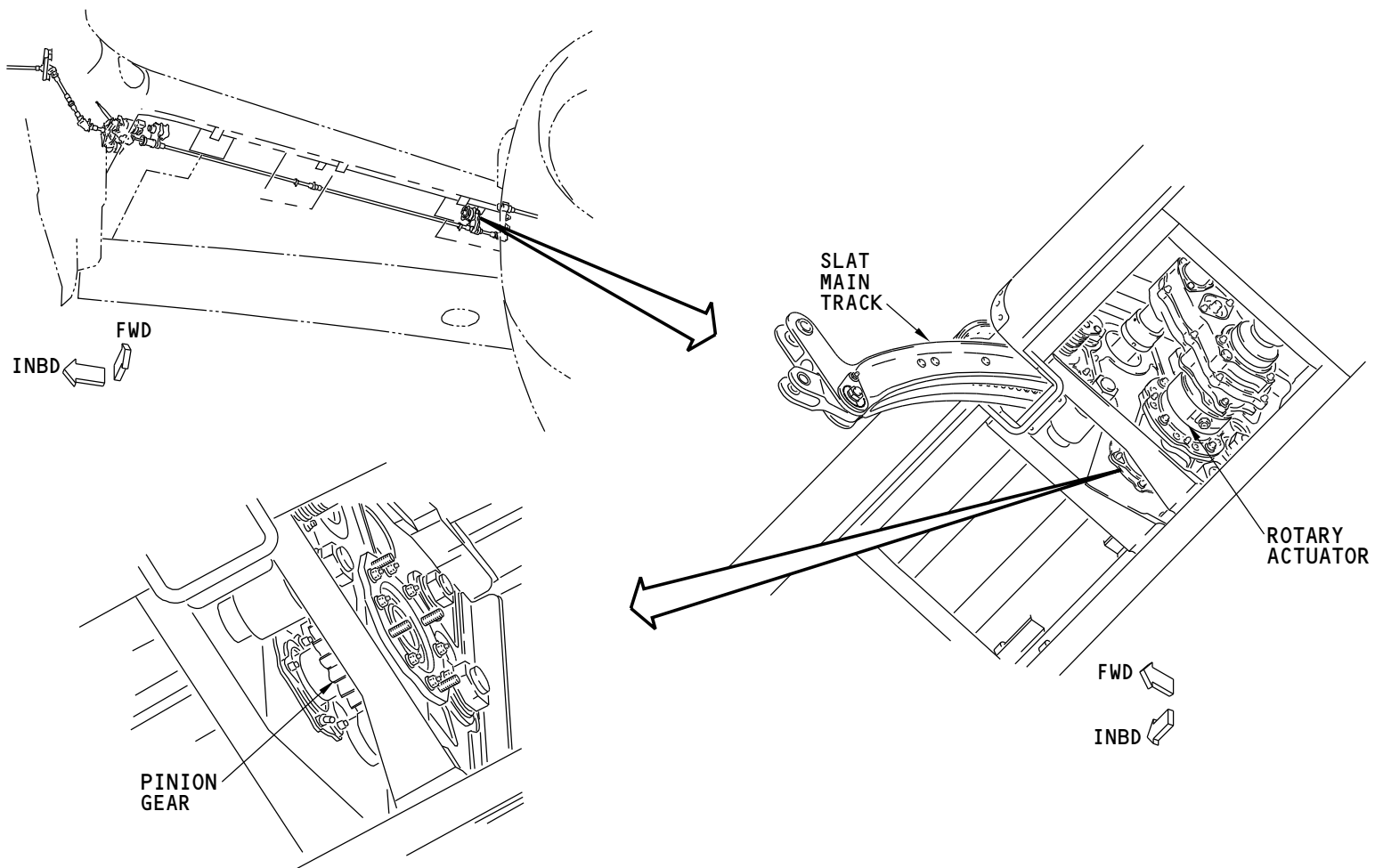
The center main track of the inboard slats does not have stops. Make sure that you hold the center main track so it does not fall when you remove the inboard slat.

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LEADING EDGE SLATS - PINION GEARS AND SLAT MAIN TRACKS

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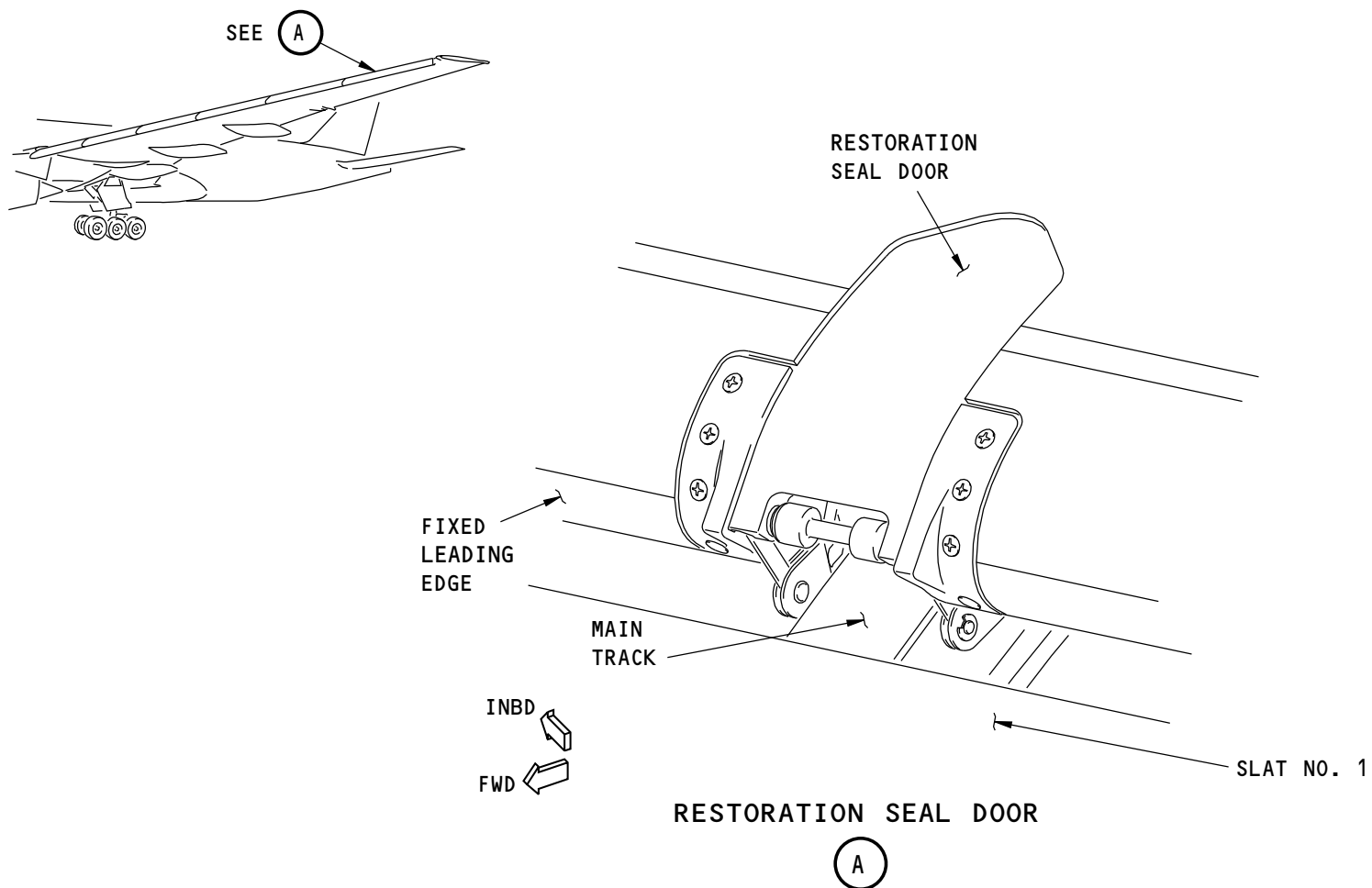
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OUTBOARD SLAT MAIN TRACK - RESTORATION SEAL DOOR

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**LEADING EDGE SLATS - AUXILIARY ARM AND TRACK****Purpose**

The auxiliary arm and track control the rotation of the inboard slats as the slats extend.

There are three auxiliary arms and tracks for each inboard slat. The outboard slats do not use auxiliary arms or tracks.

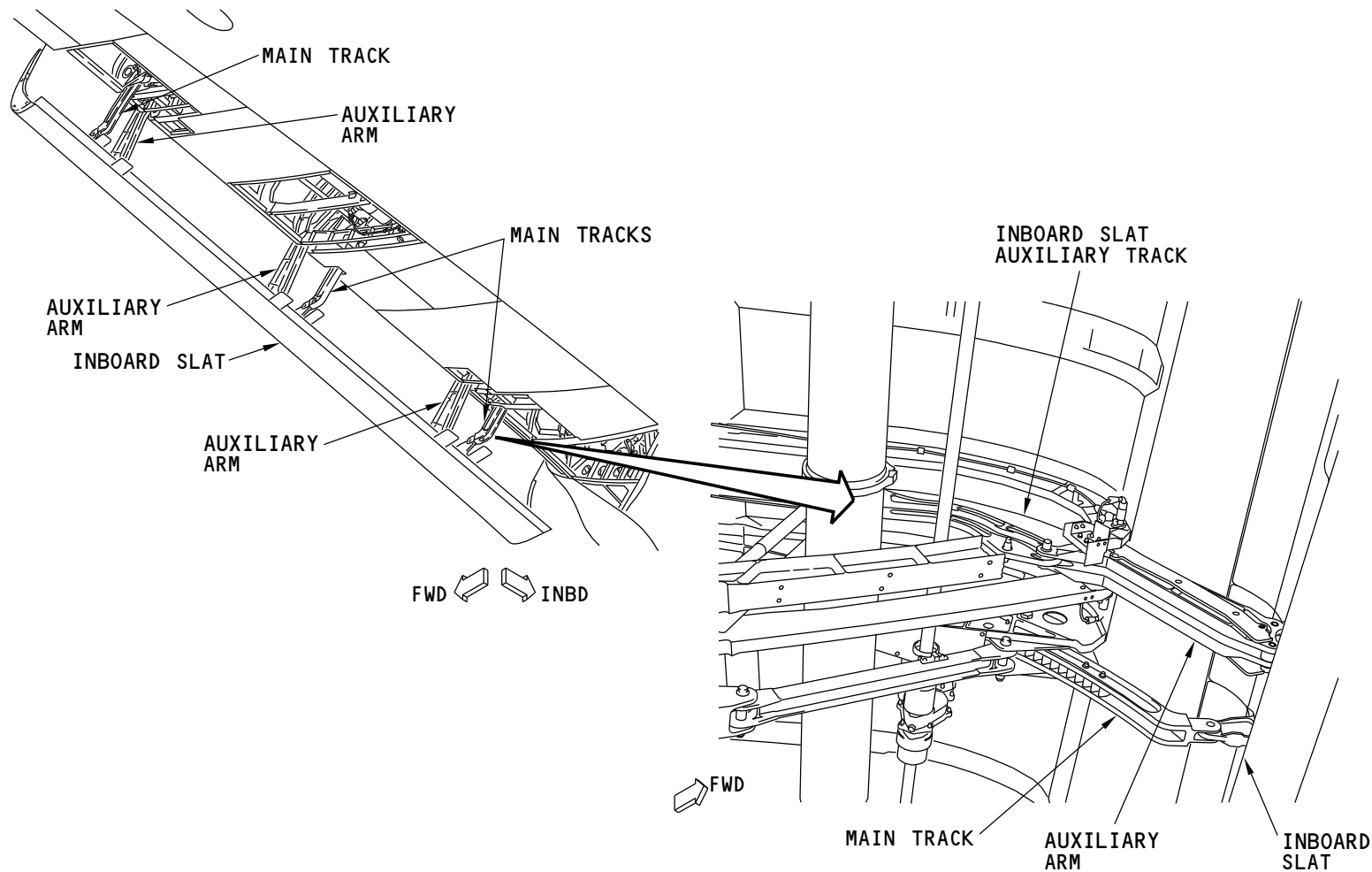
Location

The auxiliary arms attach to the slats. The auxiliary tracks are in the fixed leading edge of the wings. Remove the access panels under the wing to get access.

