

CHAPTER

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26	Sep 15/2021		50	Sep 15/2021	
27	Sep 15/2021		51	Sep 15/2021	
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AUTOFLIGHT**

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DIGITAL FLIGHT CONTROL SYSTEM - INTRODUCTION

General

The digital flight control system (DFCS) does these functions:

- Autopilot
- Flight director
- Altitude alert
- Speed Trim and MCAS
- Mach trim
- Autothrottle.

The DFCS has a mode control panel (MCP), two flight control computers (FCC), and actuator inputs to the flight control system. Each FCC can do all of the first five functions, but only FCC A has the autothrottle function.

Autopilot

The FCCs get inputs from several systems such as the air data inertial reference system (ADIRS) and the flight management computer (FMC) and sends commands to the aileron and elevator actuators. These actuators control the movement of the ailerons and elevators, which control the flight path of the airplane. There are two autopilots, autopilot A from FCC A and autopilot B from FCC B. When you engage an autopilot from the MCP, the autopilot controls the airplane attitude through these phases of flight:

- Climb
- Cruise
- Descent
- Approach
- Go-around
- Flare.

Flight Director

The FCCs get inputs from several systems and send flight director commands to the MDS to provide guidance for the pilots. When the MCP flight director switches are on, the flight director display shows on the MDS. The flight crew can use the flight director commands to control the attitude of the airplane. The flight director commands do not show at flare.

Altitude Alert

As the airplane gets near or flies away from the MCP selected altitude, an alert occurs. This alert warns the pilots that they are getting near or leaving the MCP selected altitude. This warning occurs with or without the autopilots engaged or the flight directors on.

Speed Trim System

The Speed Trim System (STS) function provides speed and pitch stability augmentation. Speed stability augmentation is provided by the Speed Trim function. Pitch stability augmentation is provided by the Maneuvering Characteristics Augmentation System (MCAS) function.

The Speed Trim function keeps the speed set by the pilots with commands to the horizontal stabilizer when the engine thrust is high and the airspeed is low. This function primarily occurs during takeoff and only operates when the autopilots are not engaged. The flight directors may be on or off.

Maneuvering Characteristics Augmentation System (MCAS) function is an additional pitch augmentation flight control law within the Speed Trim System that enhances pitch characteristics in manual flight with flaps up and at elevated AOA's. This function only operates when the autopilots are not engaged. The flight directors may be on or off.

Mach Trim

As the speed of the airplane increases, the nose starts to drop. This is called mach tuck. When the airplane airspeed is more than mach 0.615, the mach trim function gives an up elevator to keep the nose of the airplane level. This function operates with or without the autopilot engaged or the flight director on.

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DIGITAL FLIGHT CONTROL SYSTEM - INTRODUCTION

Autothrottle

The autothrottle (A/T) function in flight control computer A (FCC A) uses data from airplane sensors to calculate engine thrust. The A/T system controls engine thrust in response to mode requests from the flight crew through the DFCS MCP and flight deck switches, and from the FMC. The A/T system operates from takeoff to touchdown.

Abbreviations and Acronyms

- AAM - autopilot actuator monitor
- AC - alternating current
- accel - acceleration
- actr - actuator
- ACQ - acquire
- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- ADR - air data reference
- AFCS - automatic flight control system
- AFDS - autopilot flight director system
- AGS - air/ground system
- AI - attitude indicator
- ail - aileron
- alt - altitude
- ALT - alternate
- ANN - annunciator
- annun - annunciator
- ANT - antenna
- AOC - approach-on-course
- A/P - autopilot
- APP - approach
- ARINC - Aeronautical Radio Incorporated
- A/S - airspeed
- ASA - autoflight status annunciator
- A/T - autothrottle
- BAT - battery
- BITE - built-in test equipment
- BOV - bias out of view
- CAPT - captain
- CAA - Civil Aviation Authority
- CAS - computed airspeed
- cat - category
- cau - caution
- C/B - circuit breaker
- CDU - control display unit
- CH - channel
- chg - change
- CLB - climb
- CMD - command
- C/O - change over
- cont - control
- CPU - central processing unit
- CRS - course
- CWS - control wheel steering
- DC - direct current
- deg - degree
- DPC - display processing unit
- DFCS - digital flight control system
- DISC - disconnect
- DMA - direct memory access
- DME - distance measuring equipment
- DN - down
- elec - electric

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DIGITAL FLIGHT CONTROL SYSTEM - INTRODUCTION

- elev - elevator
- ELEX - electronic
- eng - engage
- exc - excitation
- FAA - Federal Aviation Administration
- FCC - flight control computer
- F/D - flight director
- DFDAU - digital flight data acquisition unit
- FGN - foreign
- FIM - Fault Isolation Manual
- flt - flight
- FMA - flight mode annunciator
- FMC - flight management computer
- FMCS - flight management computing system
- F/O - first officer
- FPA - flight path angle
- FPM - feet per minute
- FREQ - frequency
- FWD - forward
- G/A - go-around
- gnd - ground
- GPS - global positioning system
- GPWC - ground proximity warning computer
- G/S - glideslope
- hdg - heading
- hld - hold
- hyd - hydraulic
- Hz - hertz
- IAS - indicated airspeed
- IFSAU - integrated flight system accessory unit
- ILS - instrument landing system
- inh - inhibit
- instr - instrument
- intlk - interlock
- I/O - input/output
- IR - inertial reference
- IRS - inertial reference system
- kts - knots
- l - left
- lbs - pounds
- LCD - liquid crystal display
- LCL - local
- LED - light emitting diode
- LNAV - lateral navigation
- LOC - localizer
- LRU - line replaceable unit
- LSK - line select key
- LT - light
- LVDT - linear variable differential transformer
- lvl - level
- MA - master
- MASI - mach airspeed indicator
- MB - marker beacon
- MCAS - maneuvering characteristic augmentation system function
- MCP - mode control panel
- MCU - modular concept unit
- MDS - max display system
- MLS - microwave landing system
- Mmo - mach maximum operating
- MMR - multimode receiver

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DIGITAL FLIGHT CONTROL SYSTEM - INTRODUCTION

- mst - master
- MSU - mode select unit
- NAV - navigation
- NCD - no computed data
- ND - navigation display
- NSS - neutral shift sensor
- OC - on course
- O/D - out of detent
- OSS - over station sensor
- P - push
- PAM - performance assessment monitor
- PB - push-button
- PCU - power control unit
- PFD - primary flight display
- pnl - panel
- posn - position
- press - pressure
- prev - previous
- prim - primary
- PSEU - proximity switch electronic unit
- PSI - pounds per square inch
- PTH - path
- R - right
- RA - radio altimeter
- RAM - random access memory
- rad - radio
- REF - reference
- REQ - request
- REU - remote electronics unit
- RF - radio frequency
- rly - relay
- RST - reset
- rud - rudder
- sec - second
- sel - select
- sens - sensor
- SMYDC - stall management yaw damper computer
- snsr - sensor
- SPD - speed
- SPM - surface position monitor
- spn - spin
- stab - stabilizer
- STS - speed trim system function
- surf - surface
- sw - switch
- sync - synchronization
- sys - system
- TAS - true airspeed
- THR - throttle
- T/O - takeoff
- TO/GA - takeoff/go-around
- T/R - thrust reverser
- TR - transformer rectifier
- TRK - track
- typ - typical
- V - volts
- V2 - scheduled target speed
- vert - vertical
- VHF - very high frequency
- Vmo - maximum operating velocity

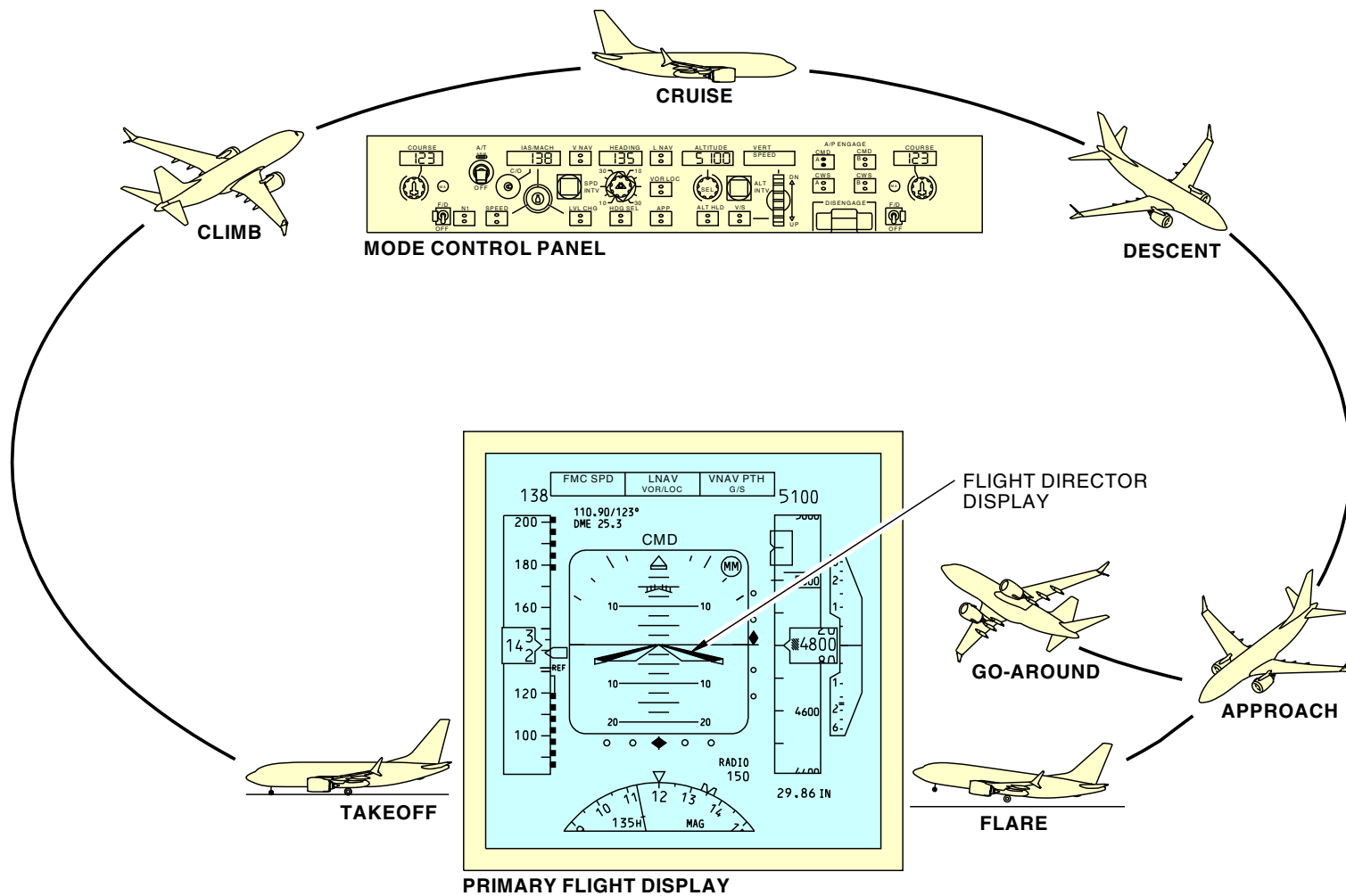
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DIGITAL FLIGHT CONTROL SYSTEM - INTRODUCTION

- V/S - vertical speed
- VNAV - vertical navigation
- VOR - VHF omnidirectional range
- WARN - warning
- WHL - wheel
- X-CH - cross channel
- XCHAN - cross channel
- xmtr - transmitter
- xfer - transfer

DIGITAL FLIGHT CONTROL SYSTEM - INTRODUCTION



DFCS - INTRODUCTION

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DFCS - GENERAL DESCRIPTION

Mode Control Panel

The mode control panel (MCP) is the primary interface between the flight crew and the flight control computers (FCCs). The crew uses the MCP to do these functions:

- Engage the autopilots
- Turn on the flight directors
- Select the mode of operation
- Select course and heading
- Select target speeds and altitude.

Other crew inputs to the FCCs are from these components:

- Autopilot (A/P) disengage switches
- Takeoff/Go-around (TO/GA) switches
- Control wheel steering (CWS) force transducers
- Autoflight status annunciators (ASAs).

FCC A and B

The FCCs use data from the MCP, sensors, and these systems to calculate the autopilot and flight director commands:

- Radio navigation systems
- Air data inertial reference system (ADIRS)
- Flight management computer system (FMCS)
- Autothrottle (A/T) system
- Control surface position sensors
- Autopilot actuator position sensors.

The FCCs also use the data to calculate these commands and alerts:

- Speed trim system commands
- Mach trim commands
- Altitude alerts

- Autopilot disengage warnings.

Autopilot Commands

The autopilot can be in the command (CMD) or the control wheel steering (CWS) mode. In the CMD mode, the FCC calculates the commands which go to the autopilot actuators. The actuators cause the inputs to the power control units (PCU) to move which control the ailerons and elevator. In the CWS mode, force transducers under the control columns sense control wheel and control column forces from the pilots and send these signals to the FCC. The FCC sends the commands to the autopilot actuators to control the ailerons and elevator. The FCC also sends commands to the stabilizer trim electric actuator to trim the stabilizer.

The autopilot mode shows on the MAX Display System (MDS) above the attitude indicator. To disengage the autopilot, the pilot pushes the disengage switches on the control wheel. When the autopilot disengages, an aural warning is heard from the aural warning module and the red A/P light on the autoflight status annunciator (ASA) flashes. The ASA warning and aural alert can be reset if the pilot pushes the red A/P annunciator on the ASA or pushes the A/P disconnect switch.

Flight Director Commands

When the flight directors are on, the FCC calculates the guidance commands that show on the MDS. There is no movement of the control surfaces and no alert if the flight directors are turned off. When you set the flight director mode on the MCP, the mode and its status also show on the MDS display.

Altitude Alert

The altitude alert function uses the altitude that is set on the MCP. The FCCs tell the flight crew when the airplane approaches or departs the set altitude. The autopilot or flight directors do not have to be on for this alert to operate. There is an aural indication from the remote electronic unit (REU) and a visual indication on the MDS displays.

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**DFCS - GENERAL DESCRIPTION****Speed Trim System**

The FCCs send speed trim system signals to the stabilizer trim primary electric actuator to control the horizontal stabilizer movements. Speed trim control enhances the airplane speed stability at low air speeds. As the airplane speed slows, the stabilizer is moved to a more nose down position to increase the speed. As the speed increases, the stabilizer is moved to a more nose up position to decrease the speed. MCAS control enhances pitch stability by increasing control column forces when at elevated AOA through nose down stabilizer movement. When AOA is reduced below the threshold, the stabilizer is moved nose up to the position before any nose down stabilizer movement occurred. The Speed Trim System only operates if the autopilot is not engaged.

Mach Trim

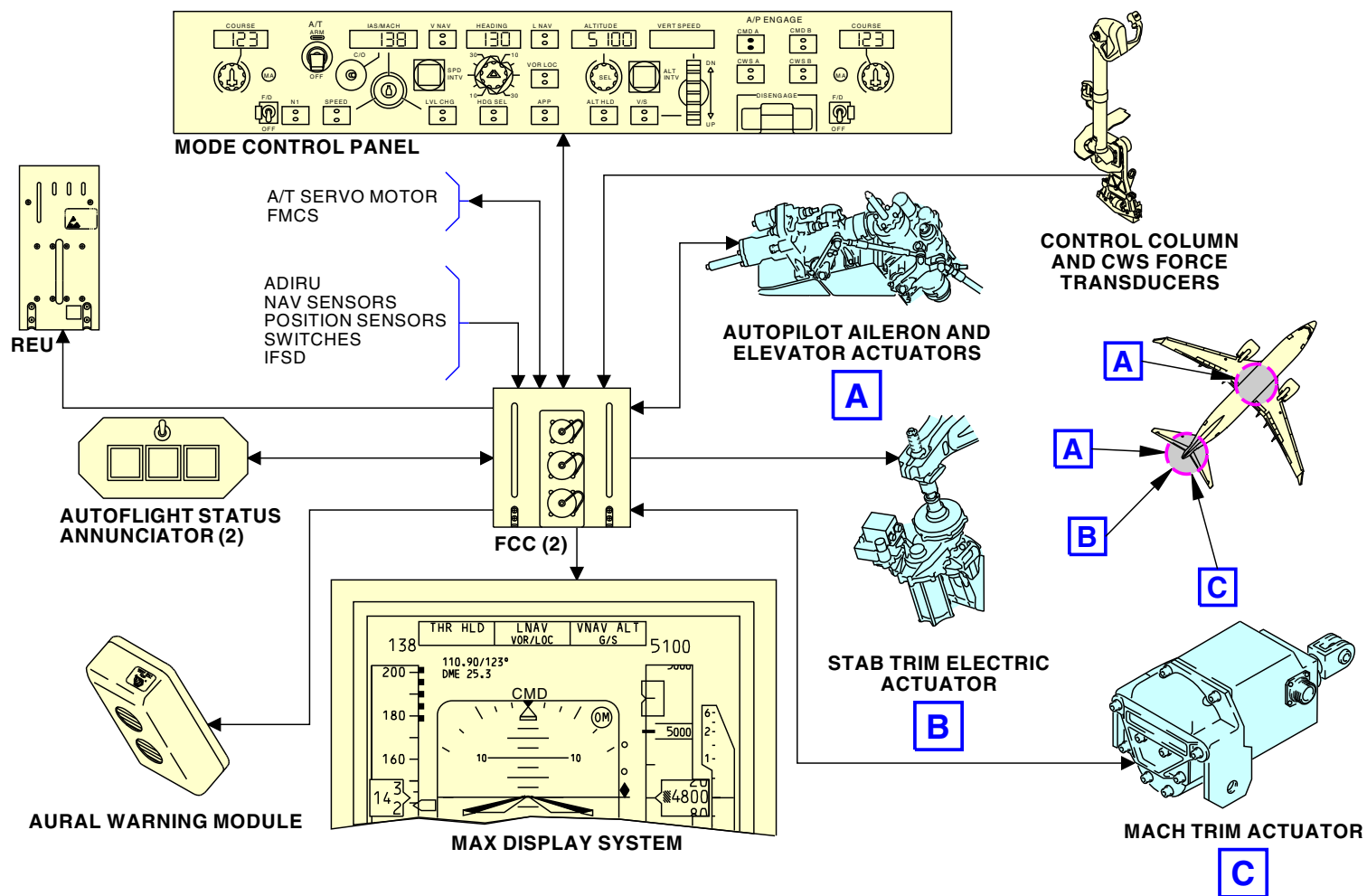
The FCCs send mach trim signals to a mach trim actuator to control the elevator movements. As the mach trim actuator output shaft moves, it turns the feel and centering unit which moves the input to the elevator PCUs. This moves the elevator. The mach trim signal keeps the nose up at high air speeds. The mach trim actuator also causes the elevator to be in a more nose down position during takeoff which allows the pilots to move the stabilizer to a more nose up position. This allows a more nose up attitude if there is an engine failure during takeoff and is called the FCC controlled neutral shift enable (FCNSE) region.

Built-In-Test-Equipment (BITE)

The DFCS has interfaces with the FMCS to show the BITE condition on the control display units (CDU). The BITE function helps find failures.

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DFCS - GENERAL DESCRIPTION



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DFCS - GENERAL DESCRIPTION

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**DFCS - FLIGHT COMPARTMENT COMPONENT LOCATION****Flight Compartment**

The mode control panel (MCP) is on the P7 glareshield.

The captain autopilot disengage switch is on the captain control wheel. The first officer autopilot disengage switch is on the first officer control wheel.

Flight Control Panel

The speed trim fail and mach trim fail annunciators have interface with the digital flight control system (DFCS). They are on the flight control panel.

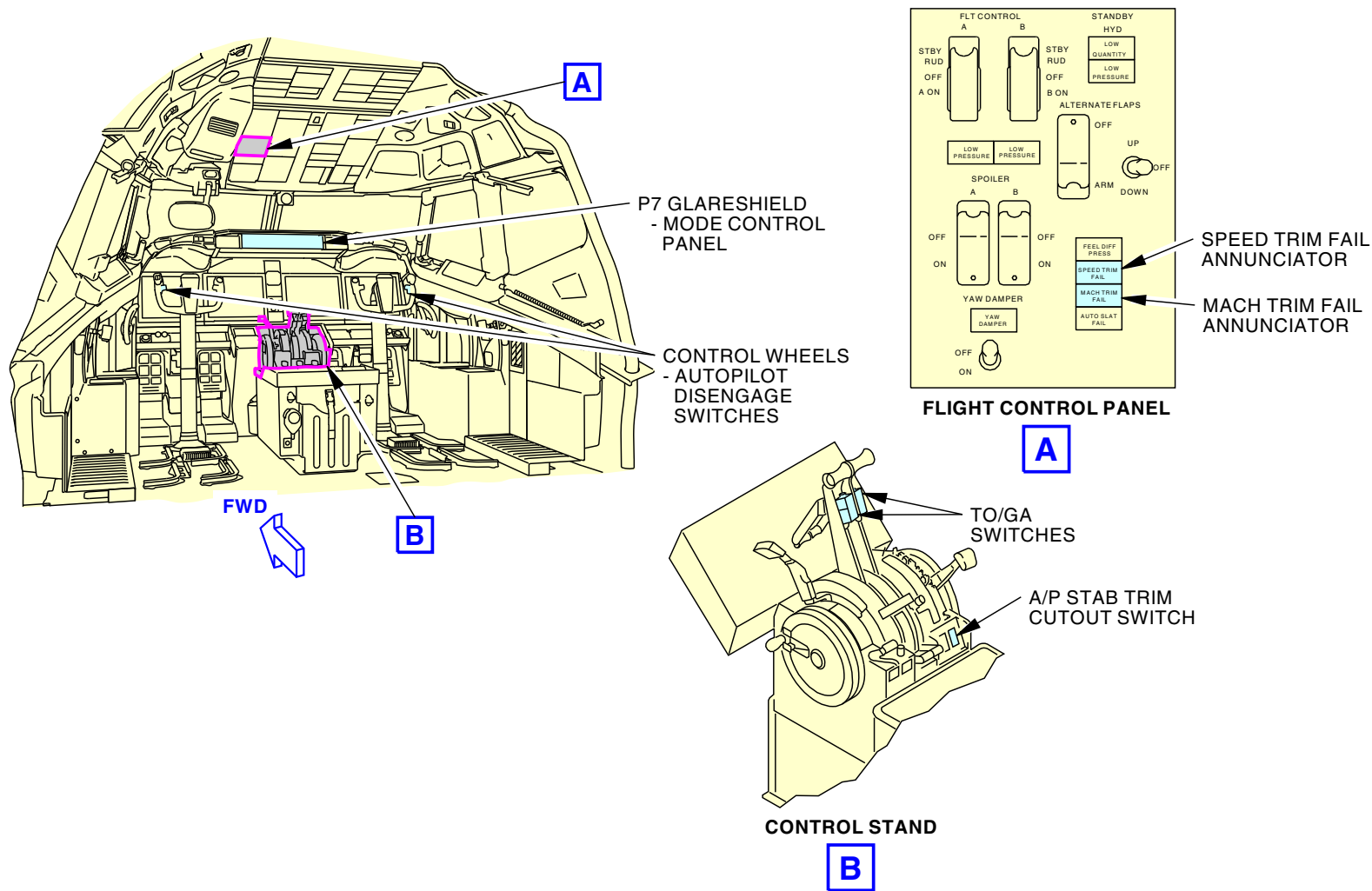
Control Stand

The captain and first officer takeoff/go-around (TO/GA) switches are on the thrust levers. The thrust levers are on the control stand.

The autopilot (A/P) stab trim cutout switch has interface with the DFCS. It is on the control stand.

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DFCS - FLIGHT COMPARTMENT COMPONENT LOCATION



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DFCS - FLIGHT COMPARTMENT COMPONENT LOCATION

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DFCS - INSTRUMENT PANEL COMPONENT LOCATIONS

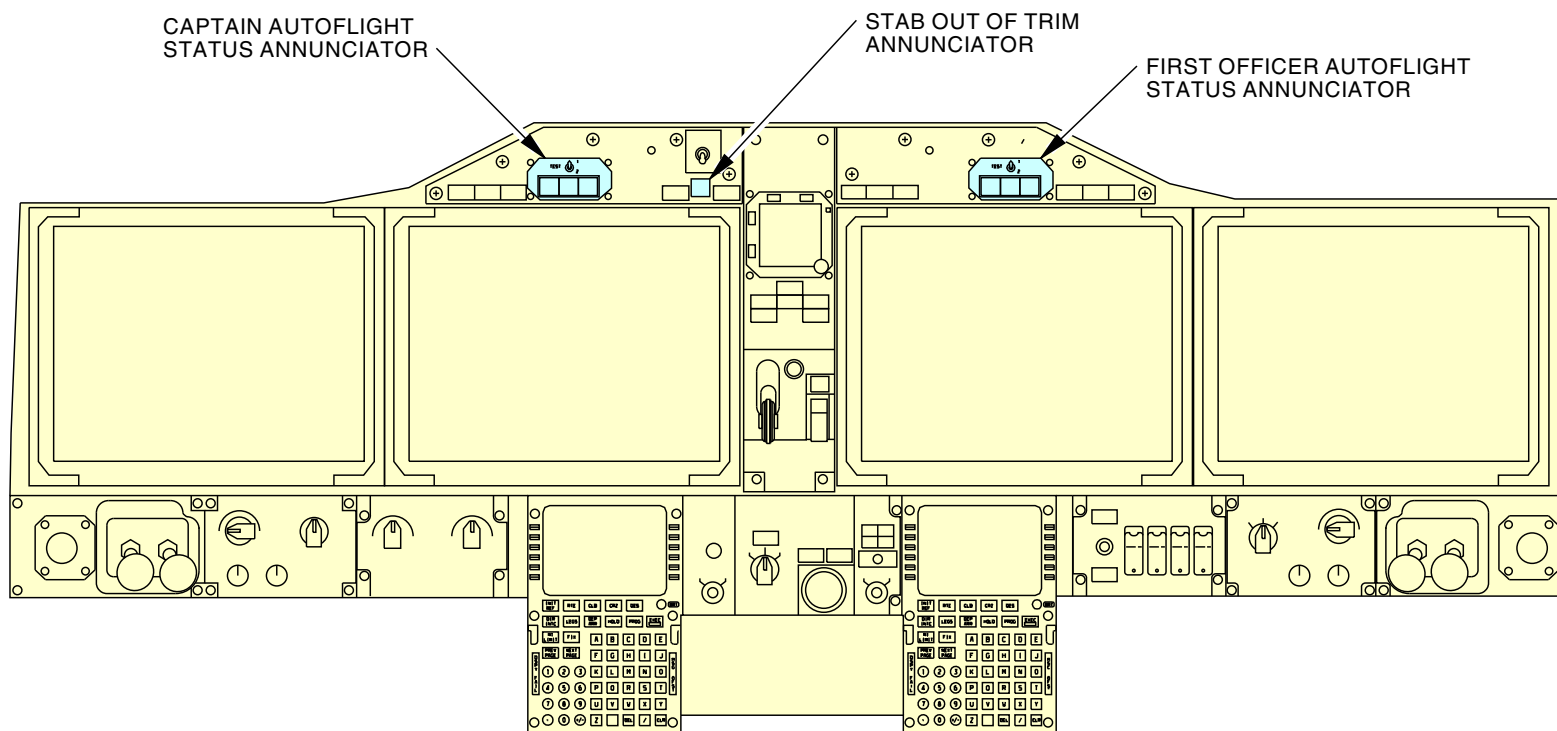
Instrument Panel

The stab out of trim annunciator has interface with the DFCS.

The stab out of trim annunciator and the captain autoflight status annunciator (ASA) are on the P1-3 panel. The first officer ASA is on the P3-1 panel.

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DFCS - INSTRUMENT PANEL COMPONENT LOCATIONS



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DFCS - INSTRUMENT PANEL COMPONENT LOCATIONS

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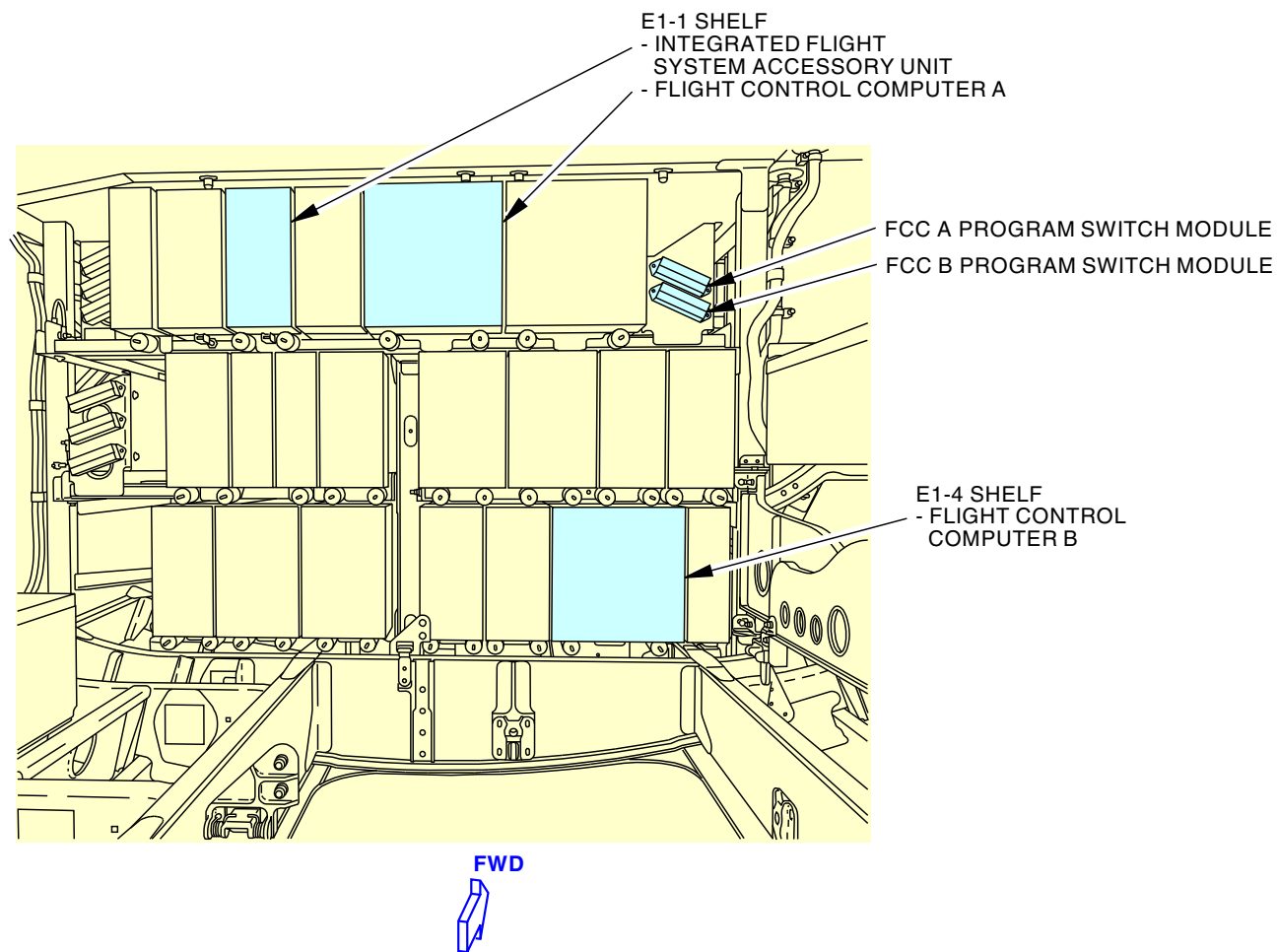
DFCS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATION

E-1 Rack

The integrated flight system accessory unit (IFSAU) is on the E1-1 shelf. The flight control computer (FCC) A is also on the E1-1 shelf. The FCC B is on the E1-4 shelf. The program switch modules for FCC A and FCC B are also on the E1 rack.

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DFCS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATION



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DFCS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATION

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DFCS - TAILCONE COMPONENT LOCATION

Tailcone Component Locations

The autopilot elevator actuators are on the left side of the forward bulkhead of the tail cone.

The elevator position sensor is on the lower right side of the bulkhead in the tail cone.

Stabilizer position sensor B is on the right side of the elevator feel and centering unit. It shows on the graphic. Stabilizer position sensor A is on the left side of the elevator feel and centering unit and is not shown.

The mach trim actuator is on top of the elevator feel and centering unit.

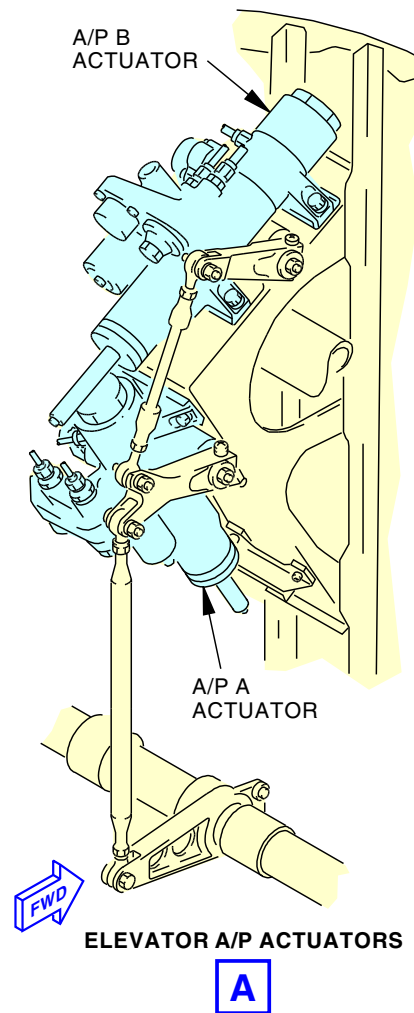
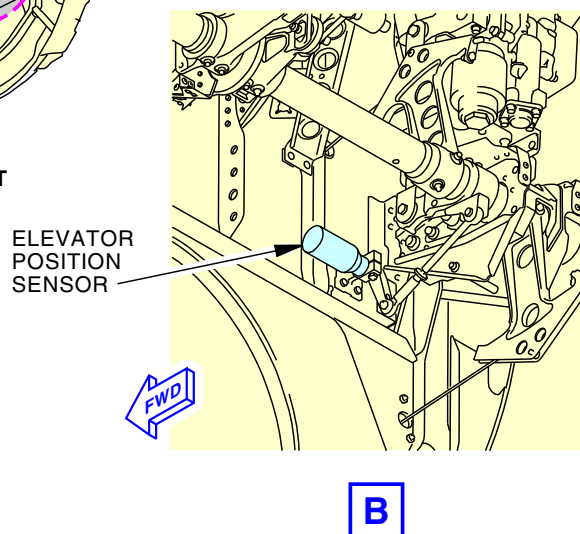
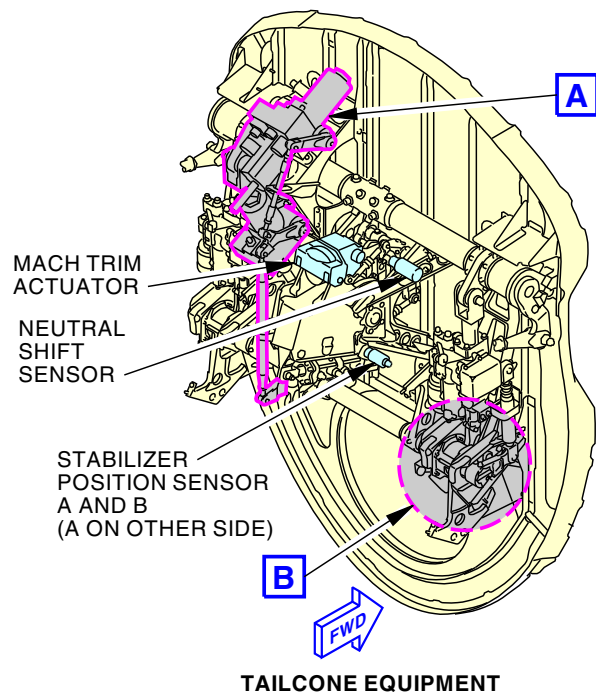
The neutral shift sensor is on the right side of the elevator feel and centering unit.

Training Information Point

When you install the neutral shift sensor, follow the instructions in this caution.

 CAUTION	PUT THE CRANK ARM IN THE CORRECT UP DIRECTION. THE CRANK ARM NOT IN THE CORRECT UP DIRECTION CAN CAUSE DAMAGE TO EQUIPMENT.
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DFCS - TAILCONE COMPONENT LOCATION



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DFCS - TAILCONE COMPONENT LOCATION



DFCS - FORWARD EQUIPMENT COMPARTMENT COMPONENT LOCATIONS

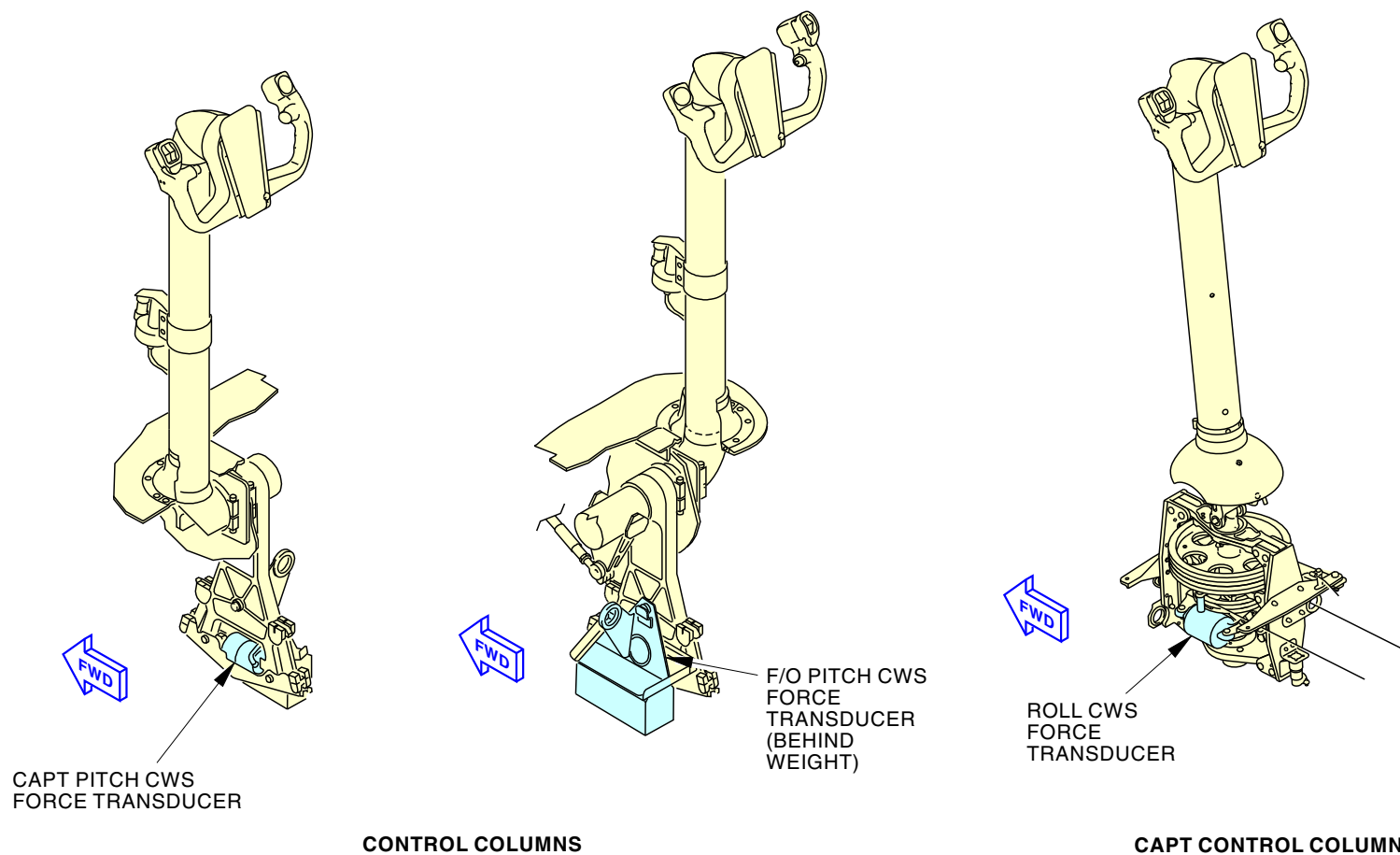
Lower Control Column Component Locations

The captain's and first officer's pitch CWS force transducers are between the support and the forward quadrants on the torque tube. The torque tube is between the captain's and first officer's control column.

The roll CWS force transducer is below the captain's control column.

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DFCS - FORWARD EQUIPMENT COMPARTMENT COMPONENT LOCATIONS



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DFCS - FORWARD EQUIPMENT COMPARTMENT COMPONENT LOCATIONS

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DFCS - WHEEL WELL COMPONENT LOCATIONS

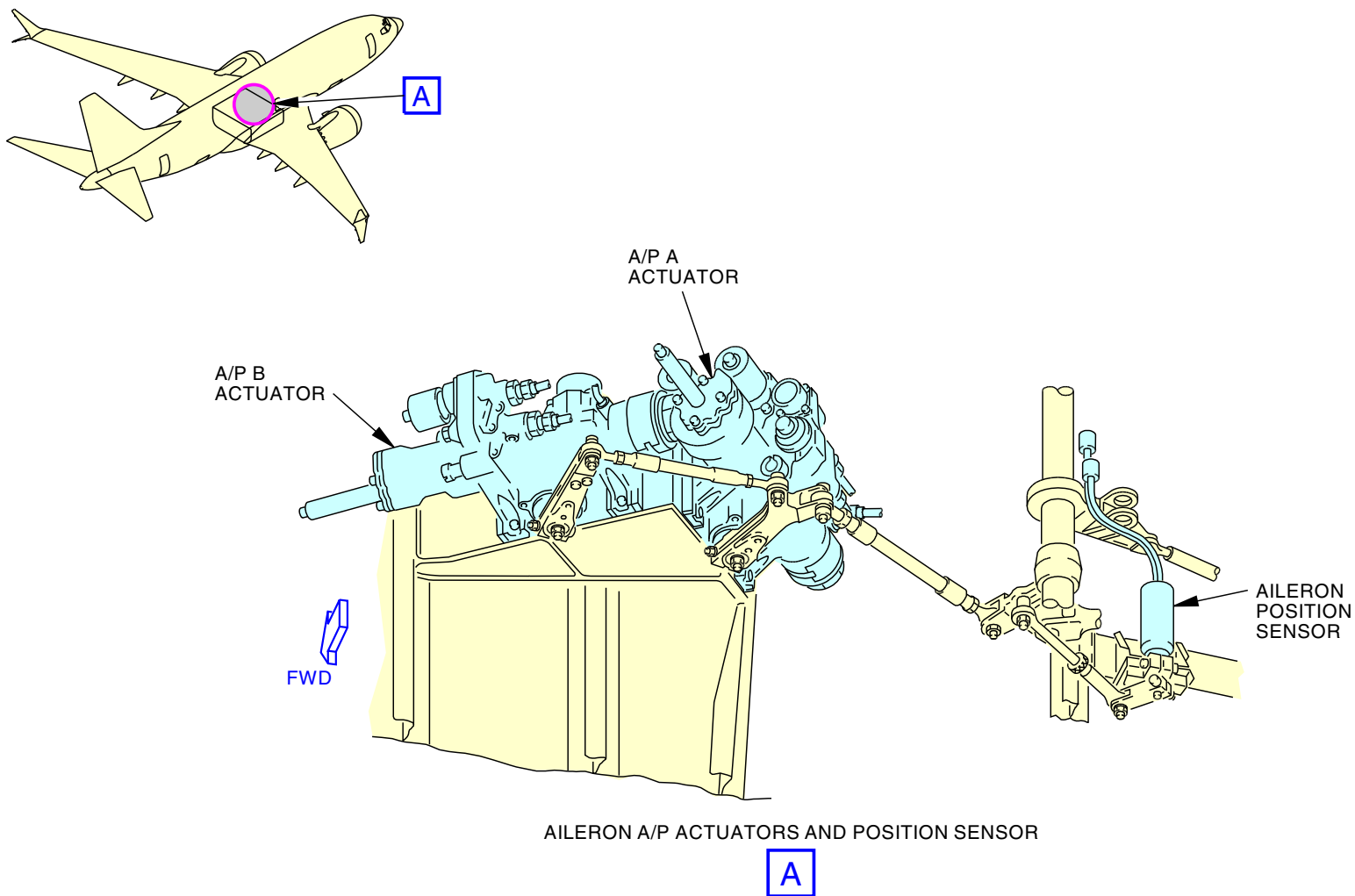
Wheel Well Component Locations

The autopilot aileron actuators for systems A and B are in the main gear wheel well. They are on a support bracket on the left forward wall of the wheel well.

The aileron position sensor is on the forward wall of the main wheel well. It is between the autopilot aileron actuators and the aileron power control units (PCUs).

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DFCS - WHEEL WELL COMPONENT LOCATIONS



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DFCS - WHEEL WELL COMPONENT LOCATIONS

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DFCS - VERTICAL FIN COMPONENT LOCATION

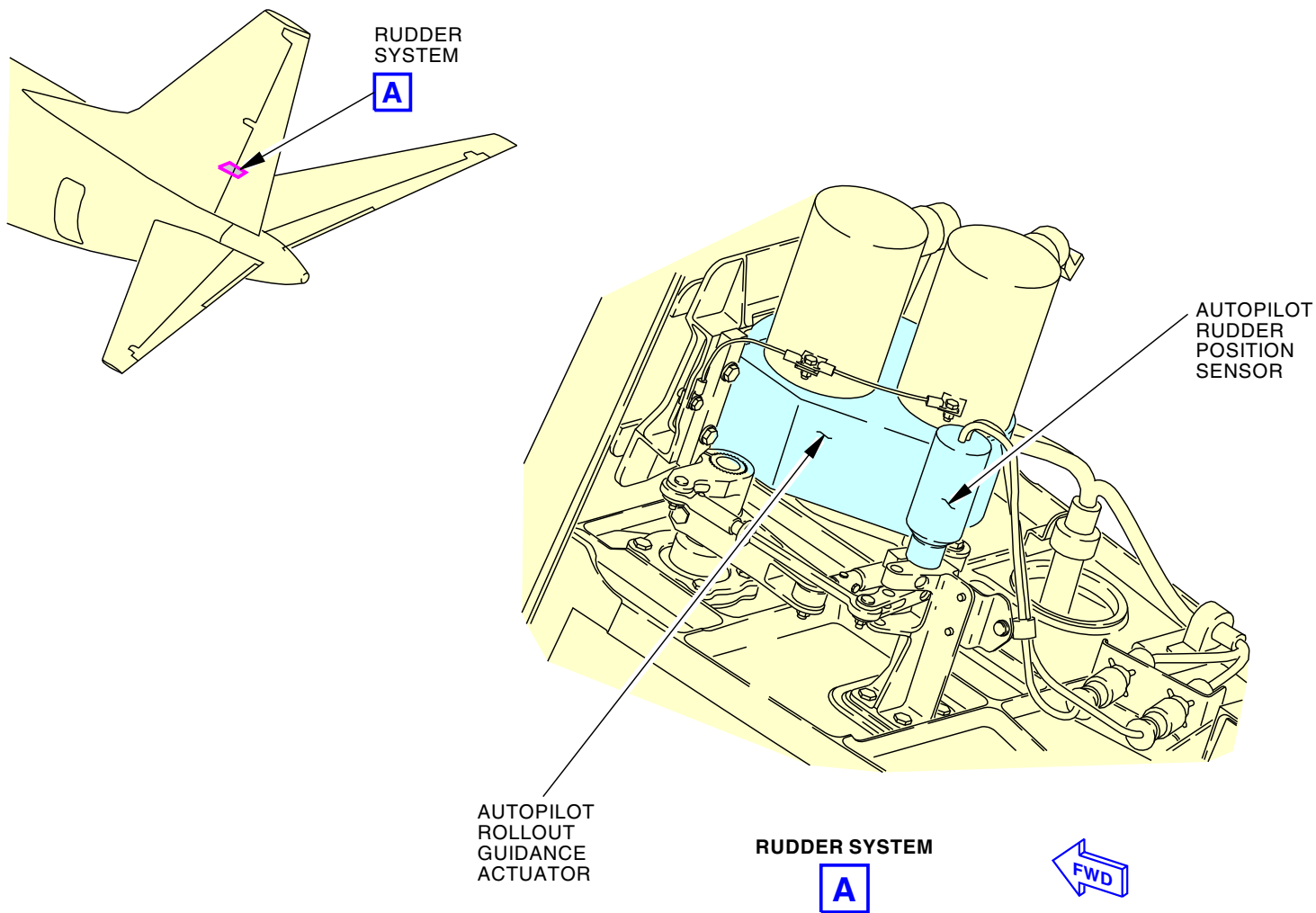
Vertical Component Locations

The rudder rollout guidance actuator is in the vertical fin. It is mounted on a bracket on the vertical fin rear spar.

The autopilot rudder position sensor is mounted aft of the rear spar.

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DFCS - VERTICAL FIN COMPONENT LOCATION



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DFCS - VERTICAL FIN COMPONENT LOCATIONS

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**DFCS - POWER INTERFACE INTRODUCTION****General**

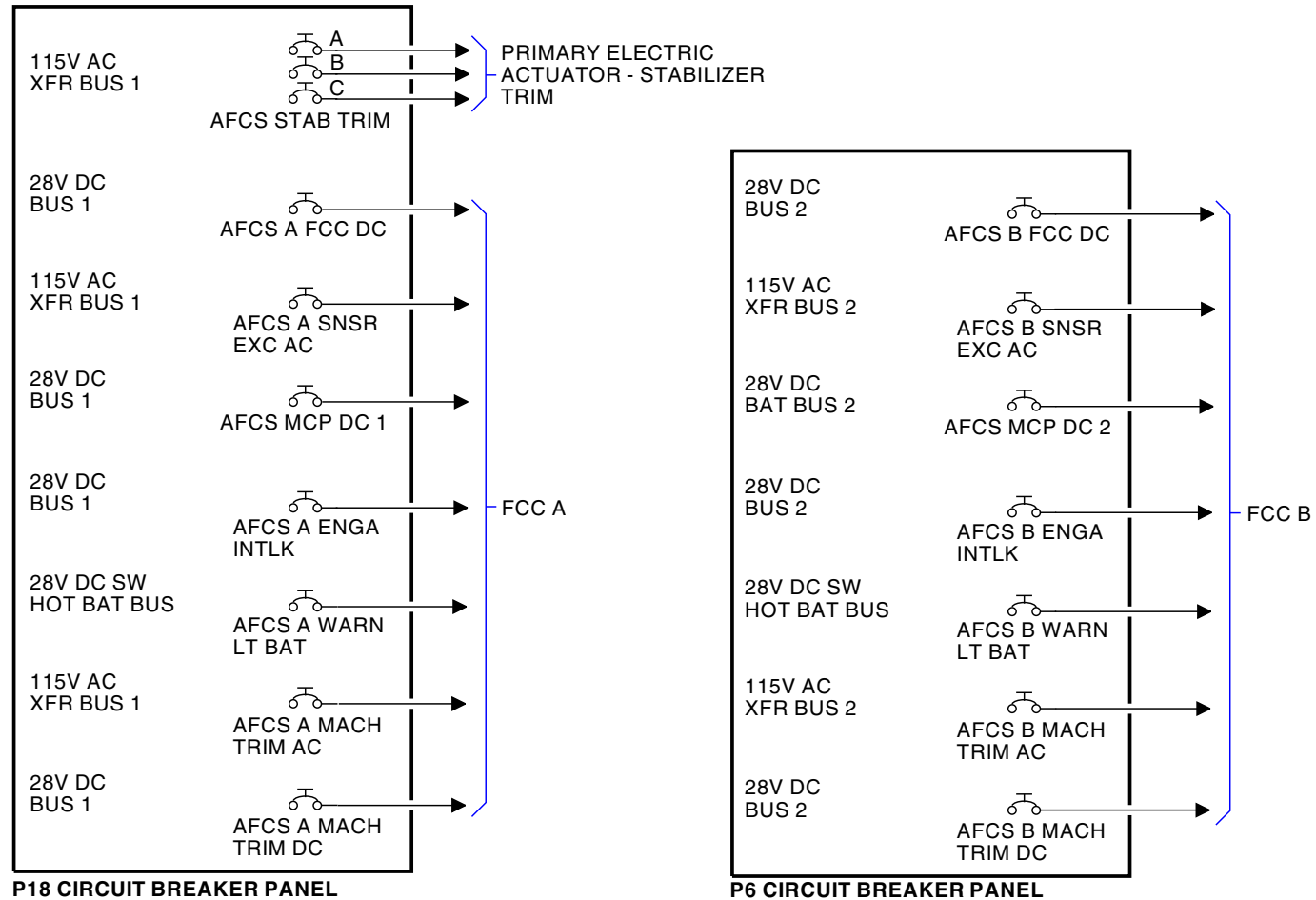
There are several circuit breakers that supply power to the flight control computers (FCC). Much of the power goes through other switches and circuits before the FCCs.

DC Power Interruptions and Voltage Transients

If the 28 VDC power interruption is less than 40 msec, there will be no changes in the mode or output of the DFCS. If the interruption is more than 40 msec, but less than 7 seconds, the autopilot will disengage but other functions (F/D modes, trim functions, and warnings) will continue. If the interruption is more than 7 seconds, the DFCS will initialize to its initial power setup.

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DFCS - POWER INTERFACE INTRODUCTION



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DFCS - POWER INTERFACE INTRODUCTION

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**DFCS - POWER INTERFACE****Stabilizer Trim Electric Actuator Power**

The 115v AC transfer bus 1 supplies three phase AC power to the stabilizer trim electric actuator.

FCC Power

The 28V DC buses 1 and 2 supply power to their onside flight control computers (FCC). The 115V AC transfer buses 1 and 2 supply power to the integrated flight system accessory unit (IFSAU).

The IFSAU uses transformers to change each 115V AC to a 26V AC sensor excitation power supply. The IFSAU supplies this power to the onside FCC as a reference voltage for the CWS force transducers and flap position transmitters.

Mode Control Panel (MCP) Power

The 28V DC buses 1 and 2 supply power to the MCP.

Sensor Excitation Power

The IFSAU supplies excitation power to these sensors:

- Captain pitch control wheel steering (CWS) force transducer
- First officer pitch CWS force transducer
- Roll CWS force transducer
- Right flap position transmitter
- Left flap position transmitter.

The CWS force transducers get excitation power from both 26V AC transformers. The flap position sensors only get 26V AC power from their onside transformer.

On Ground Signal

If the airplane is on the ground, the proximity switch electronics unit (PSEU) sends the 28V DC on ground signal to the FCCs. The FCCs use this signal to find if the airplane is on the ground or in the air.

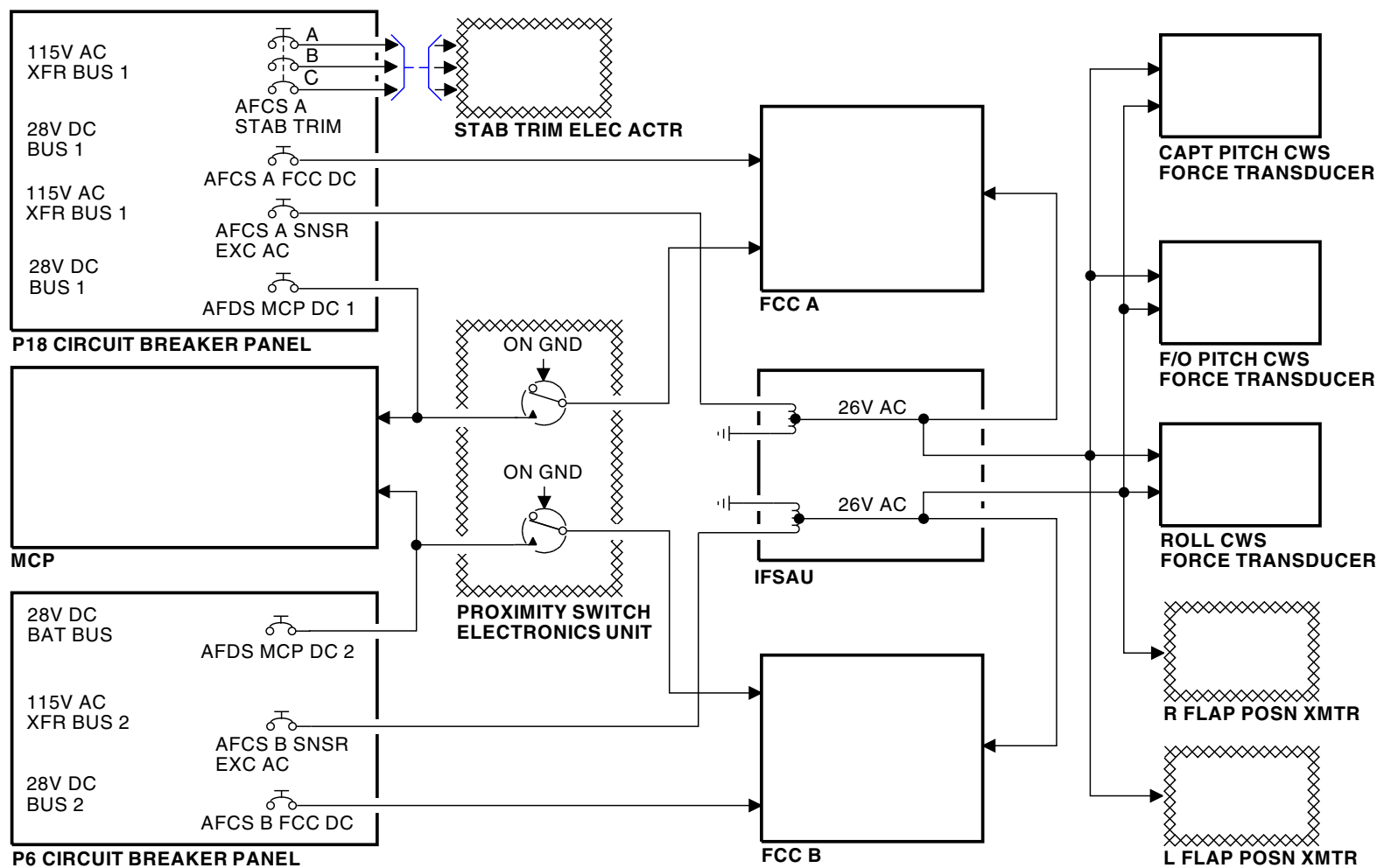
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DFCS - POWER INTERFACE



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DFCS - POWER INTERFACE

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**DFCS - SENSOR AND ACTUATOR EXCITATION POWER****Autopilot Actuator Excitation Power**

The FCCs supply 14V AC, 1800 Hz pitch and roll excitation power to the autopilot actuators. Each aileron and elevator autopilot actuator gets excitation power from its inside FCC.

Sensor Excitation Power

The FCCs supply roll excitation power to the aileron position sensor.

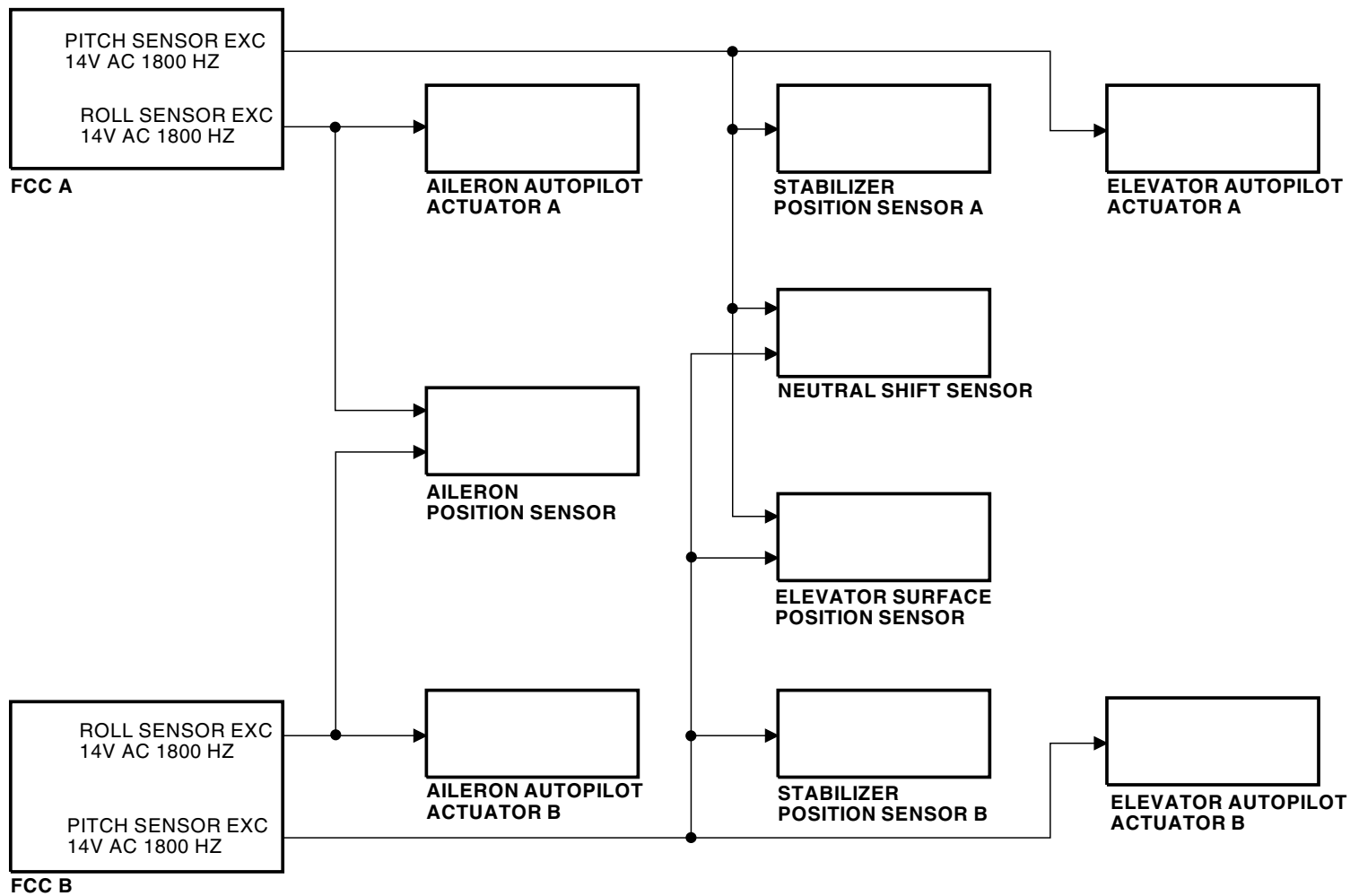
The FCCs supply pitch excitation power to these sensors:

- Neutral shift sensor
- Elevator surface position sensor

The stabilizer position sensor A gets pitch excitation power from FCC A. The stabilizer position sensor B gets pitch excitation power from FCC B.

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DFCS - SENSOR AND ACTUATOR EXCITATION POWER



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**DFCS - SYSTEM INTERLOCK POWER INTERFACE-1****General**

The FCCs monitor signals from these components to determine if they can engage the autopilots (A/Ps):

- Hydraulic pressure switches on the aileron and elevator A/P actuators A and B
- Auto speed brake module
- Capt A/P disengage switch.

Power

The 28V DC buses 1 and 2 send engage interlock power to these components:

- Hydraulic pressure switches on the aileron and elevator A/P actuators A and B
- Auto speed brake module
- F/O A/P disengage switch
- Radio Altimeter (R/A) < 10 feet relays A and B
- FCC A and B.

Hydraulic Pressure Switches

Each A/P actuator has a hydraulic pressure switch. When the hydraulic pressure is high, the switches close and send 28V DC to the FCCs. The switch must be open to show no pressure to engage the autopilot. The switch must close within 3.5 seconds to show the actuator has hydraulic pressure to keep the autopilot engaged.

Auto Speed Brake Module

When the wheels spin up during landing and the speed is more than 60 knots, the auto speed brake module sends 28V DC to the FCCs. The FCCs use this signal to disengage the autopilot if go-around is started after the airplane touches down.

A/P Disengage Switches

Normally, 28V DC goes through both A/P disengage switches to the FCCs. If either the captain or the first officer pushes the A/P disengage switch, 28V DC does not go to the FCCs. This will disengage the autopilots or remove the disengage warning if the autopilots are disengaged.

Speed Brake Deployment Signal

When the FCC calculates that the radio altitude is less than 10 feet, it sends a ground to the R/A < 10 FT relay. This relay is an input to the speed brake deployment circuit.

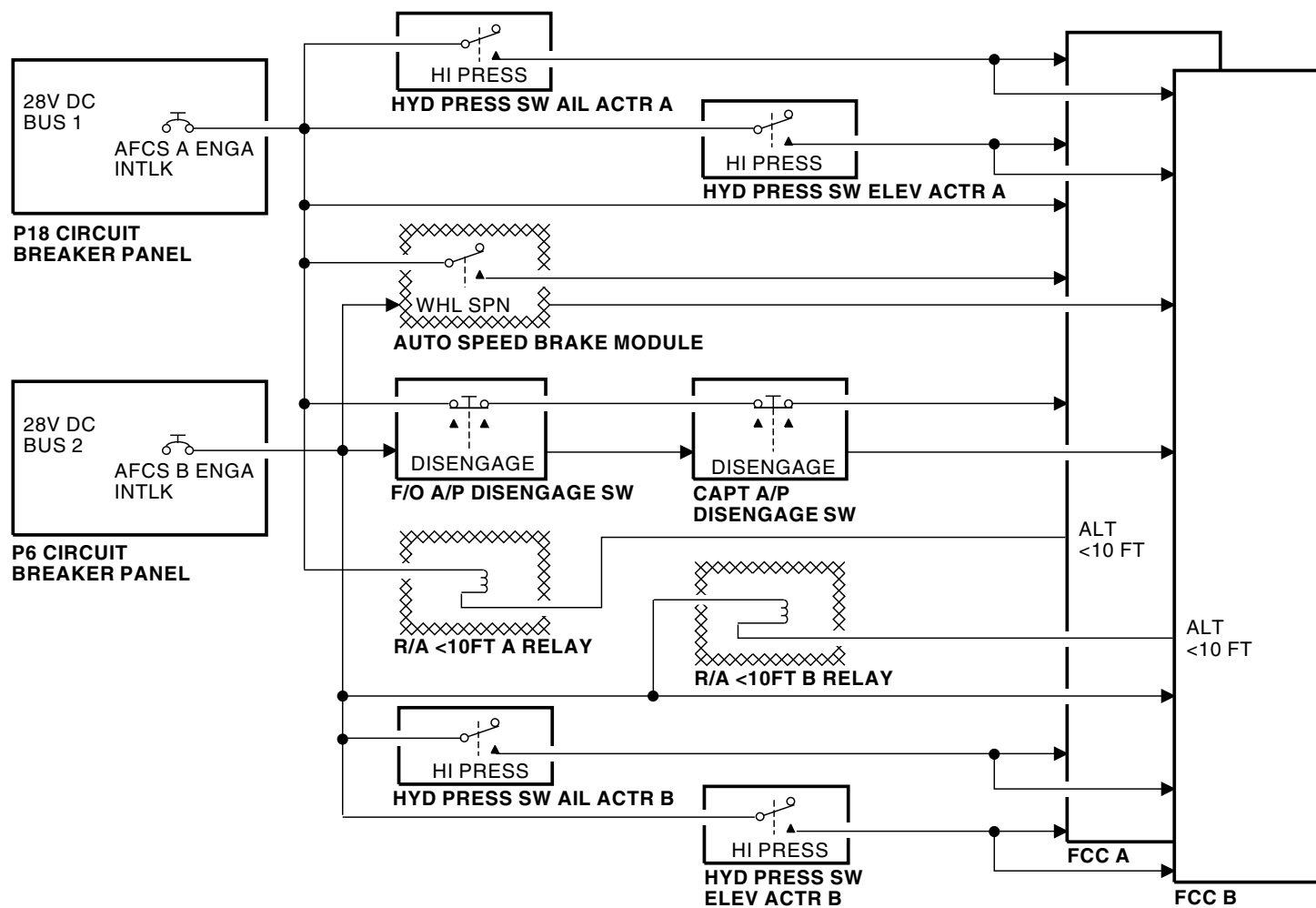
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DFCS - SYSTEM INTERLOCK POWER INTERFACE-1



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DFCS - SYSTEM INTERLOCK POWER INTERFACE-1

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**DFCS - SYSTEM INTERLOCK POWER INTERFACE-2****General**

These components also get power from the engage interlock circuit breakers:

- MCP
- Annunciator and dim module.

The IFSAU gets 28V DC power from the AFCS INTLK 2 circuit breaker.

IFSAU

The IFSAU has isolation diodes that let the engage interlock power go to these components:

- Main electric stabilizer trim relay
- Autopilot stabilizer trim cutout relay.

Main Electric Stabilizer Trim Relay

When the trim relay is in the off position, the AFCS engage interlock power goes to the FCCs. This signal tells the FCC that the manual electric trim is not operating. When the manual electric trim switches operate, the relay goes to the trim position and the power does not go to the FCCs. This causes the autopilot to disengage.

Autopilot Stabilizer Trim Cutout Relay

When the cutout relay is in the normal position, the AFCS engage interlock power goes to the FCCs. This lets the autopilot engage. If the relay is in the cutout position, the power does not go to the FCCs and the autopilot cannot engage.

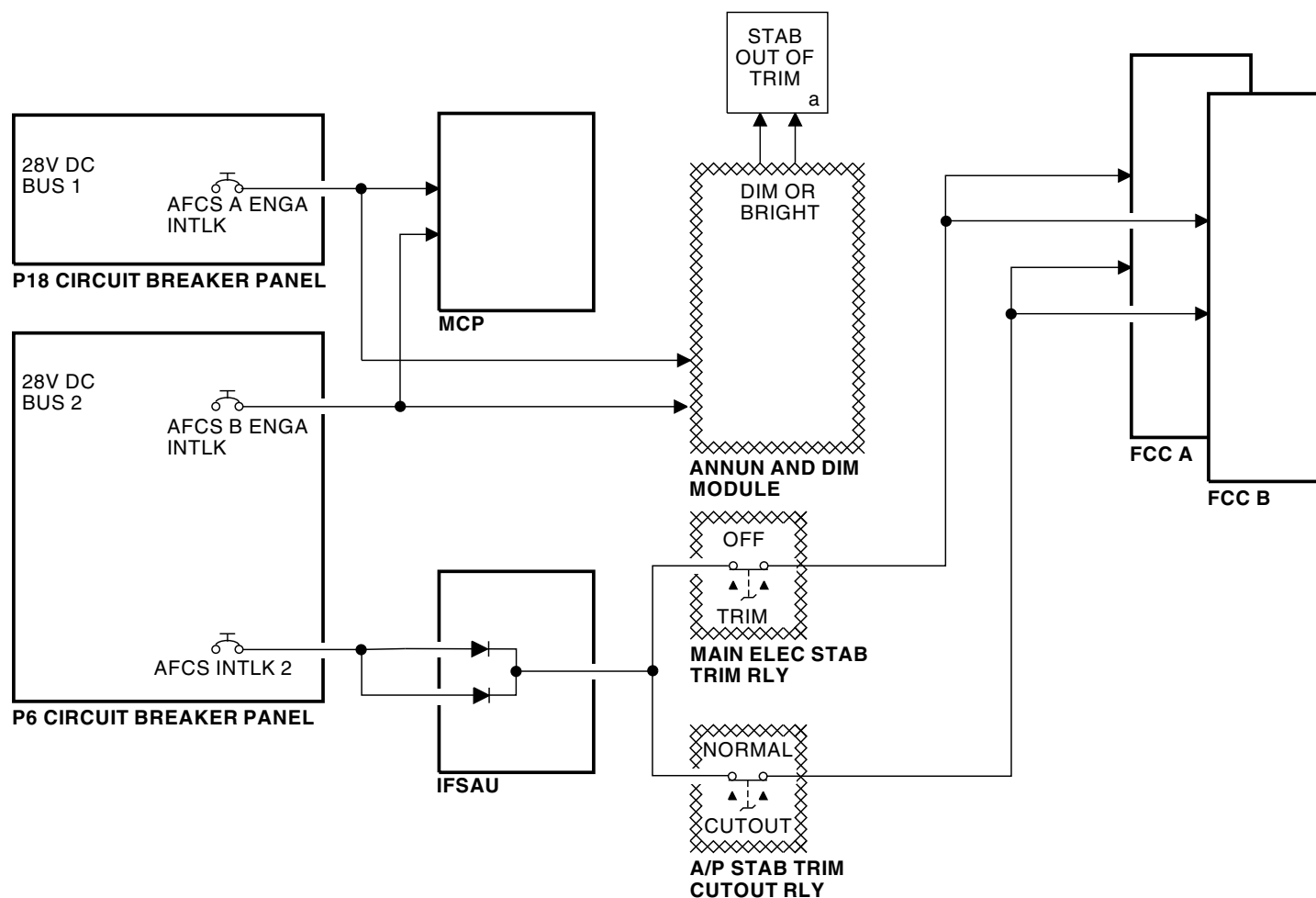
Annunciator and Dim Module

The annunciator and dim module uses the AFCS engage interlock power for the stab out of trim annunciator light.

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DFCS - SYSTEM INTERLOCK POWER INTERFACE-2



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DFCS - SYSTEM INTERLOCK POWER INTERFACE-2

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DFCS - ANNUNCIATION AND WARNING POWER INTERFACE

General

These components have an interface with the FCC annunciation and warning circuits:

- Capt and F/O A/P disengage switches
- IFSAU
- MCP
- FCC A and B
- Capt and F/O autoflight status annunciators (ASA)
- Aural warning module
- Flight data acquisition unit (FDAU)
- A/T computer
- Remote electronics unit (REU).

Power

The 28V DC switched hot battery bus supplies power for the autopilot warning circuits. The circuit breaker for the A system supplies power to these components:

- FCC A
- Capt and F/O A/P disengage switches
- IFSAU
- Capt ASA.

The circuit breaker for the B system supplies power to these components:

- FCC B
- IFSAU
- F/O ASA.

A/P Disengage Switches

When you push the A/P disengage switch once, the switch stops 28V DC power from going to these components:

- FCC A
- FCC B
- MCP.

This signal disengages the active autopilot.

When you push the A/P disengage switch a second time, the switch stops the disengage aural warning. It also turns off the A/P red flashing warning light on the ASAs.

IFSAU

The power from the two circuit breakers go to the IFSAU where it goes through isolation diodes to give 28V DC power to the MCP.

FCC

The FCC A sends an airspeed warning signal to the capt ASA to cause the amber A/T light to flash. FCC B sends an airspeed warning signal to the F/O ASA to cause the amber A/T light to flash. This signal occurs if the FCC finds that the A/T system cannot hold the airspeed.

The two FCCs send an altitude alert aural warning signal to the REU. This gives the alert tone in the headsets and the speakers.

The FCCs send an A/P warning signal to the capt and F/O ASAs and to the FDAU to turn the red A/P lights on steady. This signal occurs if any of these conditions are present:

- The two FCCs are not compatible
- The DFCS is in BITE
- The stab trim warning is active and the FCC is in dual approach below 800 feet.

**DFCS - ANNUNCIATION AND WARNING POWER INTERFACE****MCP**

The MCP sends an A/P warning signal to the capt and F/O ASAs to turn the flashing red A/P lights on when the A/P disconnects. It sends an A/P warning signal to both ASAs to turn the steady red A/P lights on when these conditions occur:

- An FCC fails the power up test on the ground
- During A/P go-around the FCC cannot acquire the MCP altitude
- The MCP bus fails during A/P pitch go-around.

The MCP also sends the A/P warning signal to the FDAU. The MCP sends an A/P horn signal to the aural warning module to give the A/P disconnect aural warning.

Autoflight Status Annunciators

When you push the A/P light on either ASA, it sends an autopilot (A/P) warning reset signal to both FCCs and to the MCP. When you push the A/T light on either ASA, it sends an autothrottle (A/T) warning reset signal to the FCCs and to the A/T computer.

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The diagram illustrates the A/P Warning System architecture. It features two main power distribution panels: P18 (top left) and P6 (bottom left). P18 is connected to a 28V DC SW HOT BAT BUS and provides power to AFCS A WARN LT BAT, A/P WARNING RESET (CAPT A/P DISENGAGE SW), and FCC A. P6 is also connected to a 28V DC SW HOT BAT BUS and provides power to AFCS B WARN LT BAT, A/P WARNING RESET (F/O A/P DISENGAGE SW), and FCC B. The central MODE CONTROL PANEL contains a POWER SUPPLY and A/P WARN A/P HORN. FCC A and FCC B manage the warning logic, including AIRSPEED WARN ANNUN, ALT ALERT AURAL WARN, and A/P WARN signals. These signals are processed by A/T and A/P computers, which then trigger the AURAL WARN MODULE and FDAU (REU). The system also includes A/T and A/P AUTOFLIGHT STATUS ANNUNCIATORS and various reset buttons for A/P and A/T warnings.

DFCS - ANNUNCIATION AND WARNING POWER INTERFACE

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**DFCS - POWER TRANSFER INTERFACE****General**

During a dual channel operation, each FCC must be on an isolated power source. FCC A gets dc power from DC bus 1 and FCC B gets dc power from DC bus 2. Normally, the two dc buses are connected with the bus tie relay. If either FCC is in the active G/S mode, it will cause the bus tie relay to open. This will separate the DC power sources to the two FCCs.

These components are part of the circuit that controls the bus tie relay:

- FCC A and B
- Bus power control unit
- IFSAU
- Standby power control unit.

Power

The hot battery bus supplies 28V DC power to one side of the bus tie relay.

FCC

When either FCC A or FCC B is in the active G/S mode, it sends a DC bus isolation signal to the IFSAU. This signal engages a relay to the G/S engage position.

Standby Power Control Unit

When power is normal, the tie close signal energizes an electronic switch. This switch supplies a ground to the IFSAU.

IFSAU

When the IFSAU relay is in the G/S not engaged position, the ground from the bus transfer switch goes to the bus tie relay. If a G/S engaged signal comes from an FCC, the IFSAU relay goes to the G/S engaged position and the ground goes away from the bus tie relay.

Bus Tie Relay

When a ground comes from the IFSAU, the relay closes. This connects the two 28V DC buses together. If there is no ground from the IFSAU, the relay is not energized. Therefore, the two 28V DC buses are isolated.

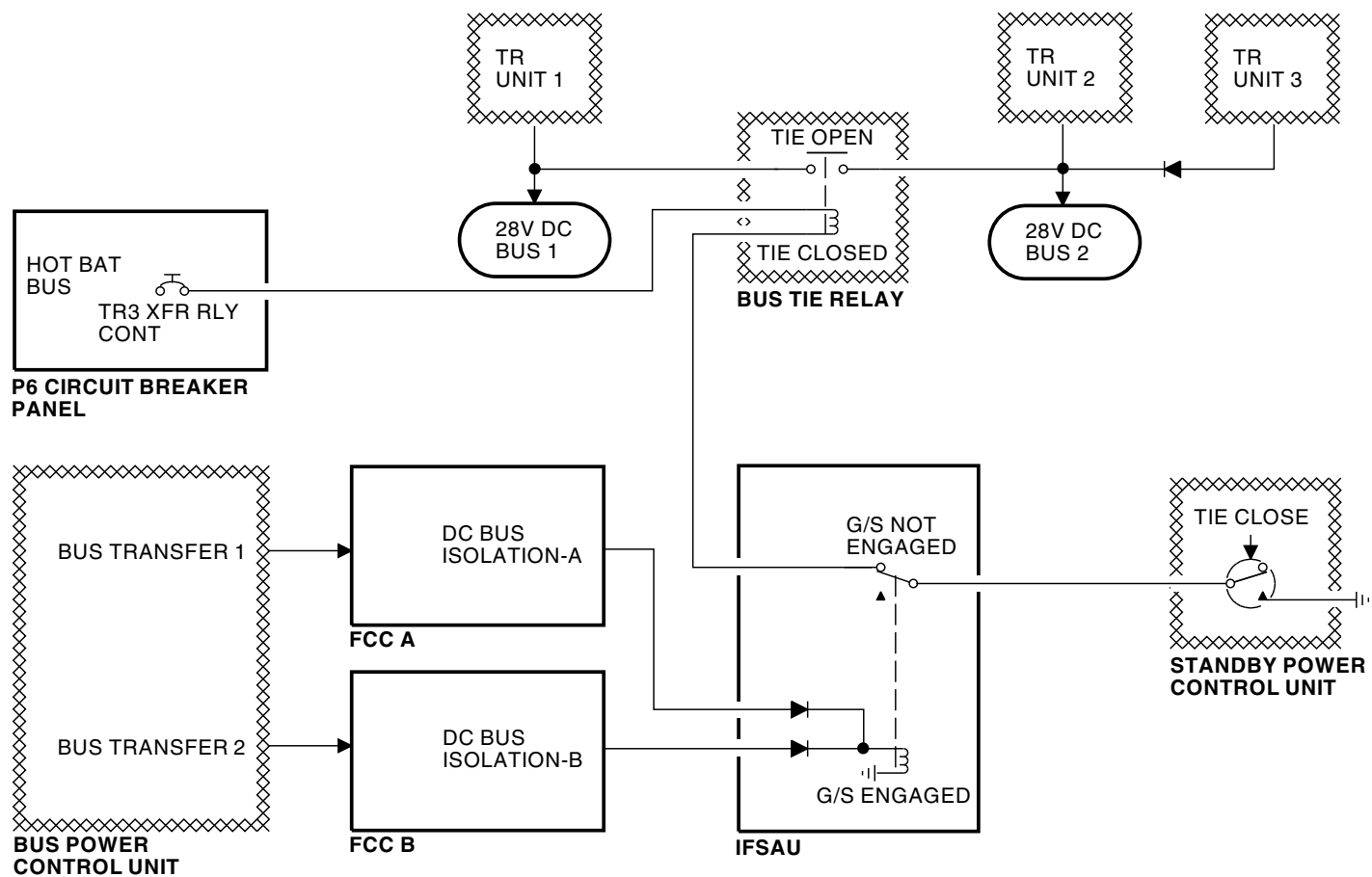
Bus Power Control Unit

Normally the transformer rectifier (TR) units get their power from different 115V AC generator buses. If a transfer occurs so that the TRs get their power from the same generator, the 28V DC buses are not isolated. The bus power control unit knows this transfer has occurred and inhibits the bus transfer (autoland) signal to each FCC. This tells the FCCs that the DC buses cannot be isolated so the dual autopilot mode is not allowed.

The BPCU sends each FCC a bus transfer (autoland) signal when one of the following is true:

- The external power contactor (EPC) and the onside bus tie breaker (BTB) is closed
- The aux power breaker (APB) and the onside BTB is closed
- Or the onside generator control breaker (GCB) is closed.

DFCS - POWER TRANSFER INTERFACE



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DFCS - POWER TRANSFER INTERFACE

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**DFCS - FLIGHT CONTROL COMPUTER DIGITAL INPUT INTERFACE-1****General**

These components send digital data to the FCCs:

- MMR 1 and 2
- VOR/MB 1 and VOR 2
- DME 1 and 2.

MMR

The FCCs receive digital data from MMR receivers 1 and 2. The MMR receivers send ILS localizer and glideslope deviation data to the FCCs to calculate the roll and pitch commands during the approach mode. The FCCs use localizer deviation data to calculate the roll commands during a localizer only approach.

VOR/MB

FCC A receives digital data from the VOR/MB 1 receiver. FCC B receives digital data from the VOR/MB 2 receiver. The VOR receivers send VOR frequency and VOR omnibearing data to the FCCs. The FCC uses this data to capture and track a VOR course during the VOR mode.

DME

FCC A receives digital data from the DME 1 interrogator. FCC B receives digital data from the DME 2 interrogator. The DME interrogators send DME frequency and DME distance data to the FCCs. The FCCs use the DME frequency to identify the correct channel and then use the DME distance sent directly after the correct frequency. The FCCs use DME distance to calculate a capture point for the VOR course and to determine if the airplane is over the VOR station.

If DME data is not available, the FCCs will use VOR data to do the same calculations.

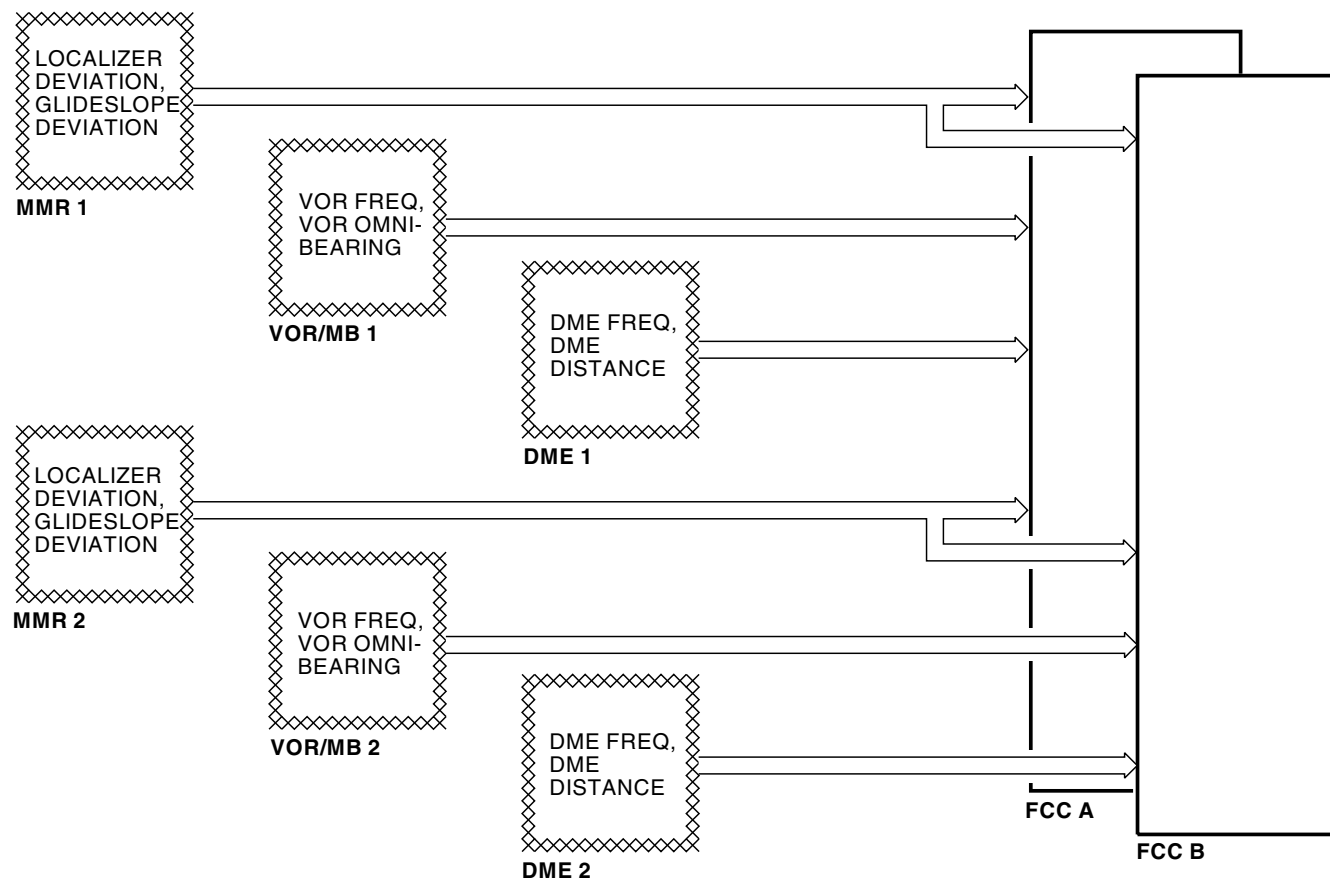
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DFCS - FLIGHT CONTROL COMPUTER DIGITAL INPUT INTERFACE-1



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**DFCS - FLIGHT CONTROL COMPUTER DIGITAL INPUT INTERFACE-2****General**

These components also send digital data to the FCCs:

- Flight management computers (FMC) 1 and 2
- Radio altimeters (RA) 1 and 2
- Stall management yaw damper (SMYD) 1 and 2.

FMC

If the FMCS transfer relays are in the BOTH ON L positions, FMC 1 sends digital data to FCC A and B. If the FMCS transfer relays are in the BOTH ON R positions, FMC 2 sends digital data to FCC A and B. If the FMCS transfer relays are in the NORMAL positions, FMC 1 sends digital data to FCC A and FMC 2 sends digital data to FCC B. The FMC sends this data to the FCCs:

- FMC target altitude to calculate VNAV commands
- FMC target airspeed to calculate VNAV commands
- FMC target mach to calculate VNAV commands
- Vertical speed command to calculate VNAV commands
- Greenwich mean time and date to record time of faults in BITE
- Horizontal command signal to calculate LNAV commands
- Flight number to record inflight faults in BITE
- FMC discrete data to control the DFCS and A/T in VNAV and LNAV
- BITE test word for BITE information.

RA

RA 1 sends radio altitude data to FCC A. RA 2 sends radio altitude to FCC B. The FCCs use radio altitude to calculate these:

- Localizer gains
- Glideslope gains
- Air/ground discrete
- A/T command during flare
- Altitude trip points

- When you can engage the A/P.

SMYD

SMYD 1 sends this data to FCC A:

- Flap angle to compare with flap position data from the flap position transmitter
- Stick shaker AOA to help calculate the F/D TO/GA command
- FC minimum operating speed to calculate the alpha floor speed
- SMYD discrete data to show when a stall warning occurs.

SMYD 2 sends the same data to FCC B.

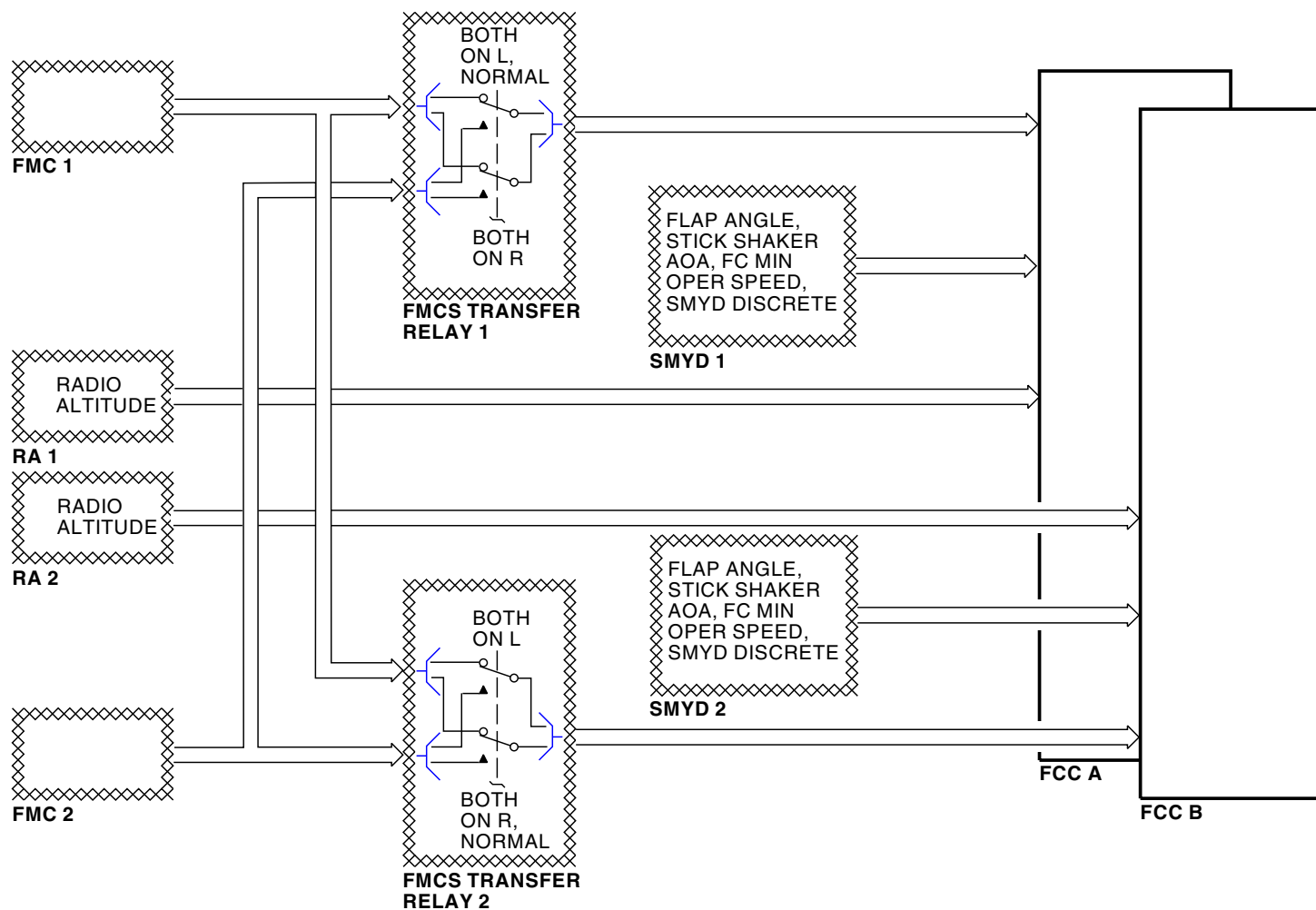
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DFCS - FLIGHT CONTROL COMPUTER DIGITAL INPUT INTERFACE-2



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**DFCS - FLIGHT CONTROL COMPUTER DIGITAL INPUT INTERFACE-3****General**

These components also send digital data to the FCCs:

- Autothrottle (A/T) function in FCC A
- The display processing computer (DPC) 1 and 2
- Left and right air data inertial reference units (ADIRU).

FCC-A Autothrottle Function

The autothrottle function in FCC A sends A/T discrete digital data to both FCCs. The FCCs use this data to determine the mode the A/T is in and to which modes it will allow a change.

DPC

The DPCs send the engine N1 signal data to the FCCs to calculate the speed trim fade-out gain and the maximum alpha angle for go-around. The DPC also send discrete data to the FCCs to tell the FCCs which DPC sends data to which display unit.

ADIRU

Each ADIRU sends these air data reference (ADR) signals to its inside FCC:

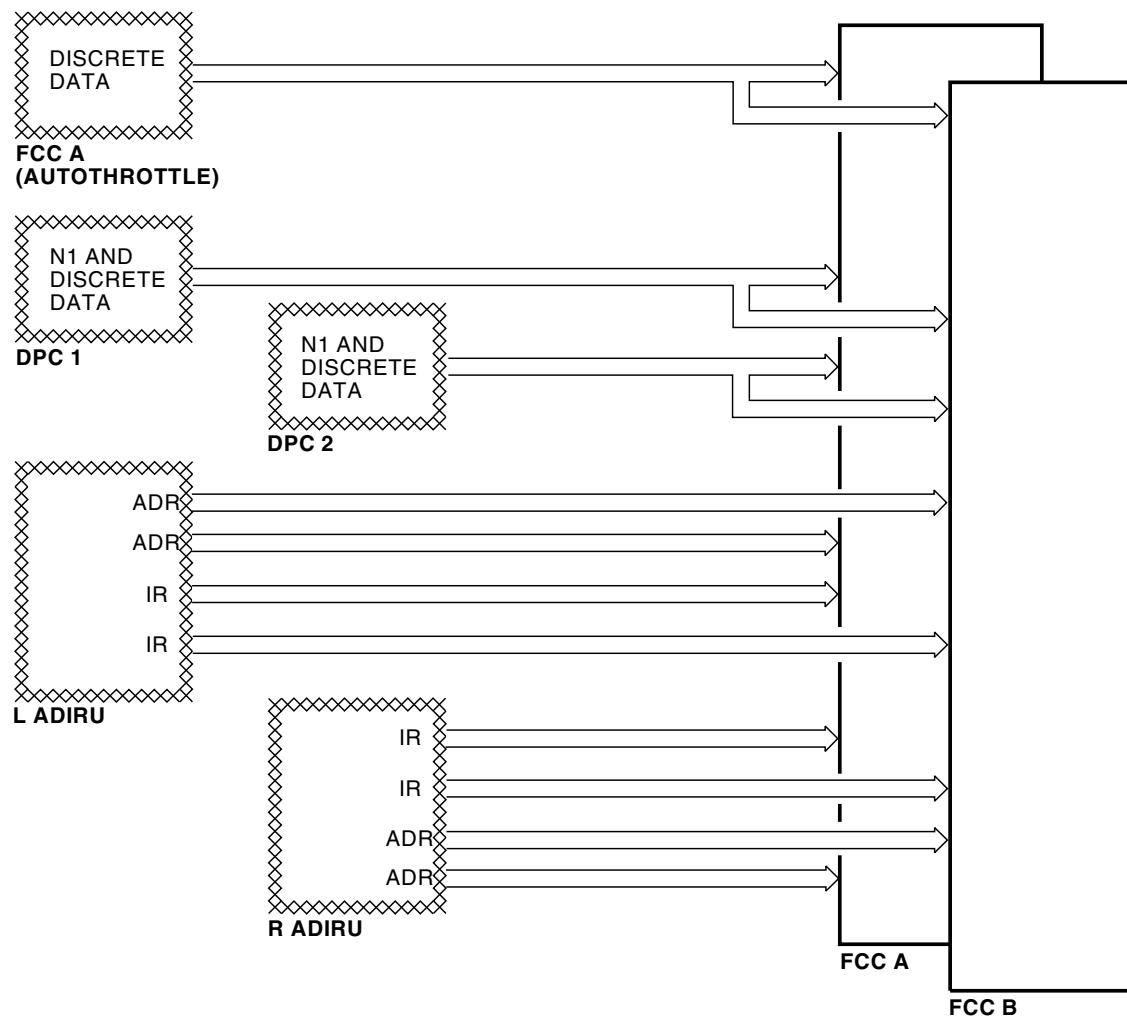
- Uncorrected altitude
- Baro corrected altitude number 1
- Baro corrected altitude number 2
- Mach
- Computed airspeed
- Maximum allowable airspeed (VMO/MMO)
- True airspeed
- Static pressure
- Total pressure
- Indicated angle of attack.

Each ADIRU sends these inertial reference (IR) signals to the two FCCs:

- Ground speed
- True track angle
- True heading
- Magnetic track angle
- Magnetic heading
- Flight path acceleration
- Pitch angle
- Roll angle
- Body longitudinal acceleration
- Body lateral acceleration
- Pitch attitude rate
- Roll attitude rate
- Inertial altitude
- Vertical acceleration
- Inertial vertical speed.

