FUEL SYSTEM

FUEL DISTRIBUTION SYSTEM

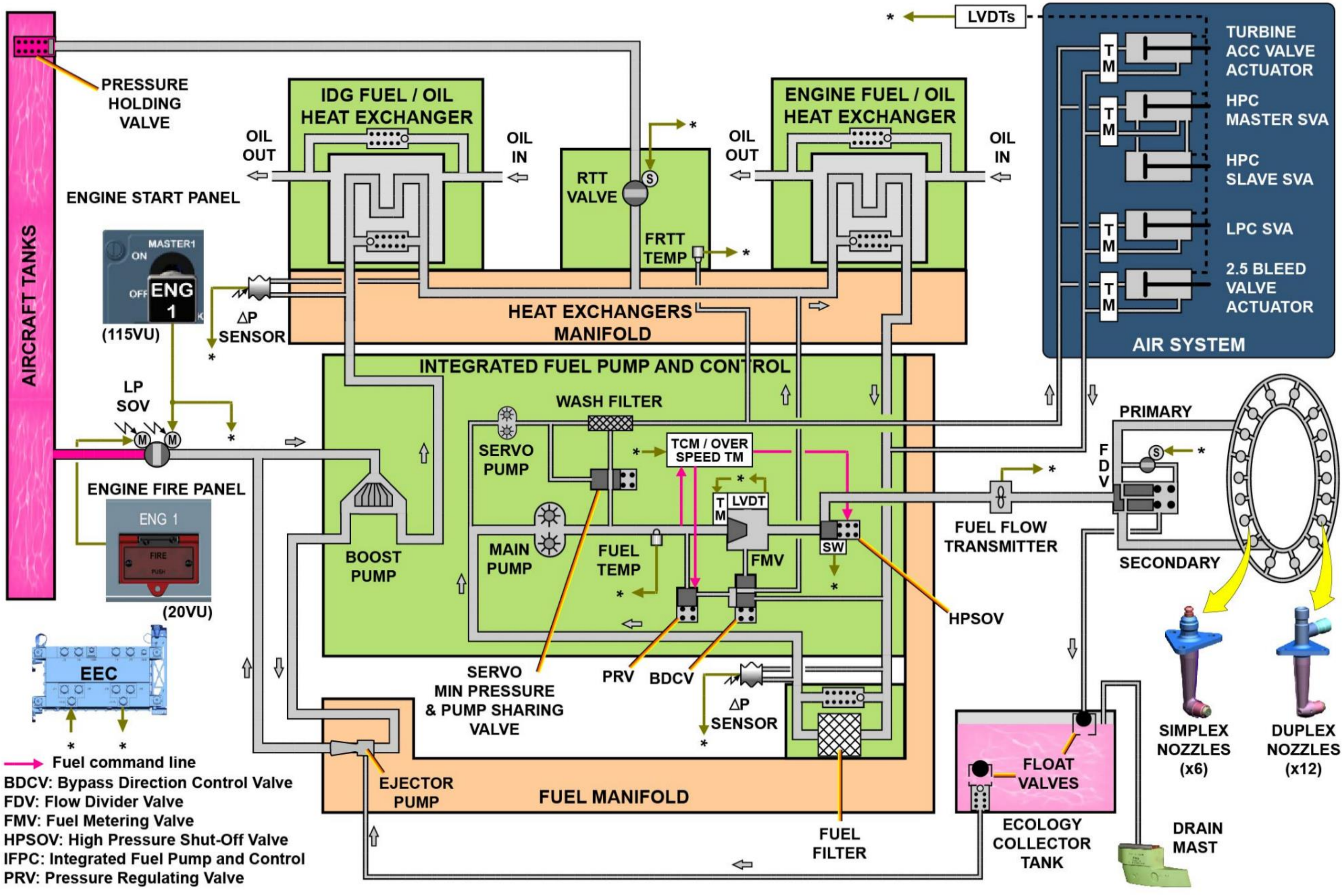
The Fuel Distribution System supplies metered, filtered fuel to the engine at the pressure and flow rate necessary to meet all engine operating requirements.

The fuel is also heated to prevent ice formation.

The system supplies metered fuel to the fuel nozzles for combustion, and sends pressurized fuel to engine component actuators for servo pressure.

System components are shown below.