Physical Description

The auxiliary arms have rollers which move in grooves in the auxiliary tracks. As the slats move, the auxiliary arms force the slats to rotate.

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LEADING EDGE SLATS - AUXILIARY ARM AND TRACK

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LEADING EDGE SLATS - INBOARD AND OUTBOARD SLATS

Purpose

The inboard and outboard slats increase the lift of the wing during takeoff and landing. They are retracted during cruise.

Physical Description

The inboard and outboard slats are made of aluminum skins and ribs with an aluminum honeycomb trailing edge wedge.

The dimensions of the inboard slats are approximately 221 inches by 32 inches (5.6 m by 0.81 m). The inboard slat weighs approximately 205 lb to 218 lb (93 kg to 99 kg).

The dimensions of the outboard slats vary. The length of the outboard slats vary from approximately 145 inches to 177 inches (3.7 m to 4.5 m). The width of the outboard slats is 24 inches (0.61 m). The outboard slats weigh from 76 lb to 218 lb (34 kg to 99 kg).

Location

The inboard slat is between the fuselage and the engine, along the leading edge of the wing.

The outboard slats are outboard of the engines, along the leading edge of the wing.

Functional Description

The slats have three positions: up, sealed, and gapped. At the up position, the slats are fully retracted. At the sealed position, the trailing edge of the slats touches the leading edge of the wings.

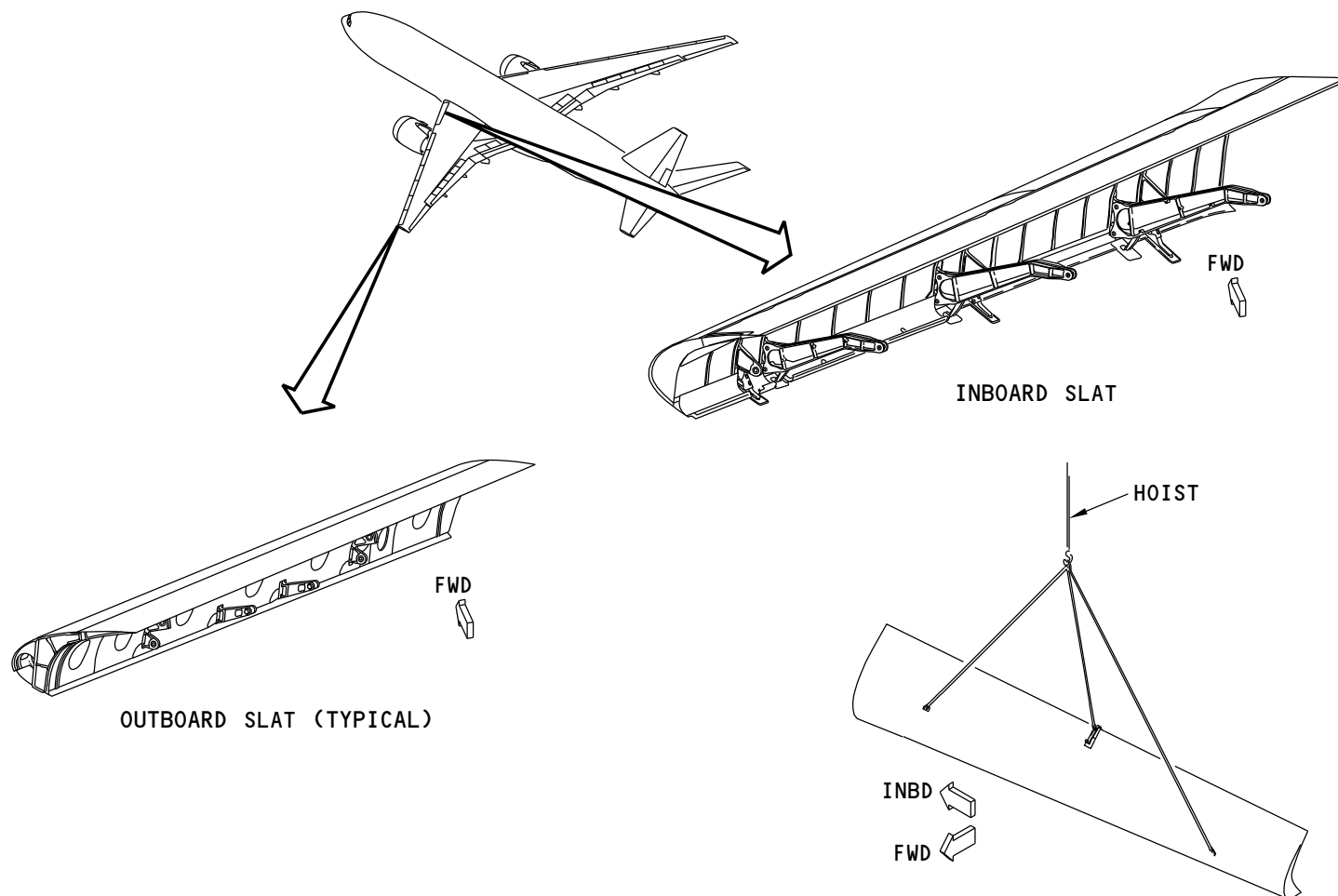
At the gapped position, there is a gap between the trailing edge of the outboard slats and the leading edge of the wings. When the inboard slat is in the gapped position, there is a very small gap at the outboard end of the slat, and no gap at the inboard end.

Training Information Point

It is not necessary to use a spreader bar to lift the slats.



MAKE SURE THE THRUST REVERSER COWLS ARE NOT FULLY OPEN WHEN YOU OPERATE THE FLAPS AND SLATS. THE SLATS CAN HIT THE THRUST REVERSER COWLS IF THEY ARE OPEN. THIS CAN CAUSE INJURY TO PERSONS OR DAMAGE TO EQUIPMENT.



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LEADING EDGE SLATS - INBOARD AND OUTBOARD SLATS

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LEADING EDGE SLATS - KRUEGER FLAP OFFSET GEARBOX, TORQUE TUBE, AND ROTARY ACTUATOR**General**

The krueger flaps seal the gap between the inboard slat and the engine strut. This increases the effect of the slats. There is one krueger flap offset gearbox, torque tube, and rotary actuator for each krueger flap.

Location

The krueger flap is between the inboard slat and the engine strut, along the leading edge of each wing. The krueger flap actuation assembly is in the fixed leading edge of the wings, between the engine and the inboard slat. Remove the access panel on the upper side of the wing or extend the slats to get access.

Krueger Flap

The krueger flaps are made of aluminum skins and aluminum castings. The width of the krueger flaps is approximately 30 inches (0.76 m) and it weighs approximately 19 lb (9 kg).

The krueger flap has two positions: retracted and extended. It moves to the extended position when the slats are in the sealed or gapped positions. It moves to the retracted position when the slats are at the up position.

Offset Gearbox

The offset gearbox connects to the slat drive torque tubes. Gears in the offset gearbox transmit the power from the torque tubes to the rotary actuator.

The offset gearbox is filled with grease and sealed. The offset gearbox weighs approximately 8 lb (4 kg).

Torque Tube

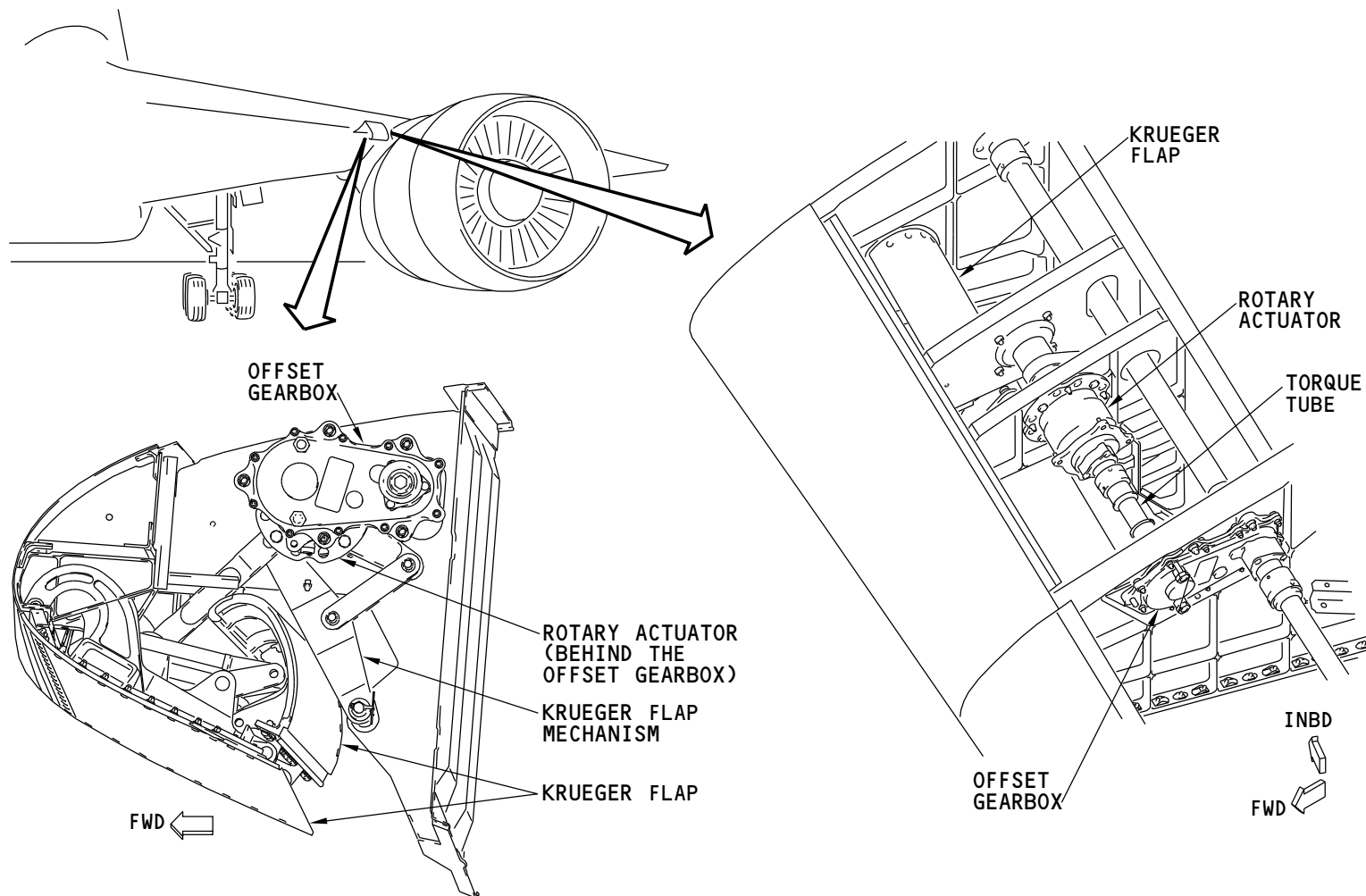
The torque tube transmits the power from the gearbox to the rotary actuator.

The end fittings are bolted on to the ends of the torque tube.