The FCCs use the ADIRU data to calculate many different commands. To see what DFCS functions use the ADIRU data, look at the functional description pages for the autopilot, flight director, speed trim system, mach trim, altitude alert, and autothrottle.

DFCS - FLIGHT CONTROL COMPUTER DIGITAL INPUT INTERFACE-3



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DFCS - FLIGHT CONTROL COMPUTER DIGITAL INPUT INTERFACE-3

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**DFCS - FLIGHT CONTROL COMPUTER DIGITAL OUTPUT INTERFACE****General**

The FCCs send digital data to these components:

- Mode control Panel (MCP)
- DPCs 1 and 2
- Flight data acquisition unit (FDAU).

Each FCC also sends cross-channel digital data and BITE data to the other FCC. The cross-channel digital data includes several items so the two FCCs can compare and synchronize data. These are some of the items:

- Flight director data
- Dual autopilot synchronization data
- Mode status data.

MCP

Each FCC sends digital data to the MCP. This data includes these parameters:

- Target mach
- Target airspeed
- Selected course number 1
- Selected course number 2
- Selected heading
- Selected altitude
- Selected airspeed
- Selected vertical speed
- Selected mach
- Flap position
- Flight director roll command
- Flight director pitch command
- Airspeed bug drive
- Spoiler 4 position

- Spoiler 9 position
- Flight path angle rate
- AFDS discrete word 1, 2, 3, and 4
- DFCS BITE response.

The MCP uses the data from the master FCC to display in the MCP windows and light the MCP mode select pushbuttons. The MCP also passes the master FCC data to other systems which shows in the next pageset.

DPC

Each FCC sends digital data to the two DPCs. This data includes these parameters:

- Selected course number 1
- Selected course number 2
- Selected heading
- Selected altitude
- Flight director roll command
- Flight director pitch command
- Airspeed bug drive
- AFDS discrete word 2 and 4 to give flight mode annunciation data, altitude alert warnings, and localizer and glideslope deviation warnings.

The DPCs send these data to the display units to show flight director commands and DFCS status to the crew.

FDAU

The FCCs send digital data to the DFDAU to save in the flight recorder.

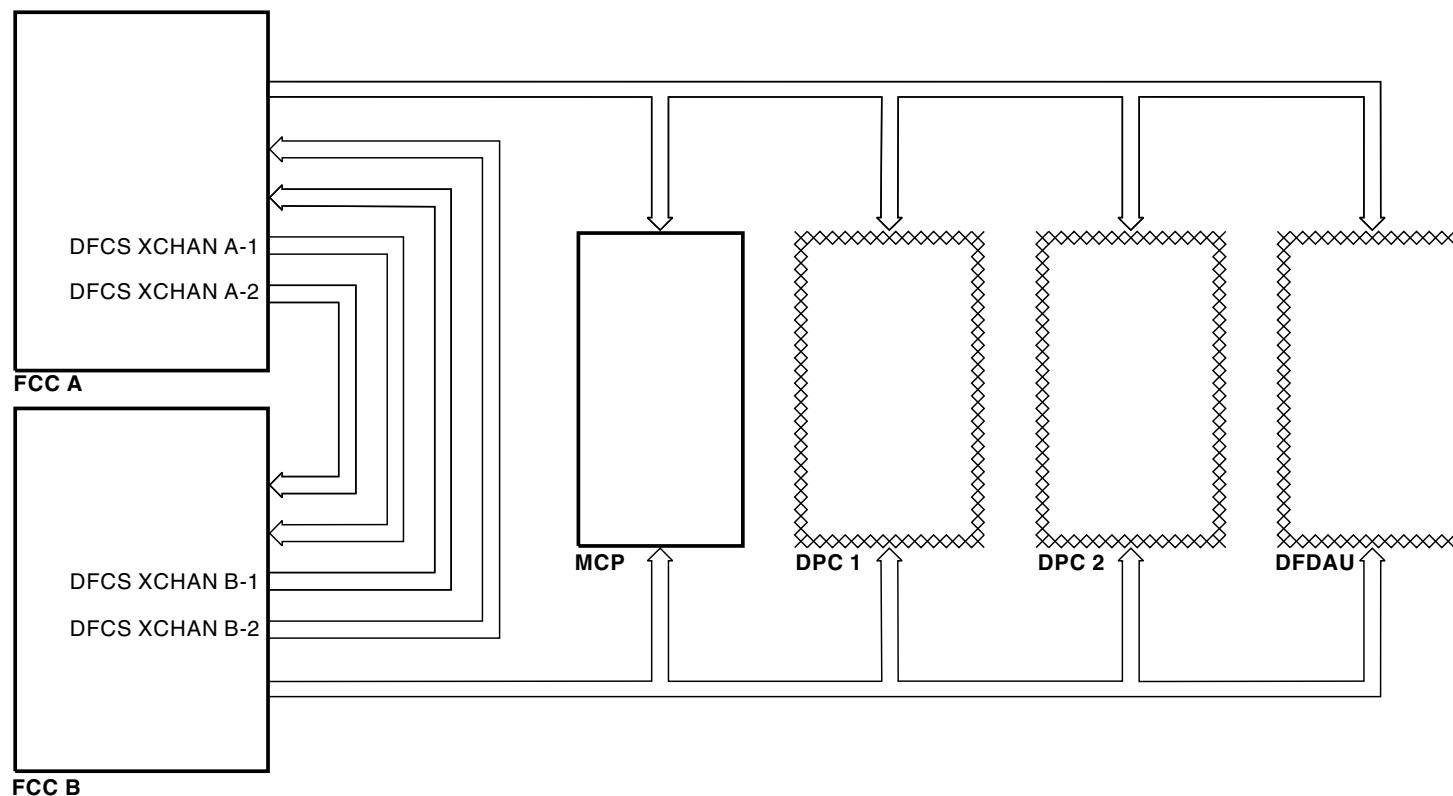
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DFCS - FLIGHT CONTROL COMPUTER DIGITAL OUTPUT INTERFACE



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DFCS - MODE CONTROL PANEL DIGITAL OUTPUT INTERFACE

General

The MCP sends digital data to these components:

- FCC A and B
- The display processing computer (DPC) 1 and 2
- Ground proximity warning computer (GPWC).
- Autothrottle (A/T)
- SMYD 1 and 2
- FMC 1 and 2.

FCC

When the flight crew selects mode commands and flight path variables on the MCP, the data goes to the FCCs on a digital data bus. These are the data that go to the FCCs:

- Selected heading that the crew chose
- Selected course number 1 and 2 that the crew chose
- Altitude window wrap that shows the altitude that the crew chose
- MCP maintenance discrete to indicate the type of MCP in the airplane
- MCP discrete to show the modes that the crew chose
- MCP display change to show when a change is made on one of the MCP controls
- MCP identification to show the type of MCP.

DPC

The MCP sends selected heading and selected course data to each DPC to show on the display units.

GPWC

The MCP sends the selected course to the GPWC for use by the envelop modulation function.

MCP Bus 3

The MCP gets data from both FCCs and also a signal to show which FCC is the master FCC. The MCP then sends all of the master FCC data out on MCP bus 3 to these systems:

- Autothrottle
- SMYD 1 and 2
- FMC1 and 2.

Autothrottle

The MCP sends this data to the Autothrottle:

- Target mach
- Target airspeed
- Selected altitude
- Spoiler 4 position
- Spoiler 9 position
- Flight path angle rate
- AFDS discrete word 1, 2, and 3 which show the DFCS mode and status.

The Autothrottle uses this data to compute the thrust lever servo rates for the A/T servo motors.

SMYD

The MCP sends AFDS discrete word 4 to the SMYDs to show if either or both autopilots are engaged in the CMD or CWS mode.

FMC

The MCP sends this data to FMC 1 and 2:

- Selected course number 1 and 2
- selected airspeed
- selected mach

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DFCS - MODE CONTROL PANEL DIGITAL OUTPUT INTERFACE

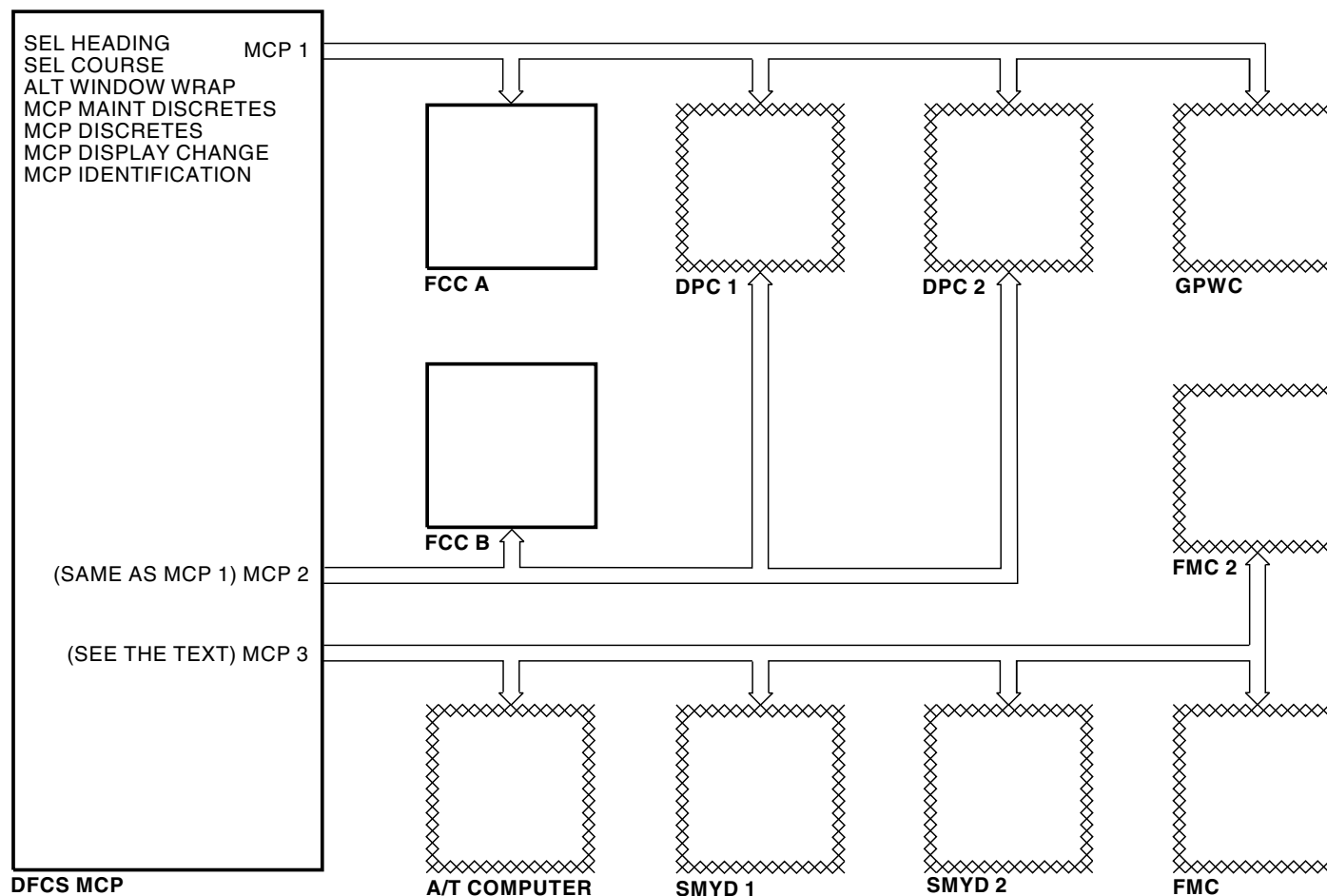
- Selected altitude
- Flap position
- AFDS discrete word 1 and 3 to give DFCS mode and status
- Digital flight control system (DFCS) BITE response.

The FMC uses this data to determine the status and mode of the DFCS and it also uses this data to show the BITE data.

The FMC uses this data to determine the status and mode of the DFCS and it also uses this data to show the BITE data. When the crew uses the speed and altitude intervention buttons, the FMC uses this data to modify the VNAV path and speed.

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DFCS - MODE CONTROL PANEL DIGITAL OUTPUT INTERFACE



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**DFCS - MODE CONTROL PANEL ANALOG INTERFACE****MCP**

When the flight crew engages either autopilot in command (CMD) or control wheel steering (CWS), the MCP sends engage signals go to the FCCs. When the crew turns on either flight director, the MCP sends F/D turn on signals to the FCCs.

You energize the master test relay when the master test switch is in the test position. This sends 28V DC to do a test of the MCP light emitting diodes (LEDs).

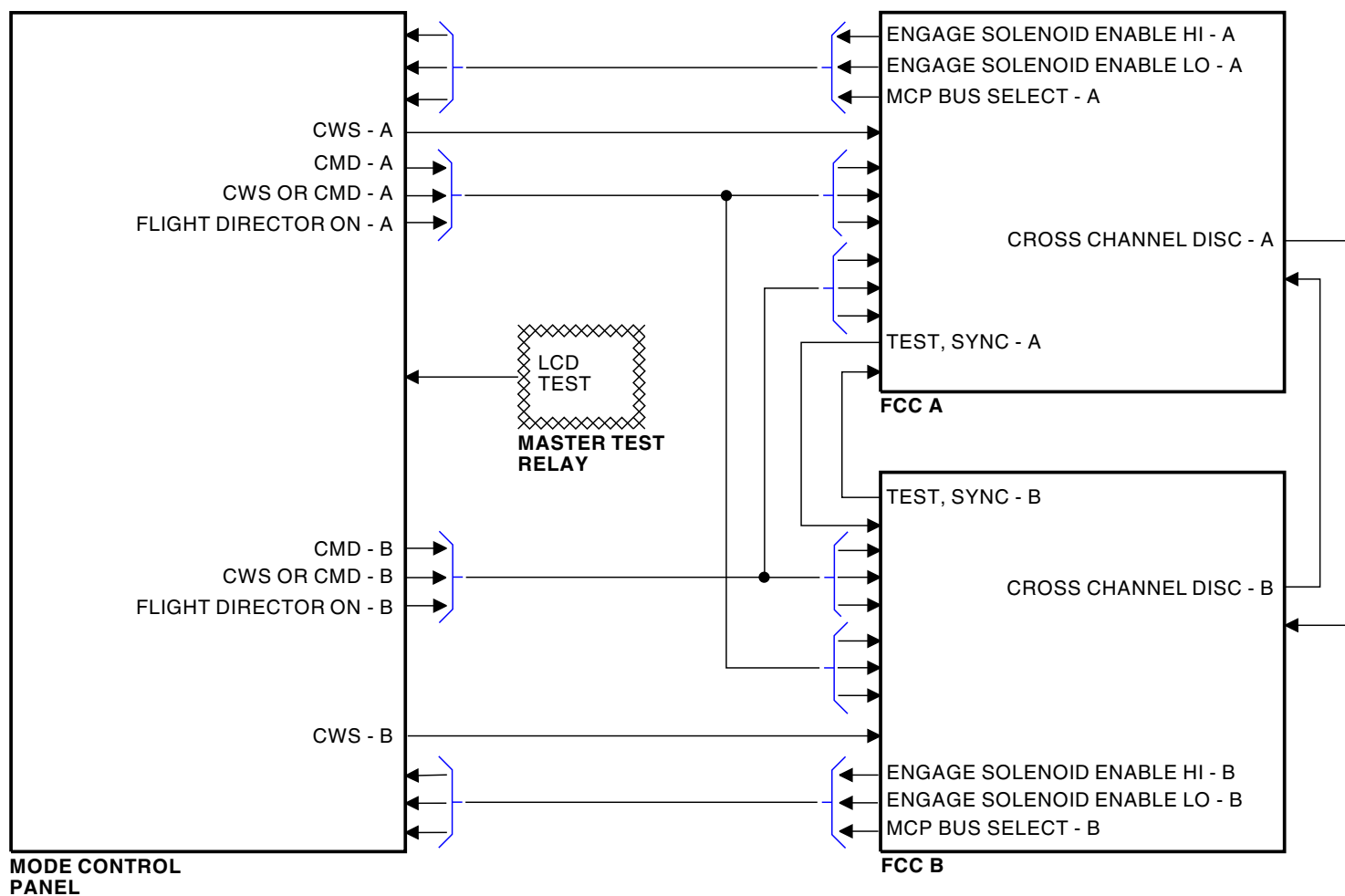
FCC

Each FCC sends data to the MCP to tell the MCP if it can engage the A/Ps. To engage an A/P, the FCC must send an engage solenoid enable high signal and an engage solenoid enable low signal. The enable high signals shows that CPU 1 in the FCC is valid. The enable low signals shows that CPU 2 in the FCC is valid. Each FCC also tells the MCP which FCC is the master FCC. The MCP uses data from the master FCC and also sends the master FCC data on to other systems.

The FCCs send test, synchronization, and autopilot disconnect signals between each other.

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DFCS - MODE CONTROL PANEL ANALOG INTERFACE



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DFCS - MODE CONTROL PANEL ANALOG INTERFACE

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**DFCS - ROLL SENSOR ANALOG INTERFACE****General**

The FCCs and MCP have an interface with these components when a roll mode is active for the autopilot:

- A/P aileron actuators A and B
- Roll CWS force transducer
- Aileron position sensor

Aileron A/P Actuators

The A/P aileron actuators send the aileron actuator position data to the inside FCC. This position data comes from the linear variable differential transformer (LVDT).

MCP

When you engage the A autopilot to CMD or CWS, the MCP sends an engage signal to A/P aileron actuator A. This lets A hydraulic fluid into the actuator. The MCP also sends this signal to FCC A. The FCC then commands the actuator main piston to synchronize to the aileron position. When you engage the B autopilot to CMD or CWS, the MCP sends an engage signal to A/P aileron actuator B. This lets B hydraulic fluid into the actuator. The MCP also sends this signal to FCC B. The FCC then commands the actuator main piston to synchronize to the aileron position.

Roll CWS Force Transducer

The roll CWS force transducer sends a signal to the FCCs. This signal is in proportion to the turning force on the control wheels.

Aileron Position Sensor

The aileron position sensor measures the position of the ailerons. It sends a signal in proportion to this position to the FCCs.

Spoiler Control Electronics

The spoiler control electronics (SCE) sends the spoiler 4 and spoiler 9 positions to the FCCs.

FCC

The FCC A sends a signal to A/P aileron actuator A to engage the detent solenoid valve. This pressurizes the main piston and locks it to the output shaft. It also sends the roll command signals to this actuator. The FCC B sends a signal to A/P aileron actuator B to engage the detent piston. This pressurizes the main piston and locks it to the output shaft. It also sends the roll command signals to this actuator.

Each FCC sends its inside aileron position data to the other FCC.

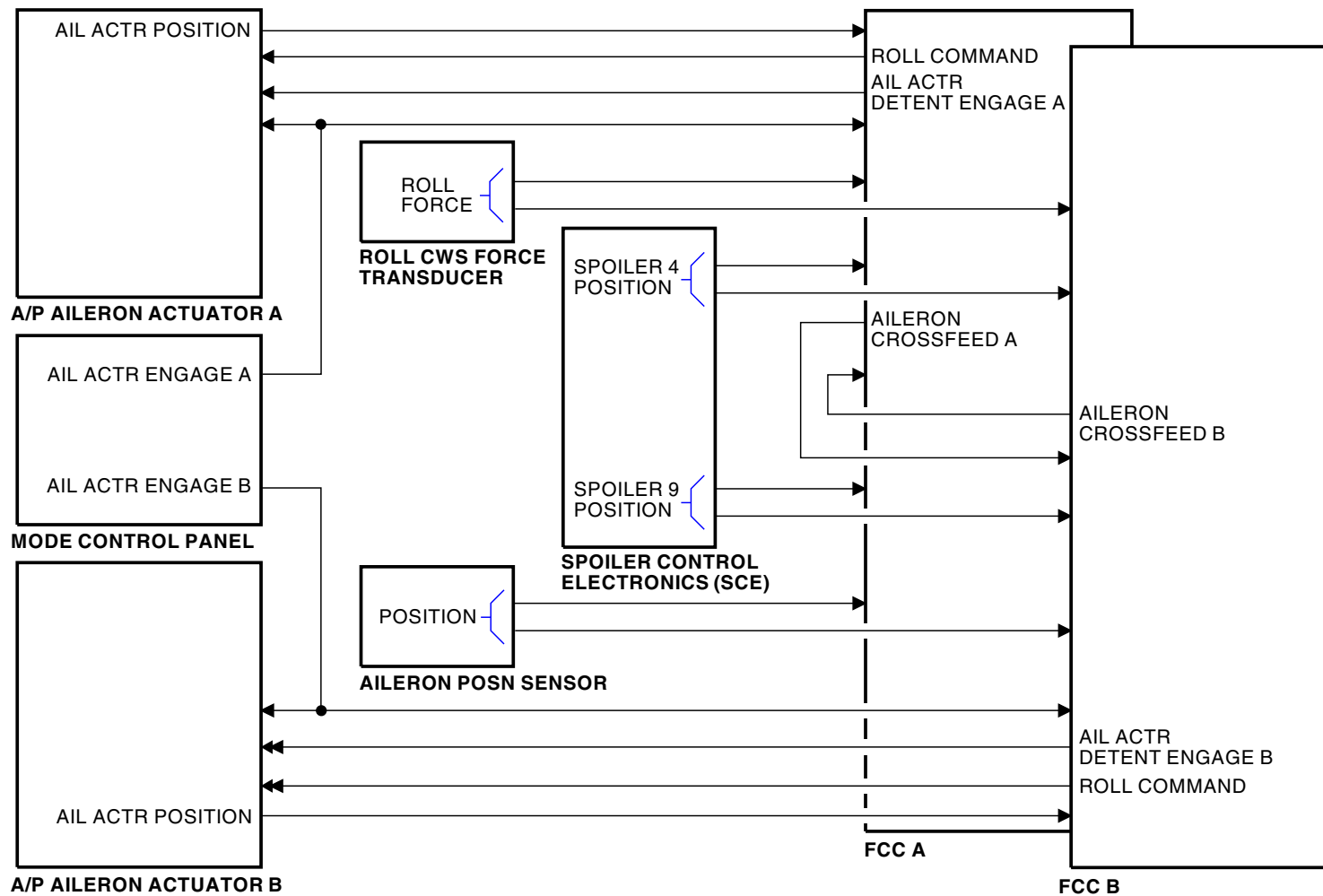
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DFCS - ROLL SENSOR ANALOG INTERFACE



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DFCS - ROLL SENSOR ANALOG INTERFACE

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**DFCS - PITCH SENSOR ANALOG INTERFACE****General**

The FCCs and MCP have an interface with these components when a pitch mode is active for the autopilot (A/P):

- A/P elevator actuators A and B
- Captain pitch CWS force transducer
- First officer pitch CWS force transducer
- Left and right flap position transmitters
- Stabilizer position sensors A and B
- Neutral shift sensor
- Elevator position sensor.

A/P Elevator Actuators

The A/P elevator actuators send the elevator actuator position data to its inside FCC. This position data comes from the linear variable differential transformer (LVDT).

MCP

When you engage the A autopilot to CMD or CWS, the MCP sends an engage signal to A/P elevator actuator A. This lets A hydraulic fluid into the actuator. The MCP also sends this signal to FCC A. The FCC then commands the actuator main piston to synchronize to the elevator position. When you engage the B autopilot to CMD or CWS, the MCP sends an engage signal to A/P elevator actuator B. This lets B hydraulic fluid into the actuator. The MCP also sends this signal to FCC B. The FCC then commands the actuator main piston to synchronize to the elevator position.

Captain Pitch CWS Force Transducer

The captain pitch CWS force transducer sends a signal to the FCCs. This signal is in proportion to the force on the captain control column.

Flap Position Transmitters

The left flap position transmitter sends the left flap position data to FCC A. The right flap position transmitter sends the right flap position data to FCC B.

Elevator Position Sensor

The elevator position sensor measures the position of the elevators. It sends a signal in proportion to this position to both FCCs.

First Officer Pitch CWS Force Transducer

The first officer pitch CWS force transducer sends a signal to both FCCs. This signal is in proportion to the force on the first officer control column.

Stabilizer Position Sensors

The stabilizer position sensors measure the position of the stabilizer. Stabilizer position sensor A sends a position signal to FCC A and to the digital flight data acquisition unit (DFDAU). Stabilizer position sensor B sends a position signal to FCC B.

Neutral Shift Sensor

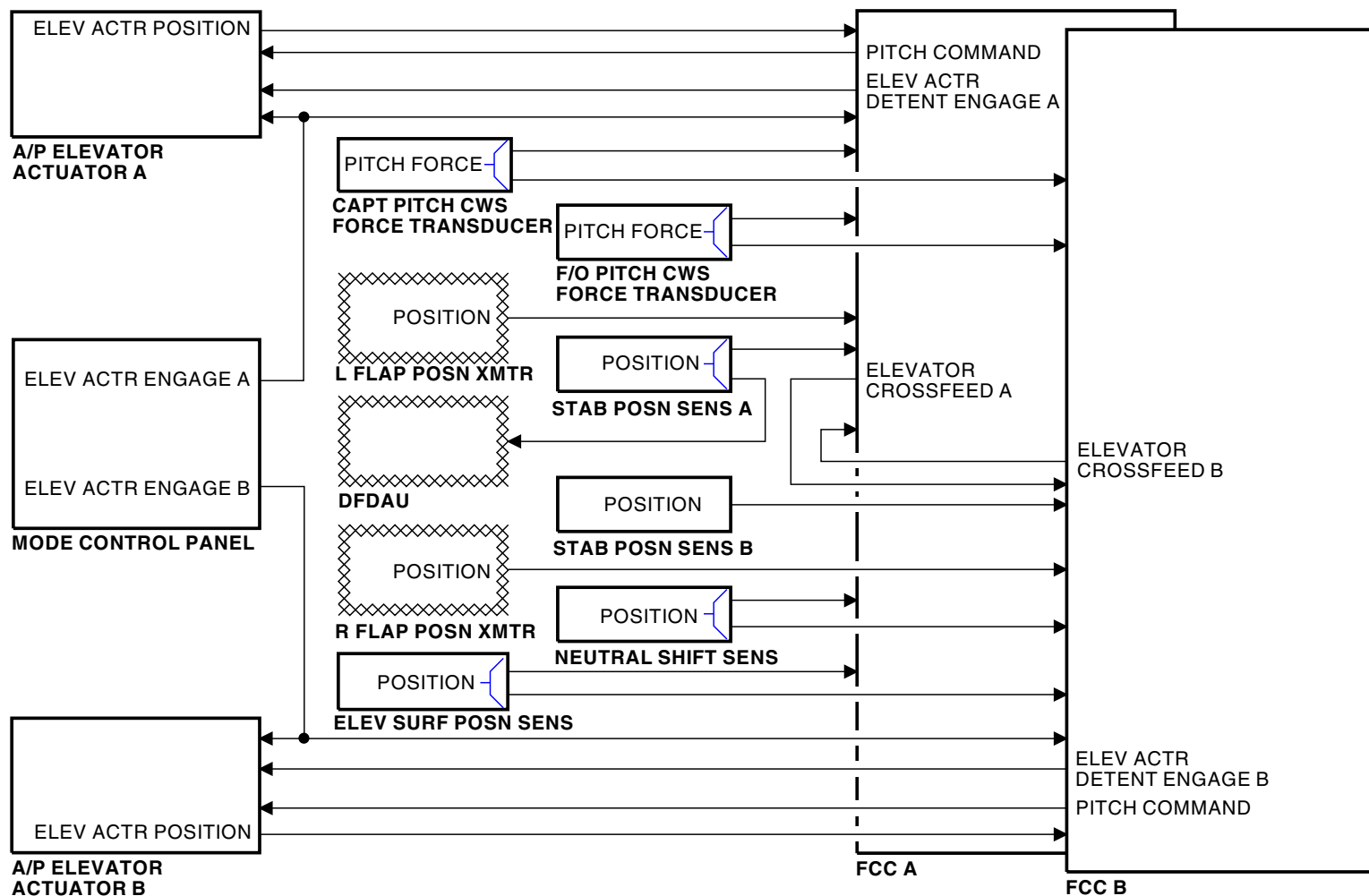
The neutral shift sensor measures the relative position between the stabilizer and the elevator. It sends this signal to both FCCs.

FCC

The FCC A sends a signal to A/P elevator actuator A to engage the detent piston. This pressurizes the main piston and locks it to the output shaft. It also sends the pitch command signals to this actuator. The FCC B sends a signal to A/P elevator actuator B to engage the detent piston. This pressurizes the main piston and locks it to the output shaft. It also sends the pitch command signals to this actuator.

Each FCC sends its inside elevator position data to the other FCC.

DFCS - PITCH SENSOR ANALOG INTERFACE



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DFCS - PITCH SENSOR ANALOG INTERFACE

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**DFCS - RUDDER COMMAND AND CONTROL ANALOG INTERFACE****General**

The FCCs have an interface with these components when rudder commands are in operation for the autopilot (A/P):

- Rudder servo assembly
- Rudder position sensor.

FCC Rudder Drive

The FCC rudder drive gives automatic rudder control during:

- Approach
- Landing
- Go-around
- Landing rollout.

A rudder servo assembly gives the torque for movement.

Rudder Servo Assembly

The rudder servo assembly has two rudder servos. The rudder surface moves by dc induction motors in the rudder servo assembly. FCC A gives the drive to one of the servo motors and FCC B gives the drive to the other servo motor.

Each servo has an engage clutch for which engage logic from the FCC is necessary. There is FCC logic if the process lanes of the FCC are valid.

Tachometer feedback of the servo motor goes to lane 1 and 2 of the onside FCC.

Rudder Position Sensor

The dual channel rudder position sensor measures motion of the rudder. The position data goes to FCC A and FCC B.

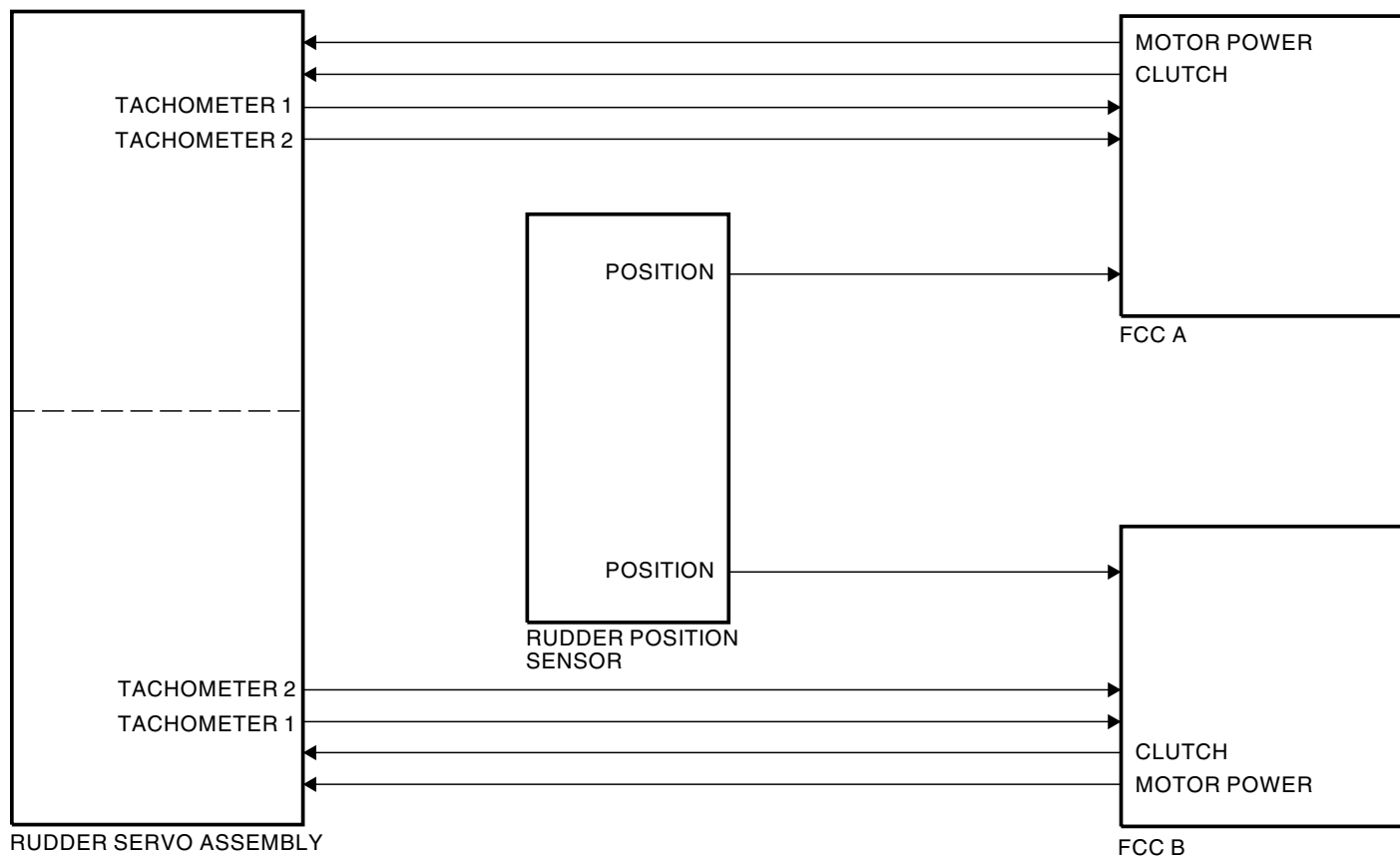
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DFCS - RUDDER COMMAND AND CONTROL ANALOG INTERFACE



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DFCS - RUDDER COMMAND AND CONTROL ANALOG INTERFACE

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**DFCS - SPEED AND STAB TRIM ANALOG INTERFACE****General**

The speed and stabilizer trim system function of the FCC have an interface with these components:

- Stab trim warning light
- Column switching module A/P cruise trim and stab trim cutout switches
- Flight control panel
- Stab nose up and down limit switches
- Left elevator tab solenoid valve
- Stabilizer trim electric actuator.

FCC

The FCCs send stabilizer trim actuator clutch and nose up and down trim signals to the column switching module. The FCCs also send a flap down signal to the stabilizer trim electric actuator. This signal controls the speed of the stabilizer trim electric actuator. When the flaps are down, the speed is three times the speed when the flaps are up.

Stab Trim Warning Light

If either FCC calculates that the stabilizer is out of trim, it sends a stabilizer out of trim warning signal to the stab trim warning light to turn it on.

Column Switching Module

The column switching module sends signals to the FCCs to show when the control column moves to the forward or aft position. If the column switching module indicates the control column moves opposite of the stab trim command, the FCCs stop automatic trim signals except for MCAS nose down stabilizer commands.

The column switching module sends a clutch engage signal through the A/P cruise trim cutout switch to the stabilizer trim actuator. It also sends the trim up and trim down drive signals to the stab trim cutout relay. These signals then go through the stab nose limit switches to the stabilizer trim actuator.

Flight Control Panel

The flight control panel receives a speed trim system warning signal from each FCC. Both FCCs must send a fail signal to turn on the speed trim fail annunciator.

Recall signals from the master caution annunciators and reset signals from the master caution lights go to the flight control panel. These signals turn on the speed trim fail light if only one FCC speed trim system fails.

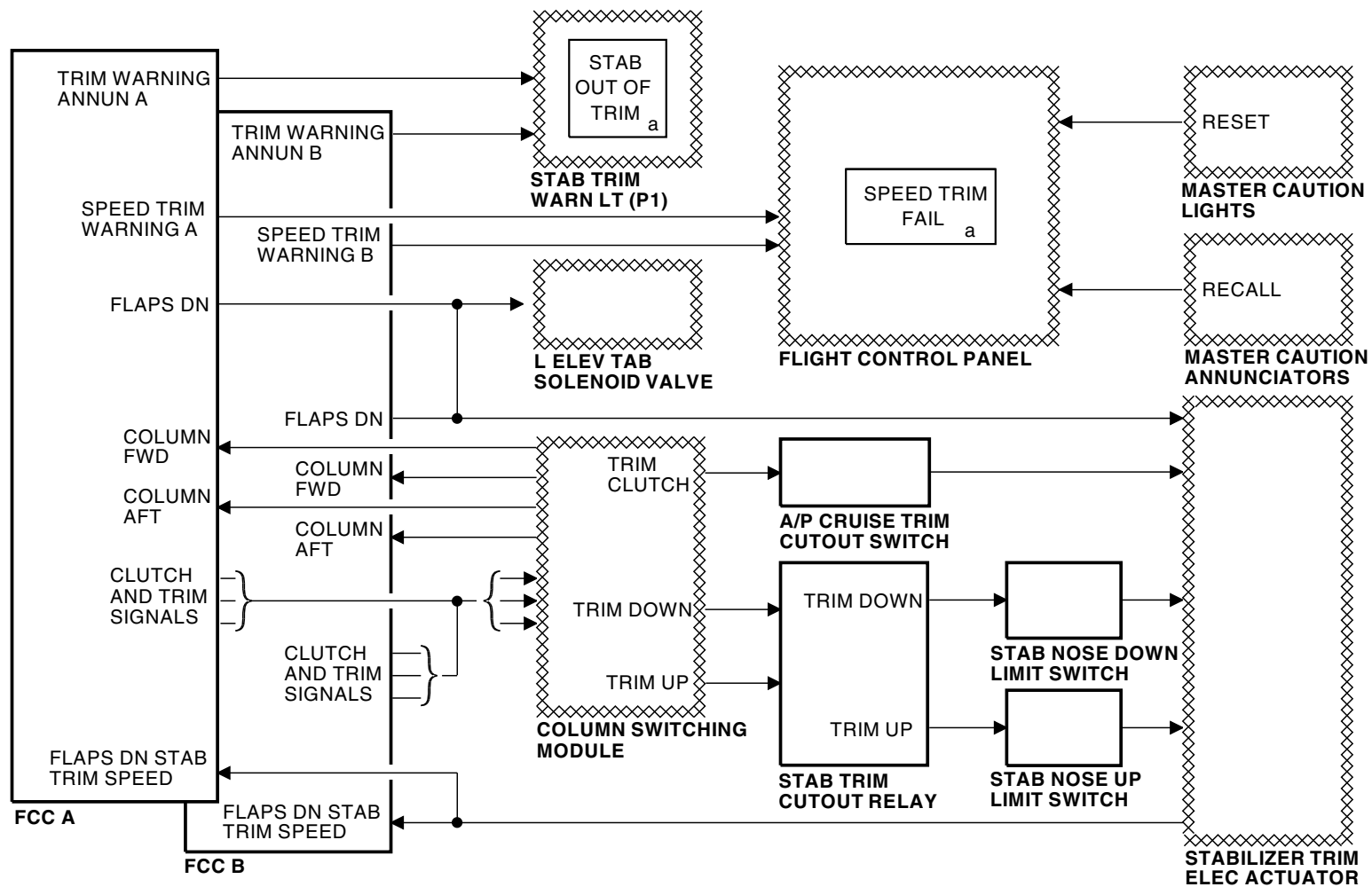
Left Elevator Tab Solenoid Valve

When the flaps are one unit or more (FLAPS DN) and the hydraulics are on, the elevator tabs move in the same direction as the elevator. This gives an increase in the elevator performance for an engine-out takeoff condition. The FCCs supply the FLAPS DN signal to the left elevator tab solenoid valve.

Stabilizer Trim Electric Actuator

The stabilizer trim electric actuator sends a signal to the FCCs that tells if the actuator is in the low or high speed. The position of the flaps cause the speed of the actuator to change.

DFCS - SPEED AND STAB TRIM ANALOG INTERFACE



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DFCS - SPEED AND STAB TRIM ANALOG INTERFACE

**DFCS - MACH TRIM ANALOG INTERFACE****General**

The mach trim function of the FCC interfaces with these components:

- Mach trim actuator
- Integrated flight system accessory unit (IFSAU)
- Flight control panel.

Power

The 115V AC transfer bus 1 and 28V DC bus 1 send mach trim power to FCC A. The 115V AC transfer bus 2 and 28V DC bus 2 send mach trim power to FCC B. The 28V DC bus 2 also sends power to the IFSAU.

Mach Trim Actuator

The mach trim actuator sends the mach trim position signal to the FCCs.

IFSAU

Only one FCC can control the mach trim actuator at a time. The IFSAU receives the FCC select signal from FCC B. This signal controls a relay in the IFSAU to find which FCC will give the mach trim actuator signals. The IFSAU sends the mach trim select status signal to the FCCs to show which FCC is in control. The IFSAU then sends mach trim power and motor drive signals to the mach trim actuator.

Flight Control Panel

The flight control panel receives a mach trim warning signal from each FCC. Both FCCs must send a fail signal to turn on the mach trim fail annunciator.

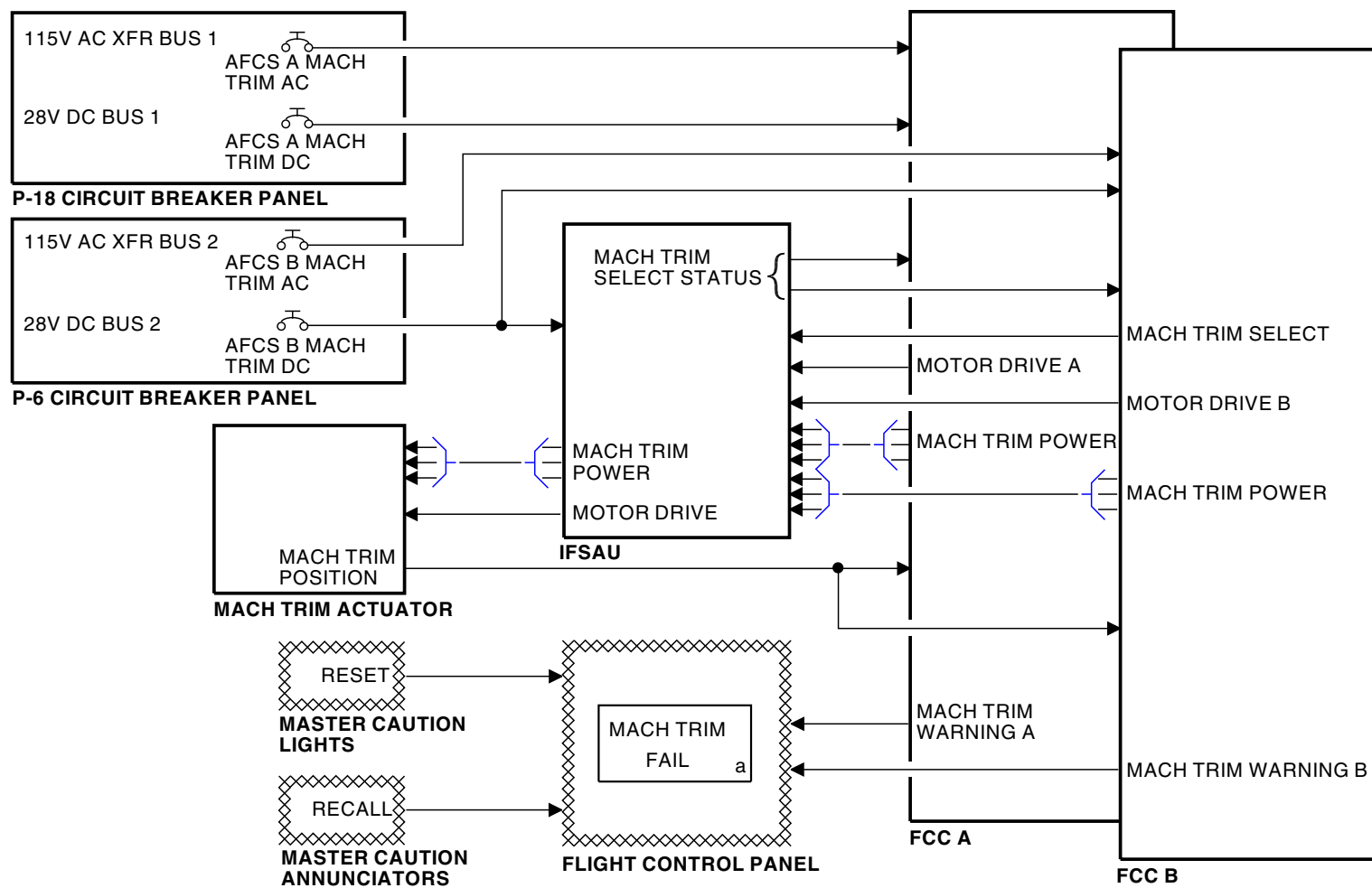
Recall signals from the master caution annunciators and reset signals from the master caution lights go to the flight control panel. These signals can turn on the mach trim fail light if only one FCC mach trim fails.

FCC

The FCCs send mach trim power and motor drive signals to the IFSAU. FCC B sends a signal to the IFSAU to set which FCC will supply mach trim data to the mach trim actuator. Each time the airplane lands, the FCCs switch control of the mach trim actuator.

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DFCS - MACH TRIM ANALOG INTERFACE



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DFCS - MACH TRIM ANALOG INTERFACE

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**DFCS - VHF NAVIGATION ANTENNA SWITCHING ANALOG INTERFACE****General**

These components have an interface with the FCCs to select the VHF navigation antennas. They also prevent a change in frequency of the multi-mode receivers (MMR) during an autopilot approach mode:

- Dual VOR/LOC antenna
- Dual Localizer antenna
- RF power dividers 1 and 2
- Localizer antenna switches 1 and 2
- IFSAU
- MMR receivers 1 and 2
- Radio altimeters (RA) 1 and 2
- Capt and F/O navigation control panels.

VOR/LOC Antenna

The VOR/LOC antenna receives the VOR and localizer signals and sends them through the RF power dividers to localizer antenna switches 1 and 2.

Localizer Antennas

These antennas receive the localizer signal and send it directly to the localizer antenna switches.

Localizer Antenna Switches

The localizer antenna switch selects the VOR/LOC antenna or the localizer antenna. If the FCC is in the approach or localizer mode, it sends an ILS test inhibit/antenna signal to the IFSAU. This signal energizes a switch which sends a ground to one side of the switch. If the navigation control panel selects a localizer frequency, it sends 28v dc to the other side of the switch. These signals cause the relay to energize so the receivers use the localizer antenna in the nose radome. If you do not select an ILS frequency, the receivers use the VOR/LOC antenna in the vertical stabilizer. Also, if you do not use the FCC in the approach or localizer mode, the receivers use the VOR/LOC antenna.

Each switch sends a signal to its onside FCC to tell it which antenna is in use.

FCC

When the A system autopilot or flight director is in the approach or localizer mode, it sends an ILS test inhibit/antenna A signal the IFSAU. It also sends an ILS receiver tuning inhibit signal to these components:

- MMR 1
- RA 1
- Capt navigation control panel.

When the B system autopilot or flight director is in the approach or localizer mode, it sends an ILS test inhibit/antenna B signal the IFSAU. It also sends an ILS receiver tuning inhibit signal to these components:

- MMR 2
- RA 2
- F/O navigation control panel.

The tune inhibit signal does not let the control panel and receivers tune to an unwanted frequency unless the crew pushes the transfer switch on the nav control panel.

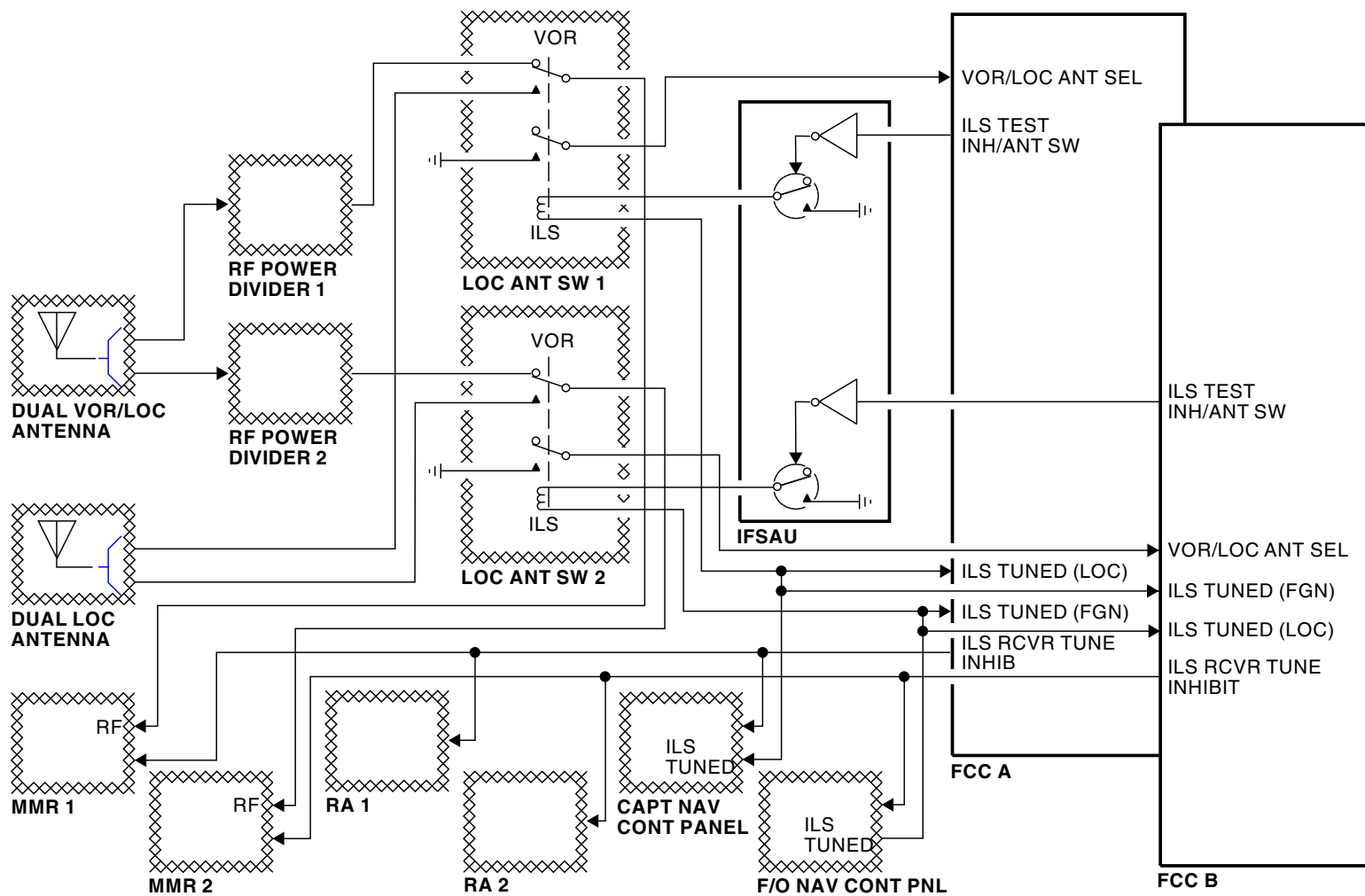
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DFCS - VHF NAVIGATION ANTENNA SWITCHING ANALOG INTERFACE



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DFCS - VHF NAVIGATION ANTENNA SWITCHING ANALOG INTERFACE

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**DFCS - TRANSFER SWITCHES ANALOG INTERFACE****General**

These components have an interface with the FCCs as part of the engage and interlock circuit:

- IRS transfer switch
- VHF navigation transfer switch
- Frequency transfer switch on the Capt and F/O navigation control panels.

The DFCS monitors these switches to see if a change occurs. The sensor output that the DFCS uses for an active mode in the autopilot or flight director must show on either the instruments for the captain or first officer. If it does not, the DFCS will not allow the autopilot or flight director mode. If a switch occurs such that both autopilots and instruments on both sides receive data for the same sensor, dual autopilot and dual flight director modes can not occur.

IRS Transfer Switch

If you change the IRS functions from NORMAL to BOTH ON 1 or BOTH ON 2, the FCCs receive the change from the IRS transfer switch. When the pilots change away from one of the IRSs, out of the NORMAL position, the autopilot disengages and the flight director commands will BOV on the side that changed (channel A if BOTH ON 2).

Normally, the FCCs use pitch and heading data from the on-side IRS and roll data from the off-side IRS. The autopilot will engage only if the IRS transfer switch is in the NORMAL position. This is to prevent a possible ADIRU failure that could cause a pitch and roll hardover or a yaw damper and elevator hardover.

For dual F/D approach or TO/GA, an IRS switch out of NORMAL will cause BOV.

VHF Navigation Transfer Switch

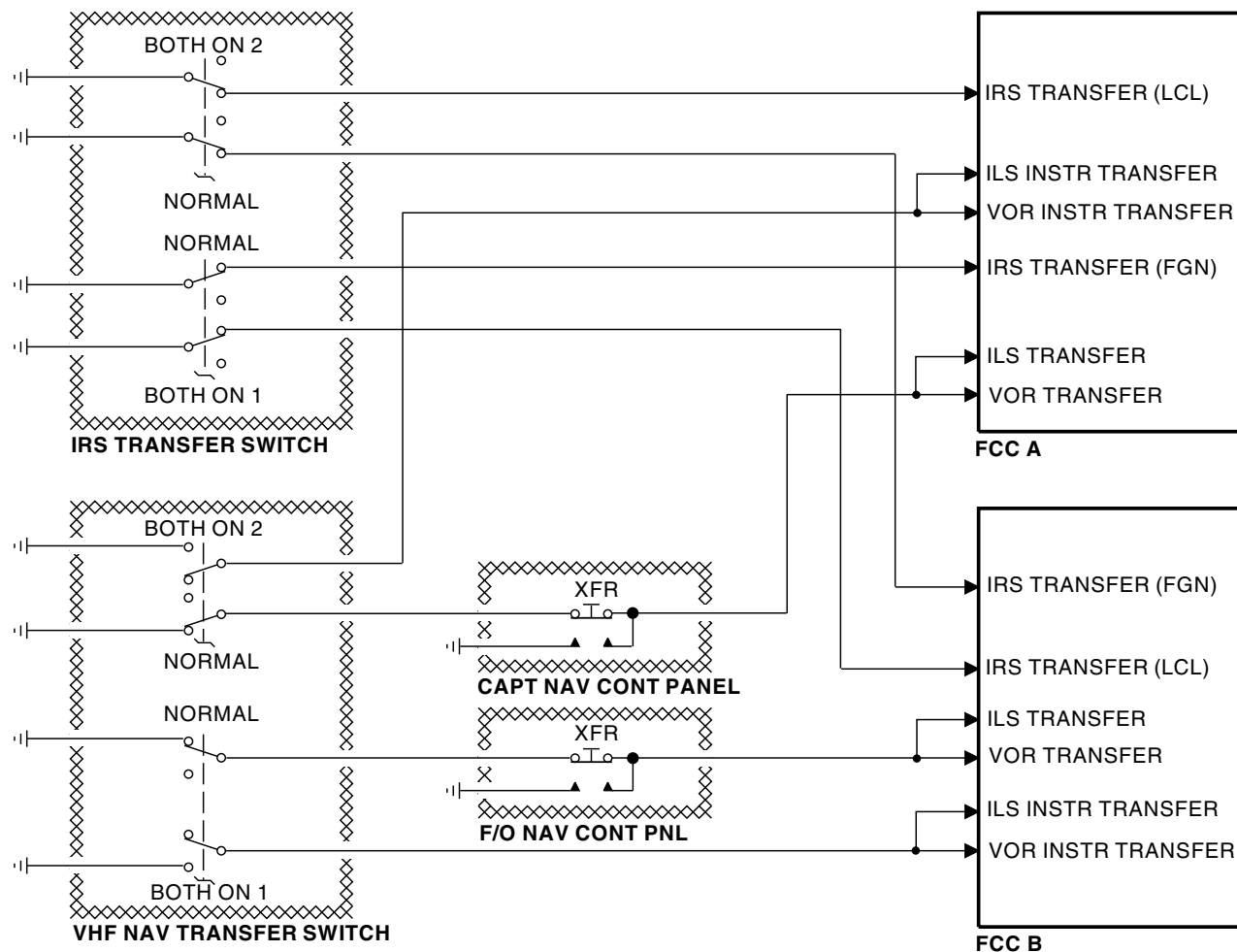
If you change the VHF navigation receivers from NORMAL to BOTH ON 1, FCC B gets VOR/ILS transfer and VOR/ILS instrument transfer signals to show the change. If you change the VHF navigation receivers from NORMAL to BOTH ON 2, FCC A gets VOR/ILS transfer and VOR/ILS instrument transfer signals to show the change.

The DFCS cannot use VOR/ILS data that does not show on the instruments.

VHF Navigation Control Panel

When you push the frequency transfer switch on the navigation control panel, a VOR/ILS transfer signal goes to the onside FCC to show that the VOR/LOC frequency will change. The FCC will reset the mode if the autopilot is in the VOR/LOC mode. The autopilot will disengage if it is in the approach mode. The pilot may select the VOR/LOC mode or reengage the autopilot after the frequency change.

DFCS - TRANSFER SWITCHES ANALOG INTERFACE



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DFCS - TRANSFER SWITCHES ANALOG INTERFACE

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**DFCS - MISCELLANEOUS SYSTEMS ANALOG INTERFACE****Proximity Switch Electronics Unit**

When the proximity switch electronics unit gets an input that the gear is down, it sends a ground to FCC A and B.

Takeoff/Go Around (TO/GA) Switches

When you push either TO/GA switch, a ground goes to these components:

- Stall management yaw dampers (SMYD) 1 and 2
- Autothrottle function in FCC A
- FCC A and B.

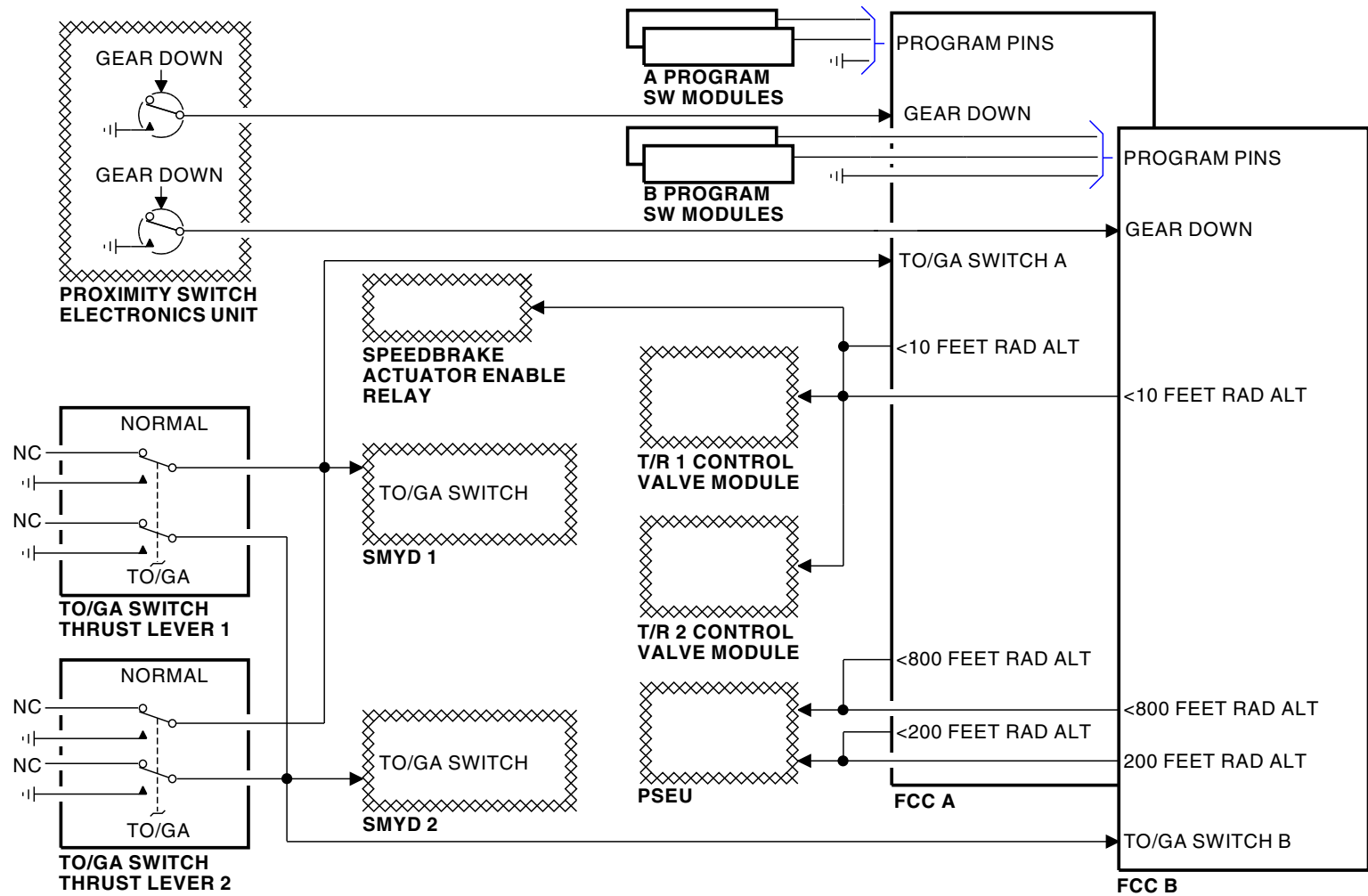
FCC

There are several program pins that set the airplane identification and configuration of the FCC. You can ground some pins when you connect them to a burndy block. Other pins connect to program switch modules which contain dip switches.

There are two autopilot (A/P) system A program switch modules that connect to several program pins on FCC A. There are two A/P system B program switch modules that connect to several program pins on FCC B. To ground one of these program pins, you put the dip switch in the ON position. The OFF position supplies an open to the program pin.

Each FCC calculates altitude trip points from the radio altimeter data. When the altitude is less than 10 feet, the FCC sends a discrete to the thrust reverser (T/R) control valve modules and the auto speedbrake module. When the altitude is less than 800 feet, it sends a discrete to the spoiler deployment system and the landing gear system. The 800' discrete is used for warning logic in the PSEU..

DFCS - MISCELLANEOUS SYSTEMS ANALOG INTERFACE



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DFCS - MISCELLANEOUS SYSTEMS ANALOG INTERFACE

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - MODE CONTROL PANEL - PHYSICAL DESCRIPTION****Purpose**

The mode control panel (MCP) supplies the interface between the flight crew and the digital flight control system (DFCS). The MCP does these functions:

- Engages the autopilot
- Turns on the flight directors
- Selects the operation mode
- Arms the autothrottle
- Controls parameter selection
- Displays data.

Physical Description

The MCP weighs approximately 15 lbs. The MCP installs in the glareshield with four screws on the front of the panel. There are two screws on the bottom of the MCP that also attach to the glareshield. Three electrical receptacles on the rear of the MCP connect to the airplane wiring.

Each mode selector switch on the MCP contains six light emitting diodes (LED). The switches and the LEDs are not line replaceable units (LRUs).

There are six liquid crystal displays (LCDs). They show these selected parameter values:

- Course 1 and 2
- IAS/MACH
- Heading
- Altitude
- Vertical speed.

Three lamps give backlight to the five position LCD display. Two lamps give backlight to the three position LCD display. These lamps and the LCDs are not LRUs.

There are 52 incandescent lamps for the light plate. These lamps are also not LRUs.

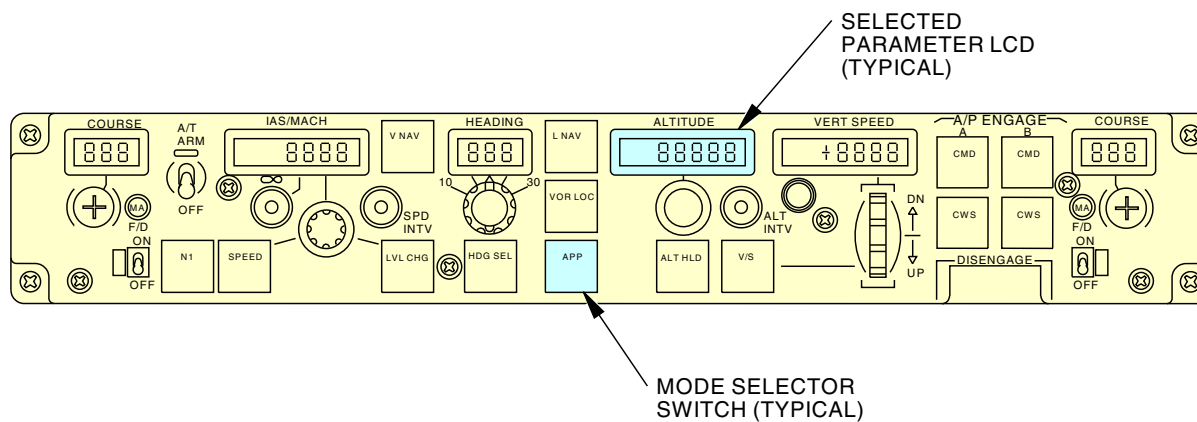
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DFCS - MODE CONTROL PANEL - PHYSICAL DESCRIPTION



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DFCS - MODE CONTROL PANEL - PHYSICAL DESCRIPTION

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**DFCS - MODE CONTROL PANEL - FUNCTIONAL DESCRIPTION****General**

These are the major components of the mode control panel (MCP):

- ARINC 429 bus selector
- Channel A and B processors
- LCD indicators and controls
- Mode selector and A/P engage switches
- A/T switch and indicator
- A/P switches and indicators
- light sensors.

ARINC 429 Bus Selector

When an FCC becomes the master FCC and takes control of the MCP displays, it sends an MCP bus select signal to the MCP. The ARINC 429 bus selector then sends that FCC's data to the channel A processor and on to the FMC and the A/T. The MCP always uses the FCC A data unless the FCC B sends a bus select signal and the FCC A did not.

Channels A and B Processors

The MCP contains two separate microprocessors; a channel A processor and a channel B processor.

The channel A processor receives FCC data from the bus selector. The channel A processor does most of the MCP functions. The data then goes to the FCC A and to the channel B processor.

The channel B processor replaces the course 1 select data with the course 2 select data. The processor then sends all of the data on to the FCC B.

The channel B processor receives signals from the light sensors. The signals control the brightness of the LCD backlights and the mode selector switch LEDs.

The channel B processor calculates the A/P warning signal and sends it to the captain's and first officer's autoflight status annunciators (ASA).

Mode Selector and Toggle Switches

These switches send data to the channel A processor:

- F/D toggle switches
- A/P engage switches
- Mode selector switches.

The processor sends the A/P engage and mode select signals to the FCC. The FCC makes sure that all necessary conditions are satisfactory before it engages the A/P or selects the mode.

Mode Selector and Light Annunciators

The channel A processor receives engagement and mode select data from the FCC that has control. The processor then lights these annunciators:

- F/D master light LEDs
- A/P engage switch LEDs
- Mode selector switch LEDs.

LCDs and Selectors

The channel A processor receives data from these selectors. It then sends the data to the LCD display:

- Course 1 and 2 selectors
- Altitude selector
- Heading selector.

The channel A processor receives data from the IAS/MACH and vertical speed selectors and sends this data to the FCC. The FCC calculates the correct IAS/MACH and vertical speed and sends it to the MCP to show on their displays.



DFCS - MODE CONTROL PANEL - FUNCTIONAL DESCRIPTION

Autopilot Engage Logic

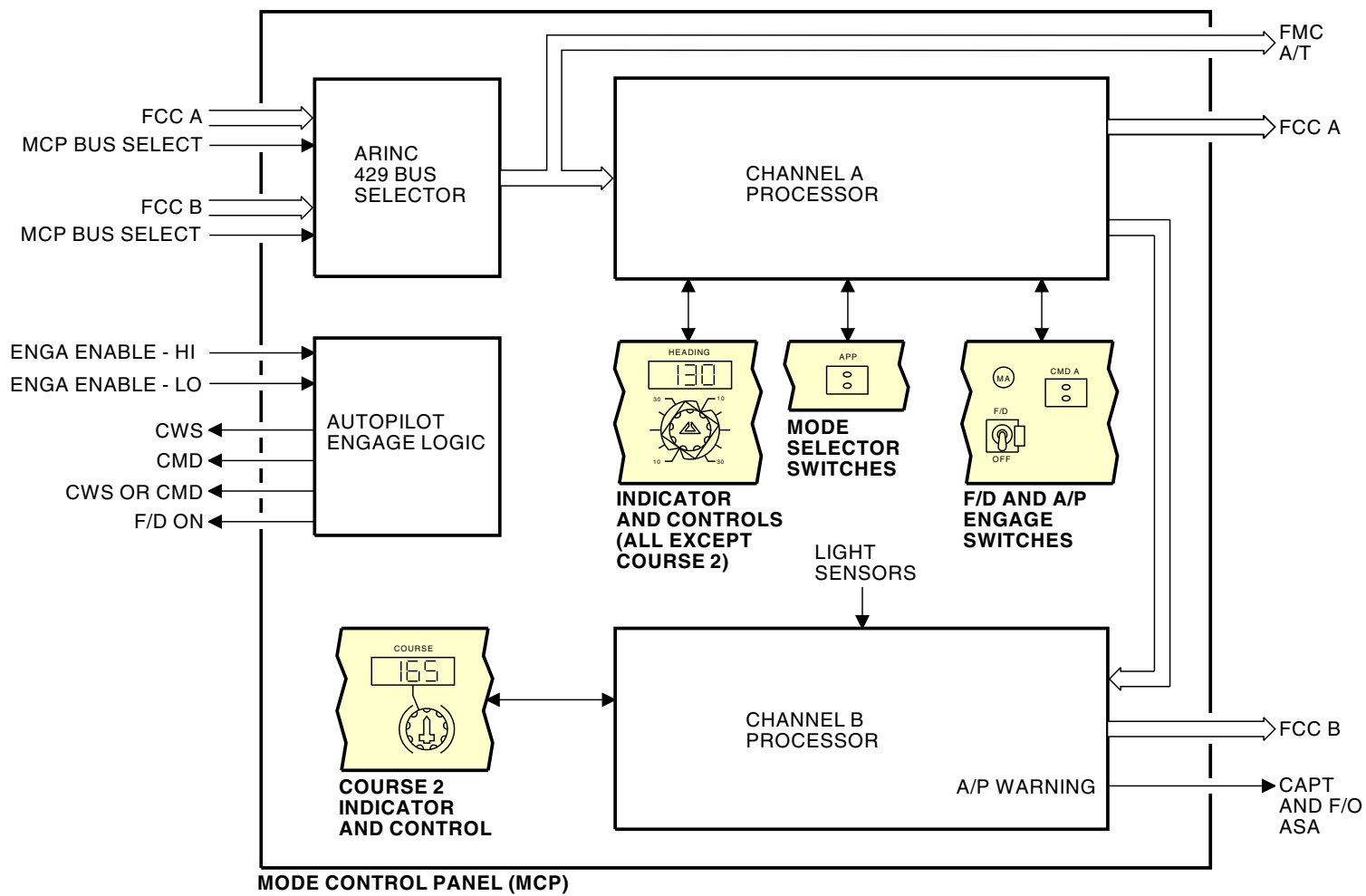
The engage enable signals, high and low, come from the FCCs. When the crew selects an autopilot mode, the MCP sends one of these engage signals to the FCCs:

- CWS only
- CMD only
- CWS and CMD.

The MCP also sends a signal that shows if the flight directors are on.

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DFCS - MODE CONTROL PANEL - FUNCTIONAL DESCRIPTION



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DFCS - MODE CONTROL PANEL - FUNCTIONAL DESCRIPTION

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - MODE CONTROL PANEL - CONTROLS AND DISPLAYS****General**

There are many switches, knobs, and push-buttons on the MCP that the crew uses to control the FCC. There are also many displays to show selected parameter values.

Course Selectors

The course selectors 1 and 2 select the instrument landing system (ILS) course or the VHF omnidirectional range (VOR) course. Course selector 1 is for the captain ILS or VOR system. Course selector 2 is for the first officer (F/O) ILS or VOR system.

Course Displays

The two course displays show the VOR or ILS course you select. The display range is from 000 to 359 degrees.

Flight Director (F/D) Switches

Two F/D switches turn on and turn off the F/D function in the FCCs. The captain F/D switch usually controls FCC A and you usually only see the F/D commands on the captain display. The F/O F/D switch usually controls FCC B and you usually only see the F/D commands on the F/O display.

Master Lights (2)

The master light shows which FCC controls the mode selection. If the master light above the captain F/D switch is on, FCC A controls the mode selection. If the master light above the F/O F/D switch is on, FCC B controls the mode selection.

Autothrottle (A/T) Arm Switch

When you put the switch to the ARM position, the A/T system arms. An electrical solenoid holds the switch in the ARM position. You disconnect the A/T if you put the switch to the OFF position.

A/T Arm Light

The light comes on when the A/T is in the arm mode. The A/T ARM switch light will illuminate on the MCP when the Master Test and Dimming Switch is set to the TEST position.

IAS/MACH Selector

The IAS/MACH selector sets the MCP airspeed or mach.

IAS/MACH Display

The display shows indicated airspeed (IAS) or the mach number. The IAS shows from 100 to 399 kts in one knot increments. The mach shows from 0.60 to 0.89 mach in 0.01 mach increments.

The display has a warning flag that flashes for underspeed and overspeed conditions. The left position in the LCD shows this flag.

The IAS/MACH display is blank when the VNAV mode is active.

IAS/MACH Change/Over Switch

When you push this switch and the airspeed is more than mach 0.6, it changes the display from IAS in knots to mach or from mach to IAS in knots. If the airspeed is less than mach 0.6, the display will only show knots and the change over switch does not do anything.

Speed Intervention Push-button

The crew uses this push-button only in the VNAV mode. When you push the push-button, the IAS/MACH shows the FMC target speed. Turn the IAS/MACH selector to change the FMC target speed. This push-button then lets the crew change the FMC target speed and stay in VNAV.

Heading Selector

The heading selector changes the flight crew selected heading for the airplane.

**DFCS - MODE CONTROL PANEL - CONTROLS AND DISPLAYS****Heading Display**

The display shows the heading the flight crew selects. The display range is from 000 to 359 degrees.

Bank Angle Selector

The bank angle selector lets the flight crew set the maximum allowable bank angle. You can set the maximum bank angle to one of these angles:

- 10 degrees
- 15 degrees
- 20 degrees
- 25 degrees
- 30 degrees.

This variable bank angle only has an effect in the VOR and heading select modes.

Altitude Selector

The altitude selector sets the reference altitude for the DFCS. One revolution of the knob changes the altitude 6400 feet.

Altitude Display

This display shows the altitude the flight crew selects. The altitude range is from 0 to 50,000 feet.

Altitude Intervention Push-button

When you push this push-button in the VNAV mode, you can change the FMC target altitude and you can remove altitude constraints in the flight plan. You can remove up to eight restrictions with the push-button. You can change the FMC altitude and stay in VNAV. There is no indication on the MCP to show you selected the altitude intervention. The only indication is on the FMC LEGS page on the CDU.

Vertical Speed Thumbwheel

To set the vertical speed, turn the vertical speed thumbwheel. Turn the thumbwheel UP to make a nose up change in the value. Turn the thumbwheel DN to make a nose down change in the value. The thumbwheel has increments of 50 feet per minute (fpm) from 0 to 1000 fpm and 100 fpm for more than 1000 fpm.

Vertical Speed Display

This display shows the flight crew selected vertical speed. The vertical speed range is from -7,900 fpm to +6,000 fpm.

Autopilot (A/P) Engage Switches

There are four A/P engage switches. Two switches are for FCC A and two are for FCC B. The switches engage an autopilot to command (CMD) or control wheel steering (CWS).

The switches are push-button/light type switches. If the pre-engage logic is correct, the A/P engages and the switch light comes on when you push the switch. If the pre-engage logic is not correct, the A/P will not engage and the switch light will not come on when you push the switch.

After you engage the A/P, some conditions must stay correct or the autopilot disengages. If the A/P disengages, the switch light goes off.

A/P Disengage Bar

You disengage the A/P when you push the A/P disengage bar down.

Mode Selector Switches

These are the mode selector switches:

- Autothrottle N1
- Autothrottle speed
- Level change
- Heading select
- Approach

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DFCS - MODE CONTROL PANEL - CONTROLS AND DISPLAYS

- VNAV
- LNAV
- VOR LOC
- Altitude hold
- Vertical speed.

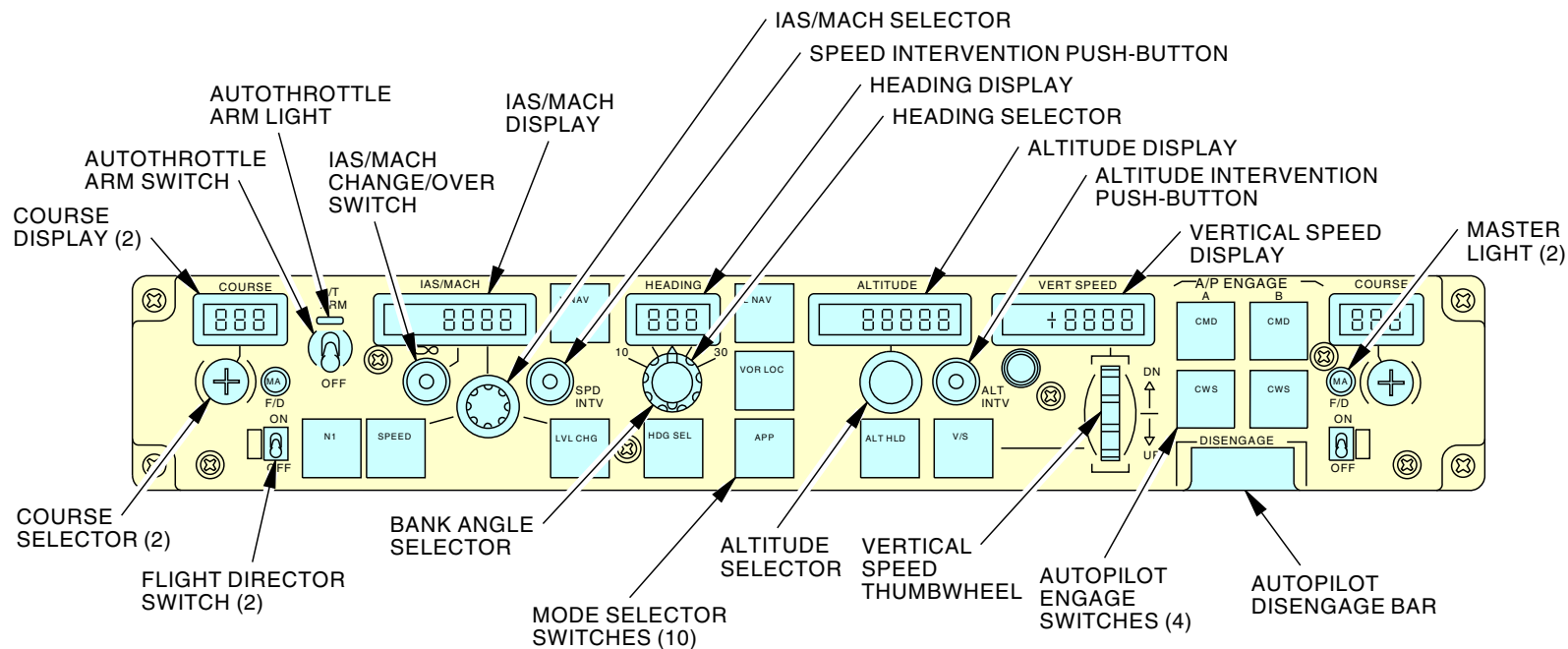
If a mode selector switch light is on, you can turn off that mode when you push the switch again.

Light Sensors

Two photo diode light sensors on the MCP front panel monitor the light in the crew compartment area. The sensors control the brightness of the LCDs.

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DFCS - MODE CONTROL PANEL - CONTROLS AND DISPLAYS



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DFCS - MODE CONTROL PANEL - CONTROLS AND DISPLAYS

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DFCS - FLIGHT CONTROL COMPUTER - PHYSICAL DESCRIPTION

Purpose

The purpose of the flight control computer (FCC) is to get data inputs and calculate these functions:

- Autothrottle function
- Autopilot commands
- Flight director commands
- Altitude alerts
- Speed trim system commands
- Mach trim commands.

The input data is from the pilot through the MCP and sensor inputs. The FCC also sends signals to control surface actuators and shows displays on the MDS.

Loadable Software

The software in the FCC is loadable. The software can be loaded using the data loader and the data loader control panel. The software can be loaded after these conditions are met:

- Successful long term power-up
- Valid data signals
- Airplane is on the ground
- Groundspeed is less than 60 knots
- No wheel spin
- No autopilot is engaged.

The software can be cross-loaded from one FCC into the other FCC.

NOTE: Do not interrupt power to the system during software loading. If power is interrupted, you will need to do the software load procedure again.

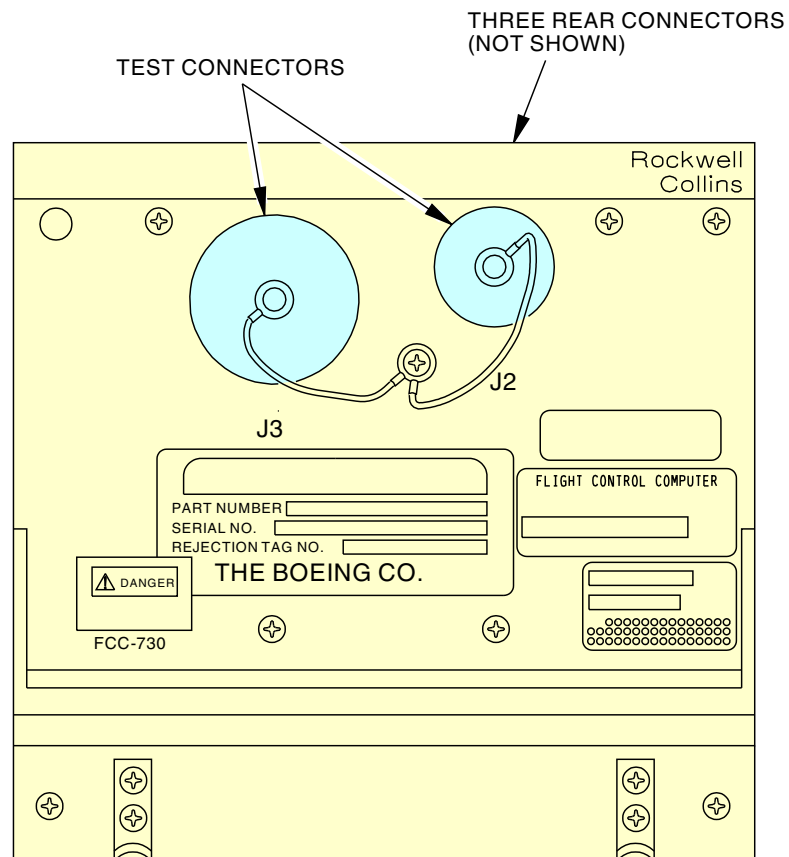
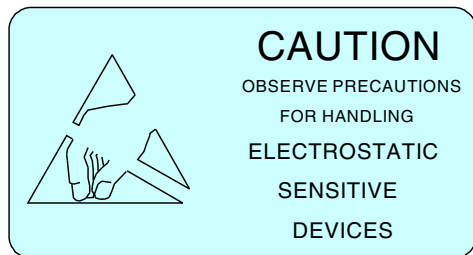
Physical Description

The FCC is 6 MCU in size. Any connector on the back is for interface signals and test connectors with covers are on the front. The two FCCs are the same and interchangeable line replaceable units (LRU).

**CAUTION**

DO NOT TOUCH THE FCC BEFORE YOU DO THE PROCEDURE FOR DEVICES THAT ARE SENSITIVE TO ELECTROSTATIC DISCHARGE. ELECTROSTATIC DISCHARGE CAN CAUSE DAMAGE TO THE FCC.

DFCS - FLIGHT CONTROL COMPUTER - PHYSICAL DESCRIPTION



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DFCS - FLIGHT CONTROL COMPUTER - PHYSICAL DESCRIPTION

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**DFCS - FLIGHT CONTROL COMPUTER - FUNCTIONAL DESCRIPTION****General**

The flight control computer (FCC) is a digital computer. It takes inputs from many systems to calculate the flight control signals. The FCC contains these components:

- Direct memory access (DMA) system
- Computer processing units (CPUs) 1 and 2
- Program memory
- Power supply.

DMA System

The DMA system has these components:

- DMA I/O devices
- DMA controller
- DMA RAM.

The FCC can receive and send these types of data:

- Digital
- Analog
- Discrete.

The DMA I/O devices receive ARINC 429 data or convert analog and discrete signals to ARINC 429 data. This data then goes to the DMA controller. The DMA I/O devices also convert ARINC 429 data to analog and discrete signals before it goes to other systems.

The DMA controller controls all data to and from the FCC and all data between CPU 1 and CPU 2. It keeps the data in the DMA RAM.

CPUs

Each FCC has two 16-bit CPUs. The two processors have different part numbers to make sure that a design problem is not in both processors. The CPUs calculate different commands. This prevents a failure of both autopilot (A/P) pitch and roll commands at the same time.

The CPU 1 calculates these commands:

- Flight director (F/D) pitch and roll commands
- Mach trim commands
- Stabilizer and speed trim system commands
- Altitude alert commands
- A/P roll commands in cruise and approach
- A/P pitch commands in cruise
- A/P alternate pitch commands in approach
- Autoland (approach, flare, go-around) monitor
- Aileron limiter signals
- Engage/interlock high signal
- Mode and annunciator warning logic.

The CPU 2 calculates these commands:

- A/P pitch commands in approach
- A/P alternate roll commands in approach
- Stabilizer and speed trim system warnings
- Aileron limiter monitor
- Autoland monitor
- Engage/interlock low signal
- Software data loader.

When in the approach mode, the CPUs calculate the same roll and pitch commands. The CPUs compare these commands before they send them to the A/P actuators. When in autoland, the two processors look at sensor data to make sure the control surfaces move correctly. Also, both CPUs continue to look at engage and interlock signals.

If the commands or signals do not agree, either CPU can disengage the autopilot. This occurs because the MCP needs the high and the low engage/interlock signal to engage the autopilot and keep it engaged. The CPU 1 can remove the high signal and the CPU 2 can remove the low signal.

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**DFCS - FLIGHT CONTROL COMPUTER - FUNCTIONAL DESCRIPTION****Program Memory**

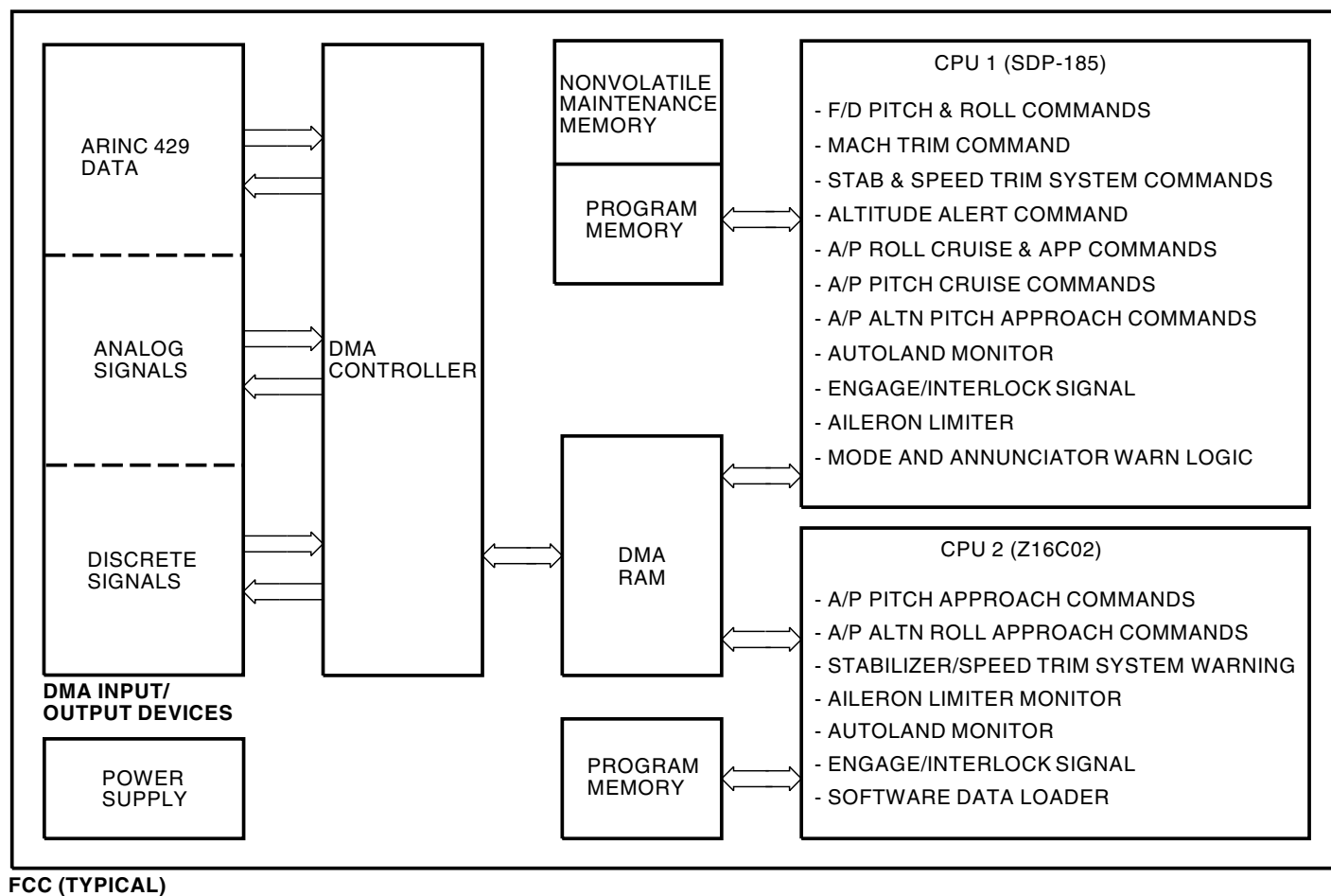
Each CPU has its own memory to keep data and calculate commands. The CPU 1 also has access to the nonvolatile maintenance memory to keep BITE data as it occurs.

Power Supply

The power supply gets 28V DC and 115V AC. It changes the 28V DC to 14V AC, 1800 Hz for control surfaces position sensors. It changes the 28V DC to several other DC voltages for use within the FCC. It also changes the 115V AC to 26V AC for the mach trim actuator.

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DFCS - FLIGHT CONTROL COMPUTER - FUNCTIONAL DESCRIPTION



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DFCS - FLIGHT CONTROL COMPUTER - FUNCTIONAL DESCRIPTION

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**DFCS - CONTROL SURFACE POSITION SENSORS****Single Synchro Sensor**

A single synchro sensor has one synchro and only one output. The stabilizer position sensor B is the only single synchro sensor. This sensor is not interchangeable with the dual sensors.

Dual Synchro Sensors

A dual synchro sensor has two synchros with two outputs. The dual synchro sensors measure the position of these control surfaces:

- Aileron
- Elevator
- Elevator neutral shift
- Stabilizer (sensor A).

These sensors are the same and are interchangeable.

Aileron Position Sensor

The aileron position sensor measures the movement of the aileron input torque tube. One output of the sensor goes to the FCC A and the other goes to the FCC B.

Elevator Position Sensor

The elevator position sensor measures the movement of the elevator lower input torque tube. One output of the sensor goes to the FCC A and the other goes to the FCC B.

Elevator Neutral Shift Sensor

The horizontal stabilizer and the elevator operate together to supply pitch control of the airplane. For each position of the horizontal stabilizer, there is one position of the elevator that makes the two operate together as one control surface. This is the neutral shift position. The elevator neutral shift sensor supplies an electrical signal that is in proportion to the elevator neutral reference position. The elevator neutral shift sensor measures the movement of the elevator feel and centering unit. One output of the sensor goes to the FCC A and the other output goes to the FCC B.

Spoiler Position Sensors

The spoiler position sensors measure the movement of spoilers. One output of the sensor goes to the FCC A and the other goes to the FCC B.

Stabilizer Position Sensor A

The stabilizer position sensor A measures the position of the horizontal stabilizer. One output of the sensor goes to the FCC A and the other goes to the flight data acquisition unit (FDAU).

Stabilizer Position Sensor B

The stabilizer position sensor B measures the position of the horizontal stabilizer. The output of the sensor goes to the FCC B.

Physical Description

The dual synchro sensor is a cylindrical unit. It is 5.3 inches long and 1.6 inches in diameter. The sensor weighs 0.75 pounds.

The single synchro sensor is a cylindrical unit. It is 4.4 inches long and 1.3 inches in diameter. This sensor weighs 0.4 pounds.

The two sensors turn +/- 140 degrees. There are index marks on the case and the input shaft of the sensor. These marks help align the sensor.

Functional Description

The two-wire input to the synchros comes from the FCCs. It is 14V AC at a frequency of 1800 Hz. The three-wire output can change from 0V AC to 6.36V AC as the input shaft turns from 0 degrees to +140 degrees. It can change from 0V AC to 6.36V AC with a phase change of 180 degrees as the input shaft turns from 0 degrees to -140 degrees.

Training Information Point

Examine the alignment reference marks when you install a position sensor.

The DFCS BITE current status test finds a failure of the sensors. You use the DFCS BITE rigging tests to do a check of the sensor adjustment. You also use DFCS BITE analog sensors test to see the sensor output.

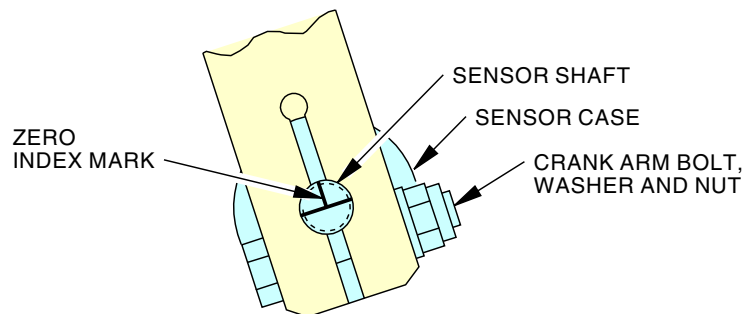
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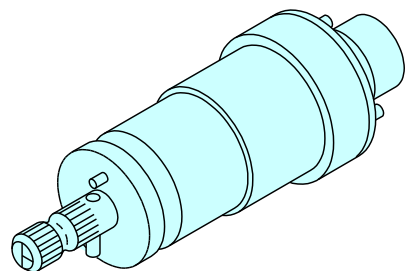
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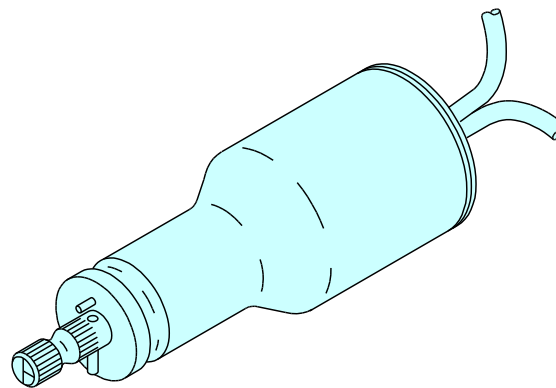
DFCS - CONTROL SURFACE POSITION SENSORS



POSITION SENSORS INSTALLATION



SINGLE SYNCHRO POSITION SENSOR



DUAL SYNCHRO POSITION SENSOR

DFCS - CONTROL SURFACE POSITION SENSORS

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DFCS - CONTROL WHEEL STEERING FORCE TRANSDUCER

General

The purpose of the control wheel steering (CWS) force transducer is to supply electrical signals which vary in proportion to the force on the transducer. These are the CWS force transducers on the airplane:

- Captain pitch CWS force transducer
- First officer pitch CWS force transducer
- Roll CWS force transducer.

The pitch transducers measure the force on each control column. The roll transducer measures the force on either control wheel.

Physical Description

The force transducer is a cylindrical unit. It is 5 inches long and 2.25 inches in diameter.

Functional Description

The force transducer has two sensors. Each sensor is a linear variable differential transformer (LVDT). One output goes to the FCC A and the other goes to the FCC B.

The transducer has a spring assembly with two coils and two armatures. A bearing assembly is at each end of the transducer. You use the bearing assembly to install the unit. The transducers are adjustable. There are stops to prevent the spring assembly from being extended too far.

The input to the force transducer is 26V AC at 400 Hz. The output changes from 0V AC to 6.2V AC as the force changes from 0 pounds to +119 pounds. It can change from 0V AC to 6.2V AC with a phase change of 180 degrees as the input force changes from 0 to -119 pounds.

Training Information Point

The DFCS BITE status test can find a failure of the force transducer. You use the DFCS BITE rigging test to do a check of the transducer adjustment. You also use the DFCS BITE analog sensors test to see the transducer output.

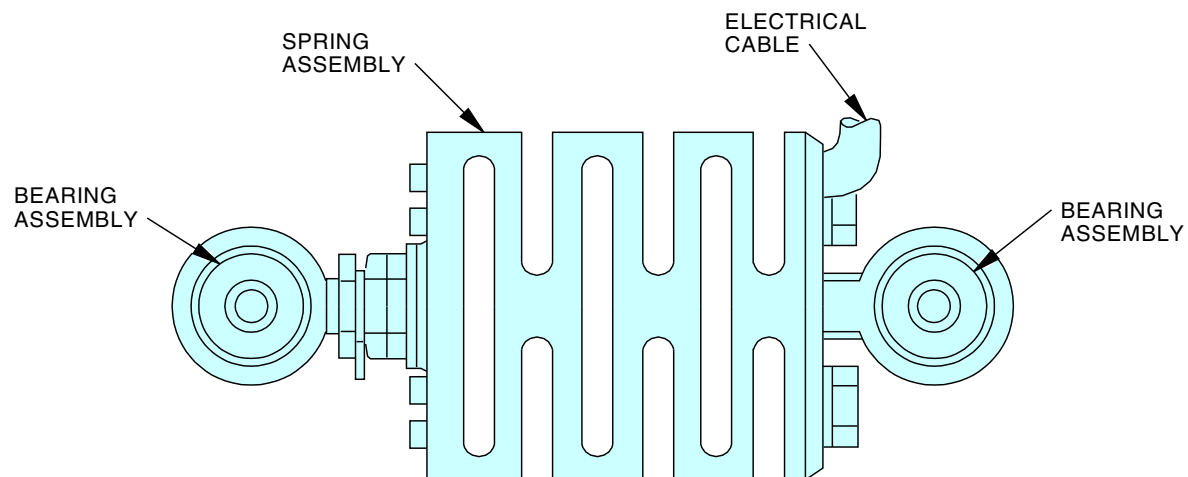
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DFCS - CONTROL WHEEL STEERING FORCE TRANSDUCER



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DFCS - CONTROL WHEEL STEERING FORCE TRANSDUCER

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DFCS - ROLL CWS FORCE TRANSDUCER - LOCATION

Roll CWS Force Transducer Component Locations

You attach one end of the roll CWS force transducer to the bus drum assembly. You attach the other end to the control drum assembly.

