

CHAPTER

80

Engine Starting GE 115

(GE90-100 SERIES ENGINES)

CHAPTER 80
ENGINE STARTING GE 115

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**CHAPTER 80
ENGINE STARTING GE 115**

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ENGINE STARTING - INTRODUCTION

General

The engine starting system uses pneumatic power to turn the N2 shaft during an engine start. You also use the system to motor the engine.

The engine starting system operates on the ground and in the air. Flight deck switches and the EEC control the system.

The engine starting system uses these pneumatic power sources:

- Auxiliary power unit (APU)
- Ground power unit (GPU)
- Opposite operating engine.

- stby - standby
- typ - typical
- vlv - valve

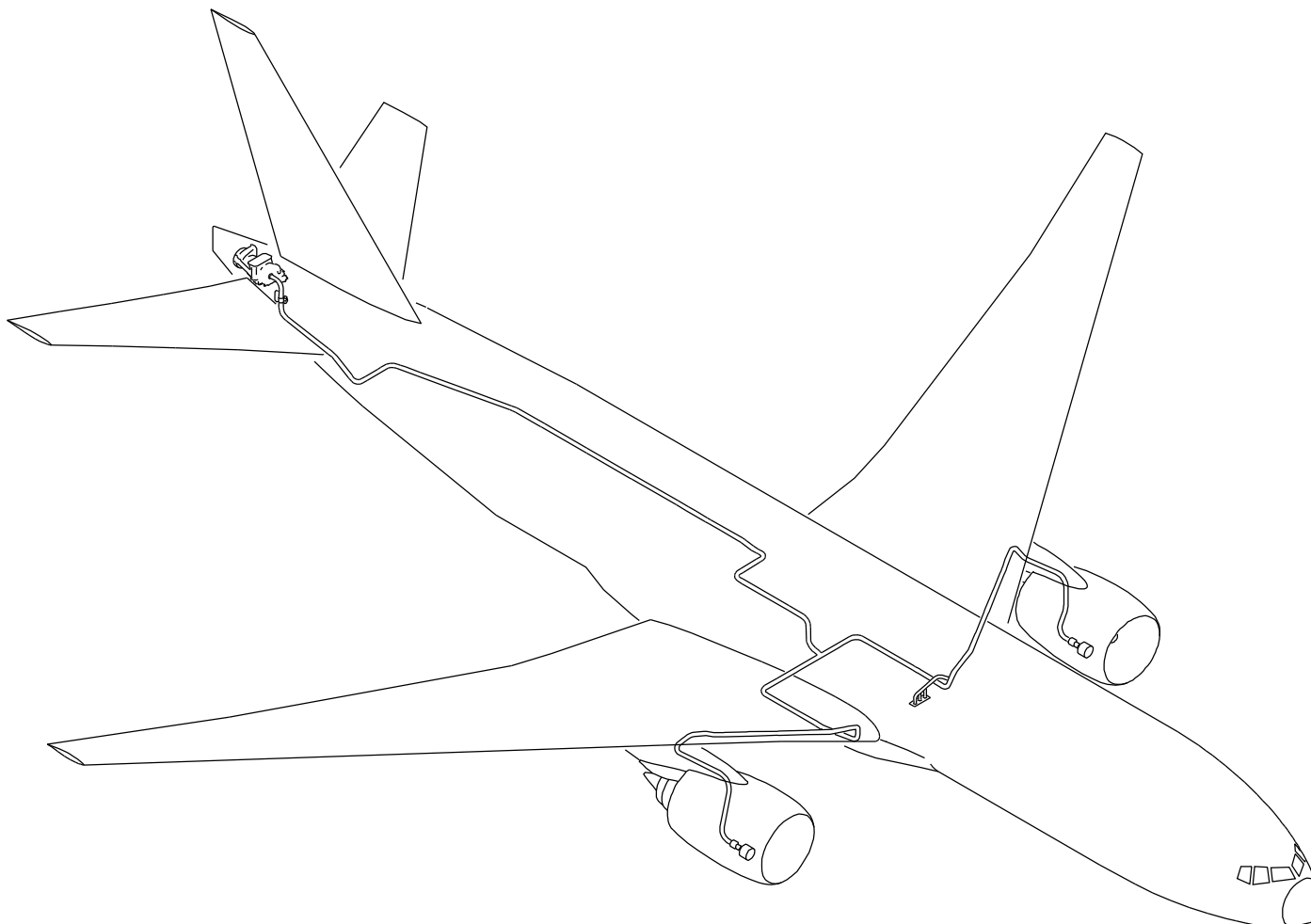
Abbreviations and Acronyms

- AIMS - airplane information management system
- APU - auxiliary power unit
- ASCPC - air supply cabin pressure controller
- capt - captain
- EEC - electronic engine control
- EDIU - engine data interface unit
- EICAS - engine indication and crew alerting system
- ELMS - electrical load management system
- flt - flight
- GPU - ground power unit
- inst - instrument
- LRU - line replaceable unit
- max - maximum
- mgmt - management
- OPAS - overhead panel ARINC system
- PRSOV - pressure regulating and shutoff valve
- QAD - quick attach detach
- SAV - starter air valve

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ENGINE STARTING - INTRODUCTION

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**ENGINE STARTING - GENERAL DESCRIPTION****General**

The EEC controls the engine starting system using these inputs:

- (1) Flight Deck Controls
- (2) Electrical Power
- (3) Pneumatic Power.

Start Selection

The engines can be started manually or automatically, you control the type of start with the autostart switch.

The autostart switch sends a signal to the EEC on the systems ARINC 629 buses. When the autostart switch is in the ON position, the EEC controls fuel and ignition, and monitors the engine parameters. The fuel control switch must be in the RUN position for the EEC to do an autostart.

When the autostart switch is in the OFF position, you manually control and monitor the engine start.

Engine Starting

When you put the start/ignition selector to the START position it does these functions:

- (1) Energizes a relay in the ELMS to supply 115v ac power to the EEC.
- (2) Energizes a relay in the ELMS to supply 28v dc power to the EEC to open the SAV.
- (3) Sends analog and digital start signals to the EEC.
- (4) Sends a discrete signal to the air supply cabin pressure controller (ASCPC).

The AIMS supplies a ground for a solenoid that holds the engine start/ignition selector in the START position. The EEC sends a digital signal to tell the AIMS when to release the selector. If the AIMS does not receive the signal from the EEC, it uses N2 to decide when to release the selector.