Rotary Actuator

The offset gearbox turns the rotary actuator. The rotary actuator moves the krueger flap mechanism.

The rotary actuator is filled with grease and sealed. The rotary actuator weighs approximately 6 lb (3 kg).



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LEADING EDGE SLATS - KRUEGER FLAP OFFSET GEARBOX, TORQUE TUBE, AND ROTARY ACTUATOR

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**LEADING EDGE SLATS - KRUEGER FLAP MECHANISM****Purpose**

The krueger flap mechanism moves the krueger flap.

Location

The krueger flap mechanism is in the fixed leading edge of the wings, between the engine and the inboard slat. Remove the access panel on the upper side of the wing to get access.

Functional Description

There is one krueger flap mechanism for each krueger flap.

The krueger flap mechanism attaches to the rotary actuator. As the rotary actuator rotates, the links in the krueger flap mechanism move. These links force the krueger flap to extend or retract.

As the slats extend to the sealed position, the krueger flap moves to the extended position. As the slats extend to the gapped position, the geometry of the links in the krueger flap mechanism prevent more movement of the krueger flap.

Training Information Point

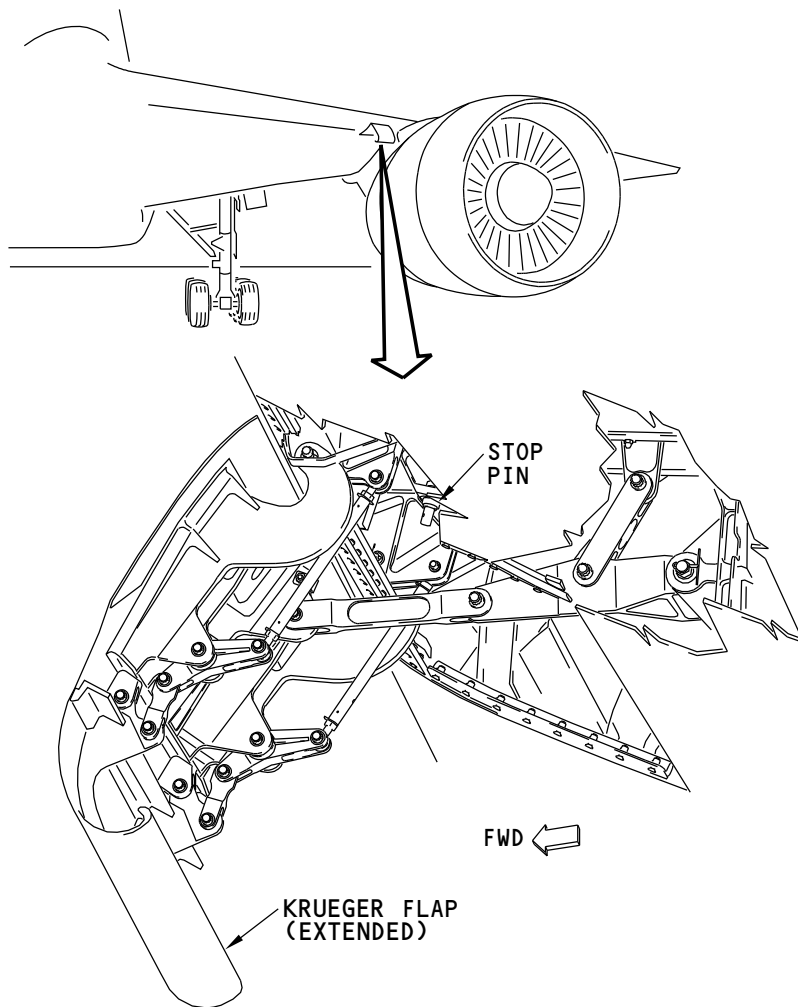
When you rig the LE slat system, preload the krueger flap rotary actuator with the slats in the retracted position.

Adjust the stop pin to align the krueger flap with the leading edge of the wing.

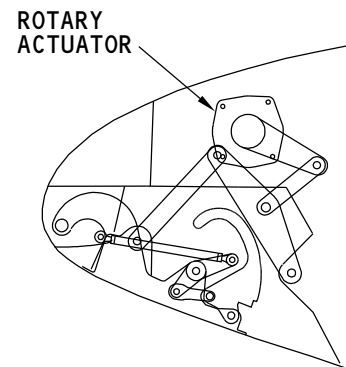
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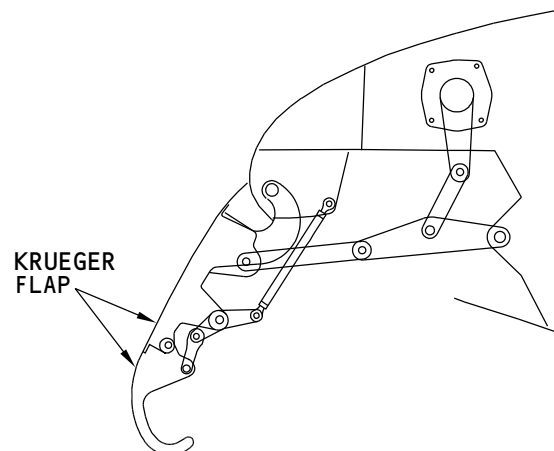
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LEADING EDGE SLATS - KRUEGER FLAP MECHANISM



KRUEGER FLAP MECHANISM - RETRACTED



KRUEGER FLAP MECHANISM - EXTENDED

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - PRIMARY MODE CONTROL

General

Only one FSEU commands the slats in the primary mode.

In the primary mode, the FSEU controls:

- Slat retraction and extension
- Flap/slat sequence
- Cruise inhibit
- Hydraulic isolation (CHIS)
- Autoslat extension
- Low-speed control
- Shutoff control.

For redundancy, both channels in the FSEU must agree on the slat command. Each channel controls switches that are connected in series. Both channels must send the same command to the switches for the FSEU to energize the commanded solenoid.

The two coils in each solenoid of the primary control valve receive electrical power from different power sources. The FSEU controls the ground for one of the coils in each solenoid.

The FSEU also controls the solenoid in the autoslat priority valve.

Slat Retraction and Extension

The FSEU compares the flap lever position to the slat position. The slats retract if the flap lever position is less than the slat position. The slats extend if the flap lever position is greater than the slat position.

Flap/Slat Sequence

This function controls the sequence of the retraction and extension of the flaps and slats.

See the high lift control section for more information about the primary mode flap and slat sequence (SECTION 27-03).

Cruise Inhibit

This function prevents slat extension during cruise. This happens when the airspeed is more than 275 knots or the altitude is above 20,300 feet. This function prevents slat extension during cruise. This happens when the airspeed is more than 275 knots or the altitude is above 20,300 feet.

Hydraulic Isolation (CHIS)

If the hydraulic quantity in the center hydraulic system reservoir is below 0.40, the FSEUs disengage the primary slat mode. The FSEUs then engage the secondary mode for the slats only. If both engines continue operating for more than 10 seconds, then the primary mode re-engages.

See the main hydraulic system section for more information about the center hydraulic isolation system (SECTION 29-10).

Autoslat Extension

This function commands the slats to extend if the airplane approaches a stall condition. To make sure the slats receive enough hydraulic power, the FSEUs also command the autoslat priority valve to reduce the hydraulic flow to the main landing gear system.

Low-Speed Control

This function reduces the speed of slat movement as the slats approach the commanded position. The FSEU energizes the low-speed solenoid when the slats are less than approximately seven torque tube turns from the commanded position.

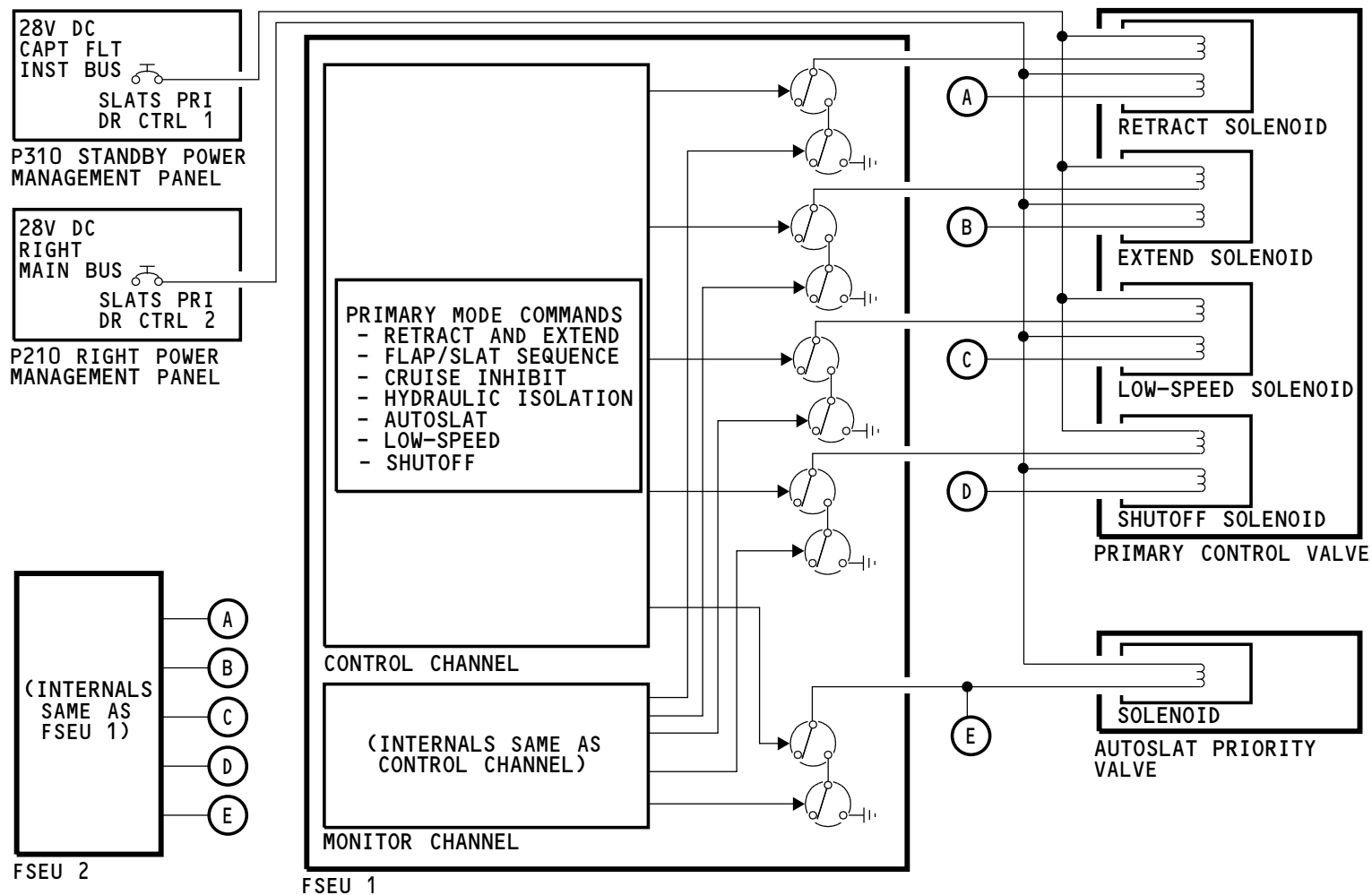
Shutoff Control

The FSEU energizes the shutoff solenoid valve to open when there is a retract or extend command.

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - PRIMARY MODE CONTROL

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - AUTOSLAT EXTENSION

General

The autoslat extension function improves the wing stall performance if the airplane approaches a stall condition. This function also makes sure the slats get enough hydraulic power when the autoslat function is active.