Roll CWS Force Transducer Operation

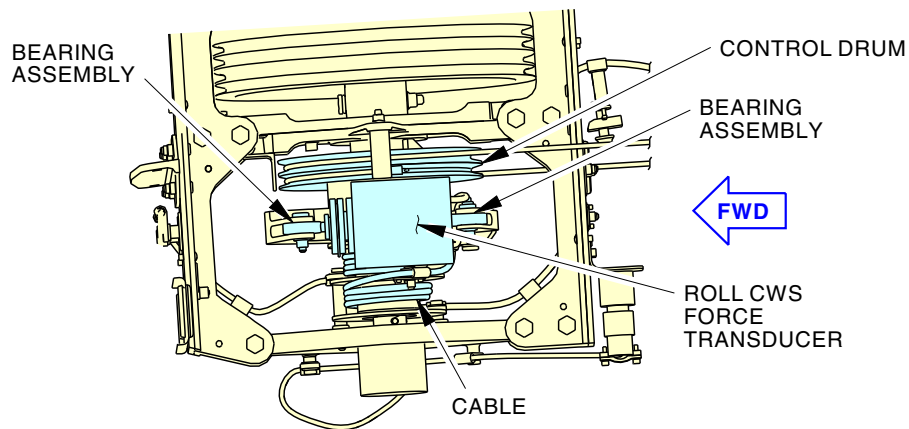
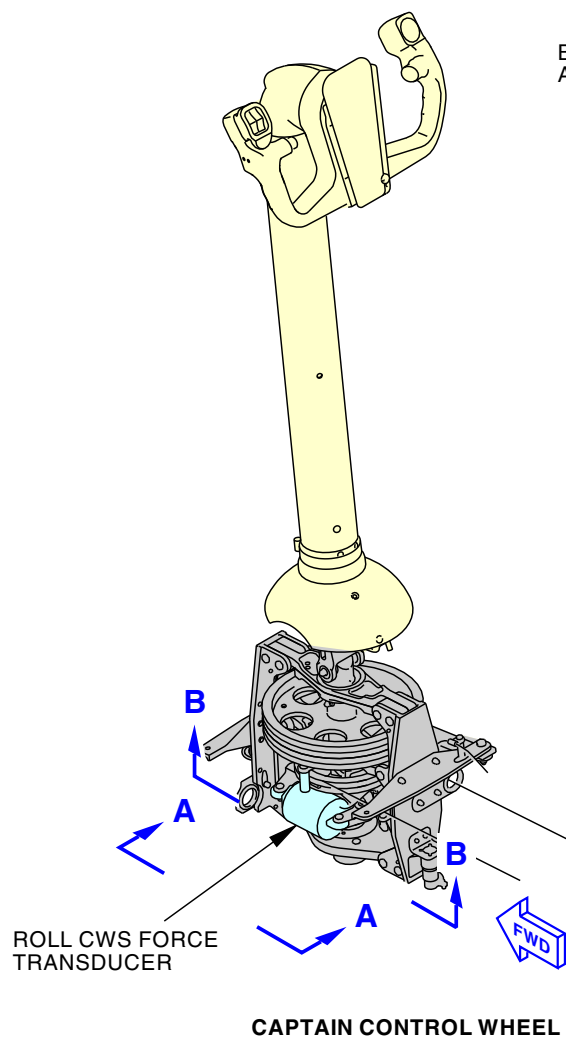
When the autopilot is disengaged and the pilot turns the control wheel, the bus drum turns. This causes the right arm that is attached to the force transducer to turn. The force transducer is very rigid so it turns the left arm which causes the control drum to turn. This moves the aileron cables to the aileron input torque tube and causes the ailerons to move.

When the autopilot is engaged, the aileron A/P actuator is pressurized and the actuator holds the aileron input torque tube so it cannot move. This does not let the control drum turn so the left arm that is attached to the force transducer cannot move. When the pilot turns the control wheel, the right arm attached to the force transducer compresses or expands the force transducer. The shim clearance area allows the movement of the right arm. This provides the electrical signal to the FCCs. The FCCs send a command to the aileron A/P actuator to move the input torque tube and then the ailerons.

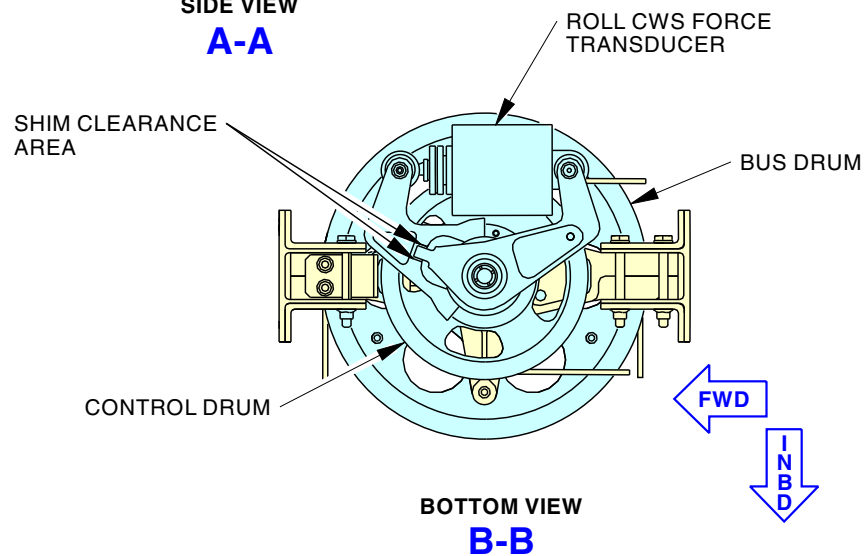
If the force transducer breaks, the tab on the right arm contacts the gap edge of the left arm and the bus drum rotation turns the control drum.

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DFCS - ROLL CWS FORCE TRANSDUCER - LOCATION



SIDE VIEW
A-A



BOTTOM VIEW
B-B

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DFCS - ROLL CWS FORCE TRANSDUCER - LOCATION

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**DFCS - PITCH CWS FORCE TRANSDUCER - LOCATIONS****Pitch CWS Force Transducers Locations**

There are two pitch CWS force transducers. One transducer is on the control quadrant at the lower end of the captain control column. The other one is on the control quadrant at the lower end of the first officer control column.

Pitch CWS Force Transducer Operation

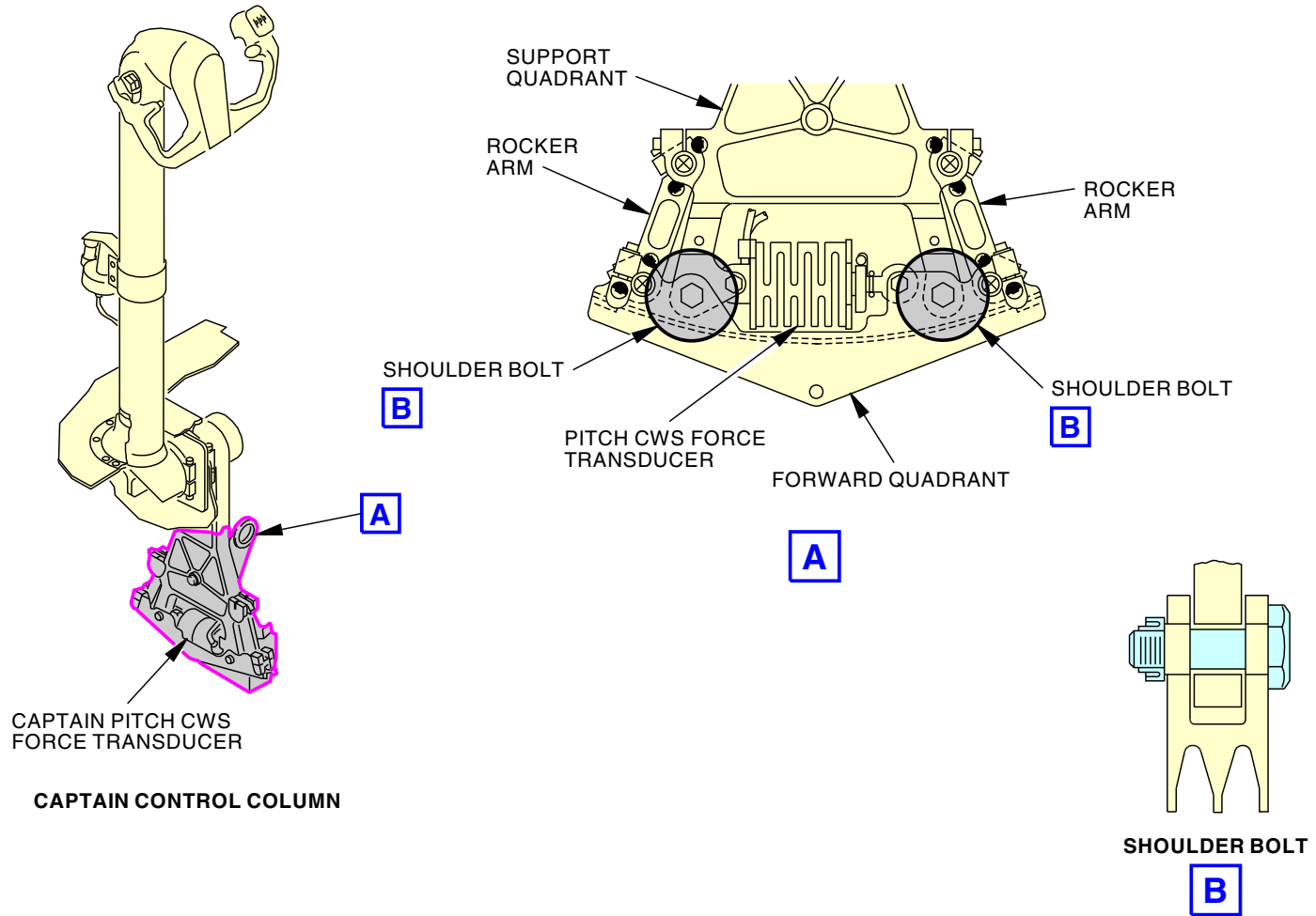
When the autopilot is disengaged and the pilot moves the control column, the support quadrant turns. This causes the left arm of the support quadrant that is attached to the force transducer to move. The force transducer is very rigid so it moves which causes the forward quadrant to turn. This moves the elevator cables to the elevator input torque tube and causes the elevator to move.

When the autopilot is engaged, the elevator A/P actuator is pressurized and the actuator holds the elevator input torque tube so it cannot move. This does not let the forward quadrant move so the right attachment to the force transducer cannot move. When the pilot moves the control column, the left support quadrant arm attached to the force transducer compresses or expands the force transducer. The shoulder bolt allows the movement of the left arm. This provides the electrical signal to the FCCs. The FCCs send a command to the elevator A/P actuator to move the input torque tube and then the elevator.

If the force transducer breaks, the support quadrant contacts the center of the shoulder bolts and the forward quadrant turns to move the elevator control cables.

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DFCS - PITCH CWS FORCE TRANSDUCER - LOCATIONS



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DFCS - PITCH CWS FORCE TRANSDUCER - LOCATIONS



DFCS - AUTOPILOT ACTUATOR - INTRODUCTION

Purpose

The purpose of the autopilot actuator is to change electrical commands from the FCC into a hydraulically controlled mechanical output. The outputs of the actuators become inputs to the aileron and the elevator power control units (PCU). The PCUs move the control surfaces.

Operation

There are four autopilot actuators on the airplane. They operate independently. Two actuators control the ailerons and two actuators control the elevators. One aileron and one elevator actuator receive electrical signals from the FCC A. These actuators get hydraulic pressure from hydraulic system A. The other aileron and elevator actuator receives electrical signals from the FCC B. These actuators get hydraulic pressure from hydraulic system B.

You can control the ailerons with only aileron actuator A or aileron actuator B. In the dual mode, you use the two aileron actuators A and B together. This is also the way the elevator actuators operate.

Shear rivets on the actuator output cranks protect against jams inside the actuator. The pilot can override any jam with the application of approximately 100 pounds at the controls. This will break the shear rivets.

Physical Description

The actuator is approximately 17.5 inches long, 7.5 inches wide and about 6.0 inches high. The actuator weighs approximately 15.5 pounds with no hydraulic fluid in it.

These are the line replaceable units (LRU) on the actuator:

- Actuator solenoid valve
- Detent solenoid valve
- Electrohydraulic servo valve
- Hydraulic pressure switch.

The linear variable differential transformer (LVDT) measures the position of the actuator main piston. It is not an LRU.

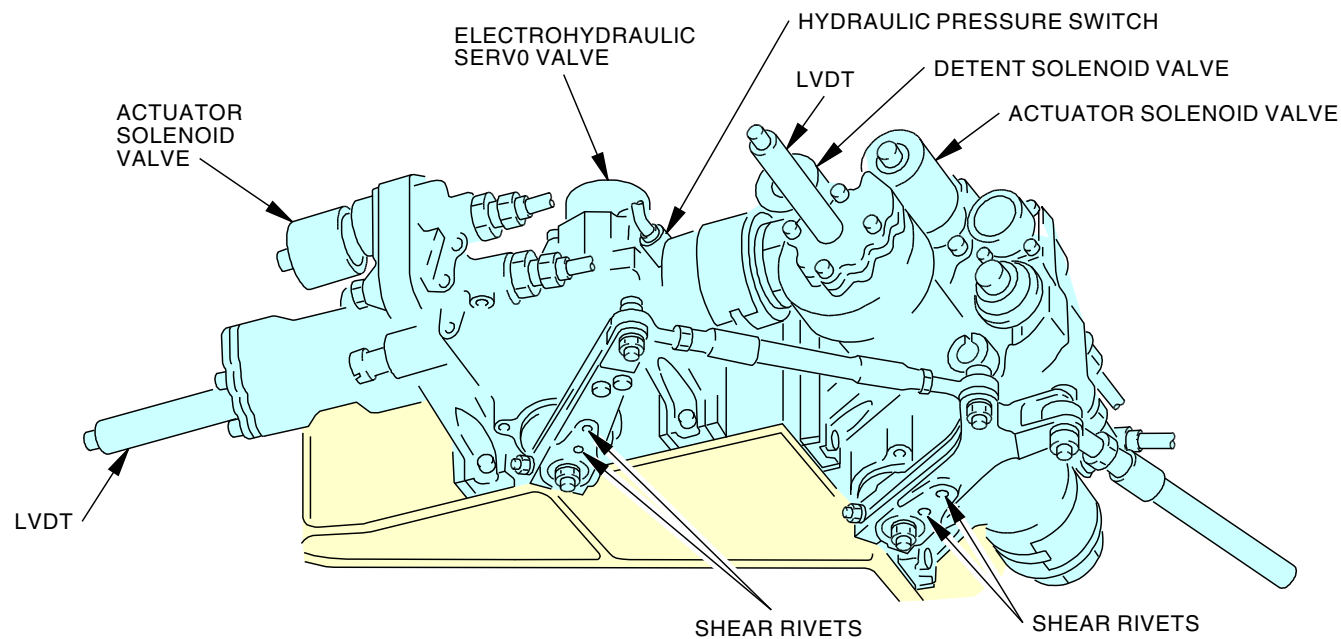
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DFCS - AUTOPILOT ACTUATOR - INTRODUCTION



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DFCS - AUTOPILOT ACTUATOR - INTRODUCTION

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**DFCS - AUTOPILOT ACTUATOR - FUNCTIONAL DESCRIPTION****General**

The autopilot actuator changes an electrical signal from the FCC to a hydraulic pressure. This moves the main piston and the output crank. The actuator position sensor supplies a signal to the FCC.

Before Autopilot Engagement

The actuator solenoid is not energized before engagement of the autopilot. This prevents hydraulic pressure in the autopilot actuator. Without hydraulic pressure, the detent piston springs move the detent pistons away from the internal output crank. This lets the output crank move freely as the control surfaces move.

Autopilot Engagement

When you engage the autopilot, a signal from the mode control panel (MCP) energizes the actuator solenoid. This pressurizes the electrohydraulic servo valve and the detent solenoid. The detent control engage orifice that is between the actuator and detent solenoids does these two things:

- It keeps the maximum flow to the pressure regulator to a limit to protect from hydraulic overpressure
- Gives a time delay for synchronization.

Synchronization of the Autopilot Actuator

The control surface position sensor (aileron or elevator) sends a signal through the FCC to the electrohydraulic servo valve. This moves the main piston to a position that aligns with the position of the internal output crank. When this is synchronized, it prevents a sudden movement of the control surface when the FCC engages the detent solenoid.

After the main piston and the internal output crank are synchronized, the FCC sends a signal to energize the detent solenoid. This pressurizes the detent pistons and they touch the sides of the internal output crank. The pressure regulator keeps the hydraulic pressure at a safe limit. The hydraulic pressure also closes the hydraulic pressure switch. The switch sends a signal to the FCC to show that the autopilot actuator is ready to operate.

Normal Operation

A command signal from the FCC A/P to the electrohydraulic servo valve causes the main piston to move. A movement of the main piston now causes a movement of the output crank and the control surface. The rate limiting orifices control the rate of movement of the main piston.

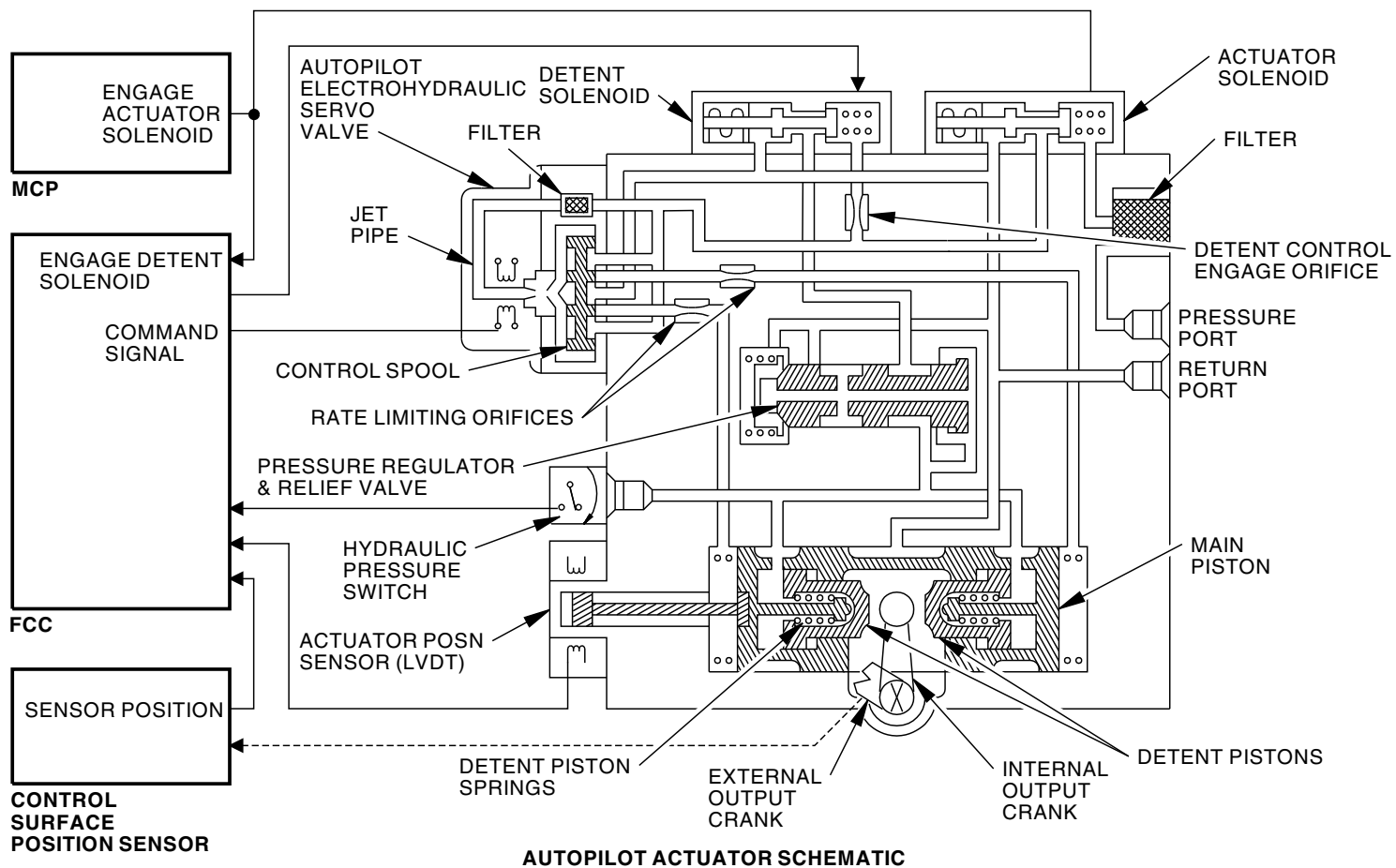
Camout

A camout condition is when the main piston moves but the detent pistons cannot move with the main piston. Therefore, the output crank does not move with the main piston. Camout lets the pilot mechanically override the autopilot and also gives protection against hardover failures.

Mechanical Override

When CWS is not the active mode, the pilot can mechanically override the autopilot actuator. A force of approximately 25 pounds on the control column or wheel can override the actuator. If both channels A and B are active, approximately 50 pounds of force is necessary to override the two actuators. The relief valve opens when override pressure goes to the detent pistons.

DFCS - AUTOPILOT ACTUATOR - FUNCTIONAL DESCRIPTION



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DFCS - AUTOPILOT ACTUATOR - FUNCTIONAL DESCRIPTION

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**DFCS - AUTOPILOT ACTUATOR - ELECTROHYDRAULIC SERVO VALVE****Purpose**

The purpose of the electrohydraulic servo valve is to get an electrical signal from the FCC and control the hydraulic pressure to the main piston.

Physical Description

The electrohydraulic servo valve is approximately 1.5 inches high and about 1.6 inches in diameter. It weighs approximately 1 pound. These are the four hydraulic ports:

- Input pressure port for the jet pipe controller
- Return port
- Two output ports for the two sides of the main piston.

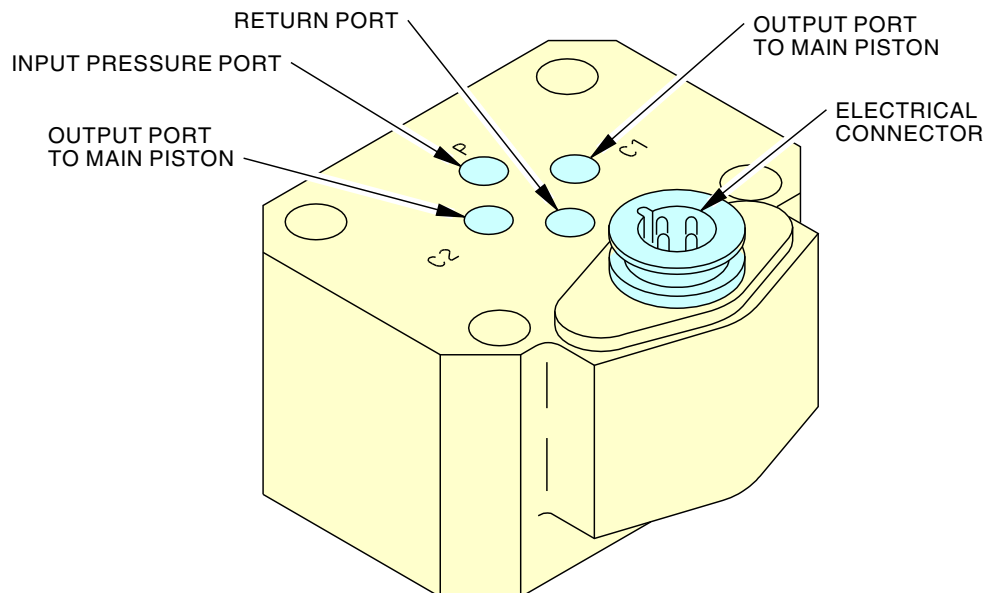
A four pin electrical connector attaches the wires from the FCC.

Functional Description

When an electrical signal comes from the FCC, it moves the jet pipe in the electrohydraulic servo valve. This causes the pressure at each end of the control spool to change. This causes the control spool to move which changes the output pressure in each of the two output ports. The autopilot actuator uses this change in the output lines to move the main piston.

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DFCS - AUTOPILOT ACTUATOR - ELECTROHYDRAULIC SERVO VALVE



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DFCS - AUTOPILOT ACTUATOR - ELECTROHYDRAULIC SERVO VALVE

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**DFCS - AUTOPILOT ACTUATOR - HYDRAULIC PRESSURE SWITCH****Purpose**

The purpose of the hydraulic pressure switch is to tell the FCC when the detent hydraulic pressure gets to the operational level. The autopilot actuator is then ready to get signals from the FCC to move the control surfaces.

Physical Description

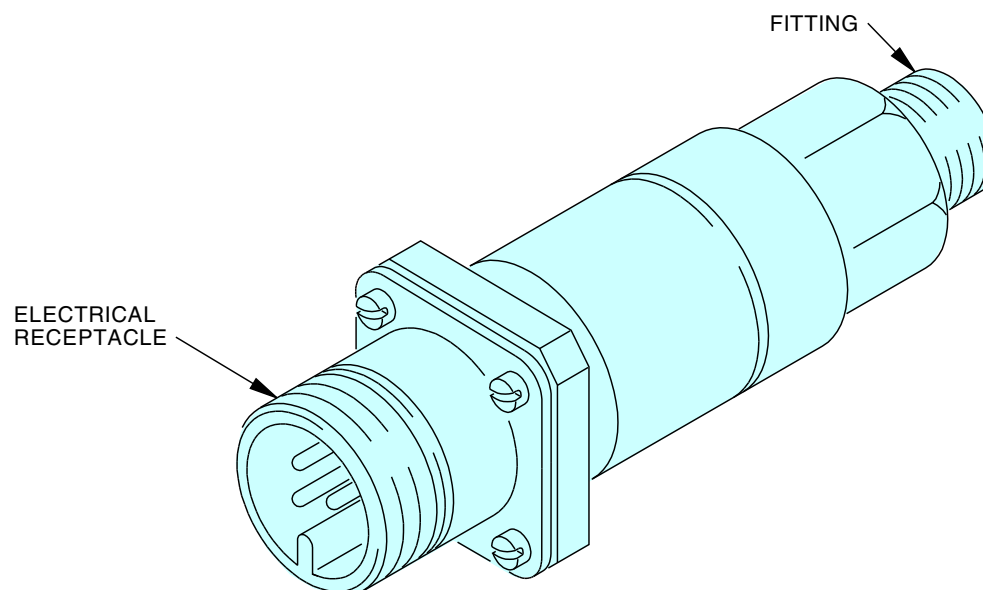
The switch is approximately 3.6 inches long and has a maximum diameter of approximately 1.0 inches. The switch weighs approximately 3.1 ounces. One end of the switch has a fitting. It attaches to the autopilot actuator. The other end has a receptacle. It attaches to an electrical connector.

Functional Description

The switch energizes when the hydraulic pressure increases between 300 and 500 psi. The switch disconnects when the pressure decreases to between 500 and 300 psi.

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DFCS - AUTOPILOT ACTUATOR - HYDRAULIC PRESSURE SWITCH



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DFCS - AUTOPILOT ACTUATOR - HYDRAULIC PRESSURE SWITCH

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**DFCS - AUTOPILOT ACTUATOR - SOLENOID VALVES****Purpose**

The purpose of the solenoid valves (both actuator and detent solenoids) is to open its valve when it receives an electrical signal. When the valve opens, it lets hydraulic pressure go to the components within the autopilot actuator.

Physical Description

Each solenoid is approximately 2.8 inches high and 1.7 inches in diameter. the solenoid weighs approximately .7 pounds. These are the three hydraulic ports in the solenoid:

- Pressure for input hydraulic pressure
- Return for the hydraulic fluid to go to the reservoir
- Cylinder for the output of hydraulic pressure.

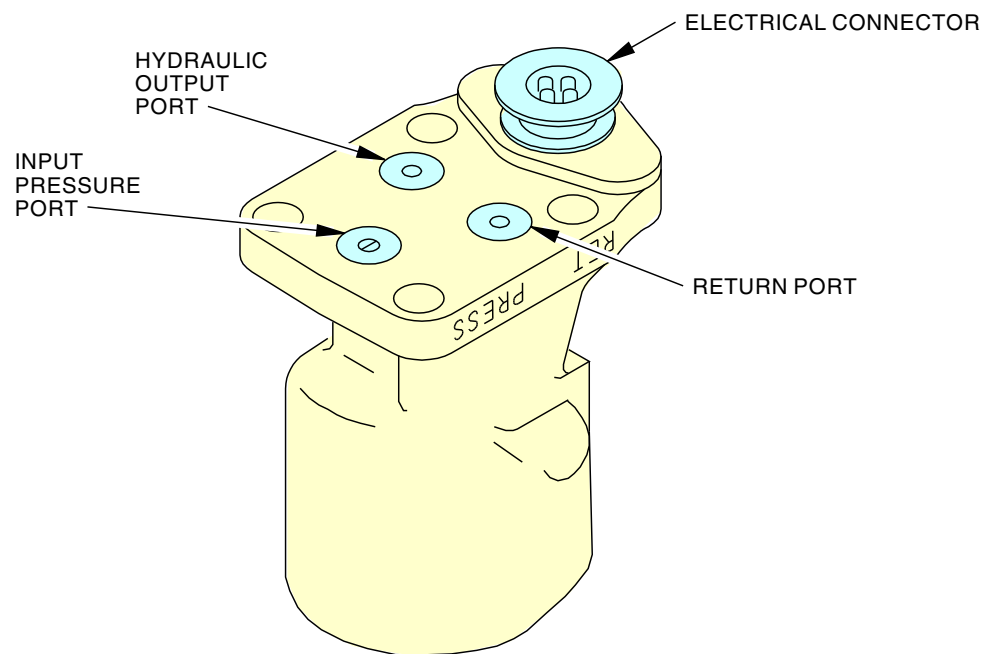
An electrical connector attaches the wires from the FCC.

Functional Description

When the solenoid receives an electrical signal, it energizes a hydraulic relay. This lets the hydraulic pressure go from the pressure port to the cylinder port. When the electrical signal stops, the pressure at the cylinder port goes to return.

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DFCS - AUTOPILOT ACTUATOR - SOLENOID VALVES



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DFCS - AUTOPILOT ACTUATOR - SOLENOID VALVES

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**DFCS - AUTOFLIGHT STATUS ANNUNCIATOR****Purpose**

The purpose of the autoflight status annunciator is to show these annunciations:

- Autopilot warning
- Autopilot disconnect
- Start BITE test
- Autothrottle (A/T) disengage
- Airspeed Warning
- Alert messages on the FMC or an FMC fails.

Physical Description

The autoflight status annunciator is 3.25 in. (8.25 cm) wide, 1.5 in. (3.8 cm) high and approximately 5.2 in. (13.2 cm) deep. The annunciator weighs approximately 1.1 lb (0.5 kg).

Three warning light annunciators are on the front. The color of the A/P light can be red or amber. The color of the A/T light can be red or amber. The FMC light can only be amber. There is also a three position switch that you can use to do a test of the lights.

Operation

When you push the test switch to the number 1 position, all three annunciator lights come on amber. When you push the test switch to the number 2 position, the A/P and A/T annunciators come on red. The FMC annunciator comes on amber.

If the A/P annunciator flashes red, you can turn off that light if you push the annunciator. If the A/T annunciator flashes red, you can turn off that light if you push the annunciator. If the FMC annunciator is amber, you can turn off that light if you push the annunciator.

Warning Annunciations

The red A/P annunciator flashes when an A/P disconnects. The red A/P annunciator comes on steady when any of these conditions occurs:

- DFCS is in BITE
- The foreign FCC part number is invalid
- The power up test fails on the ground
- The MCP bus fails when the airplane is in A/P pitch G/A
- The airplane is above 400 feet and cannot exit A/P G/A to altitude acquire because single channel pitch authority is not available
- The stab out of trim warning is set and the airplane is in dual pitch A/P below 800 feet.

The red A/T annunciator flashes when the A/T disengages. The red A/T annunciator comes on steady when the A/T is in BITE.

The amber A/T flashes when the A/T is in the MCP or FMC SPD mode and the FCC calculates an A/T speed warning. The speed warning occurs when the true airspeed is 10 knots above the target speed or 5 knots below the target airspeed and is not accelerating to the target speed. The flaps must be down for the warning to occur.

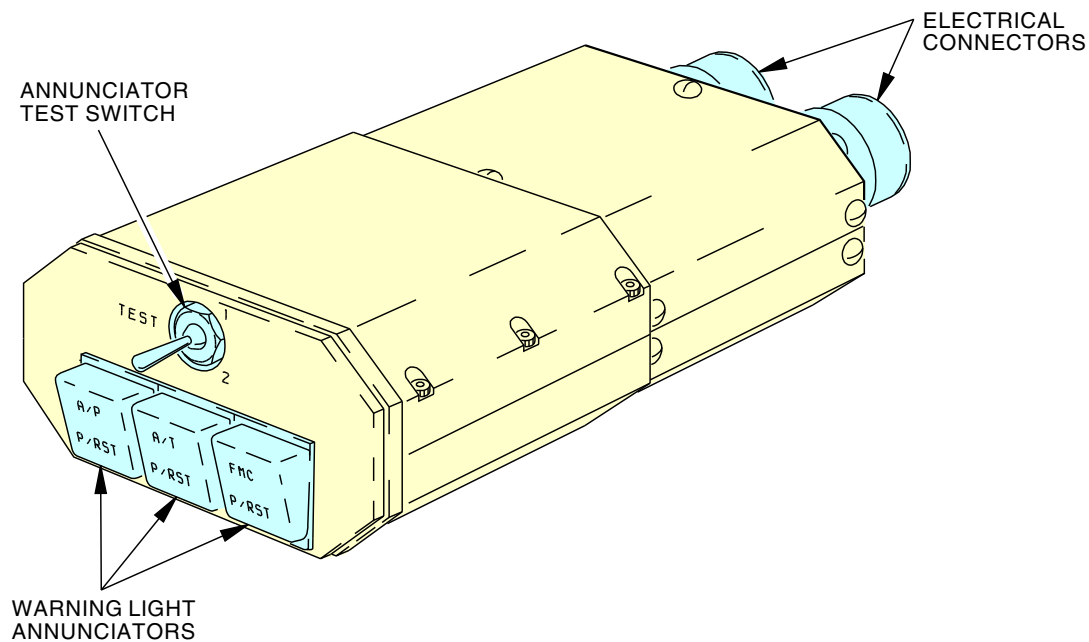
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DFCS - AUTOFLIGHT STATUS ANNUNCIATOR



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DFCS - AUTOFLIGHT STATUS ANNUNCIATOR

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DFCS - AUTOFLIGHT STATUS ANNUNCIATOR - FUNCTIONAL DESCRIPTION

General

The autoflight status annunciator has these functions:

- Autopilot (A/P) system annunciations
- Autothrottle (A/T) system annunciations
- Flight management computer system (FMCS) annunciations.

A/P System Annunciations

A ground signal can turn on the red or the amber A/P annunciator lights. When you push the A/P annunciator, a reset signal goes from the annunciator to the FCCs and the mode control panel (MCP). This also turns off the A/P annunciator if it flashes red or flashes amber.

A/T System Annunciations

A ground signal can turn on the red or the amber A/T annunciator lights. When you push the A/T annunciator, a reset signal goes from the annunciator to the FCCs and the A/T computer. This also turns off the A/T annunciator if it flashes red or flashes amber.

FMCS Annunciations

A ground signal can turn on the amber FMC annunciator light. Either an FMC failure or an FMC alert message sets one logic circuit in the annunciator. This turns on an electronic switch which sends a ground to the FMC amber light. This keeps the amber light on. When you push the FMC annunciator, a reset signal goes to the logic circuit and resets it so that the light goes off.

Test Switch

When the test switch is in the number 1 position, a ground goes to the A/P and A/T amber lights. A ground also goes to the FMC message logic circuit to turn on the electronic switch. This does a test of the amber lights.

When the test switch is in the number 2 position, a ground goes to the A/P and A/T red lights. A ground also goes to the FMC fail logic circuit to turn on the electronic switch. This does a test of the red A/P and A/T lights and the amber FMC lights.

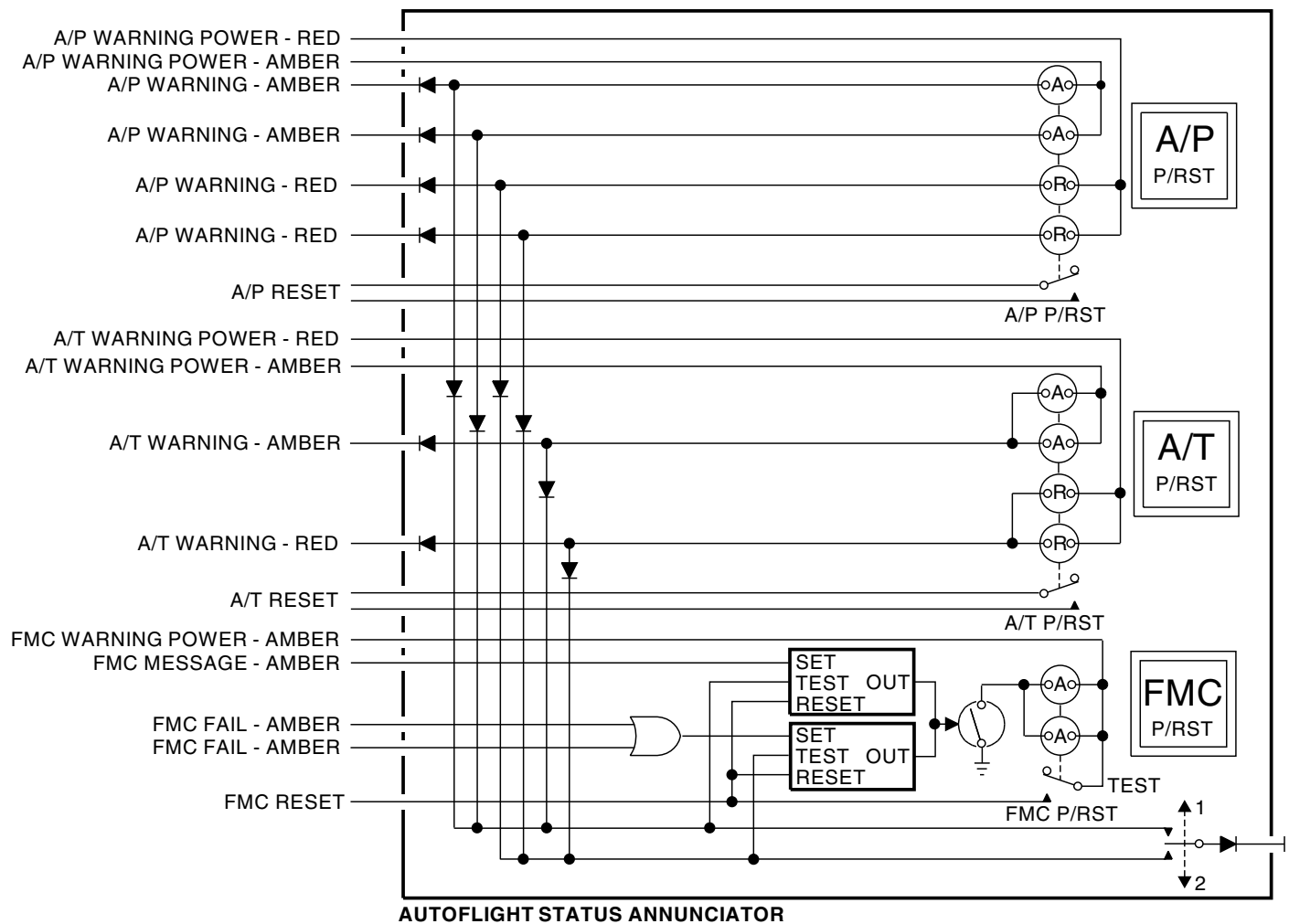
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DFCS - AUTOFLIGHT STATUS ANNUNCIATOR - FUNCTIONAL DESCRIPTION



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DFCS - AUTOFLIGHT STATUS ANNUNCIATOR - FUNCTIONAL DESCRIPTION

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**DFCS - INTEGRATED FLIGHT SYSTEM ACCESSORY UNIT****Purpose**

The purpose of the integrated flight system accessory unit (IFSAU) is to give an interface between the DFCS and the airplane systems.

Physical Description

The IFSAU is a 3 MCU box. It uses a single camloc-type hold down handle to carry the unit and to connect it in the E-1 rack. There are four electrical connectors on the back of the IFSAU.

Functional Description

The IFSAU contains two printed circuit cards. The A1 card is the autopilot card. The A2 card is the flight instrument card.

The A1 card contains electronic components to do these operations:

- Supply 26V AC sensor power
- FCC mach trim selection
- DC bus isolation
- Navigation transfer
- Autoland transfer
- Autoland warning logic.

The A2 card contains electronic components to do these operations:

- VOR/ILS test inhibit
- ADIRU warning/crew call horn
- Right ADIRU five minute power off delay after AC loss
- Isolation diodes.

See the ADIRS section for more information on the operation of the IFSAU.
(SECTION 34-21)

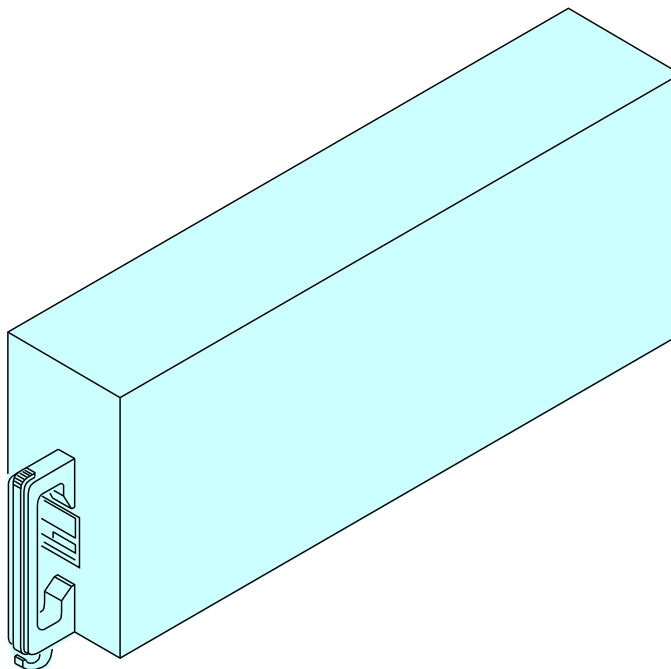
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DFCS - INTEGRATED FLIGHT SYSTEM ACCESSORY UNIT



DFCS - INTEGRATED FLIGHT SYSTEM ACCESSORY UNIT

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

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**DFCS - MACH TRIM ACTUATOR****Purpose**

As the airplane speed gets very fast, the center of lift moves aft and the airplane starts to nose down. This is mach tuck. One purpose of the mach trim actuator is to trim the elevator at these high speeds to raise the nose to correct for mach tuck.

The other purpose of the mach trim actuator is to move the elevator when the airplane is in the FCC controlled neutral shift region (FCNSE). This region occurs when the flaps are not in the up position and either engine N1 is more than 18%. This increases the elevator movement during takeoff.

Physical Description

The mach trim actuator is 9.3 inches long, 4.8 inches wide and 4.0 inches high. The output shaft can move about .5 inches.

Location

The mach trim actuator is on the top of the elevator feel and centering unit. When the actuator moves, it causes the feel and centering unit to turn.

Functional Description

An electric motor turns a gear train that causes the output shaft to move in and out. There is an electric brake that holds the output shaft when the motor is not on. A synchro is on the gear train and an electrical signal tells the FCCs the position of the output shaft.

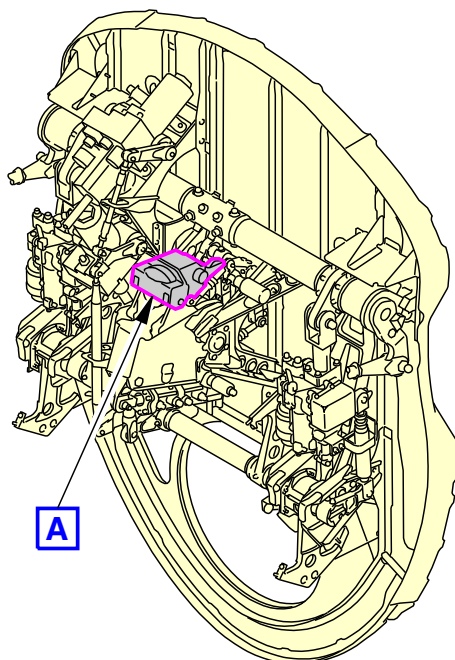
The motor operates with 115V AC 400 Hz power to the fixed phase motor windings. When the motor gets 36V AC 400 Hz power to the phase control winding, it will turn.

Before the motor turns, the brake windings must get 28V DC to release the brake. When you remove power from the control windings, you also remove power from the brake windings. This immediately stops the motor.

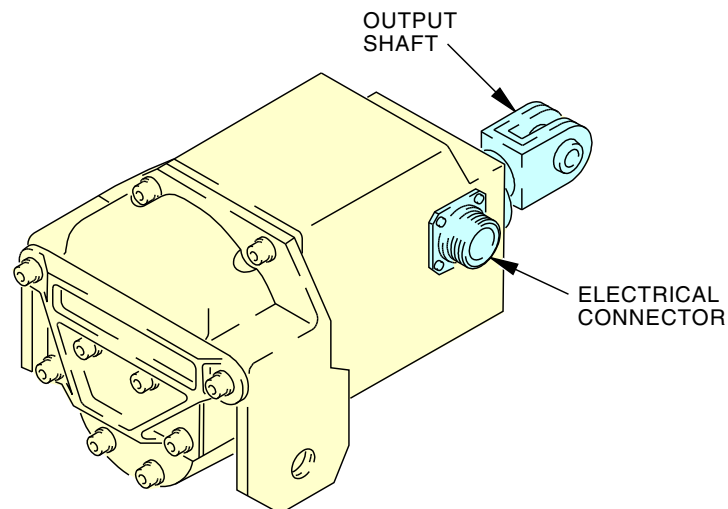
When the position synchro gets 26V AC 400 Hz power, an output voltage goes to the FCCs to show the position of the mach trim actuator.

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DFCS - MACH TRIM ACTUATOR



TAILCONE AREA



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DFCS - MACH TRIM ACTUATOR

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**DFCS - TAKEOFF/GO-AROUND SWITCH****General**

The purpose of the takeoff/go-around (TO/GA) switch is to set the takeoff or the go-around mode for these systems:

- Autothrottle (A/T) system
- Stall management yaw damper (SMYD) system
- Digital flight control system (DFCS).

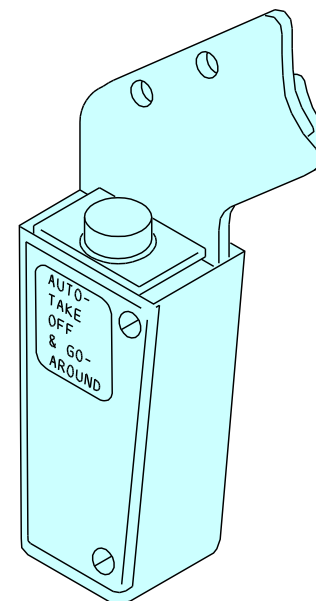
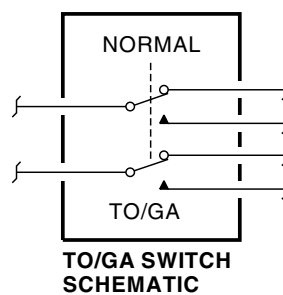
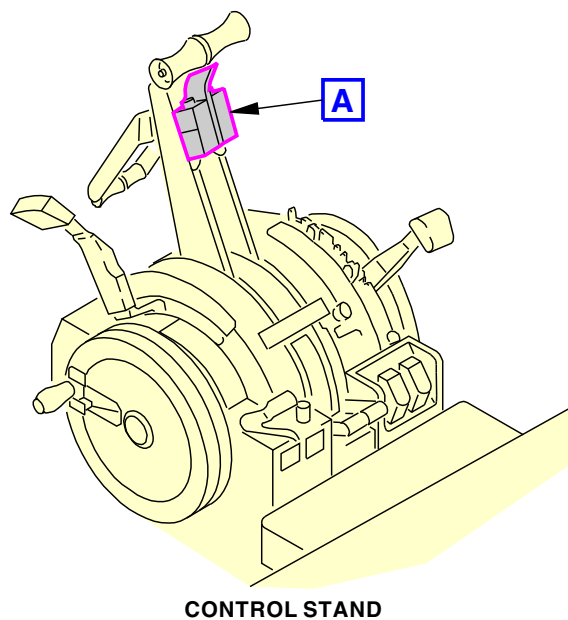
There are two TO/GA switches on the control stand. One switch is on each thrust lever. Each switch is a momentary action pushbutton switch.

Physical Description

The TO/GA switch is approximately 2.5 inches long, 1.1 inches wide, and .9 inches deep.

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DFCS - TAKEOFF/GO-AROUND SWITCH



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DFCS - TAKEOFF/GO-AROUND SWITCH

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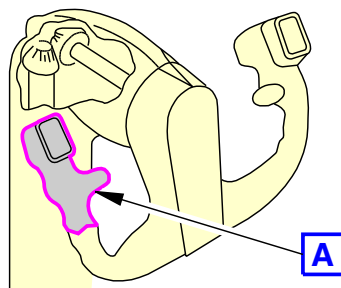
**DFCS - AUTOPILOT DISENGAGE SWITCH****General**

There are two A/P disengage switches. One is on the outboard side of the captain control wheel. The other is on the outboard side of the first officer control wheel. The two switches can disengage both FCCs and turn off both ASAs.

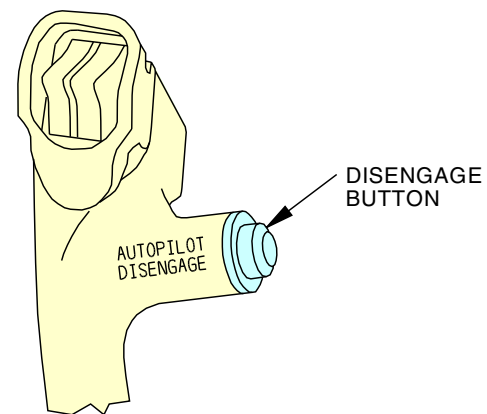
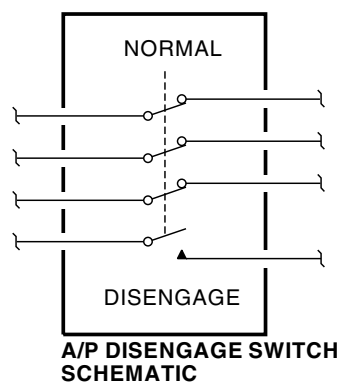
Each switch is a momentary pushbutton switch. Each switch has three normally-closed contacts and one normally-open contact.

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DFCS - AUTOPILOT DISENGAGE SWITCH



CAPTAIN CONTROL WHEEL



AUTOPILOT DISENGAGE SWITCH

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DFCS - AUTOPILOT DISENGAGE SWITCH

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**DFCS - FUNCTIONAL DESCRIPTION - AUTOPILOT CONTROLS****General**

These are the autopilot (A/P) functions of the flight control computer (FCC):

- A/P roll control
- A/P pitch control
- Autoland
- Engage interlocks
- Warning and annunciations
- Stabilizer trim.

The autopilot can control the airplane two ways. In the command (CMD) mode, it controls the airplane automatically with no control column inputs from the pilots. In the control wheel steering (CWS) mode, it controls the airplane using control column inputs from the pilots.

Changes between A/P modes do not supply unwanted movement. Changes between the A/P and flight director (F/D) modes do not supply unwanted movement or F/D commands.

A/P Names

The A/P may be called one of these names:

- Channel A or channel B.
- Local (LCL) or foreign (FGN)
- Master or slave.

The A/P channel A is the A/P from FCC A and the A/P channel B is from FCC B.

For A/P channel A, the LCL A/P is FCC A and the FGN A/P is FCC B. For A/P channel B, the LCL A/P is FCC B and the FGN A/P is FCC A.

When the crew engages one A/P, that A/P is the master and the other A/P is the slave. When the crew engages both A/Ps (dual mode), the first A/P engaged is the master and the second engaged is the slave. The master A/P controls the mode displays on the flight mode annunciator (FMA) and the data that goes to the A/T and FMCS.

A/P Roll Control

The roll control function uses data from several airplane sensors and the roll CWS force transducer to calculate a roll command. The roll command goes to the aileron A/P actuators to move the control surfaces through the aileron PCUs. The FCCs use feedback signals from these sensors to calculate the roll commands:

- Aileron position sensor
- Spoiler position sensors
- Flap position transmitter
- Aileron A/P actuator position sensors.

A/P Pitch Control

The pitch control functions use data from several airplane sensors and the pitch CWS force transducers to calculate a pitch command. The pitch command goes to the elevator A/P actuators to move the control surfaces through the elevator power control units (PCU). The FCCs use feedback signals from these sensors to calculate the pitch commands:

- Elevator position sensor
- Elevator neutral shift sensor
- Stabilizer position sensors
- Flap position transmitter
- Elevator A/P actuator position sensors.

Autoland

The autoland function consists of these parts of the flight path:

- Approach
- Flare
- Go-around.

The autoland function will only operate if both FCC A and FCC B are engaged. The autoland function contains both pitch and roll commands.

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - FUNCTIONAL DESCRIPTION - AUTOPILOT CONTROLS****Engage Interlocks**

The autopilot engage interlock circuits monitor these functions:

- Power
- Operation
- Components.

With normal conditions, the circuits let the autopilot engage. If conditions are not normal, the autopilot disengages or the autopilot will not engage.

Warning and Annunciations

The warning and annunciation function sends normal and non-normal indications of the autopilot performance to these components:

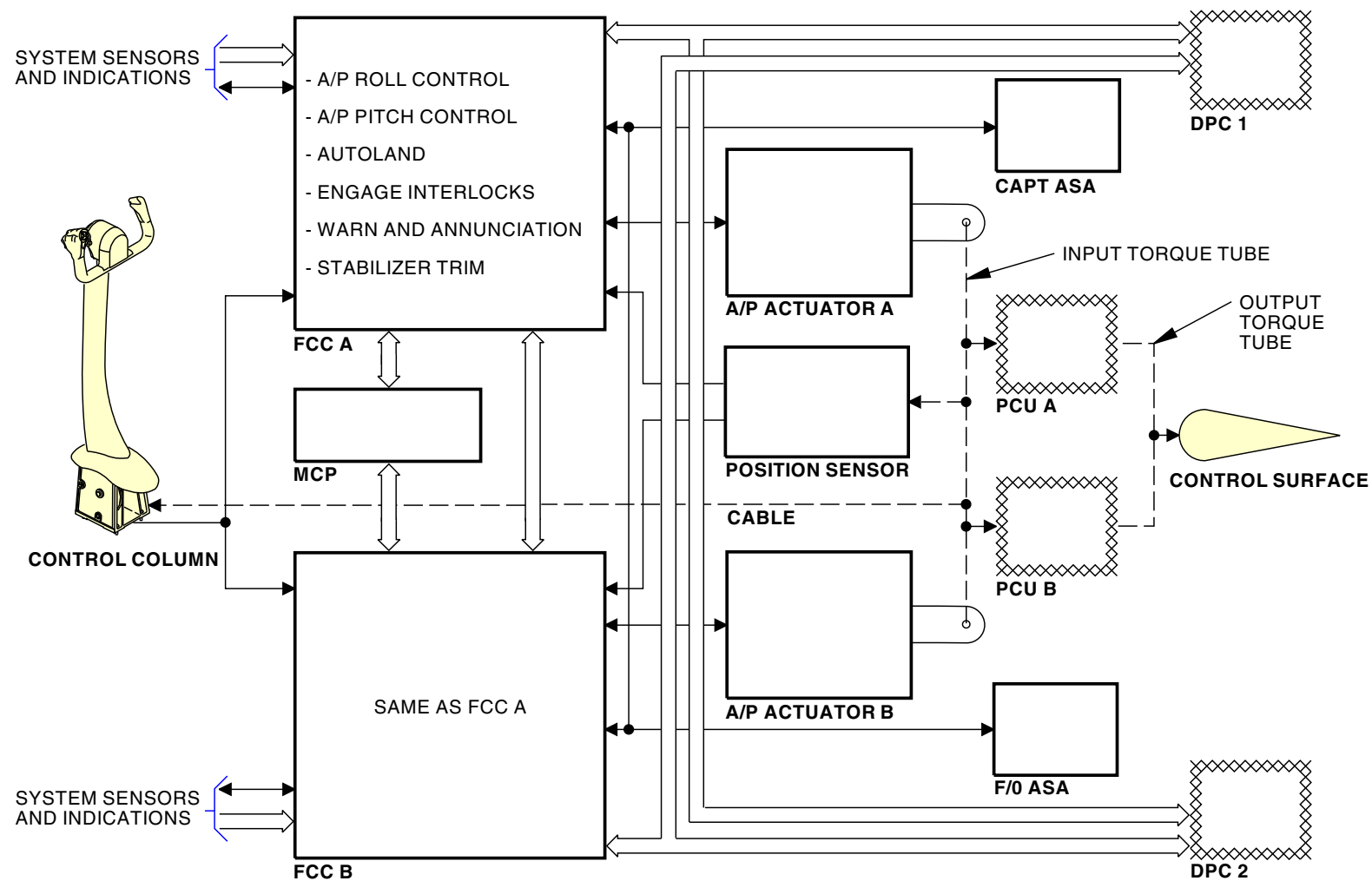
- Captain autoflight status annunciator (ASA)
- First Officer ASA
- The display processing computer (DPC)
- Flight control panel
- MCP IAS/MACH indicator
- Stab out of trim light.

Stabilizer Trim

When the autopilot is engaged, it sends trim commands to the stabilizer. The stabilizer trim system uses the same stab trim electric actuator that the speed trim system uses.

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DFCS - FUNCTIONAL DESCRIPTION - AUTOPILOT CONTROLS



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DFCS - FUNCTIONAL DESCRIPTION - AUTOPILOT CONTROLS



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**DFCS - FUNCTIONAL DESCRIPTION - A/P ROLL CONTROL****General**

The FCC calculates the aileron commands for the roll modes that go to the aileron autopilot actuators. They also calculate the flight director (F/D) commands that go to the DPCs.

The FCCs calculate the roll commands for these roll modes:

- Lateral navigation (LNAV)
- Heading select (HDG SEL)
- Very high frequency omni range (VOR)
- Localizer (LOC)
- Go-around (G/A)
- Takeoff (T/O).

The crew can also engage the A/P in roll control wheel steering (CWS).

LNAV

In the LNAV mode, the roll command is the LNAV steering command that the FCC gets from the FMC.

HDG SEL

The FCC uses these inputs to calculate the heading select roll command:

- MCP HDG SEL mode selector pushed
- MCP selected heading
- Airplane magnetic heading
- True airspeed
- MCP bank angle limit.

VOR

These are the three submodes of the VOR mode:

- VOR capture
- VOR on-course

- VOR over-station.

The FCC uses these inputs to calculate the VOR roll commands for the three submodes:

- MCP VOR/LOC mode selector pushed
- MCP selected course
- Airplane magnetic track
- VOR omnibearing
- DME distance
- True airspeed
- MCP bank angle limit
- Airplane roll attitude
- Uncorrected altitude.

LOC

These are the three submodes of the LOC mode:

- LOC arm
- LOC capture
- LOC on-course.

The FCC uses these inputs to calculate the LOC roll commands for the three submodes:

- MCP VOR/LOC mode selector pushed
- MCP selected runway heading
- Airplane magnetic track
- Lateral acceleration
- Airplane roll attitude
- Localizer deviation
- Radio altitude
- Glideslope (G/S) engaged.

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - FUNCTIONAL DESCRIPTION - A/P ROLL CONTROL****Roll G/A**

The FCC uses the airplane magnetic track to calculate the roll G/A command.

Roll T/O

The FCC uses these inputs to calculate the roll T/O command:

- MCP selected heading
- Airplane magnetic heading.

Roll CWS

The attitude hold and the heading hold are two submodes of the roll CWS mode. The FCC uses these inputs to calculate the CWS roll commands for the submodes:

- Roll CWS force transducer
- Airplane magnetic heading
- True airspeed
- Airplane roll attitude
- Airplane roll rate.

Autopilot Aileron Commands

The FCC can use the roll commands from all the modes except the roll T/O mode to calculate the autopilot aileron command. The FCC also applies roll limits to the aileron commands. The FCC also uses these signals to calculate the aileron command:

- Airplane roll attitude
- Airplane roll rate
- Roll A/P aileron actuator position
- Aileron Position.

The FCC uses the roll command to calculate the pitch commands to increase the pitch as the airplane rolls.

Flight Director Roll Commands

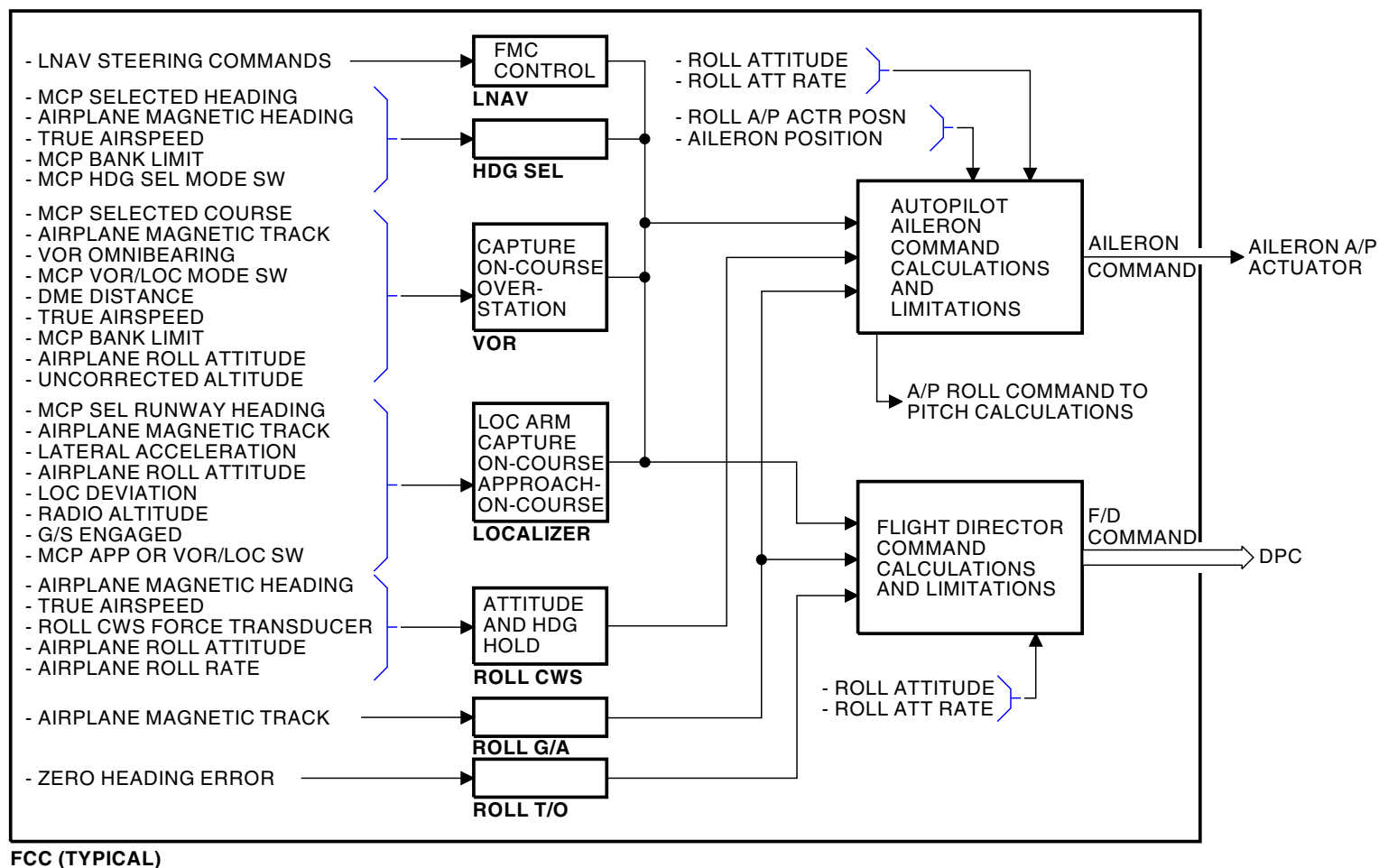
The FCC can use the roll command from all the modes except the roll CWS mode to calculate the F/D commands. The FCC also applies roll limits to the F/D commands. The FCC also uses the airplane roll attitude and roll rate to calculate the F/D commands.

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DFCS - FUNCTIONAL DESCRIPTION - A/P ROLL CONTROL



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DFCS - FUNCTIONAL DESCRIPTION - A/P ROLL CONTROL

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**DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH CRUISE CONTROL****General**

The FCC control laws calculate the elevator commands that go to the elevator autopilot actuators for the pitch modes. They also calculate the F/D commands that go to the DPCs. There are cruise pitch modes and takeoff/approach pitch modes

The FCCs calculate the pitch commands for these cruise pitch modes:

- Vertical navigation (VNAV)
- Altitude acquire (ALT ACQ)
- Altitude hold (ALT HOLD)
- Vertical speed (V/S)
- Level change (LVL CHG).

The crew can also engage the A/P in pitch CWS.

VNAV

The FCC uses these inputs to calculate the VNAV speed (VNAV SPD) and VNAV path (VNAV PTH) pitch commands:

- MCP VNAV mode selector pushed
- FMC target altitude
- FMC target V/S
- FMC target airspeed
- FMC target mach
- FMC discretes
- MCP selected altitude.

ALT ACQ

The FCC automatically selects the altitude acquire mode when the airplane approaches the MCP selected altitude. There are no mode selector switches to select this mode.

The FCC uses these inputs to calculate the altitude acquire pitch commands:

- MCP selected altitude
- Baro corrected altitude
- True airspeed
- Inertial vertical speed
- Inertial altitude
- Uncorrected altitude.

ALT HOLD

You can select the altitude hold mode with the ALT HLD pushbutton. The FCC selects the altitude hold mode automatically when the airplane reaches the MCP selected altitude.

The FCC uses these inputs to calculate the altitude hold pitch commands:

- MCP ALT HLD mode selector pushed
- Speed and altitude reference from the altitude acquire mode
- Uncorrected baro altitude
- True airspeed
- Inertial vertical speed
- Inertial altitude.

Vertical Speed

The FCC uses these inputs to calculate the vertical speed pitch commands:

- MCP V/S mode selector pushed
- Inertial vertical speed
- True airspeed
- MCP selected V/S.

**DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH CRUISE CONTROL****LVL CHG**

In the level change mode, the A/P uses the elevator to control the airplane speed. The FCC uses these inputs to calculate the level change pitch commands:

- MCP LVL CHG mode selector pushed
- MCP selected altitude
- MCP selected speed
- Longitudinal acceleration
- True airspeed
- Airplane pitch attitude
- Flap angle
- Angle of airflow
- Inertial V/S and acceleration
- calibrated airspeed.

Pitch CWS

The FCC uses these inputs to calculate the CWS pitch command.

- Captain pitch CWS force transducer
- First officer pitch CWS force transducer
- Computed airspeed
- Uncorrected baro altitude.

Autopilot Elevator Commands

The FCC can use the pitch commands from all the cruise modes to calculate the autopilot elevator command. The FCC also applies pitch limits to the aileron commands. The FCC also uses these signals to calculate the elevator command:

- Airplane pitch attitude
- Airplane pitch rate
- Pitch A/P elevator actuator position

- Elevator Position
- Neutral shift sensor position
- A/P roll command.

Flight Director Pitch Commands

The FCC can use the pitch command from all the cruise modes except the pitch CWS mode to calculate the F/D commands. The FCC also applies pitch limits to the F/D commands. The FCC also uses the airplane pitch attitude to calculate the F/D commands.

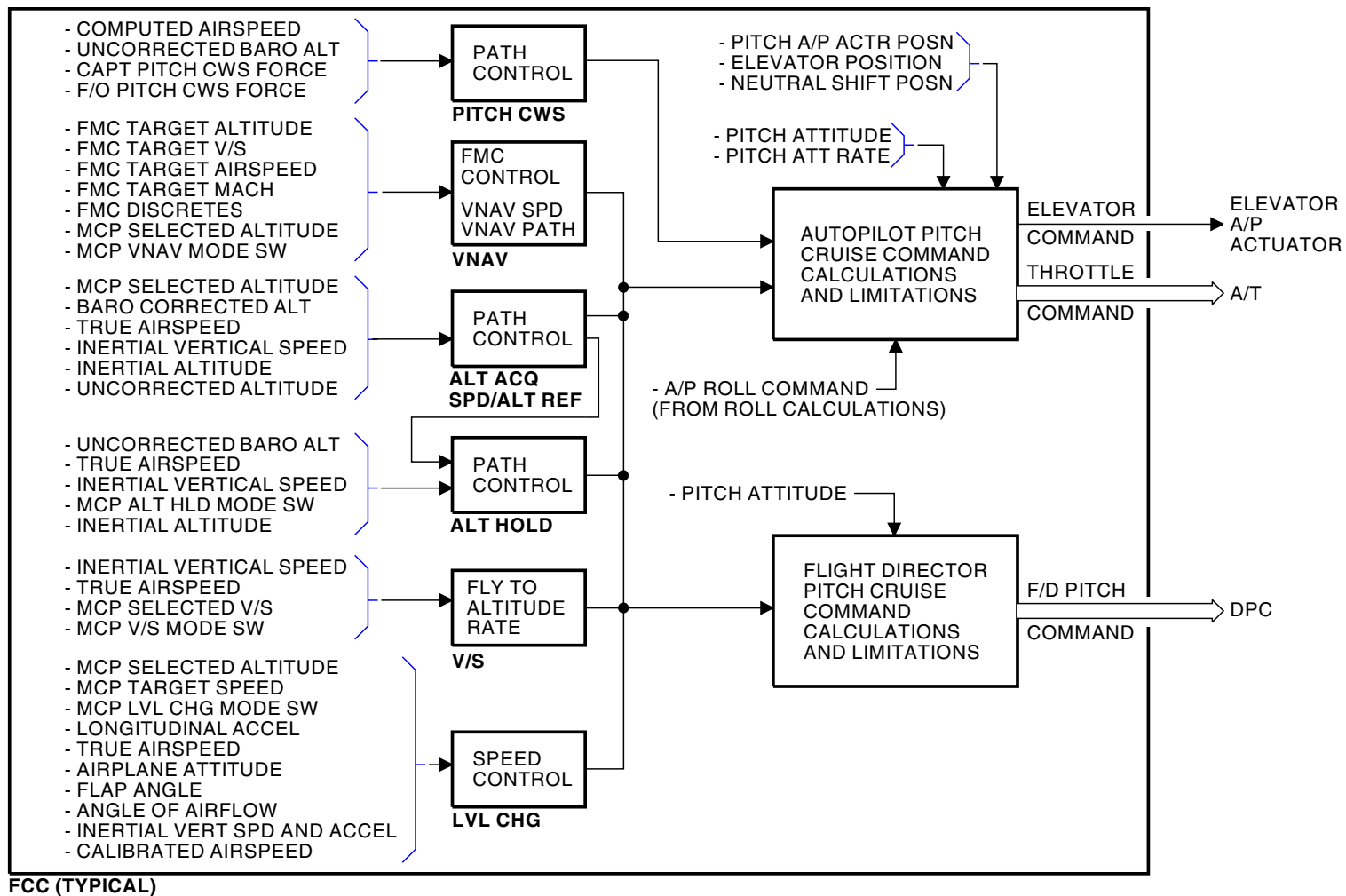
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DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH CRUISE CONTROL



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DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH CRUISE CONTROL

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH APPROACH CONTROL****General**

The pitch takeoff/approach mode consists of the approach/go-around (G/A) mode and the takeoff (T/O) mode. The T/O mode is a flight director mode only.

Approach/Go-Around Mode

The pitch approach/go-around mode has these submodes:

- G/S capture
- G/S track
- Approach-on-course
- Flare
- Go-around.

The FCC uses these inputs to calculate the approach/go-around pitch command:

- MCP APP mode selector pushed
- Inertial vertical speed and acceleration
- Airplane pitch attitude and pitch rate
- Longitudinal acceleration
- Flight path acceleration
- G/S deviation
- Radio altitude
- True and computed airspeed
- Nav receiver tuned to LOC frequency
- Stabilizer position and trim
- Flap angle
- A/P pitch actuator position
- Engine N1
- Angle of airflow
- Wheel speed
- TO/GA switch

- ground speed
- squat switch.

Takeoff Mode

The FCC calculates the takeoff mode commands with same inputs as the approach/go-around mode.

Autopilot Elevator Command

The FCC uses the pitch commands from the approach/go-around mode to calculate the autopilot elevator command. The FCC also applies pitch limits to the aileron command. The FCC also uses these signals to calculate the elevator command:

- Pitch A/P elevator actuator position
- Elevator Position
- Neutral shift sensor position
- Airplane pitch attitude
- Airplane pitch rate
- A/P roll command.

Flight Director Pitch Command

The FCC can use the pitch command from both modes to calculate the F/D command. The FCC also applies pitch limits to the F/D command. The FCC also uses the airplane pitch attitude to calculate the F/D command.

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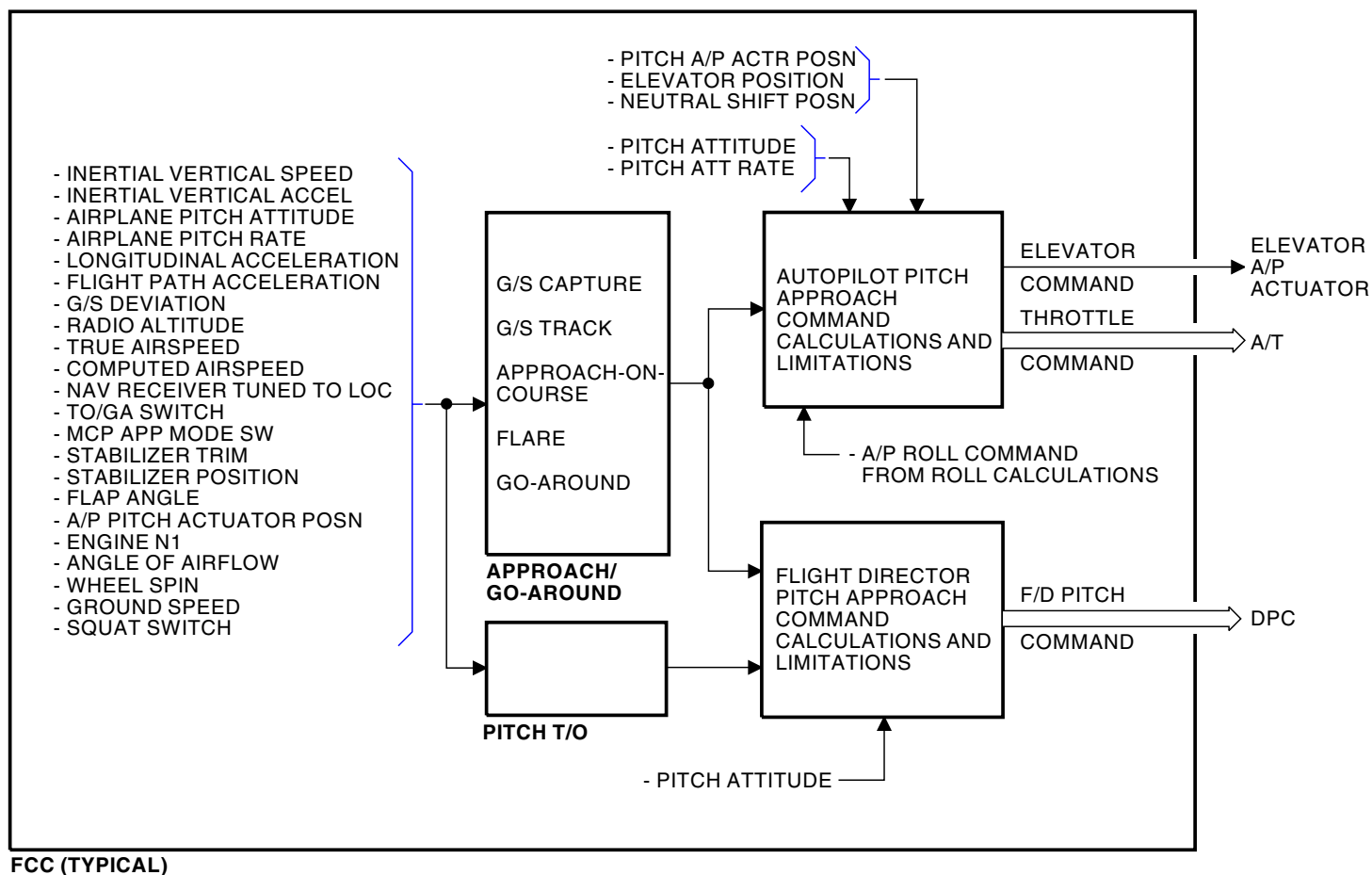
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DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH APPROACH CONTROL



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DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH APPROACH CONTROL

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DFCS - AUTOPILOT RUDDER ROLLOUT GUIDANCE ACTUATOR - INTRODUCTION

General

The FCC calculates the rudder command for the yaw control that goes to the rudder autopilot servo. The FCCs provide yaw control after these conditions occur:

- Approach-on-course (AOC)
- Dual channel engagement.

The FCCs calculate the yaw command for these modes:

- Runway alignment
- Rollout (ROLLOUT)
- Go-around (TO/GA).

Runway Alignment

If an engine fails after the rudder autopilot servo is engaged, the FCCs calculate a yaw command to compensate for the asymmetric thrust.

When there are crosswinds, the FCC calculates yaw commands to align the airplane with the runway centerline. These commands begin when the airplane is at 450 feet radio altitude. The FCC aligns the airplane to the runway using a maximum of 5 degrees sideslip.

The FCC uses these inputs for runway alignment:

- Ground speed
- Localizer deviation
- Runway heading.
- Magnetic heading
- Sideslip angle
- Rudder surface position
- Radio altitude.

There is no annunciation for runway alignment.

Rollout

During rollout, the FCC calculates yaw commands to follow the runway centerline after touchdown. The yaw commands go to the rudder servo to move the rudder and to backdrive the rudder pedals. This allows the yaw command to drive the nose wheel steering.

The rollout mode engages when the gear altitude is less than 2 feet. The autopilot will disengage during rollout when ground speed decreases to 40 knots.

The FCC uses these inputs to calculate the yaw command for rollout:

- Localizer deviation
- Rudder surface position
- Yaw rate
- Cross-runway acceleration
- Radio altitude.

Roll G/A

The FCC uses the yaw control to provide engine-out compensation during go-around.

The FCC uses these inputs to calculate the yaw command for go-around:

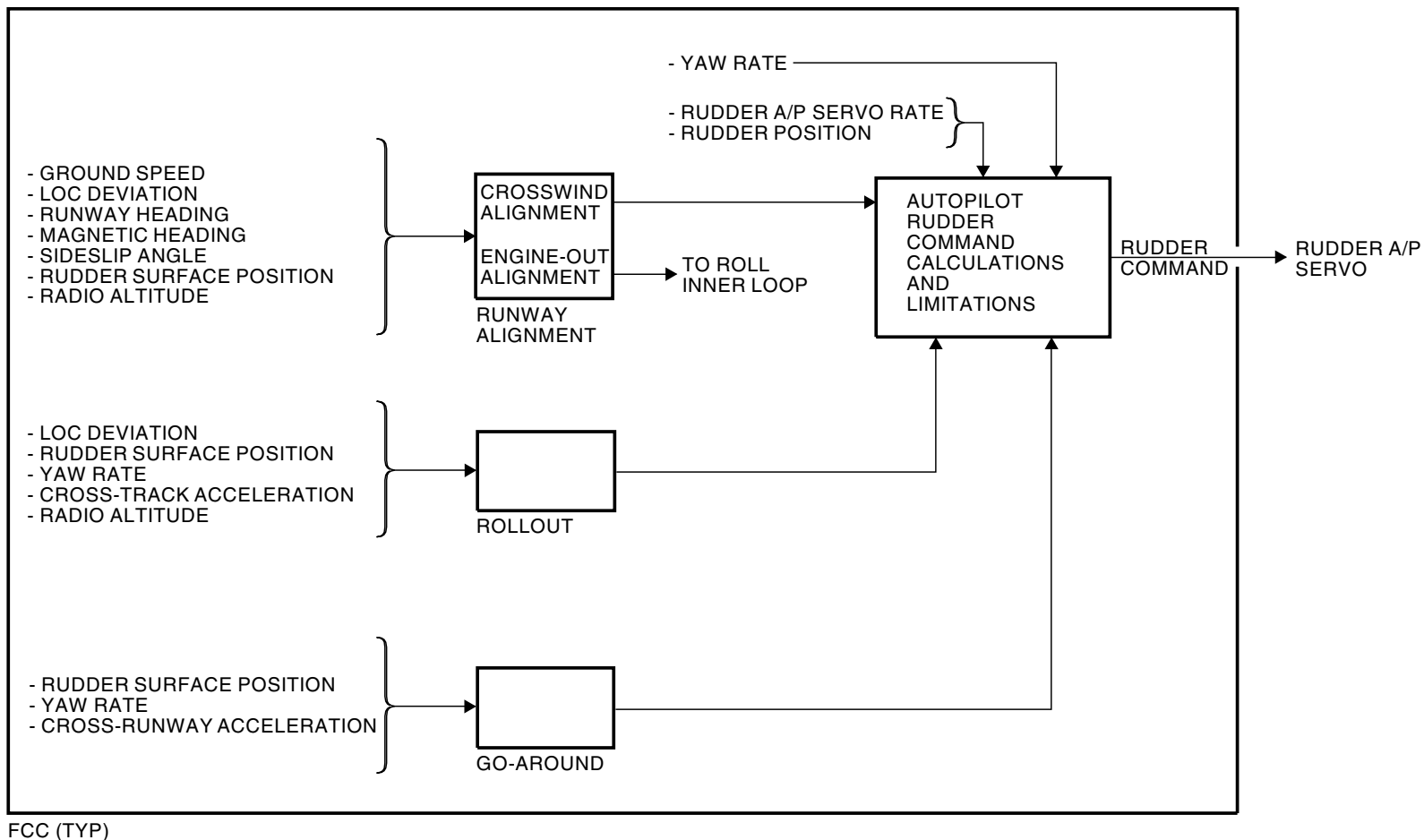
- Rudder surface position
- Yaw rate
- Cross-track acceleration.

Autopilot Rudder Commands

The FCC uses these signals to calculate the rudder command:

- Airplane yaw rate
- Rudder autopilot servo rate
- Rudder position.

DFCS - AUTOPILOT RUDDER ROLLOUT GUIDANCE ACTUATOR - INTRODUCTION



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DFCS - FUNCTIONAL DESCRIPTION - A/P YAW APPROACH

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**DFCS - FUNCTIONAL DESCRIPTION - A/P AUTOLAND****General**

The autoland function is the dual channel (FCC A and FCC B) operation of the digital flight control system (DFCS). To make an autoland approach, you use the autoland function. The autoland function consists of these operations:

- Synchronization
- Initialization
- Equalization
- Monitors

These functions are necessary to engage the autoland function.

Synchronization

When each FCC is engaged in the autopilot command mode (CMD) or CWS, the A/P actuators for that FCC synchronize their outputs to the control surface position. This occurs before the FCC energizes the detent solenoids. This prevents a sudden movement of the control surfaces when the actuator detent piston clamps onto the output shaft.

Initialization

The CPU 1 and CPU 2 in the FCC that is engaged first calculate the control laws. At initialization, the first FCC transfers the control law data to the CPUs in the second FCC. The first FCC also transfers the data between its own CPUs. FCC A and FCC B have the same data so they should agree on the pitch and roll commands.

Equalization

The FCCs compare the two elevator A/P actuator output positions and make them the same if there is a difference. This also occurs for the aileron A/P actuators. This makes sure that the actuators agree with each other.

Monitors

These are the three monitor circuits that monitor the performance of the two FCC autopilots:

- Surface position monitor
- A/P actuator position monitor
- CPU command monitor.

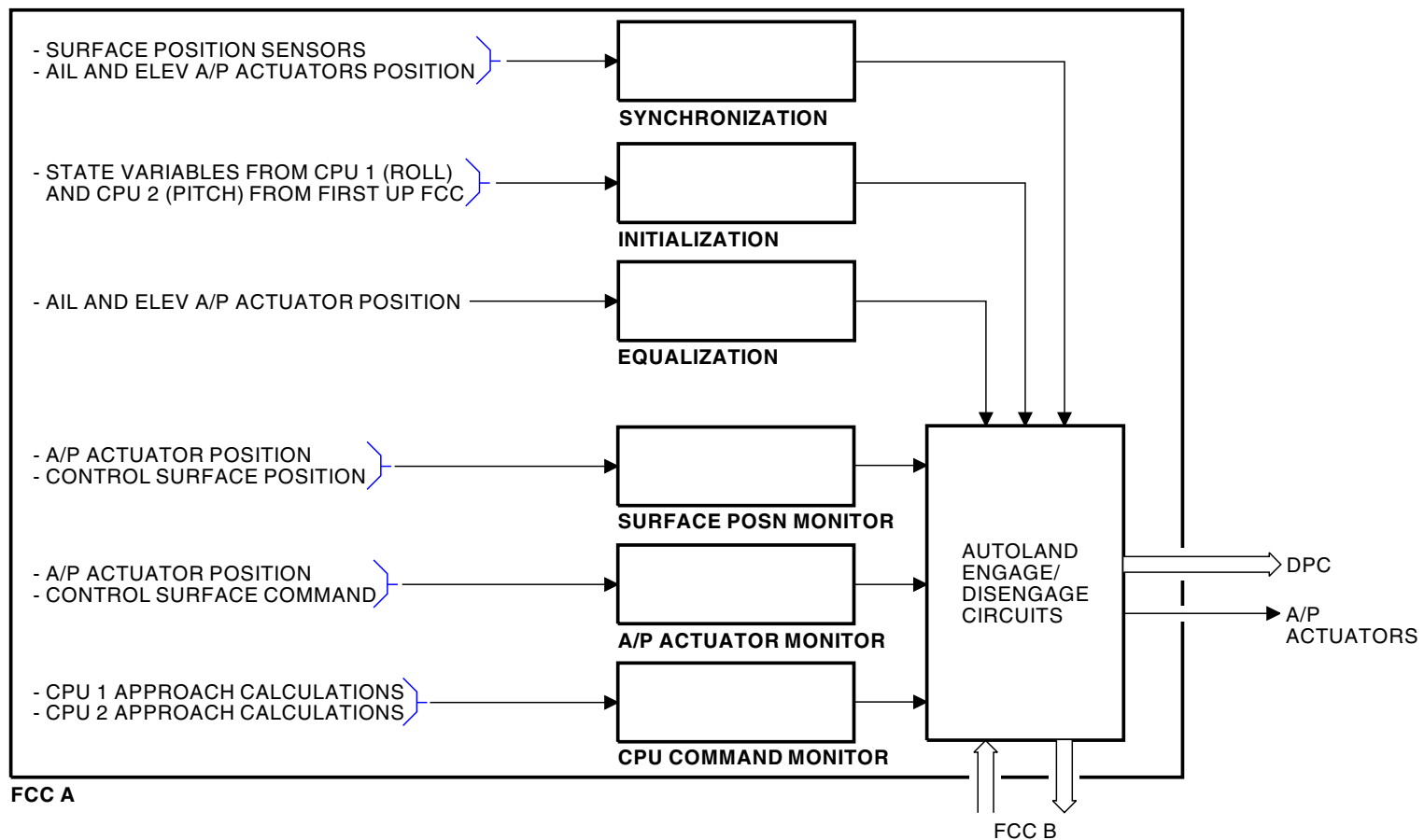
The surface position monitor compares the position of the A/P actuator and the control surface.

The A/P actuator position monitor compares the position of the actuator to the autopilot command.

The CPU command monitor compares the calculations made by the primary CPU and the alternate CPU.

Any differences will disengage the autoland function and the autopilots.

DFCS - FUNCTIONAL DESCRIPTION - A/P AUTOLAND



DFCS - FUNCTIONAL DESCRIPTION - A/P AUTOLAND

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**DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE INTERLOCK SCHEMATIC****General**

Engage and warning monitor circuits in the FCCs and MCP monitor important autopilot (A/P) functions.

MCP

There are two autopilot engage switches on the MCP for each autopilot system. These let the flight crew engage the autopilot. You can engage the autopilot in the command (CMD) or control wheel steering (CWS) mode. When you push one of the autopilot engage switches, an engage relay energizes and the autopilot engage switch light comes on if the engage enable signals from the FCC are valid.

When the autopilot engages, the MCP sends a signal to these components:

- Aileron A/P actuator
- Elevator A/P actuator
- FCC.

This signal energizes the actuator solenoid and tells the FCC that it has energized the A/P actuators. The MCP also tells the FCC which mode the crew selects.

The crew can disengage the autopilots with the captain's or first officer's disengage switches or the autopilot engage switches. There is also a disengage bar on the MCP that lets the flight crew quickly disengage the autopilots. If the autopilot disengages, the light on the autopilot engage switch goes out and the A/P disengage warning shows on the ASAs. The system aileron and elevator A/P actuators also de-energize.

FCC

The autopilot engage interlock circuits in the FCC monitor these items and send an engage enable signal to the MCP:

- Operation
- Power
- Components.

To engage the autopilot, the pre-engage logic must be valid. To keep the autopilot in the engage mode, the hold logic must be valid. The autopilot engage logic table shows these logic conditions.

CPU 1 sends a high engage enable signal to the MCP. CPU 2 sends a low engage enable signal to the MCP. The MCP needs both signals to engage the autopilot.

The FCC sends a signal to the A/P actuators to energize the detent solenoids. This occurs after the actuators synchronize to the control surface position. If the detent hydraulic pressure is not present 3.5 seconds after the detent solenoids are energized, the autopilot does not remain engaged.

During the cruise modes, you can only engage one autopilot, A or B. If autopilot A is engaged and the crew chooses to engage autopilot B, A will disengage after B has engaged.

When in the dual approach mode, you can engage both autopilots at the same time. After you push the APP mode selector switch on the MCP, you can push the second A/P CMD engage switch. The second system autopilot actuators synchronize to the control surfaces and engage the detent pistons after the airplane is in the approach-on-course mode.

If the airplane is on a dual approach and the crew pushes a TO/GA switch, both A/Ps stay engaged in the go-around mode.

The autopilot disengages if any of the general disengage conditions shown on the autopilot engage logic table are present. The roll and pitch mode disengage tables show the roll and pitch conditions that will cause the autopilot to disengage.

A cross channel digital bus supplies engage and disengage data between the FCCs.

Training Information Point

When the FCC is in BITE, you can engage the autopilot in CMD or CWS.

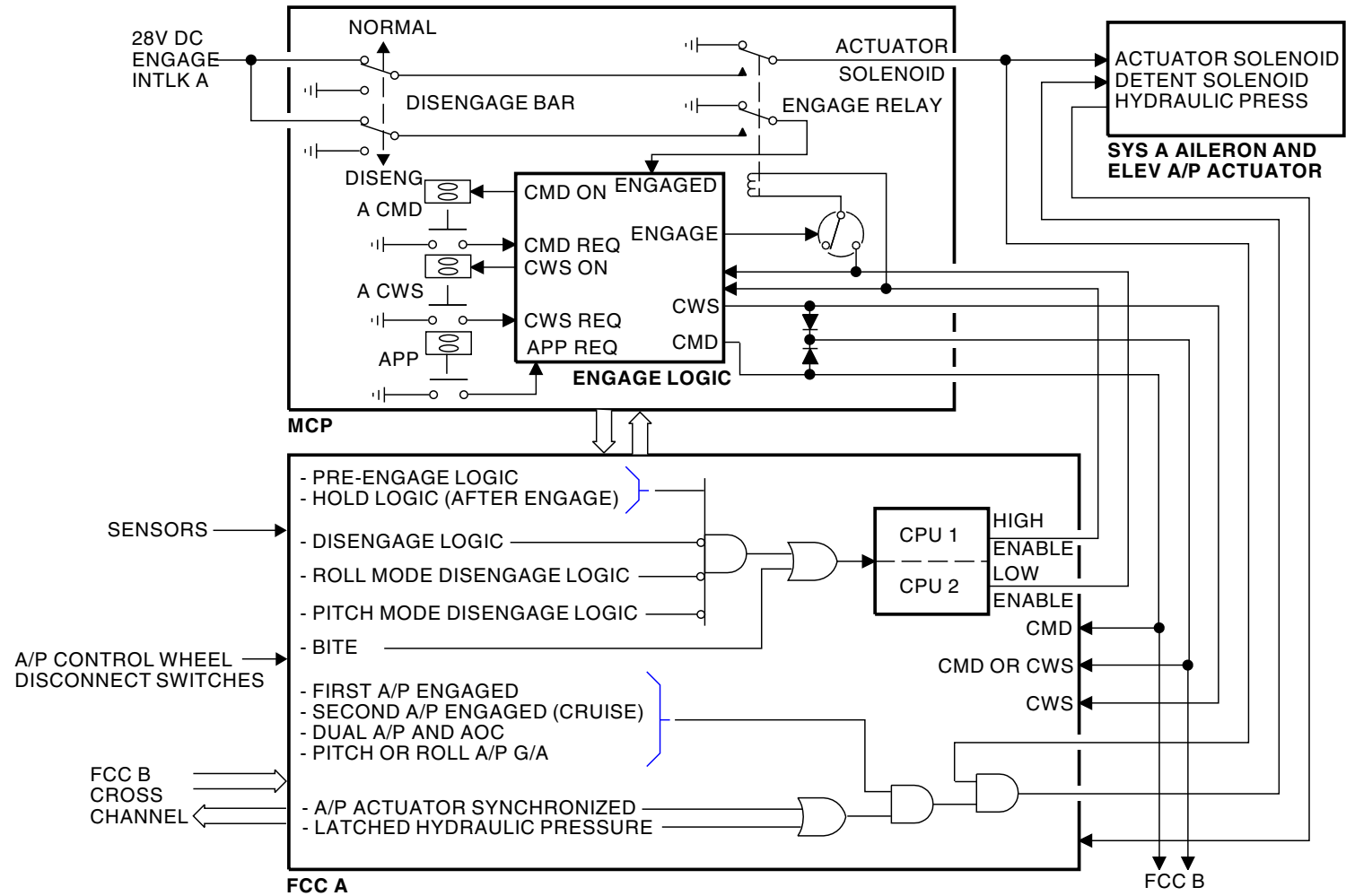
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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE INTERLOCK SCHEMATIC



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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE INTERLOCK SCHEMATIC



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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE LOGIC TABLE-1

General

The table shows some of the functions that the autopilot engage interlock circuits monitor and the conditions that they cause. These are the three conditions:

- Pre-engage - shows the functions necessary to engage the autopilot
- Hold - shows the functions necessary to keep the autopilot engaged
- Disengage - shows functions that disengage the autopilot.

Engage and Disengage Functions

1. The stabilizer trim cutout switch must be in the normal position.
2. The crew must not push a main electric trim switch to manually trim the stabilizer.
3. The A/P stabilizer trim system must not try to trim nose up and nose down at the same time.
4. The stab trim motor is a two-speed motor and the speed depends on the position of the flaps. The motor speed and flap position must agree. A 10-second delay allows for flap movement.
5. The captain and first officer must not push A/P disengage switches.
6. Before the A/P engages, the A/P actuator hydraulic pressure switches must show no hydraulic pressure.
7. After the A/P actuators synchronize, the FCC energizes the detent solenoid. There must be hydraulic pressure in 3.5 seconds.
8. The FCC 115V AC must be valid. A delay allows an interrupt of 0.5 seconds.
9. The dc engage interlock is the power source for several interlocks and is necessary for pre-engage and hold logic.
10. The FCC 28V DC and the internal power supplies must be valid.

11. The power-up test monitors these components and functions and they must pass the test:

- CPU 1 and 2
- Autoland
- Go-around (G/A).

The FCC also does these continuous checks:

- Read only memory (ROM)
- Random access memory (RAM)
- Direct memory access (DMA) controller
- Digital to analog and analog to digital converters
- Program flow and master timer, also called heartbeat.

The FCC does these continuous autopilot checks:

- Actuator position transducers (LVDT) for an open circuit
- Neutral shift sensor for reasonable data
- Actuator commands to the actuator movement.

12. Any force on the control wheel must be less than 3 pounds. Any force on the control column must be less than 5 pounds.

13. This inertial reference data from the ADIRU must be valid:

- Roll angle
- Roll rate
- Pitch angle
- Pitch rate.

14. This air data from the ADIRU must be valid except when the autopilot is in the flare arm mode:

- Computed airspeed (CAS)
- Uncorrected baro altitude.



DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE LOGIC TABLE-1

15. You can engage only one autopilot when in the cruise mode. When you try to engage the second autopilot, the first autopilot will disengage. The first autopilot will disengage after the second autopilot actuators are fully pressurized.
16. The captain or the first officer can disengage the autopilots if one pushes a disengage switch.
17. If the MCP bus is invalid, the autopilot will disengage in all the modes except the approach mode after approach on course.
18. A local AC bus transfer disengages the local autopilot in CMD. You may engage the autopilot again unless the foreign autopilot is in the approach and CMD modes.