See the engine air supply section for more information about the ASCPC (SECTION 36-11).

Starter Air Valve and Engine Starter

The EEC controls the Starter Air Valve (SAV). When the valve is open, pneumatic power from the airplane air supply goes to the engine starter. This causes the engine starter to turn the N2 rotor.

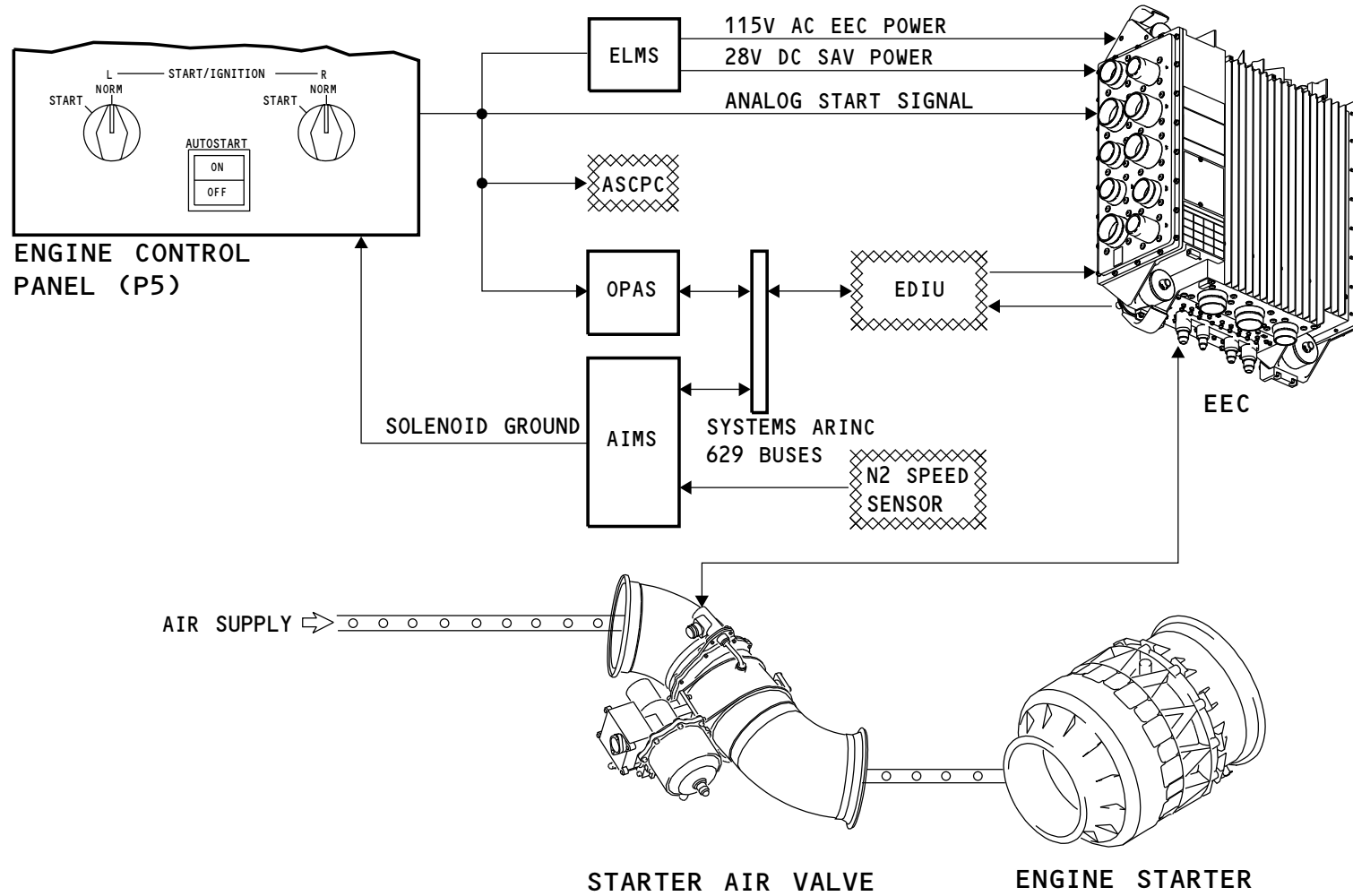
The starter air valve has a pressure sensor that measures the pressure downstream of the valve. The sensor sends a signal to the EEC. The EEC uses this to find the valve position.

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ENGINE STARTING - GENERAL DESCRIPTION

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**ENGINE STARTING - COMPONENT LOCATIONS - ENGINE****General**

You open the fan cowls and thrust reversers to get access to these engine starting system components:

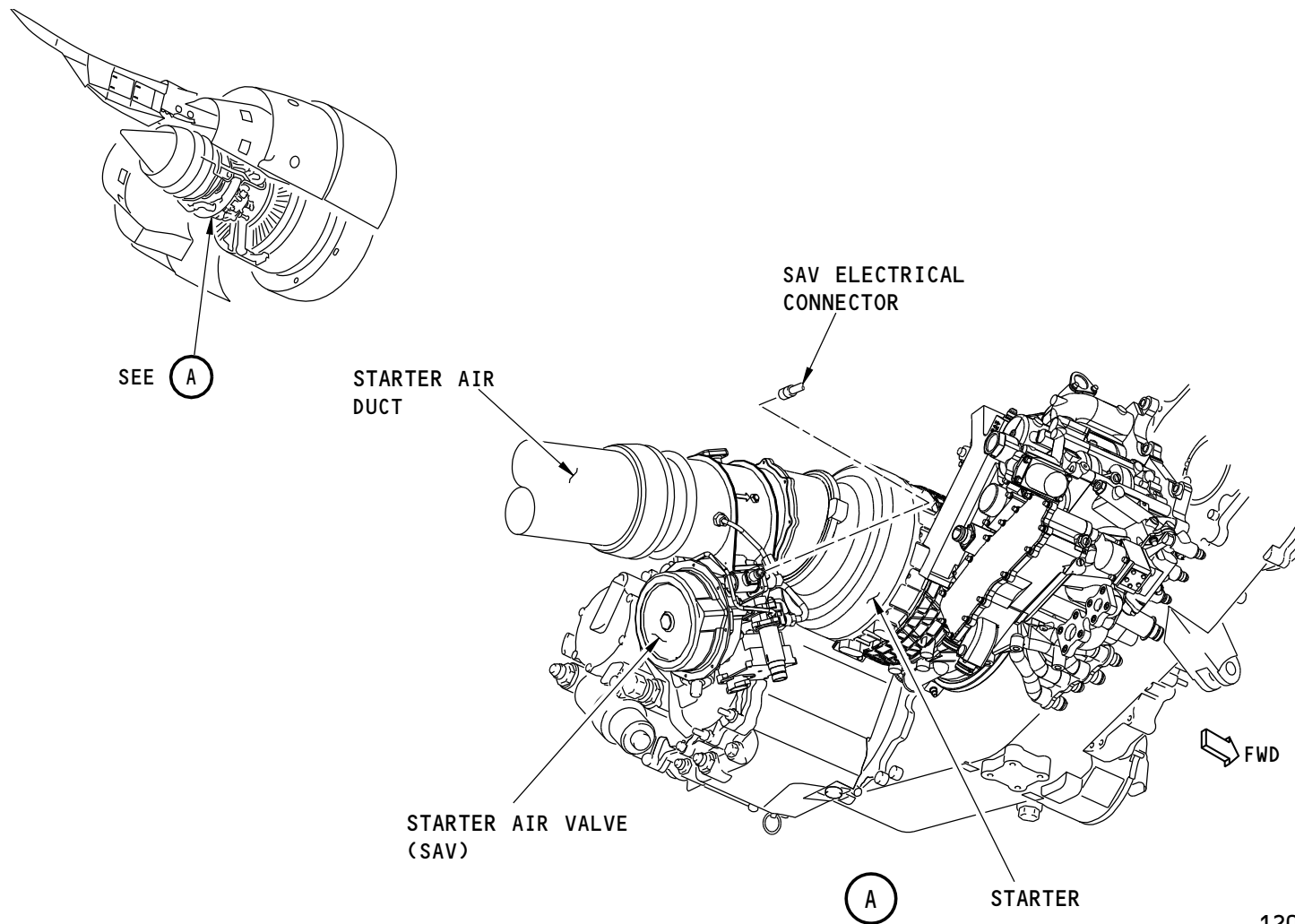
- Starter air duct
- Starter air valve
- Starter manual override cable
- Starter air pressure sensor
- Engine starter.

All of the engine starting system components are just aft of the accessory gearbox.

Training Information Point

Before performing maintenance on the Starter Air Valve (SAV), make sure the pneumatic system is depressurized.

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ENGINE STARTING - COMPONENT LOCATIONS - ENGINE

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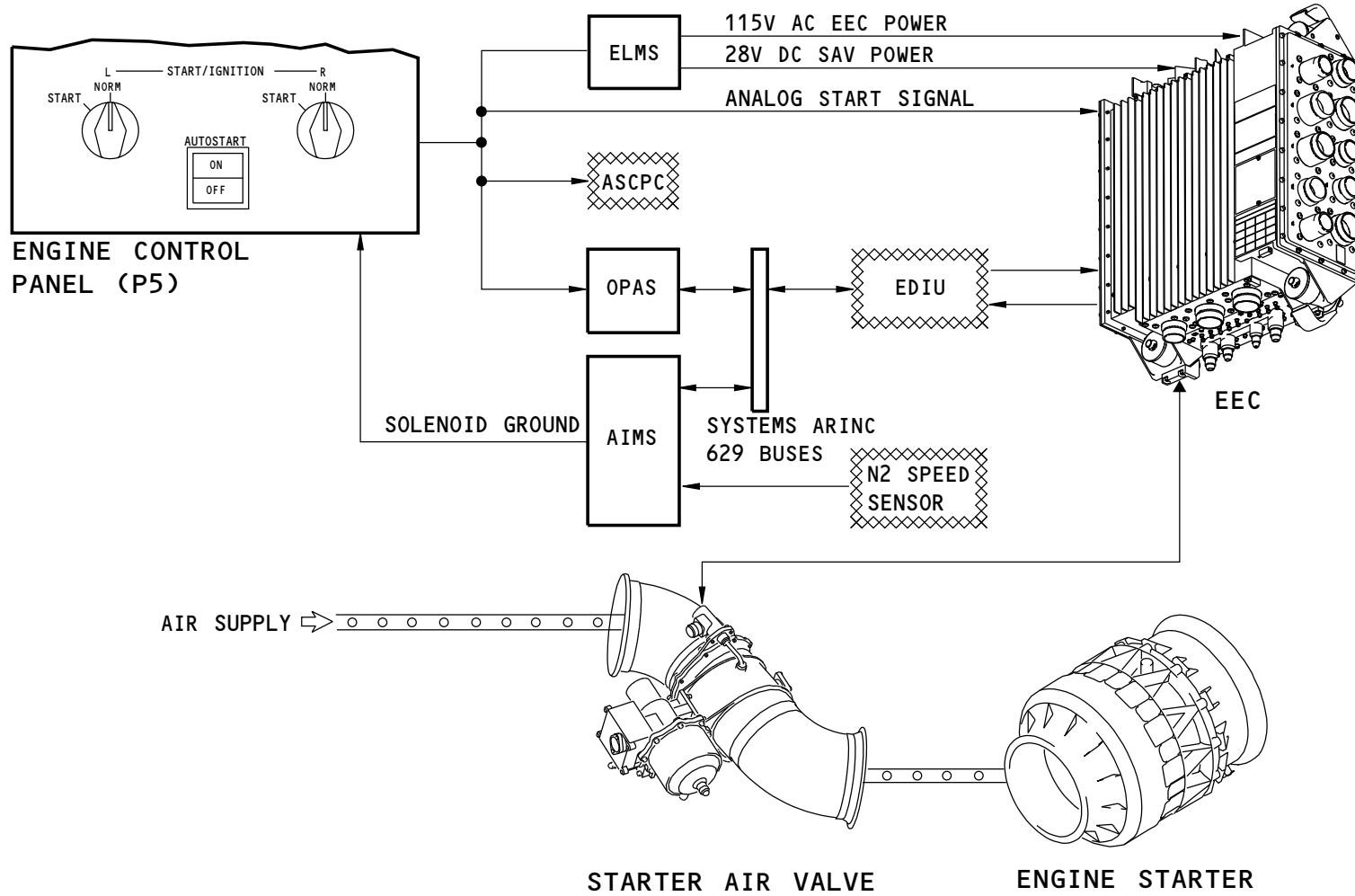


ENGINE STARTING - COMPONENT LOCATIONS - FLIGHT DECK

Engine Start Controls

The engine start/ignition selectors and the autostart switch are on the cargo fire/engine control panel on the P5 overhead panel.