Autoslat

The autoslat function operates only in the primary mode and when the slats are in the sealed position. This function does not operate if the airspeed is more than 246 knots.

The warning electronics unit (WEU) sends an autoslat request to the FSEUs if the airplane approaches a stall condition. If the flap lever is in the 1, 5, 15, or 20 unit positions at this time, the FSEUs command the slats to extend to the gapped position. At this same time, the FSEUs energize the solenoid in the autoslat priority valve. This reduces the hydraulic flow to the landing gear systems. Thus, more hydraulic power can go to the slats.

The WEU also sends an autoslat request to the HYDIM cards and the air supply-cabin pressure controllers (ASCPCs). The HYDIM cards turn on both air driven pumps (ADPs). The ASCPCs operate some pneumatic valves to make sure the ADPs get enough air power.

See the main hydraulic system section for more information about the center hydraulic system (SECTION 29-10). See the pneumatic chapter for more information about the ASCPCs and the pneumatic system (CHAPTER 36).

Five seconds after the WEU removes the autoslat request, the FSEUs command the slats back to their commanded position and de-energize the solenoid in the autoslat priority valve.

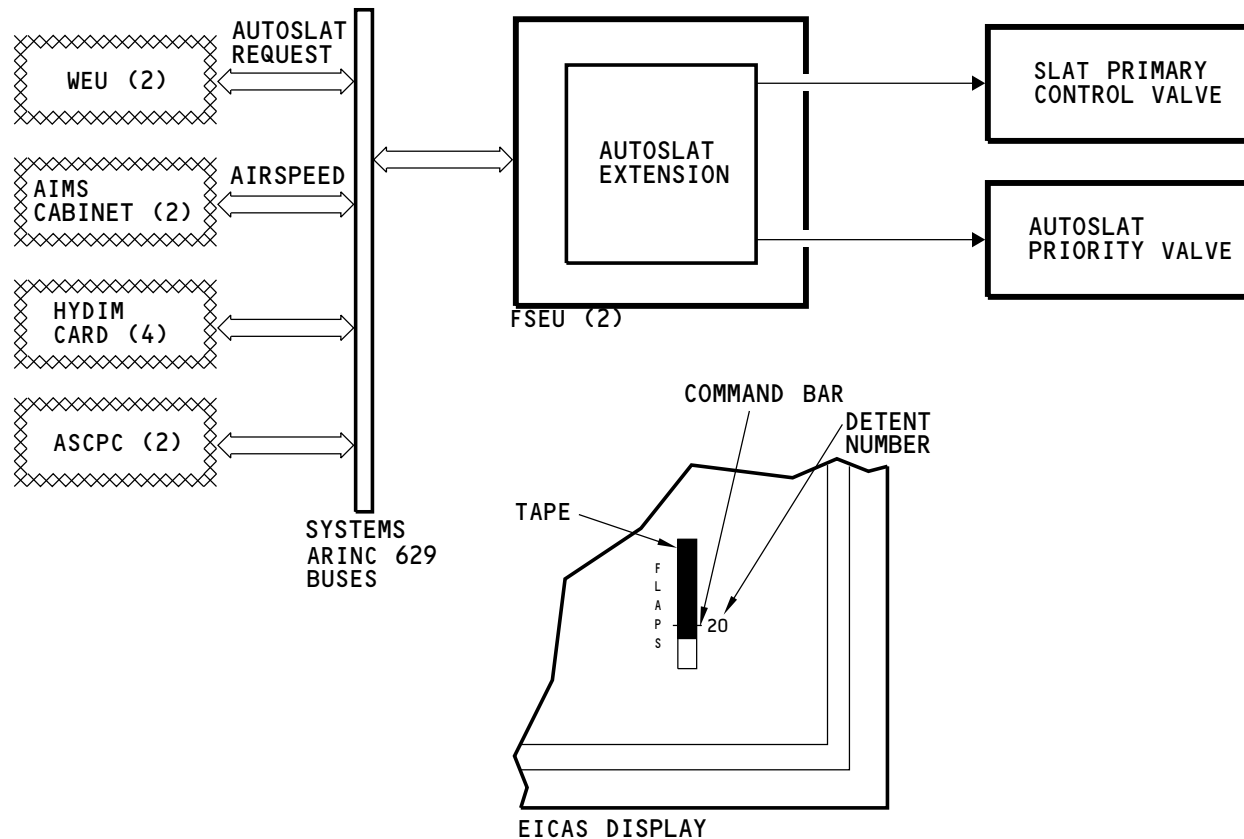
Indication

There are no messages to show that the autoslat function is active. The only indication is on the flap/slat position indication on the EICAS display and the EICAS compacted engine display. The tape in the indication extends beyond the commanded position. The color of the command bar and the detent number change to magenta.

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - AUTOSLAT EXTENSION

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - SECONDARY MODE CONTROL

General

The operation of the slats in the secondary mode is the same as for the flaps.

See the trailing edge flaps section for more information about the flaps secondary mode control (SECTION 27-51).

Only one FSEU commands the slats in the secondary mode. The FSEU controls:

- Secondary mode engage
- Retraction and extension
- Flap/slat sequence
- Cruise inhibit
- Slat Load relief
- Secondary mode auto test.

For redundancy, both channels in the FSEU must agree on the slat command.

In the secondary mode, the FSEUs energize relays. The relays control the electrical power to the electric motor, clutch, and bypass solenoid. The alternate mode also uses these relays.

Secondary Mode Engage

When the FSEU engages the secondary mode, it energizes the bypass/clutch relay.

See the high lift control section for more information about the mode selection (SECTION 27-03).

This relay has three functions.

First, the bypass/clutch relay supplies power to the bypass solenoid in the primary control valve. This stops hydraulic operation in the primary mode.

Second, this relay supplies power to the clutch in the electric motor. This permits the electric motor to move the slat drive system.

Third, the bypass/clutch relay supplies power to the extend and retract relays. These relays do not energize until the FSEUs supply the grounds for them.

Retraction and Extension Control

The FSEU compares the flap lever position to the slat position. The slats retract if the flap lever position is less than the slat position. The slats extend if the flap lever position is greater than the slat position.

Either FSEU can energize the extend and retract relays to move the slats. These relays supply 115v ac power to the electric motor.

Flap/Slat Sequence

This function controls the sequence of the retraction and extension of the flaps and slats. See the high lift control section for more information about the secondary mode flap and slat sequence (SECTION 27-03).

Cruise Inhibit

This function prevents slat extension during cruise. This happens when the airspeed is more than 275 knots or the altitude is above 20,300 feet.

Slat Load Relief

This function commands the slats to retract if the airspeed increases above the slat load relief limit.

Secondary Mode Auto Test

The secondary mode auto test does a test of the operation of the secondary mode. After 100 flight cycles, the FSEUs begin the test when the slats are commanded to extend. The test does these things:

- Disengages the primary mode
- Engages the electric motor clutch
- Extends the slats for two seconds using the electric motor.

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**LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - SECONDARY MODE CONTROL**

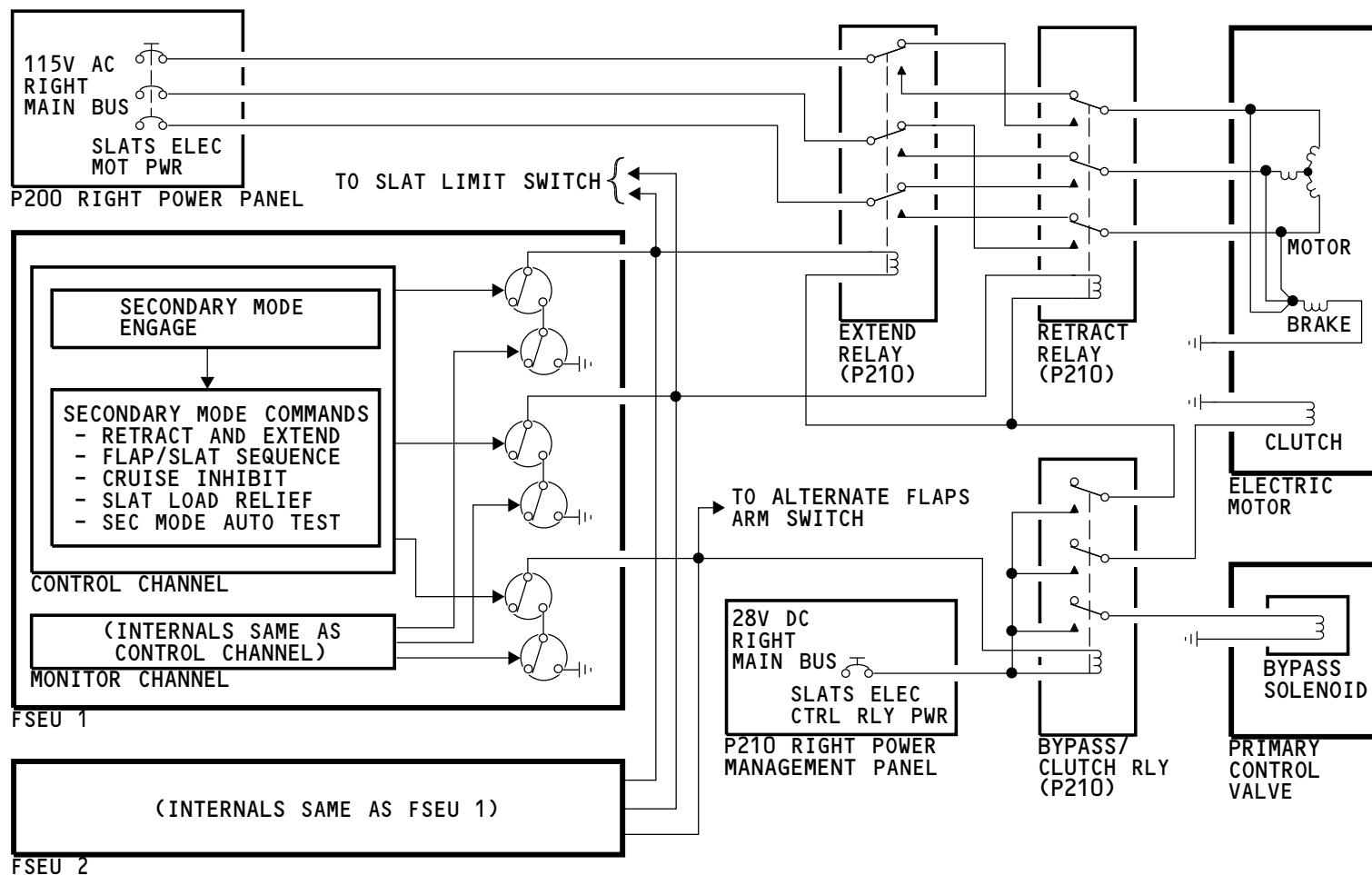
One flight cycle is when all of these conditions occur for two seconds:

- Airplane not on the ground
- Airspeed is greater than 70 knots
- Flap lever is at up
- Slats are at up.

When the slats extend for two seconds in the secondary mode, the test stops and the primary mode engages again. The slats then move to the commanded position in the primary mode.

If the slats fail to extend within four seconds during the secondary mode auto test, the SLATS SECONDARY FAIL status message shows.

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - SECONDARY MODE CONTROL

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**LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - SECONDARY MODE LOAD RELIEF****General**

The slat load relief function prevents damage to the slats and their support structures from large aerodynamic forces. Slat load relief limits the position of the slats as a function of airspeed.

Slat load relief operates in the secondary mode only.