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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE LOGIC TABLE-1

CONDITIONS	PRE-ENGAGE	HOLD	DIS-ENGAGE
1. A/P STAB TRIM CUTOUT SWITCH NORMAL	X	X	
2. MAIN ELECTRIC TRIM SWITCHES NOT PUSHED	X	X	
3. BOTH TRIM UP AND TRIM DOWN NOT AT THE SAME TIME	X	X	
4. AUTO STAB TRIM MOTOR SPEED MATCH FLAP SETTING (10 SECOND DELAY)	X	X	
5. A/P DISENGAGE SWITCHES NOT PUSHED	X	X	
6. A/P ACTUATOR HYDRAULIC PRESSURE SWITCHES SHOW NO PRESSURE	X		
7. A/P ACTUATOR HYD PRESS SWITCHES SHOW PRESSURE WITHIN 3.5 SEC AFTER DETENT		X	
8. FCC 115V AC IS VALID (.5 SEC DELAY FOR INTERRUPTS)	X	X	
9. DC ENGAGE INTLK POWER IS VALID	X	X	
10. FCC 28V DC POWER AND INTERNAL POWER SUPPLIES ARE VALID	X	X	
11. POWER UP AND CONTINUOUS MONITOR CHECKS ARE VALID	X	X	
12. LESS THAN 3 LBS FORCE ON CONTROL WHEEL AND 5 LBS FORCE ON CONTROL COLUMN	X		
13. SELECTED ADIRU INERTIAL DATA IS VALID	X	X	
14. CAS AND UNCORRECTED BARO ALTITUDE ARE VALID, EXCEPT WITH FLARE ARMED	X	X	
15. AUTOPILOTS CHANGE ENGAGEMENT WHEN IN CRUISE MODE			X
16. CAPT OR F/O PUSHES THE A/P DISENGAGE SWITCH			X
17. MCP BUS INVALID IN ALL MODES EXCEPT APPROACH MODE AFTER AOC			X
18. LCL AC BUS TRANSFER			

CAN BE RE-ENGAGED IN ANY MODE EXCEPT APP MODE WITH FGN IN CMD

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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE LOGIC TABLE-1

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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE LOGIC TABLE-2

General

The table shows more of the functions that the autopilot engage interlock circuits monitor and the conditions that they cause. These are the three conditions:

- Pre-engage - shows the functions necessary to engage the autopilot
- Hold - shows the functions necessary to keep the autopilot engaged
- Disengage - shows functions that disengage the autopilot.

Engage and Disengage Functions

19. If the crew wants to make a dual approach in CMD, they must put the other A/P in CMD at a radio altitude more than 800 feet.

20. The IRS transfer switch must be in the NORMAL position to engage the autopilot.

21. If the IRS transfer switch is in the BOTH ON 1 or BOTH ON 2 position, the autopilot will disengage and cannot be reengaged.

22. The VHF NAV transfer switch must be in a position so that the data that the autopilot uses also shows on the MDS.

23. The flap position data from the flap transmitters must agree with the flap position data from the SMYD.

24. The signal from the SMYD that shows a stall condition and activates the stick shaker must not have been active for more than 5 minutes.

25. The selected baro corrected altitude from the ADIRU must be valid.

26. The option pin that shows the FCC can do the dual approach, CAT IIIA (50 ft DH), must be selected in the second up channel FCC.

27. The VHF nav control panel for the second up channel must be tuned to the ILS frequency.

28. The FCC that is the second up channel for a dual approach must be on a different power bus than the first up FCC.

29. The autopilot that is the second up for the dual approach must be in the CMD and not the CWS mode.

30. During a dual approach if one autopilot disengages, the other autopilot also disengages.

31. The trim sensors monitor compares the neutral shift expected value from stabilizer position and Mach trim feedback with the actual NSS input. If the difference is more than 0.5 elevator degrees and in dual autoland, the autopilot will disengage.

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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE LOGIC TABLE-2

CONDITIONS	PRE-ENGAGE	HOLD	DIS-ENGAGE
19. FOR DUAL APP WITH FGN IN CMD AND AND RA > 800 FT	X	X	
20. IRU TRANSFER SWITCH IN NORMAL POSITION	X	X	
21. IRU TRANSFER SWITCH OUT OF THE NORMAL POSITION			X
22. VHF NAV TRANSFER SWITCH IN THE CORRECT CONFIGURATION	X	X	
23. REDUNDANT SOURCE OF FLAP POSITION DATA MUST AGREE	X	X	
24. STICK SHAKER SIGNAL FROM THE SMYD MUST NOT BE ACTIVE	X	X	
25. SELECTED BARO CORRECTED ALTITUDE MUST BE VALID	X	X	
26. CAT IIIA (50 FT DH) OPTION SELECTED IN SECOND UP CHANNEL DURING APPROACH	X	X	
27. THE SECOND UP CHANNEL IN DUAL MUST BE TUNED TO THE ILS FREQUENCY	X	X	
28. THE SECOND UP CHANNEL MUST BE ON ITS OWN POWER BUS	X	X	
29. SELECT CWS FOR THE SECOND UP CHANNEL IN DUAL			X
30. THE OTHER CHANNEL DURING A DUAL APPROACH DISENGAGES			X
31. DIFF BETWEEN NEUTRAL SHIFT EXPECTED VALUE AND NSS > 0.5 ELEV DEGS AND DUAL			X

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DFCS - FUNCTIONAL DESCRIPTION - A/P ENGAGE LOGIC TABLE-2

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DFCS - FUNCTIONAL DESCRIPTION - A/P ROLL MODE DISENGAGE LOGIC TABLE

General

The table shows the roll mode conditions that cause the autopilot to disengage.

Disengage Conditions

1. The magnetic heading must be valid when in the CWS heading hold or the autopilot will disengage. If the magnetic heading fails while in the heading mode, the A/P will go to the CWS mode first and then disengage.

2. If the radio altitude is less than 2,000 feet and the A/P is not in flare arm, it will disengage if the crew pushes a TO/GA switch.

3. If the crew pushes a TO/GA switch after touchdown (wheel spin greater than 60 knots), both autopilots will disengage.

4. The LOC antenna must switch to the forward antenna when in the approach mode and the crew tunes to a LOC frequency. If it does not switch within 4.5 seconds, the autopilots will disengage.

5. When in the dual (autoland) mode for at least 5 seconds, the FCC monitors these:

- Autopilot actuator monitor (AAM)
- Surface position monitor (SPM)
- CPU monitor.

If a monitor shows a failure, the autopilots will disengage.

6. If the NAV transfer switch is in the BOTH ON 1 position, the B A/P disengages. If the NAV transfer switch is in the BOTH ON 2 position, the A A/P disengages.

7. After LOC engage, if the LOC receiver is not valid or a beam anomaly occurs, the autopilot disengages. There is a 10 second delay to allow for interrupts.

A beam anomaly occurs if the localizer beam rate is greater than 0.13 degrees/second and the beam deviation is greater than 0.3 degrees.

8. The autopilots will disengage below 350 feet if in dual mode and not in flare arm mode.

9. The true airspeed (TAS) must be valid in the CWS heading hold mode.

10. The lateral acceleration from the ADIRU must be valid or the autopilot will disengage in certain modes.

11. The magnetic track angle from the ADIRU must be valid or the autopilot will disengage in certain modes.

12. If the autopilots are in the dual mode and one disengages, the other will disengage. This does not occur when one autopilot disengages because the other goes out of the G/A pitch mode.

13. If these conditions occur, the autopilot will disengage:

- Radio altimeter is not valid
- GS and LOC are engaged
- A/Ps are not in the flare arm mode.

A 2 second delay allows for short interruptions.

14. If both autopilots are in the flare arm mode, both radio altimeters must fail before the autopilots disengage.

15. If these conditions occur, the autopilot disengages:

- Autopilots are in the approach mode
- Local AC bus transfers
- Foreign autopilot is in the CMD mode.

16. If the aileron command is more than the allowable limits, the autopilot disengages.

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DFCS - FUNCTIONAL DESCRIPTION - A/P ROLL MODE DISENGAGE LOGIC TABLE

CONDITIONS	SELECTED MODES								
	CWS	HDG	L NAV	VOR ENG	LOC ENG	APP PB	APP LOC ENG	APP OC	G/A
1. MAGNETIC HEADING INVALID AND HDG HOLD	X	1							
2. TO/GA SWITCH PUSHED WHEN RA < 2000 FT AND NOT IN FLARE ARM	X	X	X	X	X	X	X	X	
3. TO/GA SWITCH PUSHED AFTER TOUCHDOWN (WHEEL SPIN)								X	
4. AFT LOC ANTENNA (4.5 SEC DELAY)						X	X	X	
5. DUAL ROLL CHANNEL MONITOR TRIP								X	X
6. NAV TRANSFER SWITCH OUT OF NORMAL				X	X	X	X	X	
7. LOC RECEIVER INVALID OR BEAM ANOMALY (10 SEC DELAY)							X	X	
8. DUAL IN CMD AND RA < 350 FT AND NOT IN FLARE ARM							X	X	
9. TAS INVALID AND HDG HOLD	X								
10. LATERAL ACCELERATION INVALID					X		X	X	
11. MAGNETIC TRACK ANGLE INVALID				X	X		X		X
12. DUAL IN CMD AND ONE DISENGAGE, EXCEPT INTENTIONAL G/A EXIT						X	X	X	X
13. RA INVALID, G/S AND LOC ENGAGED AND NOT FLARE ARM (2 SEC)							X	X	
14. BOTH RADIO ALTIMETERS INVALID AND FLARE ARM								X	
15. LCL OR FGN BUS TRANSFER AND FGN IN CMD						X	X	X	
16. AILERON COMMAND LIMITS EXCEEDED	X	X	X	X	X	X	X	X	X

1 A LOSS OF MAGNETIC HEADING CAUSES A REVERSION TO ROLL CWS AND THEN DISENGAGES THE A/P

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DFCS - FUNCTIONAL DESCRIPTION - A/P ROLL MODE DISENGAGE LOGIC TABLE

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DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH MODE DISENGAGE LOGIC TABLE

General

The table shows the pitch mode conditions that cause the autopilot to disengage.

Disengage Conditions

1. This is an unsafe flight condition. When the autopilot is in a speed mode, the airplane should be climbing but it is not, and it approaches a stall, the A/P disengages.
2. This is another unsafe flight condition. When the autopilot is in a speed mode, the airplane should be descending but it is not, and it approaches the VMO/MMO limit, the A/P disengages.
3. When the autopilot is in the G/S engage mode, it will disengage if the G/S receiver is not valid and the radio altitude is above 60 feet. There is a 4.5 second delay to allow for interrupts.
4. When in the dual (autoland) mode for at least 5 seconds, the FCC monitors these:
 - Autopilot actuator monitor (AAM)
 - Surface position monitor (SPM)
 - CPU monitor.
5. The autopilots will disengage below 350 feet if in the dual mode and not in the flare arm mode.
6. If the autopilots are in the dual mode and one disengages, the other will disengage. This does not occur when one autopilot disengages because the other goes out of the G/A pitch mode.
7. An autopilot goes out of the G/A pitch mode when the crew sets a cruise pitch mode. The other autopilot will disengage when this occurs.
8. If the radio altitude is less than 2,000 feet and the A/P is not in flare arm, it will disengage if the crew pushes a TO/GA switch.
9. An invalid longitudinal acceleration from the ADIRU causes the autopilot to disengage.

10. An invalid vertical acceleration from the ADIRU causes the autopilot to disengage.
11. An invalid vertical speed from the ADIRU causes the autopilot to disengage.
12. An invalid flight path acceleration from the ADIRU when in the dual mode causes the autopilot to disengage.
13. If these conditions occur, the autopilot will disengage:
 - Radio altimeter is not valid
 - G/S and LOC are engaged
 - A/Ps are not in the flare arm mode.

A two-second delay allows for short interruptions.

14. If both autopilots are in the flare arm mode, both radio altimeters must fail before the autopilots disengage.
15. After G/S engage, if the G/S receiver is invalid or a beam anomaly occurs the autopilot disengages. There is a 10 second delay to allow for interrupts.
16. If the minimum operating speed from the stall management yaw damper is invalid, the autopilot disengages.
17. If the elevator command is more than the allowable limits, the autopilot disengages.

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DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH MODE DISENGAGE LOGIC TABLE

CONDITIONS	SELECTED MODES						
	CWS	V/S ALT ACQ ALT HOLD	V NAV	LVL CHG	GS ENG	APP OC	G/A
1. CLB CMD AND ALPHA WARNING AND NOT CLIMBING AT MIN V/S AND NOT ON GRD (5 SEC)			X	X			
2. DES CMD AND VMO/MMO WARNING AND NOT DESCENDING AT MIN V/S AND NOT ON GRD (10 SEC)			X	X			
3. GLIDESCOPE INVALID AND RA > 60 FT (4.5 SEC DELAY)					X		
4. DUAL CHANNEL MONITOR TRIP AND DUAL ENGAGED						X	X
5. DUAL IN CMD AND RA < 350 FT AND NOT FLARE ARM					X	X	
6. BOTH A/P CMD, FGN A/P DISENGAGE (EXCEPT INTENTIONAL G/A EXIT)						X	X
7. INTENTIONAL G/A EXIT AND RA > 400 FT (DISENGAGE 2ND IN CMD)							X
8. TO/GA SWITCH PUSHED WHEN RA < 2000 FT AND NOT IN FLARE ARM	X	X	X	X	X	X	
9. LONGITUDINAL ACCELERATION INVALID					X	X	X
10. VERTICAL ACCELERATION INVALID					X	X	X
11. VERTICAL SPEED INVALID					X	X	X
12. FLIGHT PATH ACCELERATION INVALID, DUAL ENGAGE					X	X	X
13. RA ALT INVALID, LOC AND G/S ENGAGED AND NOT FLARE ARM (2 SEC)					X	X	
14. BOTH RADIO ALTIMETERS INVALID AND FLARE ARM						X	X
15. G/S RECEIVER INVALID OR BEAM ANOMALY (10 SEC DELAY)					X	X	
16. MIN OPERATING SPEED FROM STALL MANAGEMENT YAW DAMPER INVALID				X			
17. ELEVATOR COMMAND LIMITS EXCEEDED	X	X	X	X	X	X	X

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DFCS - FUNCTIONAL DESCRIPTION - A/P PITCH MODE DISENGAGE LOGIC TABLE

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**DFCS - FUNCTIONAL DESCRIPTION - A/P WARNING LIGHTS****General**

The red A/P warning light on the autoflight status annunciator (ASA) can flash red or stay on steady red. The captain and the first officer red A/P warning lights are in parallel so they go on at the same time.

Steady Red A/P Warning Light

Circuits that can cause the steady red A/P warning light are in these components:

- FCC A and FCC B
- Mode control panel (MCP).

FCC A and FCC B

The steady red light will come on if the stab out of trim warning is set and all of these conditions are present:

- Airplane is in dual pitch mode
- The radio altitude is between 50 and 800 feet
- A/P G/S is engaged.

If the light is on when the airplane goes below 50 feet, it will stay on.

The light will also come on if the DFCS is in BITE or if the FCCs can not operate together.

The FCC will supply an A/P warning signal to the MCP if any of these conditions are present:

- The airplane is on the ground and the FCC fails the power up test
- The airplane is above 400 feet and cannot exit A/P G/A to altitude acquire because single channel pitch authority is not available
- The airplane is in A/P pitch G/A and the MCP bus fails.

MCP

If the MCP receives an A/P warning signal from either FCC and the flashing red A/P circuit is not on, the red A/P warning lights will come on steady. The steady red A/P warning lights will only go off if the condition that causes the warning goes away.

Flashing Red A/P Warning Light

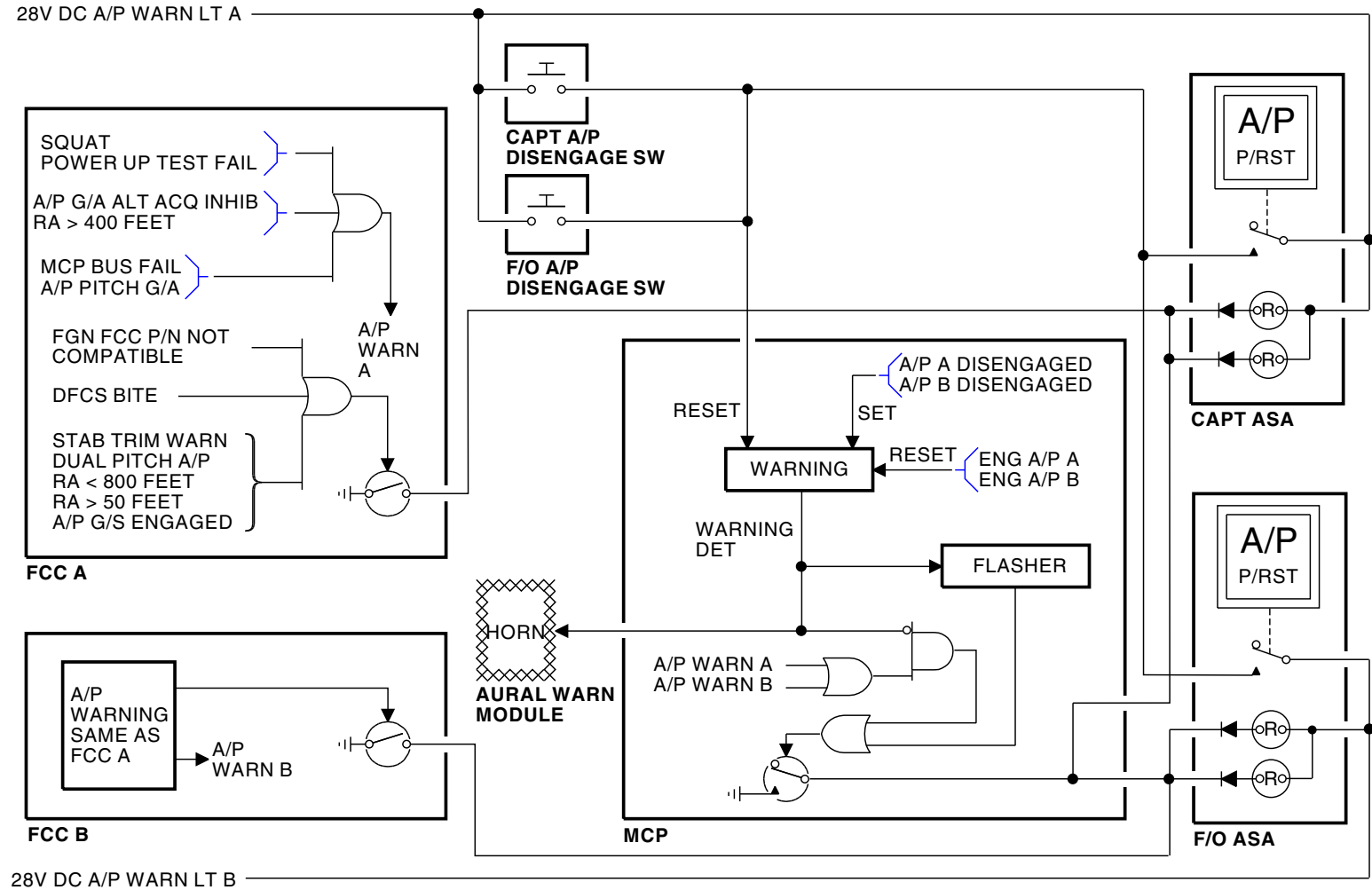
The circuits that cause the flashing red A/P warning lights are in the MCP. If autopilot A or autopilot B disengage, the warning detector will turn on a flasher. This flasher will cause the red A/P warning lights in the ASAs to flash. The detector will also send a signal to the aural warning module which turns on the horn.

To reset the horn and flashing lights, push any one of these switches:

- Captain A/P disengage switch
- First officer A/P disengage switch
- A/P light on the captain ASA
- A/P light on the first officer ASA.

If either autopilot engages, the warning resets.

DFCS - FUNCTIONAL DESCRIPTION - A/P WARNING LIGHTS



2368532 S00061517595_V1

DFCS - FUNCTIONAL DESCRIPTION - A/P WARNING LIGHTS

22-11-00-060

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**DFCS - FUNCTIONAL DESCRIPTION - A/P ILS DEVIATION WARNING****General**

The FCC supplies a warning to the DPCs when the airplane is on an ILS approach and it moves too far away from the ILS path. The localizer and glideslope scales change color from white to amber. The pointers flash at a 4 Hz rate.

FCC A supplies the deviation warning when it is in the command mode. FCC B supplies the warning if it is the only FCC in the command mode.

Localizer Deviation Warning

The localizer warning occurs if these conditions are present:

- Autopilot is in the approach-on-course mode
- A/P A or A/P B is in command mode
- Localizer mode is active
- APP mode selector switch is set
- Radio altitude is less than 1500 feet for 3 seconds
- Local FCC should supply the warning
- Localizer deviation exceeds 0.293 degree limit.

If the other FCC finds that the warning should be set and it is not, it sets the warning after 7 seconds.

Glideslope Deviation Warning

The glideslope warning occurs if these conditions are present:

- Autopilot is in the approach-on-course mode
- A/P A or A/P B is in command mode
- Glideslope mode is active
- APP mode selector switch is set
- Radio altitude is less than 1500 feet for 3 seconds
- Local FCC should supply the warning
- Glideslope deviation exceeds 0.35 degree limit below glideslope.

The warning will not occur if the airplane is below 100 feet. If the warning occurs and the airplane passes below 100 feet, it will stay on below 100 feet.

If the other FCC finds that the warning should be set and it is not, it sets the warning after 7 seconds.

ILS Deviation Warning Test

The FCC does a test to show the crew that if a warning occurs, it shows on the MDS. The display for the test is the same as the warning display. FCC A starts the test. It will occur if these conditions are present:

- A/P A or A/P B is in command mode
- Localizer or glideslope is engaged
- APP mode selector switch is set
- Radio altitude is less than 1500 feet for 3 seconds.

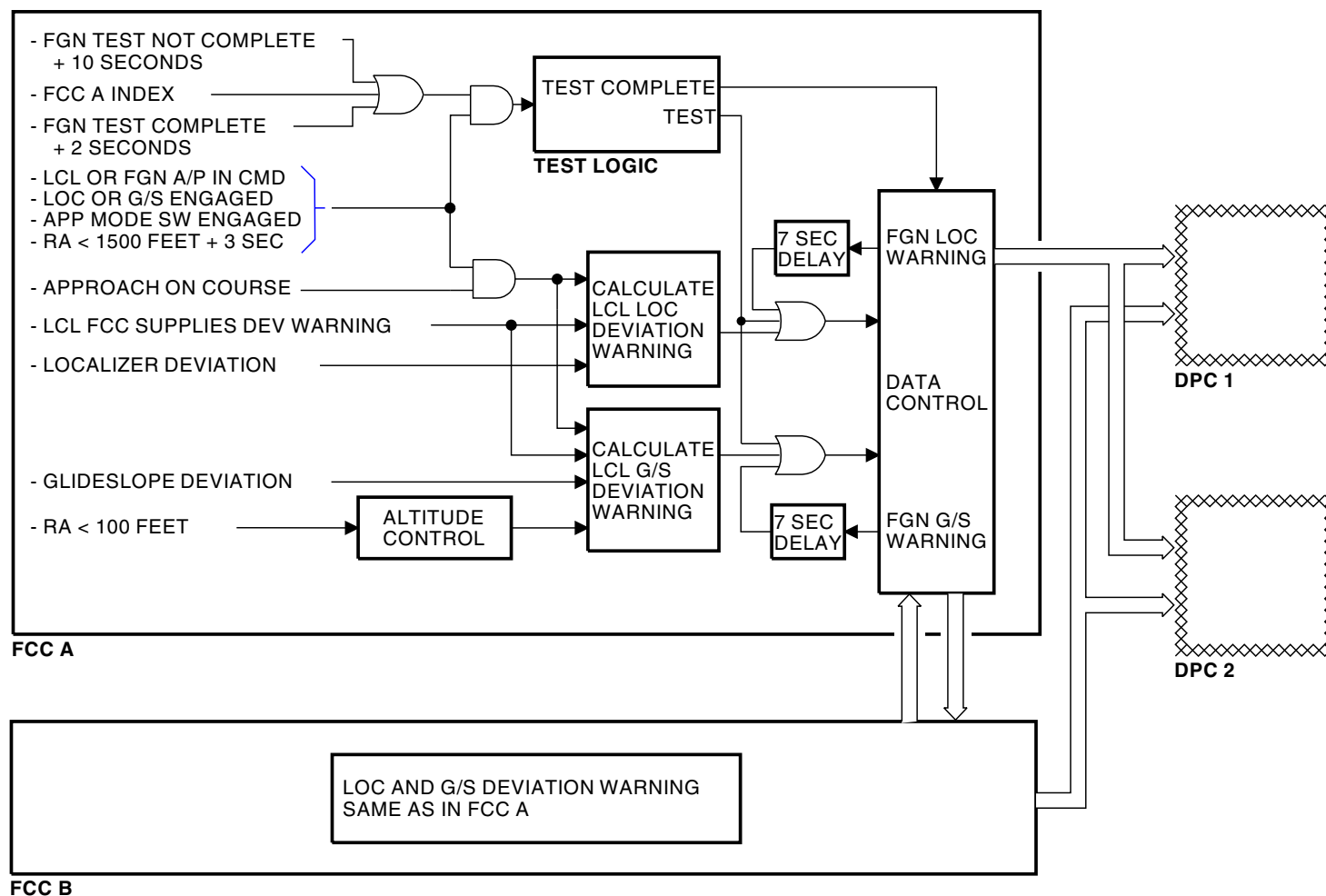
The test lasts for two seconds. A test complete signal goes to FCC B. After a two-second delay, FCC B starts the test. If FCC B does not get the test complete signal from FCC A, it starts its own test 10 seconds after it finds the above conditions.

22-11-00**SIA ALL EFFECTIVITY**

D633AM102-SIA

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DFCS - FUNCTIONAL DESCRIPTION - A/P ILS DEVIATION WARNING



2368533 S00061517597_V1

DFCS - FUNCTIONAL DESCRIPTION - A/P ILS DEVIATION WARNING

22-11-00-061

SIA ALL	EFFECTIVITY
	D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details

22-11-00

**DFCS - FUNCTIONAL DESCRIPTION - MCP AIRSPEED FLAGS****General**

The DFCS supplies envelope command limits and annunciation for these limits:

- Alpha floor
- Gear placard
- Flap placards
- Performance limit
- VMO/MMO.

Alpha Floor

The autopilot (A/P), flight director (F/D), and autothrottle (A/T) alpha floor limit is the minimum speed available for airspeed control that will override manual speed selection or FMC commands. The limit is approximately 1.3 times the stall speed.

Gear Placard

The gear placard reversion limits the maximum speed command to the gear placard speed and controls to that speed when the gear is extended.

Flap Placards

The flap placards reversion limits the maximum speed command to the flap placards speed and controls to that speed when the flaps are extended.

VMO/MMO

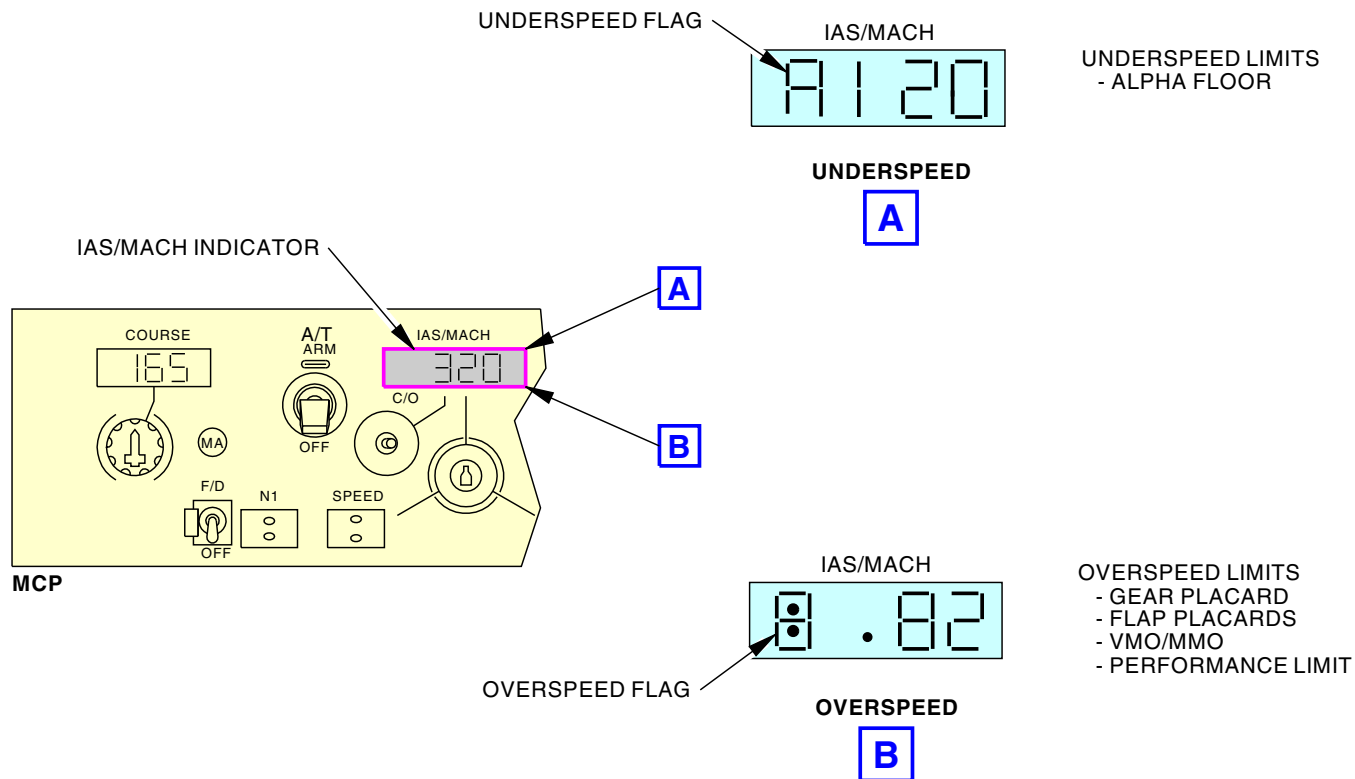
The VMO/MMO reversion supplies a limit to the maximum speed that the crew can select or the FMCS can control. The DFCS commands the A/T to a speed mode or engages to a speed on elevator mode when the airplane reaches the VMO/MMO speed.

Performance Limit

The DFCS only enables the performance limit reversion when in VNAV PATH operation. For VNAV PATH descent, the performance limit reversion causes the mode to change to level change as a result of an FMC reversion request discrete. This request is to prevent the airplane from exceeding any speed constraints.

EFFECTIVITY	
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DFCS - FUNCTIONAL DESCRIPTION - MCP AIRSPEED FLAGS



DFCS - FUNCTIONAL DESCRIPTION - MCP AIRSPEED FLAGS

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22-11-00

SIA ALL EFFECTIVITY

D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - FUNCTIONAL DESCRIPTION - MCP ALTITUDE WINDOW WARNING****General**

The DFCS supplies an altitude window warning when one of these conditions occurs:

- The altitude in the FCC memory changes without any change of the altitude selector
- The altitude in the FCC memory does not agree with the value in the MCP altitude display for five seconds.

Warning

The warning that the DFCS supplies contains these items:

- The aural warning comes on for 2 seconds and then is off for 8 seconds and continues this sequence
- An amber border appears around the altitude display
- The altitude that shows in the MCP altitude display is 50,000 feet.

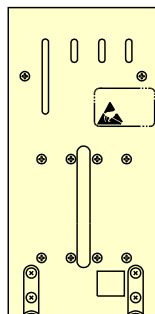
This warning continues until it is reset. Reset occurs if the crew turns the altitude selector or the airplane lands.

The warning does not occur if the glideslope mode is engaged or the radio altitude is less than 400 feet. However, if the warning occurs before either of these conditions occur, the warning stays until it is reset. The warning occurs on the ground if a continuous altitude selector knob motion signal is received by the FCC.

When the warning is reset, the altitude display goes to the last altitude shown plus any changes to the altitude selector that the FCC detected.

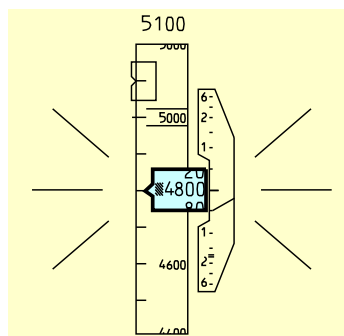
EFFECTIVITY	
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DFCS - FUNCTIONAL DESCRIPTION - MCP ALTITUDE WINDOW WARNING

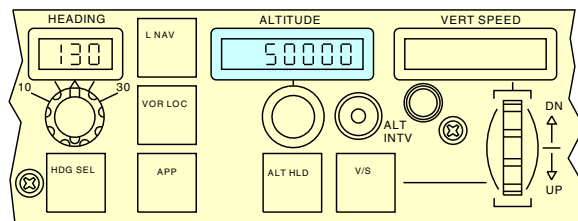


REMOTE ELECTRONICS UNIT

1. AURAL WARNING REPEATS
 - ON FOR 2 SECONDS
 - OFF FOR 8 SECONDS



2. AMBER BORDER AROUND THE AIRPLANE ALTITUDE DISPLAY FLASHES



MCP

3. ALTITUDE DISPLAY GOES TO 50,000 FEET

2368535 S00061517601_V1

DFCS - FUNCTIONAL DESCRIPTION - MCP ALTITUDE WINDOW WARNING

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**DFCS - FUNCTIONAL DESCRIPTION - FLIGHT DIRECTOR COMMANDS****General**

These are the flight director (F/D) functions that the FCC does:

- F/D roll control
- F/D pitch control
- F/D commands bias out of view (BOV)
- Fault detection.

Changes between F/D modes do not cause unwanted F/D commands. Changes between the A/P and F/D modes do not cause unwanted A/P or F/D commands.

F/D Names

Like the A/P, the F/D may be called one of these names:

- Channel A or channel B.
- Local (LCL) or foreign (FGN)
- Master or slave.

It is the same for the F/D as it is for the A/P, except for the master/slave relation when at least one A/P is engaged. If an A/P is engaged in CMD, it is the master.

F/D Pitch and Roll Controls

The FCC uses almost the same control laws to calculate the F/D pitch and roll commands as it uses to calculate the A/P pitch and roll commands.

The FCC does not use surface position sensor data to calculate the F/D commands because the F/D does not move the control surfaces. The F/D commands go to the display processing computer (DPC) to show on the MDS instead of to the A/P actuators.

F/D Commands BOV

The autopilot disengages if a non-normal condition occurs. For flight director, the flight director commands on the MDS are biased out of view so the pilot cannot see them.

F/D Comparator

The flight director comparator operates during these conditions:

- Takeoff mode and below 400 feet
- Go around mode and below 400 feet
- Approach mode and below 800 feet.

During this time, the F/D comparator detects the F/D failures which are not detected by continuous monitoring or annunciated by a sensor valid and which could provide erroneous information to the pilot-in-command. In each FCC, this monitor compares local pitch and roll F/D commands with the corresponding cross-channel F/D commands. The local F/D only is BOV if the difference exceeds a given value.

Fault Detection

The fault detection circuit continually monitors the operation of the FCC. If it finds a failure, it sends a signal to the MDS to show the F/D flag on the attitude indicator.

SIA 007-999; SIA 001-006 POST SB 737-22A1342

Low Speed Flight Conditions

The following occurs in the event that airspeed decreases into the amber band. The autopilot will disconnect one second after stick shaker activation for autopilot/flight director modes that do not provide active speed protection with the exception of flare mode. At the same time, the pitch and roll flight director guidance will BOV. Pitch and roll flight director guidance returns when the airspeed has returned to the top of the amber band. The roll mode will stay unchanged when the flight director resumes. The pitch mode will transition to level change (LVL CHG) if the previous mode was ALT HLD or VNAV PATH, or will stay unchanged if the mode is G/S, G/P, V/S or VNAV PATH. Re-engagement of the autopilot is inhibited until the airspeed returns to the top of the amber band.

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ECCN 9E991 BOEING PROPRIETARY - See title page for details



DFCS - FUNCTIONAL DESCRIPTION - FLIGHT DIRECTOR COMMANDS

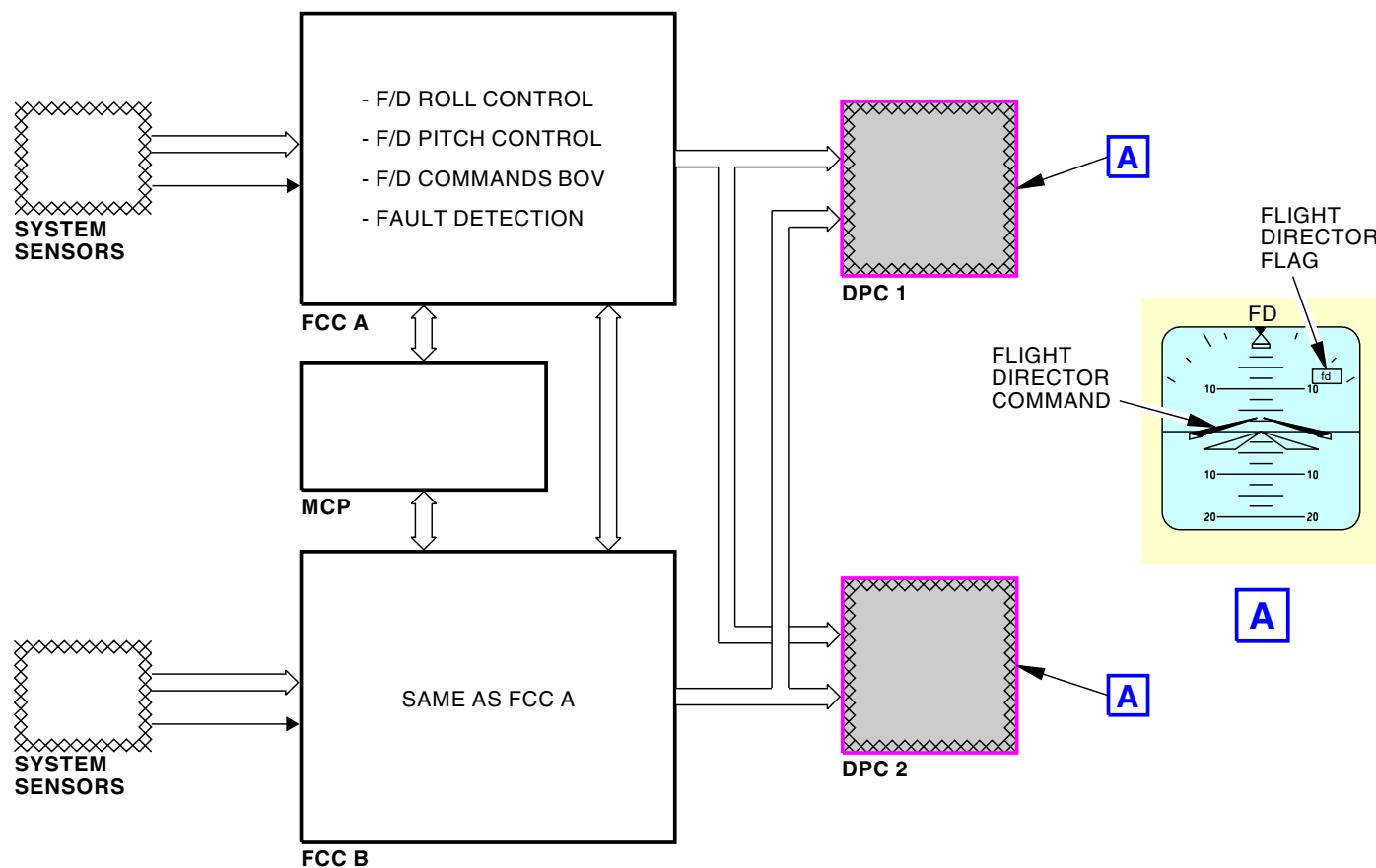
SIA 007-999; SIA 001-006 POST SB 737-22A1342 (Continued)

Flight director guidance can be brought back, and the autopilot engagement inhibit can be removed, before airspeed returns to the top of the amber band if LVL CHG or V/S is selected for flaps UP through flaps 10, or just LVL CHG when flaps are 15 or lower. Selection of TO/GA when the mode is available, will also bring back the flight director guidance and remove the autopilot engagement inhibit. For G/S or G/P, only the selection of TO/GA will bring back the flight director guidance and remove the autopilot engage inhibit prior to reaching the top of the amber band, as other mode selections are not allowed.

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DFCS - FUNCTIONAL DESCRIPTION - FLIGHT DIRECTOR COMMANDS



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DFCS - FUNCTIONAL DESCRIPTION - FLIGHT DIRECTOR COMMANDS

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**DFCS - FUNCTIONAL DESCRIPTION - F/D FLAG AND BOV****General**

The bias out of view (BOV) and failure warning circuits in the FCCs monitor important flight director (F/D) and FCC functions. Under certain conditions, the F/D command display on the MDS does not show and the F/D flag shows. The FCC also selects which FCC is the master.

MCP

The MCP has two switches that turn on or off F/D A or F/D B. There is a master flight director indicator light above each F/D switch. This light shows which FCC is the master FCC.

FCC

The flight director (F/D) bias out of view (BOV) circuits monitor these items:

- Operation
- Power
- Components.

During normal conditions, the F/D commands show on the MDS when the crew turns on a F/D switch. If conditions are not normal, the F/D commands to the display processing computer (DPC) is no computed data (NCD). The F/D roll and pitch mode BOV tables show when the F/D commands are BOV.

The FCC calculates a failure warning signal if any of these conditions exist:

- No FCC power
- Failure of internal power supply
- Loss of FCC heartbeat monitors
- Loss of F/D monitors
- Failure of servo amplifiers.

A cross channel digital bus supplies F/D commands and BOV data between the FCCs. Normally the flight directors operate independently. However, if the local power bus transfers under these condition, the switched FCC will get F/D commands from the other FCC:

- When in TO/GA at any altitude
- When in F/D approach with G/S and LOC engaged and under 800 feet.

Master FCC

With one or both autopilots in CMD, the master FCC is the autopilot first in CMD. If no autopilot is in CMD, the first F/D on is the master FCC. These are three conditions when only the F/Ds are on and both FCCs are the master:

- In approach with G/S engaged and LOC capture
- In G/A with radio altitude less than 400 feet
- In T/O with radio altitude less than 400 feet.

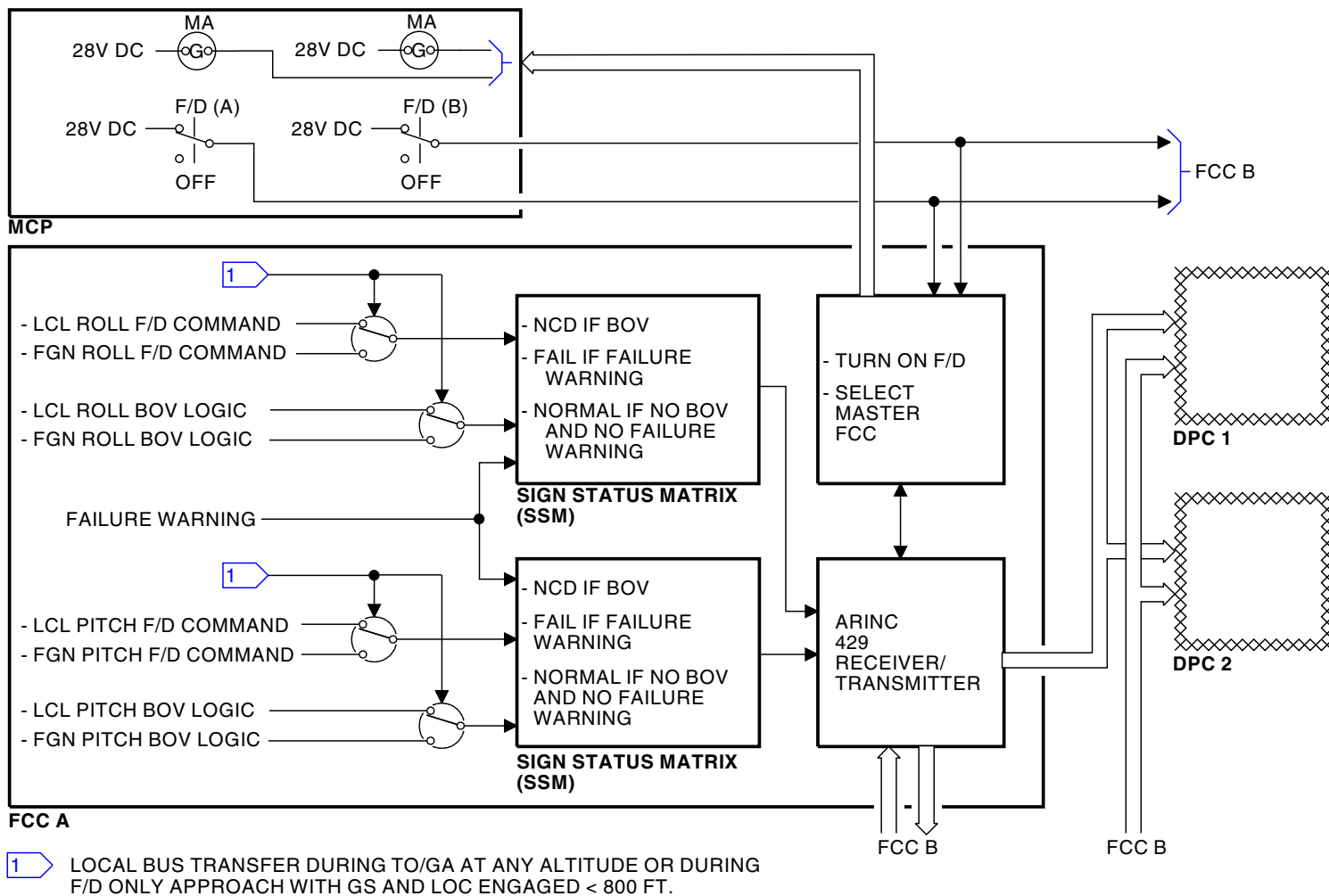
MDS

The FCC biases the entire symbol out of view if either roll or pitch F/D command is NCD.

The failure warning signal causes the F/D flag to appear on the MDS and the F/D command to BOV.

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DFCS - FUNCTIONAL DESCRIPTION - F/D FLAG AND BOV



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DFCS - FUNCTIONAL DESCRIPTION - F/D FLAG AND BOV

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DFCS - FUNCTIONAL DESCRIPTION - F/D ROLL MODE BOV LOGIC TABLE

General

The table shows the conditions that cause the flight director (F/D) to bias out of view (BOV) the F/D integrated cue. The F/D integrated cue will BOV because the roll mode is BOV.

BOV Conditions

These conditions cause the flight director to BOV:

- The roll command is BOV when the F/D is off except when the F/D is in the pop-up mode
- The roll command is BOV when the F/D is on and the crew did not set a roll mode
- The selected VOR or LOC receiver is invalid. There is an 8-second delay for the VOR signal and a 2-second delay for the LOC signal
- The LVAV signal from the flight management computer (FMC) is invalid
- The crew tunes to a VOR frequency after localizer capture. Also the other A/P is in CMD and LOC capture, however, the local VHF navigation control panel is tuned to a VOR frequency
- The radio altimeter is invalid for more than 2 seconds and the F/D is in the LOC capture mode
- The other A/P is in CMD and VOR capture, however, the local VHF navigation control panel is tuned to a LOC frequency
- The flare mode is active
- The true airspeed (TAS) is invalid
- The lateral acceleration from the ADIRU is invalid
- The magnetic track angle from the ADIRU is invalid
- The roll angle from the ADIRU is invalid
- The magnetic heading from the ADIRU is invalid
- A transfer of the IRS transfer switch to the BOTH ON R or the BOTH ON L position will BOV the F/D roll display
- An AC bus transfer with no A/P in CMD, both F/Ds are on, and above 800 feet will BOV the F/D roll display. If the transfer occurs below 800 feet, the F/D commands come from the other FCC

- The F/D comparator compares the roll commands from both F/Ds. If the difference is more than the set limit, the F/D roll display is BOV
- If the NAV transfer switch is in the BOTH ON 1 position, neither A/P is in CMD, and both F/Ds are on, F/D B will BOV. If the NAV transfer switch is in the BOTH ON 2 position, neither A/P is in CMD, and both F/Ds are on, F/D A will BOV
- An MCP bus invalid signal causes the roll F/D display to BOV. For the takeoff (T/O) and go-around (G/A) modes this occurs when below 400 feet
- The roll rate from the ADIRU is invalid.

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DFCS - FUNCTIONAL DESCRIPTION - F/D ROLL MODE BOV LOGIC TABLE

CONDITIONS	SELECTED MODES							
	TO	HDG	L NAV	VOR ENG	LOC ENG	APP LOC ENG	APP OC	G/A
1. F/D OFF, EXCEPT IN POP UP MODE	X	X	X	X	X	X	X	X
2. F/D ON AND NO ROLL MODE SELECTED	-	-	-	-	-	-	-	-
3. SELECTED VOR OR LOC RECEIVER INVALID (VOR 8 SEC/LOC 2 SEC)				X	X	X	X	
4. LNAV INVALID			X					
5. LOC CAPTURED AND A VOR FREQUENCY IS TUNED					X	X	X	
6. RA INVALID (2 SEC DELAY) AND LOC CAPTURE					X	X	X	
7. VOR CAPTURED AND A LOC FREQUENCY IS TUNED				X				
8. FLARE							X	
9. TAS INVALID	X	X						
10. LATERAL ACCELERATION INVALID					X	X	X	
11. MAGNETIC TRACK ANGLE INVALID				X	X	X		
12. ROLL ANGLE INVALID	X	X	X	X	X	X	X	X
13. MAGNETIC HEADING INVALID	X	X						
14. IRS TRANSFER AND NEITHER A/P IN CMD AND BOTH F/D ARE ON	X				X	X	X	X
15. AC BUS TRANSFER AND NEITHER A/P IN CMD AND BOTH F/D ARE ON						2	2	
16. F/D COMPARATOR	X						1	X
17. VHF NAV TRANSFER AND NEITHER A/P IN CMD AND BOTH F/D ARE ON				X	X	X	X	
18. MCP BUS INVALID (5 SEC DELAY)	3	X	X	X				3
19. ROLL RATE INVALID		X	X	X	X			

1 NEITHER A/P IN CMD AND RA < 800 FEET 2 AC BUS TRANSFER WITH RA > 800 FEET 3 MCP BUS INVALID WHEN RA < 400 FEET

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DFCS - FUNCTIONAL DESCRIPTION - F/D ROLL MODE BOV LOGIC TABLE

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DFCS - FUNCTIONAL DESCRIPTION - F/D PITCH MODE BOV LOGIC TABLE 1

General

The table shows the conditions that cause the flight director (F/D) to bias out of view (BOV) the F/D integrated cue. The F/D integrated cue will BOV because the pitch mode is BOV.

BOV Conditions

These conditions cause the flight director to BOV:

- If the NAV transfer switch is in the BOTH ON 1 position, neither A/P is in CMD, and both F/Ds are on, F/D B will BOV. If the NAV transfer switch is in the BOTH ON 2 position, neither A/P is in CMD, and both F/Ds are on, F/D A will BOV
- The pitch angle and vertical speed from the ADIRU are invalid.
- The roll angle from the ADIRU is invalid.

- The pitch command is BOV when the F/D is off except when the F/D is in the pop-up mode
- The pitch command is BOV when the F/D is on and the crew did not set a pitch mode
- The foreign A/P is in CMD and G/S engaged, however, the local VHF navigation control panel is tuned to a VOR frequency
- The radio altimeter is invalid for more than 2 seconds
- The selected G/S receiver is invalid. There is a 2 second delay for the G/S signal
- This is an unsafe flight condition. The F/D is in a speed mode, the airplane should be climbing but it is not, and it approaches a stall
- This is another unsafe flight condition. The F/D is in a speed mode, the airplane should be descending but it is not, and it approaches the VMO/MMO limit
- The MCP is set for a higher altitude, however, the FMC command is V/S descent. There is a 0.5 second delay
- The MCP is set for a lower altitude, however, the FMC command is V/S climb. There is a 0.5 second delay
- The FMC target V/S is invalid.
- The autopilot is in the G/A mode, but the F/D does not go into G/A because of a failure. This causes the pitch F/D command to BOV
- The flare mode is active
- An AC bus transfer with no A/P in CMD, both F/Ds are on, and above 800 feet will BOV the F/D pitch display. If the transfer occurs below 800 feet, the F/D commands come from the other FCC

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DFCS - FUNCTIONAL DESCRIPTION - F/D PITCH MODE BOV LOGIC TABLE 1

CONDITIONS	SELECTED MODES											
	TO	V/S	MCP ALT ACQ	MCP ALT HLD	LVL CHG IAS	LVL CHG MAC	VNV SPD	VNV V/S	VNV ALT ACQ	VNV ALT HLD	G/S ENG	G/A
1. F/D OFF, EXCEPT IN POP UP MODE	X	X	X	X	X	X	X	X	X	X	X	X
2. F/D ON AND NO PITCH MODE SELECTED	-	-	-	-	-	-	-	-	-	-	-	-
3. SELECTED LCL VOR TUNED AND FGN CMD AND G/S ENGAGED											X	
4. RA INVALID (2 SEC DELAY FOR G/S ONLY)											X	
5. G/S RECEIVER INVALID (2 SEC DELAY)											X	
6. CLB CMD, ALPHA WARN, NOT CLB MIN V/S, IN AIR (5S)					X	X	X					
7. DES CMD, VMO/MMO, NOT DES MIN V/S, IN AIR (10 SEC)					X	X	X					
8. MCP ALT CLB AND FMC V/S DESCENT (0.5 SEC DELAY)								X				
9. MCP ALT DES AND FMC V/S CLIMB (0.5 SEC DELAY)								X				
10. FMC TARGET V/S INVALID								X				
11. PITCH A/P G/A AND NOT F/D G/A												X
12. FLARE											X	
13. LCL AC BUS XFER AND NO A/P IN CMD AND BOTH F/D ON											1	
14. VHF NAV XFER AND NO A/P IN CMD AND BOTH F/D ON											X	
15. PITCH ANGLE AND VERTICAL SPEED INVALID	X	X	X	X	X	X	X	X	X	X	X	X
16. ROLL ANGLE INVALID		X	X	X				X	X	X	X	

1 AC BUS TRANSFER WHEN RA > 800 FEET

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DFCS - FUNCTIONAL DESCRIPTION - F/D PITCH MODE BOV LOGIC TABLE 1

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DFCS - FUNCTIONAL DESCRIPTION - F/D PITCH MODE BOV LOGIC TABLE 2

General

This table also shows the conditions that cause the flight director (F/D) to bias out of view (BOV) the F/D integrated cue. The F/D integrated cue will BOV because the pitch mode is BOV.

BOV Conditions

These conditions also cause the flight director to BOV:

- The pitch attitude rate data from the ADIRU is invalid
- The vertical acceleration from the ADIRU is invalid
- The longitudinal acceleration from the ADIRU is invalid
- The static pressure from the ADIRU is invalid
- The true airspeed from the ADIRU is invalid
- The baro uncorrected altitude from the ADIRU is invalid
- The baro corrected altitude from the ADIRU is invalid
- The computed airspeed from the ADIRU is invalid
- The mach data from the ADIRU is invalid
- The F/D comparator compares the pitch commands from both F/Ds. If the difference is more than the set limit, the F/D pitch display is BOV
- The FMC target altitude is invalid
- The FMC target airspeed/mach is invalid
- An MCP bus invalid signal causes the pitch F/D display to BOV. For the takeoff (T/O) and go-around (G/A) modes this occurs when below 400 feet
- The flight path acceleration from the ADIRU is invalid
- If the foreign F/D pitch display is BOV and there is an AC bus transfer, the local F/D pitch display will BOV.

EFFECTIVITY	
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DFCS - FUNCTIONAL DESCRIPTION - F/D PITCH MODE BOV LOGIC TABLE 2

CONDITIONS	SELECTED MODES											
	TO	V/S	MCP ALT ACQ	MCP ALT HLD	LVL CHG IAS	LVL CHG MAC	VNV SPD	VNV V/S	VNV ALT ACQ	VNV ALT HLD	G/S ENG	G/A
17. PITCH ATTITUDE RATE INVALID	X										X	X
18. VERTICAL ACCELERATION INVALID	X				X		X				X	X
19. LONGITUDINAL ACCELERATION INVALID	X				X	X	X					X
20. STATIC PRESSURE INVALID					X	X	X					
21. TRUE AIRSPEED INVALID	X	X	X	X	X	X	X	X	X	X		X
22. BARO UNCORRECTED ALTITUDE INVALID		X	X	X	X	X	X		X	X		
23. BARO CORRECTED ALTITUDE INVALID		X	X	X								
24. COMPUTED AIRSPEED INVALID	X				X		X					X
25. MACH INVALID						X	X					
26. F/D COMPARATOR	X										X	X
27. FMC TARGET ALTITUDE INVALID									X	X		
28. FMC TARGET AIRSPEED/MACH INVALID							X					
29. MCP BUS INVALID (5 SEC DELAY)	1	X	X	X	X	X	X	X	X	X		1
30. FLIGHT PATH ACCELERATION INVALID	X											X
31. FGN F/D IS BOV AND AC BUS TRANSFERS		X	X	X	X	X	X	X	X	X		

1 MCP BUS INVALID WHEN RA < 400 FEET

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DFCS - FUNCTIONAL DESCRIPTION - F/D PITCH MODE BOV LOGIC TABLE 2

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - FUNCTIONAL DESCRIPTION - ALTITUDE ALERT****General**

The FCCs compare baro-corrected altitude with the selected reference altitude on the Mode Control Panel (MCP). If the difference is within certain limits, the FCC causes an altitude alert warning.

FCC A uses the captain baro-corrected altitude from the left ADIRU and FCC B uses the First Officer baro-corrected altitude from the right ADIRU.

Altitude Alert Function

When you approach the selected altitude from above or below and are 900 feet from the selected altitude, the altitude alert starts. The alert consists of a one second aural warning and a bright white box around the airplane altitude display and the selected altitude display on the MDS. The visual warning continues until the airplane is less than 200 feet from the selected altitude.

If the airplane now climbs or descends more than 200 feet from the selected altitude, a one second aural warning occurs and a flashing amber box shows around the airplane altitude display. The visual warning stops for these conditions:

- Airplane returns to within 200 feet of the selected altitude
- You change the altitude on the MCP
- The airplane is more than 900 feet from the selected altitude

Altitude Alert Conditions

One FCC supplies the warning. FCC A normally gives the altitude alert warning. FCC B only gives the warning for these conditions:

- FCC A baro-corrected altitude is invalid
- Only FCC B autopilot is engaged in CMD and FCC B baro-corrected altitude is valid
- Only FCC B flight director is on and FCC B baro-corrected altitude is valid.

If the FCC captures the glideslope or the crew lowers the flaps more than 20 degrees, the FCC does not give the altitude alert warning.

Loss of Baro-Corrected Altitude

If the baro-corrected altitude in both FCCs is invalid and the airplane is in the air, these events occur:

- The referenced altitude and its display on the MCP goes to 50,000 feet
- The visual warning display on the MDS flashes
- A single aural warning occurs.

The crew cannot change the selected altitude display, but if they turn the altitude select knob, the visual warning stops.

If one of the FCC baro-corrected altitudes becomes valid, the altitude alert warning stops and the crew can change the selected altitude on the MCP.

22-11-00**EFFECTIVITY**
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The diagram illustrates the logic for altitude alerting system (AAS) display cancellation and tone generation based on MCP altitude selection. It shows three scenarios where the AAS display is cancelled:

- Scenario 1 (Top Left):** The aircraft is at 900 FT. The MCP altitude is selected as 200 FT. A "1 SEC TONE" is generated, and the display is cancelled.
- Scenario 2 (Top Right):** The aircraft is at 200 FT. The MCP altitude is selected as 900 FT. A "1 SEC TONE" is generated, and the display is cancelled.
- Scenario 3 (Bottom):** The aircraft is at 200 FT. The MCP altitude is selected as 900 FT. A "1 SEC TONE" is generated, and the display is cancelled.

The diagram also includes a central section showing the AAS display with a white box around the airplane altitude display and the selected altitude, and an amber box around the airplane altitude display. The display shows 5200 FT. Below the display, there are three callouts explaining the boxes:

- THE WHITE BOX SHOWS AROUND THE AIRPLANE ALTITUDE DISPLAY AND THE SELECTED ALTITUDE**
- THE AMBER BOX SHOWS AROUND THE AIRPLANE ALTITUDE DISPLAY AND FLASHES**
- THE AMBER ALTITUDE ALERT DISPLAY IS REMOVED WHEN A NEW ALTITUDE IS SELECTED**

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DFCS - FUNCTIONAL DESCRIPTION - ALTITUDE ALERT

22-11-00

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**DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM/AUTOPILOT TRIM BLOCK DIAGRAM****General**

The speed trim system (STS) provides speed and pitch stability augmentation. Speed stability augmentation is provided by the Speed Trim function in STS. Pitch stability augmentation is provided by the Maneuvering Characteristics Augmentation (MCAS) function in STS. The speed trim system is only operational when the autopilot is not engaged.

The air data inertial reference unit (ADIRU) sends these signals to the FCC for speed trim system calculations:

- Computed airspeed (CAS)
- Mach
- Inertial vertical speed
- Roll angle
- Pitch rate
- Angle of attack.

The display processing computer (DPC) send the engine N1 inputs to the FCC. The flap position sensors send the flap position data to the FCC. The radio altimeters send altitude data to the FCC. The FCC calculates speed trim system command signals. It sends the signals through these switches to the stabilizer trim electric actuator:

- Column switching module
- A/P stabilizer trim cutout switch
- Stabilizer limit switches.

Speed Trim Stability

The speed trim function controls the stabilizer to oppose any change of airspeed. An increase in CAS causes a nose up trim command to the stabilizer. A decrease in CAS causes a nose down trim command to the stabilizer. The signals from the stabilizer position sensors stop the commands when the stabilizer moves the correct amount.

The FCC trims the stabilizer nose down as speed decreases and to allow for speed trim above the stickshaker AOA and idle thrust. When the stabilizer position reaches its limit, the trim stops. When the trim starts to exceed the aft column cutout position, the trim stops. The FCC stops the speed trim function if the roll angle is more than 40 degrees.

MCAS Pitch Stability

The MCAS function controls the stabilizer in the nose down direction to increase control column forces when at elevated AOA. When AOA is reduced below the threshold, the stabilizer is moved nose up to the position before any nose down stabilizer movement occurred.

FCC Selection For Speed Trim System

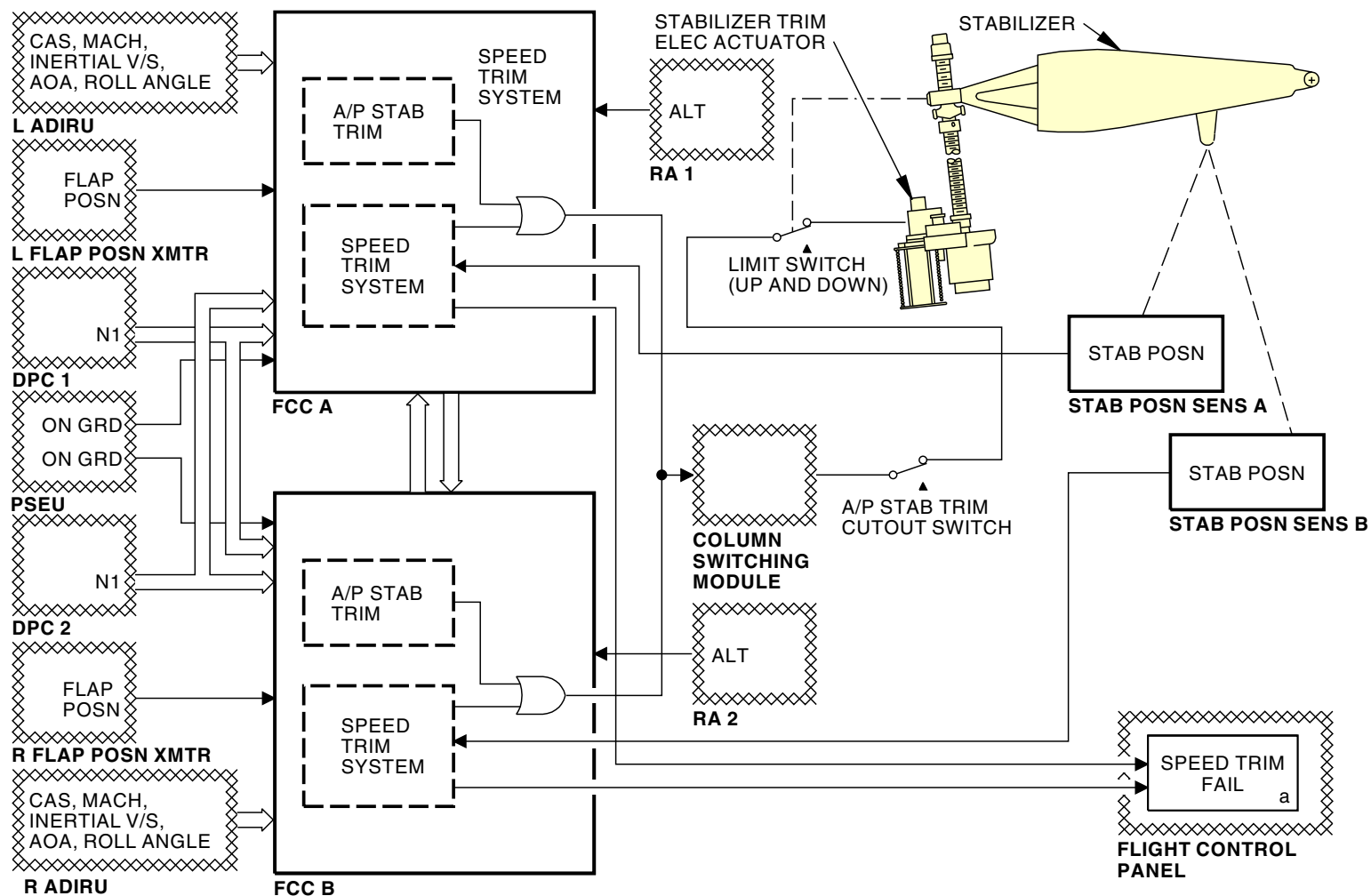
Only one FCC at a time supplies the speed trim system signal to the stabilizer trim electric actuator. When the FCCs get electrical power, FCC A supplies the speed trim system signals. If power remains on the FCCs, the on ground signal from the proximity switch electronics unit (PSEU) switches the FCC which supplies the speed trim system signals. If one FCC fails, the other FCC automatically supplies the speed trim system signal.

Speed Trim System Failure Display

The speed trim fail annunciator on the flight control module will show when the speed trim system functions in the FCC meet certain failure conditions.

EFFECTIVITY	
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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM/AUTOPILOT TRIM BLOCK DIAGRAM



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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM/AUTOPILOT TRIM BLOCK DIAGRAM

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**DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM FUNCTIONS****General**

The FCC supplies these signals to do the speed trim system functions:

- Speed trim nose up
- Speed trim nose down
- Speed trim reference hold
- Speed trim warning
- Flaps position.

Maneuvering Characteristic Augmentation System (MCAS)

MCAS is a function within the FCC designed to enhance pitch stability at elevated angles of attack (AOA). The purpose is to increase control column forces by commanding the stabilizer in the nose down direction at elevated AOA's.

Stabilizer is commanded at a rate of 0.27 degrees per second with stabilizer inputs limited to 0.65 degrees at high Mach, and 2.5 degrees at low Mach.

The 737-8/9 is limited to 0.40 degrees at 0.82 Mach.

The control law is designed to allow the flight crew to use electric stabilizer trim switches to stop and reverse MCAS, or set the STAB TRIM CUTOUT switches to CUTOUT to inhibit MCAS operation.

If the MCAS is inhibited, the SPEED TRIM light will illuminate.

The MCAS logic computes automated stabilizer deflection as follows:

- Initial nose down stabilizer trim command
- Stabilizer deflection
- Return stabilizer to the stabilizer position before MCAS.

MCAS function required the following interfaces/inputs:

- SMYD - Flap Position Validity
- ADIRU - True Airspeed (TAS), Vertical Speed, Roll Angle, Mach, Vane AOA, Pitch Rate, and Yaw Rate
- Radio Altimeter

- Stabilizer Position Sensor (Analog Synchro)
- Flap Position (Analog Synchro)
- PSEU - Squat switch
- Column Cutout Switches
- Pilot Main Electric Trim
- Warning Light with Driving Circuit
- Integrated Flight SYstems Accessory Unit (IFSEU).

MCAS commands the stabilizer trim as a function of:

- Flap position (flaps must be up)
- Angle of Attack
- Pitch rate
- True airspeed
- Mach.

SIA 007-999; SIA 001-006 POST SB 737-22A1342

MCAS Engage and Stabilizer Trim Integrity Monitoring

MCAS Engage is computed in the FCC lane 2 CPU and is transmitted via the lane 1 CPU. The lane 1 CPU will only transmit MCAS Engage (as computed by the lane 2 CPU) if the autopilot or CWS are not engaged and the flaps are UP (as determined by the lane 1 CPU). The purpose of this change is to reduce the likelihood of transmittal of an erroneous MCAS Engage discrete due to a lane 2 CPU failure.

In addition, the lane 1 CPU will inhibit transmittal of FCC Trim Up or Trim Down commands by the lane 2 CPU, if the commands are in opposition to the elevator surface position by an amount greater than that of the mechanical control column cutout switches, with the exception that the Trim Down command will not be inhibited when the lane 1 MCAS Engage discrete is True. The magnitude of the software column cutout thresholds was set to a value outside of the mechanical control column cutout switches in order to not interfere with the mechanical switches, but yet to still be effective if the mechanical switch fails to activate.

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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM FUNCTIONS

SIA 007-999; SIA 001-006 POST SB 737-22A1342 (Continued)

Cross-FCC Trim Monitor

The cross-FCC trim monitor provides additional protection against erroneous FCC trim commands caused by postulated failures in the FCC lane 2 CPU or I/O chips. This monitor is implemented in lane 2 of the FCC. While the FCCs are powered, each FCC is continuously monitoring the other FCC channel except during dual channel operation.

The FCC channel in which the autopilot or CWS is engaged, or which is the STS selected channel, is referred to as the operational FCC channel. The other FCC channel is referred to as the standby FCC channel.

The monitor compares the trim up and trim down command outputs from both FCCs with its own trim command calculation. The operational channel performs its normal stabilizer trim command calculations for use by the monitor. The standby channel switches its data sources to use the same data as the operational channel, with the exception of elevator surface position, flap position, gear up indication, pilot electric trim input, and some mode discretes, in order to perform stabilizer command calculations for use by its monitor.

If the stabilizer trim discretes outputs differ from the trim command calculation in the local channel's monitor for a cumulative 2 seconds, as determined by a two second up/down counter, then the local channel will take control of STS, and send a discrete to lane 1 of the foreign channel, indicating that the monitor has tripped. This will cause lane 1 of the foreign channel to prevent transmittal of the foreign channel's lane 2 stabilizer trim discrete outputs. If able, lane 2 of the foreign channel will then set a SPEED TRIM FAIL discrete that will be observed during pilot execution of the descent phase master caution recall checklist procedure.

If the foreign channel's autopilot or CWS is engaged at the time the local channel's lane 2 monitor has tripped, the autopilot or CWS will disconnect, accompanied by the autopilot disconnect warning aural and visual indications. Further attempts to engage the foreign channel's autopilot or CWS will be inhibited. Autopilot and CWS operation may still be available via the local channel.

In addition to the above, both channels will set the NO AUTOLAND discrete, causing NO AUTOLAND to be annunciated for the fail-operational configured airplanes. Both channels will also attempt to set the STAB OUT OF TRIM light to illuminate when on ground and below 30 knots. This is to ensure that there is a maintenance action in the event that the failed FCC channel is unable to report itself as failed using the SPEED TRIM FAIL light.

SIA ALL**Speed Trim Commands**

These input data and an adjustable gain control make the speed trim nose up and nose down commands:

- Stabilizer command
- Stabilizer position
- Inertial vertical speed (not used during F/D TO/GA).

The FCC uses computed airspeed (CAS) to calculate the stabilizer command signal.

This data goes through synchronizers before they are combined. The combined signals go through these components:

- Electronic switch
- Adjustable gain amplifier
- Speed trim detector.

Synchronizers

The synchronizer makes a reference signal from the input so that when speed trim starts, it compares the current value to the reference value. The synchronizers operate until conditions are met to calculate the speed trim commands and send them to the stabilizer actuator. This occurs when all of these conditions are true:

- Airplane is in the air for more than 10 seconds
- No manual electric trim for at least five seconds
- Autopilot in both FCCs is not engaged

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM FUNCTIONS**

- Flaps are down, gear is up, or CAS is less than 226 knots
- Speed trim function is valid.

The airplane is in the air if the squat switch shows it is in the air or if the radio altimeter shows an altitude more than 10 feet.

The output signal from the synchronizer is the difference between the reference signal and the input signals. The synchronizer is not used for computing MCAS stabilizer commands.

Speed Trim Cutout Electronic Switch

The stall detection circuit monitors the flap position and the angle of airflow. Near stall, the speed trim function trims the stabilizer to a nose down condition to allow for trim above the stickshaker AOA and idle thrust. The trim continues until the stabilizer gets to its limits or the aft column cutout position is exceeded.

If the roll angle from the ADIRU is more than 40 degrees, it opens an electronic switch and stops the speed trim signals.

Gain Control For Adjustable Amplifier

The FCC uses these inputs to calculate the fade out gain of the output amplifier:

- Reference stabilizer position
- Average of the N1 signals from the DPCs
- Flap position
- Mach.

The gain is 100 percent for a 1.5 degree stabilizer position with flaps down or -0.75 degree stabilizer position with flaps up. The gain is zero for a -3.0 degree stab position with flaps down or a -2.5 degree stab position with flaps up. The gain is 100 percent for an average N1 more than 80 percent or zero for an average N1 less than 60 percent. The gain is 100 percent for a Mach less than 0.5 or zero for a Mach more than 0.68.

Speed Trim Detector

The detector calculates if the trim signal should be a nose up or a nose down command. It also makes sure that the signal is there for at least 0.5 seconds before it calculates the command.

Nose Up and Nose Down Commands

The speed trim nose up and nose down commands use these signals:

- Nose up or nose down signal from the speed trim detector
- Airplane is in the air for more than 10 seconds
- No manual electric trim for at least five seconds
- Autopilot in both FCCs is not engaged
- Flaps are down, gear is up, or CAS is less than 226 knots
- Speed trim function is valid
- FCC is selected to give the speed trim system functions.

The MCAS nose up and nose down commands use these signals:

- Airplane is in the air for more than 10 seconds
- Flaps are up
- Autopilot in both FCCs is not engaged

SIA 001-006 PRE SB 737-22A1342

- Mach is between 0.20 and 0.84

SIA 007-999; SIA 001-006 POST SB 737-22A1342

- Mach is between 0.15 and 0.84

SIA ALL

- Speed trim system is valid
- AOA transitions above MCAS threshold after all of the above are true
- FCC is selected to give the speed trim system functions.

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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM FUNCTIONS

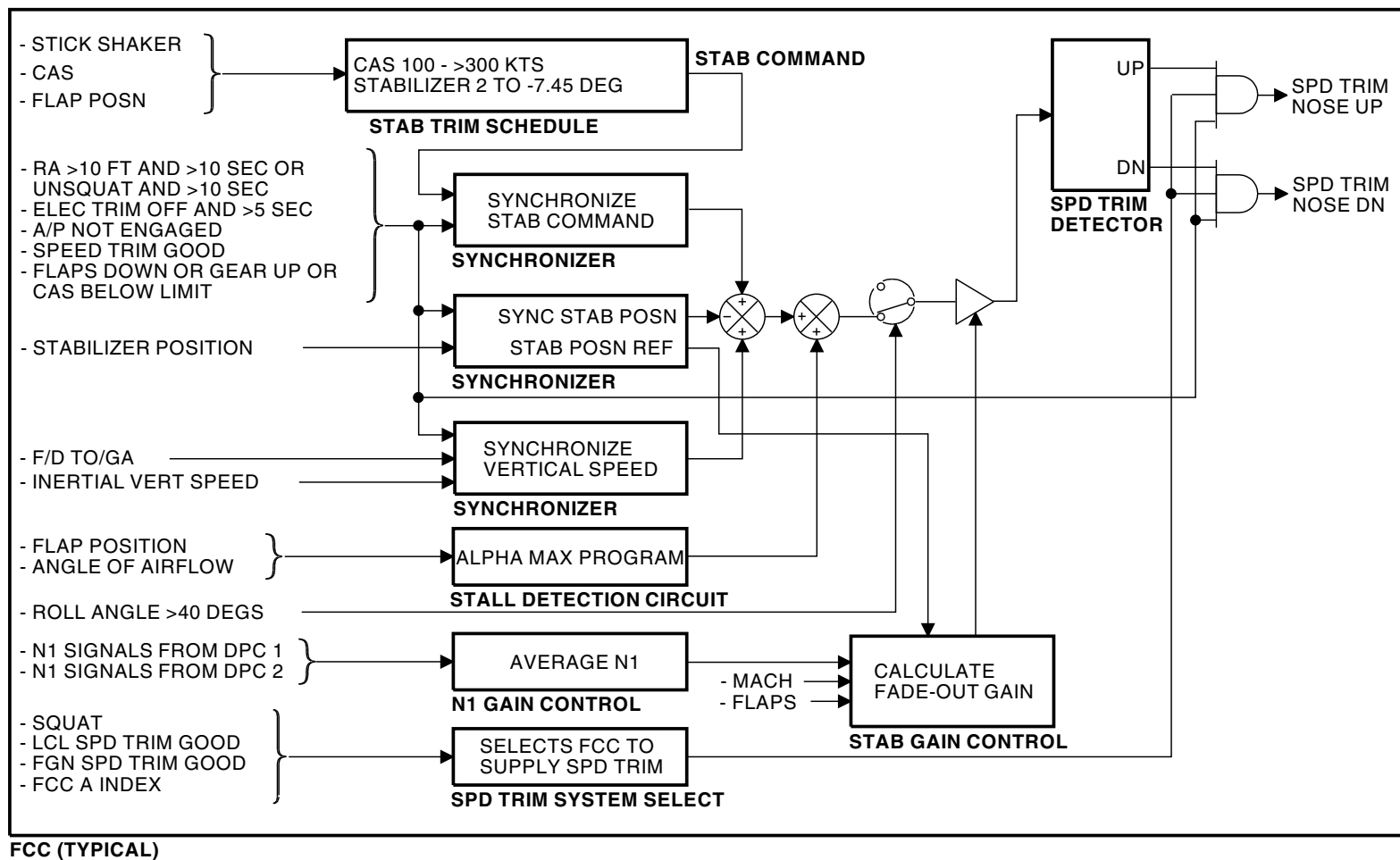
Speed Trim System Selection

The speed trim system select circuit looks at these signals to calculate if the FCC should control the speed trim system functions:

- Airplane is not on the ground
- Local and foreign FCC speed trim functions are good
- Which FCC is FCC A.

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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM FUNCTIONS



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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM FUNCTIONS

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**DFCS - FUNCTIONAL DESCRIPTION - A/P STABILIZER TRIM FUNCTION****General**

The FCC supplies trim signals to the stabilizer when the autopilot is engaged. The stabilizer trim function calculates these signals:

- A/P stab trim nose up
- A/P stab trim nose down.

The autopilot calculates how far it can move the elevator (elevator authority) and how far it commands the elevator to move (elevator command). If the ratio of the command to the authority is too large, the autopilot trims the stabilizer to decrease this ratio. If it did not do this, the elevator movement may reach its limit and the autopilot could no longer move the elevator in one direction.

Elevator Authority and Command

If the autopilot is in the pitch go-around (G/A) mode, the authority is 9 degrees. If the autopilot is not in the pitch go-around mode then the autopilot uses these signals to calculate the elevator authority:

- Total air pressure
- Static air pressure
- Stabilizer position.

If the flaps are between 0 and 7 degrees, the authority is limited to 3 degrees.

If the flaps are up, the autopilot uses the A/P elevator command. If the flaps are down, the autopilot uses these signals to calculate the elevator command:

- Elevator position
- Neutral shift sensor position
- Flare spring bias.

Flare Spring Bias

The flare spring bias commands the stabilizer to a nose up position. The autopilot commands the elevator to move down to hold the nose in the present attitude. If there is an autopilot disconnect, the elevators return to the neutral position. This flare spring bias then causes the airplane to pitch nose up.

These conditions must occur for the autopilot to calculate the flare spring bias:

- Airplane in dual approach mode
- Radio altitude below 400 feet
- Airplane not in pitch G/A mode.

The autopilot uses the stabilizer position and flap position to calculate the flare spring bias.

Stabilizer Trim Detector

The trim detector looks at the ratio of the elevator command to the elevator authority. If the elevator command is between 10% and 25% of the elevator authority for a limited time, it supplies a trim nose up or trim nose down signal. It stops the signal when the elevator command is less than 2% of the elevator authority.

If the airplane is in the pitch G/A mode, the detector supplies a trim signal if the ratio is more than 10% for 500 out of 800 milliseconds.

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**DFCS - FUNCTIONAL DESCRIPTION - A/P STABILIZER TRIM FUNCTION**

SIA 007-999; SIA 001-006 POST SB 737-22A1342

Stabilizer Trim Inhibit

During flaps down operation, nose up autotrim is inhibited at three knots below the amber band speed.

SIA ALL**A/P Stab Trim Commands**

The autopilot must meet these conditions before the stab trim nose up or stab trim nose down signal from the detector becomes a trim command:

- A/P is engaged
- Airplane is not in flare
- Airplane is not in the pitch CWS out of detent mode.

When the radio altitude is less than 60 feet, the FCC does not allow a nose down command.

The stab trim nose up command also occurs for 5.5 seconds after these conditions occur:

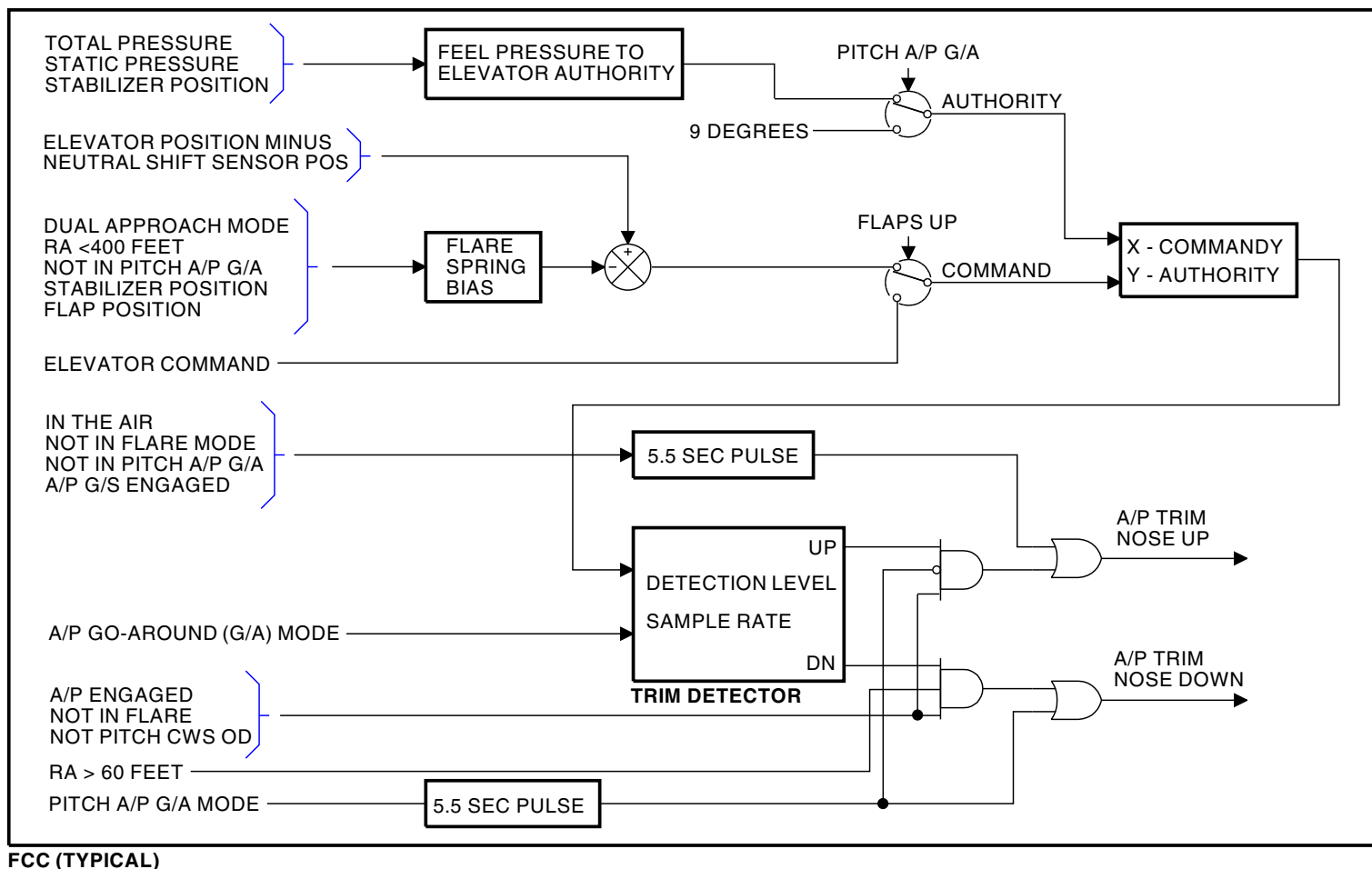
- Airplane is not in the G/A mode
- A/P G/S is engaged.

This stab trim nose up command causes the airplane to nose up as it starts the flare maneuver just before touchdown.

The stab trim nose down command also occurs from 0.2 to 5.5 seconds after the airplane is in the A/P G/A mode. Also during this time, the FCC does not allow any nose up commands.

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DFCS - FUNCTIONAL DESCRIPTION - A/P STABILIZER TRIM FUNCTION



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DFCS - FUNCTIONAL DESCRIPTION - A/P STABILIZER TRIM FUNCTION

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM AND STABILIZER TRIM COMMANDS****General**

The stabilizer trim system consists of these components:

- FCC A and FCC B
- Column switching module
- A/P stab trim cutout switch assembly
- Stab up and down limit switches
- Stab trim electric actuator.

FCC A and FCC B

The FCC can supply these commands:

- A/P trim nose up
- A/P trim nose down
- Speed trim system nose up
- Speed trim system nose down.

If the autopilot is engaged, the FCC can supply an A/P trim command. If the autopilot is not engaged, the FCC can supply a speed trim system command.

The FCC makes sure that the control column is not aft before it supplies a nose down trim command; however, the FCC allows the MCAS function within the STS is permitted to supply a nose down trim command even if the control column is aft.

The FCC supplies a trim valid signal if it does not command a nose up and nose down trim at the same time.

The FCC supplies either an A/P engaged signal or the speed trim reference hold signal as a clutch signal to the stab trim electric actuator. This signal is also used as a clutch valid signal.

The FCC supplies a flaps up signal to the stab trim electric actuator.

Column Switching Module

When the main electric trim is in operation, switches in the column switching module open. This does not let the FCC clutch signal go to the trim actuator. The FCC and the main electric trim cannot control the trim actuator at the same time.

If the pilot moves the control column forward or aft, signals go to the two FCCs. These signals do not allow the FCC to supply trim commands that do not agree with the pilot, with the exception of MCAS nose down commands.

A/P Stab Trim Cutout Switch Assembly

When the A/P stab trim cutout switches are in the cutout position, the FCC cannot control the stabilizer trim electric actuator. The 28V DC engage interlock power from the IFSAU is used to energize the cutout relay when the switch is in the cutout position. The switches open and do not let the trim commands and clutch signal go to the actuator. When the relay energizes, the 28V DC engage interlock power does not go to the FCC. This auto stab trim cutout signal tells the FCC that the switch is in the cutout position.

When the primary (PRI) or backup (B/U) stab trim cutout switches are set to CUTOUT, it stops the operation of the main electric, autopilot, and speed trim system function. The cutout switches removes FCC servo power from the stabilizer in CUTOUT position.

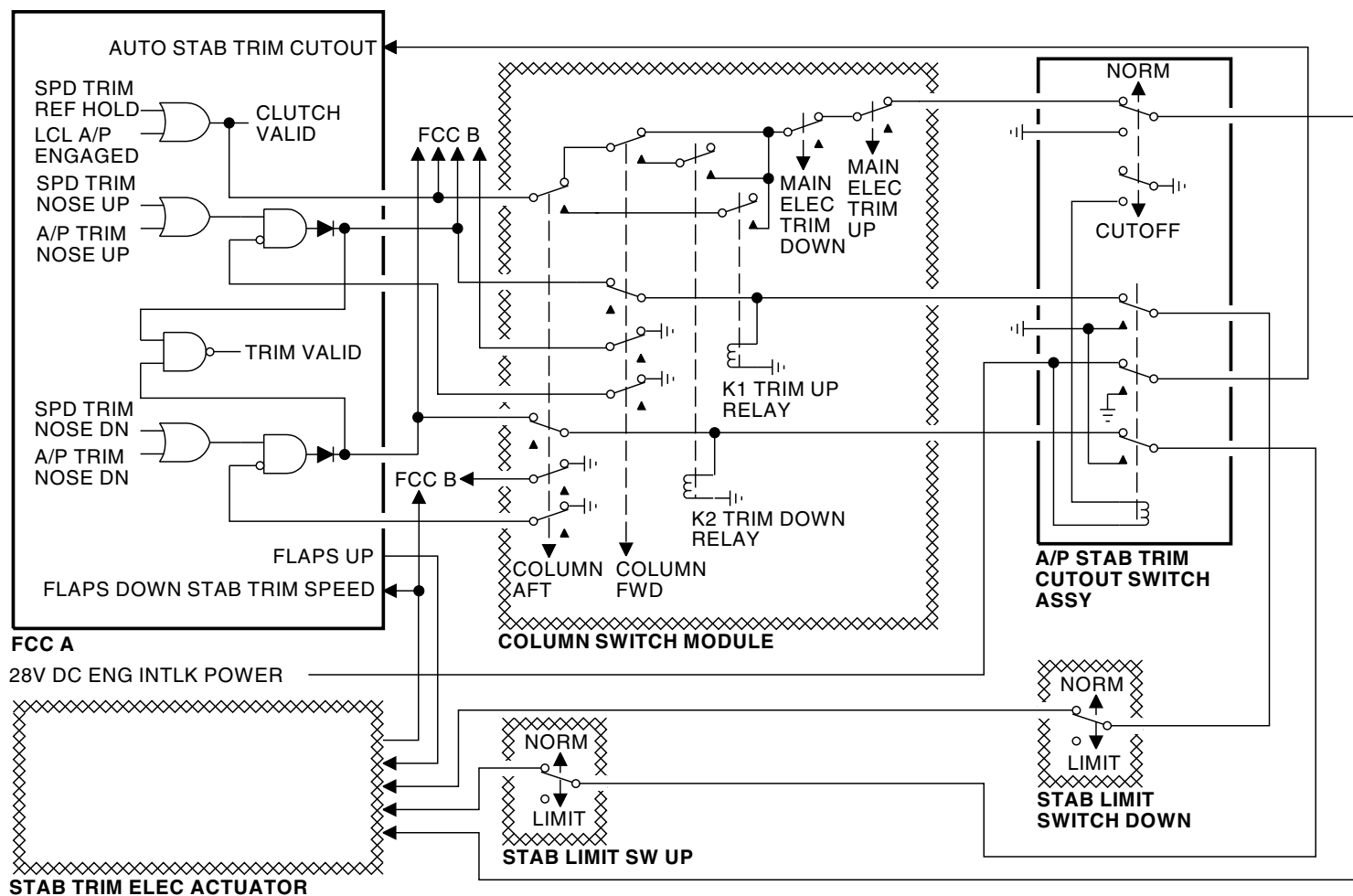
Stab Limit Up and Down Switches

The nose up and nose down trim commands go through the stab limit switches. If the stabilizer is out of limit, these switches will not let the commands go to the actuator.

Stabilizer Trim Electric Actuator

The trim actuator gets the trim commands from the FCC and moves the stabilizer. It sends a signal to the FCCs to tell them what speed the actuator is in. If the flaps are down, the actuator operates three times as fast as when the flaps are up.

DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM AND STABILIZER TRIM COMMANDS



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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM AND STABILIZER TRIM COMMANDS

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**DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM AND STABILIZER TRIM WARNINGS****General**

The FCC sends a speed trim system warning signal to the flight control module if it finds a failure in the Speed Trim System. The FCC sends a stab out of trim signal to the stab out of trim warning light if a stabilizer mistrim condition occurs.

Speed Trim System Warning

The speed trim system warning circuit supplies a warning signal if any of these conditions are not present:

- Air/ground sensors valid
- Stabilizer move in 10 seconds when commanded
- Engine N1s valid
- Stab trim position sensors valid
- Data from the air data inertial reference unit (ADIRU) valid
- Left ADIRU AOA and right ADIRU AOA are within 5.5 degrees of each other when flaps are up
- Clutch valid and trim valid signals present.

The air/ground sensors are valid if these conditions are present:

- Engines N1s are more than 18%
- Computed airspeed (CAS) is less than 80 knots
- The squat switch shows the airplane is on the ground.

The speed trim system warning circuit also supplies a warning if the FCC commands a trim up and trim down signal at the same time.

Speed Trim Fail Warning Light

If the function fails in only one FCC, the light does not come on. However, if you push either master caution recall switch when there is one failure, the speed trim fail light comes on. If you push the master caution reset switch, the light goes off.

Stab Out Of Trim Warning

The stab out of trim warning circuit looks at these conditions and if any occur, the warning may be set:

- Stabilizer does not move in 10 seconds when commanded
- Too much A/P actuator movement for 10 seconds
- Too much elevator command for 10 seconds.

Too much actuator movement means the difference between the elevator A/P actuator position and the elevator position sensor is greater than 3 degrees. If in single channel operation, the difference between the elevator A/P actuator position and the neutral shift sensor position must be less than 0.5 degrees to reset the warning.

Too much elevator command occurs when the difference between the elevator A/P actuator position and the neutral shift sensor position plus a bias is more than 5 degrees. The bias is zero unless these conditions are present and then the bias is 3 degrees nose up:

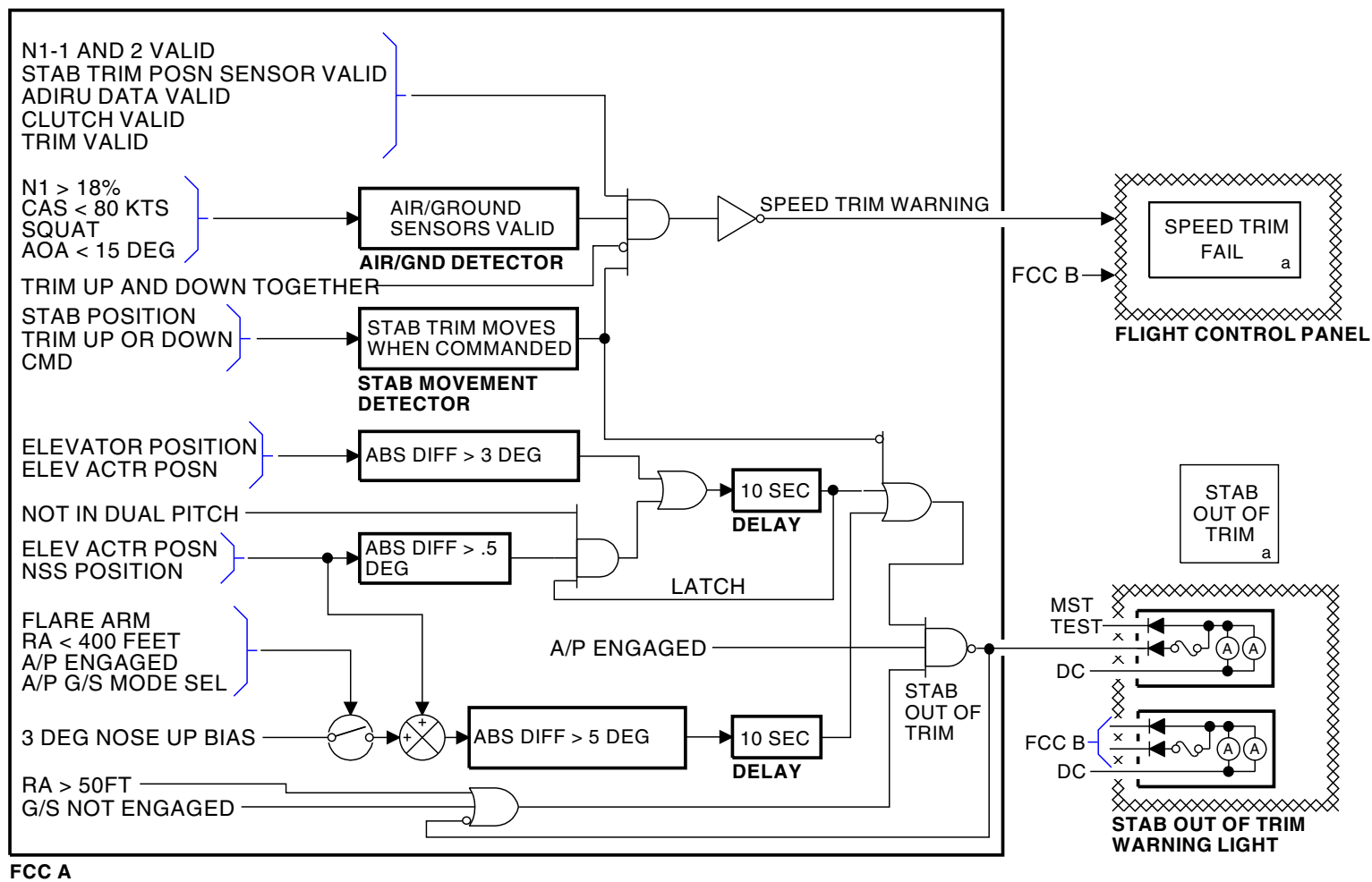
- Flare is armed
- Radio altitude is less than 400 feet
- A/P is engaged
- A/P G/S is engaged.

These conditions cause the stab out of trim annunciator to come on:

- Warning ready to set
- A/P engaged
- Radio altitude more than 50 feet or G/S not engaged or stab out of trim warning already set.

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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM AND STABILIZER TRIM WARNINGS



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DFCS - FUNCTIONAL DESCRIPTION - SPEED TRIM SYSTEM AND STABILIZER TRIM WARNINGS

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ECCN 9E991 BOEING PROPRIETARY - See title page for details



DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM BLOCK DIAGRAM

General

The mach trim system moves the elevators to prevent a nose down maneuver at high speeds. This occurs when the speed is between Mach 0.615 and Mach 0.860. The mach trim system also moves the elevators to increase a nose up maneuver at takeoff.