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ENGINE STARTING - COMPONENT LOCATIONS - FLIGHT DECK

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**ENGINE STARTING - STARTER AIR VALVE AND STARTER AIR PRESSURE SENSOR****General**

The starter air valve (SAV) opens to supply air to the engine starter.

The starter air pressure sensor supplies an air pressure signal to the EEC.
The EEC uses the signal to find the valve position.

Starter Air Valve

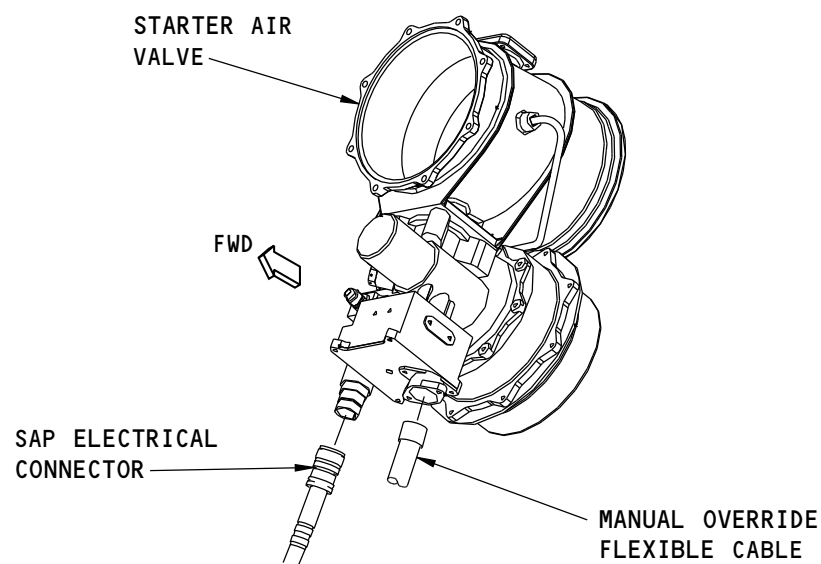
The SAV is a butterfly-type valve. A spring holds the (SAV) closed. When the EEC energizes the valve solenoid, servo air from the starter air duct opens the valve.

The SAV has a connection for a manual override flex cable. The flex cable permits you to manually open and close the valve if it does not operate automatically. The valve position indicator is near the flex cable connection.

Starter Air Pressure Sensor

The starter air pressure sensor monitors starter duct pressure downstream from the SAV. If pressure is in the duct, the sensor sends a signal to each channel of the EEC.

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ENGINE STARTING - STARTER AIR VALVE AND STARTER AIR PRESSURE SENSOR

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**ENGINE STARTING - STARTER AIR VALVE - MANUAL OVERRIDE****General**

If the starter air valve (SAV) does not open automatically, you can manually open the valve.

Location

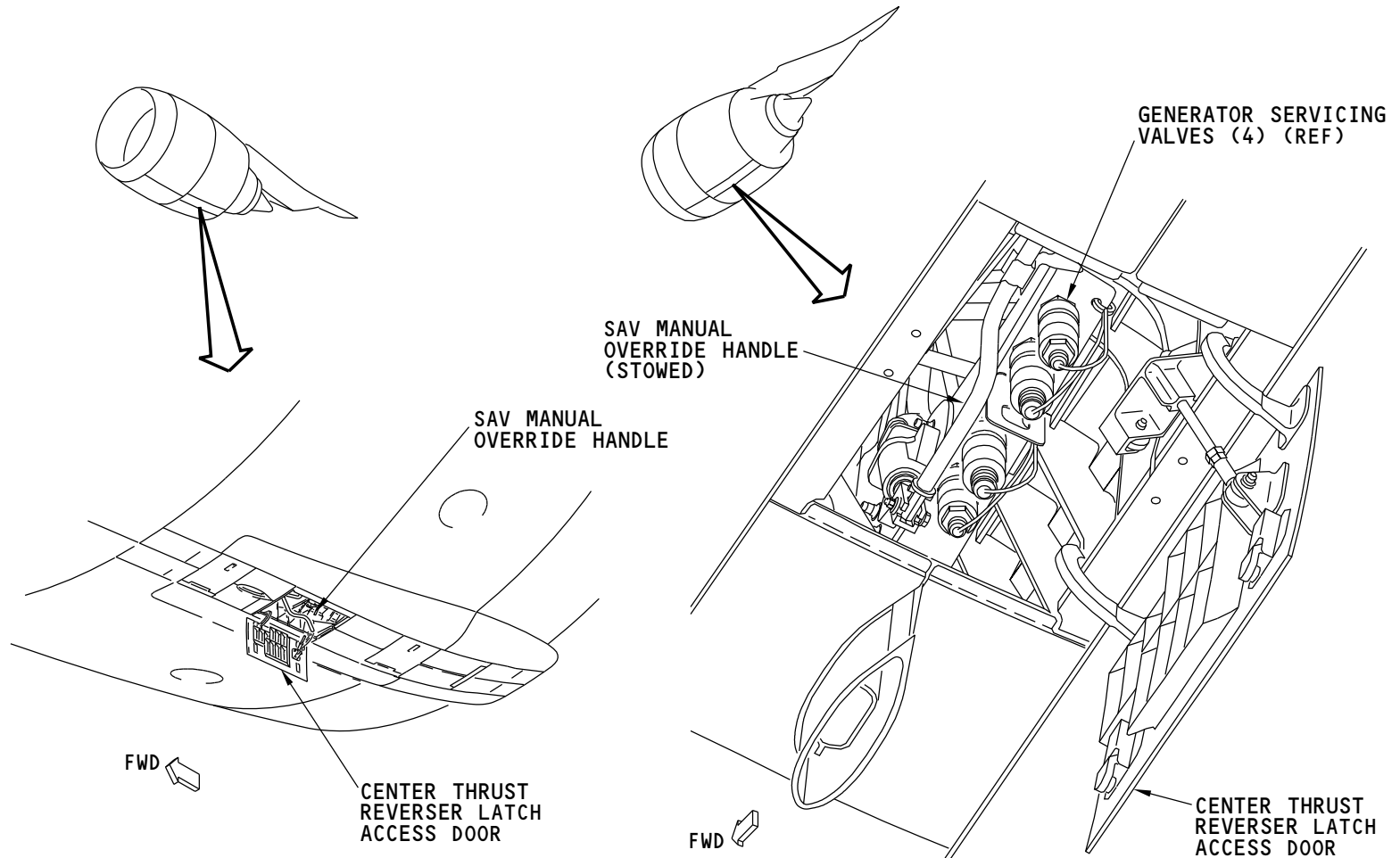
You open the center thrust reverser latch access door to get access to the starter air valve manual override handle. The handle folds down and extends out through the access opening.