Load Relief - Secondary Mode

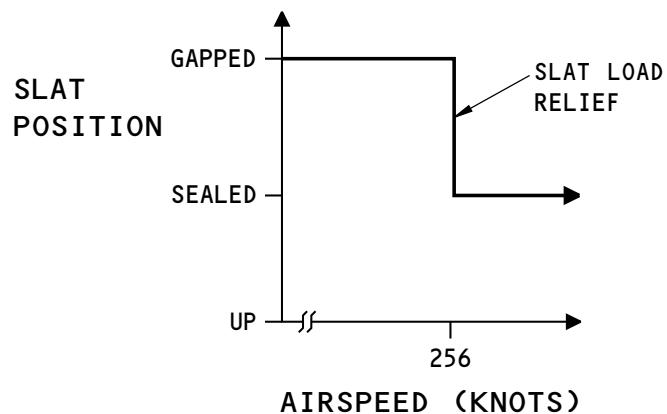
In the secondary mode, load relief is active if the flap lever is not in the up position and the airspeed is more than 256 knots. If the flap lever is not in the up position, the slats retract to the sealed position.

The load relief command resets if the airspeed is less than 256 knots or the pilot moves the flap lever to up. If the flap lever is not in the up position, the slats extend to the gapped position.

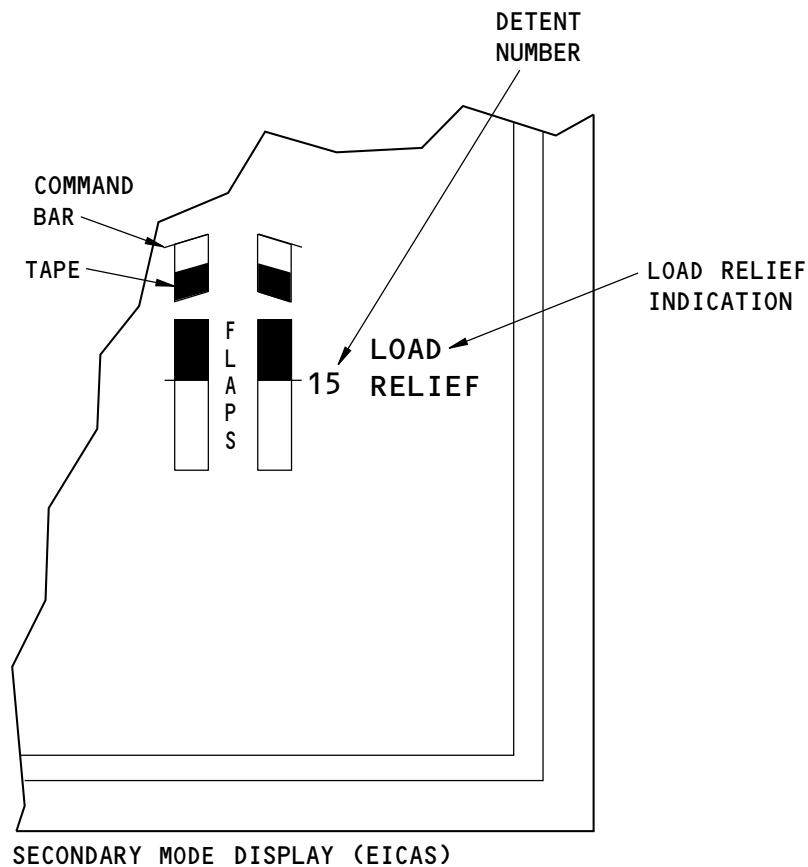
Indication

When slat load relief is active, the LOAD RELIEF message shows on the EICAS display and the EICAS compacted engine display.

The flap/slat position indication shows the position of the flap lever and the actual position of the slats. During slat load relief, the command bar and detent number change from green to magenta and the tape shows the actual position of the slats.



SLAT LOAD RELIEF - SECONDARY MODE



LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - SECONDARY MODE RELIEF

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - ALTERNATE MODE CONTROL

General

The alternate mode operation of the slats is almost the same as the alternate mode operation of the flaps.

See the trailing edge flaps section for more information about the flaps alternate mode control (SECTION 27-51).

In the alternate mode, the alternate flap/slat switches energize relays. The relays control the electrical power to the electric motor, clutch, and bypass solenoid.

The alternate mode has these functions:

- Primary and secondary mode disengage
- Extend and retract control
- Flap/slat sequence.

Primary and Secondary Mode Disengage

When you push the alternate flaps arm switch, the FSEUs receive an alternate arm discrete. The FSEUs use this discrete to disengage the primary and secondary modes.

The alternate flaps arm switch also supplies a ground for the bypass/clutch relay. The operation of the bypass/clutch relay in the alternate mode is the same as in the secondary mode.

Extend and Retract Control

When the alternate flaps selector is in the extend (EXT) position, it supplies a ground for the extend relay to extend the slats. When this relay energizes, it supplies 115v ac power to the electric motor. The slat limit switch de-energizes this relay when the slats move to their extend limit. In the alternate mode, this limit is at the sealed position.

When the alternate flaps selector is in the retract (RET) position, it supplies a ground for the retract relay to retract the slats. When this relay energizes, it supplies 115v ac power to the electric motor. The slat limit switch de-energizes this relay when the slats move to the up position.

When the alternate flaps selector is in the OFF position, the grounds for the extend and retract relays are removed. This de-energizes the relays and stops the slat movement.

Flap/Slat Sequence

During extension, both the flaps and slats extend at the same time.

During retraction, the slats do not retract until the flaps are fully retracted. The flap limit switch controls this sequence.

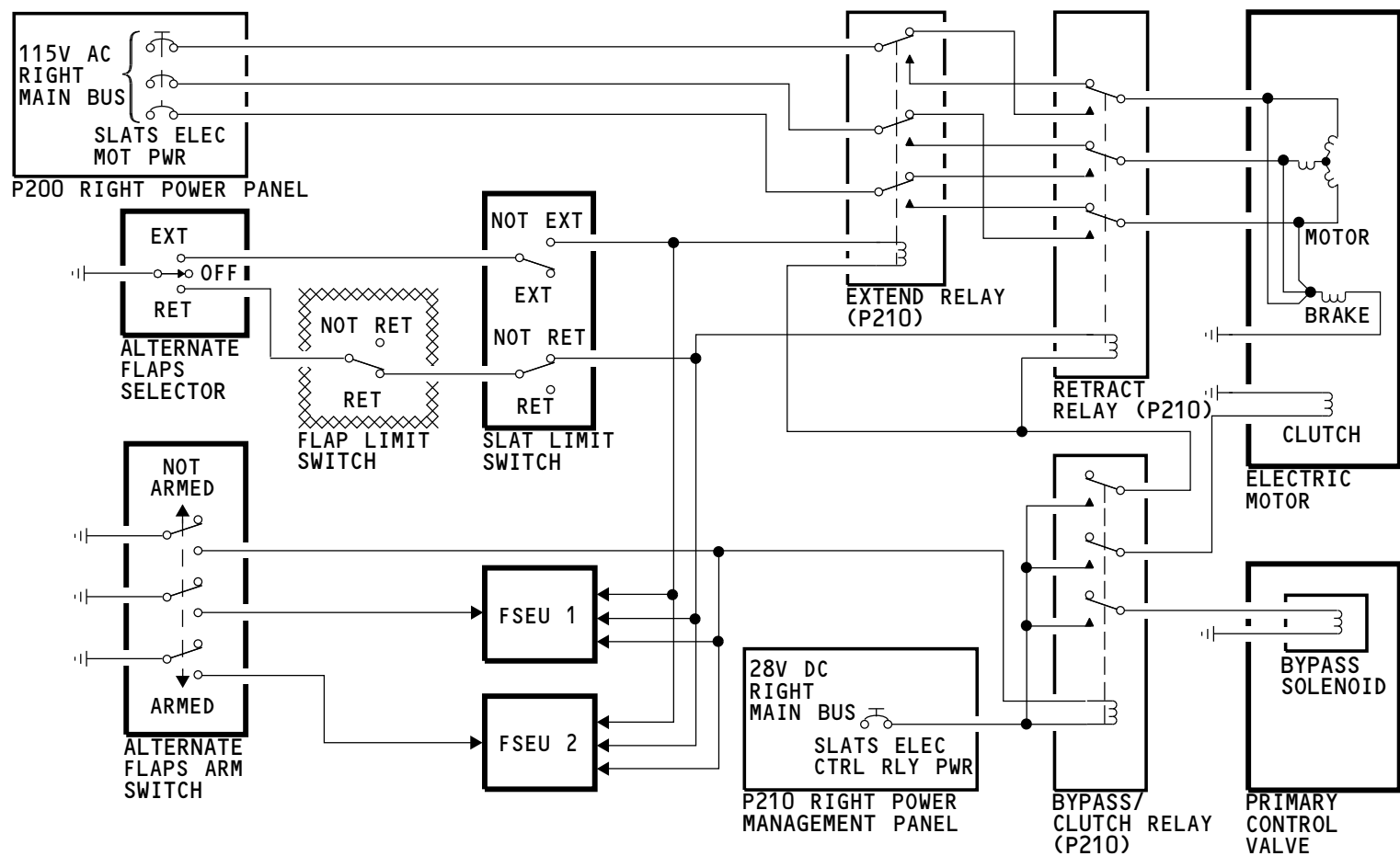
See the high lift control section for more information about the alternate mode flap and slat sequence (SECTION 27-03).

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LEADING EDGE SLATS - FUNCTIONAL DESCRIPTION - ALTERNATE MODE CONTROL

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SLAT POSITION INDICATION - GENERAL DESCRIPTION

Purpose

The slat position indication system measures the position of the slats and sends this data to the FSEUs. The FSEUs use this data for:

- Slat control
- Flap/slat position indication
- Failure detection.

Slat Control

The FSEUs use the slat position data during the slat operation in the primary and secondary modes. These modes have closed loop control of the slats. Closed-loop control stops the slat command when the slat position equals the command.

Flap/Slat Position Indication

The FSEUs send the slat position data to the airplane information management system (AIMS). The AIMS uses this data to display the flap/slat position indication on the EICAS display or the EICAS compacted engine display.

The FSEUs send the slat position data to the AIMS whenever the data is valid. This permits flap/slat position indication in all three HLCS modes. The three flap/slat position indications are:

- Primary mode display
- Secondary mode display
- Alternate mode display.