The air data inertial reference unit (ADIRU) sends the mach value to the FCC. The FCC calculates mach trim command signals. It sends the signals through the integrated flight system accessory unit (IFSAU) to the mach trim actuator. The FCC calculates the mach trim signals anytime it receives power.

The mach trim actuator is on the elevator feel and centering unit. When the actuator moves, it turns the feel and centering unit.

Autopilot Disengaged

When the autopilot is disengaged, the feel and centering unit supplies an input to the elevator power control units (PCU). This moves the elevators. A signal from the mach trim actuator tells the FCC how much it moves.

Autopilot Engaged

When the autopilot is engaged, the feel and centering unit cannot supply an input to the elevator PCUs. This is because the autopilot elevator actuators lock the elevator input torque tube. This will not let the input arms of the PCUs move. However, the mach trim actuator will turn the neutral shift sensor. The signals from the neutral shift sensor and the elevator position sensor go to the FCC. The FCC knows that the neutral shift position changes and the elevator position does not move. The FCC calculates an autopilot signal which then causes the autopilot elevator actuators to move the input to the PCUs.

FCC Selection For Mach Trim

The proximity switch electronics unit (PSEU) sends air/ground signals to the FCCs. When in the air, only one FCC supplies the mach trim signal to the mach trim actuator. FCC B controls which FCC to use and sends a signal to the IFSAU to make the selection.

Mach Trim Failure Display

The mach trim fail annunciator on the flight control module shows when the mach trim function in the FCC meets certain failure conditions.

FCC Controlled Neutral Shift Enable (FCNSE) Function

The mach trim system also moves the elevators to do an auto neutral shift function when the airplane is in the FCNSE region. The FCNSE region is when the flaps are not up and either engine N1 is more than 18%. The movement of the elevators depends on the trailing-edge flap position and the horizontal stabilizer position.

This function allows the airplane to have a larger nose up attitude during takeoff.

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DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM BLOCK DIAGRAM



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**DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM FUNCTION****General**

The FCC supplies these voltages and calculates these mach trim signals to operate the mach trim actuator:

- 26V AC mach trim excitation power
- 28V DC brake release power
- 115V AC motor excitation power
- Mach trim command signals
- Mach trim select signal
- Mach trim warning signal.

Mach Trim Excitation Power

The FCC power supply gets 115V AC from the electronics bus and changes this to the 26V AC, 400Hz position sensor excitation power.

Brake Release Power

The FCC supplies the 28V DC brake release power to the IFSAU if the FCC is in BITE or if it is in the FCC controlled neutral shift enable (FCNSE) region. The brake release power will stay for 20 seconds after the airplane exits the FCNSE region. The FCC also supplies the brake release power if all of these conditions are true:

- Airspeed is more than mach 0.60
- Airplane is in the air
- Mach trim select status signal is a ground
- Input 28V DC is good.

The FCC also supplies the 28V DC brake release power to the IFSAU if the airplane is in the FCNSE region. These conditions set the FCNSE region:

- Flaps not zero
- Either engine N1 more than 18 percent.

Motor Excitation Power

The FCC supplies the 115V AC motor excitation power to the IFSAU if the FCC is in BITE, in the FCNSE region or all of these conditions are true:

- Airspeed is greater than mach 0.60
- Airplane is in the air
- Mach trim select status signal is a ground
- Input 115V AC is good.

Mach Trim Commands

The FCC gets the mach from the ADIRU and calculates an elevator command from the mach speed. The FCC also gets the mach trim position signal from the mach trim actuator. The FCC compares the difference between these two signals and calculates the mach trim commands.

FCC Controlled Neutral Shift Enable Commands

The FCNSE command to the mach trim actuator does not change until one of these conditions occur:

- Manual electric trim occurs
- Autopilot electric trim occurs
- Flap position change occurs
- FCC enters FCNSE region because either engine N1 is more than 18 percent
- FCC exits FCNSE region because both engine N1s are less than 18 percent.

After the change occurs, the FCC calculates the new FCNSE command.

Mach Trim Select Signal

The FCC uses this data to find out which FCC should supply the mach trim signals:

- Airplane is on the ground
- Is the other, foreign, FCC good

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DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM FUNCTION

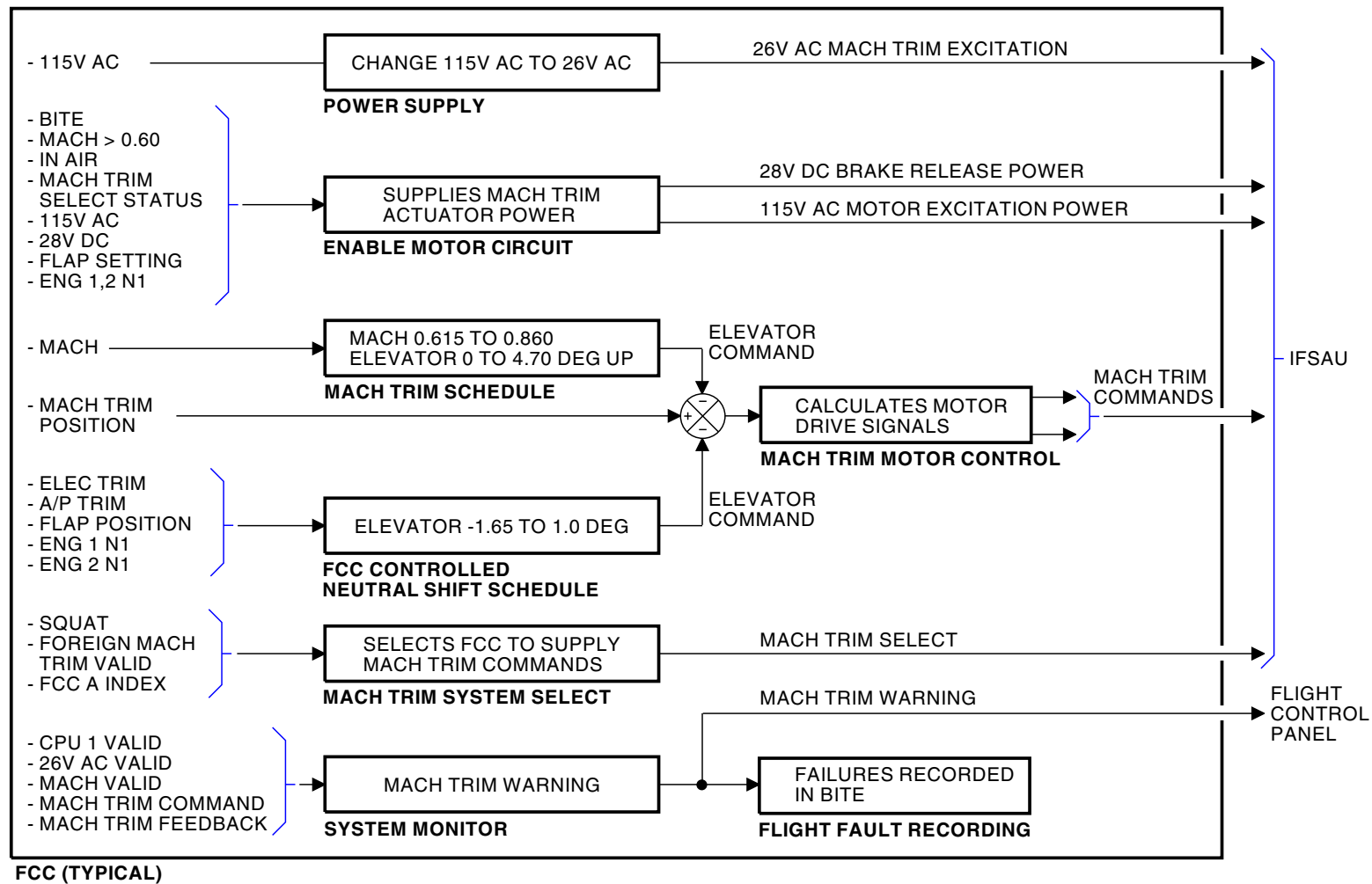
- Which FCC is FCC A.

Mach Trim Warning Signal

If the FCC finds that the mach trim function is not good, it stores the failures in its BITE memory. It also supplies a mach trim warning signal.

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DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM FUNCTION



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DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM FUNCTION

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**DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM COMMANDS****General**

Both FCCs calculate the mach trim signals to control the mach trim actuator. However, only one FCC operates the actuator. The FCC also sends a mach trim warning signal to the flight control panel when the mach trim function fails in the FCC.

FCC Selection For Mach Trim Function

Both FCCs determine which FCC should supply the mach trim command signals, however, only FCC B sends the mach trim select signal to the IFSAU. In the IFSAU, K4 and K5 control which FCC supplies the mach trim signals to the actuator.

If the mach trim select signal is a high, the relays are not energized and FCC A supplies the signals. If the mach trim select signal is a low, the relays are energized and FCC B supplies the signals.

When you turn on power to the airplane, FCC A controls the mach trim actuator. If power is not turned off, each time the airplane lands, the FCCs change which FCC controls the mach trim actuator. If the mach trim function in one FCC fails, the other FCC always controls the mach trim actuator.

Mach Trim Signals

The mach trim excitation signals supplies 26V AC excitation power to the mach trim position sensor in the actuator. The sensor position signals goes directly to both FCCs.

The brake in the actuator holds the output shaft so it does not move. When the actuator receives the 28V DC brake release power, it releases the brake.

The 115V AC motor excitation power supplies the excitation signal to the actuator motor. The motor command signals can now turn the motor to drive the output arm in or out. This causes the elevator feel and centering unit and the neutral shift sensor to turn.

The mach trim select status signal in the FCC is a ground if that FCC was selected. If it is an open, the other FCC was selected.

Mach Trim Fail Warning Light

If the mach trim function in the FCC is good, it grounds its mach trim warning signal. These signals energize relays K1 and K2 in the flight control panel. The mach trim fail light does not come on. If both mach trim functions fail, both relays deenergize and the light comes on.

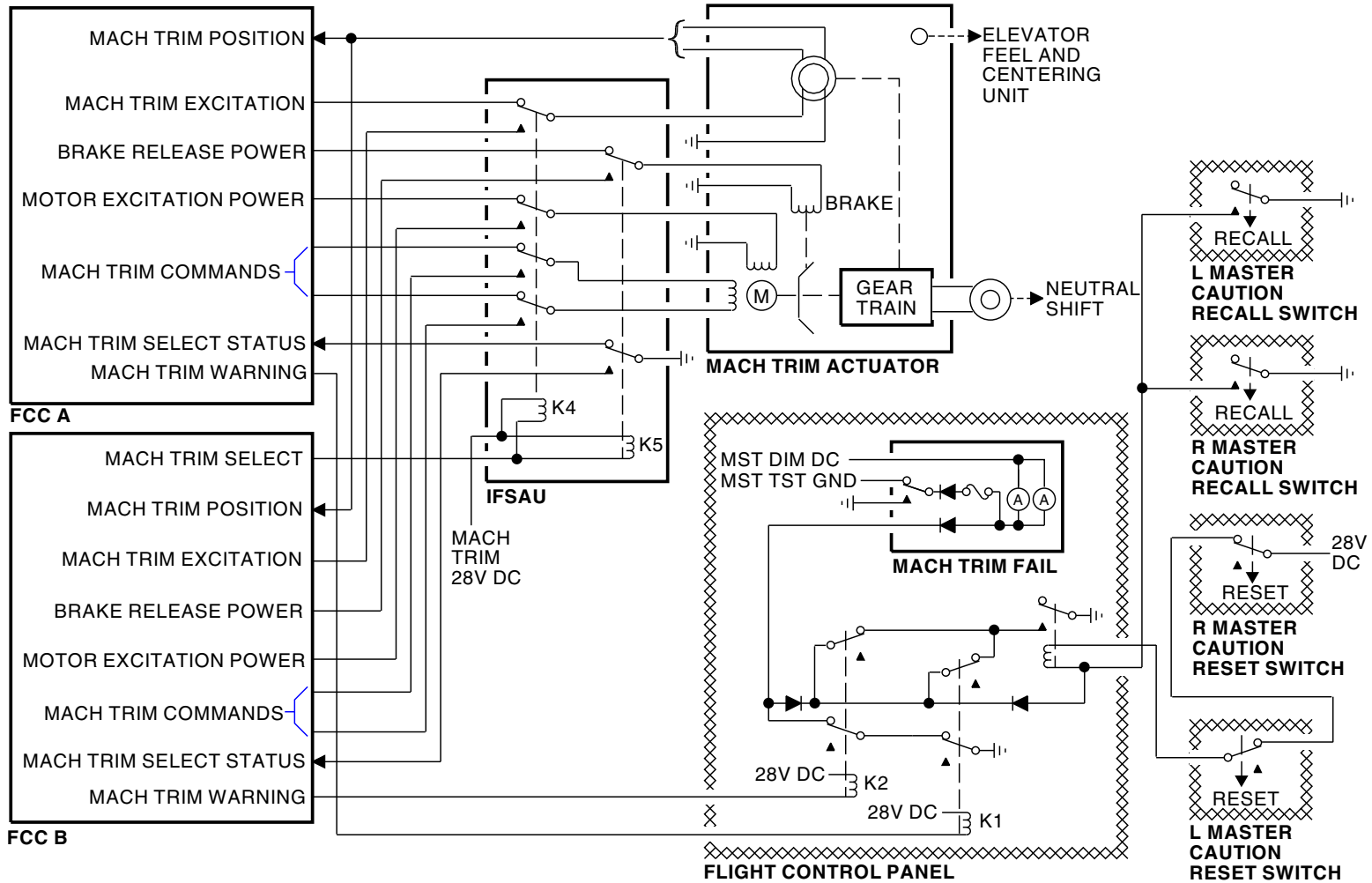
If only one function fails, the light does not come on. However, if you push either master caution recall switch when there is one failure, the mach trim fail light comes on. If you then push the master caution reset switch, the light goes off.

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DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM COMMANDS



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DFCS - FUNCTIONAL DESCRIPTION - MACH TRIM COMMANDS

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DFCS - FUNCTIONAL DESCRIPTION - PROGRAM PIN OPTIONS

General

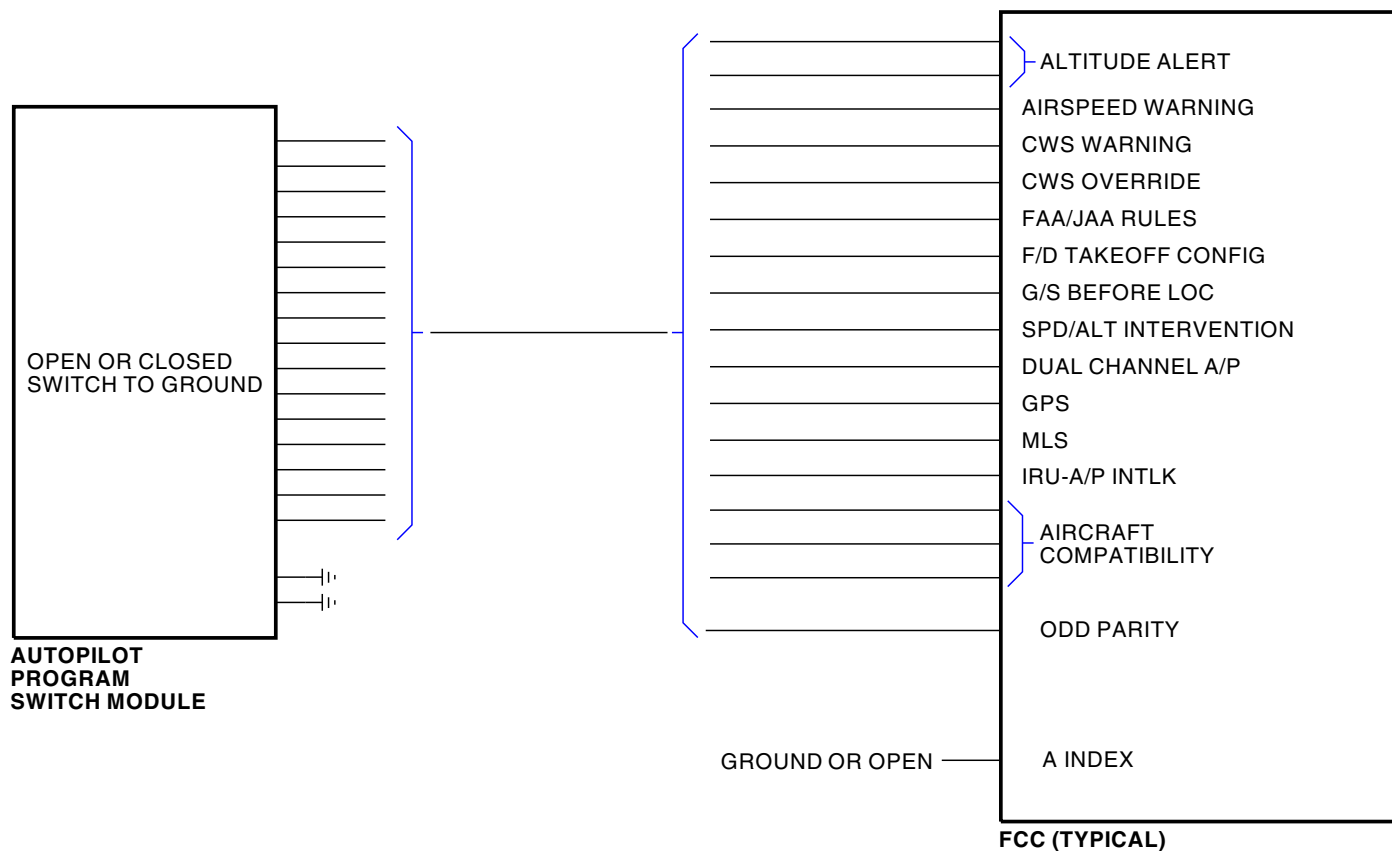
There are several FCC options available. The autopilot system A program switch module sets the options for FCC A. The autopilot system B program switch module sets the options for FCC B. These are your airplane options:

- Use 200/900 feet altitude limits in altitude alert option 3
- Permit CWS override on single channel approach
- Use FAA VMO/MMO command limits in the control laws
- Use wings level as the F/D takeoff roll mode
- Inhibit GS capture before LOC capture
- Use the altitude and speed intervention functions
- Use the dual channel autopilot operation, CAT IIIA
- The global positioning system (GPS) is installed
- Use of Autopilot with one IRU inoperative.
- This FCC is FCC A if open and FCC B if grounded.

You use the odd parity program pin to make the total number of pins that connect to ground an odd number.

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DFCS - FUNCTIONAL DESCRIPTION - PROGRAM PIN OPTIONS



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DFCS - FUNCTIONAL DESCRIPTION - PROGRAM PIN OPTIONS

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DFCS - OPERATION - OVERVIEW

General

The DFCS calculates autopilot (A/P) and flight director (F/D) commands for these flight sequences:

- Climb
- Cruise
- Descent
- Approach
- Go-around.

The DFCS calculates only F/D commands for the takeoff and only A/P commands for flare.

DFCS Modes

The pilots engage the A/P in CMD and turn on the F/Ds. The pilots use these mode selector switches on the MCP to select the roll and pitch modes for the flight sequences:

- Lateral navigation (LNAV)
- Vertical navigation (VNAV)
- Level change (LVL CHG)
- VHF omnirange (VOR)
- Localizer (LOC)
- Heading select (HDG SEL)
- Altitude hold (ALT HLD)
- Vertical speed (V/S)
- Approach (APP).

The takeoff/go-around (TO/GA) switches on the thrust levers can engage only the F/Ds in the takeoff mode. They can engage the A/Ps and F/Ds in the go-around mode.

The pilot can also engage an A/P in the CWS mode. The pilot can use roll and pitch CWS in these flight sequences:

- Climb

- Cruise
- Descent
- Approach.

Autoland

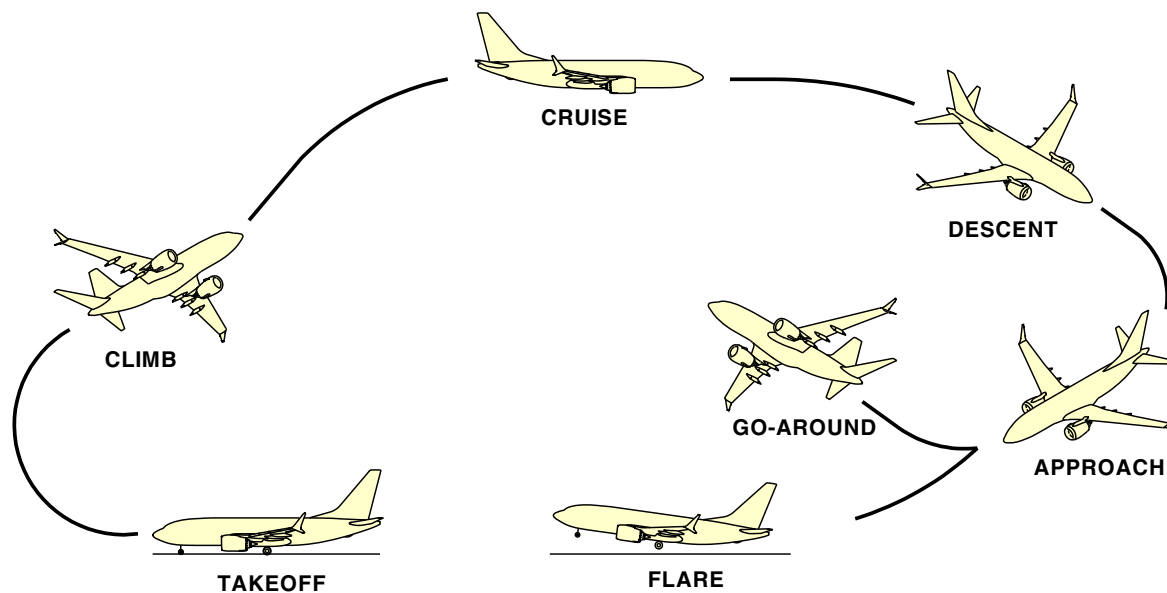
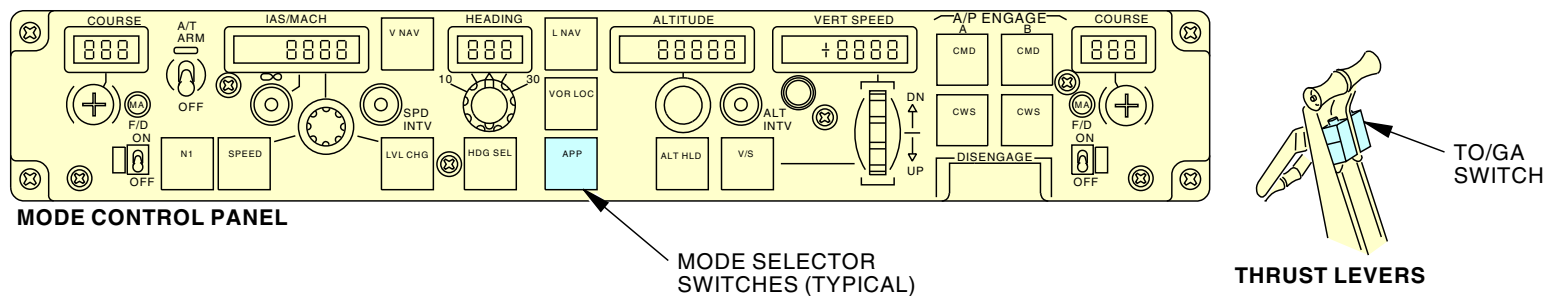
The autoland function consists of these three flight sequences:

- Approach
- Flare
- Go-around.

The DFCS will only go into autoland if the crew selects the APP mode selector switch and engages A/P A and A/P B in the CMD mode.

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DFCS - OPERATION - OVERVIEW



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DFCS - OPERATION - OVERVIEW

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**DFCS - OPERATION - FLIGHT DIRECTOR/FLIGHT MODE ANNUNCIATOR****General**

The DFCS has interface with the MDS to show these displays:

- Flight director (F/D) commands
- Flight mode annunciator (FMA)
- Selected target speed bug.

Flight Director Commands

The flight director commands show as an integrated cue on the attitude indicator (AI). The F/D commands show on the AI when the F/D switches are in the ON position or when the F/Ds are in the pop-up mode.

Flight Mode Annunciator

The modes for these functions show on the top part of the PFD:

- Autothrottle
- Roll
- Pitch.

The DFCS status shows just above the attitude indicator.

Engaged modes show in green letters and armed modes show in white letters. When the DFCS engages a new mode, a green box shows around the new mode for 10 seconds.

DFCS status annunciation shows the flight crew the operating status of the DFCS. The DFCS status annunciations that show in green are CMD and FD.

These DFCS status annunciations show in amber:

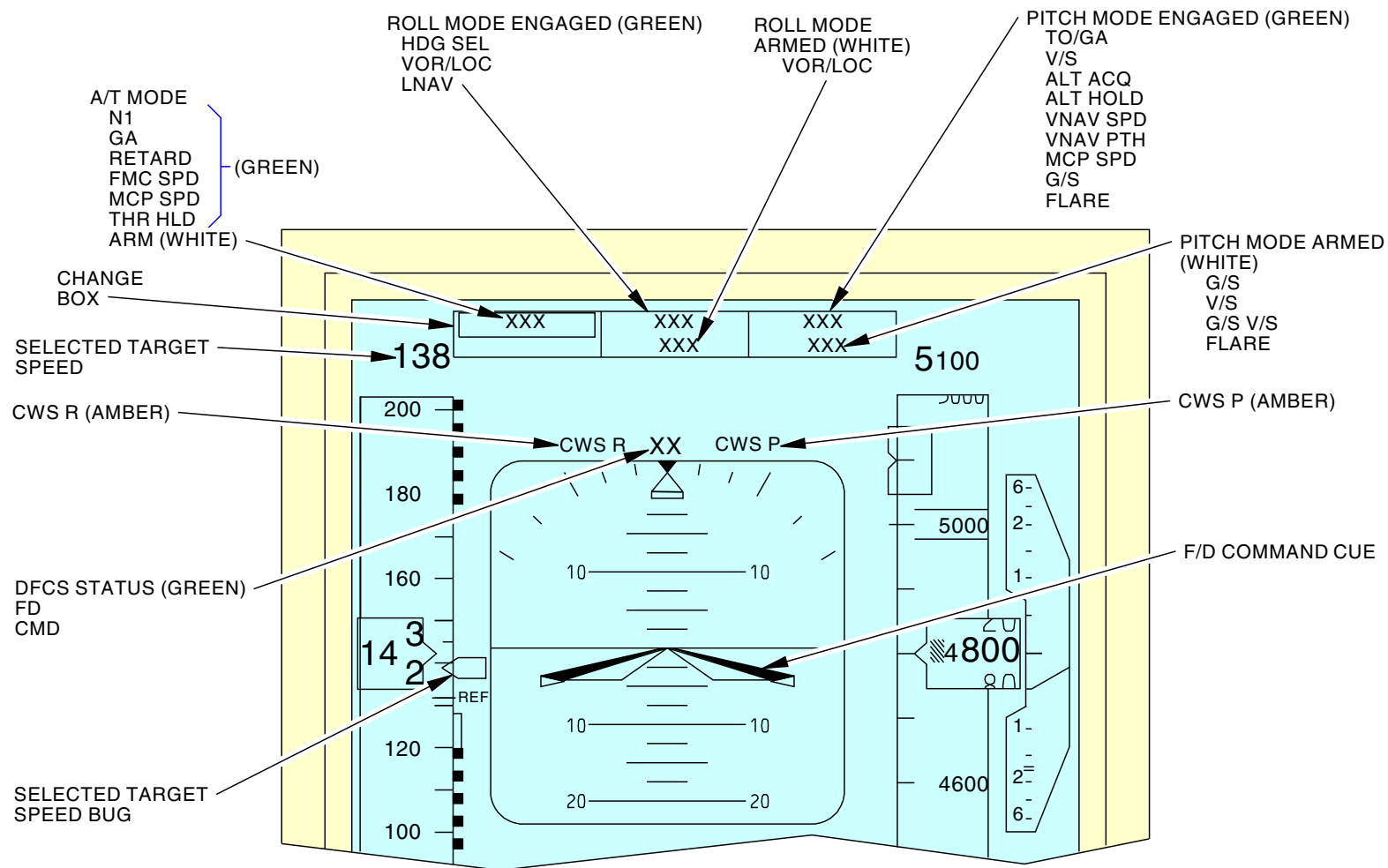
- CWS R
- CWS P.

An amber box shows around the new CWS R, CWS P or SINGLE CH status annunciation for 10 seconds.

Selected Target Speed Bug

The selected target speed shows above the airspeed tape. The magenta selected target speed bug shows on the airspeed tape. The selected target speed shows the MCP speed when the MCP IAS/MACH indicator is active. It shows the FMC target speed when the indicator is blank.

DFCS - OPERATION - FLIGHT DIRECTOR/FLIGHT MODE ANNUNCIATOR



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DFCS - OPERATION - FLIGHT DIRECTOR/FLIGHT MODE ANNUNCIATOR

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**DFCS - OPERATION - ALTITUDE DATA****General**

| The DFCS has interface with the MDS to show this information on the PFD:

- Altitude alert
- Selected altitude
- Metric selected altitude.

Altitude Alert

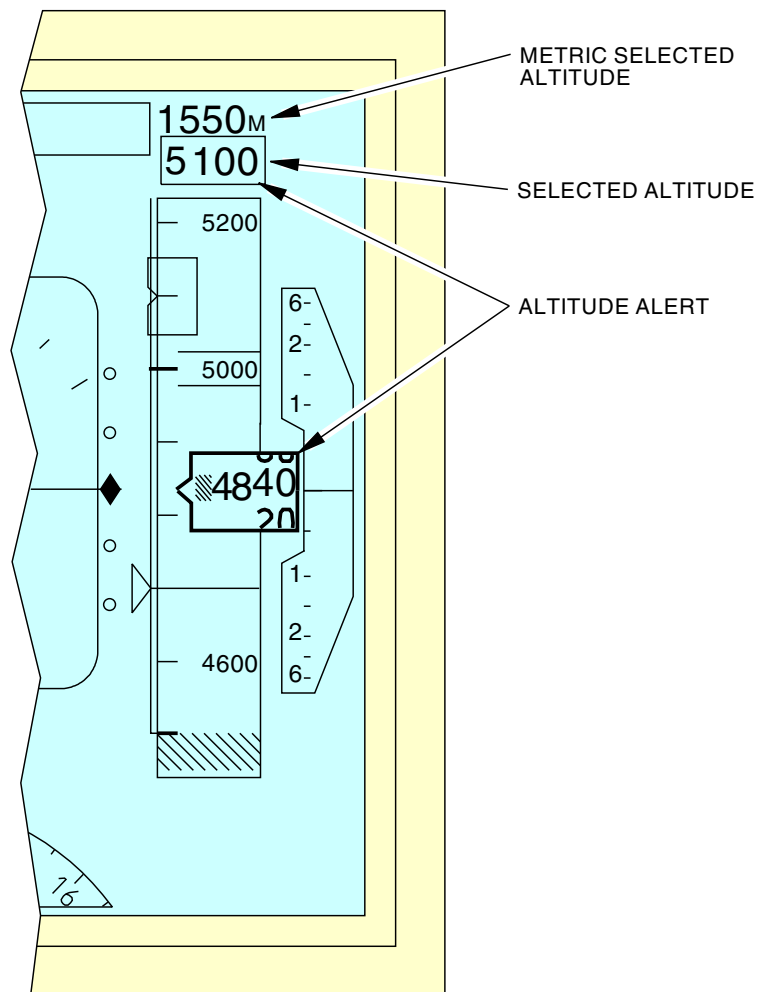
The altitude alert annunciation shows as a white or amber border around the airplane altitude display. Also there can be a white box around the selected altitude.

Metric Selected Altitude

The MCP selected altitude in meters shows above the selected altitude in feet. Both are above the altitude tape. The altitude readout is in magenta numbers and the meter symbol is a small magenta letter.

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DFCS - OPERATION - ALTITUDE DATA



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DFCS - OPERATION - ALTITUDE DATA

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DFCS - OPERATION - MDS FAILURE FLAGS

| General

These are the failure flags that show on the captain and first officer displays:

- Flight director flag
- Selected target speed flag.

If the altitude alert fails, the altitude alert annunciation does not show. If the MCP selected altitude fails, the metric selected altitude does not show.

Flight Director Flag

An amber FD flag shows on the AI when the FCC is invalid or in BITE.

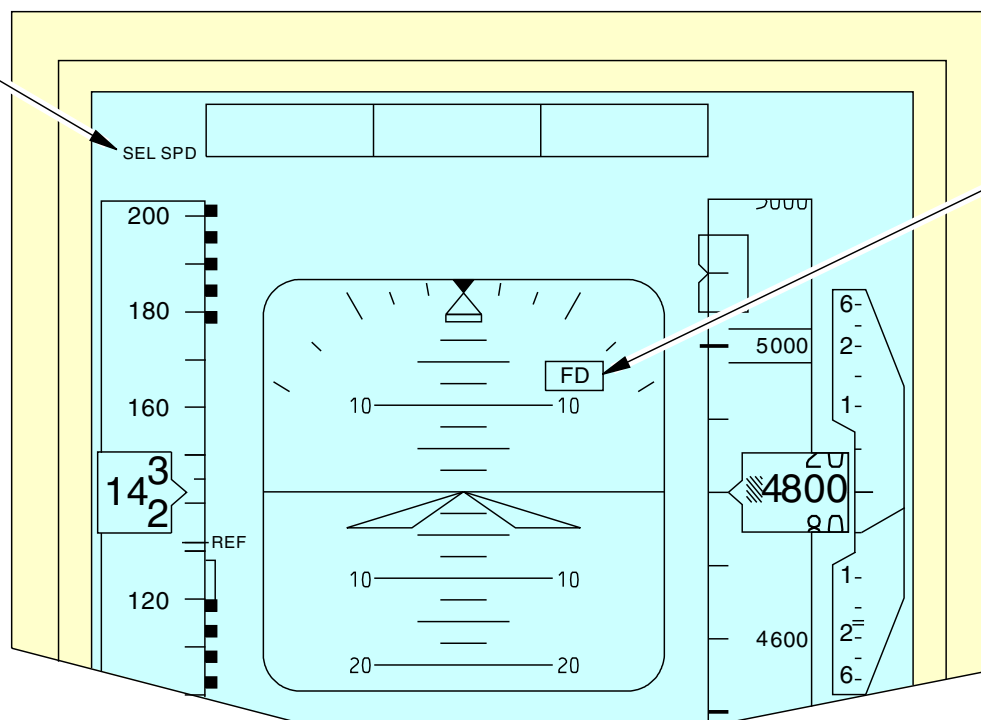
Selected Target Speed Flag

When the selected target speed is invalid, an amber SEL SPD message shows above the speed tape.

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DFCS - OPERATION - MDS FAILURE FLAGS

SELECTED TARGET
SPEED FLAG
(AMBER)



FD FLAG
(AMBER)

DFCS - OPERATION - MDS FAILURE FLAGS

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**DFCS - OPERATION - ENGAGE AUTOPILOT****General**

Autopilot engagement occurs when the pilot pushes an autopilot (A/P) CWS or CMD engage switch on the MCP. If the crew selects CWS, the A/P goes into CWS roll and CWS pitch modes. If you select CMD, the modes that the A/P goes into depend on many conditions.

Engage A/P With Flight Directors (F/D) Off

If you engage the A/P into CMD, the A/P goes to CWS roll and CWS pitch. When the crew selects a valid pitch and roll mode, the modes become active.

The F/D can be in an active roll and pitch mode while the A/P is in CWS. The mode annunciations on the FMA apply to the F/D.

Engage A/P With F/Ds On

These three conditions can occur with the F/Ds on:

- F/Ds are in TO/GA
- F/Ds are in valid roll and pitch modes. The difference between the airplane attitude and F/D commands is within valid limits
- F/Ds are in valid roll and pitch modes. The difference between the airplane attitude and F/D commands is not within valid limits.

F/Ds In TO/GA

If you engage the A/P into CMD and the roll F/D takeoff mode is LNAV, the A/P and F/Ds go to LVL CHG for the pitch mode and stay in LNAV for the roll mode. If LNAV is not the F/D roll mode, the roll mode goes to HDG SEL.

Airplane Attitude Within F/D limits

The A/P engages in CMD and the A/P modes are the same as the F/D modes.

Airplane Attitude Not Within F/D Limits

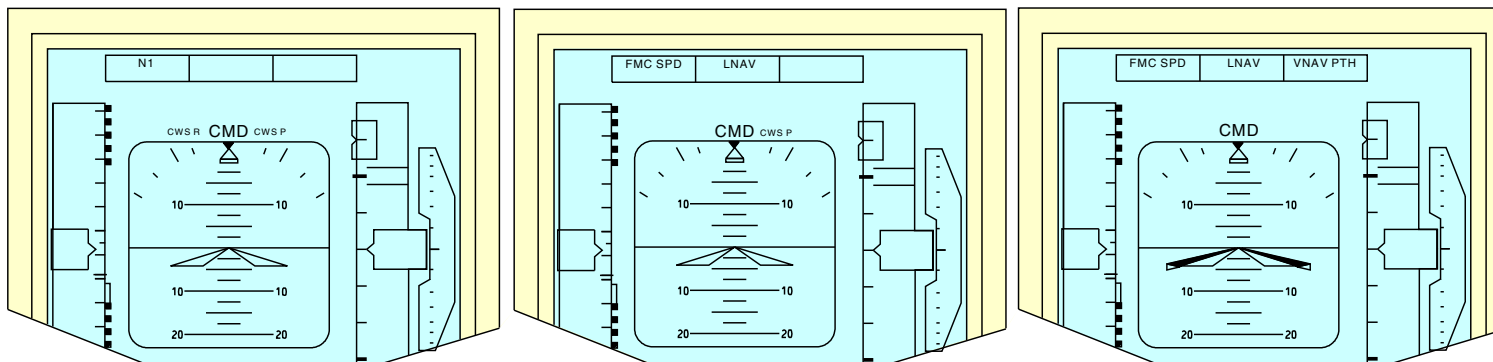
The airplane roll attitude must be within 7 degrees of the F/D commands for VOR/LOC on course or selected bank angle limit of 10 degrees. The airplane roll attitude must be within 14 degrees of the F/D commands for all other modes. If the airplane roll attitude is not within these limits, the A/P goes into CWS roll and the F/D roll mode is reset.

The airplane pitch attitude must be within 3 degrees of the F/D commands for slaved G/S engage and MCP ALT ACQ mode. The airplane pitch attitude must be within 6 degrees of the F/D commands for all other pitch modes. If the airplane pitch attitude is not within these limits, the A/P goes into CWS pitch and the F/D pitch mode is reset.

Training Information Point

The autopilot in the engaged mode is not certified for takeoff.

DFCS - OPERATION - ENGAGE AUTOPILOT



F/D OFF

- A/P ENGAGES TO CWS PITCH AND CWS ROLL

F/D ON AND PITCH LIMITS EXCEEDED

- A/P ENGAGES IN CMD FOR ROLL MODE
- A/P ENGAGES IN CWS FOR PITCH MODE

F/D ON AND WITHIN LIMITS

- A/P ENGAGES IN CMD FOR ROLL AND PITCH

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DFCS - OPERATION - ENGAGE AUTOPILOT

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DFCS - OPERATION - TAKEOFF

General

The F/D display shows roll and pitch commands during takeoff. The pilot cannot use the A/P for takeoff. The roll mode is wings level and the pitch mode is TO/GA. After the airplane goes through 400 feet radio altitude, the pilot can stay in the F/D takeoff mode or engage the autopilot to a roll and pitch mode.

The F/D does not give runway steering or rotation commands.

This is the takeoff sequence:

- Before takeoff roll
- Takeoff roll
- Lift-off
- Climbout.

Before Takeoff Roll

The pilots set all of these conditions before they start the takeoff roll:

- The captain and the first officer F/D switches are in the ON position
- Select the runway heading with the heading selector
- Select the bank angle limit with the bank angle limit control
- Set the MCP altitude with the altitude select control
- Arm the autothrottle
- Select V2 speed with the IAS/MACH select control.

These annunciations show on the captain and first officer displays:

- FD as the DFCS status
- No pitch mode annunciations
- The F/D integrated command cue is biased out of view (BOV)
- The selected target speed bug on the MASI shows the V2 speed.

The master flight director indicator light adjacent to the F/D switch that was turned on first comes on.

VNAV can be arm in F/D mode.

Takeoff Roll

When the pilot pushes a TO/GA switch on the thrust levers, these events occur:

- The FMA shows TO/GA as the active pitch mode
- The F/D pitch command shows a pitch down attitude of 10 degrees
- The F/D roll command shows a wings level attitude
- Both master lights come on to show that the F/Ds are independent
- The autothrottle engages in the takeoff thrust mode
- There is no active roll mode on the FMA.

When the airspeed is 60 knots, the F/D shows a pitch up command of 15 degrees. If an engine fails, the AC bus transfers to the good engine. The FCC on the failed engine gets the F/D commands from the unswitched FCC. The F/Ds will then show a pitch command of 12.5 degrees.

In takeoff, the flight director commands show on the AIs automatically even if the flight director switches are in the OFF position. This is the pop-up mode. It occurs when these conditions are true:

- A flight director switch is not in the ON position
- The pilot pushes a TO/GA switch
- The airspeed is more than 80 knots.

The F/Ds stay in the pop-up mode for 150 seconds after the airspeed reaches 80 knots. To turn off the F/Ds while in the pop-up mode, you must set a F/D switch to the ON position and then to the OFF position.

When both F/Ds are on, you can turn one off and the other stays on.

Lift-Off

For a normal lift-off, the F/D goes from a 15 degree nose up command to a speed or attitude command. The initial speed target is V2 plus 20 knots. The change to speed control is a function of altitude rate.

EFFECTIVITY	
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**DFCS - OPERATION - TAKEOFF**

If the climb rate is less than 300 FPM, the pitch command holds the pitch attitude. For a climb rate between 300 FPM and 1200 FPM, the pitch command holds a mixture of pitch and airspeed. For a climb rate more than 1200 FPM, the pitch command holds the target airspeed.

If an engine fails during takeoff, the target airspeed may change to these values:

- Failure at less than V2: V2 is the target airspeed
- Failure between V2 and V2 plus 20: the existing IAS is the target airspeed
- Failure at more than V2 plus 20: there is no change to the target airspeed.

The maximum airspeed limit is the flap placard speed until the airplane reaches the MCP speed. The F/D bank angle limit is 8 degrees when the airplane is below 400 feet altitude.

Ten seconds after lift-off, the speed trim system engages.

Climb Out

At a radio altitude of 400 feet, the master flight director indicator light for the F/D that was the second one turned on, goes off.

The roll command continues to hold wings level and the annunciation is blank. The pitch command continues in TO/GA to hold speed, attitude, or a mixture of speed and attitude. The pitch annunciation is still TO/GA. FD stays as the active DFCS status until the pilot engages the autopilot.

When the radio altitude is more than 400 feet, you can change the F/D pitch and roll modes. If you change just the pitch mode, the roll mode automatically goes to HDG SEL. However, you can change the roll mode without a change in the pitch mode.

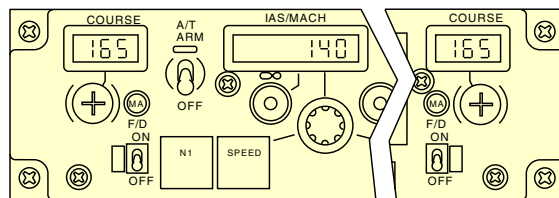
When the radio altitude is more than 400 feet, you can also engage the autopilot in CMD. When you engage the A/P in CMD, the pitch mode goes to LVL CHG and shows MCP SPD in the FMA. The roll mode goes to HDG SEL. Only the master flight director indicator light for the A/P in CMD is on. When you engage the A/P, the speed trim system stops and the auto stabilizer trim starts.

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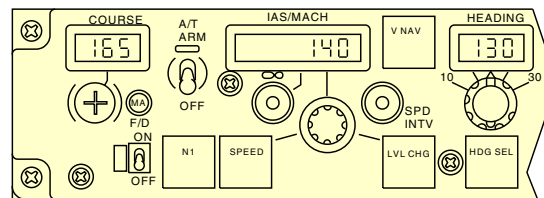
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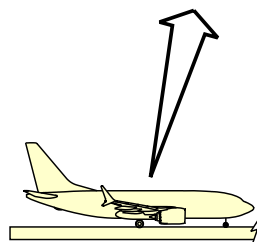
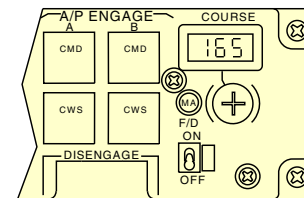
DFCS - OPERATION - TAKEOFF



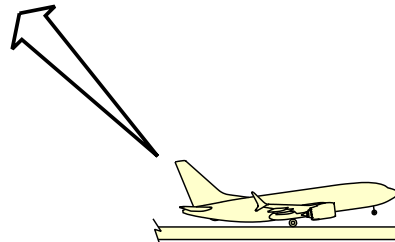
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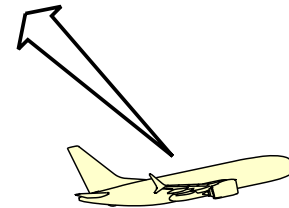
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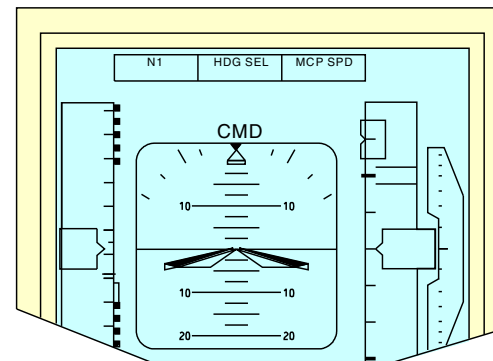
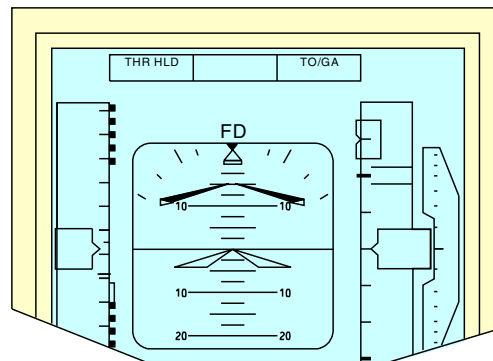
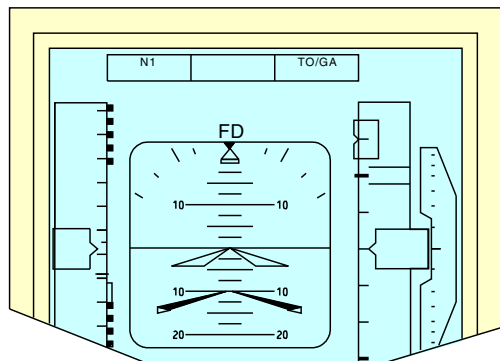
TAKEOFF START



LIFT-OFF



CLIMBOUT ABOVE 400 FEET



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DFCS - OPERATION - TAKEOFF

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**DFCS - OPERATION - TAKEOFF - LNAV SELECTED****General**

The pilot can select LNAV as the F/D roll mode during takeoff if the FMCS transfer switch is in the NORMAL position and both FMCs are operational.

Before Takeoff Roll

The pilots push the LNAV mode selector switch to select the LNAV mode. This is done before they push the TO/GA switch.

The LNAV annunciation shows in the FMA roll mode with the normal annunciations that show on the captain's and first officer's displays.

Takeoff Start

After the pilot pushes a TO/GA switch on the thrust levers, the FMA still shows LNAV in the roll mode. The pitch mode shows TO/GA. The light on the LNAV mode selector switch goes out. This means that the pilot cannot deselect the LNAV mode.

Lift-Off

If LNAV is selected, the roll mode is wings level until the airplane reaches 50 feet. The roll mode then changes to LNAV. If they push the TO/GA switch again between 50 and 400 feet, the roll mode changes to wings level.

Climb Out

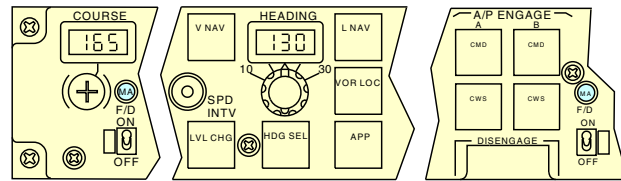
If LNAV was selected, the light on the LNAV mode selector switch comes back on when the airplane reaches 400 feet. The pilot can now deselect LNAV. The pitch annunciation is still TO/GA and the roll annunciation is still LNAV. If you change only the pitch mode, the roll mode stays in LNAV. If you engage the A/P in CMD, the pitch mode goes to LVL CHG and the roll mode stays in LNAV.

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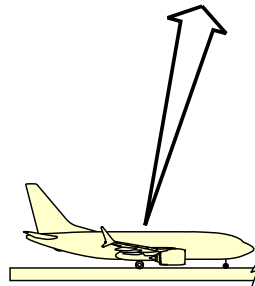
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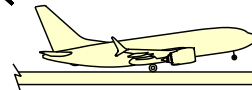
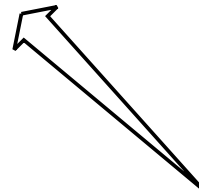
DFCS - OPERATION - TAKEOFF - LNAV SELECTED



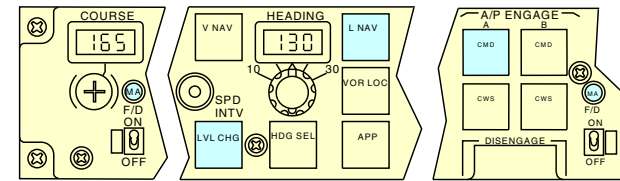
MCP



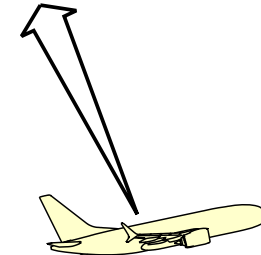
TAKEOFF START



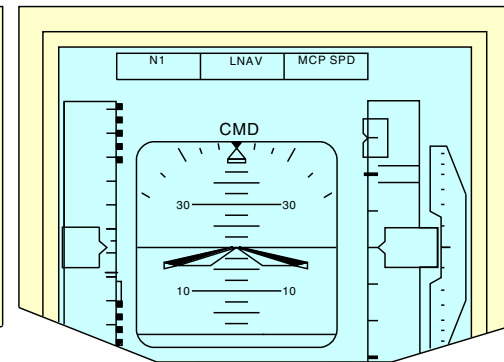
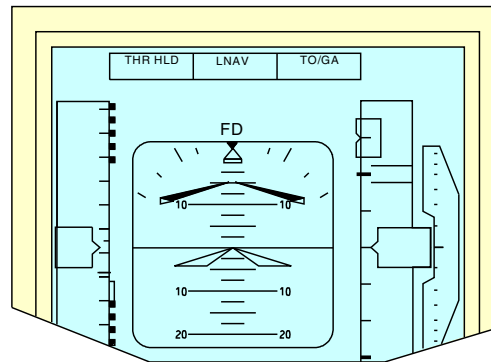
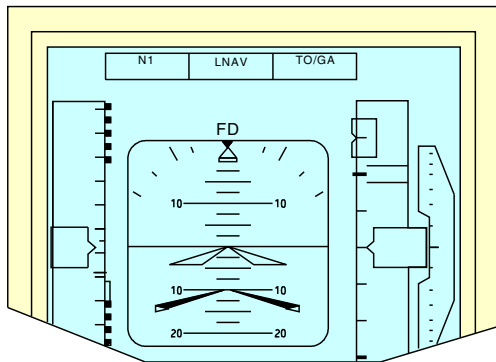
LIFT-OFF



MCP



CLIMBOUT ABOVE 400 FEET



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**DFCS - OPERATION - CLIMB/CRUISE/DESCENT INTRODUCTION****General**

After the climbout from takeoff, the crew can continue with the F/Ds and/or engage an A/P in CMD or CWS. The crew can engage only one A/P in these flight sequences.

If the F/Ds are on or an A/P is in CMD, the crew can choose DFCS modes with the mode selector switches on the MCP. If the lights on the selector switches are on, the crew can deselect that mode if they push the mode selector switch again.

The crew can use these roll mode selector switches during climb, cruise and descent:

- LNAV
- HDG SEL
- VOR.

The crew can use these pitch mode selector switches during climb, cruise and descent:

- VNAV
- V/S
- ALT HLD
- LVL CHG.

The roll and pitch modes show on the flight mode annunciators (FMAs). This includes the engaged modes and the armed modes.

LNAV

The roll commands come from the FMC when there is a valid navigation data base and an active flight plan.

HDG SEL

In this mode, the airplane turns to the heading that shows in the heading display on the MCP. The FCC calculates the command from the difference between the airplane magnetic heading and the MCP selected heading.

VOR

In this mode, the autopilot commands the airplane to fly a VOR course that shows in the course indicator on the MCP. The VOR receiver sends the FCC VOR radial data that the airplane is on. The MCP sends the FCC the VOR course that the pilot wants to fly. The difference or deviation is used to calculate the VOR command.

VNAV

The pitch commands come from the FMC when these are present:

- A valid navigation data base
- An active flight plan
- Valid performance data.

When the crew selects VNAV, the DFCS goes to either the VNAV SPD or the VNAV PTH mode.

VNAV cannot be active on the ground.

V/S

In this mode, the A/P commands the airplane to climb or descend at the MCP selected vertical speed.

ALT HLD

In this mode, the A/P commands the airplane to hold the altitude that the airplane was at when the crew selected ALT HLD or the MCP selected altitude.

LVL CHG

In this mode, the airplane changes altitude with the A/P and the autothrottle (A/T). LVL CHG commands the airplane to the MCP selected altitude at the selected airspeed. The A/P commands airspeed and the A/T controls the thrust.

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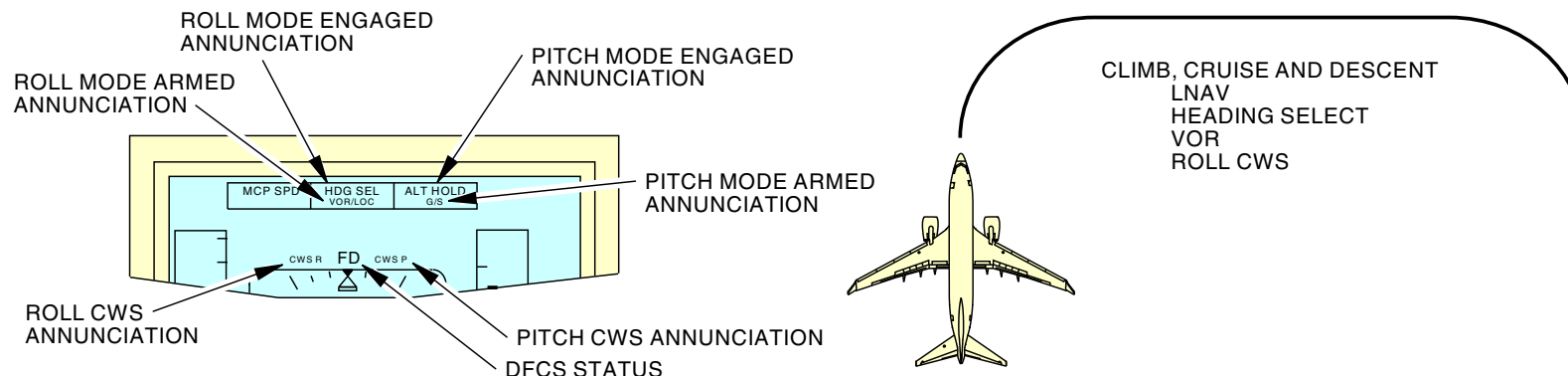
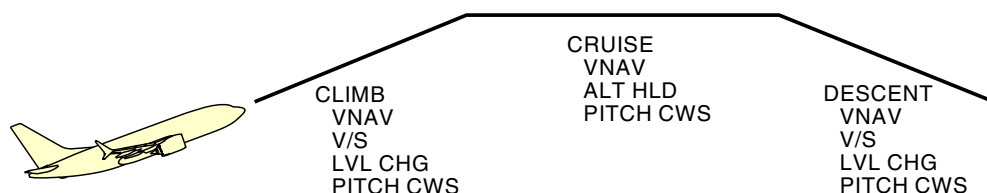
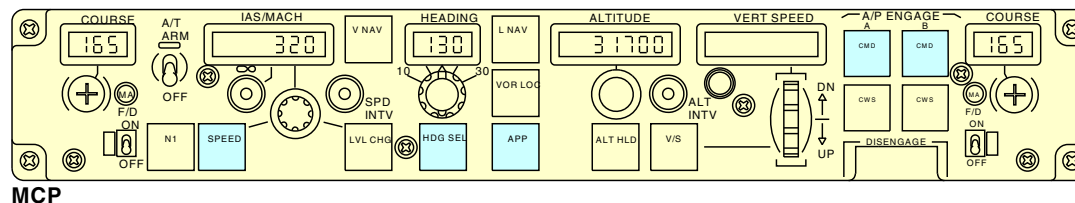
DFCS - OPERATION - CLIMB/CRUISE/DESCENT INTRODUCTION

Roll and Pitch CWS

You can also engage the A/P in roll and/or pitch CWS. In CWS, the pilot controls the airplane as if the autopilots are disengaged. Control of the airplane is from CWS force transducers that send signals through the FCCs to the A/P actuators.

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DFCS - OPERATION - CLIMB/CRUISE/DESCENT INTRODUCTION



DFCS - OPERATION - CLIMB/CRUISE/DESCENT INTRODUCTION

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**DFCS - OPERATION - LNAV****General**

The LNAV commands come from the FMC and guide the airplane on the assigned flight path. When the DFCS is in the LNAV mode, the LNAV mode annunciation shows on the FMA.

LNAV Active

To make the LNAV active, push the LNAV mode selector switch on the MCP. These conditions must be valid for LNAV to engage:

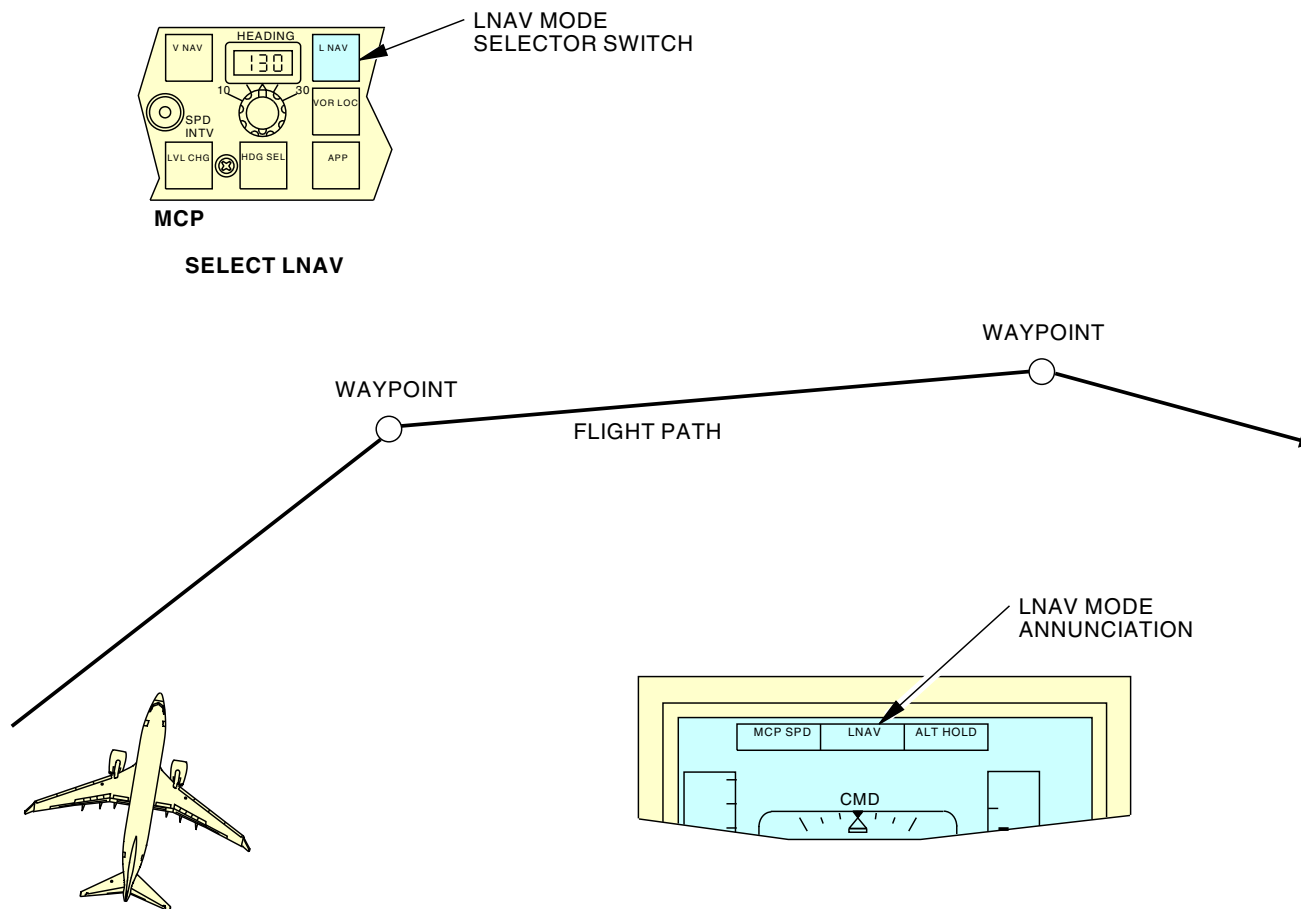
- LNAV is valid
- Baro corrected altitude is valid
- Data to calculate the lateral guidance command in the FMC is valid
- The airplane heading is towards the flight path before the next waypoint or is within 3 nm of the flight plan path.

Deselect LNAV

You can deselect LNAV if any of these conditions occur:

- Push the LNAV mode selector switch when the LNAV mode selector switch light is on
- Set the A/P to CMD with a F/D command more than 14 degrees
- A force more than 10 pounds on the control wheel with the A/P in CMD
- Activate another roll mode
- LNAV is not valid
- The airplane did not capture the localizer
- The airplane reaches the final waypoint or a route discontinuity.

DFCS - OPERATION - LNAV



DFCS - OPERATION - LNAV

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**DFCS - OPERATION - HEADING SELECT****General**

The crew uses the heading select mode to change the airplane heading. The heading that the airplane will go to is the heading value in the MCP heading indicator. The maximum bank angle in the turn is the bank angle limit set on the MCP.

The crew can engage the HDG SEL mode when they push the HDG SEL mode selector switch on the MCP. The DFCS automatically goes into the HDG SEL mode when the crew pushes the A/P CMD engage switch to leave F/D takeoff and no mode is selected.

These are the two ways to use the mode:

- Set heading before you push the HDG SEL mode selector switch
- Push the HDG SEL mode selector switch and then set the heading.

Set Heading Before Mode

Set a heading in the heading indicator and push the HDG SEL mode selector switch. These things happen:

- HDG SEL shows on the FMA
- The airplane turns in the direction for minimum heading change
- The airplane captures and holds the heading set on the MCP.

Select Mode Before Heading Is Set

Push the HDG SEL mode selector switch and set a heading in the heading indicator. These things happen:

- HDG SEL shows on the FMA
- When the pilot turns the heading knob clockwise, the airplane banks to the right
- When the pilot turns the heading knob counterclockwise, the airplane banks to the left
- The airplane captures and holds the heading set on the MCP.

Deselect HDG SEL

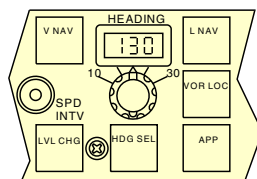
You deselect HDG SEL when you select another roll mode. You can also deselect HDG SEL if you push the HDG SEL mode selector switch when the switch light is on.

22-11-00**SIA ALL EFFECTIVITY**

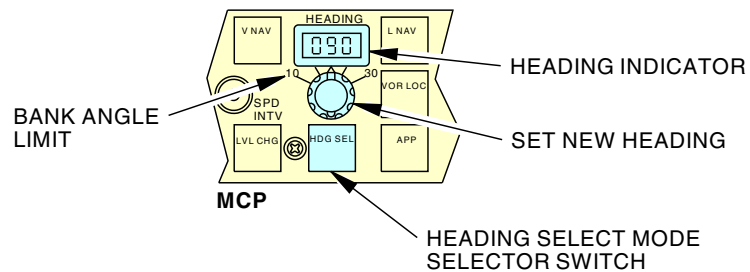
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DFCS - OPERATION - HEADING SELECT

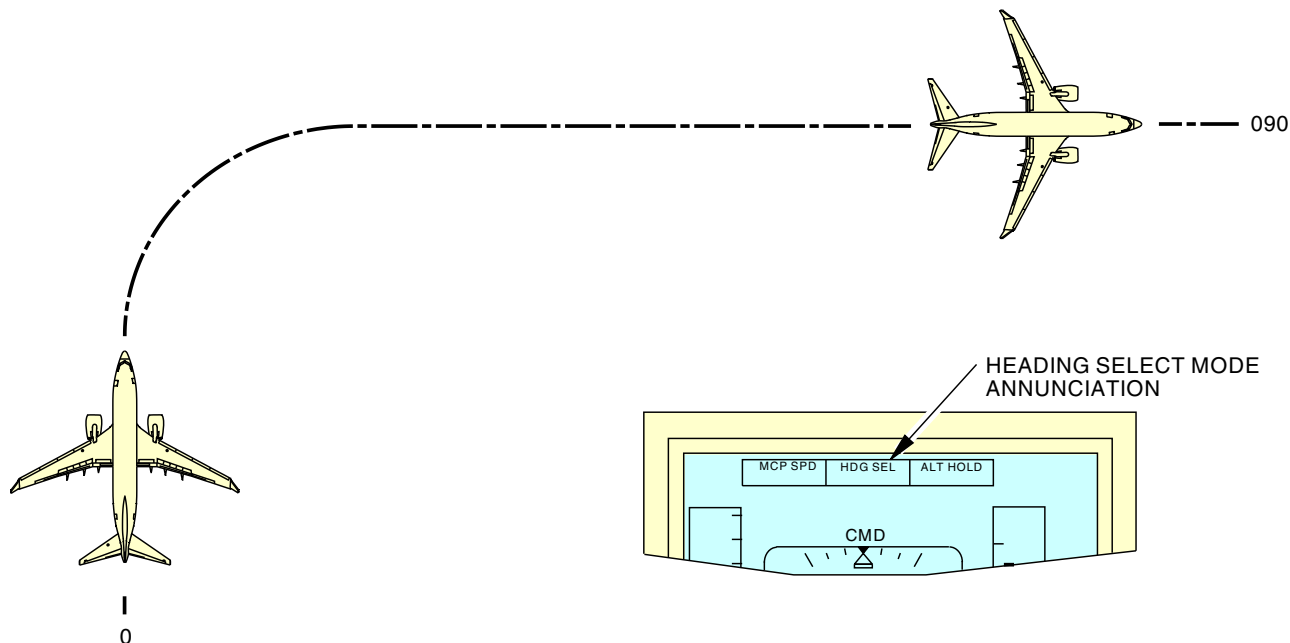


MCP



MCP

SELECT HDG SEL AND SET NEW HEADING



DFCS - OPERATION - HEADING SELECT

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**DFCS - OPERATION - VOR****General**

The VOR mode supplies automatic beam capture and guidance through the on-course and over-station-sensor phases for cruise and approach control.

To use the VOR mode, the VOR receiver must be set to the VOR frequency. The pilot uses one of the course selectors on the MCP to select the desired course. The course shows on the course display. The bank angle limit is also set on the MCP. Push the VOR LOC mode selector switch to select the VOR mode. If the VOR mode engages, the VOR LOC mode selector switch lights to show it can also be deselected.

These are the four submodes of the VOR mode:

- Arm
- Capture
- On-course (OC)
- Over-station-sensor (OSS).

Arm Submode

When you push the VOR LOC mode selector switch, the mode is the VOR arm submode. When the VOR is in the arm submode, VOR/LOC shows in small white letters on the second line of the roll position of the FMA. The FCC stays in this submode until the airplane satisfies the capture logic.

In this submode, the FCC uses this data to calculate the capture point which is where the airplane should start the turn to be on course:

- Beam deviation
- True airspeed
- Course error
- Selected bank angle limit
- Closure rate.

The FCC uses this data to calculate the closure rate:

- True airspeed
- Course error

- DME distance.

If DME distance is not available, the FCC uses the rate of change of the beam deviation to calculate the closure rate.

Capture Submode

When the airplane reaches the capture point, the VOR mode changes to the capture submode. The FCC makes sure that these conditions are valid for at least 3 seconds before the capture mode is active:

- VOR LOC mode selector switch is engaged
- Course selector was not moved
- Beam deviation is less than 22 degrees
- VOR receiver is valid.

If the FCC could not calculate the capture point, but the beam deviation is less than 0.5 degrees, the VOR mode changes to the capture submode. Also if the FCC could not calculate the capture point, but the beam deviation is less than 2 degrees for 10 seconds, the VOR mode changes to the capture submode.

The airplane will not bank more than the selected bank angle limit. The maximum roll rate is 4.0 degrees per second.

When the VOR is in the capture submode, VOR/LOC shows in large green letters on the first line of the roll position of the FMA. The FCC stays in this submode until the airplane satisfies the on-course logic.

On-Course Submode

These conditions inhibit the on-course submode:

- VOR not in the capture submode
- Bank angle is more than 7 degrees
- The over-station-sensor (OSS) is in effect.

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**DFCS - OPERATION - VOR**

The VOR on-course submode is active when these conditions occur for at least 5 seconds:

- Beam deviation is less than 1 degree
- Course error is less than 18 degrees.

The VOR on-course submode is also active when the deviation beam rate of change is less than 0.15 degrees per second for at least 10 seconds.

The airplane will not bank more than 8 degrees. The maximum roll rate is 1.3 degrees per second.

When the VOR is in the on-course submode, VOR/LOC shows in large green letters on the first line of the roll position of the FMA. The FCC stays in this submode until the airplane satisfies the OSS logic.

If the crew selects a new VOR course while in the on-course submode, the FCC goes back to the VOR capture submode.

Over-Station-Sensor Submode

The OSS logic monitors the VOR deviation beam signal for quick changes. This occurs when the airplane flies over the VOR station in the cone-of-confusion. If the deviation beam rate of change is more than 0.75 degrees per second, the FCC goes to the OSS submode. If the magnitude of the deviation beam changes is more than 6.0 degrees, the VOR also goes to the OSS submode.

The FCC stays in the OSS submode for 23 seconds after the beam deviation changes go below these OSS levels. If a DME is collocated with the VOR, the FCC also goes into the OSS submode if the absolute value of the airplane altitude minus the DME range is less than 5000 feet. This allows the airplane to go through the cone-of-confusion and also make a turn.

The airplane will not bank more than the selected bank angle limit. The maximum roll rate is 4.0 degrees per second.

When the VOR is in the OSS submode, VOR/LOC shows in large green letters on the first line of the roll position of the FMA. The FCC stays in this submode until the airplane satisfies the on-course logic.

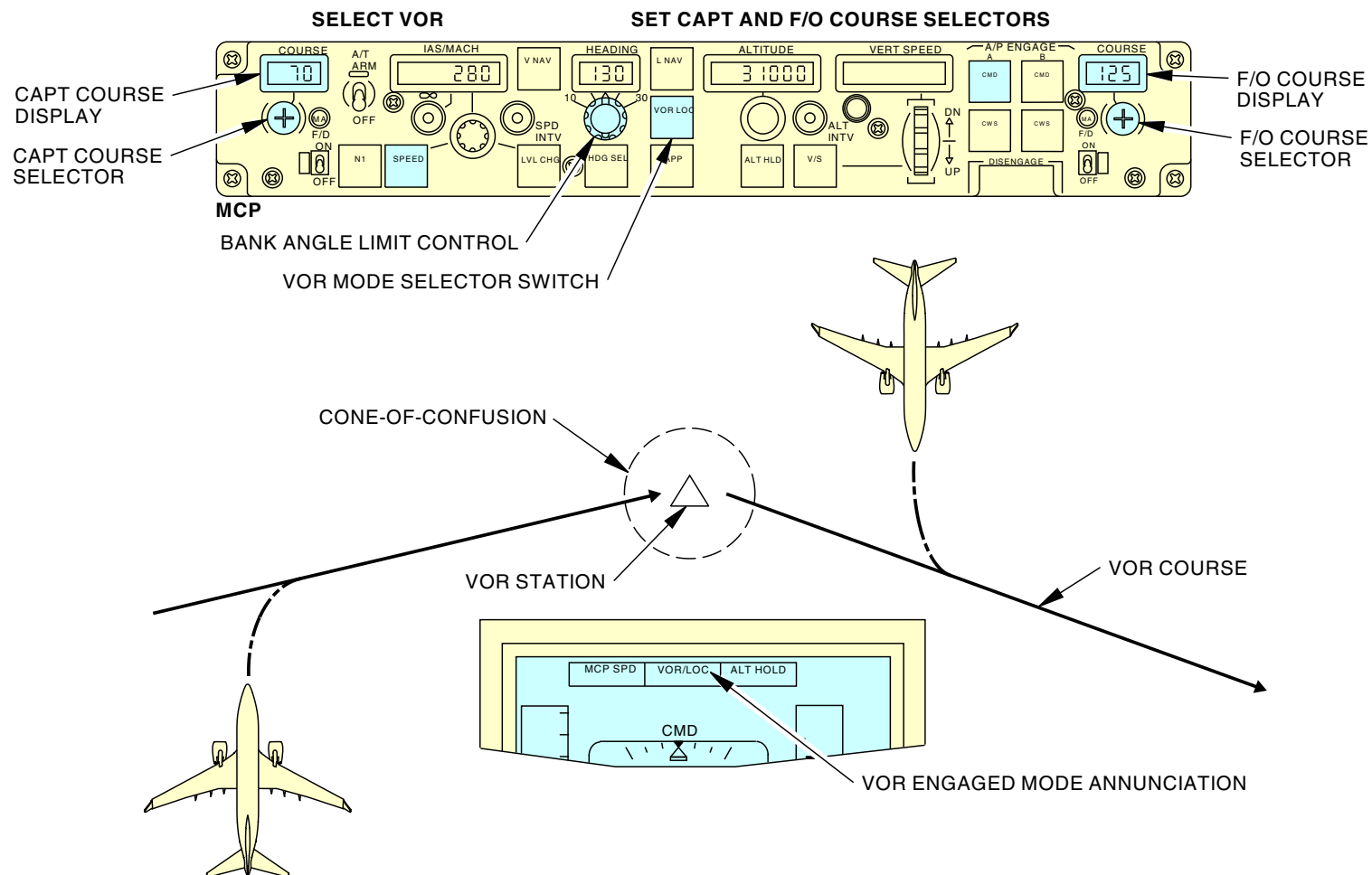
If the crew pushes the VOR LOC mode selector switch or selects another roll mode, the VOR mode is deselected. The VOR mode is also deselected if the VOR signal is not valid for more than 8 seconds and the A/P is in CMD.

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DFCS - OPERATION - VOR



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DFCS - OPERATION - VOR

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**DFCS - OPERATION - ROLL CWS****General**

In roll control wheel steering (CWS), the pilot controls the airplane as if the A/P is disengaged. The control of the airplane is from a roll CWS force transducer and through the FCC. The CWS mode has these submodes:

- Attitude hold
- Heading hold
- Roll CWS out-of-detent (O/D).

These are the three ways to engage the roll CWS mode:

- Push the CWS A/P engage switch
- Push the CMD A/P engage switch and do not select a roll mode
- When a roll CMD mode is active, apply a wheel force of more than 10 pounds (hi detent).

The FMA annunciation is the amber CWS R in the DFCS status.

The force on the control wheel, while in CWS, is one of these three levels:

- In-detent, less than 2.25 pounds if bank angle is 30 degrees or less, or less than 3.0 pounds if bank angle more than 30 degrees
- Low detent, more than in-detent level but 10 pounds or less
- Hi detent, more than 10 pounds of force.

Attitude Hold Submode

If the bank angle is more than 6 degrees when you engage the CWS mode, the A/P goes to the attitude hold submode. In this submode, the A/P holds the airplane bank to the roll attitude at the time the A/P enters the CWS mode.

The bank limit is 30 degrees. If the bank angle is more than 30 degrees when the A/P is in CWS and the control wheel force is in-detent, it decreases to and holds 30 degrees. The bank rate of change limit is 4.0 degrees per second.

Heading Hold Submode

If the bank angle is less than 6 degrees when you engage the CWS mode, the A/P goes to the heading hold submode. In this submode, the A/P decreases the bank angle to 0 degrees within 3 seconds. The A/P then maintains the airplane heading.

If the bank angle is more than 30 degrees when you engage the CWS mode, the bank angle decreases to 30 degrees. The bank rate of change limit is 4.0 degrees per second.

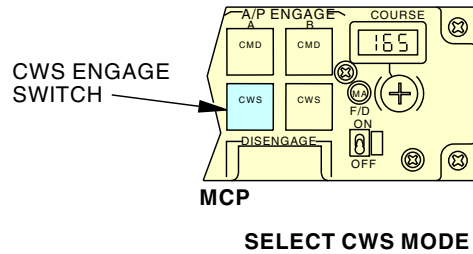
Roll CWS O/D

When the control wheel force is not in-detent, the pilot controls the airplane bank. The roll CWS force transducer sends a signal to the FCC and the FCC sends a control signal to the A/P actuators.

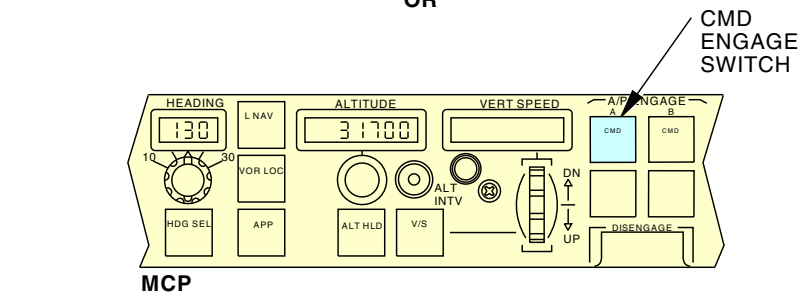
When the control wheel force is in-detent, the A/P goes to the attitude submode if the bank angle is more than 6 degrees. The A/P goes to the heading hold submode if the bank angle is less than 6 degrees.

If the A/P is in another roll CMD mode such as HDG SEL and the control wheel is in hi detent, the A/P goes to the roll CWS mode. This can also occur if the A/P is in the single approach mode.

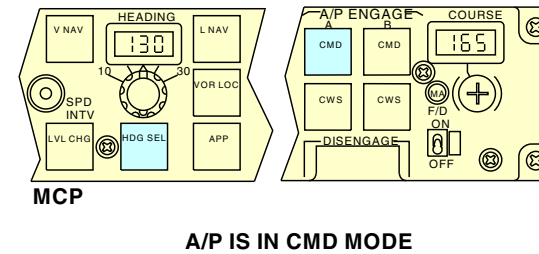
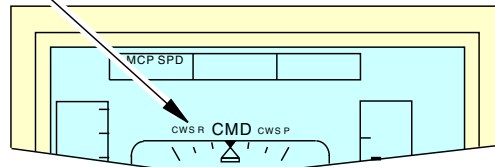
DFCS - OPERATION - ROLL CWS



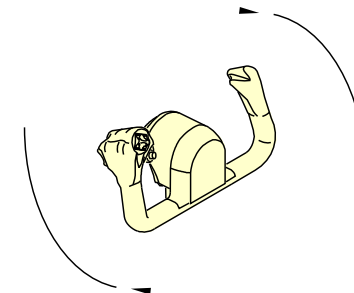
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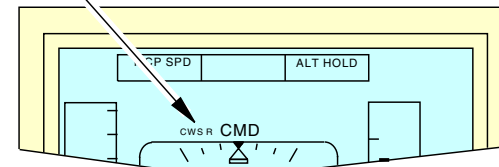
ROLL CWS MODE ANNUNCIATION



AND



ROLL CWS MODE ANNUNCIATION



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DFCS - OPERATION - ROLL CWS

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**DFCS - OPERATION - VNAV****General**

The vertical navigation (VNAV) mode supplies pitch control in response to vertical navigation data from the FMC. VNAV commands the airplane to climb or descend to the FMC target altitude at the FMC target speed. If the airplane reaches the MCP selected altitude first, it levels off at the MCP selected altitude.

Push the VNAV mode select switch to activate VNAV. VNAV becomes active when all these conditions are true:

- VNAV flight plan is active
- The airplane is more than 400 feet above the ground
- Data required to calculate the vertical guidance command is valid.

VNAV has these two active modes:

- VNAV SPD (speed)
- VNAV PTH (path).

VNAV SPD

The VNAV SPD mode controls the elevator to hold the FMC target speed. The mode is active while the airplane is climbing to the FMC altitude. If it gets to the MCP altitude first, the A/P disengages from VNAV SPD and goes into ALT HOLD. The VNAV mode selector light does not go out because the autothrottle is still in the FMC SPD mode.

When the crew resets the MCP altitude to the FMC altitude, the VNAV mode selector light goes out. To go back to VNAV, the crew pushes the VNAV mode selector switch. This reengages VNAV SPD and the airplane starts to climb to the FMC target altitude at the FMC target speed.

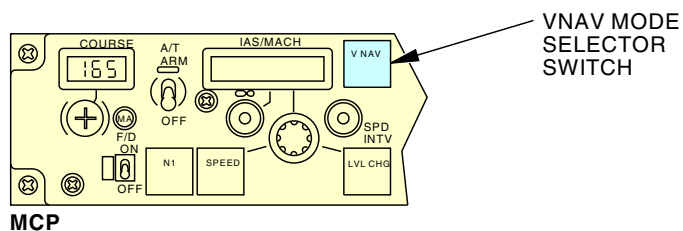
VNAV PTH

In climb, VNAV SPD changes to VNAV PTH to capture the FMC target altitude. In the VNAV PTH mode, the airplane holds the FMC altitude.

Before descent, the pilot sets an approach altitude on the MCP. At the top of descent, the throttle retards and the A/T FMA shows RETARD then ARM. The pitch mode remains in VNAV PTH and the airplane descends. LNAV must be active during the VNAV PTH descent mode. If LNAV is not active, VNAV PTH mode will disengage, but the crew can select VNAV SPD for the descent.

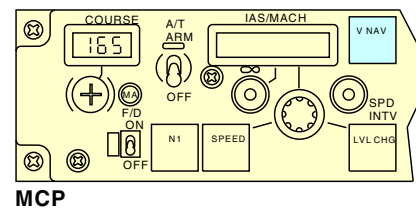
The VNAV PTH mode continues in descent until the airplane is near the approach altitude. The autothrottle mode returns to FMC SPD. VNAV PTH remains active and holds the approach altitude.

DFCS - OPERATION - VNAV



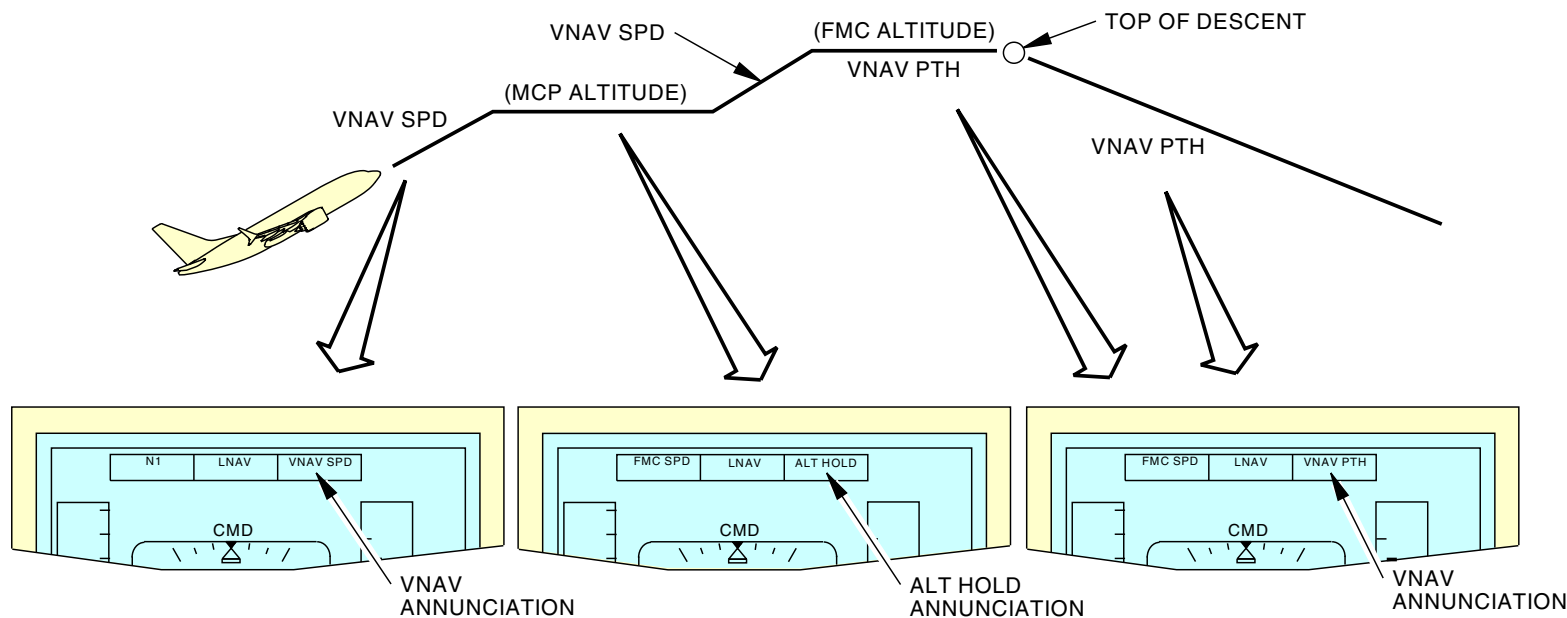
MCP

select vnav during climb



MCP

RESELECT VNAV TO CONTINUE CLIMB



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DFCS - OPERATION - VNAV

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**DFCS - OPERATION - VNAV - SPEED INTERVENTION****General**

The speed intervention pushbutton lets the crew change the FMC target speed with the MCP IAS/MACH selector and stay in the VNAV mode. The target speed that shows on the active CDU cruise page will change to the new target speed.

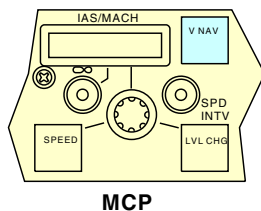
Speed Intervention Operation

When in VNAV, the FMC target speed does not show in the MCP IAS/MACH display window. This display is blank. When the pilot pushes the speed intervention pushbutton, the current FMC speed target speed shows in the IAS/MACH display and you can change the speed with the IAS/MACH selector. The new speed shows in the MCP IAS/MACH display and on the CRZ page on the CDU. An MCP shows after the speed on the CDU to show that this speed is set by the MCP IAS/MACH selector. The DFCS pitch mode is still VNAV.

To return to the original FMC target speed, push the speed intervention pushbutton again. This blanks the IAS/MACH display and the speed on the CDU returns to the original FMC target speed.

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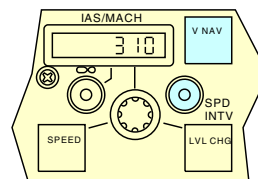
DFCS - OPERATION - VNAV - SPEED INTERVENTION



MCP

ACT ECON CRZ
CRZ ALT
FL290
TGT SPD
310

CDU



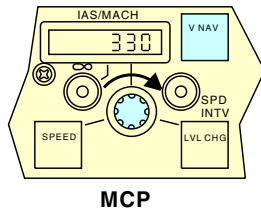
MCP

ACT ECON CRZ
CRZ ALT
FL290
TGT SPD
310

CDU

1. VNAV ACTIVE SO FMC TARGET SPEED DOES NOT SHOW IN IAS/MACH DISPLAY.

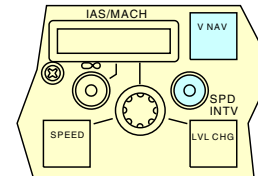
2. PUSH SPEED INTERVENTION PUSHBUTTON AND FMC TARGET SPEED SHOWS IN IAS/MACH DISPLAY.



MCP

ACT ECON CRZ
CRZ ALT
FL290
TGT SPD
330/MCP

CDU



MCP

ACT ECON CRZ
CRZ ALT
FL290
TGT SPD
310

CDU

3. TURN IAS/MACH SELECTOR TO SELECT NEW FMC SPEED. NEW SPEED SHOWS ON CDU.

4. PUSH SPEED INTERVENTION PUSHBUTTON TO RETURN TO ORIGINAL FMC TARGET SPEED.

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DFCS - OPERATION - VNAV - SPEED INTERVENTION

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**DFCS - OPERATION - VNAV - ALTITUDE INTERVENTION****General**

The altitude intervention push-button lets the crew change the FMC target altitude with the MCP altitude selector. It lets the crew climb or descend from an interim level-off altitude set by the MCP and stay in VNAV. It also lets the crew remove an altitude restriction in the flight plan each time that the altitude intervention push-button is pushed. You can push the push-button up to eight times to remove eight altitude restrictions. You can use the altitude intervention in a climb or descent.

Interim Level-off Altitude Operation

If the new MCP altitude is between the airplane altitude and the FMC target altitude, the airplane levels off at the MCP altitude. The DFCS stays in VNAV. To continue the climb or descent, change the MCP altitude to the FMC target altitude and push the altitude intervention push-button. This removes the altitude restriction at the intermediate MCP altitude and the climb or descent continues.

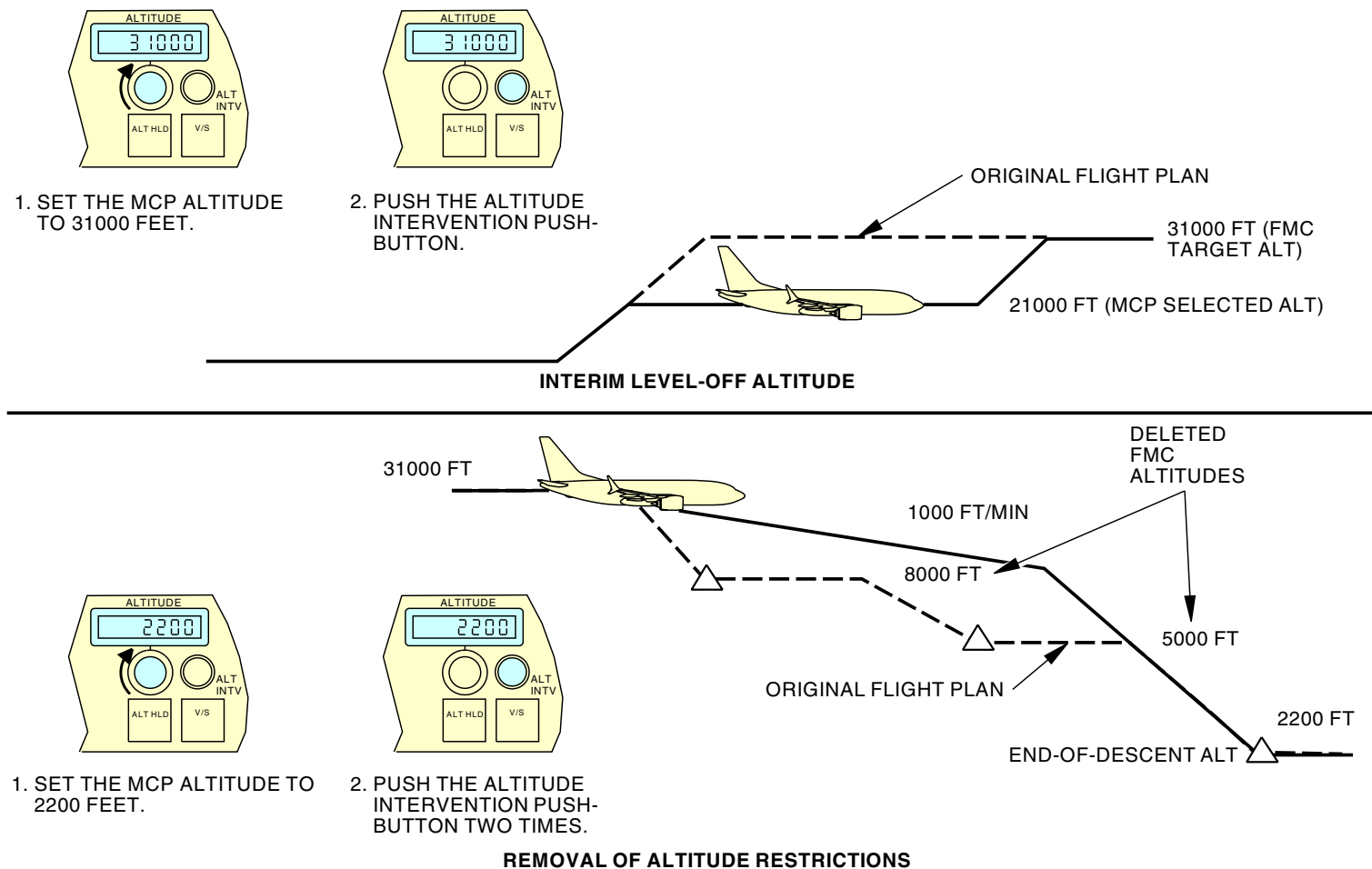
Removal of Altitude Restrictions Operation

Select the new FMC altitude with the altitude selector on the MCP. If there is one altitude restriction in the flight plan between the present airplane altitude and the new FMC altitude, push the altitude intervention pushbutton once. If there are two altitude restrictions, push the pushbutton twice. You can remove up to eight altitude restrictions.

If the airplane is in a descent and the new FMC altitude is at or above the end-of-descent altitude, the airplane descends at a rate of 1000 feet/minute until it gets to a position where it can make the planned descent rate. The DFCS pitch mode stays in VNAV path. If the new FMC altitude is below the end-of-descent altitude, the airplane starts an immediate descent and the DFCS pitch mode changes to VNAV speed. The descent speed is the speed that was in the original flight plan.

EFFECTIVITY	
SIA ALL	

DFCS - OPERATION - VNAV - ALTITUDE INTERVENTION



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DFCS - OPERATION - VNAV - ALTITUDE INTERVENTION

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**DFCS - OPERATION - VERTICAL SPEED****General**

The crew uses the V/S mode to climb or descend to the altitude set in the MCP. You cannot use the V/S mode if the airplane is at the MCP selected altitude or in the capture of the MCP selected altitude. If the airplane is at the MCP selected altitude and the crew changes the MCP selected altitude by more than 100 feet, the V/S mode will arm.

The crew can use the V/S mode to level the airplane at a set altitude.

Climb/Descend to MCP Selected Altitude

These occur when the pilot pushes the V/S mode selector switch and sets a positive or negative V/S on the MCP:

- V/S shows on the FMA in green letters
- The V/S mode selector switch LEDs turn on
- The airplane climbs or descends at the selected V/S.

When the crew pushes the V/S mode selector switch, the present vertical speed of the airplane shows in the V/S display. The crew changes the vertical speed with the V/S control wheel.

When the airplane reaches the altitude set on the MCP, the DFCS mode changes from V/S to altitude acquire (ALT ACQ) and then to altitude hold (ALT HOLD). When the DFCS goes into the ALT ACQ mode, the V/S mode selector switch LEDs go out.

Change the MCP Selected Altitude

If the crew changes the MCP selected altitude, this occurs:

- ALT HOLD is the engaged mode and shows on the FMA in green letters
- The ALT HLD mode selector switch LEDs turn on
- The V/S arms and V/S shows on the FMA in smaller white letters.

The crew turns the V/S control wheel to set the climb or descent rate. The pitch mode changes to V/S so this occurs:

- The LEDs on the ALT HLD mode selector switch go out

- The LEDs on the V/S mode selector switch turn on
- The pitch mode annunciation is V/S in green letters.

Level Off

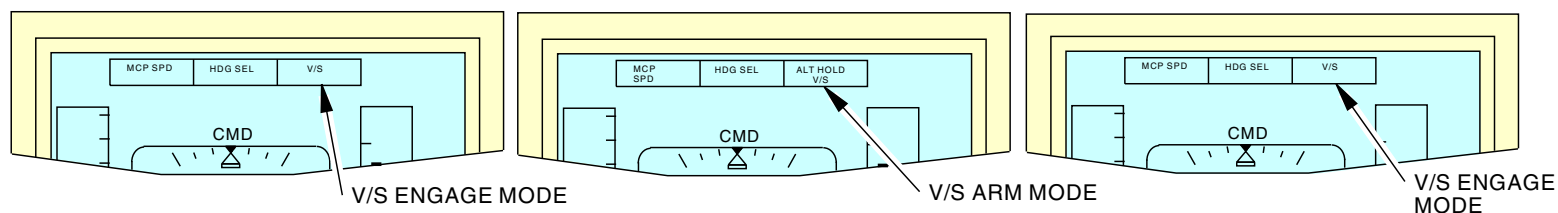
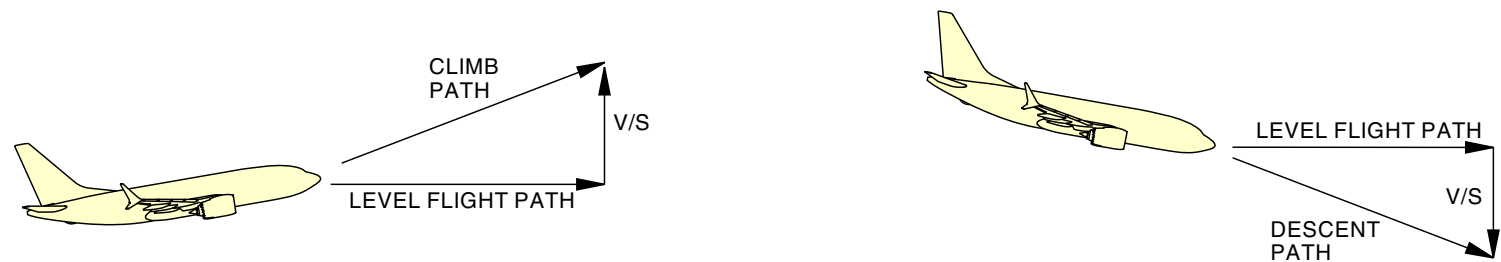
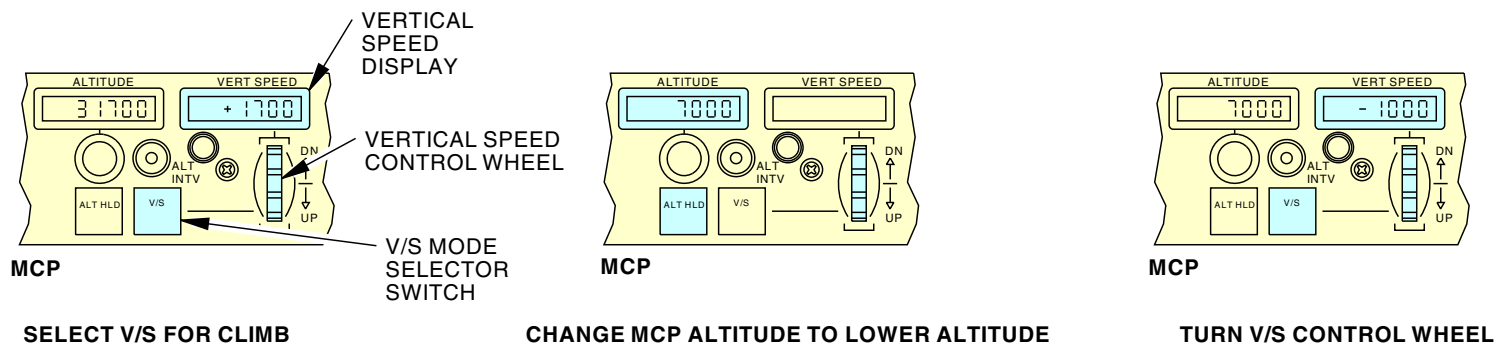
As the airplane approaches the altitude, the crew can slowly decrease the V/S to zero with the V/S control wheel. The airplane will stop its climb or descent and fly level.