Operation

Rotate the handle down, then push the handle up to engage it with the manual override flex cable. Turn the handle to open the valve (clockwise as seen looking up at the bottom of the engine). The valve has a spring that closes it, so you must hold the handle to keep the valve open. When you release the handle, the valve closes.

**CAUTION**

MAKE SURE THAT THERE IS AIR PRESSURE IN THE STARTER AIR DUCT. IF THERE IS NO AIR PRESSURE, DAMAGE TO THE STARTER AIR VALVE CAN OCCUR.



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ENGINE STARTING - STARTER AIR VALVE - MANUAL OVERRIDE

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**ENGINE STARTING - ENGINE STARTER****Purpose**

The engine starter turns the accessory gearbox for starting or motoring the engine. The accessory gearbox turns the high pressure compressor (N2) shaft.

Physical Description

The engine starter is a single stage, axial flow, turbine air motor. It attaches to the aft face of the accessory gearbox with a v-band clamp.

The starter has an oil sight glass and an oil fill and drain plug on the bottom. The plug has a magnetic chip detector for oil inspection. You remove the oil fill and drain plug by hand (push and turn). A check valve in the fill and drain port prevents oil from coming out.

Functional Description

Pneumatic power from the starter air duct turns the turbine air motor. The turbine air exhaust then goes out through the exhaust deflector baffles.

The starter uses reduction gears and a clutch mechanism to turn the output shaft. The clutch mechanism has a primary and a secondary clutch that prevent crash engagements.

Training Information Point

The engine starter uses engine oil for lubrication and cooling.

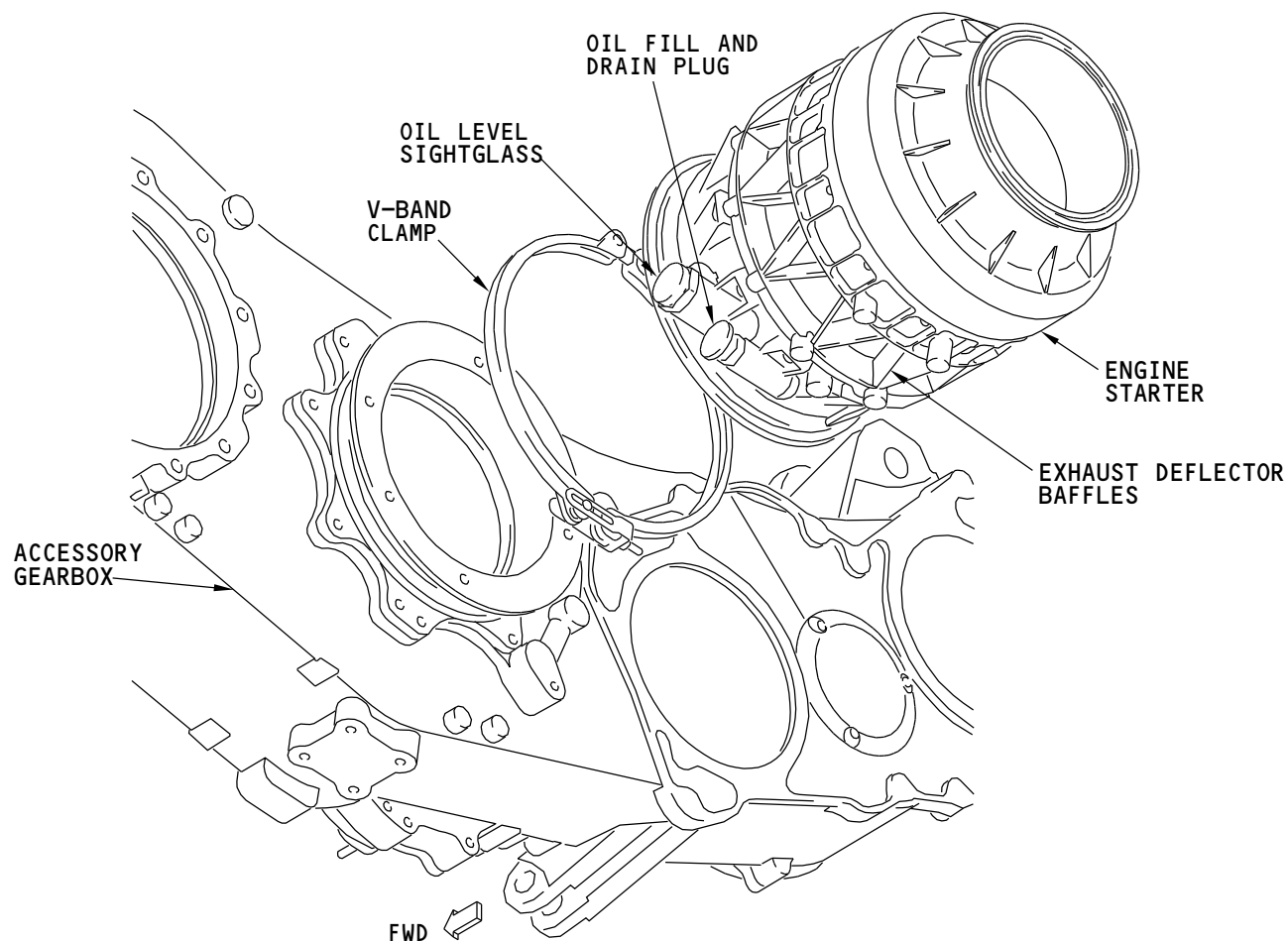
When you install a new starter, you must fill it with oil. After that, it is not necessary to add oil to the starter because it is automatically kept full with oil from the engine oil system.

You use a tool in the oil fill and drain plug port to drain and fill the starter. Do not use the oil level sightglass to get the correct oil level.