Failure Detection

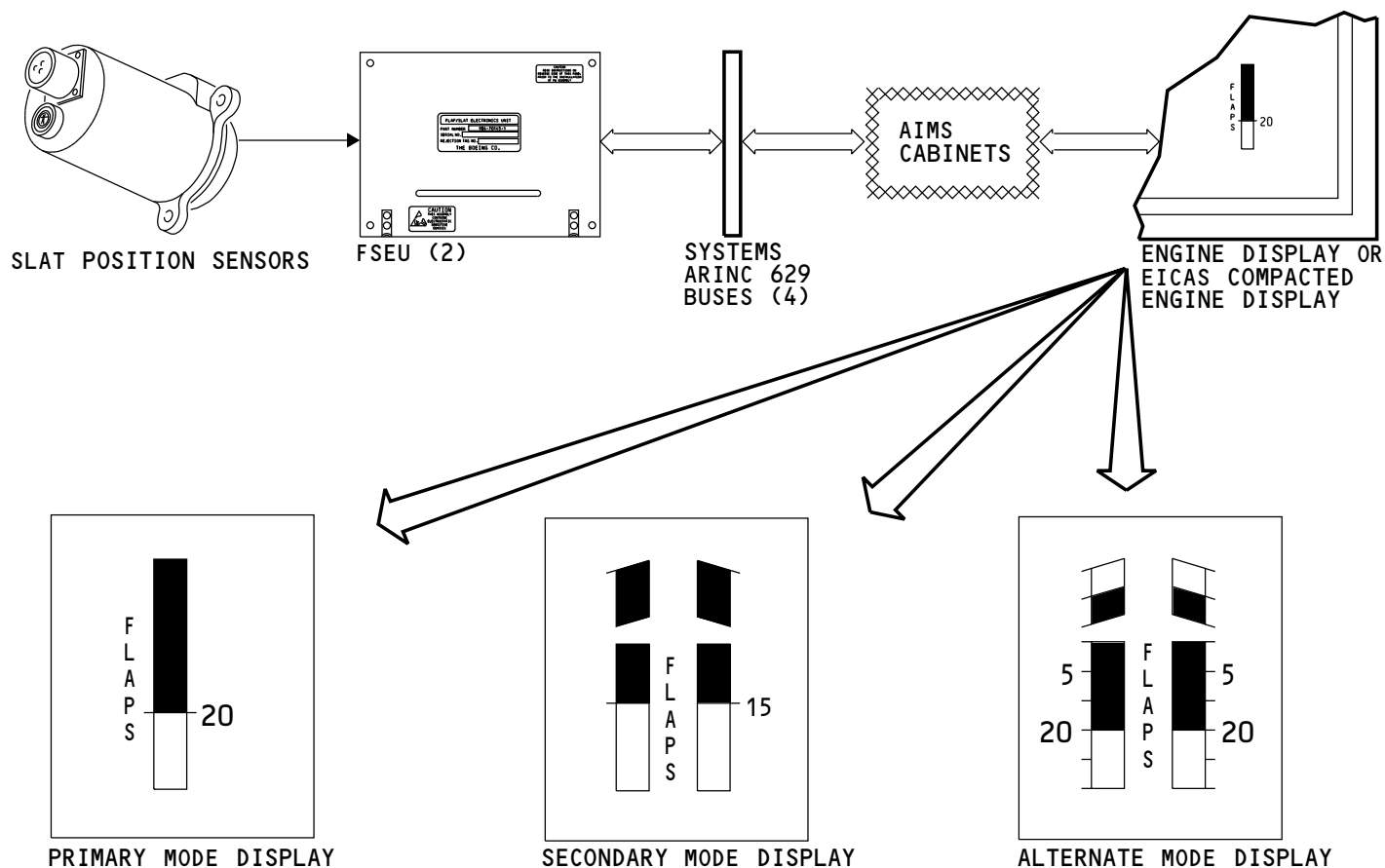
Monitors in the FSEUs compare the slat position data to the slat commands. These monitors find failures in the HLCS and the slat drive system.

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SLAT POSITION INDICATION - GENERAL DESCRIPTION

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**SLAT POSITION INDICATION - SLAT POSITION SENSORS****Purpose**

The slat position sensors supply slat position data to the FSEUs for slat control, flap/slat indication, and failure detection.

Location

The slat position sensors are on the two no-back brake offset gearboxes at the outboard ends of the slat torque tubes. Remove the access panel under the wing to get access.

Physical Description

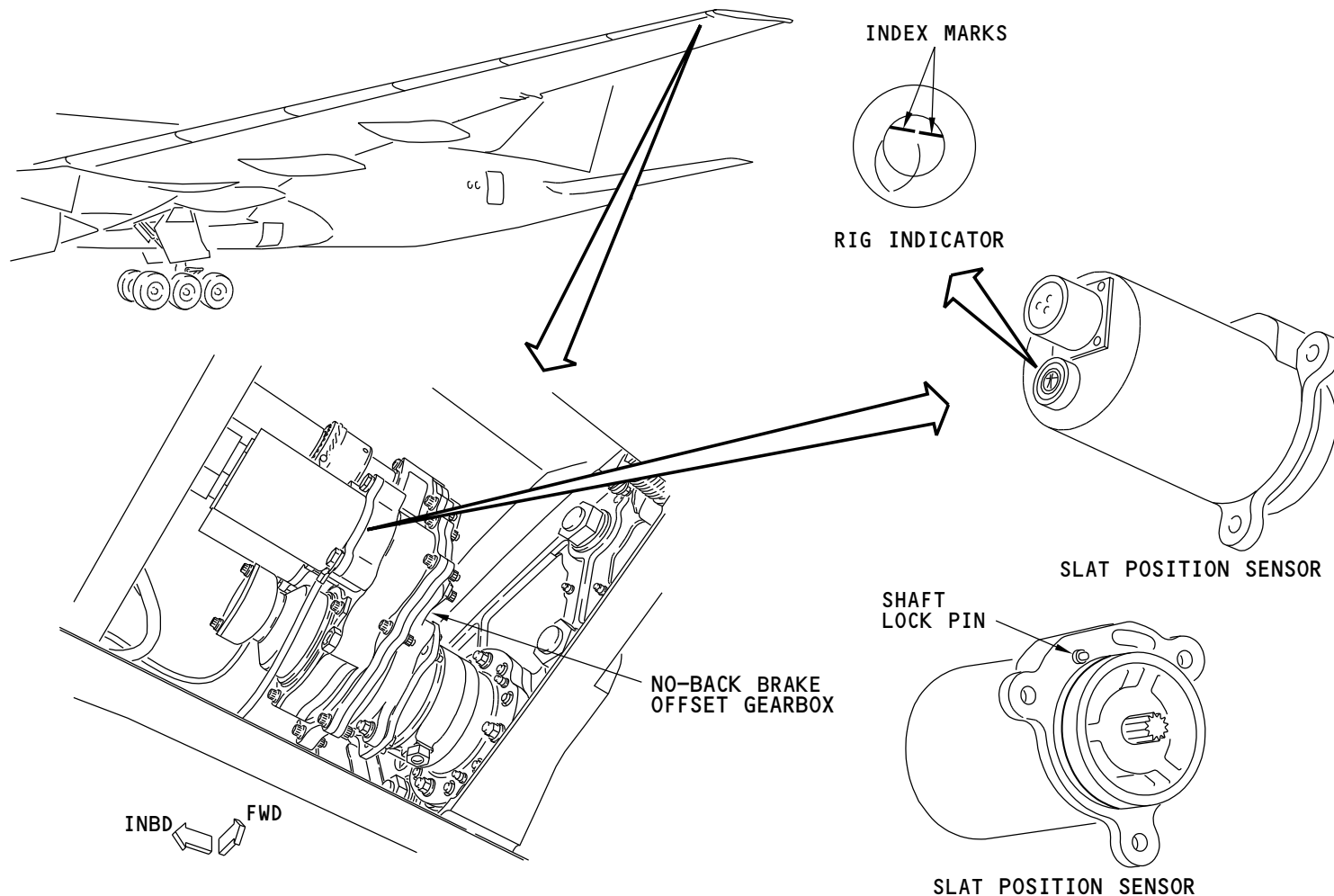
There are two slat position sensors on each of the no-back brake offset gearboxes at the outboard end of the wings. The slat position sensors are resolvers and they each have a rig indicator. The rig indicator has two marks that rotate when the position sensor shaft rotates. The two marks are in line when the slat drive line is at the UP position. All of these sensors are interchangeable with each other and with the flap position sensors.

Training Information Point

Install the slat position sensors with the slats rigged at the up position. Make sure the index marks for the rig indicator are aligned.

If the index marks on the position sensor are not aligned, you must push the shaft lock pin to turn the shaft.

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SLAT POSITION INDICATION - SLAT POSITION SENSORS

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**SLAT POSITION INDICATION - FUNCTIONAL DESCRIPTION****General**

There are four slat position sensors, two for the right wing slats and two for the left wing slats. Each FSEU interfaces with one sensor for the left slats and one sensor for the right slats. Separate power sources supply electrical power to the sensors.

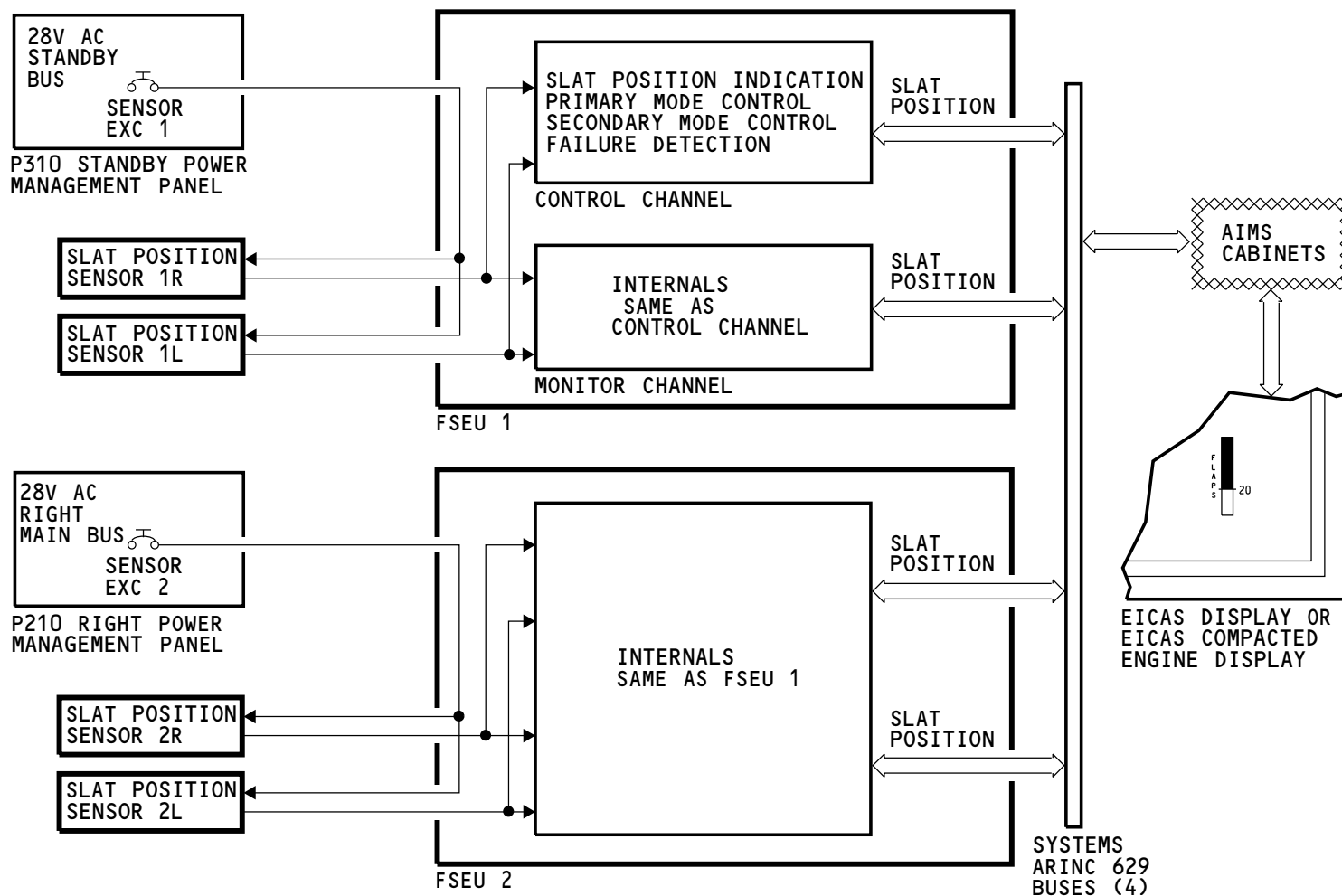
Functional Description

The slat position sensors send slat position data to both the control and monitor channels. Both of these channels use this data for:

- Slat position indication
- Primary mode control
- Secondary mode control
- Failure detection.

See the high lift control section for more information about the indications (SECTION 27-03).