- Integrated Fuel Pump and Control IFPC
- Fuel Manifold FM
- Fuel filter assembly
- Fuel return pump
- Flow Divider Valve FDV
- Fuel nozzles
- Fuel nozzle supply manifolds
- Ecology collector tank
- Return-To-Tank valve RTT


AIRCRAFT TANKS
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
ENGINE START PANEL
MASTER1
ON
OFF
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
WASH FILTER
LP SOV
SERVO PUMP
TCM / OVER SPEED TM
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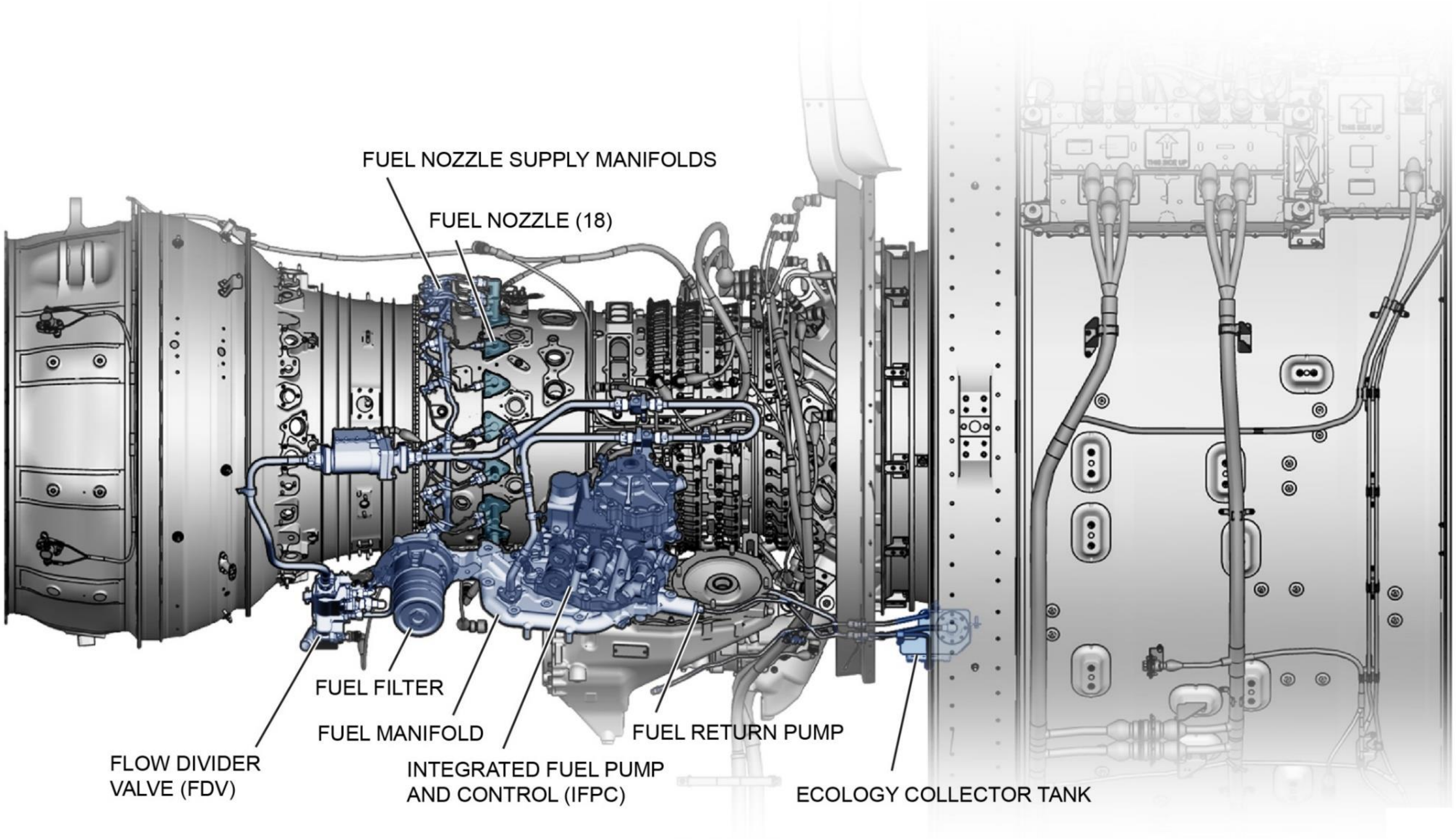
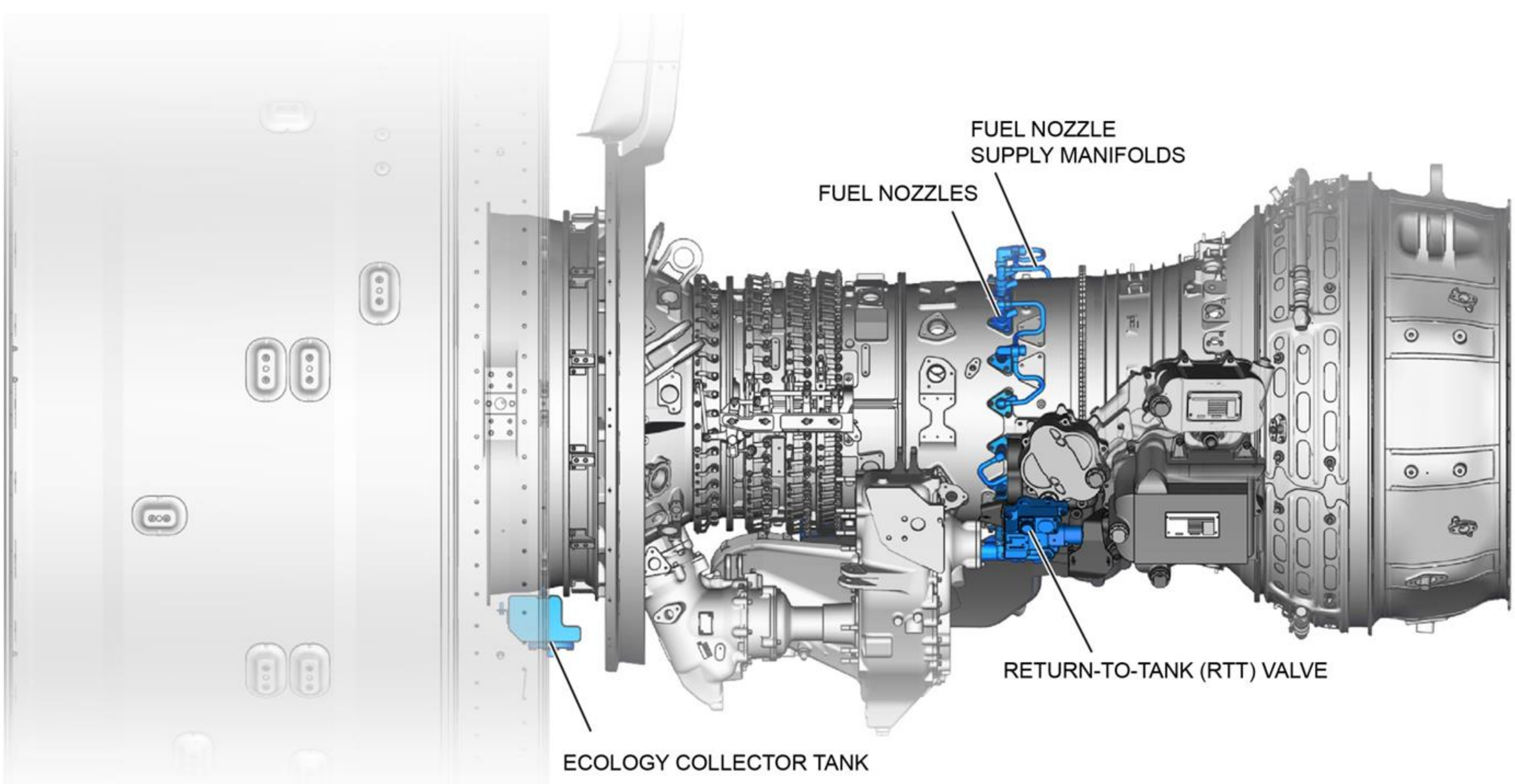