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ENGINE STARTING - ENGINE STARTER

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ENGINE STARTING - FUNCTIONAL DESCRIPTION**General**

You control the engine starting system with the autostart switch and the start/ignition selector. The EEC automatically controls the starter air valve (SAV).

Autostart Switch

The position of the autostart switch goes to the EEC digitally. When the switch is in the ON position, it arms the EEC to do an autostart operation.

Start/Ignition Selector

When you put the start/ignition selector in the START position, it sends signals to these systems and components:

- ELMS
- ASCPC
- EEC
- AIMS.

ELMS Power

The ELMS supplies 28v dc power from the captain's flight instrument bus to energize the engine start control relay. This lets 28v dc power go through the EEC to energize the SAV solenoid.

ASCPC

The ASCPC uses the start signal to control the pressure regulating and shutoff valve (PRSOV) and the isolation valves in the pneumatic system. During an engine start, the ASCPC closes the related PRSOV and opens the applicable isolation valve(s). See the engine air supply section for more information about the ASCPC (SECTION 36-11).

EEC

The EEC gets an analog start signal directly from the start/ignition selector. It also gets a digital start signal through the EDIU. These signals tell the EEC that there is a command to open the SAV.

When you put the start/ignition selector in the START position, 28v dc power goes through the EEC to energize the SAV solenoid.

The SAV logic in the EEC removes the 28v dc power from the SAV solenoid at the starter cutout speed (approximately 64 percent N2). This causes the SAV to close.

The SAV logic does not let 28v dc power energize the SAV solenoid if the N2 is more than the maximum starter engagement limit.

When the start/ignition selector moves to the NORM position, the engine start control relay de-energizes. This removes 28v dc power to the EEC.

Both channel A and channel B of the EEC get a signal of the duct pressure downstream of the SAV. The EEC uses these signals to find the SAV position.

AIMS

The AIMS controls the latching solenoid that keeps the start/ignition selector in the START position. The solenoid cannot move the selector. It only holds it in the momentary START position.

The EEC sends a digital engine start signal to the AIMS. This signal is set true when the engine start begins. When the engine start signal is true, the AIMS latches the selector by energizing the solenoid.

The EEC sets the engine start signal false when any of these conditions occur:

- The EEC aborts an autostart process
- The engine gets to the starter cutout speed (approximately 64 percent N2)

When the engine start signal is false, the AIMS releases the selector by de-energizing the solenoid. The selector automatically moves to the NORM position when the solenoid de-energizes.

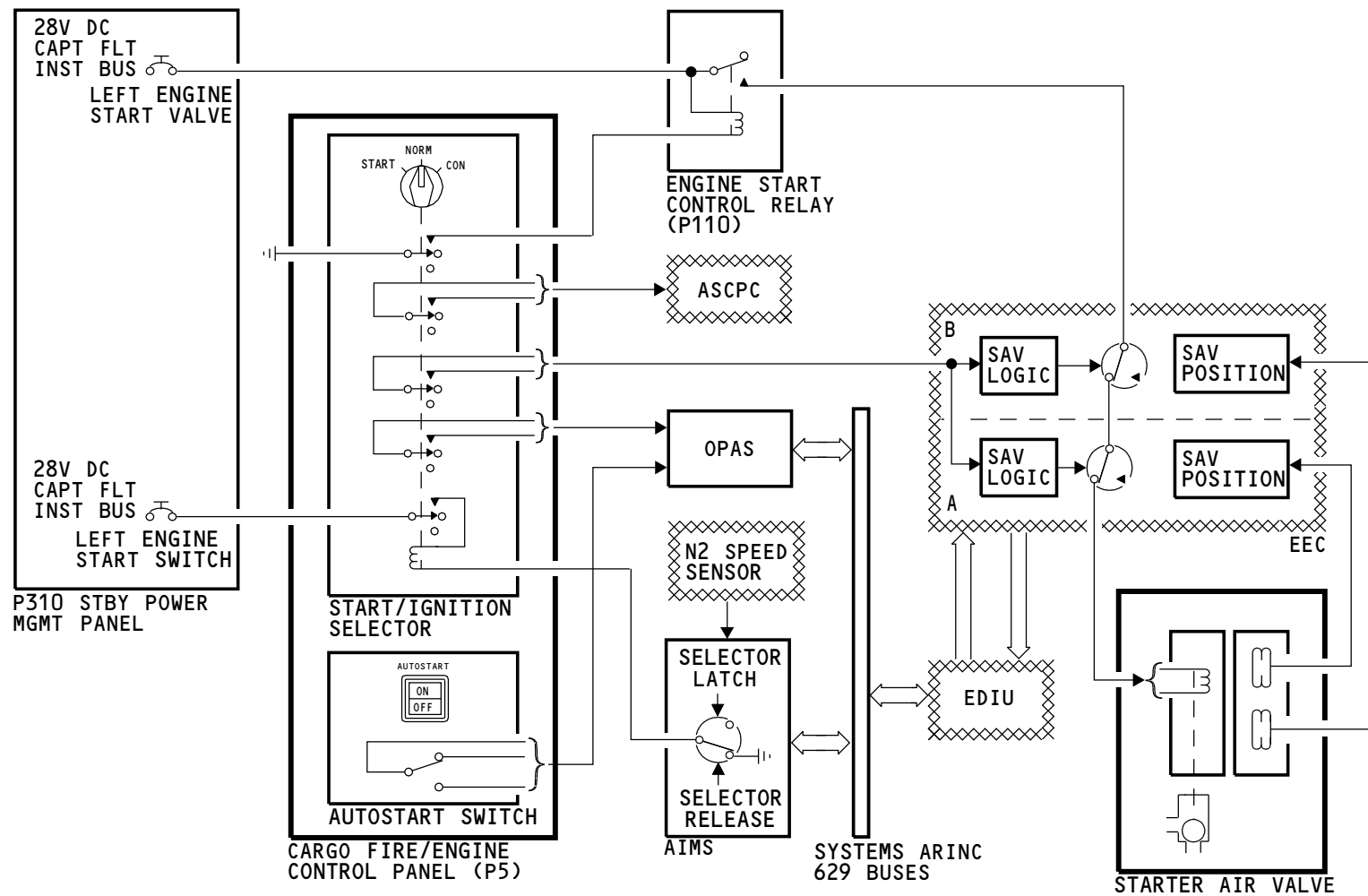
If the digital engine start signal is not valid or is not available, the AIMS uses the analog N2 signal from the N2 speed sensor to control the latching solenoid. Less than 60 percent N2, the solenoid energizes. More than 60 percent N2, the solenoid de-energizes.