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SLAT POSITION INDICATION - FUNCTIONAL DESCRIPTION

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SLAT SKEW DETECTION - GENERAL DESCRIPTION

Purpose

The slat skew detection system monitors the relative position of all the slats except for slats 1 and 14. The system does not monitor the outboard end of slats 2 and 13 and the inboard end of slats 6 and 9 for skew. The FSEUs stop the primary and secondary mode slat operation if there is a skew, an asymmetry or a secondary mode disagree condition.

Except for slats 1 and 14, the slats are in a skew when the inboard end of one or more slats is not aligned with its outboard end.

There is slat asymmetry condition when the slats on the left wing do not align with the slats on the right wing.

There is a secondary mode disagree when the slats do not move or move too slowly after a command to move in secondary mode.

Interface

The slat skew detection system has 12 proximity sensors, two for the outboard slats and four for the inboard slat on each wing.

The sensors for the inboard slat do a check of the position of targets on the inboard slat auxiliary arms. The sensors for the outboard slats are on the slat skew mechanism. This mechanism attaches to a cable that is in slats 2 through 6 in the left wing and slats 9 through 13 in the right wing. If an outboard slat (except for the most outboard slat) moves out of alignment, the cable pulls a target on the mechanism away from the sensors.

Each FSEU has interfaces with one sensor at each skew sensor location to check for a skew condition. If a skew condition exists, the FSEUs stop the primary and secondary mode slat operation.

The slats are in a skew condition if a group of slats, a single slat, or the end of a slat is not in the correct position.

If the slats are in a skew, an asymmetry or a secondary mode disagree condition, the FSEUs stop the slat drive in primary and secondary modes. The FSEUs also send a signal to AIMS to show the SLATS DRIVE caution message. The slat position display changes to the secondary mode display and the slat position indication shows in amber.

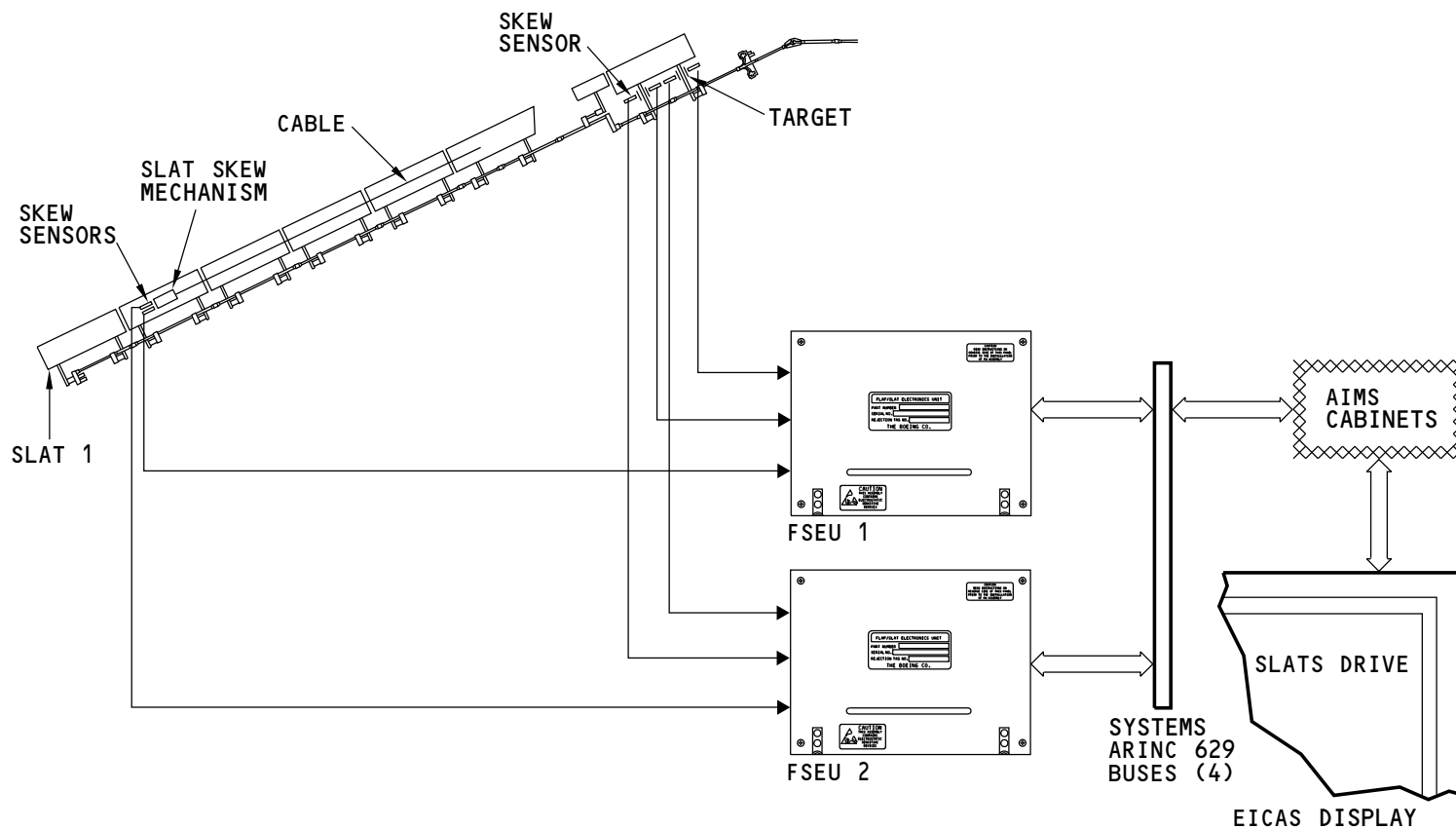
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NOTE: THE LEFT SLATS ARE SHOWN
(RIGHT SLATS ARE SIMILAR)

SLAT SKEW DETECTION - GENERAL DESCRIPTION

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SLAT SKEW DETECTION - INBOARD SLAT SKEW SENSORS AND TARGETS

Purpose

The inboard slat skew sensors and targets monitor the relative position of the inboard slats.

Location

The inboard slat skew targets attach to the inboard and outboard auxiliary arms of the inboard slat. The skew sensors attach to the support structure of the inboard and outboard auxiliary tracks in the fixed leading edge of the wing. Remove the access panel under the wing to get access.

Physical Description

The slat skew sensors are proximity sensors. Each sensor is a separate LRU and is interchangeable with the skew sensors for the outboard slats.

The targets are made of an aluminum housing with four magnet zones and four cover plates. The magnets are spaced so that the sensors are in target-near condition when the slats are in the up, sealed, and gapped positions.

Functional Description

The FSEUs monitor the impedance of the skew sensors. The impedance has a relation to the position of the targets to the sensors. As the slats move, the targets move with them and the impedance of the skew sensors change.

The FSEUs detect a target-near condition when a magnet zone is directly in front of the sensor. When no part of a magnet zone is in front of the sensor, the FSEUs detect a target-far condition. The FSEUs use this data for skew monitoring and failure detection.

Training Information Point

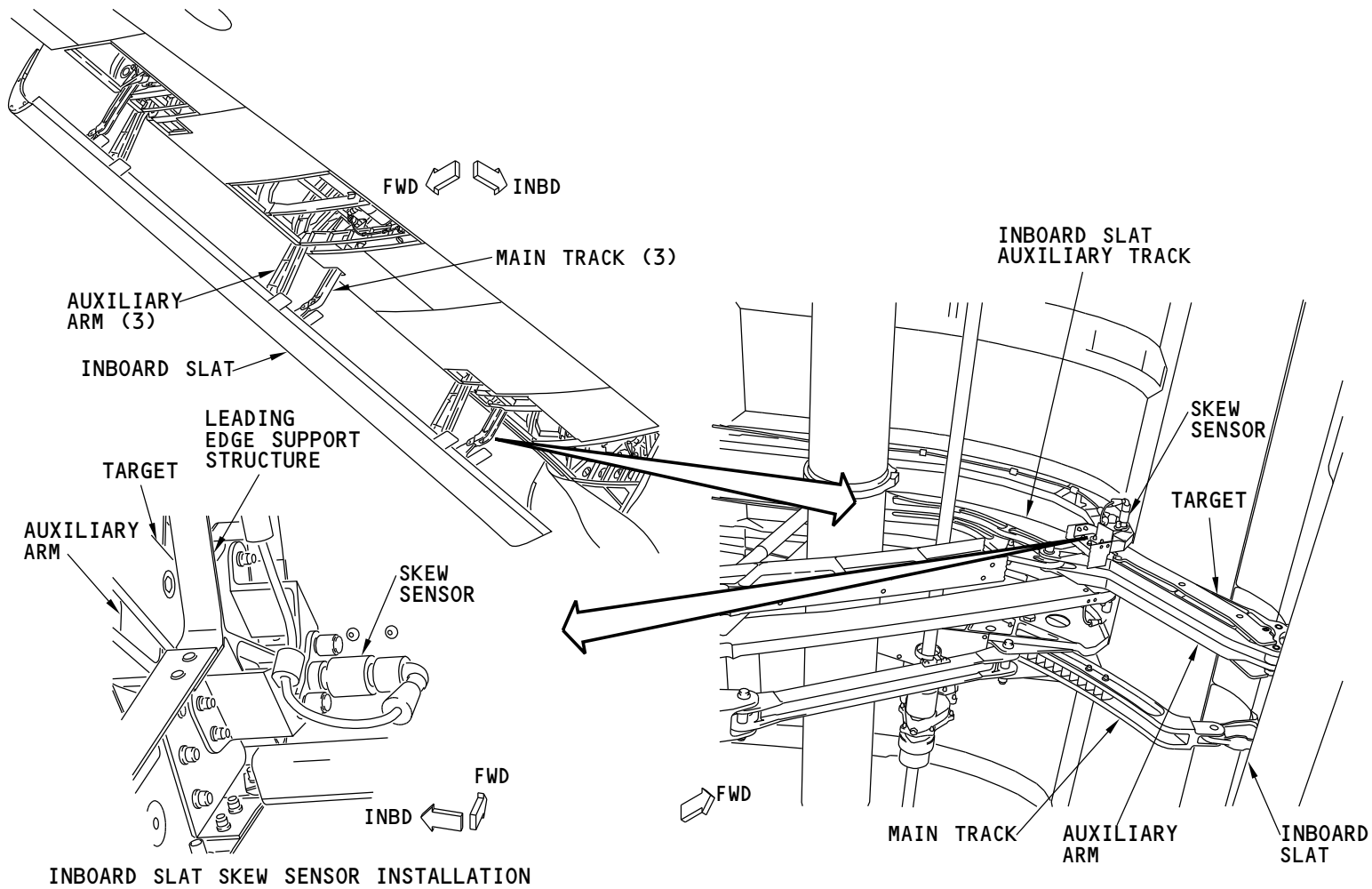
It is not necessary to rig the inboard slat skew sensors and targets after installation.

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SLAT SKEW DETECTION - INBOARD SLAT SKEW SENSORS AND TARGETS

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SLAT SKEW DETECTION - OUTBOARD SLAT SKEW MECHANISM AND CABLE

Purpose

The outboard slat skew mechanisms and cables monitor the position of all the outboard slats except slats 1 and 14, the outboard end of slats 2 and 13, and the inboard end of slats 6 and 9.

Location

The outboard slat skew mechanisms are in slat 2 and slat 13. The left cable attaches to slat 6 and to the slat skew mechanism in slat 2. The right cable attaches to slat 9 and to the slat skew mechanism in slat 13. The routing of the cables is along the inside of the slat cove skins. Remove the cove skin panels to get access to the mechanisms and cables.

Physical Description

The slat skew mechanism has two proximity sensors, a target, two latches, and internal springs. A cable attaches to the slat skew mechanism.