Reversion Mode

If the airspeed decreases to 1.3 times the stall speed, the DFCS will change to LVL CHG. If the airspeed increases to VMO, the DFCS will change to LVL CHG.

EFFECTIVITY	
SIA ALL	

DFCS - OPERATION - VERTICAL SPEED



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DFCS - OPERATION - VERTICAL SPEED

**DFCS - OPERATION - ALTITUDE HOLD****General**

When the crew pushes the ALT HLD mode selector switch, the airplane will try to hold the present altitude. The DFCS can also automatically go into the altitude hold mode when it reaches the altitude set on the MCP.

ALT HLD Mode Selector Switch

These things occur when the pilot pushes the ALT HLD mode selector switch on the MCP:

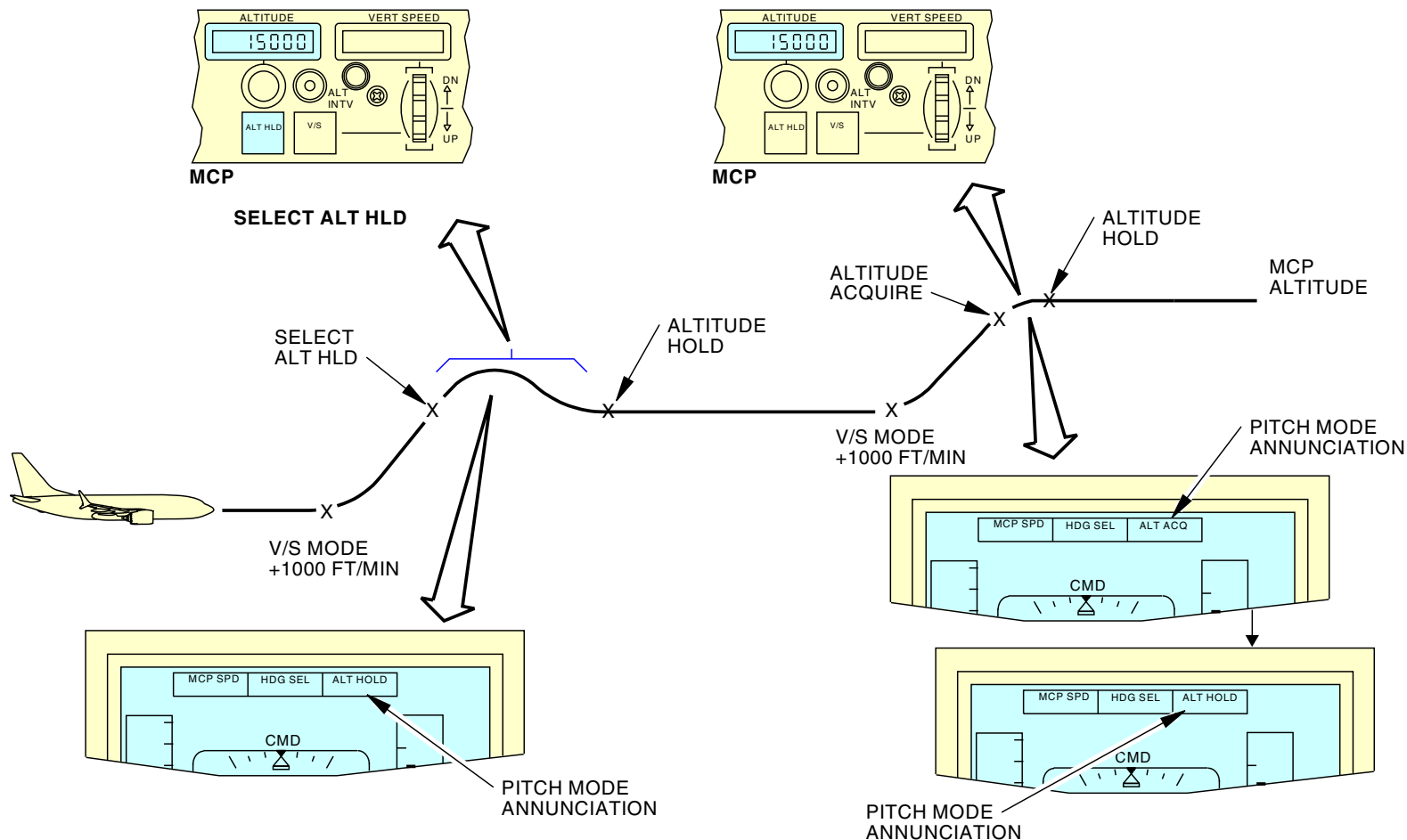
- The DFCS tries to hold the present inertial altitude, if available, or uncorrected barometric altitude if not available. The airplane will overshoot the altitude and return to it
- The ALT HLD mode selector switch LEDs turn on
- The FMA shows ALT HOLD in green letters.

Reach MCP Altitude

This altitude hold sequence starts as the airplane approaches the MCP selected altitude:

- The FMA shows ALT ACQ in green letters and the airplane starts to level off
- The airplane holds the altitude set on the MCP
- The ALT HLD mode selector switch LEDs turn on
- The FMA changes to ALT HOLD in green letters.

DFCS - OPERATION - ALTITUDE HOLD



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DFCS - OPERATION - ALTITUDE HOLD

22-11-00

**DFCS - OPERATION - LEVEL CHANGE****General**

The level change (LVL CHG) mode lets the pilot change flight levels with the DFCS and the A/T. The LVL CHG mode always commands the airplane to the MCP selected altitude. If the airplane is at the MCP selected altitude, LVL CHG will not become active.

During LVL CHG, the autothrottle controls thrust. The DFCS controls airspeed with the elevator. The speed reference is the MCP selected speed.

LVL CHG Mode Selector Switch

The pilot must set a target altitude on the MCP before they push the LVL CHG mode selector switch.

If the pilot pushes the LVL CHG mode selector switch when in VNAV, the MCP IAS/MACH indicator shows the FMC target speed. The DFCS controls to this speed until the pilot sets a new speed in the window.

If the pilot pushes the LVL CHG mode selector switch when in TO/GA, the MCP IAS/MACH indicator shows the higher of these:

- Present airspeed
- Speed set in the MCP.

If the pilot pushes the LVL CHG mode selector switch when in another mode, the MCP IAS/MACH indicator shows the present airspeed.

For all selection methods, the DFCS controls to the speed on the MCP IAS/MACH indicator until the pilot sets a new speed.

The airplane speed stays within these limits:

- Flap and gear placard speeds
- Maximum operating velocity and mach (VMO/MMO)
- Alpha floor minimum speed.

With the LVL CHG mode active, the LEDs on the LVL CHG mode selector switch are on. MCP SPD shows on the FMA in green letters.

Altitude Capture

When the airplane is at the altitude set on the MCP, the DFCS pitch mode changes to ALT ACQ and then to ALT HOLD.

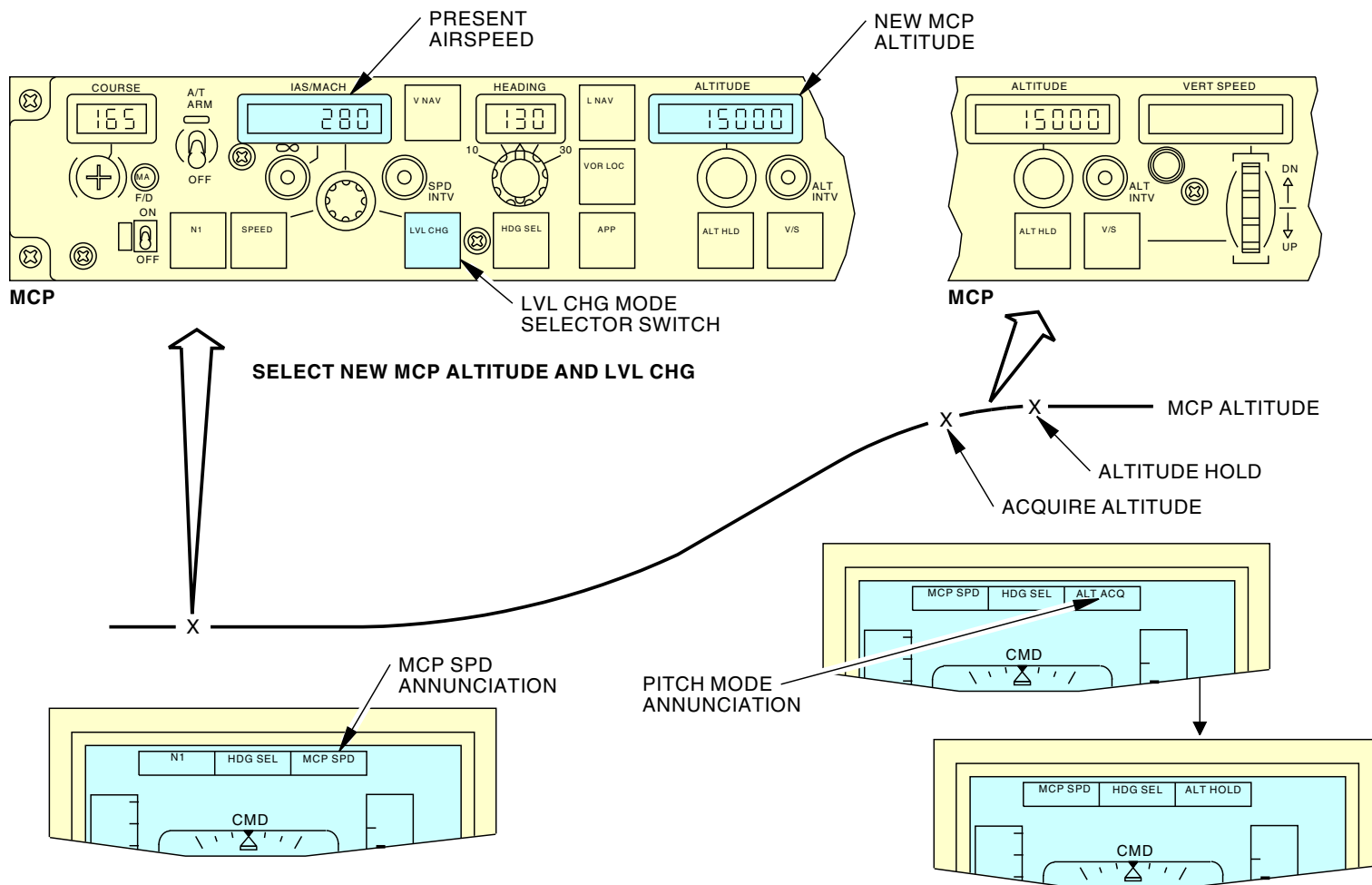
Reversion Modes

The DFCS automatically switches to the LVL CHG mode if any of these conditions occur:

- When in V/S or VNAV, the speed decreases to within 1.3 times the stall speed and flaps are less than 12.5 degrees
- When in V/S or VNAV and the A/T is disengaged or engaged at aft stop and the speed approaches VMO/MMO
- When in V/S and the airplane cannot get to the MCP selected speed.

EFFECTIVITY	
SIA ALL	

DFCS - OPERATION - LEVEL CHANGE



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DFCS - OPERATION - LEVEL CHANGE

22-11-00

**DFCS - OPERATION - PITCH CWS****General**

In pitch control wheel steering (CWS), the pilot controls the airplane as if the A/P is disengaged. The control of the airplane is from two CWS force transducers and through the FCC. The pitch CWS mode has an attitude hold and an out-of-detent (O/D) submode.

These are the three ways to engage the pitch CWS mode:

- Push the CWS A/P engage switch
- Push the CMD A/P engage switch and do not select a pitch mode
- When a pitch CMD mode is active, apply a column force of more than 21 pounds, hi detent.

The FMA annunciation is the amber CWS P in the DFCS status column.

The force on the control column, while in pitch CWS, is one of these three levels:

- In-detent, less than 5.0 pounds
- Low detent, more than in-detent level but 21 pounds or less
- Hi detent, more than 21 pounds of force.

Attitude Hold Submode

When you engage the CWS mode, the A/P goes to the attitude hold submode. In this submode, the A/P holds the airplane pitch attitude to the pitch attitude at the time the A/P enters the CWS mode.

Pitch CWS O/D

When the control column force is out-of-detent, low or hi detent, the pilot controls the airplane pitch attitude. The captain and first officer pitch CWS force transducers send a signal to the FCC. The FCC averages the two signals and the FCC sends a control signal to the A/P actuators.

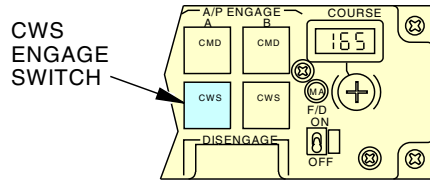
When the control column force goes back to in-detent, the A/P goes to the attitude hold submode.

If the A/P is in another pitch CMD mode, such as V/S, and the control column is in hi detent, the A/P goes to the pitch CWS mode. This can occur if the A/P is in the single approach mode, but not in the dual A/P approach mode.

If the A/P was in the ALT HOLD or the ALT ACQ mode, the force on the control column must remain until the airplane is more than 250 feet from the MCP altitude. If not, the A/P will return to the ALT HOLD or ALT ACQ mode and stay in CMD.

EFFECTIVITY	
SIA ALL	

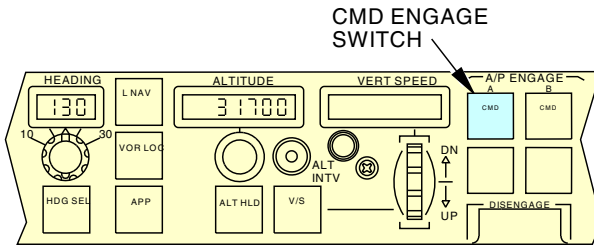
DFCS - OPERATION - PITCH CWS



MCP

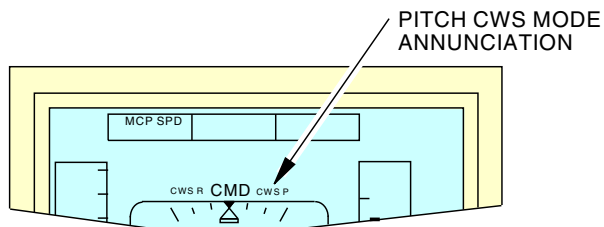
SELECT CWS MODE

OR

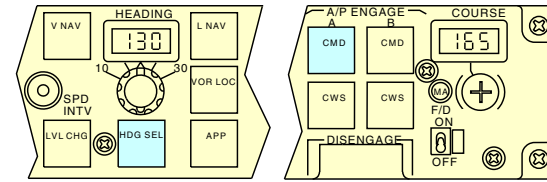


MCP

SELECT CMD MODE AND NO PITCH MODE

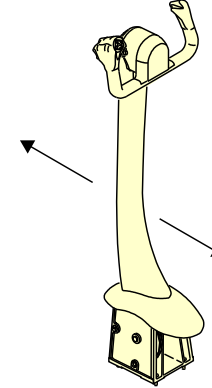


PITCH CWS MODE ANNUNCIATION

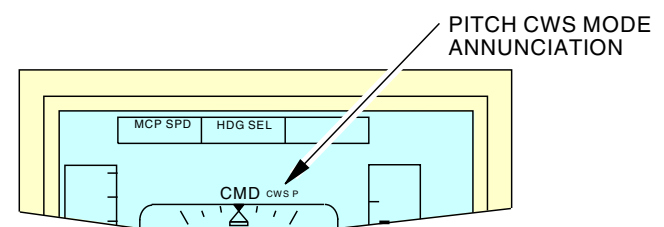


MCP

A/P IS IN CMD MODE AND



APPLY FORCE TO CONTROL COLUMN



PITCH CWS MODE ANNUNCIATION

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DFCS - OPERATION - PITCH CWS

22-11-00

**DFCS - OPERATION - APPROACH INTRODUCTION****General**

You can push the VOR LOC mode selector switch to select a VOR or LOC roll approach mode for landing. If the frequency set in the navigation control panel is a VOR frequency, the VOR roll approach mode is selected. If the frequency set in the navigation control panel is an ILS frequency, the LOC roll approach mode is selected.

You can push the APP mode selector switch to select the IAN and the glide path (G/P) and final approach course (FAC) modes for the approach.

You can also engage the A/P in CWS and use the roll CWS for A/P only commands for an approach.

VOR Approach Mode

You can select a VOR approach to the runway. The VOR approach mode is very similar to the VOR cruise mode. When in the VOR approach sequence, the beam deviation and course error signal gains are smaller than when in the cruise mode.

The VOR mode changes to approach when these conditions occur:

- True airspeed is less than 250 knots
- Radio altitude is below 1500 feet
- Landing gear is down.

LOC Approach Mode

When in the localizer mode, the ILS receiver supplies lateral guidance to capture and track the localizer beam. The flight crew uses the localizer only approach when glideslope is not available or they use a different vertical path for descent.

G/S Approach Mode

When in the glideslope mode, the ILS receiver supplies vertical guidance to capture and track the glideslope beam. To get into the G/S mode you have to push the APP mode selector switch.

IAN Approach Mode

When in integrated approach navigation mode, the FMC supplies FAC and G/P or LOC from the ILS/MMR and G/P from the FMC or LOC Backcourse from the ILS/MMR (mode initiation from the FMC) and G/P from the FMC to the EDFCS. To get into the IAN mode you have to push the APP mode selector switch.

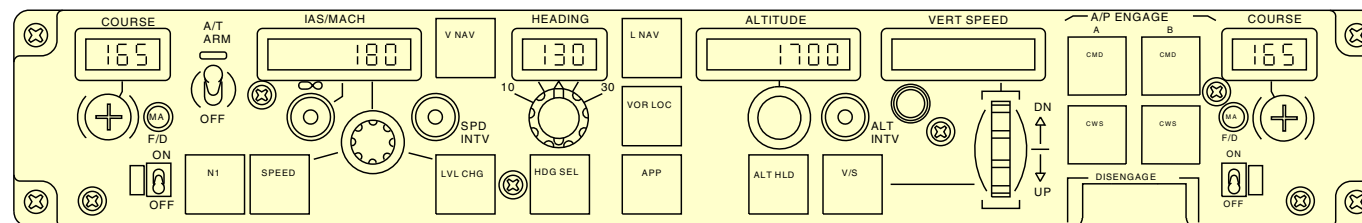
CWS Approach

You can use roll CWS for an approach. The heading hold submode does not operate but the attitude hold submode does.

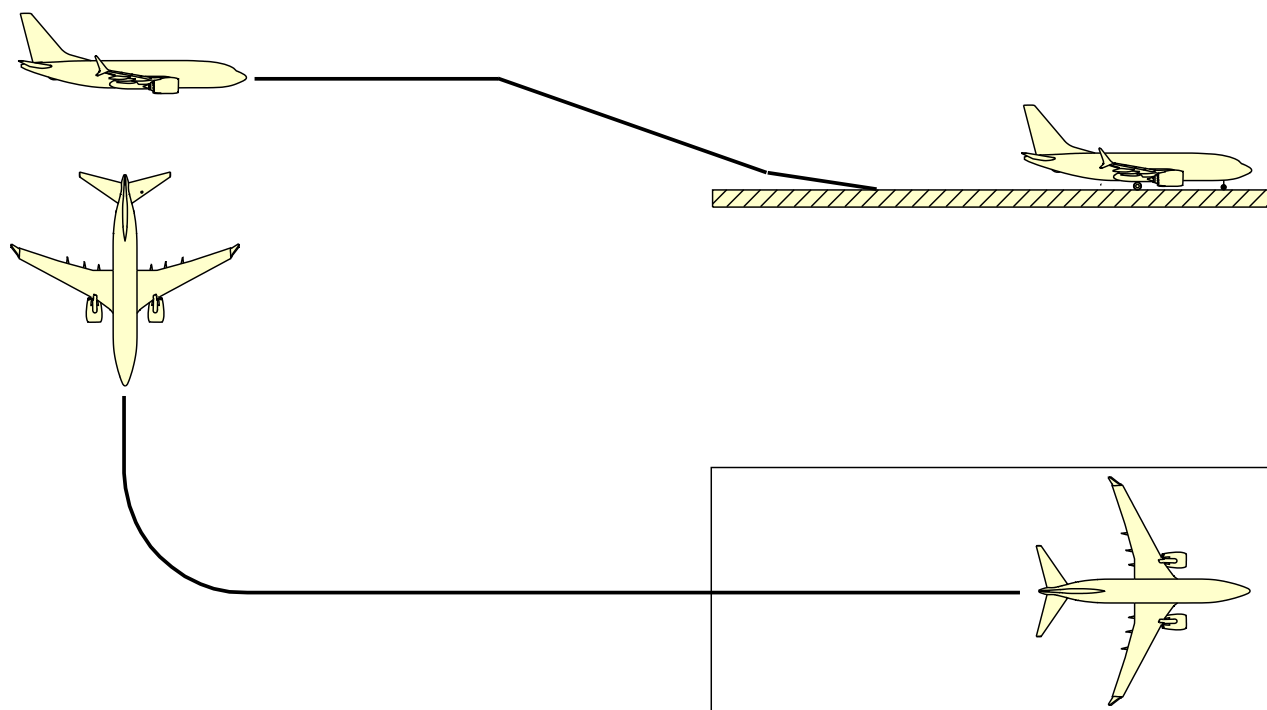
The roll CWS approach mode occurs when any of these conditions are present:

- The F/D is in LOC engaged mode and the A/P is in CWS
- VOR engaged below 250 knots and A/P in CWS
- Gear is down below 1500 feet and A/P is in CWS or in CMD with no modes selected.

DFCS - OPERATION - APPROACH INTRODUCTION



MCP



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DFCS - OPERATION - APPROACH INTRODUCTION

22-11-00

SIA ALL	EFFECTIVITY

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - OPERATION - LOCALIZER****General**

The flight crew can use the VOR LOC mode selector switch on the MCP to select a localizer only approach. The flight crew uses the localizer only approach when glideslope is not available or when they use a different vertical path for descent.

An ILS frequency must be set into the navigation control panel and the ILS course set on the MCP.

The flight crew can use another roll mode to fly the airplane to the localizer. In this example, the flight crew uses the heading select mode.

The LOC mode has these three submodes:

- Localizer arm
- Localizer capture
- Localizer on course.

Localizer Arm

The LOC mode arms when these conditions are valid:

- The crew selects an ILS frequency
- A/P is engaged in roll CWS, HDG SEL or LNAV mode
- The crew pushes the VOR LOC mode selector switch.

The VOR LOC mode selector switch on the MCP arms only the localizer mode. The MDS shows VOR/LOC in white letters. The VOR LOC mode switch light comes on.

Localizer Capture

The FCC determines the capture point of the localizer beam from this data:

- Airplane track angle
- Airplane speed
- Localizer deviation
- ILS course error
- Airplane distance to runway.

When the airplane reaches the capture point, the active roll mode changes to VOR/LOC. The FMA shows VOR/LOC in green letters. When in the VOR capture mode, the bank angle limit is 30 degrees and the roll rate limit is 7 degrees per second.

Localizer On Course

Localizer on course occurs when these conditions are valid:

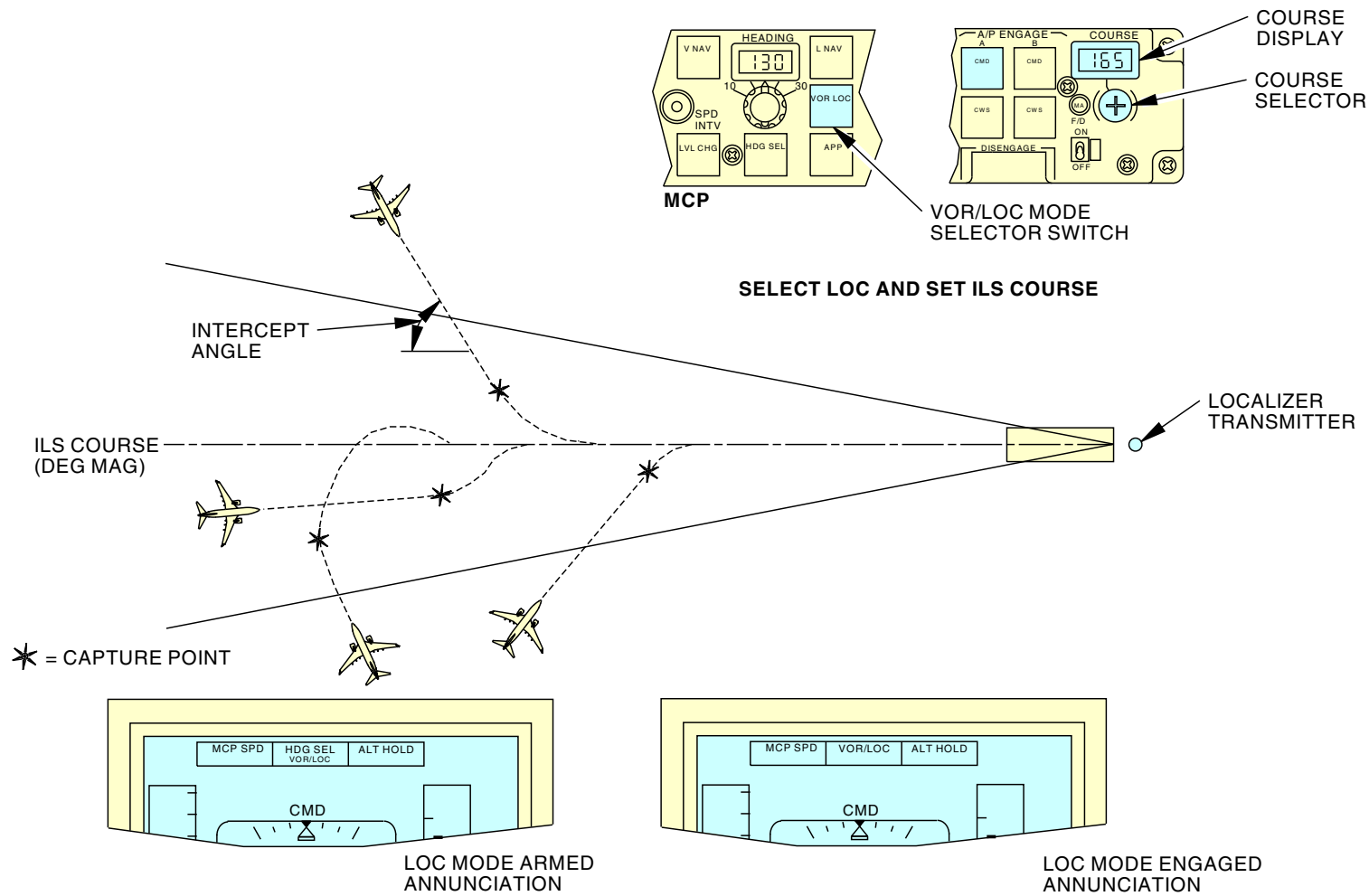
- Localizer deviation is less than 0.8 degrees
- Beam rate is less than 0.045 degrees/second
- Bank angle is less than 6 degrees.

Localizer on course also occurs for these conditions:

- The localizer was in the capture mode for more than 135 seconds
- The localizer deviation is less than 0.8 degrees.

The FCC starts to make crosswind corrections.

DFCS - OPERATION - LOCALIZER



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DFCS - OPERATION - LOCALIZER

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EFFECTIVITY	
SIA ALL	

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - OPERATION - IAN****General**

To select the integrated approach navigation as the approach pitch mode, the crew must push the APP mode selector switch. These are the glideslope submodes:

- Integrated Approach Navigation (IAN) arm
- Integrated Approach Navigation (IAN) capture.

IAN Arm

The IAN mode arms when these conditions are valid:

- With G/S OFF selected.
- One of these flight plan is active: RNAV, GPS, VOR, NDB, ILS, GLS, LOC, BCRS, LDA, and SDF.
- The crew select IAN approach on the ARRIVALS page on the FMC CDU.
- The crew pushes the APP mode selector switch.

IAN Capture

IAN capture occurs when the following is true.

- The flight plan approach is on, If the ILS or GLS type with G/S sets to off.
- There is a non-zero final approach angle on the leg into the missed approach.
- The ILS or GLS tuning is parked or G/S OFF is selected and there is no ILS/GLS Tuning Error message.
- QFE is not selected.
- The airplane is within 50 NM of top descent, within 150 NM from missed approach point or in active VNAV descent mode.

When IAN is in the capture mode, the APP mode selector switch light goes out. This means that the crew cannot deselect the approach mode by pushing the APP mode selector switch.

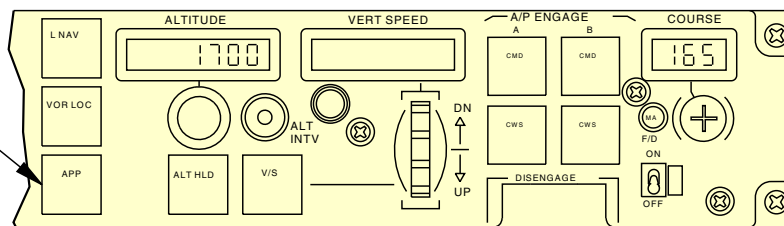
22-11-00**SIA ALL** **EFFECTIVITY**

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

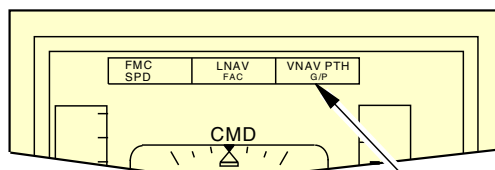
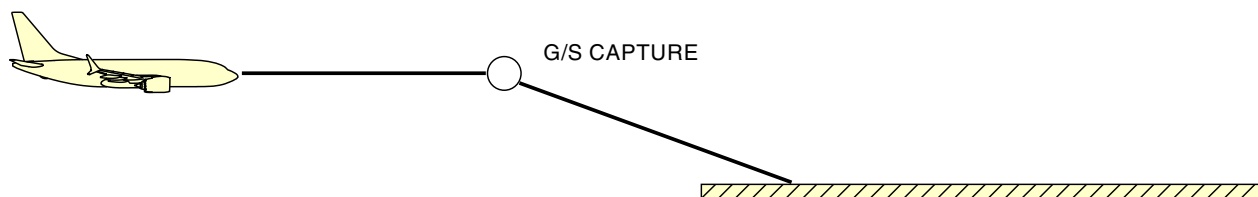
DFCS - OPERATION - IAN

APP MODE SELECTOR SWITCH
(WILL GO OUT WHEN G/S, IAN
AND LOC CAPTURED)

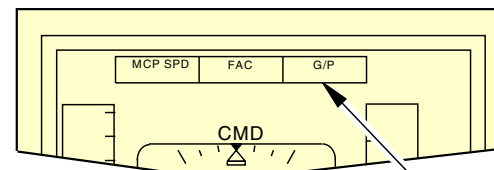


MCP

SELECT APP



IAN MODE ARMED
ANNUNCIATION



IAN MODE ENGAGED
ANNUNCIATION

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DFCS - OPERATION - IAN

**DFCS - OPERATION - GLIDESLOPE****General**

To select the glideslope as the approach pitch mode, the crew must push the APP mode selector switch. These are the glideslope submodes:

- Glideslope arm
- Glideslope capture.

Glideslope Arm

The glideslope mode arms when these conditions are valid:

- The crew selects an ILS frequency
- The autopilot or flight directors are on
- The crew pushes the APP mode selector switch.

The FMA shows G/S in white letters. The APP mode selector switch light comes on.

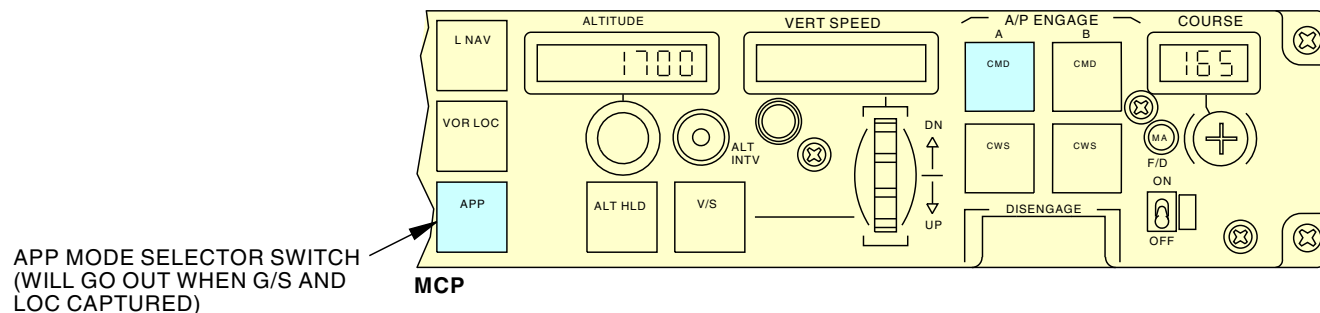
Glideslope Capture

Glideslope capture occurs when the airplane is within 0.19 degrees of beam deviation for at least 2 seconds. The pitch cruise mode is automatically disengaged and further selection of pitch cruise modes are inhibited. The FMA shows G/S in green letters.

When both the glideslope and the localizer are in the capture mode, the APP mode selector switch light goes out. This means that the crew cannot deselect the approach mode by pushing the APP mode selector switch.

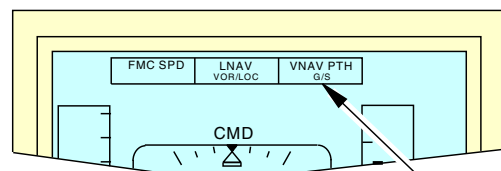
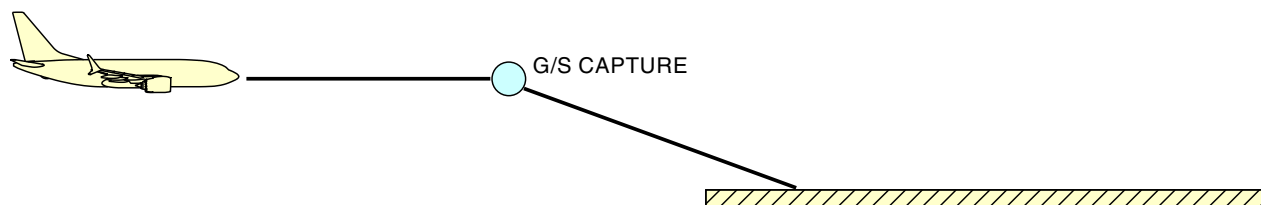
SIA ALL	EFFECTIVITY
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DFCS - OPERATION - GLIDESLOPE

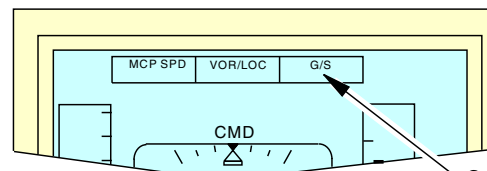


MCP

SELECT APP



G/S MODE ARMED ANNUNCIATION



G/S MODE ENGAGED ANNUNCIATION

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DFCS - OPERATION - GLIDESLOPE

22-11-00

SIA ALL	EFFECTIVITY

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ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - OPERATION - SINGLE CHANNEL APPROACH****General**

When the crew wants to make an ILS approach, they push the APP mode selector switch. The single channel approach is made with only one A/P engaged. There can be one, two or no F/Ds on.

In the approach sequence, the autopilot captures the localizer and the glideslope. The autopilot must capture the localizer before it can capture the glideslope.

After localizer and glideslope capture, the A/P goes into the approach-on-course mode.

The flight mode annunciator (FMA) shows SINGLE CH in amber in the DFCS status column from the time of localizer capture until the crew disengages the autopilot.

Approach On Course

The approach-on-course submode is the same as the localizer-on-course submode with these additions:

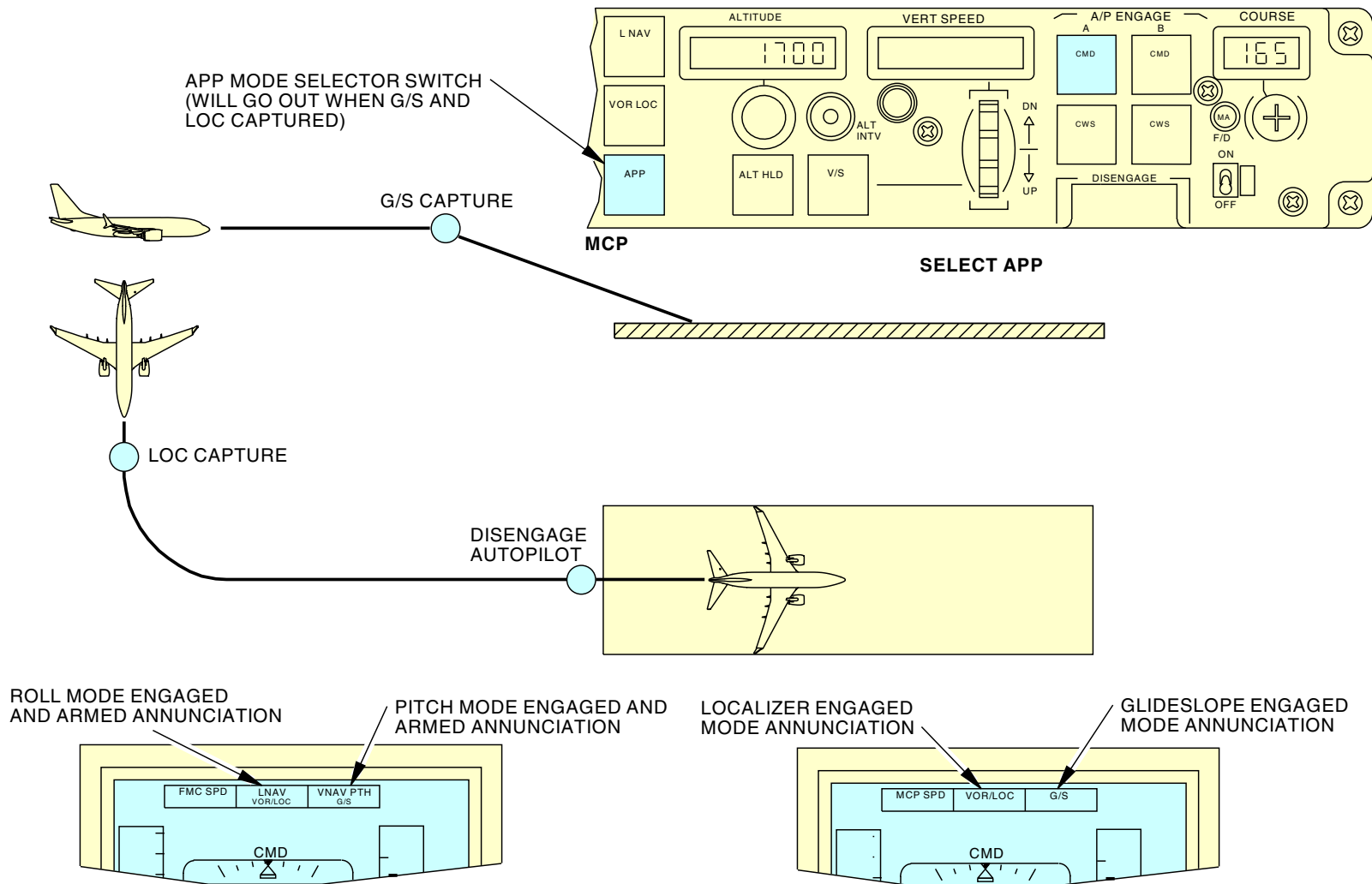
- The local radio altimeter must be valid
- The radio altitude is less than 1500 feet
- Glideslope is captured.

Single Channel Flare

Automatic flare is for dual channel approach, however, since it is part of the A/P design, it can function during single channel approaches. The flare mode does not annunciate on the FMA in a single channel approach. The autopilot should be disengaged manually when the airplane reaches the decision height.

EFFECTIVITY	
SIA ALL	

DFCS - OPERATION - SINGLE CHANNEL APPROACH



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DFCS - OPERATION - SINGLE CHANNEL APPROACH

22-11-00

**DFCS - OPERATION - DUAL CHANNEL APPROACH****General**

The crew can make a dual channel approach. They push the APP mode selector switch and then engage the second A/P in CMD. There can be one, two or no F/Ds on. This approach is similar to the single channel approach except A/P A and A/P B are engaged.

At 10 seconds after the approach on course submode is active, the FMA shows FLARE in white letters in the pitch mode. This shows the crew that the DFCS is in the dual approach mode.

Dual Autopilots

The second autopilot must be set to CMD before the airplane reaches a radio altitude of 800 feet. Below this altitude, the second autopilot cannot be engaged in CMD.

If FLARE does not show armed before the airplane reaches a radio altitude of 350 feet, the autopilots disengage.

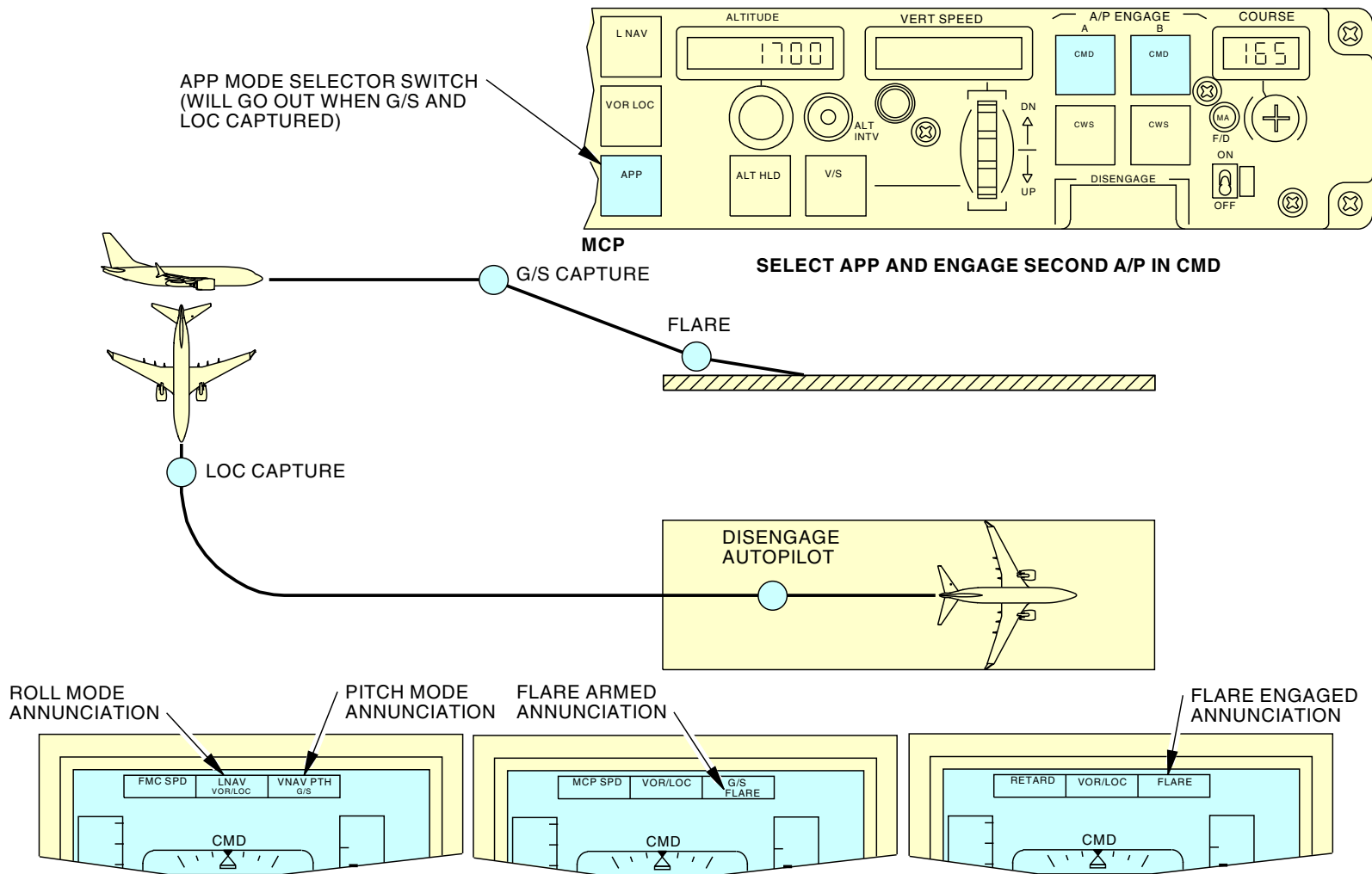
Flare

The flare mode controls the airplane to a smooth touchdown at a point past the glideslope antenna. This is a computed command and is not part of the glideslope mode.

The autopilots start the flare at a radio altitude of 50 feet. The crew should disengage the autopilot at or after touchdown.

SIA ALL	EFFECTIVITY

DFCS - OPERATION - DUAL CHANNEL APPROACH



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DFCS - OPERATION - DUAL CHANNEL APPROACH

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SIA ALL

EFFECTIVITY

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22-11-00

**DFCS - OPERATION - AUTOPILOT GO-AROUND****General**

The pilots can use the A/P go-around (G/A) mode to cancel an approach.

The A/P go-around mode consists of these conditions:

- A/P go-around arm
- A/P go-around reduced
- A/P go-around maximum
- A/P go-around exit.

A/P Go-Around Arm

A/P go-around arms when these conditions are true:

- The airplane is below 2000 feet radio altitude
- Both autopilots are engaged to CMD and the flare mode is armed or active.

The A/P G/A is available until touchdown (wheel spin up). If the crew pushes a TO/GA switch after touchdown, both A/Ps disengage, but the F/D and A/T G/A do not change.

The FMA and MCP continue to show the approach modes.

A/P Go-Around Reduced

The A/P go-around mode starts when the pilot pushes either TO/GA switch. TO/GA shows on the FMA as the active mode for the pitch mode. The roll mode annunciation is blank.

The pitch command is initially 15 degrees pitch up and then it changes to a speed control that is referenced to the flap settings. If an engine fails, the pitch command is a speed control that is referenced to the MCP speed.

The roll command holds the present magnetic track of the airplane over the ground.

The A/T command is a reduced thrust, but it still maintains a positive rate of climb.

A/P Go-Around Maximum

After the airplane reaches the reduced A/P go-around setting, the crew can push the TO/GA switch again. This increases the thrust setting.

See the autoflight system section for more information. (SECTION 22-31)

A/P Go-Around Exit

The pitch channel cannot exit from the A/P G/A mode if a single A/P cannot supply enough elevator control. When the trim conditions change so that the single A/P can supply enough elevator movement, pitch A/P G/A mode can be exited.

The ALT ACQ mode is enabled for radio altitudes more than 800 feet. The airplane levels at the MCP altitude. If the single channel A/P does not have enough elevator control, the ALT ACQ mode is inhibited. The red A/P warning light on the autoflight status annunciator comes on steady red.

If the airplane levels off at the MCP altitude, the second A/P that was turned on disengages. The MCP IAS/MACH display shows the present speed. ALT HOLD and CWS R show on the FMA. The A/P stays in CWS R until the crew selects another roll mode.

Another way to exit the A/P G/A mode is to push the HDG SEL mode selector switch. The A/P exits the roll G/A to HDG SEL, but the pitch channels remain in A/P pitch G/A. Roll is now in single channel control, but pitch is still in dual channel control. The second A/P that was turned on disengages in the roll mode and turns off its aileron A/P actuator. Both A/Ps still show that they are in CMD.

When the crew selects a pitch cruise mode such as LVL CHG, the A/P exits the pitch G/A mode. The crew cannot use pitch CWS to exit A/P pitch G/A.

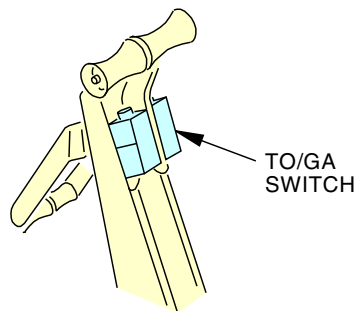
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EFFECTIVITY	
SIA ALL	

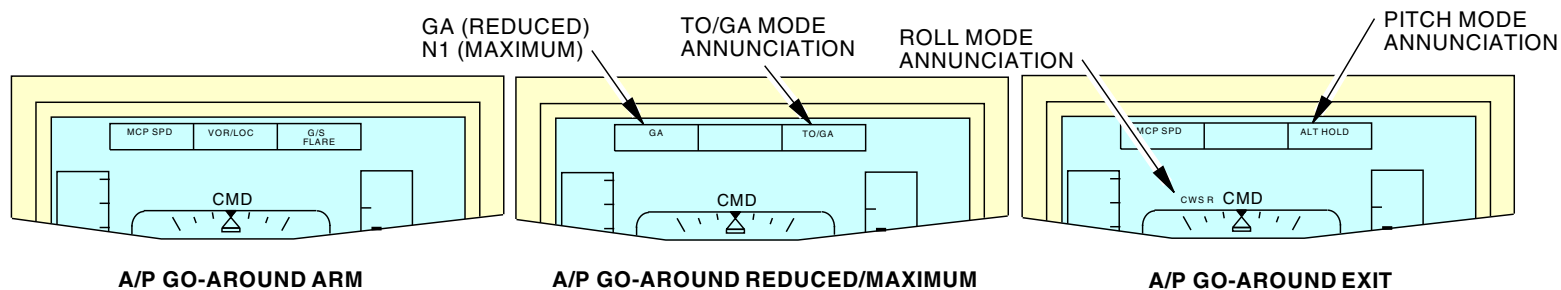
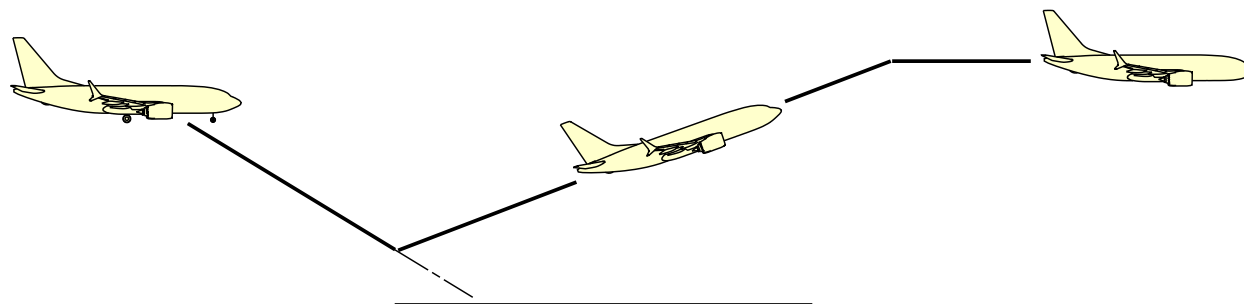
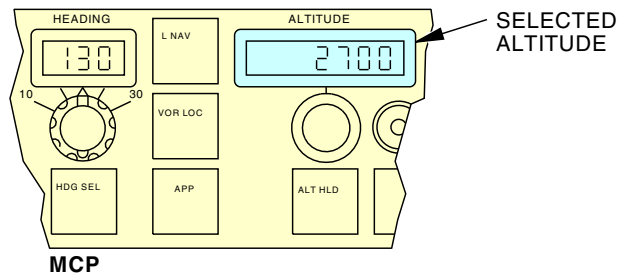
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DFCS - OPERATION - AUTOPILOT GO-AROUND



PUSH TO/GA SWITCHES



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DFCS - OPERATION - AUTOPILOT GO-AROUND

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22-11-00

**DFCS - OPERATION - FLIGHT DIRECTOR GO-AROUND****General**

The pilots can use the F/D go-around (G/A) mode if they want to cancel an approach or the airplane enters windshear conditions while landing.

The F/D go-around mode consists of these conditions:

- F/D go-around active
- F/D go-around exit.

F/D Go-Around Active

The F/D go-around mode starts when the pilot pushes either TO/GA switch and the airplane is below 2000 feet of radio altitude. TO/GA shows on the FMA as the active mode for the pitch mode. The roll mode annunciation is blank.

The pitch command is initially pitch up and then it changes to a speed control that is referenced to the flap settings. If an engine fails, the pitch command is a speed control that is referenced to the MCP speed.

The roll command holds the present magnetic track of the airplane over the ground.

In F/D go-around, the flight director display on the AIs automatically comes on even if the flight director switches are off. This is called the pop up mode. It occurs when all these conditions are true:

- A flight director switch is off
- The radio altitude is less than 2000 feet
- The pilot pushes a TO/GA switch.

F/D Go-Around Exit

Below 400 feet, the DFCS stays in F/D go-around unless the pilot sets the flight director switches to off. Above 400 feet, the pilot can set another roll or pitch mode.

Below 400 feet, the DFCS stays in the F/D go-around and the pilot can switches to LNAV operation.

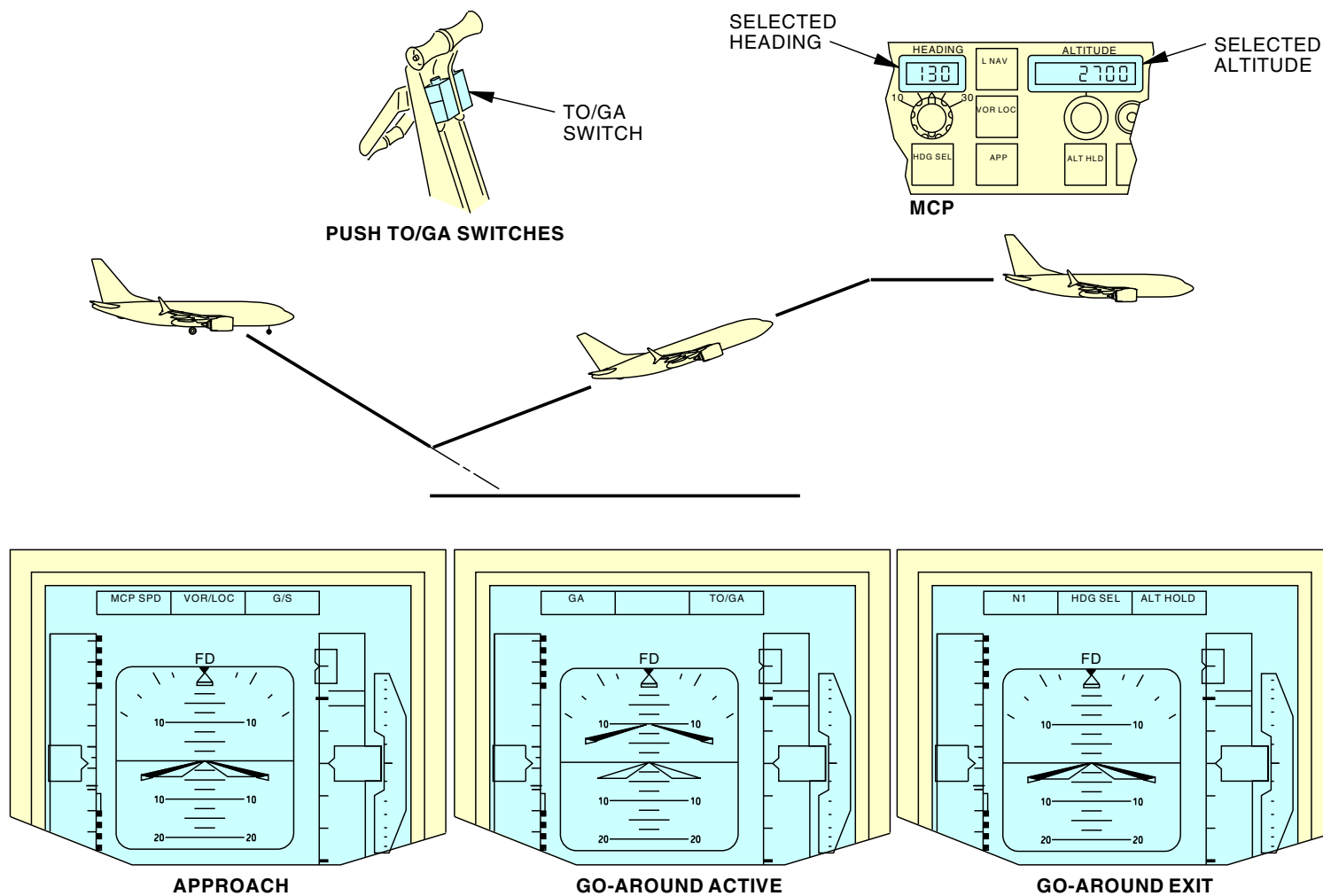
If the pilot changes the pitch mode first, the roll mode will change to HDG SEL. If the pilot changes the roll mode first, the pitch mode remains in the pitch G/A mode. In the example the airplane changed from the pitch G/A mode to the altitude hold mode.

22-11-00

EFFECTIVITY	
SIA ALL	

D633AM102-SIA

DFCS - OPERATION - FLIGHT DIRECTOR GO-AROUND



2368576 S00061517683_V1

DFCS - OPERATION - FLIGHT DIRECTOR GO-AROUND

22-11-00

**DFCS - OPERATION - AUTOFLIGHT GO-AROUND ROLL MODE - LNAV****General**

The pilot can select LNAV as the active roll mode for go-around instead of track hold when a missed approach exists in the flight plan.

Normally when an approach is selected from the ARRIVALS page, it will include a missed approach. When a missed approach is in the flight plan and the FCCs are armed for go-around, LNAV ARM will be annunciated on the FMA.

The LNAV go-around mode consists of these conditions:

- TOGA is pressed with LNAV ARM and FLARE ARM annunciated.
- TOGA is pressed with LNAV ARM annunciated and FLARE ARM is not annunciated.

TOGA is pressed with LNAV ARM and FLARE ARM annunciated

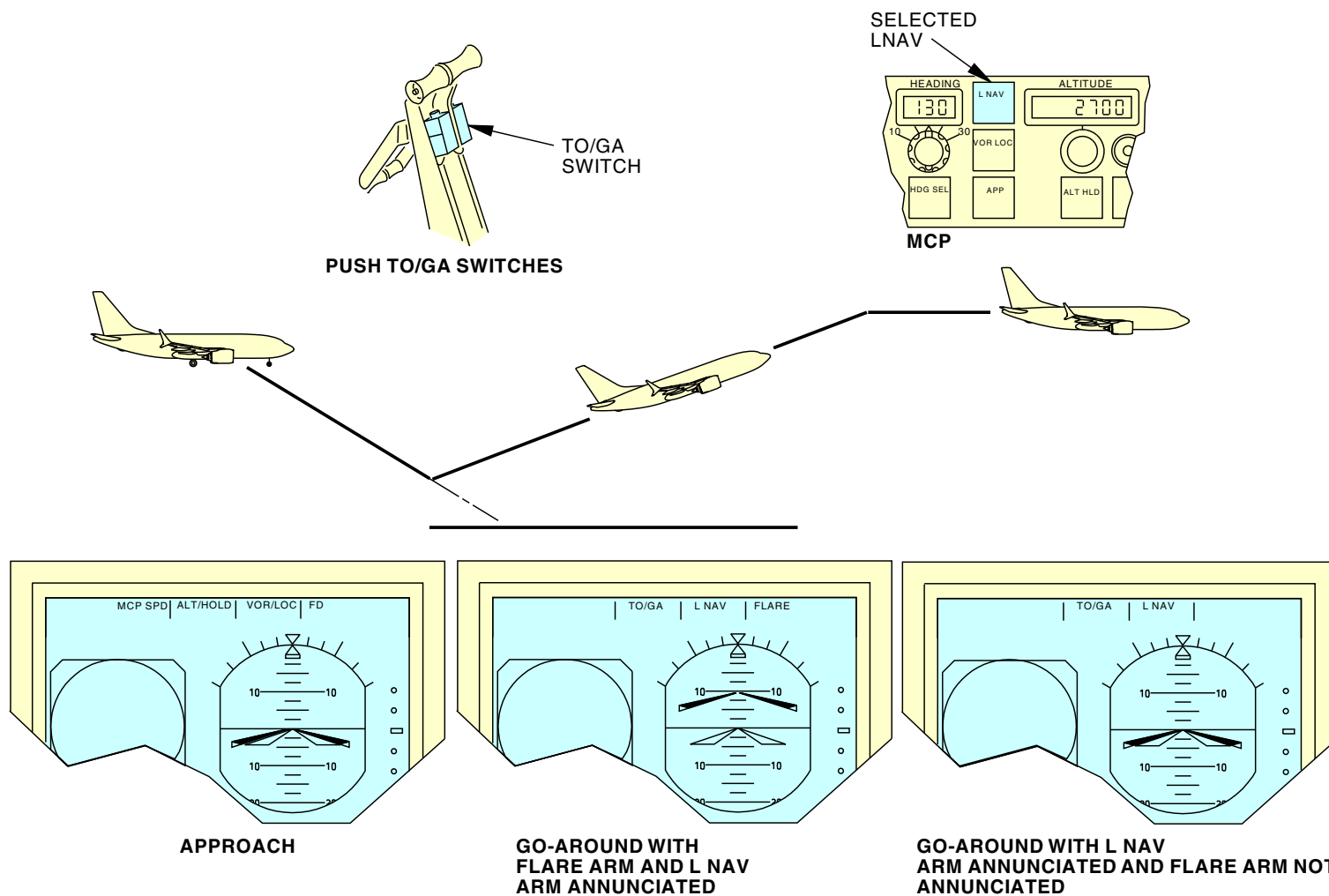
If TOGA is pressed with FLARE ARM and LNAV ARM annunciated. LNAV will engage automatically upon reaching 400 feet (AGL). Prior to this condition, TOGA will be in altitude track hold.

TOGA is pressed with LNAV ARM annunciated and FLARE ARM is not annunciated

If TOGA is pressed with LNAV ARM annunciated and FLARE ARM is not annunciated, the flight director LNAV mode will engage when the airplane is above 50 feet (AGL). Prior to this condition, TOGA will be in altitude track hold.

EFFECTIVITY	
SIA ALL	

DFCS - OPERATION - AUTOFLIGHT GO-AROUND ROLL MODE - LNAV



2368577 S00061517685_V1

DFCS - OPERATION - AUTOFLIGHT - GO AROUND ROLL MODE - LNAV

22-11-00

**DFCS - OPERATION - GROUND OPERATIONS - TO/GA SWITCH****General**

You can engage the autopilot in CMD or CWS and turn on the flight directors while on the ground. You can activate some of the modes while on the ground. You need hydraulic power to engage the autopilot.

When on the ground, the magnetic heading replaces the magnetic track so you can do several tests.

TO/GA and Flight Directors

The graphic shows what you see if you turn on the flight directors (F/D) and push the TO/GA switch on the ground.

When you turn on the captain F/D switch the master annunciator light above the switch turns on. The captain FMA shows FD. Turn on the first officer F/D switch. The first officer FMA shows FD.

When you push a TO/GA switch the first officer master annunciator turns on. Both FMAs show TO/GA and FD. The F/D commands show on the AI. The pitch command is set to -10 degrees and the roll command shows wings level.

TO/GA and Autopilot

Engage A/P A in CMD. The CMD A light comes on on the engage switch. The FMAs shows these annunciations:

- CMD
- CWS P
- CWS R

Push the TO/GA switch and the A/P disengages. The red A/P light on the ASAs flashes and the aural warning supplies a wailer sound.

22-11-00

EFFECTIVITY	
SIA ALL	

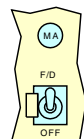
D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details

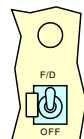
DFCS - OPERATION - GROUND OPERATIONS - TO/GA SWITCH

1. TURN ON CAPT F/D SWITCH

MA LIGHT COMES ON

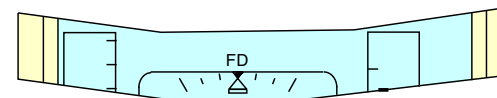
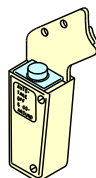


2. TURN ON F/O F/D SWITCH

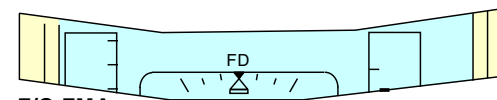


CHANGE INDICATIONS

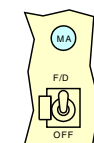
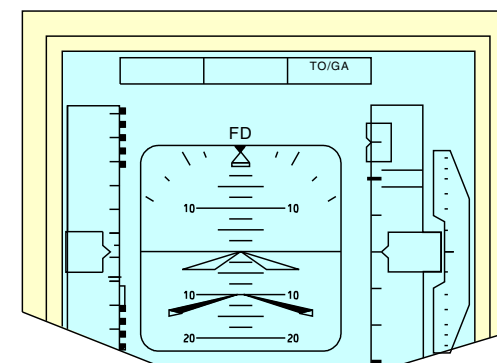
3. PUSH TO/GA SWITCH



CAPT FMA



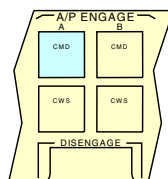
F/O FMA



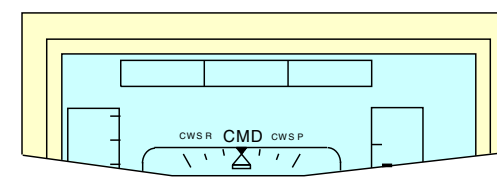
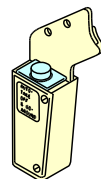
F/O MA LIGHT COMES ON

1. ENGAGE A/P A IN CMD

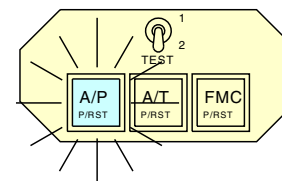
A CMD ENGAGE SW LIGHT COMES ON



2. PUSH TO/GA SWITCH



A/P DISENGAGES
A/P ANNUNCIATOR FLASHES RED
AURAL WARNING



2368578 S00061517687_V1

DFCS - OPERATION - GROUND OPERATIONS - TO/GA SWITCH

22-11-00

**DFCS - OPERATION - GROUND OPERATIONS - ROLL MODE - LNAV AND HDG SEL****General**

You can push these roll mode selector switches on the MCP and activate these modes when the airplane is on the ground and the F/Ds are on:

- LNAV
- HDG SEL
- VOR LOC.

You can push the HDG SEL or VOR LOC mode selector switch when an A/P is engaged. You cannot activate LNAV on the ground when an A/P is engaged.

LNAV

When you push the LNAV mode selector switch, the mode selector switch light comes on. You can also see LNAV and FD on the FMA. You do not see any F/D commands on the AI.

HDG SEL and Flight Directors

Turn on the F/Ds and push the HDG SEL mode selector switch. The FMA annunciator shows HDG SEL and FD. The F/D integrated cue does not show because there is no valid pitch mode. Push ALT HLD to activate a pitch mode. The FMA now also shows ALT HOLD and the F/D cue shows on the AI. Turn the selected heading to a heading different from the airplane heading. The F/D command will turn to command a turn to the selected heading.

HDG SEL and Autopilot

Engage A/P A in CMD and push the HDG SEL mode selector switch. These annunciations show on the FMA:

- HDG SEL
- CMD
- CWS P.

Turn the selected heading to a heading different from the airplane heading. The control wheel will turn to turn to the selected heading.

22-11-00

EFFECTIVITY	
SIA ALL	

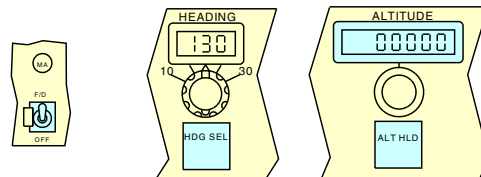
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ECCN 9E991 BOEING PROPRIETARY - See title page for details

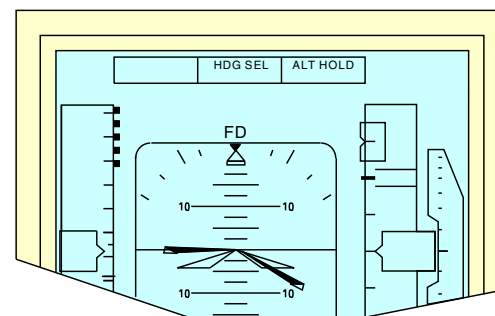
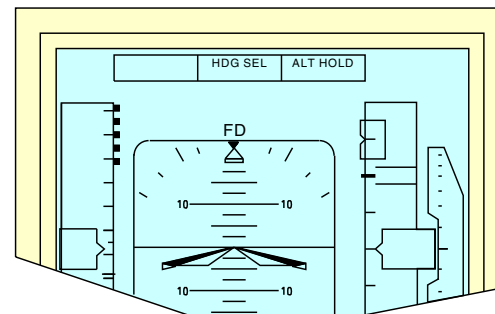
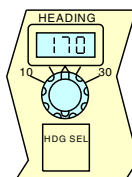
DFCS - OPERATION - GROUND OPERATIONS - ROLL MODE - LNAV AND HDG SEL

FLIGHT DIRECTOR

1. TURN ON F/D SWITCH
2. PUSH HDG SEL MODE SELECTOR SWITCH
3. PUSH ALT HLD MODE SELECTOR SWITCH

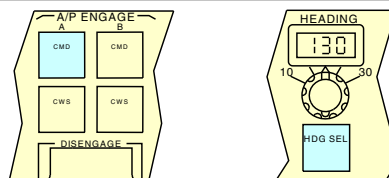


4. TURN SELECTED HEADING TO A HEADING DIFFERENT FROM THE AIRPLANE HEADING.

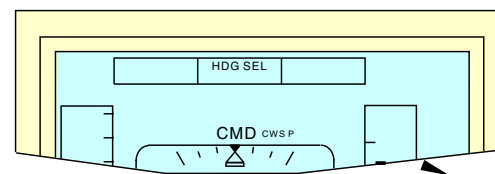
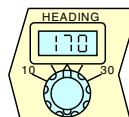


AUTOPILOT

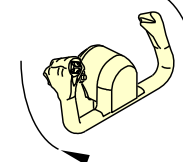
1. ENGAGE A/P A IN CMD
2. PUSH HDG SEL MODE SELECTOR SWITCH



3. TURN SELECTED HEADING TO A HEADING DIFFERENT FROM THE AIRPLANE HEADING.



CONTROL WHEEL TURNS TO TURN AIRPLANE TO SELECTED HEADING



2368579 S00061517689_V1

DFCS - OPERATION - GROUND OPERATIONS - ROLL MODE - LNAV AND HDG SEL

22-11-00

SIA ALL

EFFECTIVITY

D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - OPERATION - GROUND OPERATIONS - ROLL MODE - VOR/LOC****VOR LOC**

Unless the VOR station is very close to the airport, you will not receive a valid VOR signal. However, you may be able to receive the localizer signal.

Flight Director

Turn the F/Ds and push the VOR LOC mode selector switch. Tune the navigation control panel to the airport ILS frequency. The FMA shows VOR LOC and FD in green letters. This occurs if the ILS receiver receives a valid LOC signal. The F/D command does not show because there is no valid pitch mode. Push ALT HLD to activate a valid pitch mode. The FMA now also shows ALT HOLD and the F/D command shows on the AI. The F/D command may turn to command a turn to the localizer centerline.

Autopilot

Engage A/P A in CMD and push the VOR LOC mode selector switch. These annunciations show on the FMA if the ILS receiver has a valid localizer signal:

- VOR LOC in green letters (active)
- CMD
- CWS P.

The control wheel may turn to turn the airplane to the localizer centerline.

If the ILS receiver does not have a valid localizer signal, these show on the FMA:

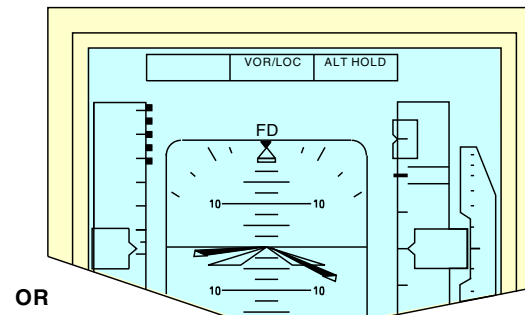
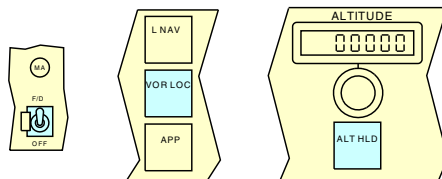
- VOR LOC in white letters (armed)
- CMD
- CWS P
- CWS R.

EFFECTIVITY	
SIA ALL	

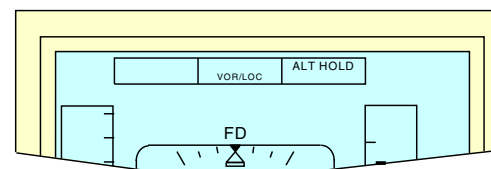
DFCS - OPERATION - GROUND OPERATIONS - ROLL MODE - VOR/LOC

FLIGHT DIRECTOR

1. TURN ON F/D SWITCH
2. TUNE THE NAV CONTROL PANEL TO THE AIRPORT ILS FREQUENCY
3. PUSH VOR LOC MODE SELECTOR SWITCH
4. PUSH ALT HLD MODE SELECTOR SWITCH

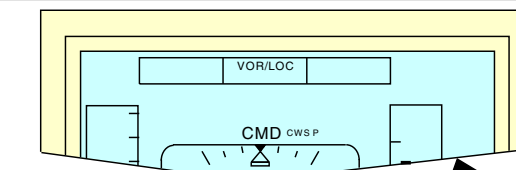
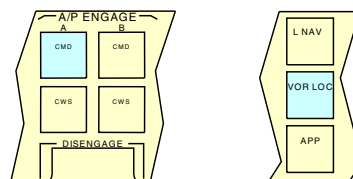


OR



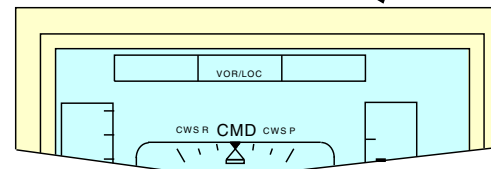
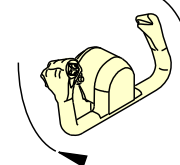
AUTOPILOT

1. ENGAGE A/P A IN CMD
2. TUNE THE NAV CONTROL PANEL TO THE AIRPORT ILS FREQUENCY
3. PUSH VOR LOC MODE SELECTOR SWITCH



CONTROL WHEEL TURNS
TO TURN AIRPLANE TO
LOC CENTERLINE

OR



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DFCS - OPERATION - GROUND OPERATIONS - ROLL MODE - VOR/LOC

22-11-00

SIA ALL

EFFECTIVITY

D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - OPERATION - GROUND OPERATIONS - PITCH MODE - ALT HOLD****General**

You can push these mode selector switches on the MCP and activate the modes when the airplane is on the ground:

- ALT HLD
- LVL CHG.

You cannot activate the VNAV mode reliably when on the ground. Depending upon the alpha vane, flaps, and SMYDC, pushing the V/S mode selector switch on the ground may cause the mode to revert to LVLCHG.

ALT HLD and Flight Directors

When you turn on the F/Ds and push the ALT HLD mode selector switch the FMA annunciator shows ALT HOLD and FD. The F/D command does not show because there is no valid roll mode. Push HDG SEL to activate a roll mode. The FMA now also shows HDG SEL and the F/D command shows on the AI. Turn the selected altitude to within 100 feet of the airplanes altitude. The ALT HLD light on the mode selector switch goes out.

ALT HLD and Autopilot

When you engage A/P A in CMD and push the ALT HLD mode selector switch these annunciations show on the FMA:

- ALT HOLD
- CMD
- CWS R.

22-11-00

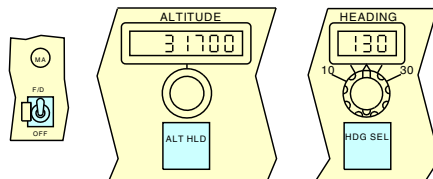
SIA ALL	EFFECTIVITY

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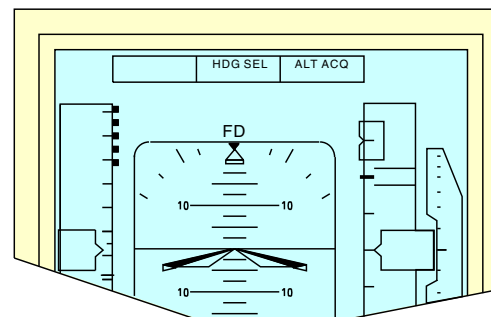
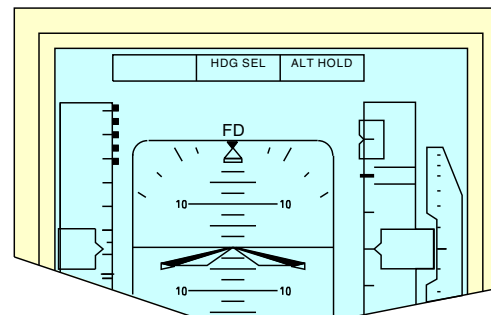
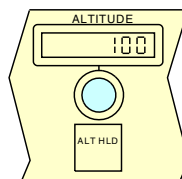
DFCS - OPERATION - GROUND OPERATIONS - PITCH MODE - ALT HOLD

FLIGHT DIRECTOR

1. TURN ON F/D SWITCH
2. PUSH ALT HLD MODE SELECTOR SWITCH
3. PUSH THE HDG SEL MODE SELECTOR SWITCH

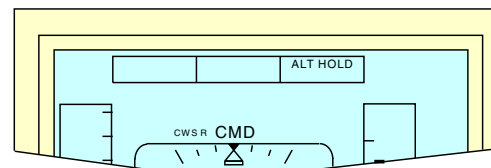
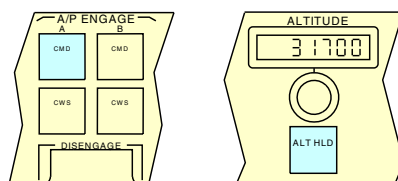


4. TURN THE SELECTED ALTITUDE TO WITHIN 100 FEET OF THE AIRPLANE ALTITUDE.
ALT HLD LIGHT GOES OUT



AUTOPILOT

1. ENGAGE A/P A IN CMD
2. PUSH ALT HLD MODE SELECTOR SWITCH



2368581 S00061517693_V1

DFCS - OPERATION - GROUND OPERATIONS - PITCH MODE - ALT HOLD

22-11-00

SIA ALL

EFFECTIVITY

D633AM102-SIA

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**DFCS - OPERATION - GROUND OPERATIONS - PITCH MODE - LVL CHG****LVL CHG and Flight Directors**

When you turn on the F/Ds and push the LVL CHG mode selector switch the FMA annunciator shows MCP SPD and FD. The F/D command does not show because there is no valid roll mode. Push HDG SEL to activate a roll mode. The FMA now also shows HDG SEL and the F/D command shows on the AI. Turn the selected altitude to within 200 feet of the airplane altitude and see these changes:

- LVL CHG light on the mode selector switch goes out
- FMA changes from MCP SPD to ALT ACQ
- F/D command moves to the top of AI.

LVL CHG and Autopilot

Engage A/P A in CMD and push the LVL CHG mode selector switch. These annunciations show on the FMA:

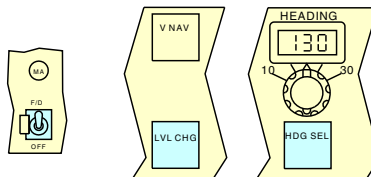
- MCP SPD
- CMD
- CWS R.

SIA ALL	EFFECTIVITY

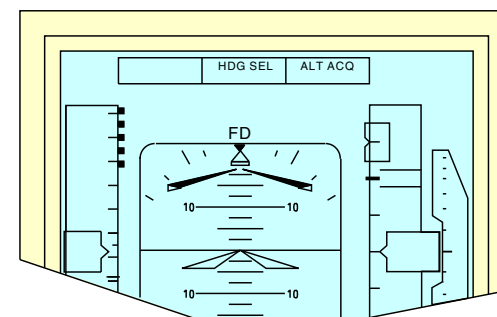
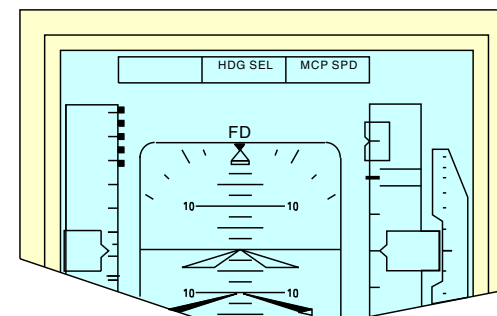
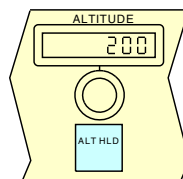
DFCS - OPERATION - GROUND OPERATIONS - PITCH MODE - LVL CHG

FLIGHT DIRECTOR

1. TURN ON THE F/D SWITCH
2. PUSH THE LVL CHG MODE SELECTOR SWITCH
3. PUSH THE HDG SEL MODE SELECTOR SWITCH

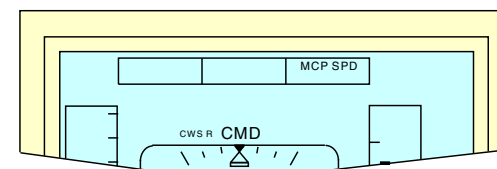
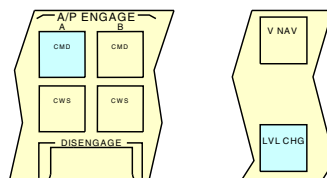


4. TURN THE SELECTED ALTITUDE TO WITHIN 200 FEET OF THE AIRPLANE ALTITUDE.



AUTOPILOT

1. ENGAGE A/P A IN CMD
2. PUSH LVL CHG MODE SELECTOR SWITCH



2368582 S00061517695_V1

DFCS - OPERATION - GROUND OPERATIONS - PITCH MODE - LVL CHG

22-11-00

SIA ALL

EFFECTIVITY

D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details

**DFCS - OPERATION - GROUND OPERATIONS - APPROACH****General**

You can activate the autopilot mode while on the ground.

APP and Flight Directors

Turn on the F/Ds and push the APP mode selector switch. The FMAs show these annunciations:

- G/S
- VOR/LOC
- FD.

The G/S annunciation will be in white letters to show the armed mode. The VOR/LOC may show in either green or white letters. It shows in green letters if the ILS receiver has a valid localizer signal. No F/D commands will show because there is no valid pitch mode.

APP and Autopilot

Engage A/P A in CMD and push the APP mode selector switch. Tune the navigation control panels to the airport ILS frequency. The FMAs show these annunciations:

- G/S
- VOR/LOC
- CMD.

The G/S annunciation shows in white letters. If the ILS receiver does not receive a valid localizer signal, VOR/LOC will show in white letters and CWS P and CWS R will show in amber letters on the FMAs. If the ILS receiver gets a valid localizer signal, VOR/LOC shows in green letters and CWS P shows in amber letters.

22-11-00

SIA ALL EFFECTIVITY

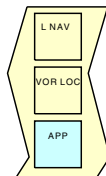
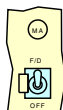
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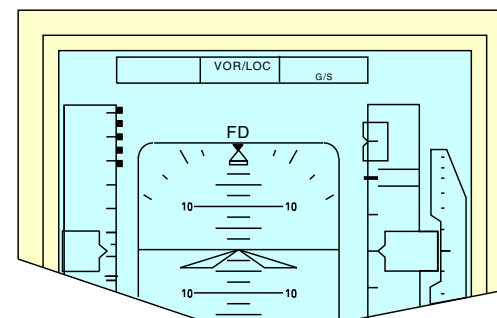
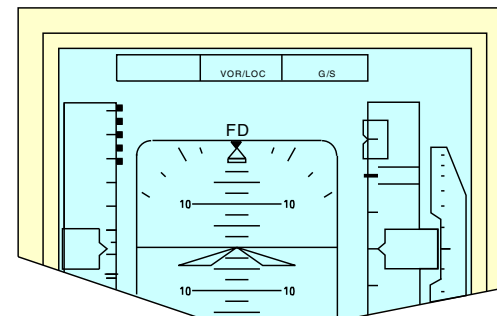
DFCS - OPERATION - GROUND OPERATIONS - APPROACH

FLIGHT DIRECTOR

1. TURN ON F/D SWITCHES
2. PUSH THE APP MODE SELECTOR SWITCH

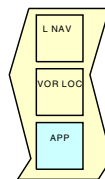
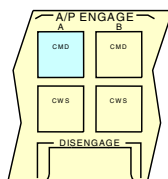


OR

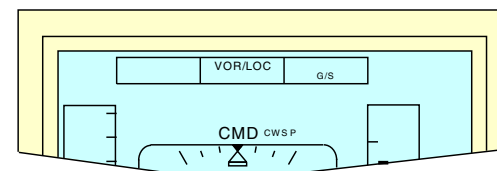
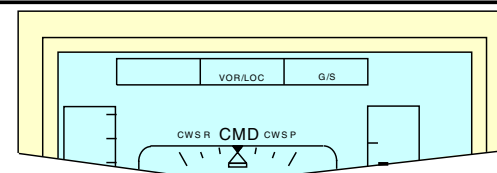


AUTOPILOT

1. ENGAGE A/P A IN CMD
2. PUSH THE APP MODE SELECTOR SWITCH



OR



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DFCS - OPERATION - GROUND OPERATIONS - APPROACH

22-11-00

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**DFCS - OPERATION - GROUND OPERATIONS - CONTROL WHEEL STEERING****General**

These are the three ways to engage an A/P in control wheel steering (CWS) on the ground:

- CWS P
- CWS R.

- Push the CWS engage switch
- Push the CMD engage switch and do not select a roll and pitch mode
- When the A/P is engaged in CMD, apply force to the control column and control wheel.

You need hydraulic pressure to engage the autopilot in the CWS mode.

CWS Engage Switch

Push the CWS A engage switch. The light on the engage switch comes on. The FMAs show CWS P and CWS R in amber letters.

CMD Engage Switch and No Modes

Push the CMD A engage switch. The light on the engage switch comes on. The FMAs show these annunciations:

- CMD
- CWS P
- CWS R.

CWS Reversion From CMD

Engage A/P A in CMD and push the HDG SEL and ALT HLD mode selector switches. This engages the A/P in a roll and pitch mode. The FMAs show these annunciations:

- ALT HOLD
- HDG SEL
- CMD.

Apply force to the control wheel and the control column until the A/P reverts to the CWS modes. The FMAs show these annunciations:

- CMD

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EFFECTIVITY	
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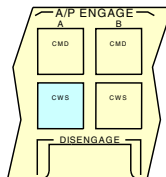
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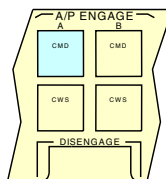
DFCS - OPERATION - GROUND OPERATIONS - CONTROL WHEEL STEERING

AUTOPILOT

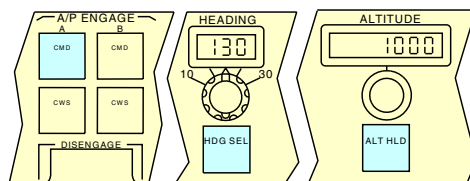
1. ENGAGE A/P A IN CWS



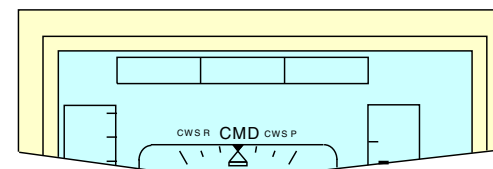
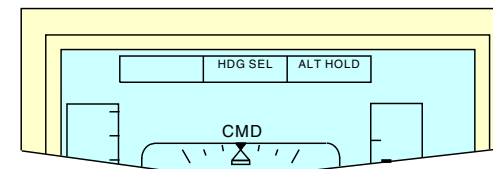
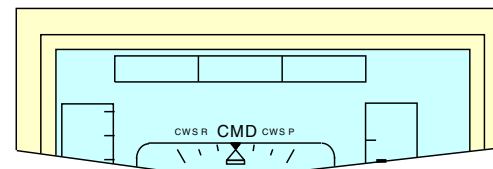
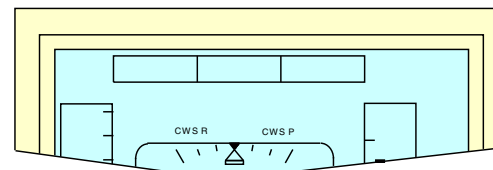
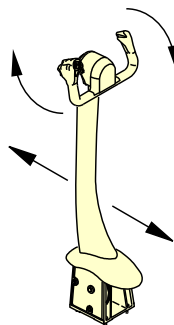
2. ENGAGE A/P A IN CMD WITH NO ROLL OR PITCH MODES SELECTED.



3. ENGAGE A/P A IN CMD AND SELECT HDG SEL AND ALT HLD.



4. TURN THE CONTROL WHEEL AND MOVE THE CONTROL COLUMN.



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DFCS - OPERATION - GROUND OPERATIONS - CONTROL WHEEL STEERING

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DFCS - SYSTEM SUMMARY 1

General

This graphic is for reference.

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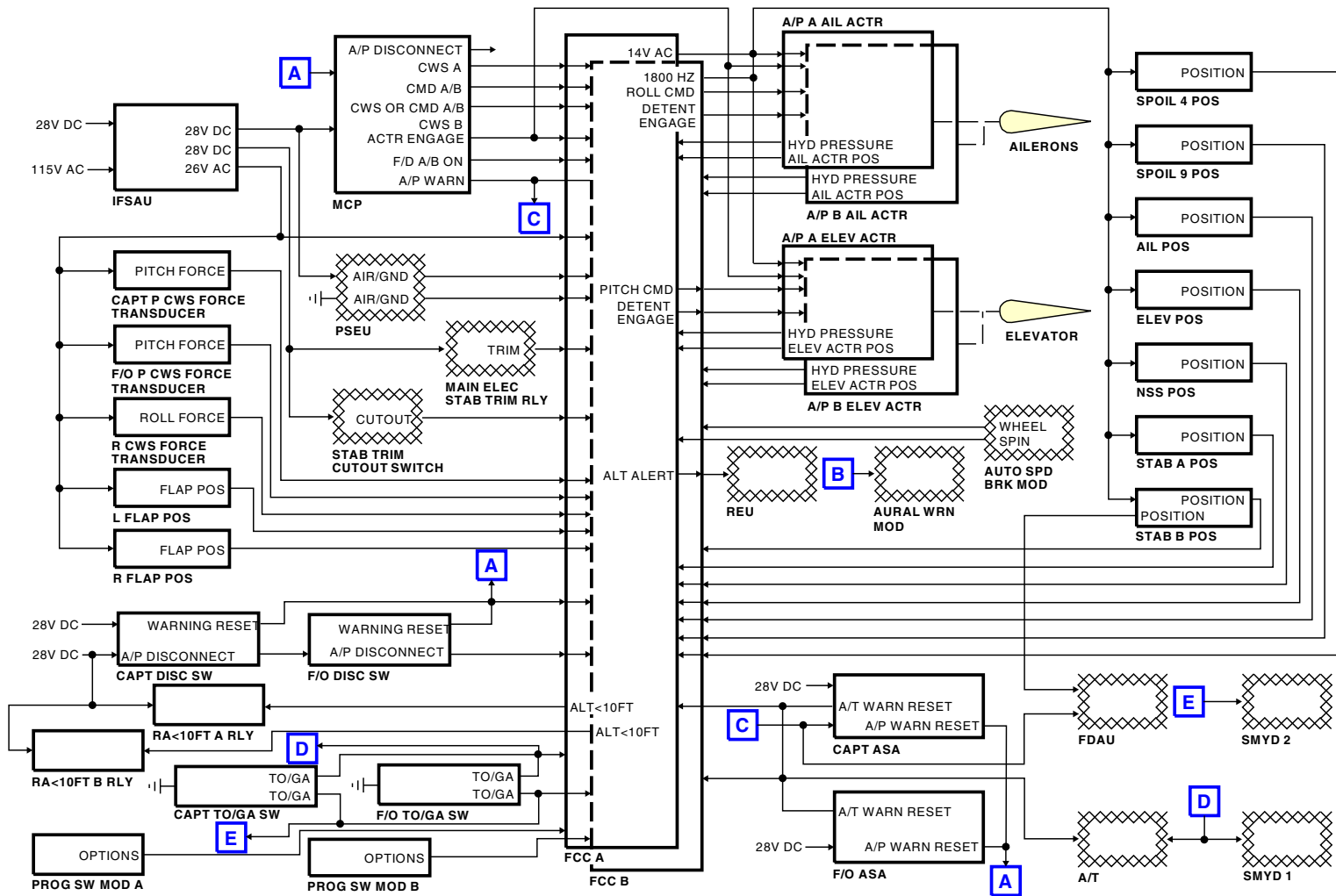
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DFCS - SYSTEM SUMMARY 1



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DFCS - SYSTEM SUMMARY 1

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DFCS - SYSTEM SUMMARY 2

General

This graphic is for reference.

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DFCS - SYSTEM SUMMARY 2

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YAW DAMPER SYSTEM - INTRODUCTION

Purpose

The yaw damper system keeps the airplane stable around the airplane yaw (vertical) axis. During flight, the yaw damper commands rudder movement in proportion to and opposite to the airplane yaw moment. This keeps unwanted yaw motion to a minimum and makes the flight smoother. The yaw damper is an autoflight system.

Unwanted airplane yaw motion is caused by either of the following conditions:

- Dutch roll
- Air turbulence.

Abbreviations and Acronyms

- ac - alternating current
- ADR - air data reference
- ADIRU - air data inertial reference unit
- AOA - angle of attack
- ARINC - Aeronautical Radio Incorporated
- ATR - Austin Trumbull Radio
- BITE - built in test equipment
- CAA - Civil Aviation Authority
- CDU - control display unit (FMC)
- CPC - cabin pressure controller
- CPU - central processing unit
- dc - direct current
- DFCS - digital flight control system
- DPC - display processing computer
- EHSV - electro-hydraulic servo valve
- FAA - Federal Aviation Administration
- FMC - flight management computer
- FMCS - flight management computer system

- FMS - flight management system
- IR - inertial reference
- I/O - input/output
- LRU - line replaceable unit
- LVDT - linear variable differential transformer
- MCP - mode control panel
- N1 - engine low pressure rotor (fan) speed
- N2 - engine high pressure rotor speed
- NN - a number from 01 to 99
- PCU - power control unit
- PLI - pitch limit indicator
- SMYD - stall management yaw damper
- SWS - stall warning system
- V - volts
- Vmin - minimum safe airspeed
- Vmax - maximum safe design airspeed
- WTRIS - wheel to rudder interconnect system
- YDS - yaw damper system

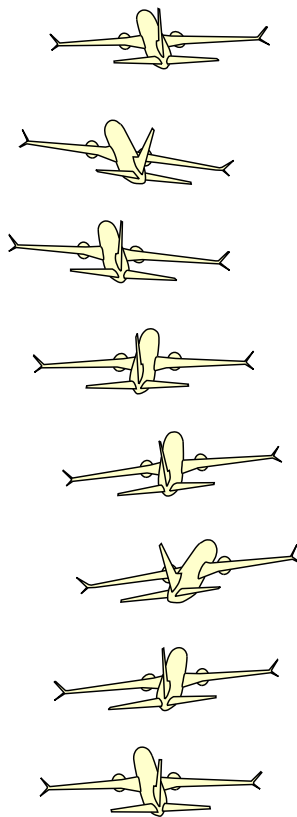
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YAW DAMPER SYSTEM - INTRODUCTION



UNWANTED YAW MOTION DUE TO DUTCH ROLL OR TURBULENCE

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YAW DAMPER SYSTEM - INTRODUCTION

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YDS - GENERAL DESCRIPTION

General

The yaw damper system is an autoflight system which moves the rudder to decrease airplane yaw motion caused by dutch roll or turbulence. The system operates for all phases of flight and is normally engaged on the ground before takeoff.

These are the components for primary yaw damping:

- SMYD 1
- Yaw damper engage switch
- Yaw damper disengage light
- Yaw damper components on the main rudder PCU.

Yaw Damper Engage Switch and Disengage Light

You engage the yaw damper system with a switch on the flight control panel. For primary yaw damping, system B hydraulic pressure is necessary and the FLT CTRL B switch must be ON. The yaw damper disengage warning light is above the engage switch. For normal yaw damper operation, the light is OFF. The light is ON to show the yaw damper is not engaged while power is on the airplane.

Main Rudder PCU

There are two rudder PCUs, a main and a standby, in the vertical stabilizer. These PCUs are hydraulic actuators that move the rudder in response to pilot rudder pedal inputs. The main rudder PCU is used only during normal operations. The standby rudder PCU is used only during standby operations.

The primary yaw damper uses the main rudder PCU to move the rudder to reduce yaw. For yaw damping, these are the four components on the main rudder PCU:

- Yaw damper solenoid valve
- Yaw damper electro-hydraulic servo valve (EHSV)
- Yaw damper LVDT
- Yaw damper actuator.