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ENGINE STARTING - FUNCTIONAL DESCRIPTION

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ENGINE STARTING - FUNCTIONAL DESCRIPTION - START PROFILE

Normal Autostart

When you enable an autostart, the EEC automatically starts the engine. You enable an autostart by doing these steps:

- Push the autostart switch to ON
- Turn the start selector to START
- Move the fuel control switch to RUN.

The EEC opens the starter air valve (SAV), which causes N2 to rotate.

The EEC starts a timer when N2 gets to 2000 RPM (21.4%). After 15 seconds, the EEC energizes one ignitor. After 18 seconds, the EEC opens the shutoff valve in the HMU to let fuel flow to the engine.

When the engine speed gets to 56 percent N2, the EEC de-energizes the igniter. At 64 percent N2, the EEC closes the SAV.

At idle, the EEC sets the AIMS engine start signal to false. This causes the AIMS to de-energize the start/ignition selector latching solenoid. The selector returns to the NORM position.

Abnormal Autostart

If the EEC finds a problem during an autostart try, it will do another autostart try. The EEC can do three autostart tries.

Before the EEC does a second or third autostart try, it motors the engine to cool it and remove any fuel.

If an autostart problem occurs after the SAV closes, the EEC waits until the engine speed gets to the maximum starter re-engagement speed before it re-opens the SAV.

The EEC uses two igniters after the first autostart try.

Manual Start

When you do a manual start, the EEC only controls some of the start sequence. It does not monitor or control starting faults. You enable a manual start by doing these steps:

- Push the autostart switch to OFF
- Turn the start selector to START.

The EEC opens the SAV, which causes N2 to rotate.

At maximum motor speed (22 percent N2 or higher), you put the fuel control switch in the RUN position. When the fuel control switch is in the RUN position, the EEC opens the shutoff valve in the HMU and energizes one igniter.

When the engine speed gets to 56 percent N2, the EEC de-energizes the igniter. At 64 percent N2, the EEC closes the SAV.

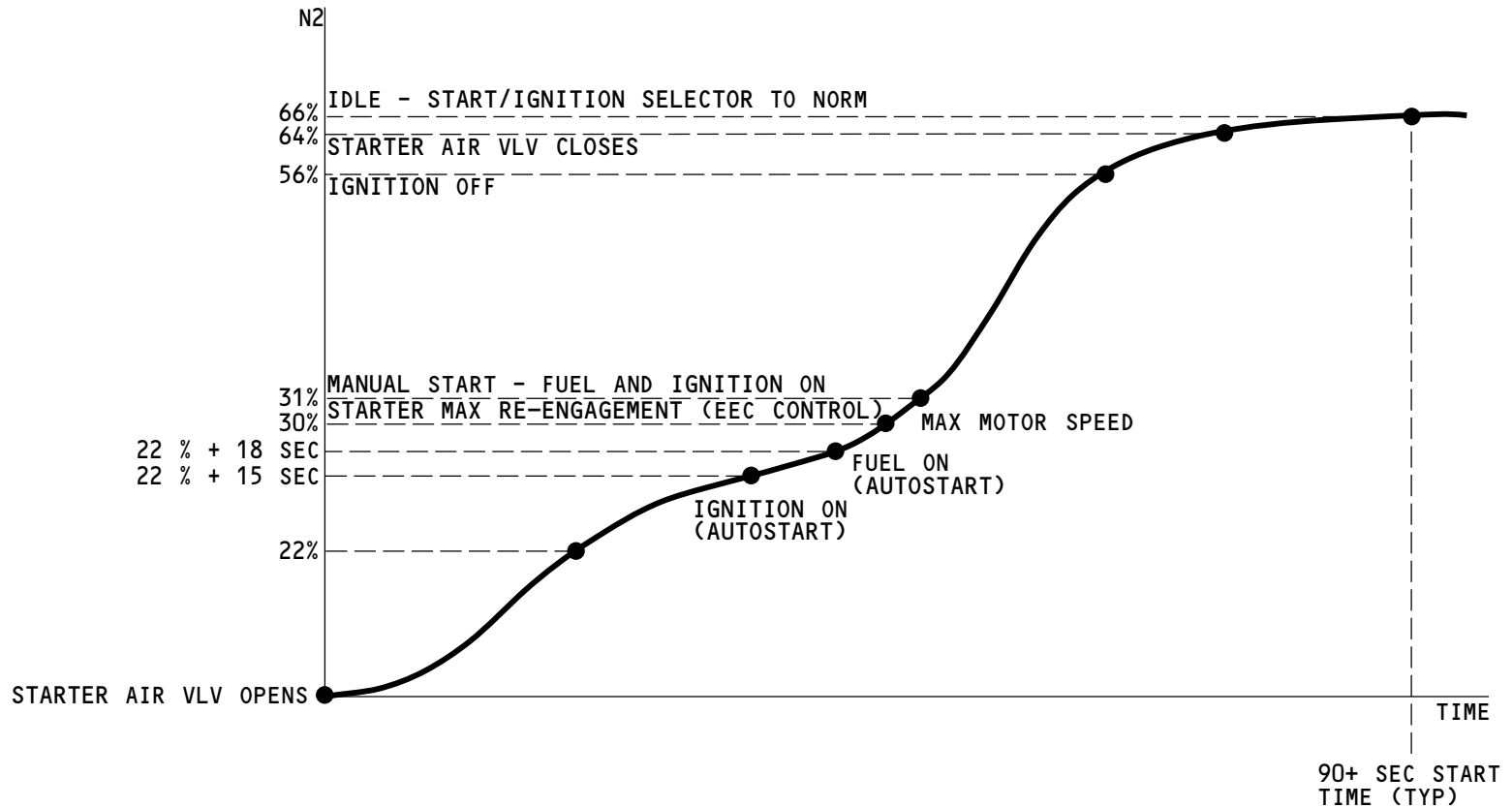
At idle, the EEC sets the AIMS engine start signal to false. This causes the AIMS to de-energize the start/ignition selector latching solenoid. The selector goes back to the NORM position.

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ENGINE STARTING - FUNCTIONAL DESCRIPTION - START PROFILE

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ENGINE STARTING - OPERATION

General

The engine starting system has these modes of operation:

- Autostart
- Manual start.