When the cable pulls on the skew mechanism, the target moves to the far position. The latches lock the target in the far position. The internal springs permit some movement of the cable before the latch sets. This adjusts for minor changes of slat position caused by wing flex, temperature changes, and normal slat movement.

The proximity sensors measure the magnetic field of the target. When the position of the target changes, the impedance of the sensors change.

Each proximity sensor is a separate LRU and is interchangeable with the skew sensors for the inboard slats. But they are not interchangeable with the landing gear proximity sensors.

Functional Description

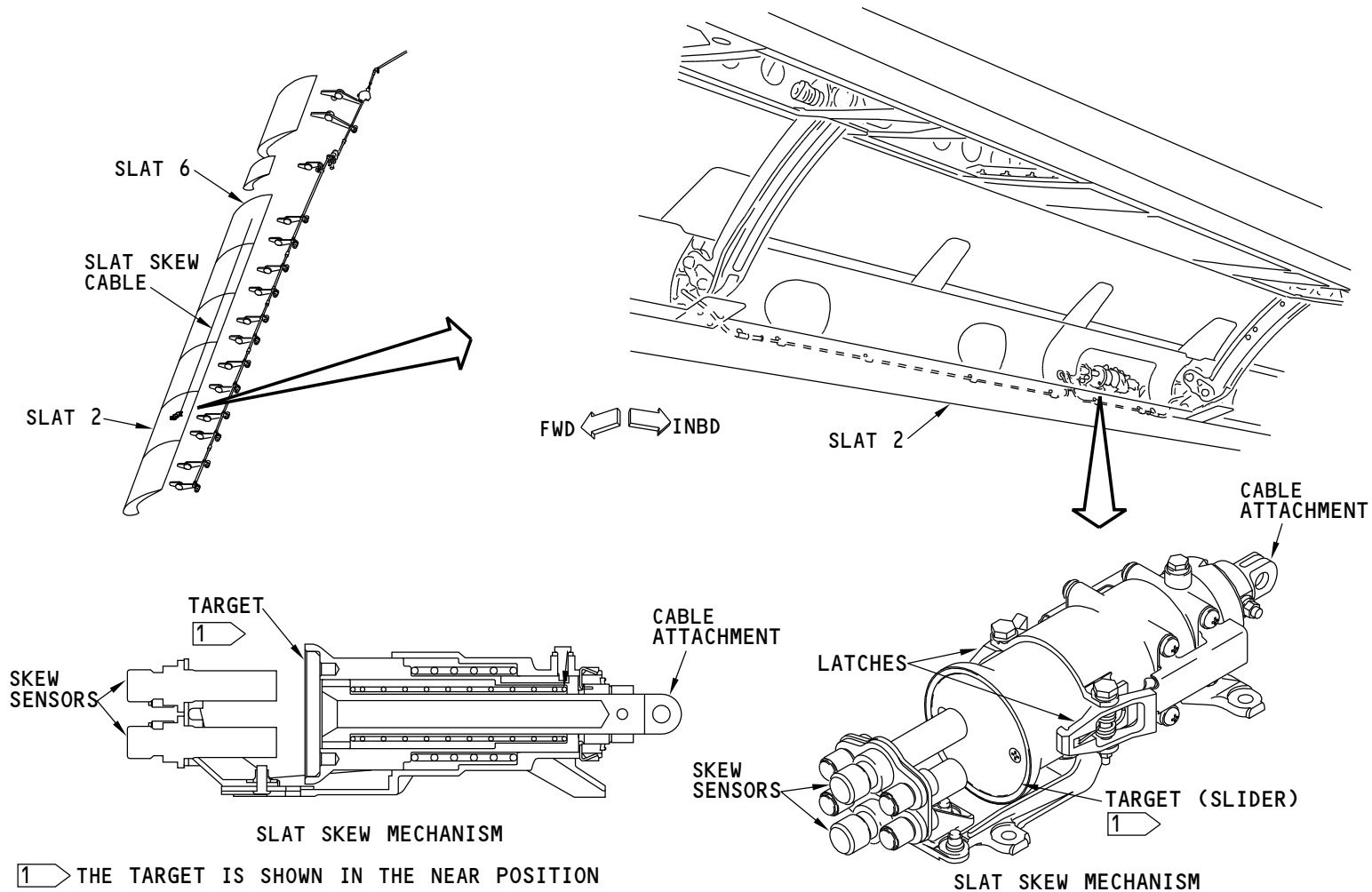
The FSEUs monitor the impedance of the skew sensors. If one of the outboard slats (except for the most outboard slat) do not align with all the others, the slat that is out of alignment pulls on the cable. This pulls on the skew mechanism, which moves the target to the far position. As the target moves away from the sensors, the impedance of the skew sensors change. The FSEUs use this data for skew monitoring and failure detection.

Training Information Point

It is necessary to rig the cable after installation of the skew mechanism or cable.



KEEP ALL PERSONNEL CLEAR OF THE SPACE BETWEEN THE SLIDER AND THE SENSORS ON THE SLAT SKEW MECHANISM. WHEN YOU RELEASE THE LATCHES, THE SLIDER WILL QUICKLY MOVE OUTBOARD. THIS CAN CAUSE INJURY TO PERSONNEL AND DAMAGE TO EQUIPMENT.



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SLAT SKEW DETECTION - OUTBOARD SLAT SKEW MECHANISM AND CABLE

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SLAT SKEW DETECTION - FUNCTIONAL DESCRIPTION

General

There are 12 slat skew sensors. Each FSEU receives data from one of the skew sensors at each slat skew sensor location.

Both channels in the FSEUs use the slat skew data for:

- The inboard slat skew monitor
- The outboard slat skew monitor
- Failure detection.

Inboard Slat Skew Monitor

The inboard slat skew monitor receives data from the inboard and outboard skew sensors for slats 7 and 8. This monitor also receives data from the slat position sensors to predict the condition of the skew sensors.

The inboard slats are in a skew condition if:

- The condition of the inboard and outboard skew sensors for slat 7 (or 8) disagree with each other, or
- The condition of the inboard and outboard skew sensors for slat 7 (or 8) both disagree with the predicted condition.

Outboard Slat Skew Monitor

The outboard slat skew monitor receives data from the skew sensors in slats 2 and 13. Normally, these sensors are in the target-near condition. The outboard slats are in a skew condition (or a slat is lost) if these sensors are in the target-far condition.

Slats Drive Shutdown

The failure detection function in the FSEUs receives input from these sensors:

- The slat skew sensors
- The slat position sensors
- The flap lever position sensors.

When both FSEUs find a failure, they stop and shutdown the slats drive. There is a slats drive shutdown when any of these conditions occurs:

- The inboard or outboard slat skew monitors find a failure (slat skew or lost slat)
- The left slat position sensors do not agree with the right slat position sensors (slat asymmetry)
- The slats do not move within five seconds after a slat command in the secondary mode (disagree).

If there is a slat skew, asymmetry, or secondary mode disagree condition, the FSEUs latch the shutdown of the primary and secondary modes. The FSEUs also send signals to AIMS to show the SLATS DRIVE caution message. The slat position display changes to the secondary mode display and the slat position indication shows in amber.

A slats drive shutdown still permits the flaps to operate in primary or secondary mode. The flaps then move to their commanded position independently of the slat position. If the slats are not at the gapped position when the slats drive shutdown occurs, the flaps cannot move more than the 20-unit position. If the slats are at the gapped position when the slats drive shutdown occurs, the flaps can move more than the 20-unit position.

To reset the latch, cycle the alternate flaps arm switch or do the primary system test on the MAT.

Skew Sensor Failure

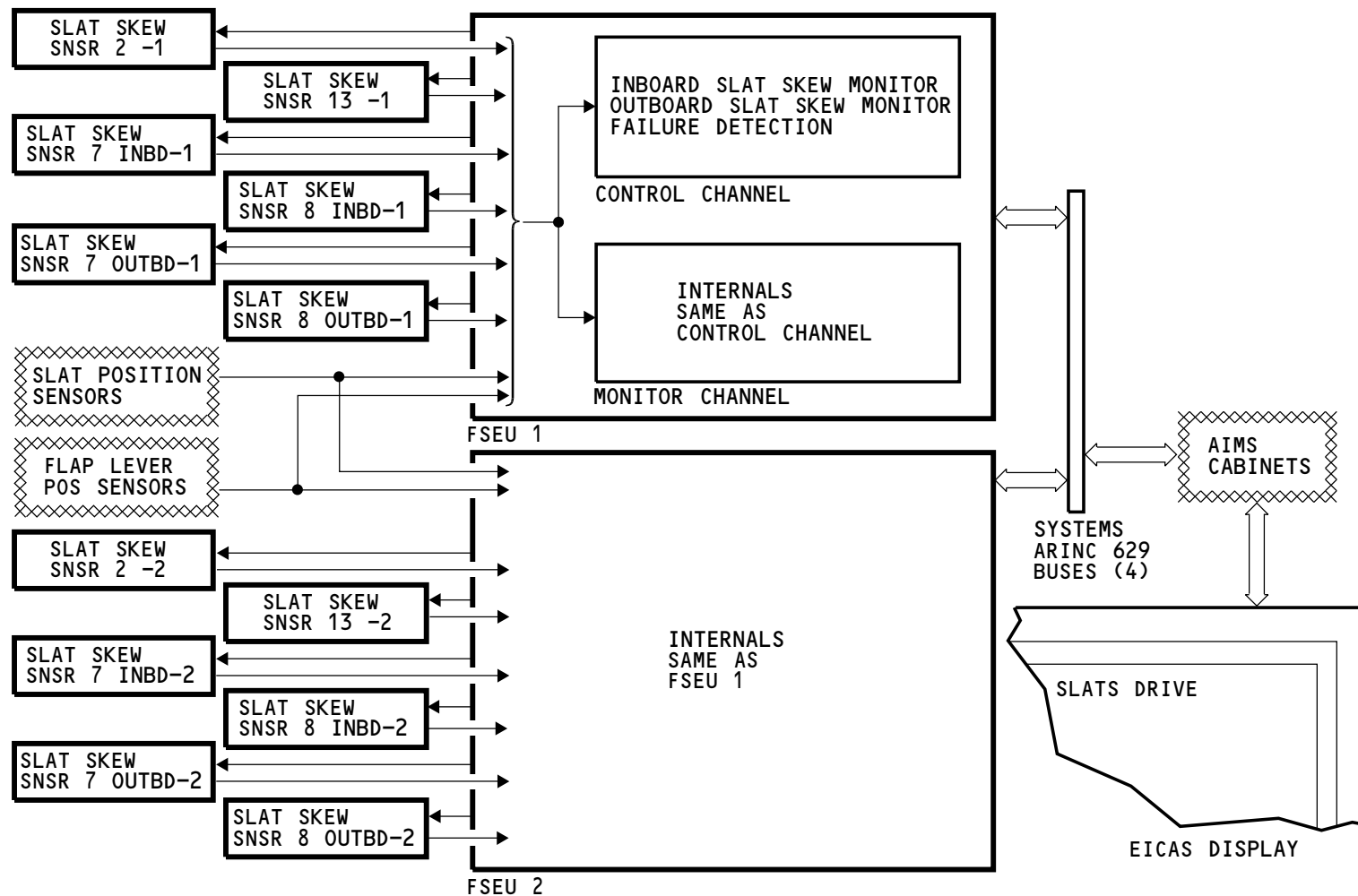
If one or more of the slat skew sensors fails, the FSEUs send a signal to the AIMS to show the FLAP/SLAT SKEW SNSRS status message.

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SLAT SKEW DETECTION - FUNCTIONAL DESCRIPTION

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