ADIRU

The air data inertial reference units (ADIRUs) send inertial and air data to the SMYDs. The data includes airspeed, attitude, yaw and roll rates, and accelerations. SMYD 1 uses this data for detection of yaw motion to calculate a command to move the rudder in the opposite direction to decrease unwanted yaw motion of the airplane.

FMC

The FMC provides airplane gross weight to the SMYDs for use in yaw damping calculations.

Trailing Edge Flaps Up Limit Switch

The trailing edge flaps up limit switches send data to the SMYDs to limit rudder travel for yaw damping when the flaps are up.

SMYD

The two SMYDs are the same. When a SMYD LRU is put in position 1, it does the primary yaw damper function during normal operations.

For primary yaw damping, both SMYDs must be operational because SMYD 1 compares its yaw damping calculations with SMYD 2 before it commands rudder movement.

For operation of the WTRIS and standby yaw damping systems, see the wheel-to-rudder section. (SECTION 27-24)

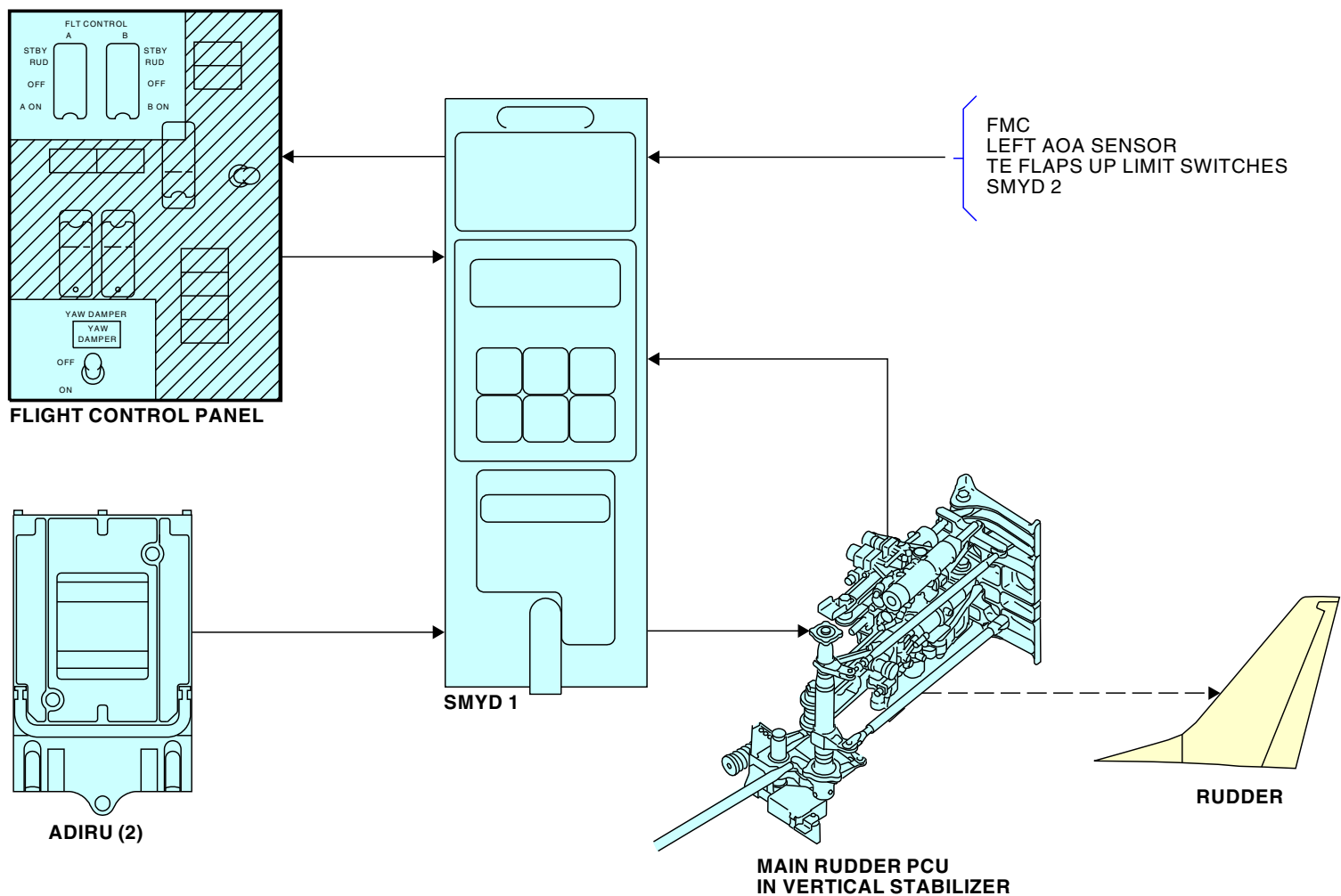
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YDS - GENERAL DESCRIPTION



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YDS - GENERAL DESCRIPTION

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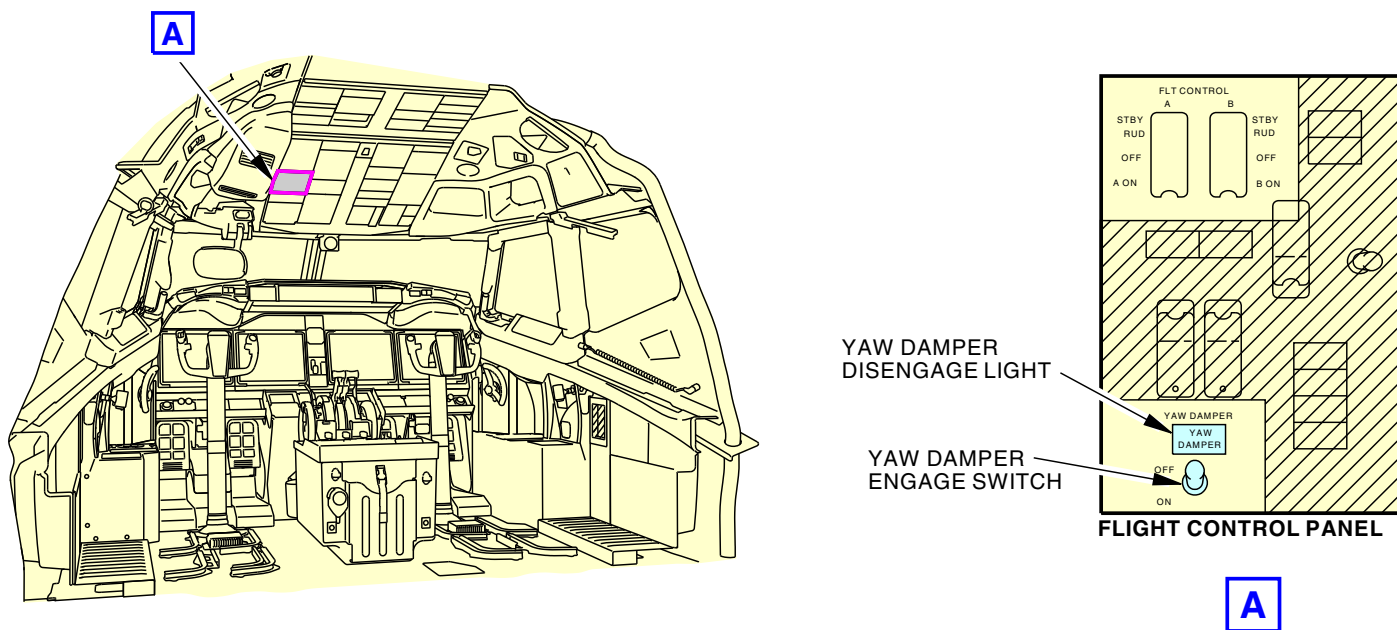
YDS - FLIGHT COMPARTMENT COMPONENT LOCATION

Engage Switch and Disengage Light

The yaw damper engage switch and the disengage light are on the flight control panel (P5 forward overhead).

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YDS - FLIGHT COMPARTMENT COMPONENT LOCATION



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YDS - FLIGHT COMPARTMENT COMPONENT LOCATION

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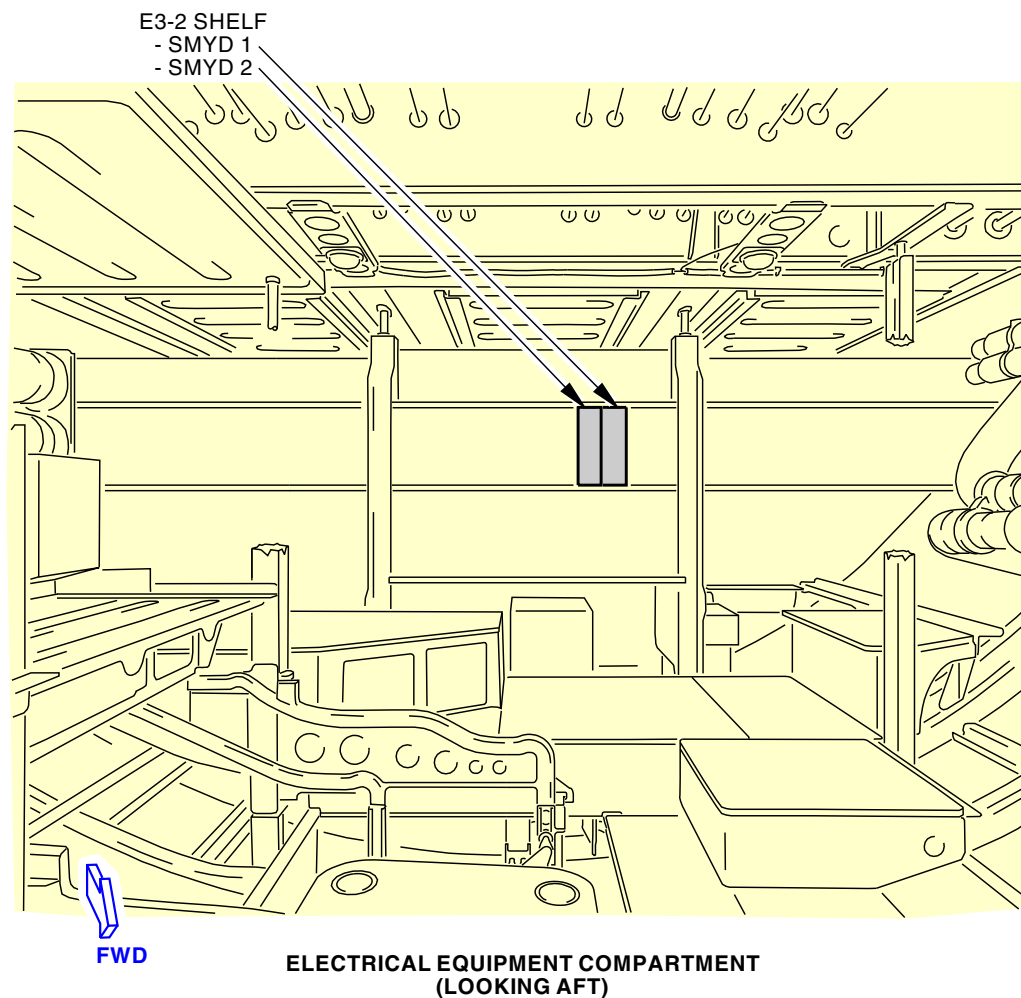
YDS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATION

Stall Management Yaw Damper

SMYD 1 and 2 are on the E3-2 shelf in the electronic equipment compartment.

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YDS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATION



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YDS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATION

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EFFECTIVITY

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**YDS - VERTICAL STABILIZER COMPONENT LOCATION****Yaw Damper Components in Vertical Stabilizer**

These yaw damper components are on the main rudder PCU in the vertical stabilizer.

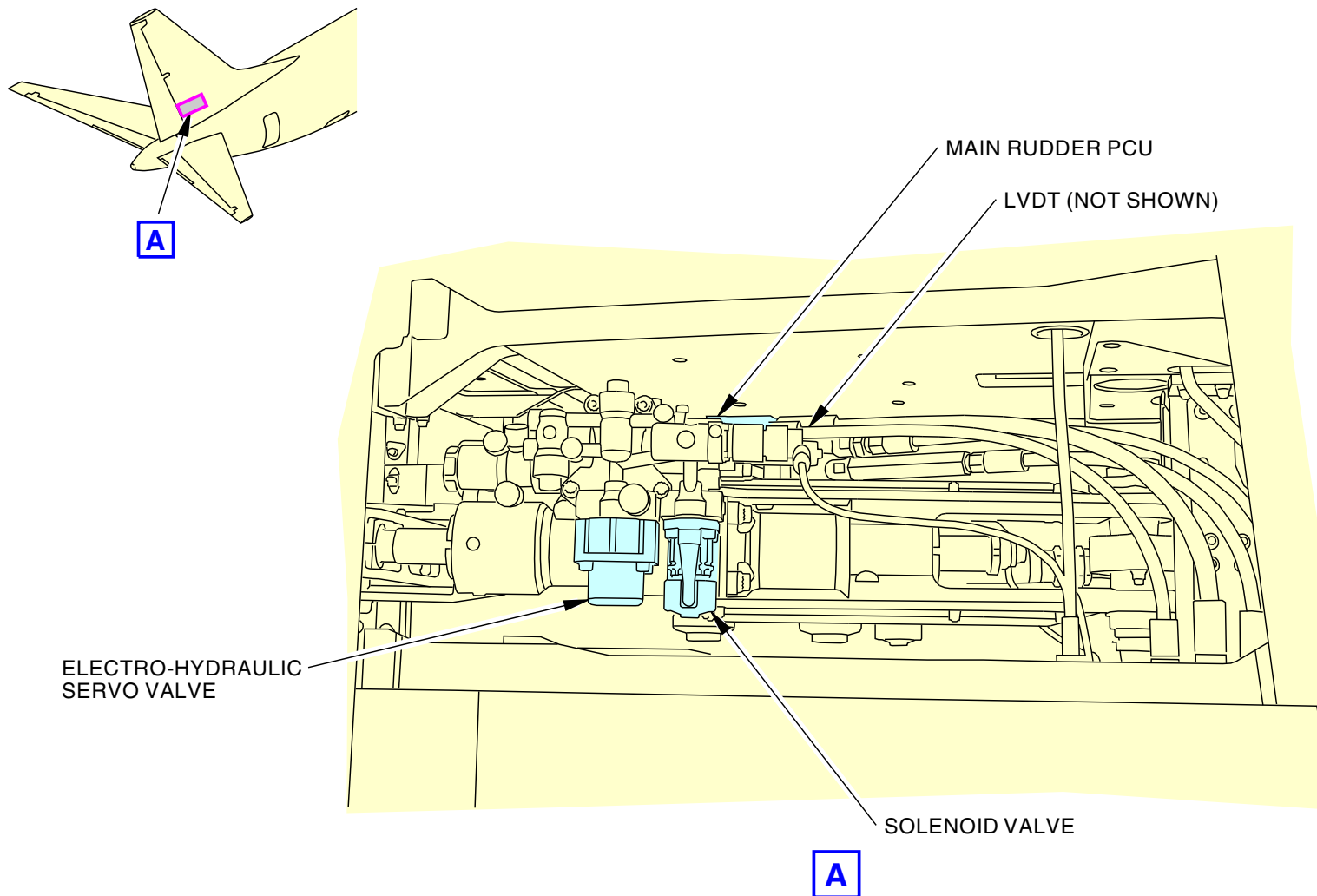
- Yaw damper solenoid valve
- Yaw damper electro-hydraulic servo valve (EHSV)
- Yaw damper actuator
- Linear variable differential transformer (LVDT).

The LVDT is not line replaceable.

Access to these yaw damper components is from an access panel on the right side of the vertical stabilizer.

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YDS - VERTICAL STABILIZER COMPONENT LOCATION



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YDS - VERTICAL STABILIZER COMPONENT LOCATION



YDS - INTERFACES

Power Interface

SMYD 1 gets 28V DC from electrical bus 1 and 28V AC from transfer bus 1.
28V DC power goes from SMYD 1 to the yaw damper engage switch.

The yaw damper LVDT gets 28V AC from the same circuit as SMYD 1.

Digital Data

The SMYD 1 receives airplane gross weight data from the FMC.

The SMYD 1 receives these air data from the left ADIRU:

- Airspeed
- Impact pressure.

The SMYD 1 receives these inertial data from the left and right ADIRUs:

- Lateral acceleration
- Roll angle
- Roll rate
- Yaw rate.

Analog Signals

SMYD 1 is enabled for primary yaw damping operation when the FLT CONTROL B switch on the flight control panel is ON.

SMYD 1 calculates and sends yaw damper commands to the yaw damper components on the main rudder PCU to move the rudder. These are the solenoid valve, EHSV, and yaw damper actuator. The LVDT on the main rudder PCU sends rudder position feedback to SMYD 1.

The trailing edge flaps up limit switch sends flap position data to SMYD 1. The SMYD uses this during yaw damping to limit rudder movement when flaps are up.

The left AOA sensor sends airplane angle of airflow information to SMYD 1.

The yaw damper disengage light receives power from the DC power and dim control.

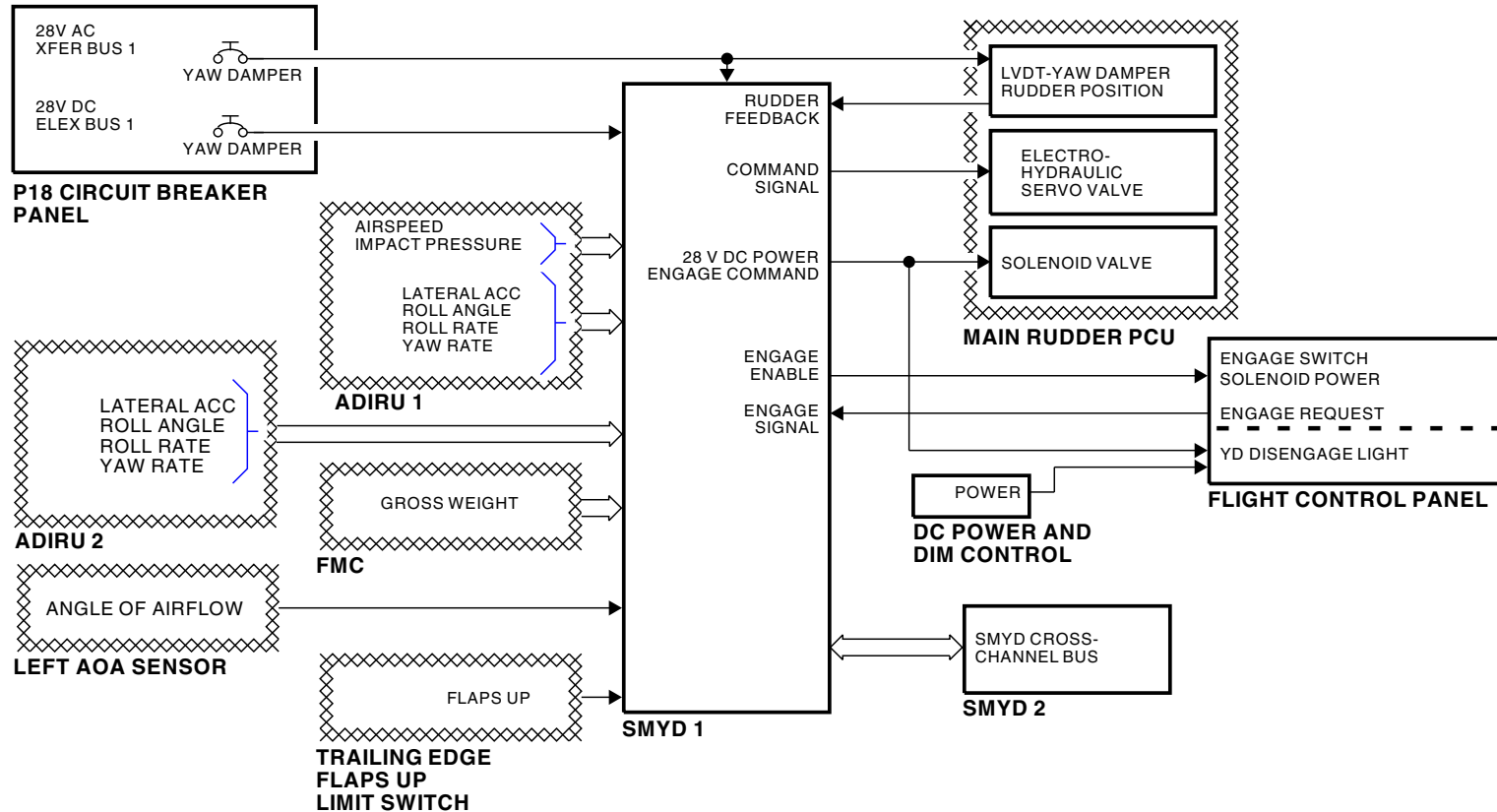
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YDS - INTERFACES



NOTE:
THIS DIAGRAM ONLY
SHOWS INTERFACES FOR
PRIMARY YAW DAMPING

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YDS - INTERFACES

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**YDS - MAIN RUDDER PCU ACTUATOR - SOLENOID VALVE****Purpose**

The yaw damper solenoid valve on the main rudder PCU pressurizes the yaw damper system. When you engage the yaw damper system, the solenoid valve sends hydraulic fluid to the electro-hydraulic servo valve (EHSV) that controls the yaw damper actuator on the main rudder PCU. This moves the rudder for yaw damping.

Physical Description

These are the three hydraulic ports in the solenoid:

- Input pressure port for input hydraulic pressure
- Output port for the output to the EHSV and yaw damper actuator
- Return port for hydraulic fluid to the reservoir.

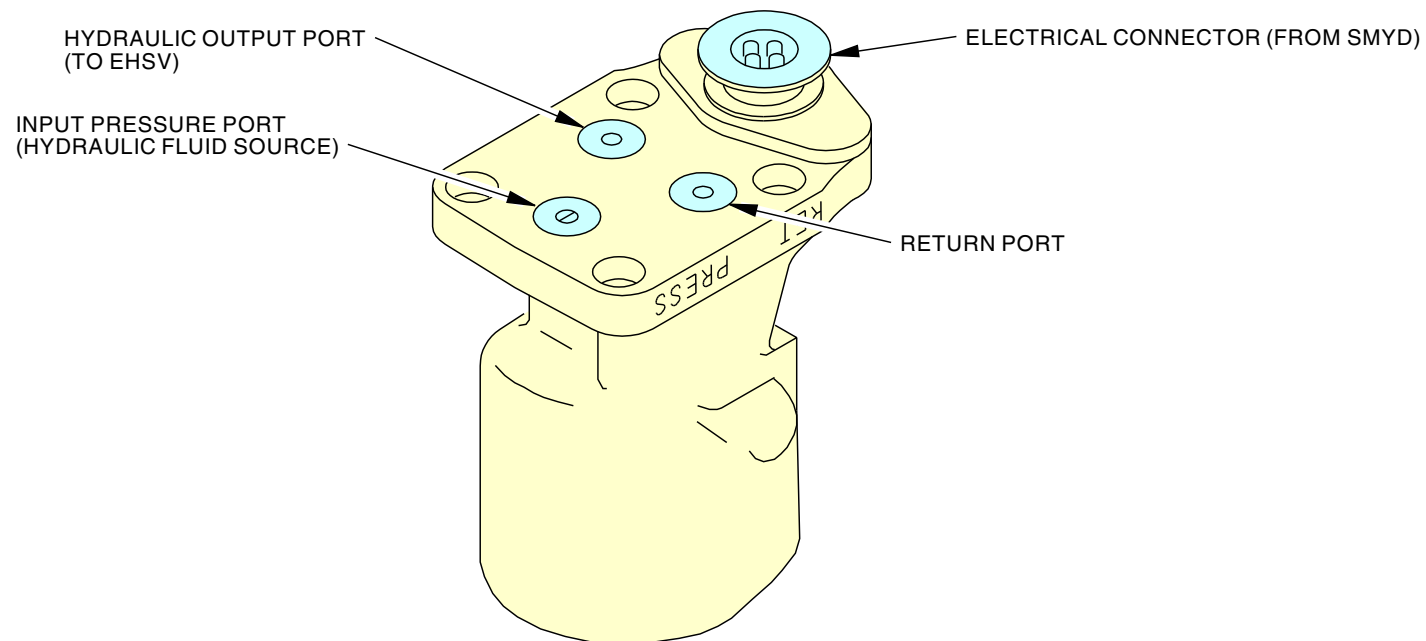
An electrical connector connects the solenoid valve to the SMYD computer.

Functional Description

When the yaw damper is engaged, it energizes the solenoid valve which ports hydraulic fluid under pressure to the EHSV and yaw damper actuator.

EFFECTIVITY	
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YDS - MAIN RUDDER PCU ACTUATOR - SOLENOID VALVE



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YDS - MAIN RUDDER PCU ACTUATOR - SOLENOID VALVE

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**YDS - MAIN RUDDER PCU - ELECTROHYDRAULIC SERVO VALVE****Purpose**

For primary yaw damping, the electrohydraulic servo valve (EHSV) on the main rudder PCU changes an electrical command signal from SMYD 1 into a controlled hydraulic flow to the yaw damper actuator on the main rudder PCU. The EHSV controls the rate and direction of the yaw damper actuator motion for rudder movement to provide primary yaw damping.

Physical Description

These are the four hydraulic ports on the EHSV:

- Input port for jet pipe controller/control spool
- Return port
- Two output ports to the yaw damper actuator.

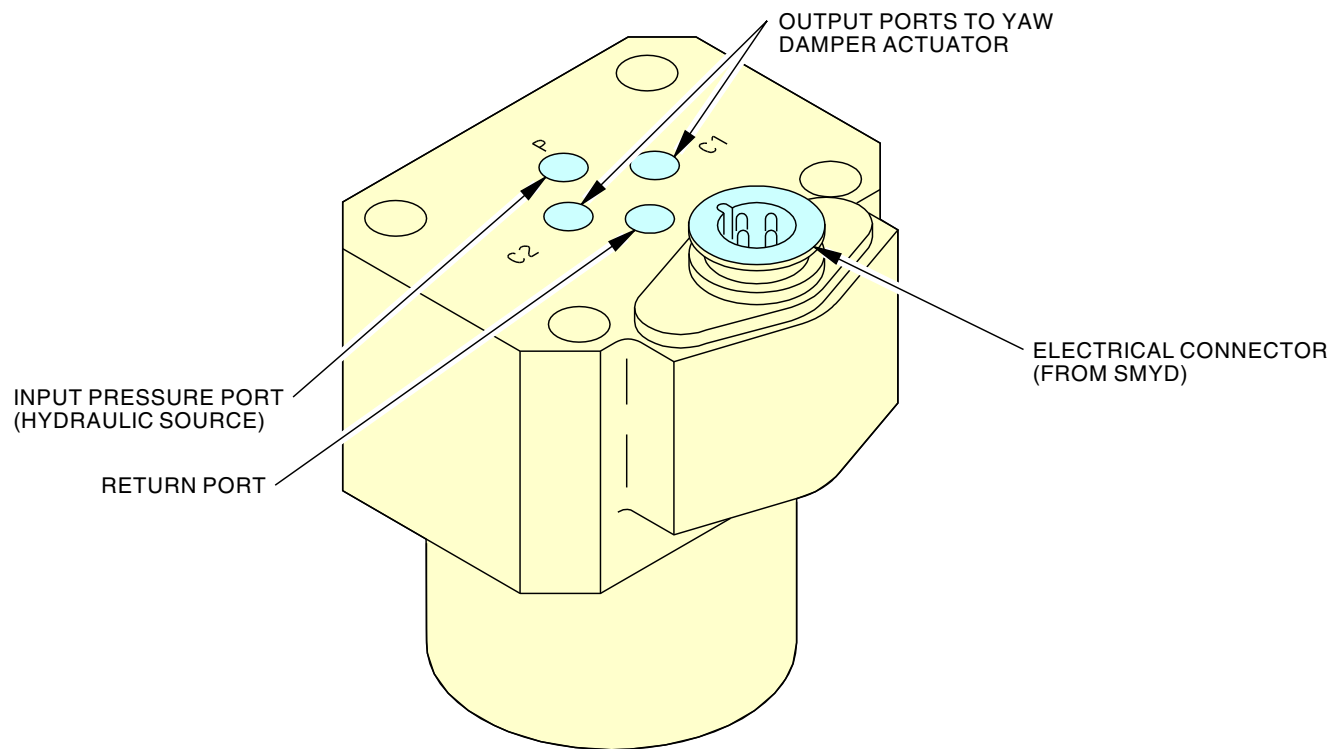
A four pin electrical connector the SMYD computer to the EHSV.

Functional Description

When an electrical signal for yaw damping comes from the SMYD computer, it moves a jet pipe in the EHSV. This causes the pressure at each end of the control spool to change. This pressure differential causes the control spool to move, which changes the output pressure in each of the two output ports. This change in the output pressure directs hydraulic fluid under pressure to move the yaw damper actuator in the desired direction for yaw damping.

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YDS - MAIN RUDDER PCU - ELECTROHYDRAULIC SERVO VALVE



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YDS - MAIN RUDDER PCU - ELECTROHYDRAULIC SERVO VALVE

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YDS - STALL MANAGEMENT YAW DAMPER

Purpose

The stall management yaw damper (SMYD) uses inertial data from the ADIRU and other data from airplane sensors to detect unwanted airplane yaw motion caused by dutch roll and turbulence. The SMYD sends commands to the main rudder PCU to move the rudder to reduce unwanted yaw.

Physical Description

The SMYD weighs 10 lbs. It uses 10 watts of power. It has these features on the front of the unit:

- Standard Boeing BITE module
- Bite instructions on the label
- BITE display
- BITE keypad.

Bite Instructions

Bite instructions on the front of the SMYD LRU describe how to do a test of the unit and use the BITE software.

Display

The SMYD BITE module has a two line amber display. Each line has eight alphanumeric characters. The display shows messages about the type of fault, maintenance message number, and fault details. For SMYD 1, the BITE interfaces with the stall management functions and primary yaw damping functions and provides fault data for these functions.

Keypad

You use the keypad to operate the SMYD BITE. The keypad has these keys:

- ON/OFF key to turn ON the BITE
- MENU key to go to the main and previous menu pages
- UP arrow key for previous page selection in a menu

- DOWN arrow key for next page selection in a menu
- YES key to answer questions
- NO key to answer questions.

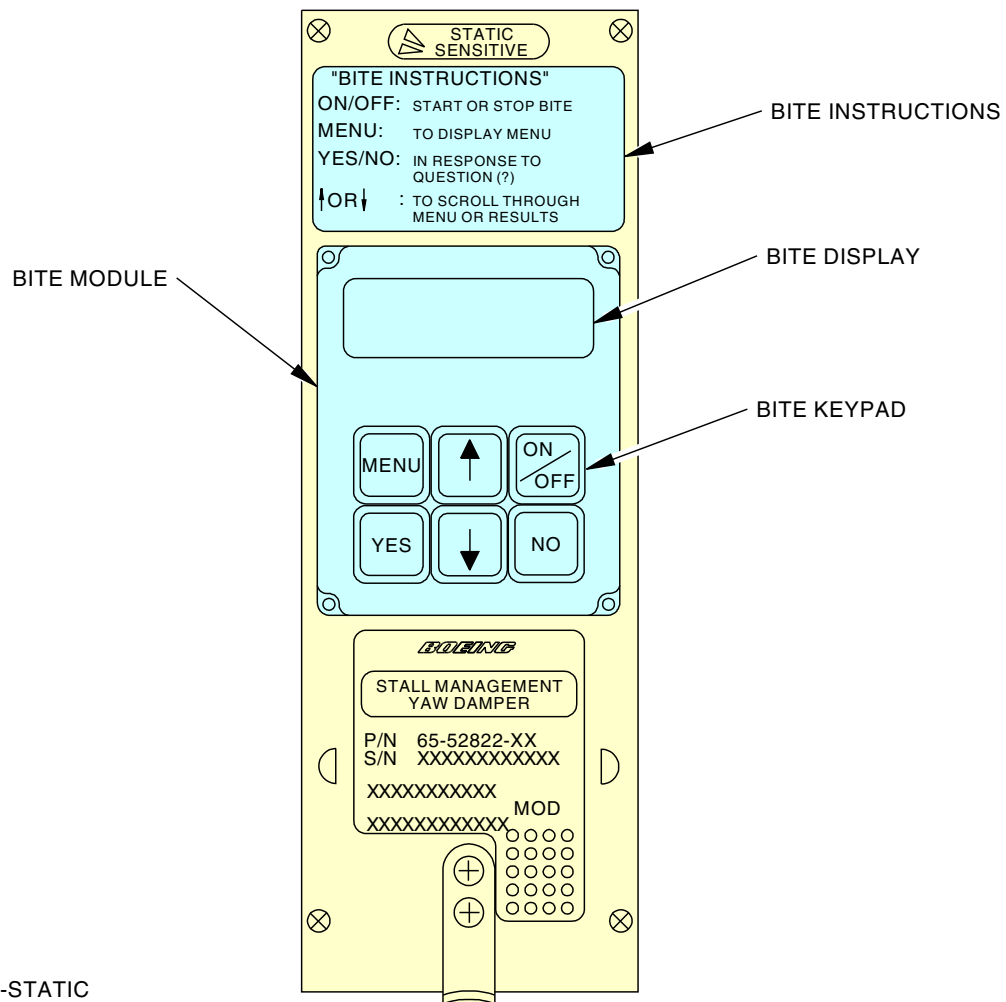
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YDS - STALL MANAGEMENT YAW DAMPER



NOTE:

THE SMYD LRU IS AN ELCTRO-STATIC SENSITIVE DEVICE. USE PROPER PROCEDURES WHEN HANDLING THE LRU.

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YDS - STALL MANAGEMENT YAW DAMPER

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YDS - SMYD 1 - FUNCTIONAL DESCRIPTION

General

The stall management yaw damper (SMYD) calculates yaw damping commands using analog and digital inputs from airplane sensors. SMYD 1 provides primary yaw damping through the main rudder PCU.

Engage Interlock

The SMYD supplies 28V DC to the yaw damper solenoid valve on the rudder PCU. When the solenoid energizes, it sends hydraulic fluid under pressure to the EHSV which applies hydraulic pressure to the yaw damper actuator to move the rudder.

Yaw Damping

The SMYD CPU has the control law software for yaw damping. These sensors send inputs to SMYD 1 for software calculations for primary yaw damping:

- MCP
- ADIRUs (inertial and air data)
- Left AOA sensor
- FMC
- LVDT on main rudder PCU
- Trailing edge flap limit switch
- SMYD 2.

If SMYD 1 senses airplane unwanted yaw motion when the yaw damper is engaged, it supplies a signal to the electrohydraulic servo valve (EHSV). The EHSV applies hydraulic pressure to the yaw damper actuator in proportion to SMYD 1 yaw damper commands. The current and polarity determine amount and direction the rudder moves. The yaw damper actuator makes a mechanical input to the rudder PCU main control valve to move the rudder. Yaw damper inputs are mechanically summed to rudder pedal inputs. For primary yaw damping, these are the limits for rudder travel:

- 2 degrees with flaps Up
- 3 degrees with flaps Down.

The LVDT on the main rudder PCU sends yaw damper actuator position data to SMYD 1. The SMYD uses the data to compare its commanded value with actual rudder movement.

The MCP sends data to the SMYD to show if either A/P is engaged.

For primary yaw damping, SMYD 2 monitors the yaw damping calculations of SMYD 1. These calculations must agree before SMYD 1 commands rudder movement. If the calculations of the two SMYDs do not agree, primary yaw damping disengages.

BITE

The SMYD has BITE test and continuous BITE functions. It stores failures in fault history for yaw damping and stall management functions. You use the keypad to interface with the BITE. The display shows test results and prompts you for input

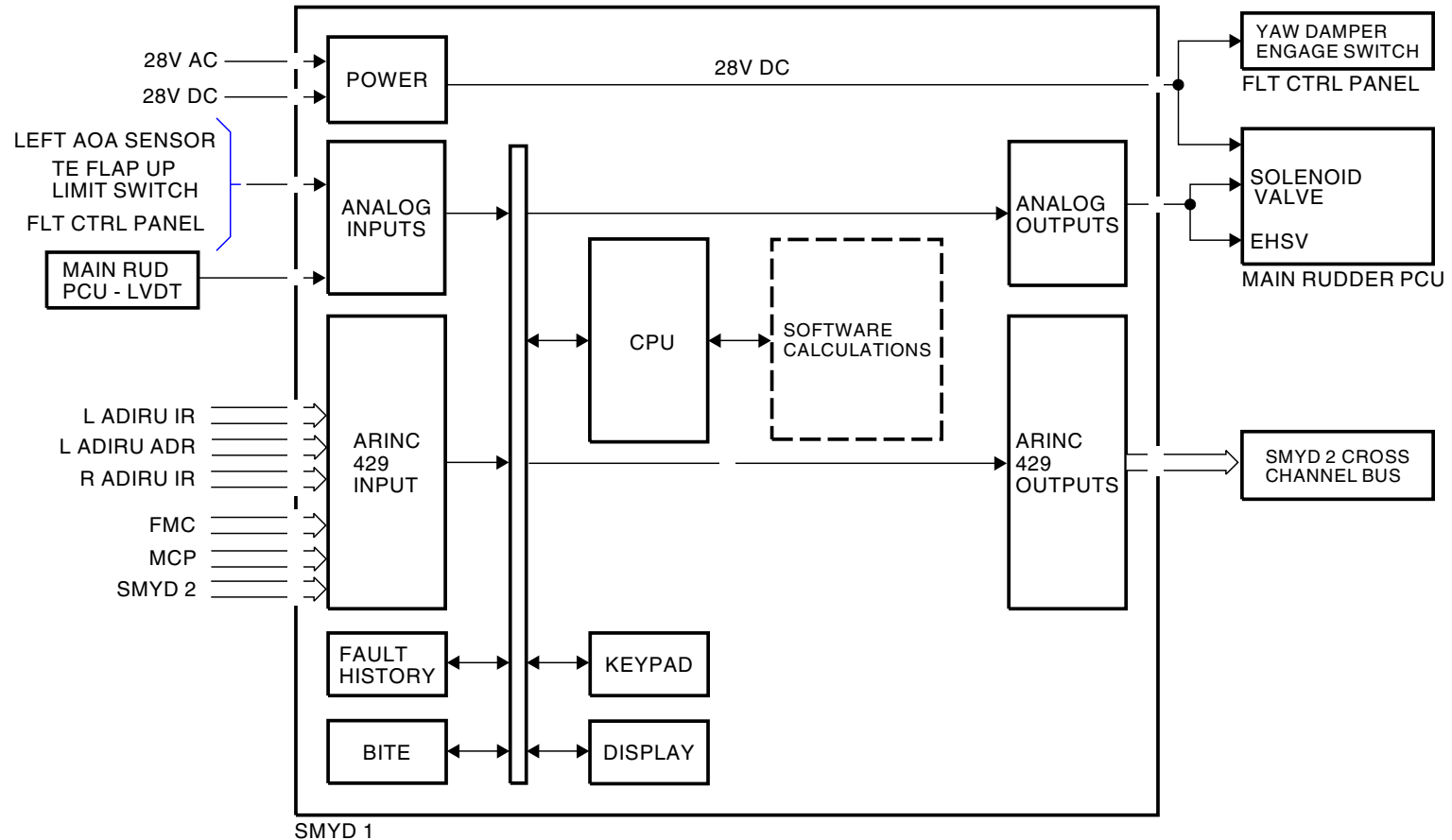
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YDS - SMYD 1 - FUNCTIONAL DESCRIPTION



NOTE:
ONLY THE INTERFACES FOR
PRIMARY YAW DAMPING ARE
SHOWN ON THIS PAGE.

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YDS - SMYD 1 - FUNCTIONAL DESCRIPTION



YDS - OPERATION

General

You use the yaw damper ON/OFF switch on the flight control panel to engage the yaw damper.

For the primary yaw damper system, the yaw damper warning light is the only indication in the flight compartment. The yaw damper warning light is on the flight control panel above the yaw damper ON/OFF switch.

Engage Switch and Warning Light

To engage the primary yaw damper system (YDS), put the yaw damper engage switch on the flight control panel to the ON position. These are the conditions necessary to engage the primary yaw damper system:

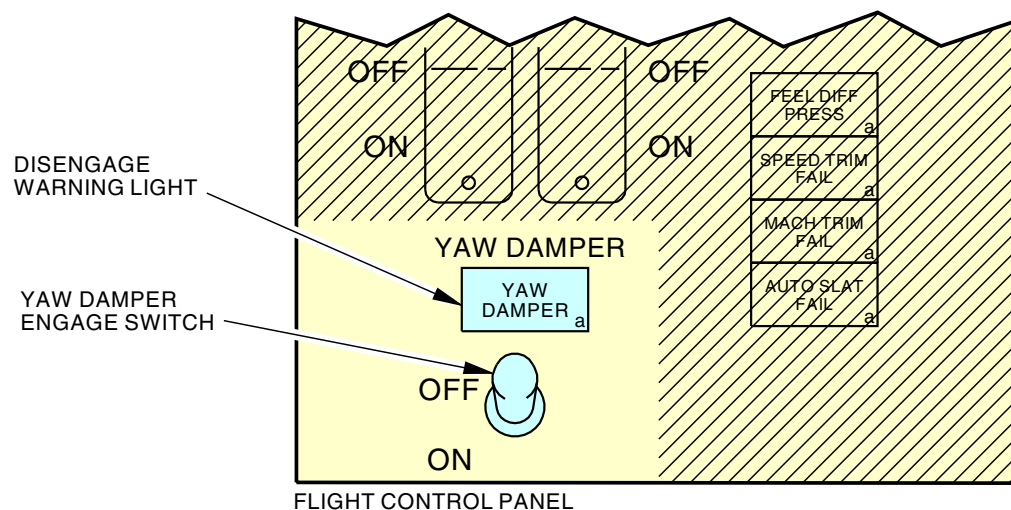
- Hydraulic system B is ON
- Flight control B is ON.

If SMYD 1 does not detect any yaw damper faults, two seconds later the yaw damper warning light will go off to show that there is normal yaw damper operation. This switch is held in the ON position electronically with a solenoid powered from the SMYD. Only SMYD 1 does primary yaw damping.

Put the switch to the OFF position to disengage the YDS. SMYD 1 removes power from the solenoid valve on the main rudder PCU and, after a two-second delay, the yaw damper warning light comes on. The warning light comes on any time the system disengages.

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YDS - OPERATION



YDS - OPERATION

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**YDS - OPERATIONS - ENGAGE INTERLOCKS****General**

There are two SMYDs on the airplane.

SMYD 1 controls primary yaw damping and turn coordination during normal operation. SMYD 2 operates WTRIS and standby yaw damping, and is discussed in the WTRIS section. (SECTION 27-24)

Engage Switch and Warning Light

You engage the primary yaw damper system (YDS) with the yaw damper engage switch on the flight control panel and with the FLT CONTROL B switch in the ON position. The SMYD does a self check and two seconds later the yaw damper warning light goes out to show that you have yaw damper operation. The switch is held in the ON position electronically with power from the SMYD.

Put the switch in the OFF position to disengage the YDS. After you put the switch to the OFF position, the yaw damper warning light comes on. The warning light comes on anytime the system disengages.

Training Information Point

The electrical ground for the disengage light is connected in series through both SMYDs. For normal operation, it is necessary to have both SMYDs installed on the airplane.

The light test can be done with the master dim and test system.

SMYDs

The two SMYDs are the same. They both do stall management and yaw damper functions. For stall management functions, both SMYDs operate together. If one function fails, the other SMYD will continue to do stall management functions.

Only one SMYD does yaw damping at a time. SMYD 1 does only primary yaw damping during normal operations. SMYD 2 does WTRIS and standby yaw damping during standby operations. This is controlled by the FLT CONTROL A and B switches on the flight control panel.

SMYD 1 uses the main rudder PCU to move the rudder for the primary yaw damper function. For primary yaw damping, SMYD 1 compares its yaw damping calculations with SMYD 2 before it sends a command to the main rudder PCU. If the SMYD 2 calculations disagree or if SMYD 2 fails, the yaw damper function in SMYD 1 disengages even though SMYD 2 is not used for primary yaw damping.

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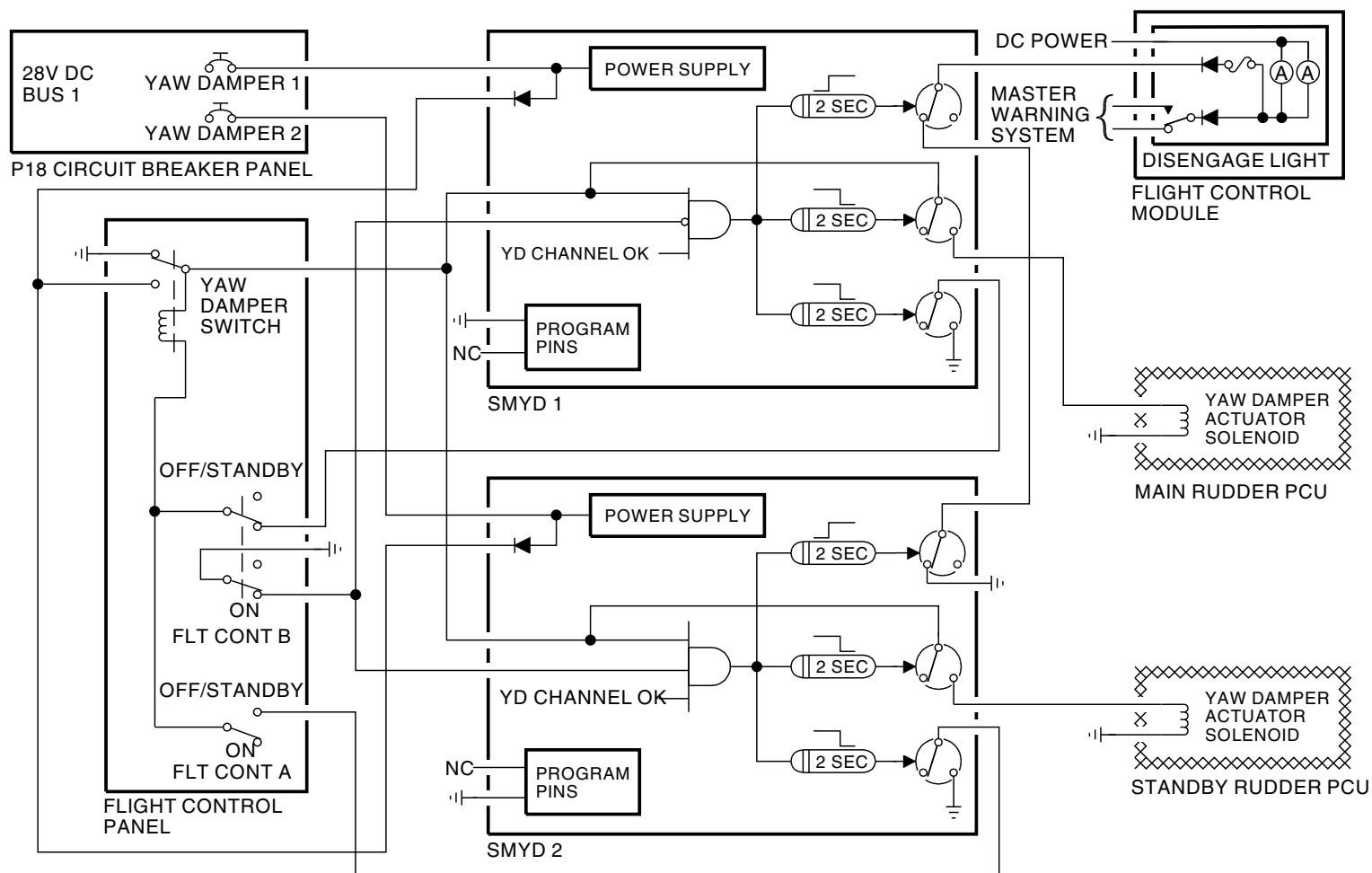
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YDS - OPERATIONS - ENGAGE INTERLOCKS



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YDS - OPERATIONS - ENGAGE INTERLOCKS

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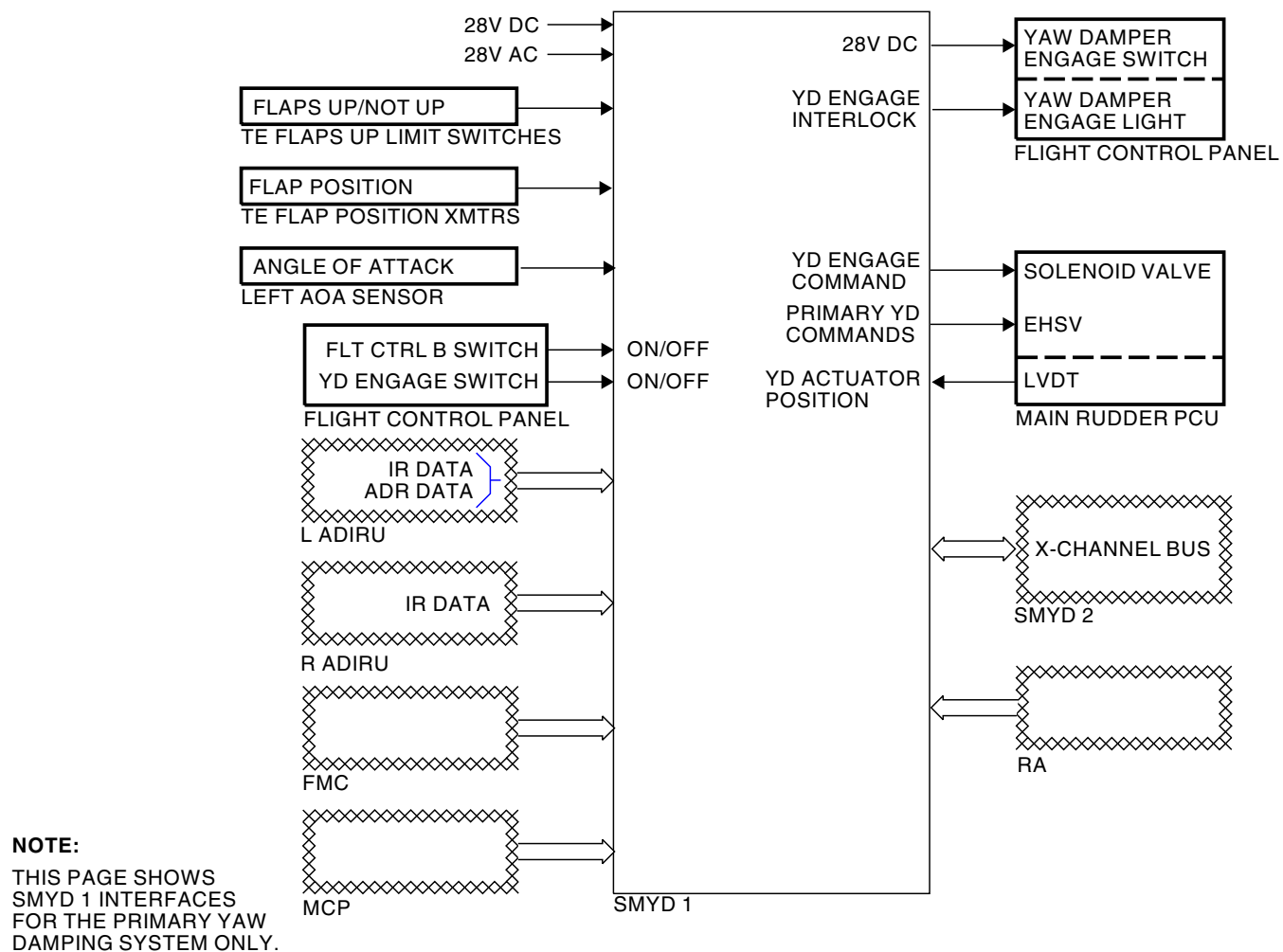
YDS - SMYD 1 - SYSTEM SUMMARY

General

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YDS - SMYD 1 - SYSTEM SUMMARY



YDS - SMYD 1 - SYSTEM SUMMARY

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AUTOTHROTTLE SYSTEM - INTRODUCTION

General

The autothrottle (A/T) function in Flight Control Computer (FCC) A (FCC A) uses data from airplane sensors to calculate engine thrust. The A/T system controls engine thrust in response to mode requests from the flight crew through the Digital Flight Control System (DFCS) Mode Control Panel (MCP) and flight deck switches, and from the Flight Management Computer (FMC). The A/T system operates from takeoff to touchdown.

The A/T is part of the Flight Management System (FMS) which includes DFCS, and Air Data Inertial Reference Unit (ADIRU).

Abbreviations and Acronyms

- ADI - attitude direction indicator
- AFCS - automatic flight control system
- AGL - above ground level
- A/P - autopilot (DFCS)
- A/T - autothrottle
- ASA - autoflight status annunciator
- ADIRU - air data inertial reference unit
- ADIRS - air data inertial reference system
- ASA - autoflight status annunciator
- ASM - autothrottle servo motor
- BARO - barometric altitude
- capt - captain
- CDU - control display unit (FMC)
- clb - climb
- clr - clear
- cmd - command
- con - continuous
- CPU - central processing unit
- CTM - cycle time monitor
- dc - direct current

- deg - degrees
- des - descent
- DIP - dual in-line package
- disc - disconnect
- disen - disengage
- DPC - display processing computer
- EDFCS - enhanced digital flight control system
- DFDAU - digital flight data acquisition unit
- DU - display unit
- EEC - electronic engine control
- elex - electronics
- FADEC - full authority digital engine control
- FCC - flight control computer
- FD - flight director (DFCS)
- FDAU - flight data acquisition unit (DFDAU)
- FDR - flight data recorder
- F/D - flight director
- flt - flight
- FMA - flight mode annunciation
- FMC - flight management computer
- FMCS - flight management computer system
- FMS - flight management system
- F/O - first officer
- fwd - forward
- G/A - go-around
- gnd - ground
- GMT - greenwich mean time
- GW - gross weight
- IAS - indicated airspeed
- KTS - knots (nautical miles per hour)

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AUTOTHROTTLE SYSTEM - INTRODUCTION

- L - left
- LSK - line select key
- MCP - mode control panel
- MCU - modular concept unit
- MDS - max display system
- MMO - maximum operating mach
- N1 - low speed compressor RPM
- N2 - high speed compressor RPM
- NCD - no computed data
- POR - power on reset
- PROM - programmable read-only memory
- pth - path
- R - right
- R - repeat
- RA - radio altimeter
- RPM - revolution per minute
- R/T - receiver/transmitter
- SMYD - stall management yaw damper
- spd - speed
- SSM - sign status matrix
- sw - switch
- TACH - tachometer
- TAS - true airspeed
- TAT - total air temperature
- THR HLD - throttle hold
- T/L - thrust lever
- TMA - thrust mode annunciation
- TMD - thrust mode display (same as TMA)
- TOD - top of descent
- T/O - takeoff
- TO/GA - takeoff/go-around
- TRA - thrust lever resolver angle
- V - volts
- VMO - maximum operating velocity
- VNAV - vertical navigation mode
- V/S - vertical speed

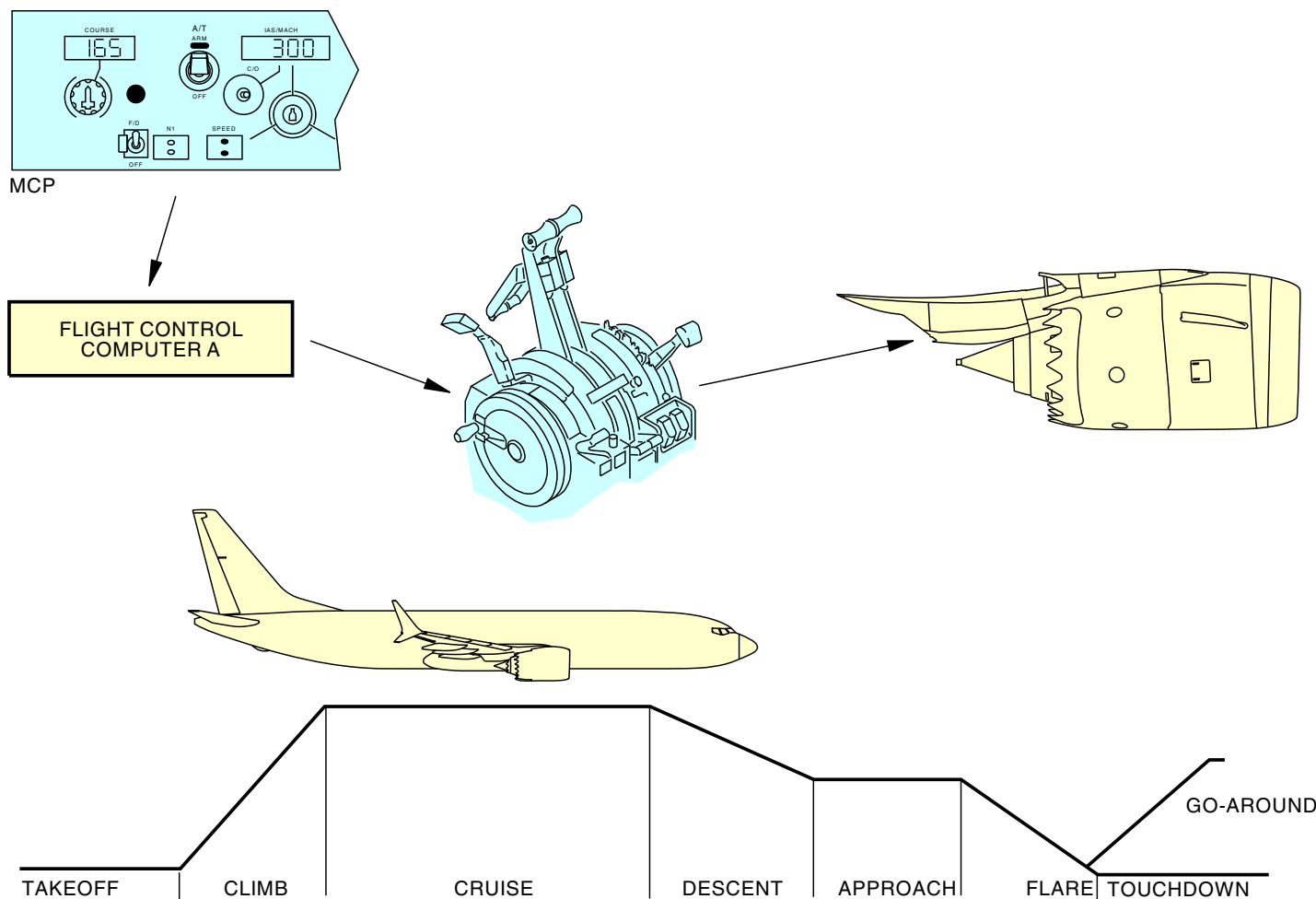
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AUTOTHROTTLE SYSTEM - INTRODUCTION



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AUTOTHROTTLE SYSTEM - INTRODUCTION

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A/T SYSTEM - GENERAL DESCRIPTION

General

The autothrottle (A/T) function in flight control computer A (FCC A) receives inputs from airplane systems, sensors, and flight deck switches to calculate and control engine thrust.

Operator interface with the A/T system is through switches on the thrust levers and the DFCS MCP. A/T modes of operation can be selected in these ways:

- Manual mode selection from the DFCS MCP
- Automatic mode selection by DFCS when engaged
- Manual selection from thrust lever TO/GA switches.

The A/T system can be engaged in N1 mode or speed mode, depending on the mode selected and the DFCS mode of operation. A/T operational modes show on the flight mode annunciation (FMA) on the MDS.

A/T System Components

The A/T interfaces with these components:

- A/T servomotors (ASMs)
- Thrust resolver (TR) packs
- Gearbox with friction brake and clutches
- Mechanical linkages to connect T/Ls to ASMs
- A/T Arm switch and mode select switches on MCP
- Thrust lever takeoff/go-around (TO/GA) switches
- Thrust lever A/T disconnect switches.

A/T Interfaces

The A/T receives digital data from these components to calculate servo motor rate commands to control engine thrust:

- Mode control panel (MCP)
- Flight control computers (FCCs)
- Electronic engine controller (EEC)

- Flight management computer (FMC)
- Radio altimeter (RA)
- Stall management yaw damper (SMYD)
- Air data inertial reference system (ADIRS)
- Autothrottle servo motors (ASM).

The A/T receives analog discrete inputs from these components:

- Mode control panel (MCP)
- Thrust lever TO/GA switches
- Thrust lever A/T disconnect switches
- Autoflight status annunciators (ASAs).

The A/T sends mode data and control signals to these components:

- ASAs
- ASMs
- FDAU
- FCCs
- FMCS
- DPCs.

DFCS Mode Control Panel (MCP)

The DFCS MCP has these switches for the A/T system:

- A/T ARM switch
- N1 mode selector
- Speed mode selector.

The A/T ARM switch is used to turn on the A/T.

The A/T N1 and speed modes may be selected manually from the MCP. When DFCS is engaged, the FCC selects the A/T modes with a mode request through the MCP to the A/T. In DFCS VNAV mode, the FCC uses FMC flight plan data to select the A/T modes.

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A/T SYSTEM - GENERAL DESCRIPTION

The MCP sends discretes for the selected A/T mode, N1 or speed, to the A/T. The MCP also sends the selected speed or FMC target speed to the A/T to use during the speed mode.

TO/GA Switches

The thrust lever TO/GA switches send analog discretes to the A/T. The TO/GA switches are used to select the takeoff or go-around mode. On the ground, the TO/GA switches select the takeoff mode. In the air, the TO/GA switches select the go-around mode if this mode is armed.

Autoflight Status Annunciators (ASA)

When the A/T disengages, it sends a signal to the ASAs to show a red flashing visual alert. You push the flashing red ASA A/T light or one of the A/T disconnect switches on the thrust levers to cancel the warning. This sends an analog signal to the A/T to reset the warning. There are no aural alerts when the A/T disengages.

Autothrottle Servo Motors (ASM)

The ASMs are below the aisle control stand and flight deck floor. The ASMs receive digital thrust rate commands from the A/T and change the data to electrical pulses to drive the servo motors. The motors drive the thrust resolver (TR) packs through a gearbox and slip clutch to move the thrust levers (T/Ls) to a desired thrust resolver angle (TRA). The ASMs receive maximum resolver position from the EECs. The ASMs monitor the TRA position and will not allow the actual TRA position to exceed the limit TRA position.

The ASMs send tachometer data and feedback signals to the A/T.

Display Processing Computer (DPC)

The A/T sends mode data to the DPCs to show A/T modes of operation on the FMA on the MDS.

The FMC calculates engine N1 limits and N1 targets during each flight phase and sends the data to the DPCs. The DPCs show N1 limits on the engine display. The DPCs send N1 targets to the EECs.

SMYD

The stall management yaw damper (SMYD) sends minimum operating speed data to the A/T for minimum speed floor control.

Radio Altimeter

During approach, the radio altimeter (RA) sends radio altitude data to the A/T. This data is used to arm the go-around mode below 2000 feet, and during Flare RETARD mode, to retard T/Ls to idle for landing.

FMC

The FMC calculates thrust N1 limits and N1 targets for each flight phase. The data goes to the DPCs. The DPCs show the N1 limits on the engine display. The DPCs send the N1 targets to the EECs which calculate equivalent TRA targets to send to the A/T to set thrust. The FMC also sends N1 targets directly to the A/T. During takeoff and max thrust go-around, the A/T uses EEC TRA targets and FMC N1 targets to set thrust.

During takeoff, climb, and max thrust go-around, the FMC N1 targets are the same as the N1 limits. During reduced thrust climb and cruise operations, the FMC N1 targets are less than the N1 limits.

The FMC calculates gross weight and sends it to the A/T to use in calculation of thrust and T/L rate commands.

The FMC has an interface for A/T for BITE.

FCC

The FCCs send mode request discretes to the A/T to select A/T modes consistent with the active DFCS mode. The A/T sends mode status to the FCC.

ADIRU

The ADIRUs send this data to the A/T:

- True airspeed
- Mach

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**A/T SYSTEM - GENERAL DESCRIPTION**

- Barometric altitude
- Atmospheric pressure
- Static outside air temperature
- Inertial vertical speed
- Acceleration.

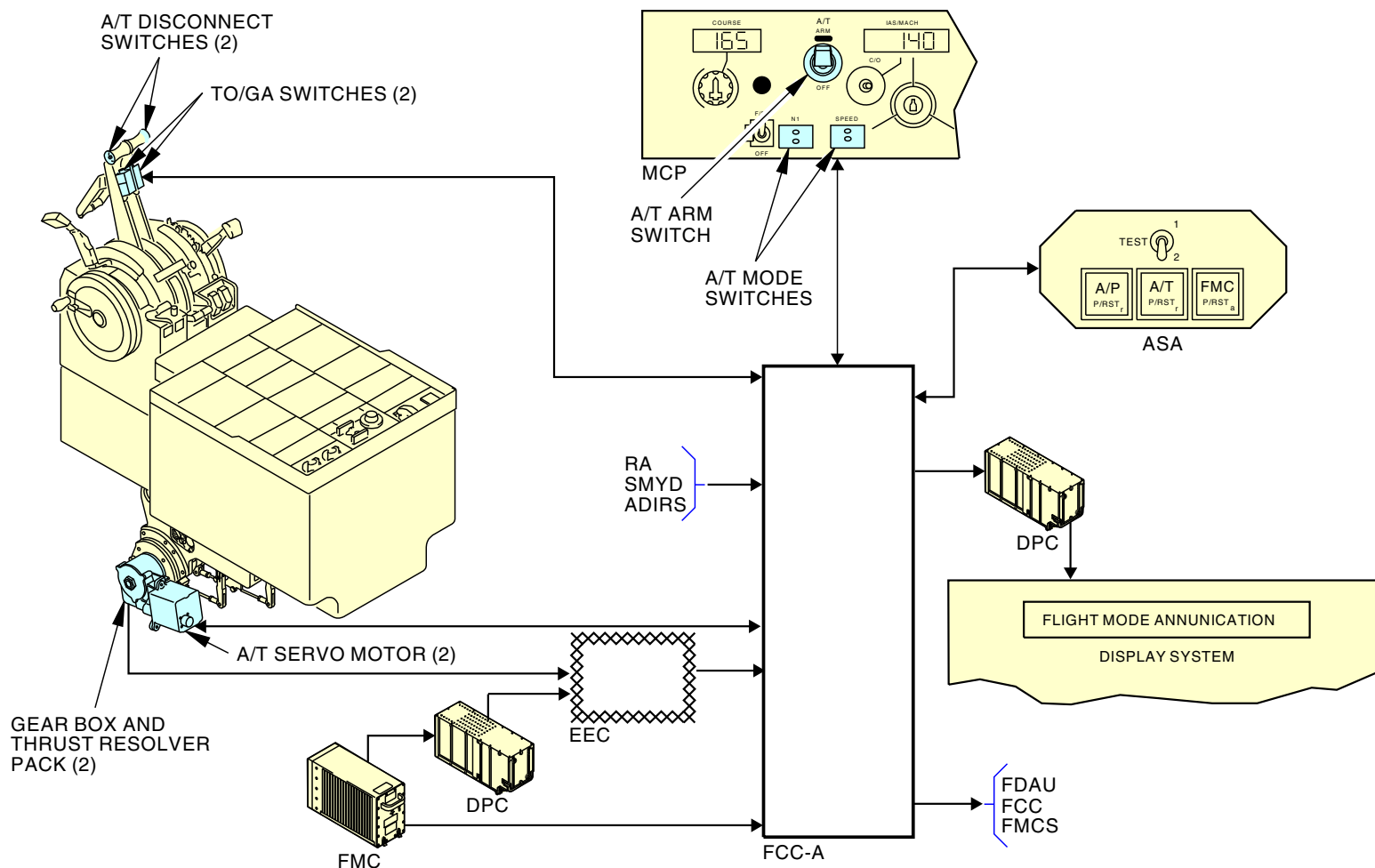
The A/T uses ADIRU data when calculating T/L rate commands to set engine thrust for precise thrust adjustments during changing flight conditions.

EEC

The DPCs send FMC N1 targets to the EECs. The EECs use the data to calculate equivalent TRA targets. The A/T uses the EEC TRA targets to set thrust during takeoff, climb, and max thrust go-around. For takeoff and max thrust go-around, the A/T initially uses EEC TRA targets to advance the T/Ls. As the T/Ls get to within 4 to 6 degrees of the FMC N1 limit, the A/T then uses FMC N1 targets to make final T/L adjustments to the FMC N1 limit.

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A/T SYSTEM - GENERAL DESCRIPTION



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A/T SYSTEM - GENERAL DESCRIPTION

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A/T SYSTEM - ELECTRONIC EQUIPMENT COMPARTMENT LOCATION

Electronic Equipment (E/E) Compartment

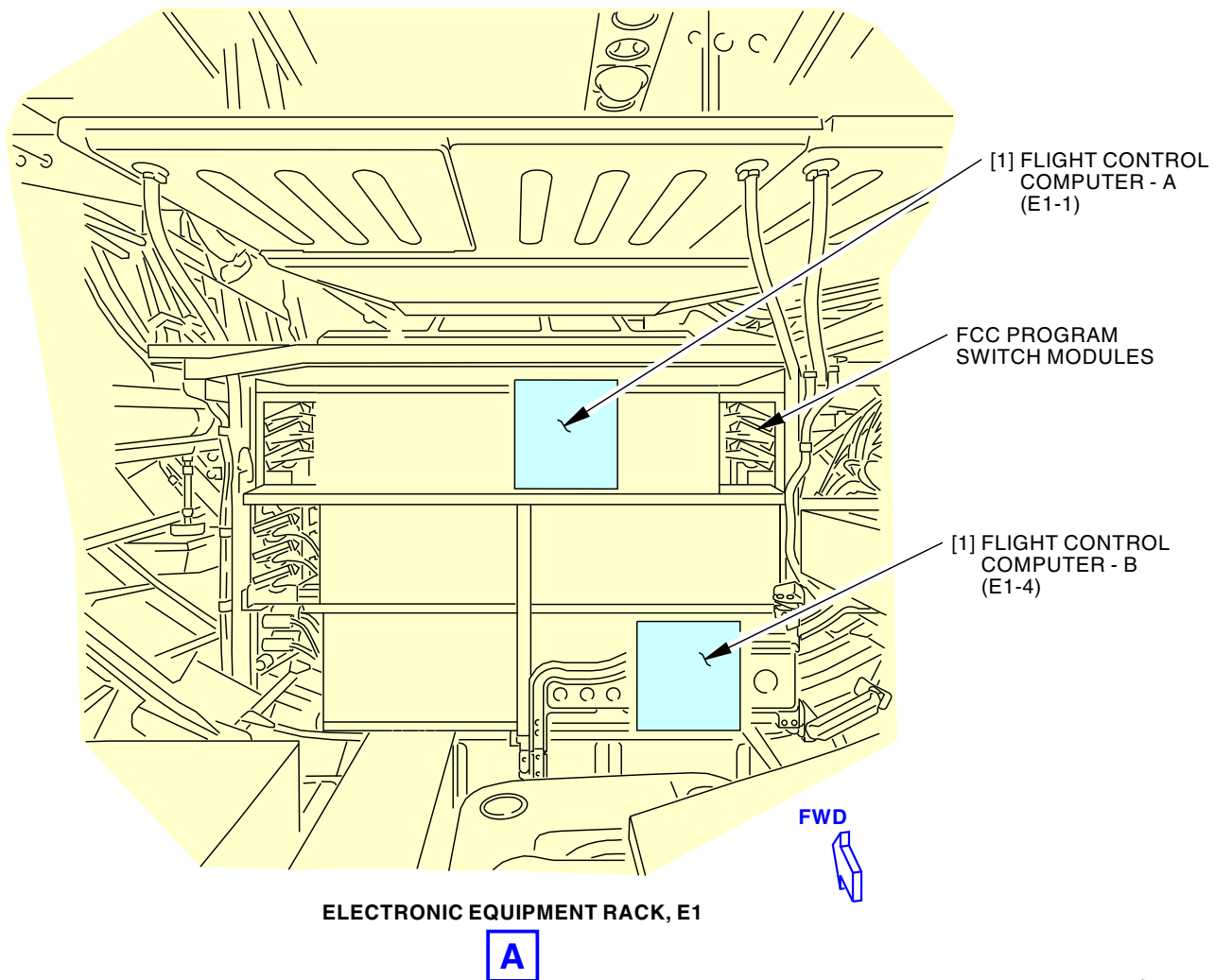
The autothrottle software function is in flight control computer A (FCC A) on the E1-1 shelf.

The autothrottle program switch modules for FCC A are on the right side of the E1-1 shelf.

FCC B also has the autothrottle software, but that software is not active.

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A/T SYSTEM - ELECTRONIC EQUIPMENT COMPARTMENT LOCATION



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A/T SYSTEM - ELECTRONIC EQUIPMENT COMPARTMENT LOCATION

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**A/T SYSTEM - FLIGHT COMPARTMENT COMPONENT LOCATION****Flight Compartment**

These components in the flight compartment have interface with the A/T system:

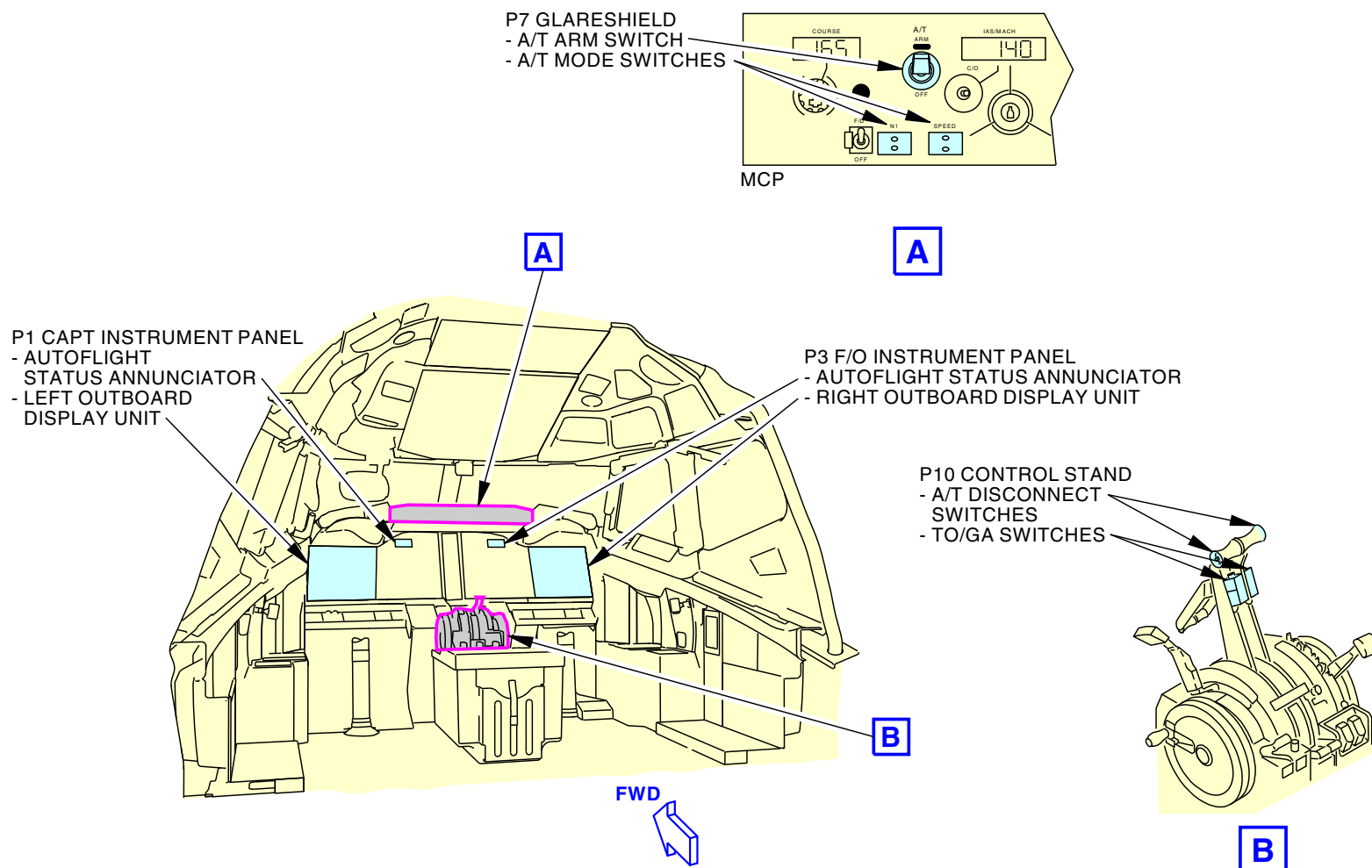
- DFCS mode control panel (MCP)
- Thrust lever TO/GA switches
- Thrust lever A/T disconnect switches
- Autoflight status annunciators (ASAs)
- Outboard flight displays and center display unit.

The A/T Arm switch and light, and the two A/T mode selector switches are on the MCP on the glareshield.

The A/T disconnect switches and TO/GA switches are on the thrust levers.

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A/T SYSTEM - FLIGHT COMPARTMENT COMPONENT LOCATION



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A/T SYSTEM - FLIGHT COMPARTMENT COMPONENT LOCATION

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A/T SYSTEM - FORWARD EQUIPMENT COMPARTMENT LOCATION

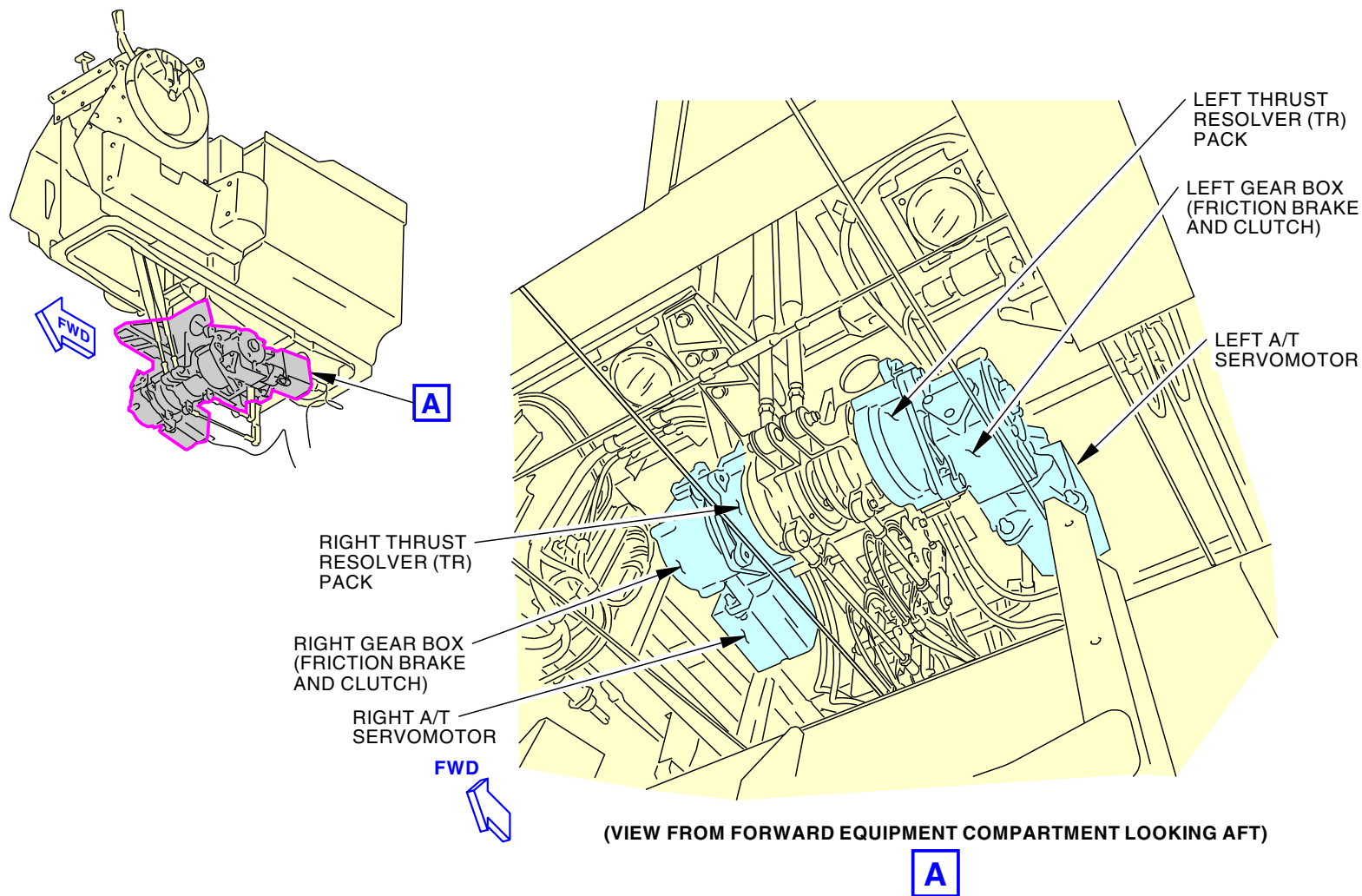
Forward Equipment Compartment

The A/T servo motors (ASMs) are in the forward equipment compartment under the P10 control stand.

The servo motors connect to the thrust levers (T/Ls) through the gearbox, the thrust resolver (TRs) packs, and mechanical linkages below the control stand.

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A/T SYSTEM - FORWARD EQUIPMENT COMPARTMENT LOCATION



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A/T SYSTEM - FORWARD EQUIPMENT COMPARTMENT LOCATION

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**A/T SYSTEM - ANALOG INTERFACE****General**

The A/T function in the FCC A receives and sends digital data and analog discretes to and from system components, sensors and switches. This section describes analog discretes.

Analog Discretes

The A/T receives these analog discretes:

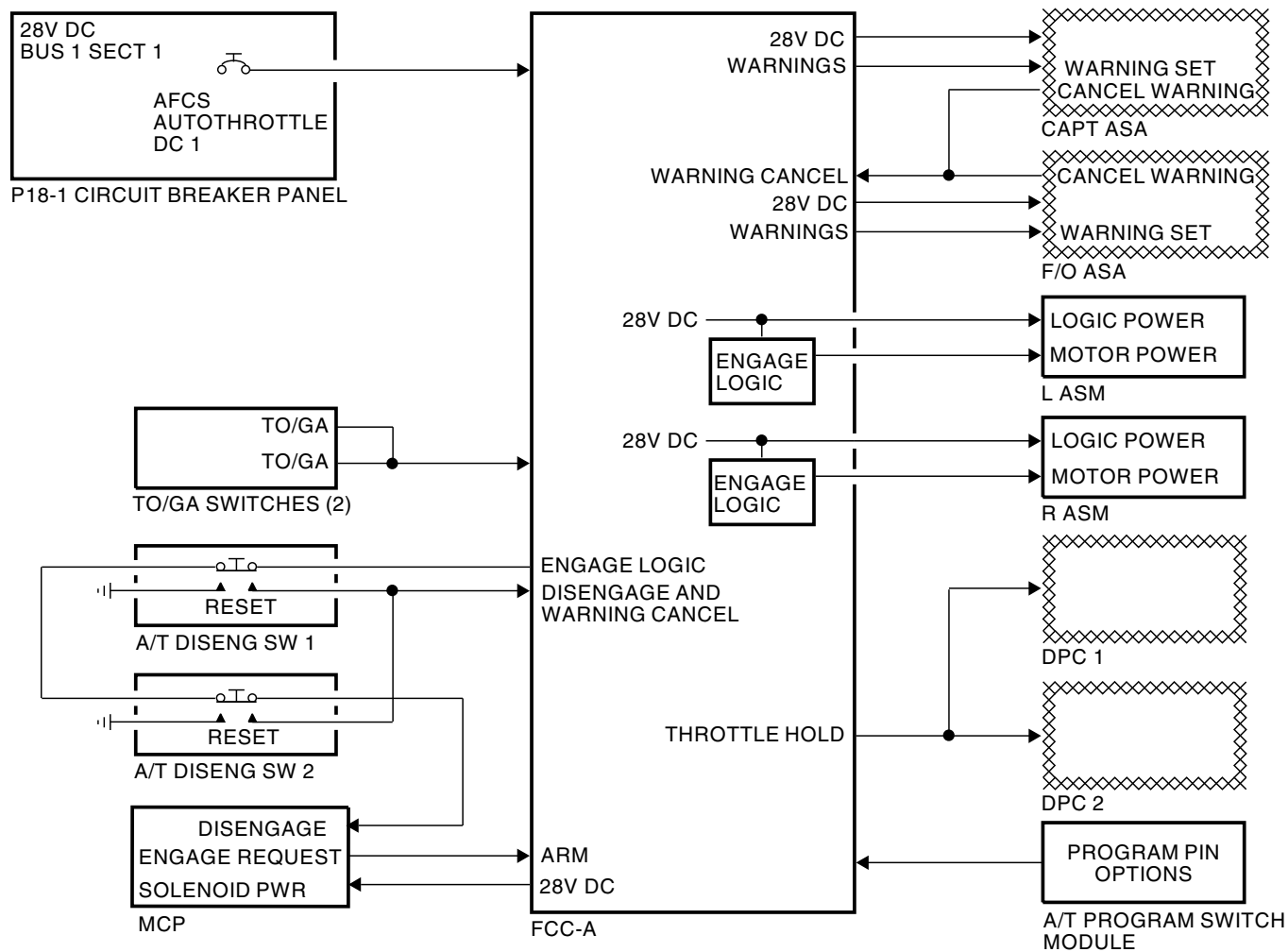
- Takeoff/go-around request from the TO/GA switches
- Disengage/reset from the T/L disengage switches
- Disengage warning cancel/reset from the ASAs
- Selected pin options from program switch modules.

The A/T supplies these analog discretes:

- Disengage logic to the Capt and F/O ASAs
- Throttle hold mode annunciation logic to the DPCs
- A/T arm logic to the DFCS MCP.

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A/T SYSTEM - ANALOG INTERFACE



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A/T SYSTEM - ANALOG INTERFACE

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A/T SYSTEM - DIGITAL INPUT INTERFACE

General

The A/T function in flight control computer A (FCC A) receives digital data from system components and sensors. The A/T function uses this data to make A/T modes active and to calculate thrust lever commands.

DFCS Mode Control Panel (MCP)

The MCP sends this data to the A/T:

- Target mach
- Target airspeed
- Selected altitude
- Flight path angle rate
- Spoiler position (left and right)
- DFCS discretes (modes).

The mach and airspeed is used by the autothrottle to control to the MCP speed or FMC speed in the VNAV mode.

Flight path angle rate is used to reduce speed variations during various pitch maneuvers (level change, altitude acquire etc).

The selected altitude is used to anticipate the new altitude during altitude acquire.

Spoiler position is used for weight calculation and for thrust split monitor during cruise.

The DFCS discretes send mode requests, N1 limit selection and mode indications to the autothrottle.

Stall Management Yaw Damper (SMYD)

The SMYD sends this data to the A/T:

- Flap angle
- Minimum operating speed
- Flap up discrete
- Main gear down discrete

- Air/ground discrete.

The flap angle is used by the autothrottle to calculate lift and drag coefficients.

Minimum operating speed is used as the minimum floor speed in the autothrottle control logic.

The discretes are used in autothrottle control logic and BITE.

SMYD 1 sends data directly to FCC A. SMYD 2 sends data through FCC B to FCC A.

Flight Management Computer (FMC)

The FMCs send this data to the A/T:

- N1 targets
- Gross weight
- Minimum speed
- FMC altitude
- Static air temperature
- FMC modes
- GMT/Date.
- BITE test information.

The autothrottle converts the target N1 values from the FMC to an equivalent TRA target. The target N1 rating is dependent on the FMC engaged mode.

Gross weight is used in the go around control logic and approach control logic.

Minimum airspeed is the lowest airspeed that is acceptable during VNAV operation.

FMC altitude from the FMC is used for anticipation of altitude acquire during VNAV operation.

SAT is used to calculate a backup TRA limit value.

The FMC mode discretes are used to determine control law gains and limits.

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**A/T SYSTEM - DIGITAL INPUT INTERFACE**

GMT and date are used in BITE for fault data storage.

BITE data is used for interactive display on the CDUs.

Radio Altimeter (RA)

The RA receiver/transmitters (R/Ts) send radio altitude to the A/T. The A/T uses this data to determine control law gains during approach and as a backup for flare retard.

Autothrottle Servo Motor (ASM)

The ASMs send this data to the A/T for feedback:

- Servo status
- Measured rate
- Measured torque.

Servo status is the current status of the ASM.

Measured rate is the actual rate (deg/sec) that the ASMs are moving the thrust levers.

Measured torque is the actual torque that is being exerted to move the thrust levers.

Electronic Engine Control (EEC)

Each EEC channel sends this data to the A/T:

- Thrust resolver angle (TRA)
- N1 command indicated
- TRA for max forward idle
- Estimated corrected thrust
- TRA for actual N1
- TRA for N1 target
- TRA for N1 max
- TRA for 5 degree/sec response.

Thrust resolver angle is used by the autothrottle to calculate an N1 command.

N1 command indicated is used to set a throttle position using the error between the target N1 (from the FMC) and the commanded N1 from the EEC.

TRA for maximum forward flat is the throttle angle below which the engine is in the idle range.

Estimated corrected thrust is used in the reduced go around control logic.

TRA for actual N1 and TRA for N1 target are used in the N1 mode control logic.

TRA for N1 maximum is used as a reversion limit in the event that the airplane is dispatched without an operative FMC and as a protection from excessive throttle angles.

TRA for 5 degree/sec response is used in the retard control logic.

Air Data Inertial Reference Unit (ADIRU)

The ADIRUs send this air data reference data to the A/T:

- Computed airspeed (CAS)
- Maximum allowable airspeed (VMO/MMO)
- Uncorrected altitude
- Baro corrected altitude
- Mach
- Static air temperature (SAT)
- Total air temperature (TAT)
- Altitude rate
- Static pressure
- Total pressure
- True airspeed
- Angle of attack (AOA).

Computed airspeed is used in the speed mode control logic.

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**A/T SYSTEM - DIGITAL INPUT INTERFACE**

VMO/MMO is used in the speed mode control logic.

Vertical speed is used in determining windshear.

Uncorrected altitude is used for autothrottle gain scheduling and in the maximum allowed N1 calculation.

Mach number is used for speed mode Mach control, weight and drag calculations.

SAT is used to calculate a backup TRA limit value.

Altitude rate is used in wind detection calculations.

Static pressure is used for normalizing thrust effects with altitude.

True airspeed is used for calculating the TAS/CAS conversion.

Angle of attack is used in calculating a backup weight for alpha floor calculation.

The ADIRUs send this inertial reference data to the A/T:

- Pitch attitude
- Roll attitude
- Body longitudinal acceleration
- Body normal acceleration
- Groundspeed
- Body pitch rate
- Vertical speed.

Pitch attitude is used for compensating the longitudinal acceleration signal for wind detection.

Roll attitude is used for thrust compensation during airplane turns.

Body longitudinal acceleration is used for control law damping and wind detection.

Body normal acceleration is used to derive a vertical speed signal for wind detection.

Groundspeed is used for cruise speed control to indicate when minimal winds are present to allow track mode corrections.

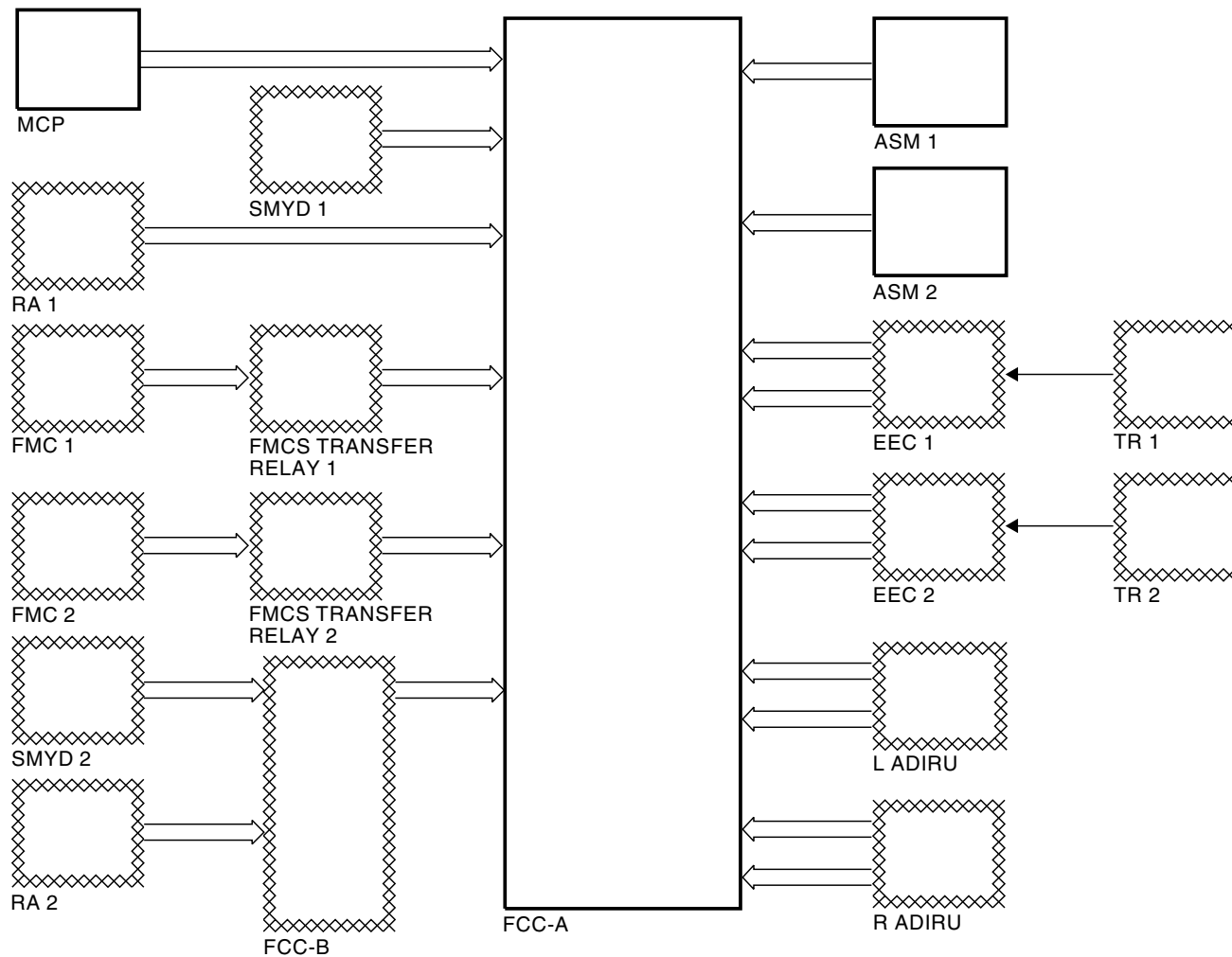
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A/T SYSTEM - DIGITAL INPUT INTERFACE



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A/T SYSTEM - DIGITAL INPUT INTERFACE

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A/T SYSTEM - DIGITAL OUTPUT INTERFACE

General

The A/T function in flight control computer A (FCC A) sends digital data to system components and sensors. The A/T function in FCC A sends this data on two digital buses to the user components.

A/T Digital Outputs

A/T bus 1 connects to these components:

- FCC A and B
- DPC 1 and 2
- FMCs
- DFDAU.

The A/T sends these parameters on bus 1:

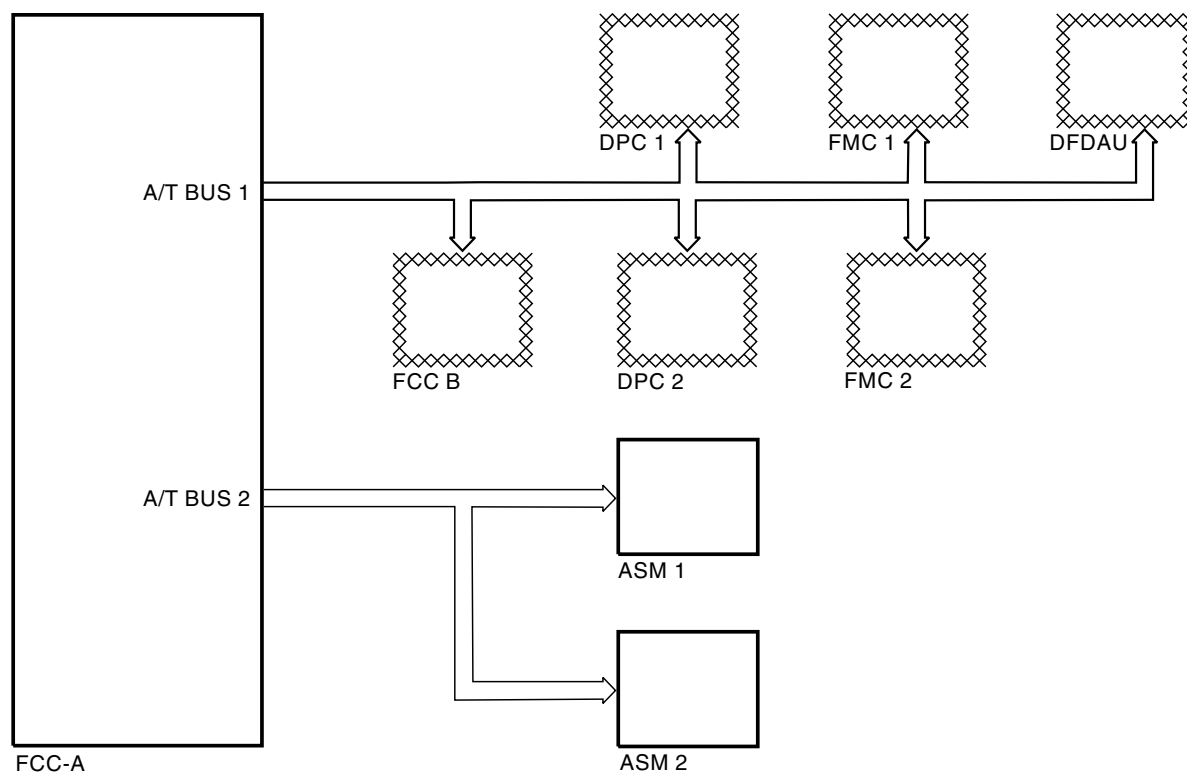
- A/T fast/slow command
- BITE response
- A/T modes and status
- Thrust rate command
- ASM measured torque
- ASM measured rate.