These are the flight deck controls you use for an engine start operation:

- Start/ignition selectors
- Autostart switch
- Fuel control switches.

It is important to monitor the engine parameters to find or prevent these fault conditions:

- Low starter air pressure
- No light-up
- Locked rotor(s)
- Hung start
- Hot start
- Starter shaft breakage
- Starter duty cycle exceedance.

Autostart Operation

This is a brief summary of the autostart operation procedure:

- Put the autostart switch in ON
- Put the engine start/ignition selector in START
- Put the fuel control switch in RUN.

The EEC automatically controls and monitors the autostart operation. During ground autostarts, the EEC starts a 15-second timer at 2000 rpm (21.4% N2). When the timer ends, ignition starts. The fuel metering valve opens three seconds later. This additional HPC motoring time helps prevent high N2 vibration from a bowed HPC rotor during the start.

The EEC will stop the start sequence for a fault condition. If the autostart fails, the EEC automatically attempts another start operation.

On the ground, the EEC permits only three tries to start the engine. If the third try fails, then the autostart operation stops.

The start/ignition selector moves to the NORM position when one of these conditions occur:

- The N2 speed gets to approximately 66 percent
- The EEC stops the autostart operation.

In the air, the autostart operation continues until the engine starts or you move the start/ignition selector to NORM.

Manual Start Operation

This is a brief summary of the manual start operation procedures:

- Put the autostart switch to OFF
- Put the engine start/ignition selector to START
- Monitor the engine parameters for the correct indications (oil pressure, vibrations, oil temperature)
- Put the fuel control switch in RUN when the starter gets to the MAX motoring speed (1 percent increase in N2 over five seconds).

You must monitor the manual start operation and stop the operation for a fault condition.

Starter Cutout

The EEC closes the starter air valve when the engine gets to 64 percent N2. The valve position shows on the air synoptic display.

Training Information Point

The EEC uses oil pressure as an input to find a starting fault. The EEC will abort the ground autostart sequence when N2 is 52.7% or more and oil pressure is less than 10 psig (69 kPa).

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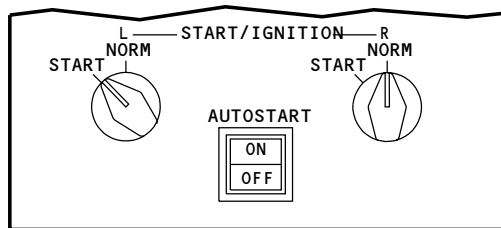
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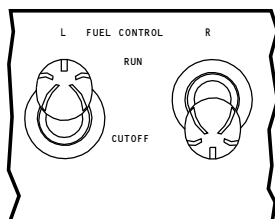
ENGINE STARTING - OPERATION

For a manual start, if the fuel control switch is put to the RUN position at less than 18 percent N₂, the advisory message ENG AUTOSTART shows to tell you the start procedure was incorrect.

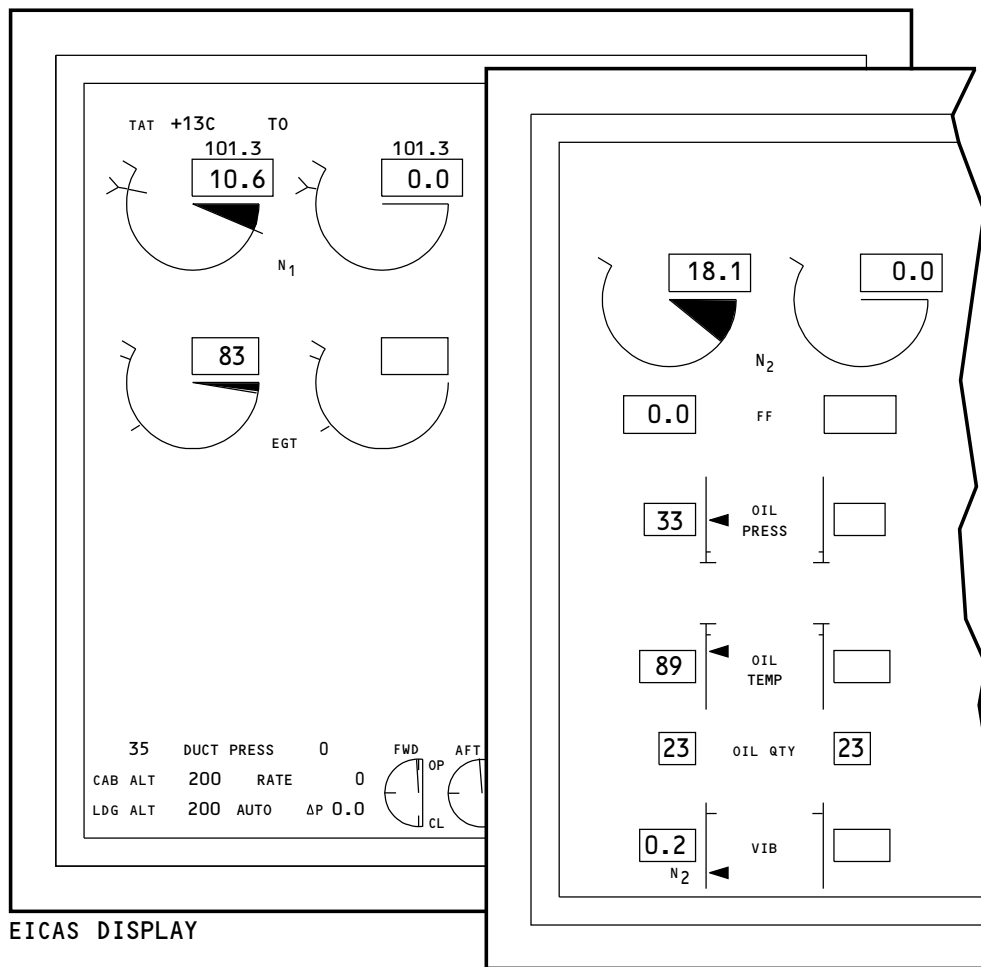
Delay of the fuel on command during start lets the HPC get to its MAX motoring speed. This will decrease the severity of bowed rotor rubs and protect the engine from blade tip damage.



ENGINE START PANEL (P5)



FUEL CONTROL SWITCHES (P10)



EICAS DISPLAY

SECONDARY ENGINE DISPLAY

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ENGINE STARTING - OPERATION

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