A/T bus 2 connects to ASM 1 and ASM 2. The A/T sends these parameters on this bus:

- Thrust rate command
- TRA selection
- TRA max limit.

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A/T SYSTEM - DIGITAL OUTPUT INTERFACE



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A/T SYSTEM - DIGITAL OUTPUT INTERFACE

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A/T SYSTEM - FLIGHT CONTROL COMPUTER

General

The A/T function in flight control computer A (FCC A) does the calculations for automatic control of engine thrust. The A/T sends the commands to the autothrottle servo motors to move the thrust levers.

Physical Description

The FCC is 6 MCU in size and weighs about 20 pounds. An electrical connector at the rear of the computer supplies the interface to other airplane components.

The FCC supplies logic power and motor power for ASM 1 and ASM 2.

Operation

The pilot uses the A/T system during these flight phases:

- Takeoff
- Climb
- Cruise
- Descent
- Approach to landing
- Go-around.

The A/T continuously monitors the system operation. If the A/T finds a fault, it puts the fault in its memory.

The A/T uses an operational and a built-in-test (BITE) program. These programs are in the computer memory.

During the operational program test, the computer uses the sensor and system inputs to make the thrust rate commands.

Training Information Point

A built-in-test (BITE) program monitors the system operation. The A/T puts faults and related components in memory. The technician uses A/T BITE on the FMCS control display units (CDUs) to look at these faults. The technician also uses BITE to do a check of system operation.

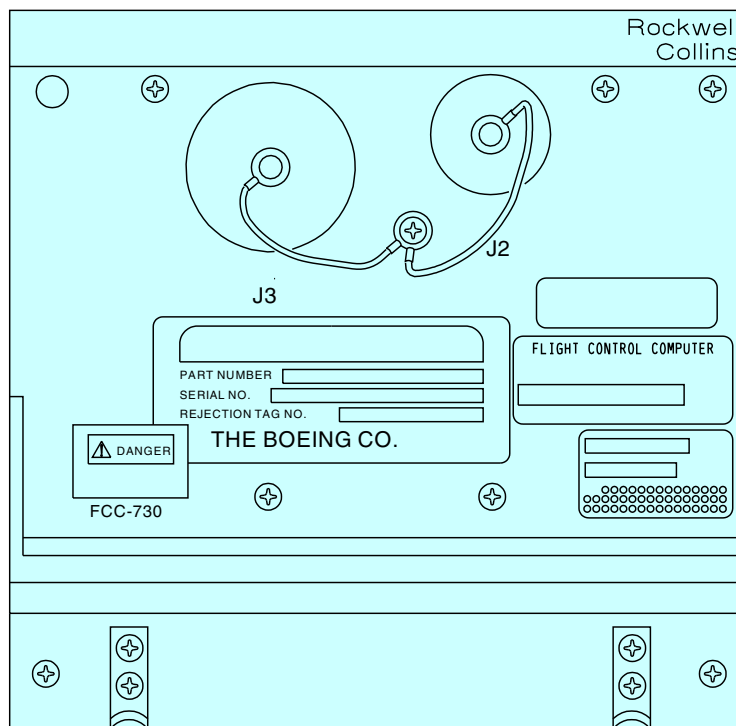
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A/T SYSTEM - FLIGHT CONTROL COMPUTER



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A/T SYSTEM - FLIGHT CONTROL COMPUTER

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A/T SYSTEM - FLIGHT CONTROL COMPUTER - FUNCTIONAL DESCRIPTION

General

The autothrottle function in flight control computer A (FCC A) takes inputs from many systems to calculate the thrust lever commands. The A/T function in the FCC has two lanes.

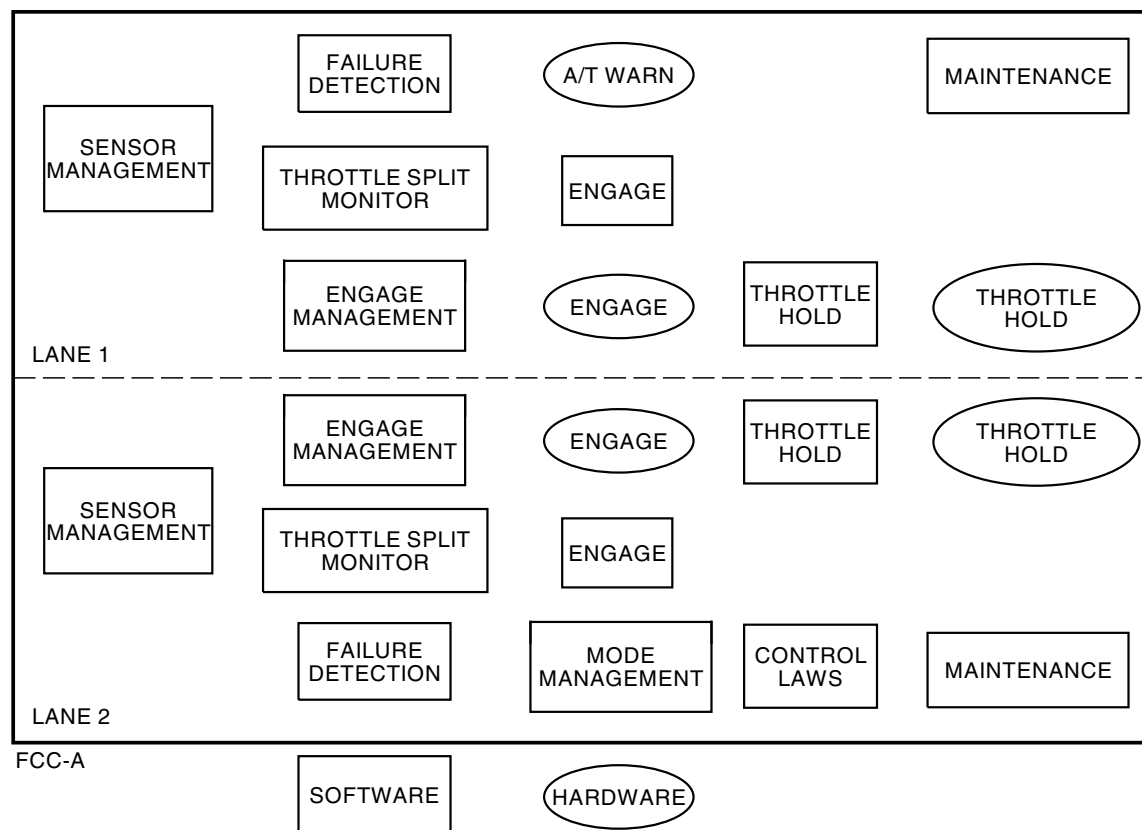
Lane 1 has the autothrottle warning monitor function. Lane 2 has the mode management and the control laws functions.

Both lanes have throttle split monitors, engage, throttle hold, failure detection, and maintenance functions.

The throttle split monitor is active in approach and cruise. In cruise this monitor provides protection against a lane 2 failure that might simultaneously command a throttle split and a hard rollover.

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A/T SYSTEM - FLIGHT CONTROL COMPUTER - FUNCTIONAL DESCRIPTION



A/T SYSTEM - FLIGHT CONTROL COMPUTER - FUNCTIONAL DESCRIPTION

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**A/T SYSTEM - A/T SERVO MOTOR****General**

The A/T servo motors (ASMs) receive commands from the A/T function in flight control computer A (FCC A). The ASMs use these commands to individually move the thrust levers forward or aft through two separate gear box assemblies. Each thrust lever has its own servo motor and gear box.

Physical Description

An ASM assembly weighs about 2 pounds and measures 3 inches by 3.3 inches by 3.5 inches. An electrical connector at the front of the ASM supplies the interface to other aircraft components. An output shaft at the rear joins the ASM to a gearbox.

Operation

The ASM consists of these components:

- Control unit
- Digital receiver
- Digital transmitter
- Motor
- Power supply.

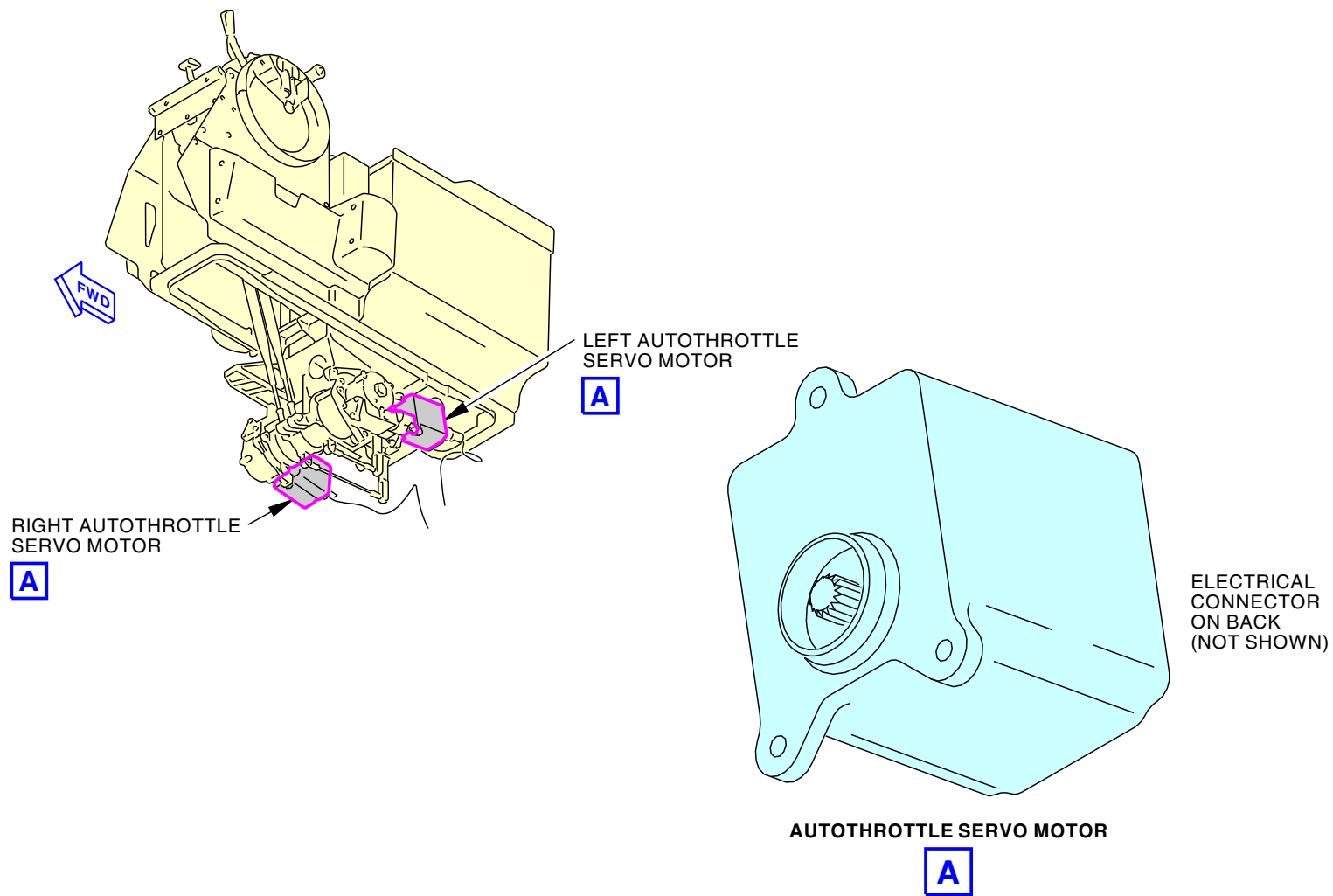
The A/T sends thrust rate commands to the ASM. The ASM uses this rate command to control the dc motor rotation. The ASM connects an output shaft to a gearbox and sends rate feedback to the A/T.

Training Information Point

A built-in test (BITE) program in the A/T does a check of the ASM operation. If BITE finds a fault, the A/T records the fault in its memory. The technician uses the FMCS CDUs to see the results of A/T BITE. The technician also uses A/T BITE to check system operation.

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A/T SYSTEM - A/T SERVO MOTOR



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A/T SYSTEM - A/T SERVO MOTOR

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**A/T SYSTEM - A/T SERVO MOTOR - FUNCTIONAL DESCRIPTION****General**

The autothrottle servo motor (ASM) receives digital, analog discrete inputs, and power from the A/T function in flight control computer A (FCC A). The ASM uses these inputs to control a motor which moves the thrust levers.

The ASM has these components:

- ARINC 429 receiver and transmitter
- Control unit
- Motor
- Power supply.

ARINC 429 Receiver

The A/T sends these signals to the ARINC 429 receiver:

- Thrust rate command
- Thrust resolver angle (TRA) selection
- TRA maximum limit.

The ARINC 429 receiver changes these signals to the proper format then sends them to the control unit.

ARINC 429 Transmitter

The ARINC 429 transmitter changes the control unit data to the proper format, and sends these signals to the A/T:

- Measured rate
- Measured torque
- Servo status.

Control Unit

The control unit receives these inputs:

- Installation programming pins
- Logic power

- Data from the digital receiver
- Rate feedback from the motor.

Using these inputs, the control unit does these:

- Decides when to send the motor rate command
- Controls how fast and what direction the motor turns
- Limits the thrust lever angle below the maximum
- Decides the installation position (right or left).

Motor

The motor is a reversible DC stepper motor. It receives motor power from the A/T when the A/T is engaged. It also receives rate command from the control unit to control the motor rotation.

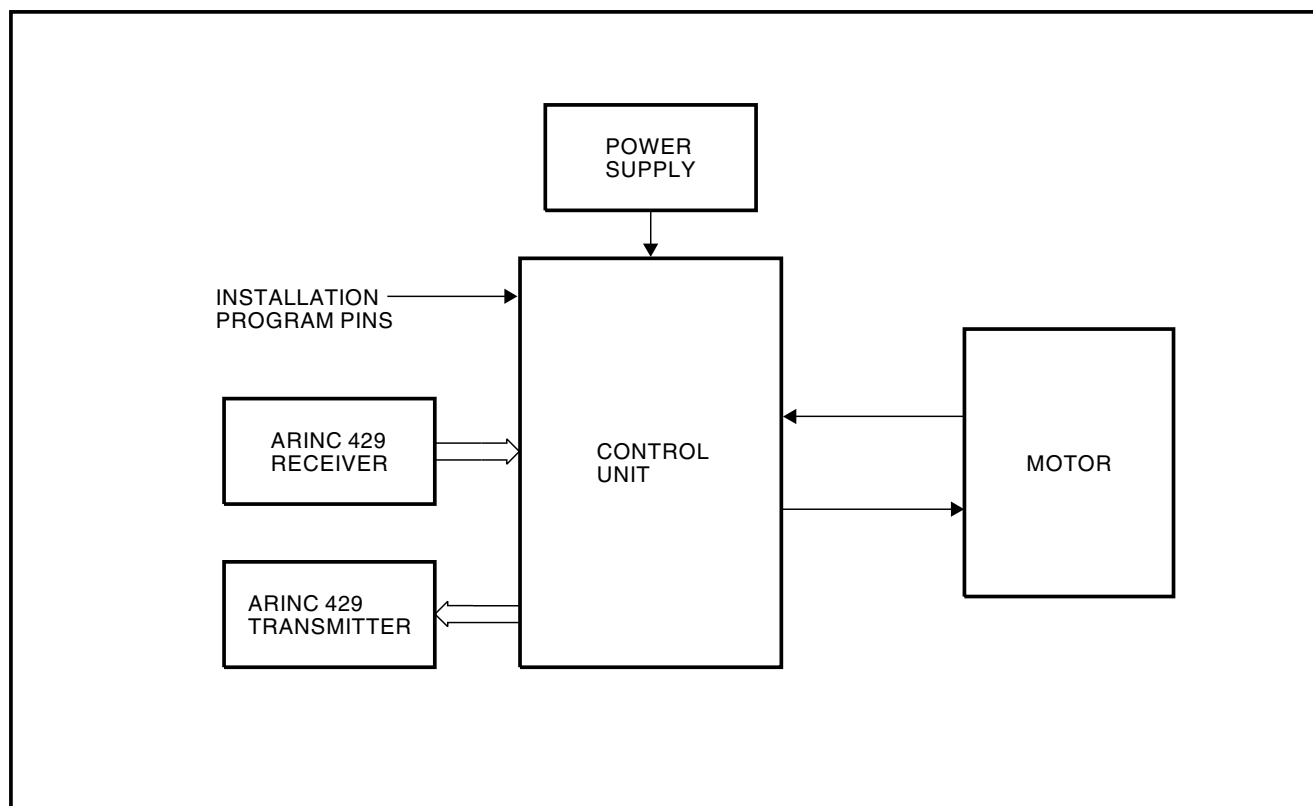
The motor sends rate feedback to the control unit. The motor has an output shaft which connects to a gearbox. The gearbox sets the thrust lever and the thrust lever angle resolver to the desired position.

Power Supply

The power supply gets 28v dc from the A/T function in FCC A. It supplies the necessary power to the control unit.

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A/T SYSTEM - A/T SERVO MOTOR - FUNCTIONAL DESCRIPTION



A/T SERVO MOTOR

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A/T SYSTEM - A/T SERVO MOTOR - FUNCTIONAL DESCRIPTION

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**A/T SYSTEM - ARM, MODE SELECT, AND THRUST LEVER SWITCHES****General**

Switches on the mode control panel (MCP) and the thrust levers select or disconnect the A/T modes.

MCP A/T Arm Switch

The A/T arm switch is on the MCP. The A/T arm switch engages the A/T system.

When you put the switch in the arm position, the green A/T arm light comes on. An engage solenoid holds the switch in the arm position if conditions are valid. The switch goes to OFF automatically if the A/T senses a problem.

You can also manually disengage the A/T when you put the A/T arm switch to OFF.

MCP A/T Mode Select Switches

The MCP has these A/T mode select switches:

- N1
- Speed.

These mode select switches are lighted. In normal operation, the DFCS automatically chooses the mode. The DFCS turns on the mode selector switch light when that mode is chosen. When a switch light is on, you can cancel that the mode by a push of the switch.

When the autopilot and flight director are off, push on the desired mode select switch to select an A/T mode. Push the active switch to turn off the mode.

Thrust Lever Switches

These switches are on the left and right thrust levers:

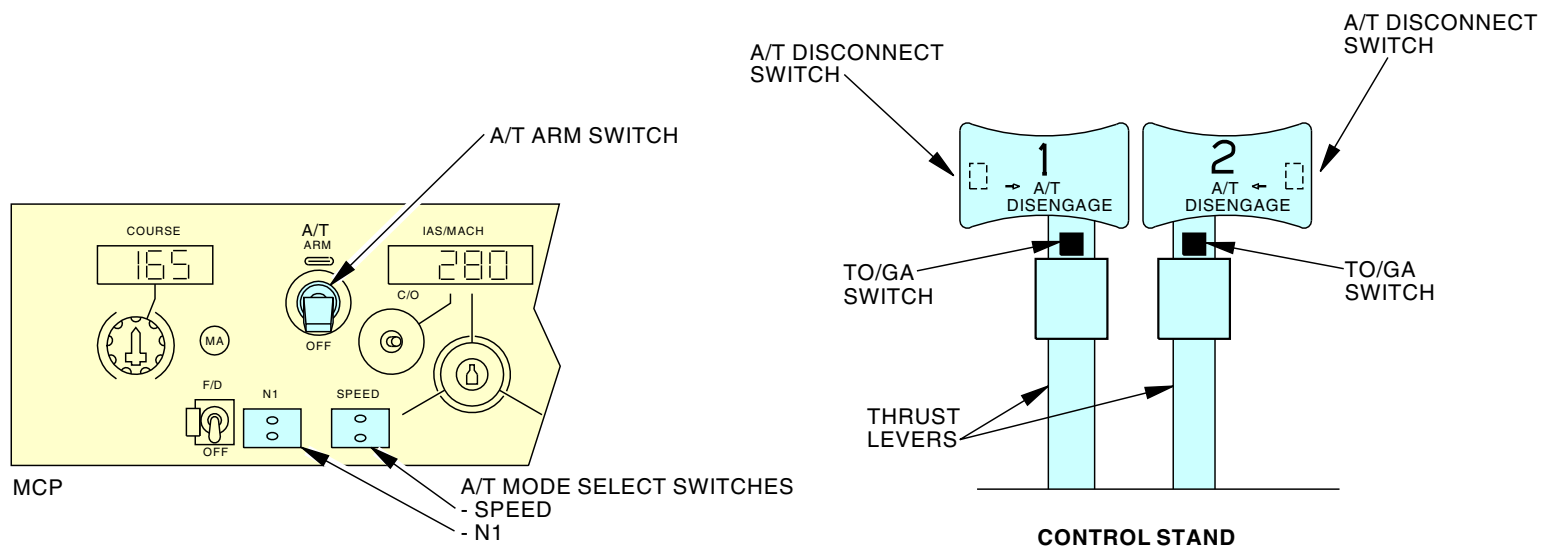
- TO/GA switches
- A/T disconnect switches.

Push the TO/GA switch to engage the DFCS and the autothrottle to either the takeoff or go-around mode. On the ground, both systems will go to the takeoff mode when you push the switch. During takeoff, the A/T system causes the engine thrust to increase to the takeoff (TO) N1 .

When you push the TO/GA switch during approach, the A/T system increases engine thrusts to a go-around (GA) thrust mode setting. This level of thrust is less than the maximum GA thrust. The engine thrust increases to the full GA thrust limit when you push the TO/GA switch a second time.

Push an A/T disconnect switch to disengage the autothrottle system. The ASA A/T red warning light flashes and the MCP A/T arm switch goes to OFF. Push an A/T disconnect switch a second time to reset the A/T warning.

A/T SYSTEM - ARM, MODE SELECT, AND THRUST LEVER SWITCHES



A/T SYSTEM - ARM, MODE SELECT, AND THRUST LEVER SWITCHES

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A/T SYSTEM - FUNCTIONAL DESCRIPTION - ENGAGE LOGIC

General

The A/T function in flight control computer A (FCC A) does checks of the sensors and A/T system performance. Input data comes in on data buses to the A/T. If the system operation and sensors are normal, the engage logic lets the A/T engage.

The A/T system uses a hardware and a software monitor. If these monitors find a problem, the system disengages. The engage logic disengages the A/T if one of these conditions occur:

- An invalid sensor or A/T system condition
- Airplane on the ground after the flight is complete
- Disengage signal from a disengage switch.

When the A/T disengages, a warning circuit starts the A/T flashing warning lights on the ASAs.

Hardware Monitor

The hardware monitor looks at the CPU cycle time and the thrust resolver angles (TRAs). If it senses a problem, it disengages the A/T.

The hardware monitor compares the TRAs for a thrust lever split condition. If both autopilots are in autoland and the A/T rapidly commands a difference of 10 degrees between the two thrust levers, the A/T disengages. This 10 degree difference is from the steady state thrust lever split value. The A/T permits a steady state split angle to let you operate with engine intermix.

Software Monitor

The software monitor uses software logic to permit system engagement. The software monitor does checks for these conditions:

- Normal operation of programmable read only memory (PROM), CPU, RAM, and timing
- Normal thrust lever positions with no thrust lever split in autoland and in cruise
- Invalid sensor conditions for the active mode
- Landing condition.

The software monitor disconnects the A/T if it senses a problem with the A/T, thrust lever split, or with the sensors. It also automatically disconnects the A/T when the airplane makes a landing.

The software monitor does a check of the TRAs and engine thrust from the EEC for thrust lever split. A rapid A/T command which produces a 10 degree difference between the two thrust levers disengages the A/T. While in cruise, engine thrust differential of 2,000 pounds also disconnects the A/T.

A/T Warning

The red A/T warning lights on the ASAs come on when the A/T disconnects or when the A/T is in BITE. The A/T warning flashes if the A/T disconnects and is steady while in BITE.

The A/T warning flasher latches on when the A/T disconnects. The flasher resets when you do one of these:

- Re-engage the A/T
- Push a disengage switch
- Push an A/T warning light.

The flasher does come on when the autothrottle disengages automatically during landing.

The flasher does not come on when the autothrottle disengages automatically during landing.

ASM Motor Power

The A/T sends 28v dc to the autothrottle servo motors if all these conditions are true:

- Not in throttle hold
- Not in cutout (disengage switch not pressed)
- A/T is engaged.

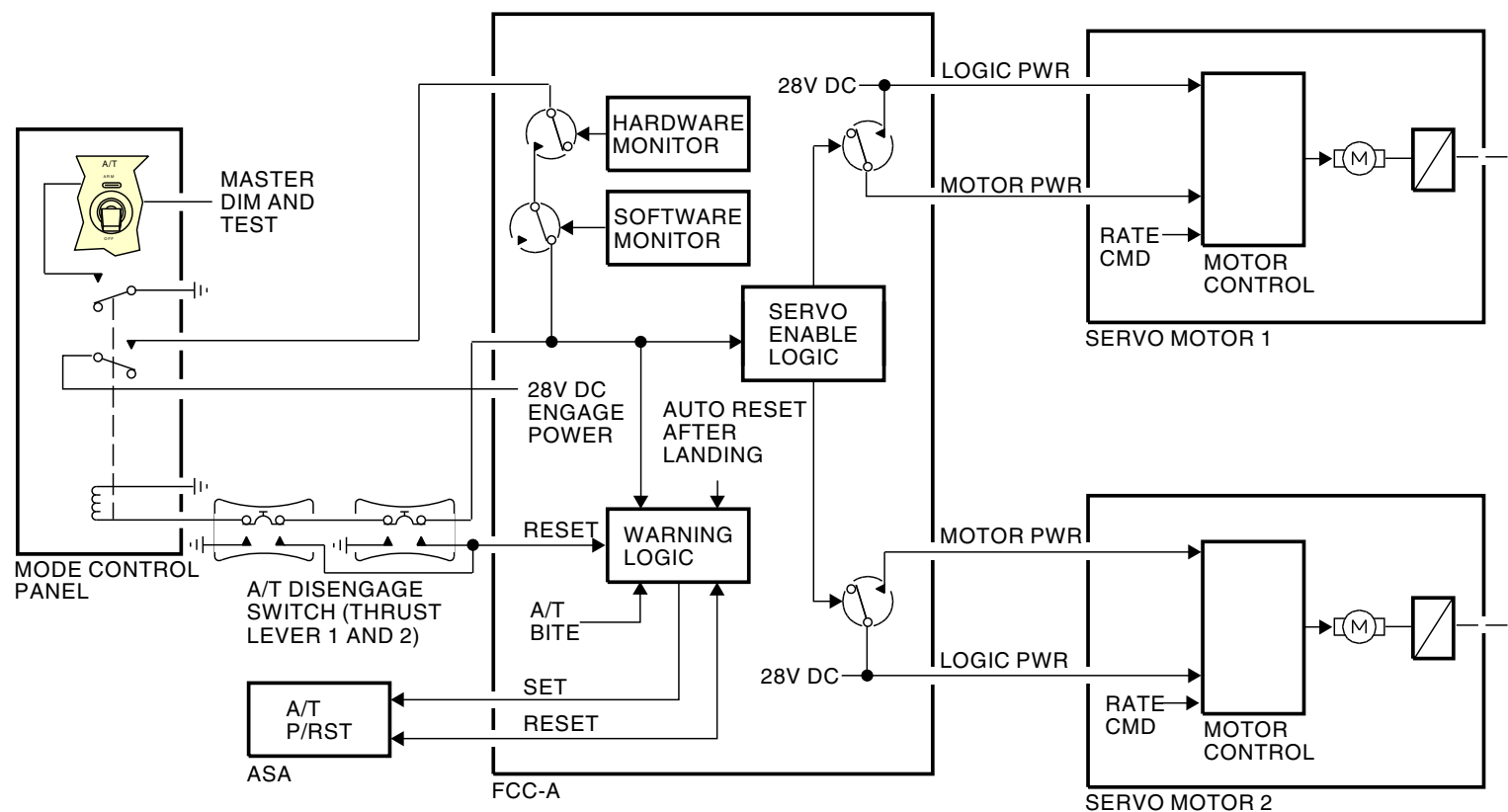
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A/T SYSTEM - FUNCTIONAL DESCRIPTION - ENGAGE LOGIC



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A/T SYSTEM - FUNCTIONAL DESCRIPTION - ENGAGE LOGIC

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**A/T SYSTEM - FUNCTIONAL DESCRIPTION - MODE SELECTION****General**

The A/T function in FCC A receives digital and analog data from different systems and sensors to determine operational modes. This data comes into the A/T through the input devices.

The A/T has two primary modes of operation, speed control and N1 control. These are the only two A/T modes that are selectable on the MCP. Depending on the flight phase and mode selected, the A/T can enter these additional modes:

- Arm
- Retard
- Throttle hold
- Go-around
- Test (on the ground).

After the A/T enters a mode, it puts mode selection data on the general ARINC output bus. These systems use the mode selection data:

- DPCs to show A/T modes
- FDAU for data download and storage to the FDR
- FCCs for A/T mode status.

The A/T controls power to the ASMs. The A/T removes power from the ASMs during throttle hold mode operation during takeoff.

This section discusses each A/T mode of operation.

N1 Mode

The N1 mode is used during these flight phases:

- Takeoff
- Climb
- Maximum thrust go-around.

In N1 mode, the A/T controls thrust to the EEC TRA target, calculated by the EEC for the equivalent FMC N1 target. The N1 mode can be selected in these four ways:

- Pilot manually selects N1 mode from the MCP
- DFCS requests N1 mode when DFCS is engaged
- TO/GA switch is pushed for takeoff (on ground)
- TO/GA switch is pushed a second time during reduced thrust go-around (in the air).

When DFCS is engaged in VNAV climb or LVL CHG climb, the FCCs command the A/T to N1 mode. When the DFCS is not engaged, the pilot can push the N1 selector switch on the MCP to manually select the N1 mode.

Throttle Hold Mode

The throttle hold mode is automatic and the A/T goes into this mode during the takeoff ground roll. In this mode, the A/T removes power to the ASMs to prevent the A/T from moving the T/Ls during the takeoff roll and initial climbout. The A/T uses two separate functions to remove power from the ASMs. One is a software function and the other is a hardware function. When both throttle hold functions agree and remove power to the servos, the A/T mode shows THR HLD on the FMA.

Arm Mode

ARM mode means that no active A/T mode has been selected. In the ARM mode, the A/T is enabled and ready to receive commands. The ASMs are powered but the A/T control logic prevents the servo motors from moving the throttles. The A/T goes to ARM mode during these conditions:

- On the ground when A/T is armed during preflight
- After THR HOLD mode above 800 feet barometric alt
- During Descent RETARD when T/Ls reach aft stops.

**A/T SYSTEM - FUNCTIONAL DESCRIPTION - MODE SELECTION****Speed Mode**

In the speed mode, the A/T controls engine thrust to control airplane speed. It does this by comparing the actual computed airspeed (CAS) from the ADIRU, to the target speed from the MCP or the FMC. These are the two A/T Speed modes:

- FMC SPD from the FMC target speed
- MCP SPD from the speed selected on the MCP.

In FMC SPD mode, the A/T controls thrust to control airplane speed to the FMC flight plan target speed. When the A/T is in MCP SPD mode, it controls thrust to control airplane speed to the target speed selected on the MCP.

The A/T Speed mode can be selected automatically or manually. If the DFCS is engaged, the DFCS selects the A/T speed mode automatically, either FMC SPD or MCP SPD, consistent with the active DFCS pitch mode. A/T MCP SPD mode may also be selected manually by a push of the A/T speed mode selector switch on the MCP.

Retard Mode

In the RETARD mode, the A/T moves the T/Ls to the aft stops. These are the two retard modes.

- Descent RETARD
- Flare RETARD.

Descent RETARD occurs during descent from altitude. Flare RETARD occurs during flare to landing. Both modes show as RETARD on the FMA on MDS.

Descent RETARD occurs during DFCS VNAV SPD descent, or when LVL CHG descent is selected on the MCP. During DFCS VNAV SPD descent, the A/T usually starts to retard the T/Ls to idle at the FMC top of descent (TOD) point. When the T/Ls get to the aft stops, the A/T mode changes from RETARD to ARM. The A/T stays in the ARM mode until a new mode is selected.

Flare RETARD occurs during landing flare. During flare retard, the A/T retards the T/Ls to idle and RETARD shows on the FMA. The T/Ls move back to the aft stops as the airplane flares for landing and touchdown. The A/T disengages 2 seconds after touchdown.

Go-Around Mode

During approach when you push a TO/GA switch once, the A/T commands a reduced thrust go-around. The A/T mode on the FMA shows GA.

During go-around, if you push a TO/GA switch a second time, the A/T commands maximum thrust go-around to the FMC go-around N1 limit. The A/T mode on the FMA changes from GA to N1.

The go-around mode resets if the N1 or the speed mode is selected on the MCP.

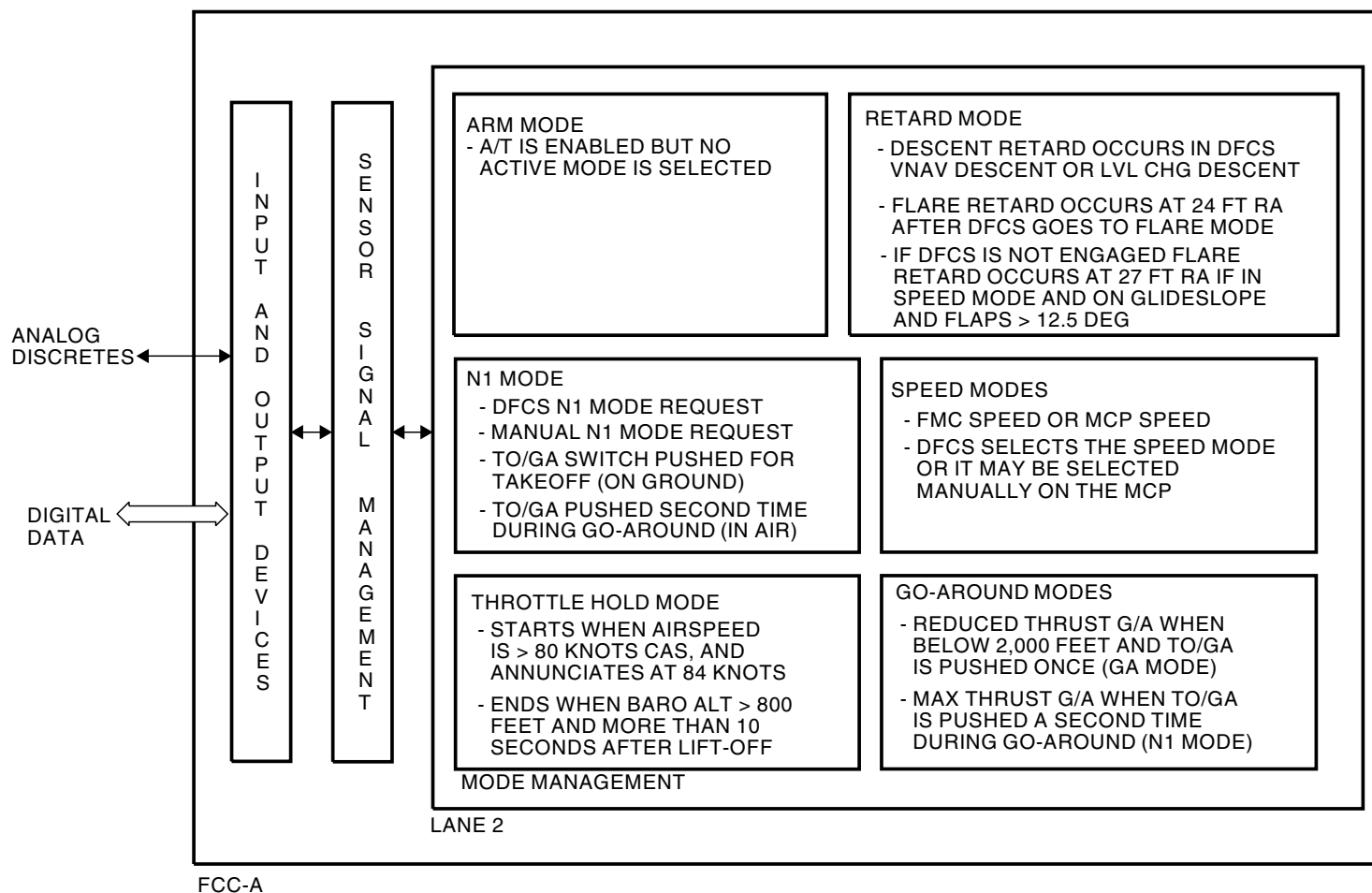
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A/T SYSTEM - FUNCTIONAL DESCRIPTION - MODE SELECTION



A/T SYSTEM - FUNCTIONAL DESCRIPTION - MODE SELECTION

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**A/T SYSTEM - FUNCTIONAL DESCRIPTION - COMMAND CALCULATION****General**

The autothrottle (A/T) receives digital data from many airplane systems to calculate thrust lever commands. The A/T calculates rate commands for the servo motors to set thrust for each mode of operation. The two primary A/T operational modes are the N1 mode and speed mode. Other A/T modes are ARM, RETARD, GA and THR HLD.

Arm

When the A/T is engaged, it is in ARM mode unless one of these modes are selected or are active:

- N1
- Speed
- Throttle Hold
- Retard.

The A/T goes into the ARM mode during takeoff after THR HOLD mode and during descent retard after RETARD mode when the T/Ls get to the aft stops.

Throttle Hold

The A/T uses these inputs during takeoff while in throttle hold mode:

- Computed airspeed
- Barometric corrected altitude
- Air/ground input.

The A/T goes into the throttle hold mode during the takeoff ground roll when computed airspeed is 80 knots. THR HLD mode annunciates on the FMA at 84 knots. In the THR HLD mode, the T/Ls remain at the takeoff N1 setting and the pilot may move the T/Ls if desired. The A/T stays in throttle hold mode until both of these conditions occur:

- Barometric altitude is 800 feet AGL
- 10 seconds after lift-off.

After takeoff is complete, the A/T changes from THR HLD to ARM mode. The A/T stays in the ARM mode until the N1 or speed mode is selected.

N1

The N1 mode is used during takeoff, climb and maximum thrust go-around. In the N1 mode, the A/T uses these inputs:

- Target N1 (FMC)
- N1 command (EEC)
- TRA target (EEC)
- TRA actual (EEC)
- TRA for N1 max (EEC).

In the N1 mode, to set thrust, the A/T uses EEC TRA targets. The EECs receive N1 targets from the FMC and calculate an equivalent TRA target and send these to the A/T. Using these EEC TRA targets, the A/T sends rate commands to the ASMs and TR packs to set thrust. Actual TRA data is transmitted from the TR packs to the EECs. The EECs compare this with the actual thrust set on the engines to provide feedback to the A/T. The EECs calculate a maximum TRA target to make sure the engine limits are not exceeded.

For takeoff and maximum thrust go-around only, the A/T uses FMC N1 targets with EEC TRA targets for more precise thrust control to the FMC N1 limit.

In takeoff or go-around, the A/T moves the T/Ls at a rate of 13.5 deg/sec to a predicted position. For final adjustments, the A/T moves the T/Ls at a maximum rate of 5 deg/sec. In modes other than TO/GA, the A/T limits thrust lever rates to 3 deg/sec.

When the A/T is not engaged and the T/Ls are moved manually, TRA data is sent from the TR packs to the EECs to set engine thrust.

Speed

In the speed mode, the A/T uses these inputs:

- Target airspeed

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**A/T SYSTEM - FUNCTIONAL DESCRIPTION - COMMAND CALCULATION**

- Target mach
- Computed airspeed
- Mach
- True airspeed
- Longitudinal acceleration
- Minimum operating speed (from SMYD).

In the speed mode, the A/T controls thrust to a target airspeed. The target speed can be either the MCP speed which is the speed selected by the pilot or FMC speed if in DFCS VNAV mode. The A/T compares the target airspeed with the actual airplane speed from the ADIRUs, either CAS or Mach. A difference between the actual and target speed causes a T/L rate command to set thrust.

The A/T compares the minimum operating speed from the SMYD and the computed airspeed from the ADIRU to set a minimum speed floor. The A/T will not allow the speed to go less than the speed floor.

Retard

There are two A/T retard modes, descent RETARD and flare RETARD. They annunciate as RETARD on the FMA.

For descent retard from cruise flight, at FMC top of descent (TOD) the A/T commands the T/Ls to reduce engine thrust to idle. In descent RETARD, the thrust levers move to the aft stops at 1 deg/sec.

Flare RETARD is used during landing flare. For flare retard, the A/T uses these inputs:

- Speed mode selection
- Flap position
- Radio altitude
- A/P flare.

The A/T goes into the flare retard mode during landing if on G/S and in MCP SPD mode. The A/T commands the T/Ls to move to the aft stops at 3 deg/sec. After landing, the T/Ls move to the idle stop at 8 deg/sec. During the flare retard mode, the T/Ls get to idle within 6 seconds.

Go-Around

In the go-around mode, the A/T uses these inputs:

- N1 mode
- Speed mode
- TO/GA switch input
- Radio altitude
- Gross weight
- Flap position.

There are two A/T go-around modes, GA and N1. For reduced thrust go-around the A/T uses an internally calculated thrust value to achieve an eight percent climb gradient. For max thrust go-around, the A/T uses FMC N1 targets and EEC TRA targets to set thrust.

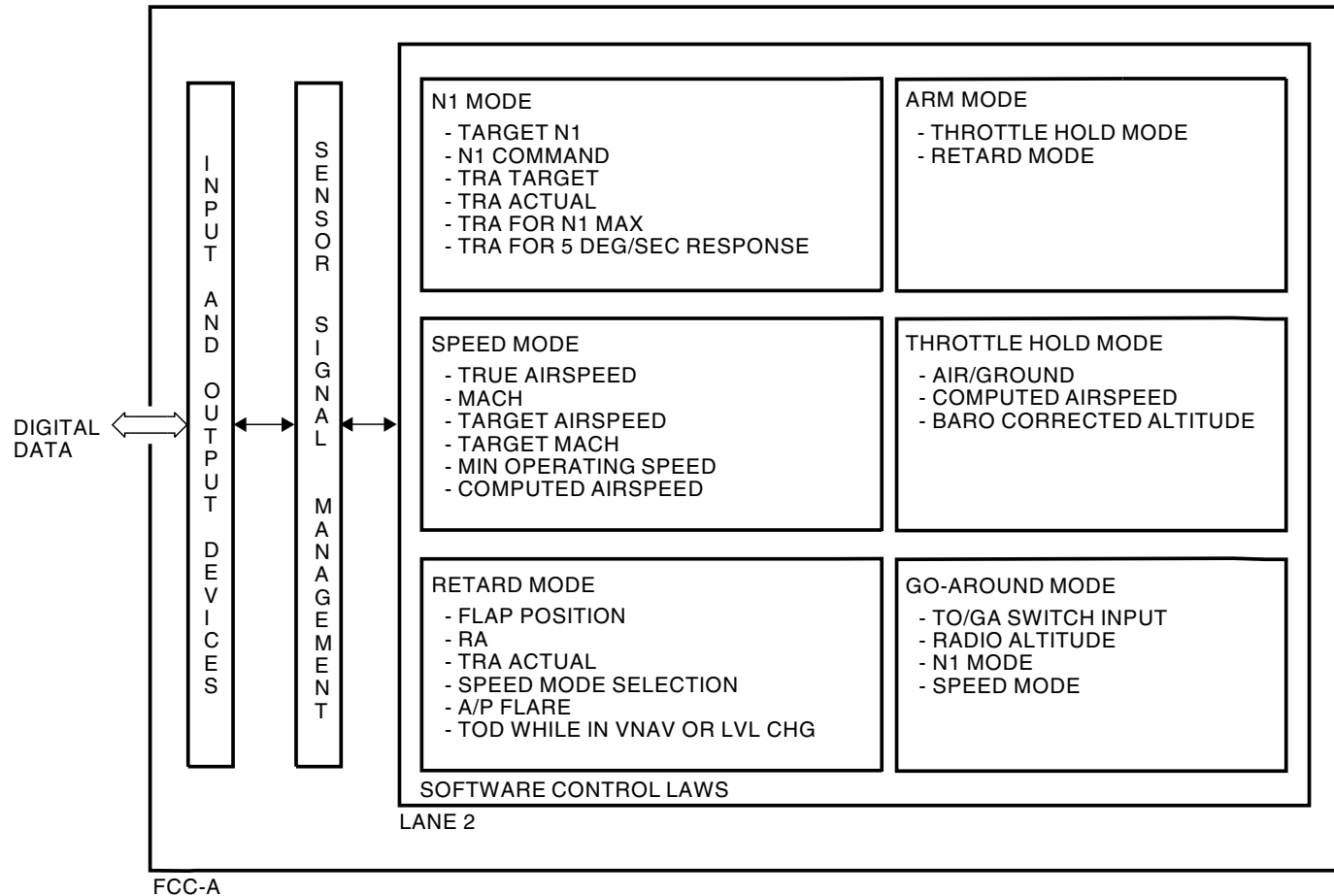
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A/T SYSTEM - FUNCTIONAL DESCRIPTION - COMMAND CALCULATION



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A/T SYSTEM - FUNCTIONAL DESCRIPTION - COMMAND CALCULATION

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**A/T SYSTEM - OPERATION - FMA****General**

A/T modes of operation show on the flight mode annunciation (FMA) at the top of the primary flight display above the ADI.

A/T Modes

The FMA shows these A/T modes:

- ARM
- N1
- THR HLD
- FMC SPD
- MCP SPD
- RETARD
- GA
- TEST.

ARM shows when the A/T system is enabled and is ready to receive commands but no active modes are selected.

N1 shows when the A/T system controls engine thrust to the FMC calculated N1 target during takeoff, climb, or max thrust go-around.

THR HLD shows during takeoff at more than 84 knots. In the throttle hold mode, the A/T removes power from the ASMs. The T/Ls stay at the thrust set for takeoff. When the airplane gains a barometric altitude of 800 feet AGL and ten seconds after liftoff, the A/T restores power to the ASMs and changes to the ARM mode. Above 800 feet, you can select either N1 or speed mode during climb out.

FMC SPD shows when the A/T controls thrust to hold the FMC target speed during DFCS VNAV pitch mode.

MCP SPD shows when the A/T controls thrust to hold the airplane speed you select on the MCP.

RETARD shows when the A/T moves the thrust levers to the idle stop. This can be either descent retard or flare retard. During descent retard, after the T/Ls reach the idle stops the A/T goes to the ARM mode.

The A/T goes into reduced thrust go-around (GA mode) when you push a TO/GA switch once during the approach. The A/T commands the thrust levers to an internally calculated thrust to achieve a reduced thrust go-around. During go-around when you push a TO/GA switch a second time, the A/T goes into N1 mode and commands the T/Ls to set thrust to the FMC N1 limit for go-around.

TEST displays when you enter A/T BITE from the FMC CDU.

When there is a mode change, a box shows around the A/T mode on the FMA display for 10 seconds.

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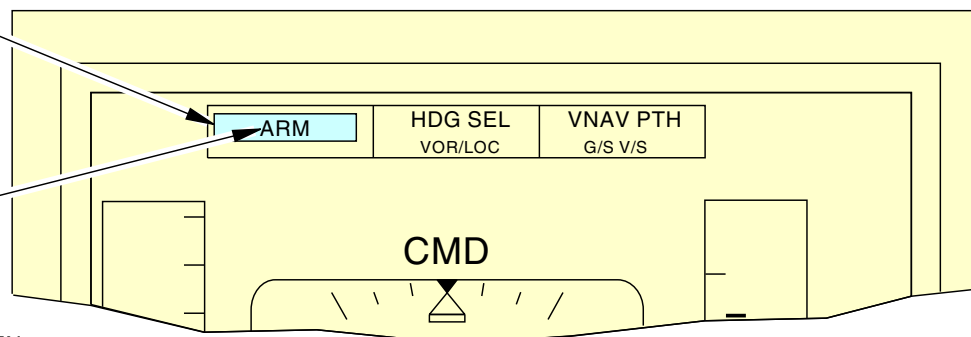
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A/T SYSTEM - OPERATION - FMA

MODE CHANGE BOX SHOWS
FOR TEN SECONDS AFTER
A MODE CHANGE OCCURS

- A/T MODES
- ARM (WHITE)
 - N1
 - μ THR HLD
 - FMC SPD
 - μ MCP SPD
 - RETARD
 - GA
 - TEST
- GREEN



FLIGHT MODE ANNUNCIATION (FMA)
ON PRIMARY FLIGHT DISPLAY (PFD)

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A/T SYSTEM - OPERATION - FMA

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A/T SYSTEM - ENGINE DISPLAY

General

The upper engine display shows these thrust annunciations that are calculated by the FMC:

- Thrust mode annunciation (TMA)
- Reference N1 cursors on the N1 dials.

Normal Operation

During normal operation, the FMC calculates the engine thrust N1 limits. The FMC sends these to the DPCs to show the reference N1 cursors on the N1 dials on the engine display. During normal operation, the reference N1 displays above the actual N1 box are blank.

The FMC also calculates the thrust modes for each flight phase and sends them to the DPC to show on the TMA at the top of the engine display.

See the flight management computer system section for more information about the thrust mode displays. (SECTION 34-61)

Non-Normal Operation

During non-normal operation when FMC N1 data is invalid or no computed data (NCD), three dashes show on the TMA in place of the FMC thrust modes. The reference N1 displays above the actual N1 box show dashes to show that the reference N1 cursors on the N1 dials are not set by the FMC.

When FMC N1 data is invalid, you can use the N1 set selector on the engine control panel to manually set the reference N1 cursors on the N1 dials. This sets the N1 cursors and shows the selected reference N1 readout digitally above the actual N1 box. The manually set N1 data is for reference only and does not go to any airplane user system.

When FMC N1 data is invalid or NCD, the A/T computer calculates a single N1 limit for both engines. The message A/T LIM shows on the engine display. In this mode, the A/T computer calculates an engine N1 limit for climb, cruise, and go-around, but not for takeoff.

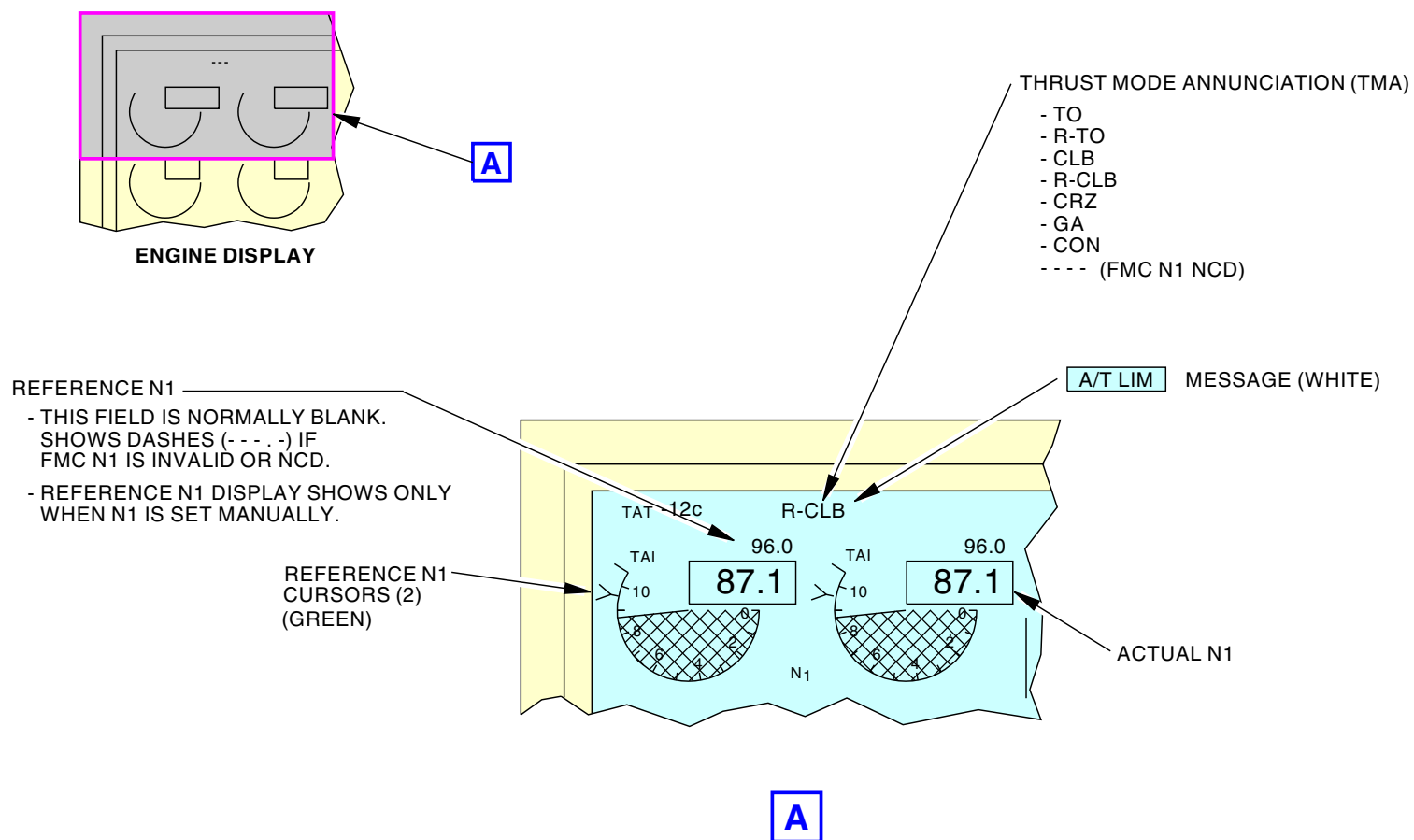
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A/T SYSTEM - ENGINE DISPLAY



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A/T SYSTEM - ENGINE DISPLAY

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**A/T SYSTEM - OPERATION - OVERVIEW****General**

The A/T operates on the ground for takeoff, and during flight. The A/T system controls engine thrust for these flight sequences:

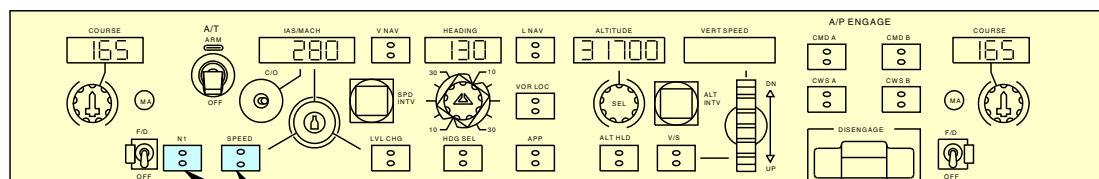
- Takeoff
- Climb
- Cruise
- Descent
- Approach
- Flare
- Go-around.

For each flight phase, the A/T N1 or speed modes may be selected from the MCP. If the DFCS is engaged, it selects the A/T mode. The N1 or speed mode select switch light comes on to show the mode is active. When the light is on, a second push removes the mode from active status.

You use the TO/GA switches to start the takeoff or go-around modes.

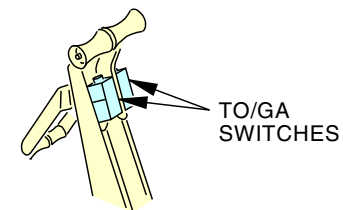
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A/T SYSTEM - OPERATION - OVERVIEW

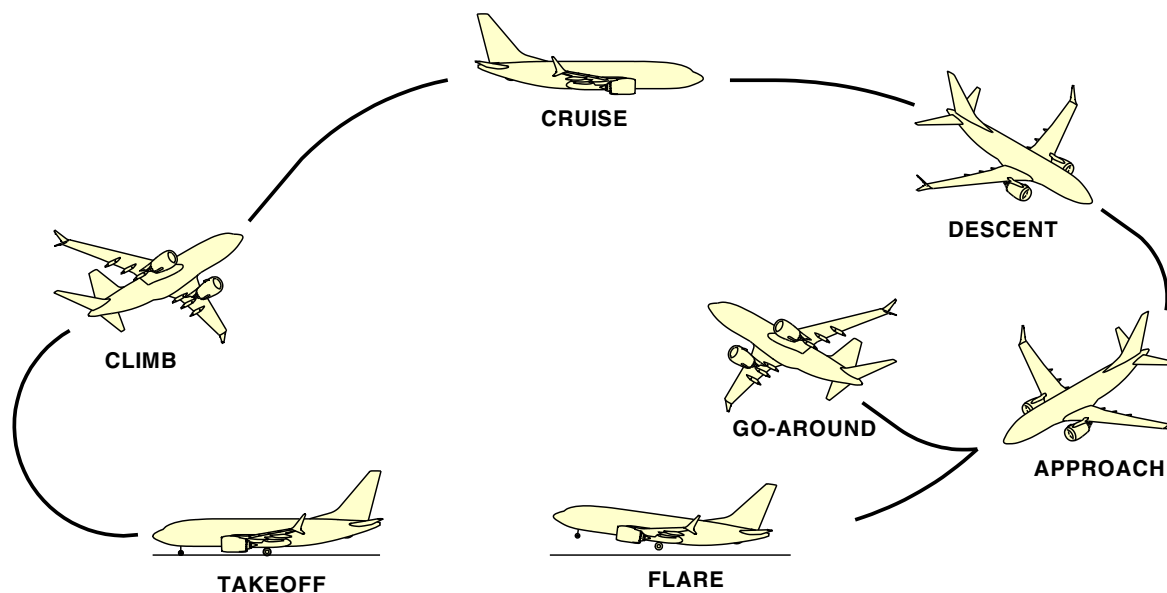


MODE CONTROL PANEL

MODE SELECT SWITCHES



THRUST LEVERS



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A/T SYSTEM - OPERATION - OVERVIEW

22-31-00

**A/T SYSTEM - OPERATION - TAKEOFF****General**

To prepare the FMS and the A/T for takeoff, you use the FMC CDU to enter the necessary preflight data, and the DFCS MCP to select parameters and set desired modes.

This is the takeoff sequence:

- Preflight
- Takeoff Start
- Takeoff Roll
- Climbout.

Preflight

These are the steps for preflight prior to takeoff:

- To preflight the FMS, enter data on the FMC CDU
- Set the DFCS MCP to takeoff modes and parameters
- Put the A/T arm switch to the ARM position on the MCP.

These are the indications after preflight is complete:

- A/T is in ARM mode
- A/T mode lights are off on the MCP
- TO is the FMC thrust mode
- N1 reference cursors are at FMC takeoff N1 limit.

Takeoff Start

At the start of the takeoff roll, the pilot pushes a TO/GA switch on the thrust levers. The A/T active mode becomes N1 for takeoff, and the A/T moves the thrust levers to the FMC calculated takeoff N1 limit.

These are the indications at the start of takeoff:

- A/T goes to N1 mode
- N1 mode light is OFF
- TO is the FMC thrust mode

- N1 reference cursors are at FMC takeoff N1 limit
- T/Ls move forward to a target TRA for the N1 limit.

Takeoff Roll

As engine thrust and RPM increase to the takeoff N1 limit, the airplane accelerates. When the airspeed gets to 80 kts, the A/T goes in to throttle hold mode. At 84 knots, the A/T mode changes from N1 to THR HLD on the FMA. These are the indications at 84 kts:

- THR HLD shows on the FMA as the active A/T mode
- TO shows on the TMA as the FMC thrust mode
- N1 reference cursors are at FMC takeoff N1 limit.

In throttle hold mode, the A/T removes power from the ASMs and does not command thrust. The T/Ls remain at the target TRA for the takeoff N1 limit. The pilot can control thrust manually if desired.

Climb Out

During the initial climb out, above a barometric altitude of 800 feet above field elevation and 10 seconds after liftoff, the A/T mode changes from THR HLD mode to ARM mode. These are the indications:

A/T goes to

- ARM mode
- TO is the FMC thrust mode
- N1 reference cursors are at FMC takeoff N1 limit
- T/Ls remain at target TRA for takeoff N1 limit.

After takeoff is complete, the pilot may select a new A/T mode from the MCP, either N1 or speed mode, when above 800 feet barometric altitude. If DFCS is engaged during climb out, DFCS selects an A/T mode, either N1 or Speed mode, consistent with the DFCS mode selected. During climb out above 800 feet baro altitude, the N1 or Speed mode light may be ON depending on the mode selected.

A/T modes show on the FMA on the primary (outboard) EFIS displays. FMC thrust modes and FMC N1 limits show on the upper engine display.

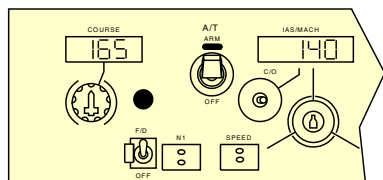
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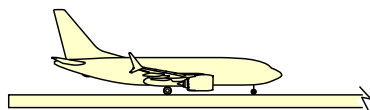
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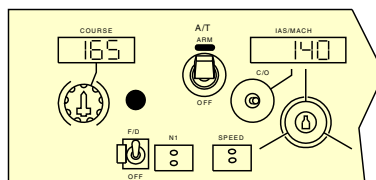
A/T SYSTEM - OPERATION - TAKEOFF



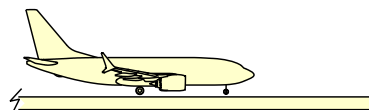
MCP



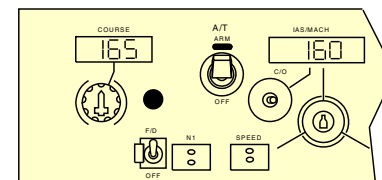
**TAKEOFF START
(AFTER TO/GA PUSHED)**



MCP



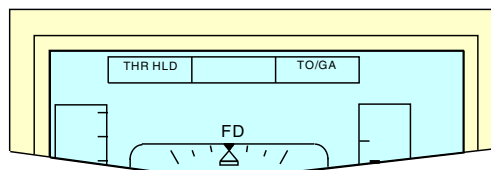
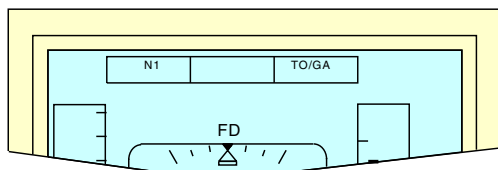
SPEED > 84 KNOTS



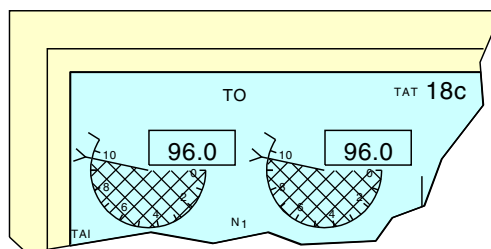
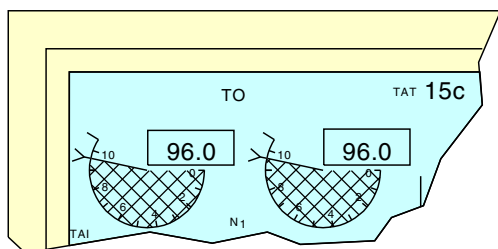
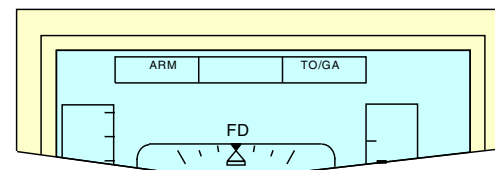
MCP



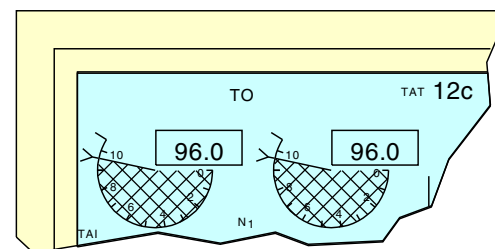
CLIMB OUT ABOVE 800 FEET



FMA ON PFD



TMA ON ENGINE DISPLAY



2368653 S00061517841_V1

A/T SYSTEM - OPERATION - TAKEOFF

22-31-00

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**A/T SYSTEM - OPERATION - CLIMB****General**

During climbout, the A/T controls engine thrust to the A/T mode selected on the DFCS MCP. This may be either N1 or speed mode, depending on what you select, or if the DFCS is engaged, the DFCS selects the A/T mode. During climb in N1 mode, the A/T advances the throttles to the target TRA calculated by the EEC for the FMC climb N1 target.

Initial Climbout

These are the possible DFCS pitch modes for climb:

- Vertical navigation (VNAV SPD)
- Level change (LVL CHG)
- Vertical speed (V/S).

After takeoff, you can engage the A/P above 400 feet radio altitude and select a DFCS pitch mode for climb. The normal pitch mode during climb is VNAV.

During takeoff and initial climbout, the A/T is in throttle hold mode. As the airplane climbs above a barometric altitude of 800 feet and 10 seconds after lift-off, these mode annunciations show:

- A/T goes from THR HLD to ARM mode
- A/T mode lights on the MCP are off
- MCP IAS/MACH window shows the selected speed
- TO is the FMC thrust mode
- N1 ref cursors stay at the FMC takeoff N1 limit
- T/Ls are at target TRA for FMC takeoff N1.

During climbout above 800 feet barometric altitude, you can select an A/T mode such as N1 or speed. If the DFCS is engaged, the DFCS selects an A/T mode consistent with the DFCS pitch mode.

VNAV Climb

Normal climbout is in DFCS VNAV pitch mode. In VNAV, the DFCS selects N1 as the A/T mode. These are the mode annunciations during VNAV climb:

- A/T is in N1 mode
- N1 mode light is ON
- MCP IAS/MACH speed window is blank
- VNAV SPD is the DFCS pitch mode
- CLB is the FMC thrust mode
- N1 ref cursors are at FMC climb N1 limit
- A/T controls T/Ls to a target TRA for FMC climb N1.

During VNAV climb, the A/T controls engine thrust to the FMC climb N1 target. The A/P uses elevators to control airspeed.

LVL CHG Climb

During climb, you can select LVL CHG on the MCP as the DFCS pitch mode and the DFCS will select N1 mode for the A/T. These are the mode annunciations in VNAV climb:

- A/T is in N1 mode
- N1 mode light is ON
- MCP IAS/MACH window shows the selected speed
- MCP SPD is the DFCS pitch mode (for LVL CHG).

In DFCS LVL CHG climb, the A/T sets thrust to the EEC TRA target. This TRA target is calculated by the EEC for an equivalent FMC climb N1 target.

V/S Climb

During climb-out, you can select V/S as the DFCS pitch mode and set the desired vertical speed. The DFCS will select MCP SPD mode for the A/T. These are the mode annunciations in V/S climb:

- A/T is in MCP SPD mode
- Speed mode light is ON

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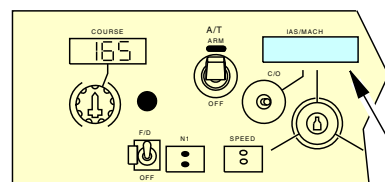
A/T SYSTEM - OPERATION - CLIMB

- MCP IAS/MACH window shows the selected speed
- V/S is the DFCS pitch mode.

During the V/S climb mode, the A/T controls engine thrust to control airspeed to the speed selected on the MCP. The A/P uses the elevator to hold the climb rate to the vertical speed rate selected on the MCP.

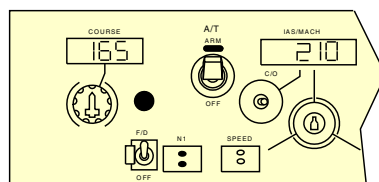
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A/T SYSTEM - OPERATION - CLIMB



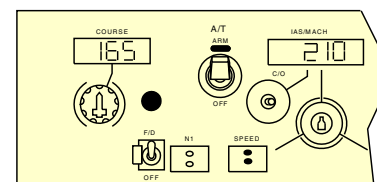
MCP

VNAV CLIMB



MCP

LEVEL CHANGE CLIMB



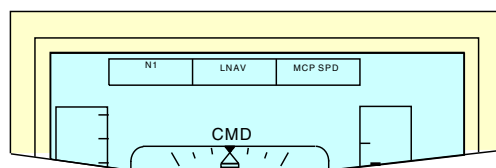
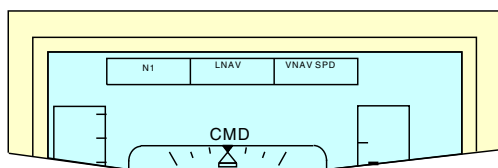
MCP

VERTICAL SPEED CLIMB

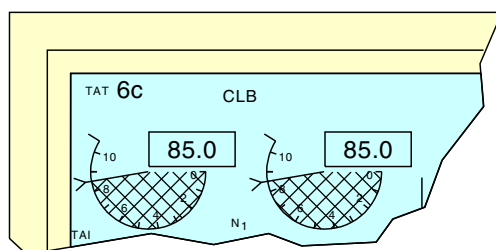
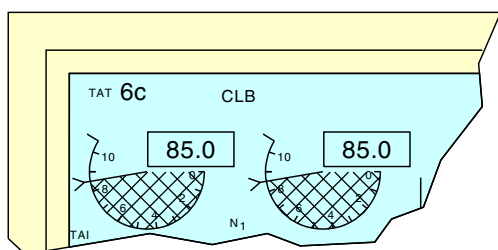
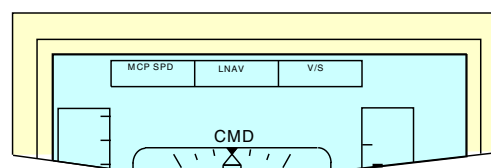
FMC SPEED IN VNAV



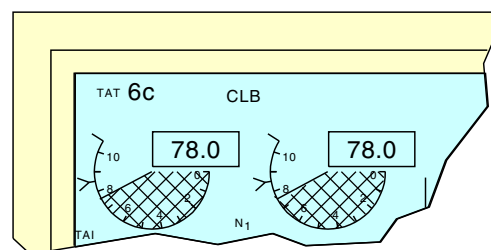
CLIMB OUT ABOVE 800 FEET



FMA ON PFD



TMA ON ENGINE DISPLAY



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A/T SYSTEM - OPERATION - CLIMB

22-31-00

**A/T SYSTEM - OPERATION - CRUISE****General**

During cruise flight, the A/T controls engine thrust to control airspeed. This may be an FMC target speed or a speed selected on the MCP.

During cruise flight, the normal DFCS pitch mode is VNAV. You can also select altitude hold (ALT HOLD) as the DFCS pitch mode.

VNAV Altitude Acquire/Altitude Hold

During DFCS VNAV climb, the airplane climbs to either the FMC target altitude or to a lower intermediate altitude selected on the MCP. The A/T is in the N1 mode. As the airplane gets near the selected altitude, the DFCS acquires and levels off at the altitude. The A/T goes from the N1 to the FMC SPD mode. These are the annunciations as the airplane levels off:

- A/T goes from N1 to FMC SPD mode
- MCP IAS/MACH window is blank
- DFCS pitch mode is ALT ACQ then ALT HOLD for level off at MCP altitude, or VNAV PTH for FMC altitude.

VNAV Cruise

During DFCS VNAV cruise, the A/T is in FMC speed mode. The A/T controls thrust to hold the FMC target airspeed while the autopilot uses the elevators to hold altitude. These are the annunciations during VNAV cruise:

- A/T is in FMC SPD mode
- A/T N1 and Speed mode lights are off on the MCP
- MCP IAS/MACH window is blank
- VNAV PTH is the DFCS pitch mode.

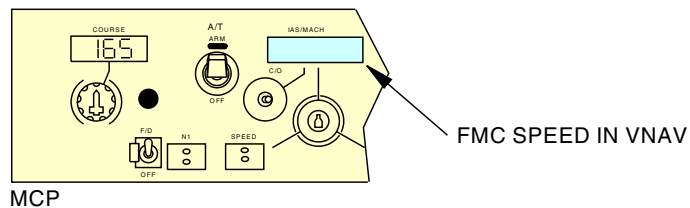
In VNAV cruise, the A/T is in FMC SPD mode and the A/T speed mode switch light on the MCP is off. When the MCP mode switch lights are off, this means that you can not de-select the active mode by a push of the switch. To change the mode you must select a new mode.

ALT HOLD

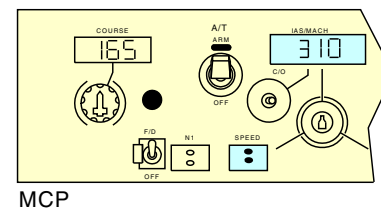
In the DFCS altitude hold mode (ALT HOLD), the target altitude is the altitude selected on the MCP. During the climb (or descent), as the airplane gets near the MCP selected altitude, DFCS acquires and then holds this altitude. The A/T controls the thrust levers to hold the selected target airspeed on the MCP while the A/P uses the elevators to hold the selected altitude on the MCP. These are the mode annunciations as DFCS acquires and holds the selected altitude in the ALT HOLD mode:

- A/T is in MCP SPD mode
- Speed mode light is ON
- MCP IAS/MACH window shows the selected speed
- ALT ACQ then ALT HOLD is the DFCS pitch mode.

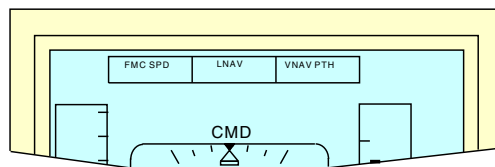
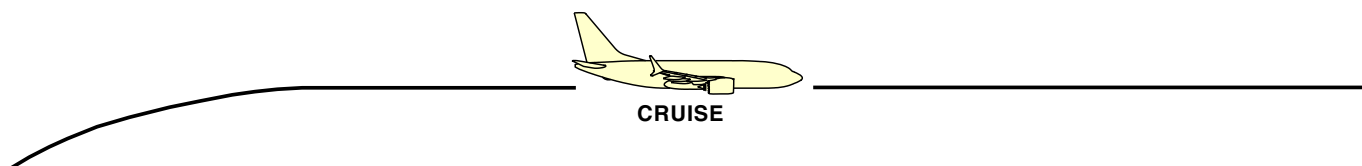
A/T SYSTEM - OPERATION - CRUISE



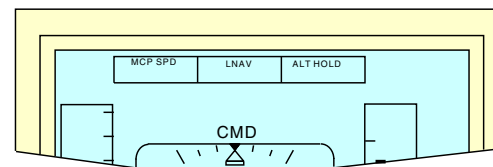
VNAV CRUISE



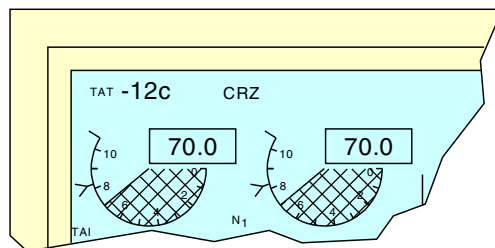
ALTITUDE HOLD



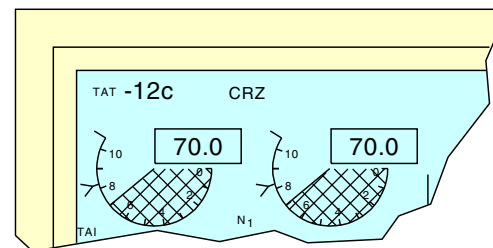
FMA ON PFD



FMA ON PFD



TMA ON ENGINE DISPLAY



TMA ON ENGINE DISPLAY

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A/T SYSTEM - OPERATION - CRUISE

**A/T SYSTEM - OPERATION - DESCENT****General**

During descent, the A/T controls engine thrust to control either the airspeed or descent rate (V/S), depending on the mode selected.

During descent, the A/T normally retards thrust to idle consistent with the DFCS pitch mode selected. The normal DFCS pitch mode during descent is VNAV. The pilot can select other modes. These are the DFCS pitch modes available for descent:

- Vertical navigation (VNAV)
- Level change (LVL CHG)
- Vertical speed (V/S).

VNAV Descent

During DFCS VNAV cruise, when the airplane gets to the FMC calculated top of descent (TOD) point, the A/T moves the T/Ls slowly to the aft stops to retard thrust to idle for descent. These are the mode indications:

- A/T goes from MCP SPD to RETARD to ARM mode
- A/T mode lights are off
- MCP IAS/MACH window is blank (FMC speed)
- VNAV is the DFCS pitch mode.

During DFCS VNAV descent, normally the thrust levers are at idle and the A/T mode is ARM. The DFCS may request an A/T mode change from ARM to FMC SPD mode to increase thrust to hold the FMC target speed or descent rate.

The airplane continues to descend to the FMC or MCP selected altitude. As the DFCS acquires and levels off at the selected altitude, the A/T changes from ARM to FMC SPD mode (if not already in FMC SPD). The A/T controls engine thrust to hold the airspeed to the FMC target speed. The autopilot stays in VNAV and uses the elevators for pitch control to hold the selected altitude.

LVL CHG Descent

LVL CHG can be selected as the DFCS pitch mode for descent (or climb). For descent, the pilot selects a lower target altitude on the MCP and selects LVL CHG. The A/T retards the engine thrust to idle and the airplane descends to the selected altitude. During LVL CHG descent, these are the mode annunciations:

- A/T goes from MCP SPD to RETARD to ARM mode
- A/T mode lights are off
- MCP IAS/MACH window shows the selected airspeed
- MCP SPD is the DFCS pitch mode.

During LVL CHG descent, the A/T sets the thrust to idle, and the DFCS uses the elevators to hold the selected MCP airspeed. The airplane descends to the selected altitude on the MCP. At level-off to this altitude, the A/T engages in speed mode and controls the throttles to provide engine thrust to keep the airplane at the MCP speed. The DFCS changes from LVL CHG to ALT HOLD pitch mode and uses the elevators to hold the MCP altitude.

V/S Descent

The V/S mode is another DFCS pitch mode used for descent (or climb). You push the V/S mode switch on the MCP to arm V/S, then set the V/S rate with the thumbwheel. These are the mode annunciations:

- A/T goes to MCP SPD mode
- Speed mode light comes ON
- MCP IAS/MACH window shows selected airspeed
- V/S is the DFCS pitch mode.

In the DFCS V/S mode, the A/T controls thrust to keep a target airspeed on the MCP. The DFCS uses the elevators to control to a V/S descent rate on the MCP, and the airplane descends to the target altitude on the MCP. When the airplane gets to the selected altitude, the A/T stays in the speed mode as it increases thrust to continue to maintain the MCP selected target airspeed. The DFCS changes from the V/S mode to ALT HOLD mode and uses the elevators to control and hold the MCP altitude.

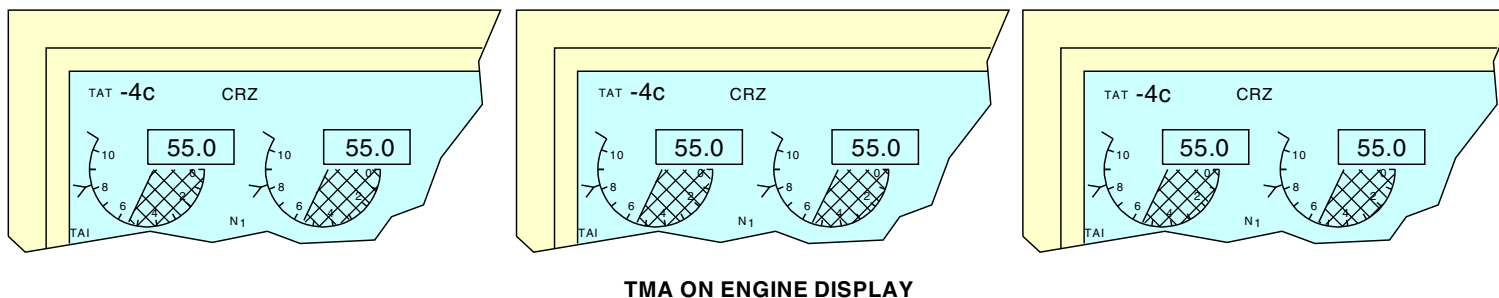
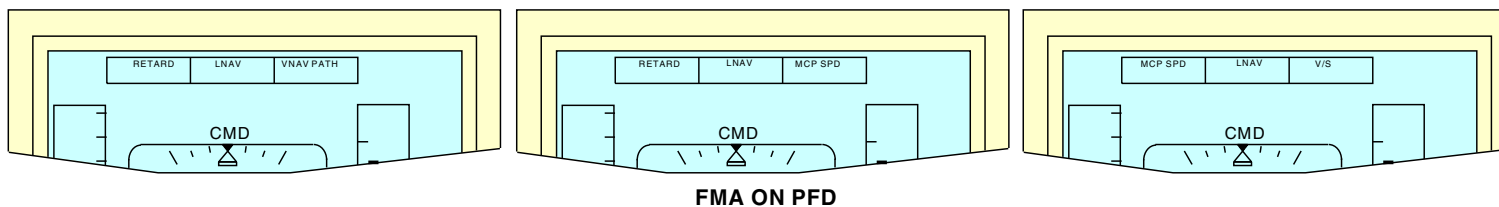
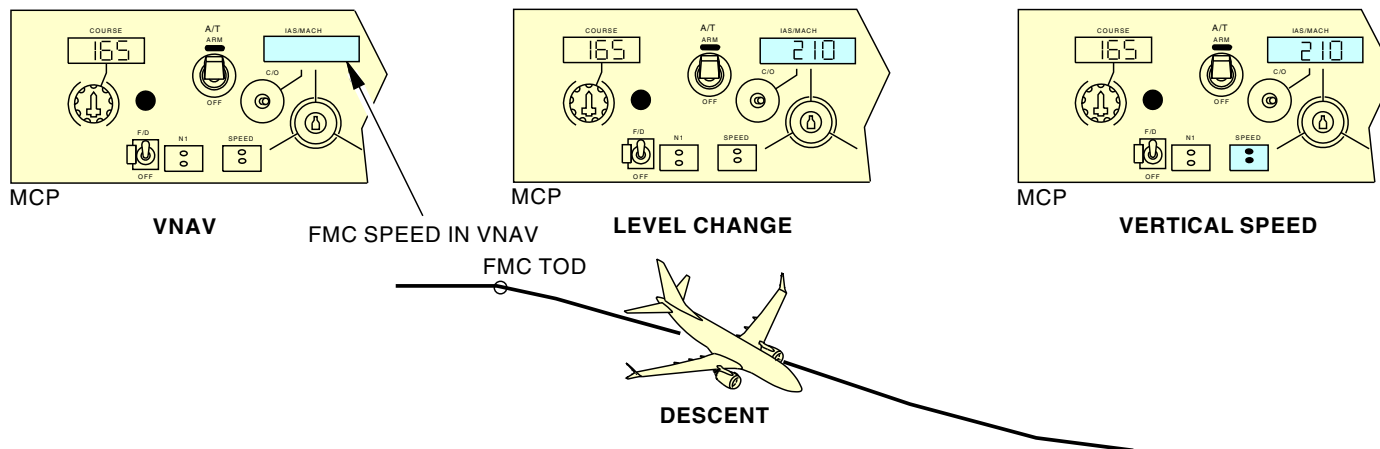
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SIA ALL EFFECTIVITY

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A/T SYSTEM - OPERATION - DESCENT



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A/T SYSTEM - OPERATION - DESCENT

22-31-00

**A/T SYSTEM - OPERATION - APPROACH****General**

During descent and before glideslope capture, the A/T is in either the ARM mode or speed mode, depending on the mode selected.

Descent Retard

During DFCS VNAV descent before glideslope capture, the A/T will normally be in descent retard and set thrust to idle or it may be in speed mode, depending on the DFCS pitch mode selected. These are the indications during descent in VNAV SPD:

- A/T retards T/Ls to idle
- RETARD mode annunciates on the FMA then ARM
- N1 and Speed mode lights are off on the MCP
- MCP IAS/MACH window is blank.

To use the A/T in speed mode during descent, select speed mode on the MCP. The DFCS can also select the A/T speed mode. These are the indications during descent in A/T MCP SPD:

- A/T is in MCP SPD mode on FMA
- A/T Speed mode light is ON on the MCP
- MCP IAS/MACH window shows pilot selected speed.

Glideslope (G/S) Capture

During descent, the DFCS approach mode (APP) may be selected. At glideslope capture, the A/T mode is MCP SPD. The DFCS pitch mode is G/S as the DFCS uses the elevator to hold the glideslope vertical path. The A/T uses the selected speed on the MCP to adjust the T/Ls for speed during the remainder of the approach. During the approach, the pilot extends flaps and reduces the airspeed on the MCP. These are the indications after G/S capture:

- A/T goes to MCP SPD mode and Speed mode light is ON
- MCP IAS/MACH window shows the selected airspeed.

Flare Retard

During the approach while on glideslope, the A/T mode is MCP SPD. At 50 feet radio altitude, the DFCS starts the flare maneuver to touchdown and sends a flare discrete to the A/T. FLARE shows as the active DFCS pitch mode on the FMA. During DFCS flare, the A/T stays in MCP SPD mode until 24 feet radio altitude and then commands flare retard and the T/Ls move to the aft stops. These are the indications during flare:

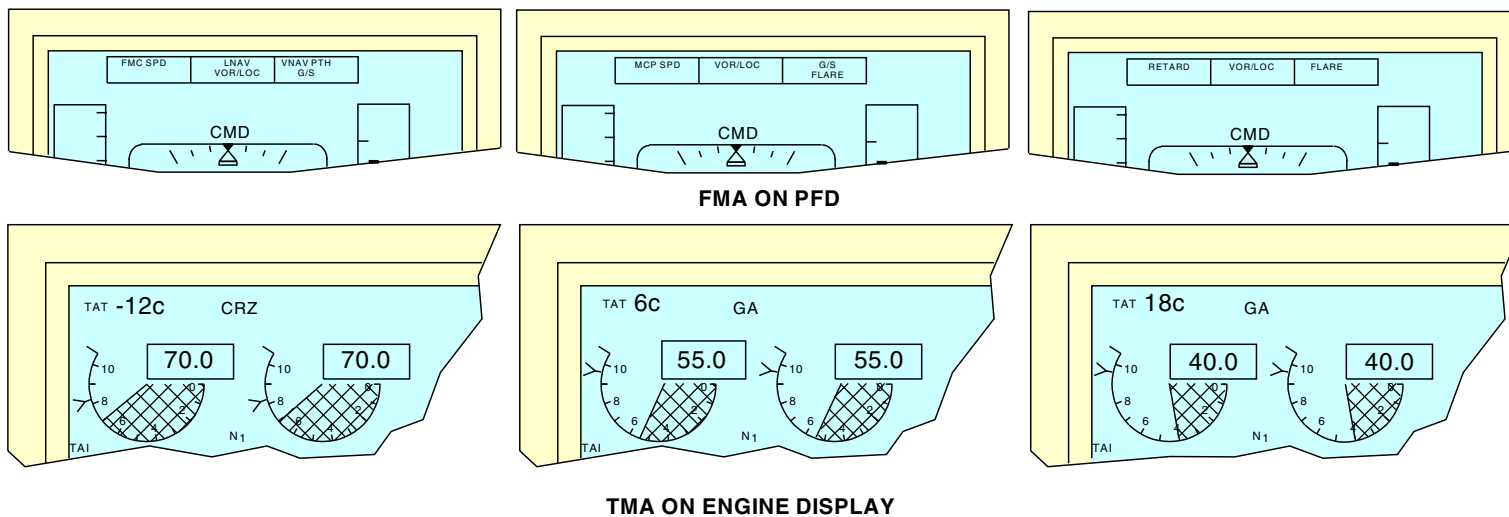
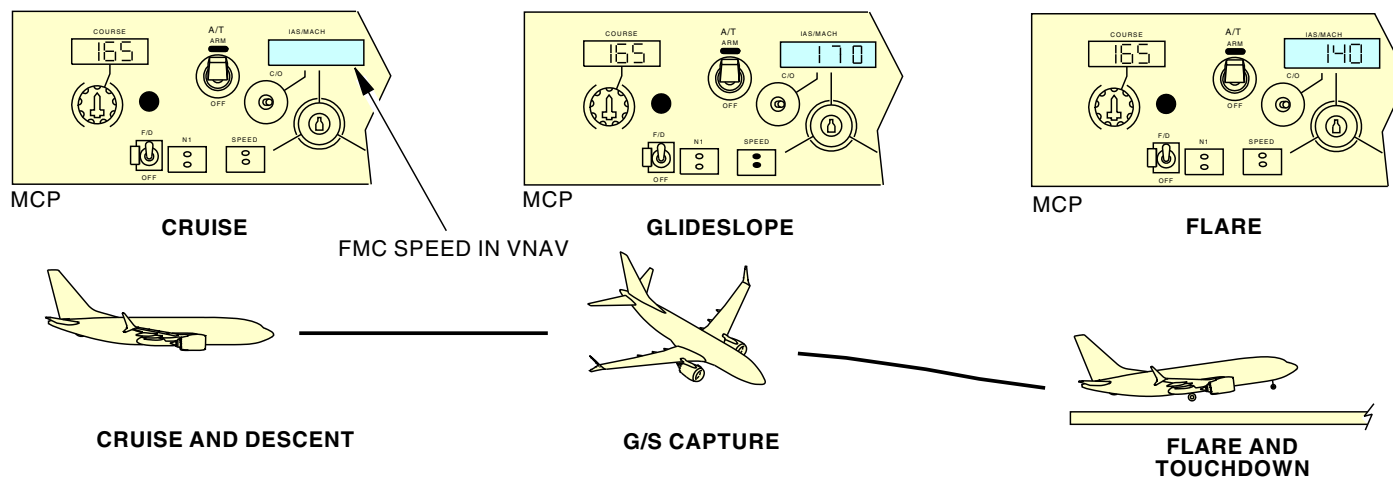
- A/T mode changes from MCP SPD to RETARD
- A/T mode lights are off.

If the DFCS is not engaged for the approach, the A/T goes into flare retard at 27 ft radio altitude if on glideslope in MCP SPD mode and flaps more than 12.5 degrees.

If the DFCS is not engaged for approach, and the two radio altimeter indications disagree with each other by more than 20 feet for more than 2 seconds, flare retard mode is inhibited.

The A/T disengages two seconds after touchdown. The A/T mode on the FMA is blank. There are no aural or visual warnings when the A/T disengages during a normal landing.

A/T SYSTEM - OPERATION - APPROACH



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A/T SYSTEM - OPERATION - APPROACH

22-31-00



A/T SYSTEM - OPERATION - GO-AROUND

General

During approach to landing while on glideslope, the A/T is in the speed mode and controls engine thrust to control to the selected MCP airspeed. The A/T arms for go-around when below 2000 feet RA. After it is armed, if you push TO/GA during the approach, the A/T goes to the go-around mode and increases thrust for go-around climb.

The A/T may be used for go-around with or without the DFCS engaged. For an autopilot go-around, both autopilots must have been engaged in command mode prior to pushing TO/GA. During go-around, the DFCS uses the elevators to control pitch to hold the airspeed selected on the MCP, while the A/T controls thrust.

Reduced Thrust Go-Around

You push a TO/GA switch to enter go-around mode. The A/T moves the thrust levers forward and engine thrust increases for the go-around climb. These are the indications for go-around:

- GA becomes the A/T mode on FMA (reduced thrust)
- T/Ls move forward for reduced thrust go-around
- GA is the FMC thrust mode
- N1 ref cursors are at FMC max go-around N1 limit.

After the first push of a TO/GA switch, the A/T commands reduced go-around thrust to achieve a nominal climb rate. The A/T calculates a thrust value to achieve an eight percent climb gradient. Normally, this will be less than the full rated go-around thrust available.

Maximum Thrust Go-Around

During go-around when you push a TO/GA switch a second time, the A/T moves the thrust levers to the full-rated go-around N1 calculated by the FMC. The A/T mode indications on the FMA and the FMC thrust mode indications on the engine display are the same as for reduced thrust go-around except for these changes:

- A/T changes from GA to N1 mode on FMA (max thrust)
- T/Ls move forward to FMC N1 limit for max thrust.

Level-Off At Altitude

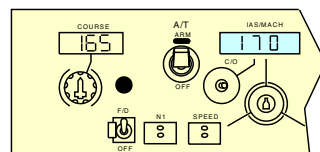
During go-around, the DFCS pitch mode annunciates TO/GA on the FMA. When the airplane gets near the MCP altitude, the A/P acquires and levels off at this altitude and goes to ALT HOLD mode. The A/T mode changes from N1 (or GA) to MCP SPD as the A/T controls the thrust levers to control to the airspeed selected on the MCP.

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EFFECTIVITY	
SIA ALL	

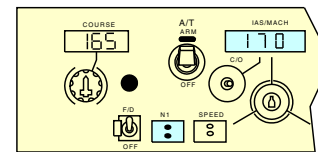
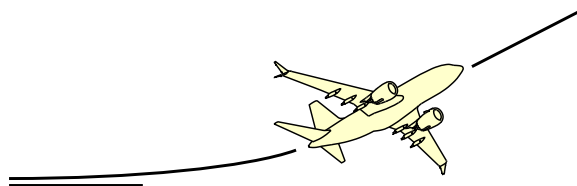
D633AM102-SIA

A/T SYSTEM - OPERATION - GO-AROUND



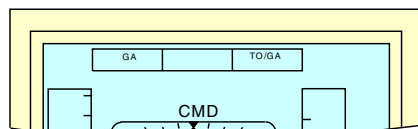
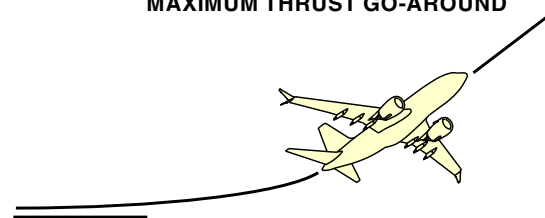
MCP

REDUCED THRUST GO-AROUND

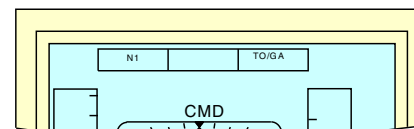


MCP

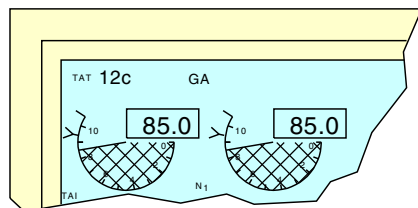
MAXIMUM THRUST GO-AROUND



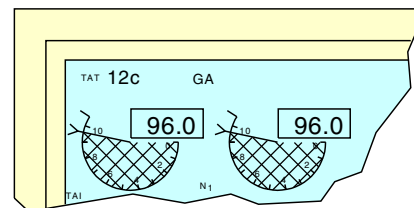
FMA ON PFD



FMA ON PFD



TMA ON ENGINE DISPLAY



TMA ON ENGINE DISPLAY

2368658 S00061517851_V1

A/T SYSTEM - OPERATION - GO-AROUND

22-31-00

SIA ALL EFFECTIVITY

D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details



A/T SYSTEM - SUMMARY

General

This page is for reference.

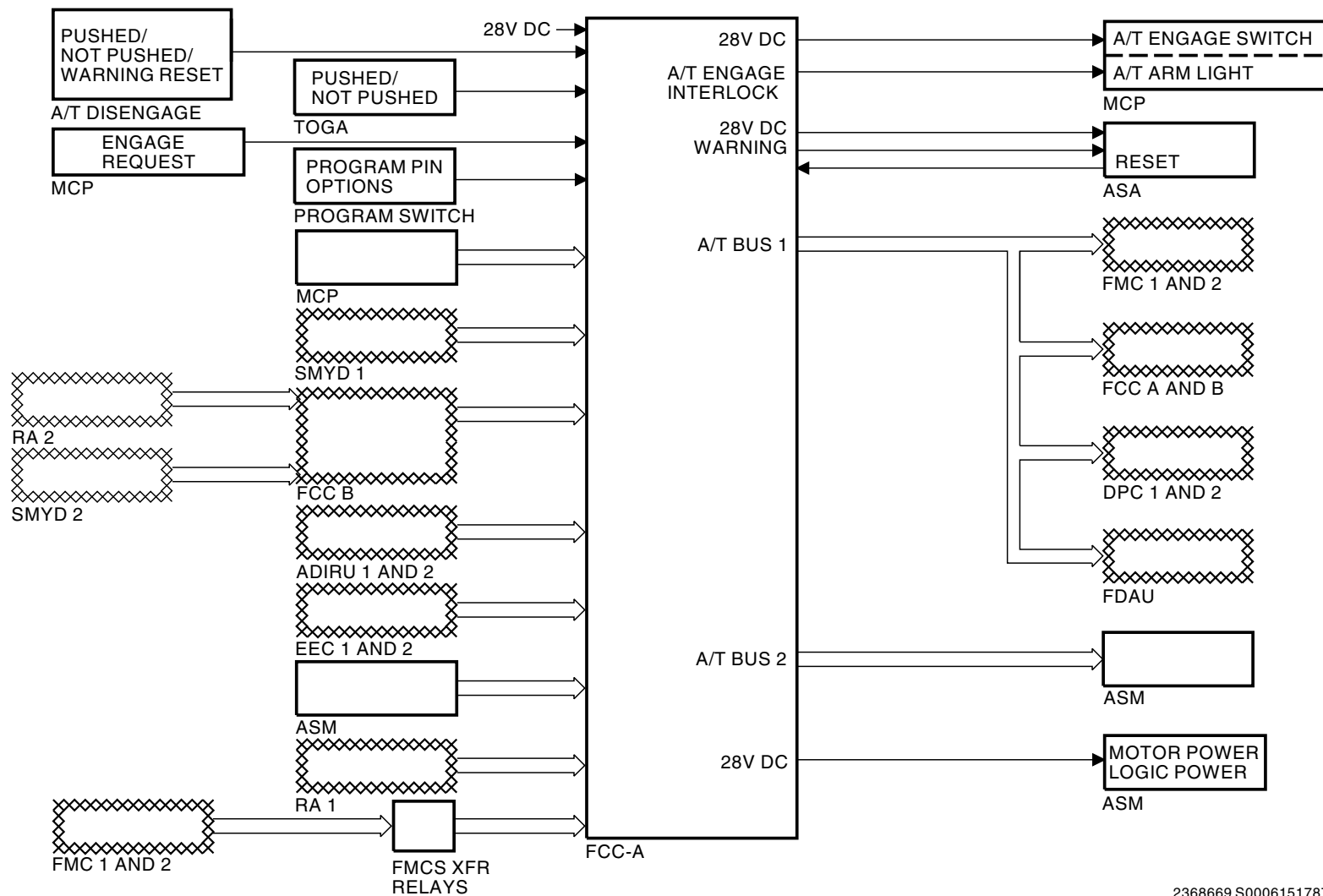
22-31-00-036

SIA ALL	EFFECTIVITY
	D633AM102-SIA

ECCN 9E991 BOEING PROPRIETARY - See title page for details

22-31-00

A/T SYSTEM - SUMMARY



A/T SYSTEM -SUMMARY

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