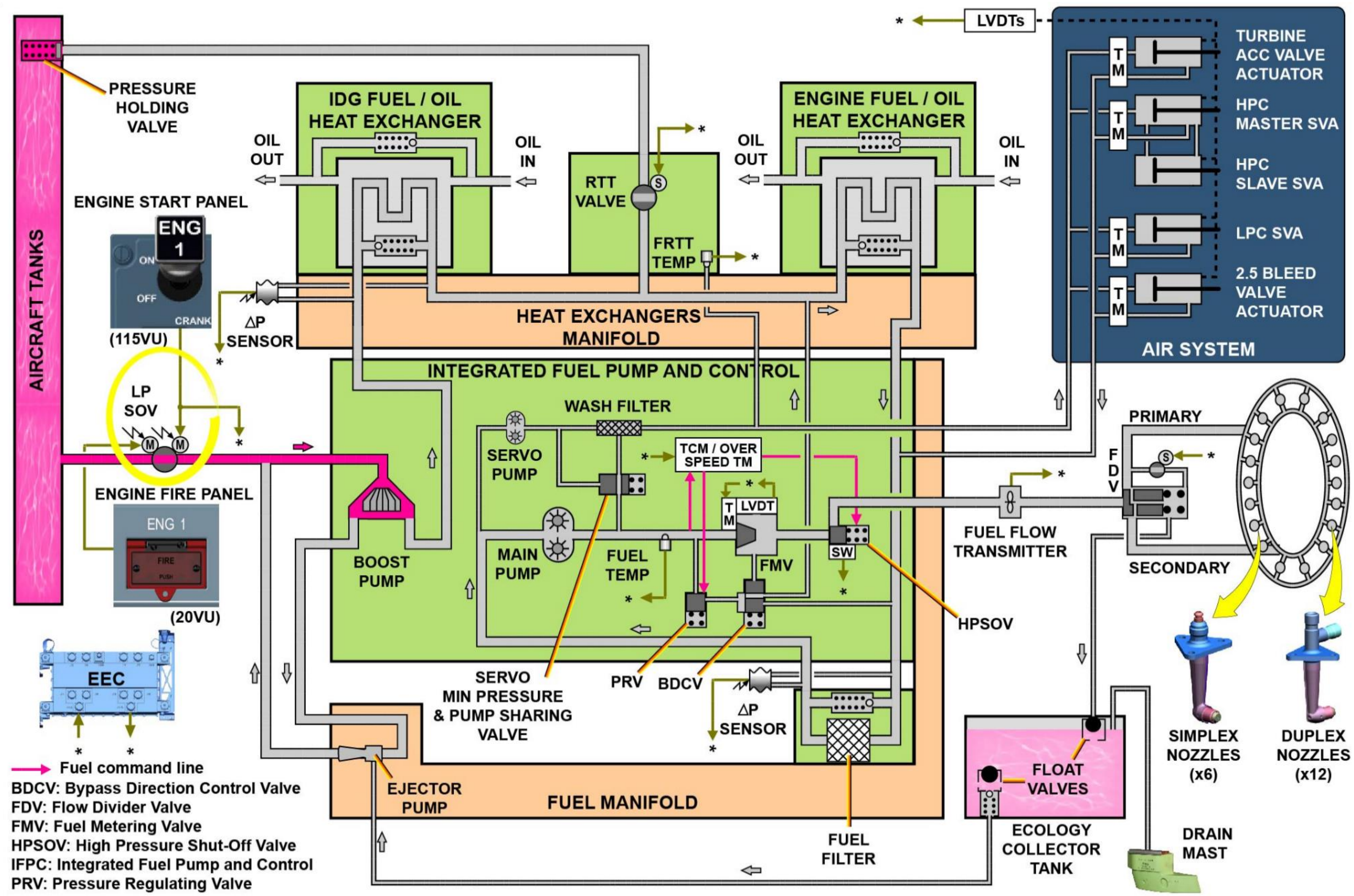
FUEL DISTRIBUTION (RH SIDE)



FUEL DISTRIBUTION (LH SIDE)

FUEL FEED FROM AIRCRAFT

When the ENGine MASTER Lever is selected ON, the Low Pressure Shut-Off Valve (LPSOV) opens and fuel from the aircraft tanks flows through the main fuel supply line to the inlet port of the boost pump in the IFPC.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HEAT EXCHANGERS AND FUEL RETURN TO TANK

The boost pump sends LP fuel from the engine fuel supply line to the IDG FOHE.

Fuel flow is used to cool down the IDG oil through the IDG FOHE and the engine oil through the engine FOHE.

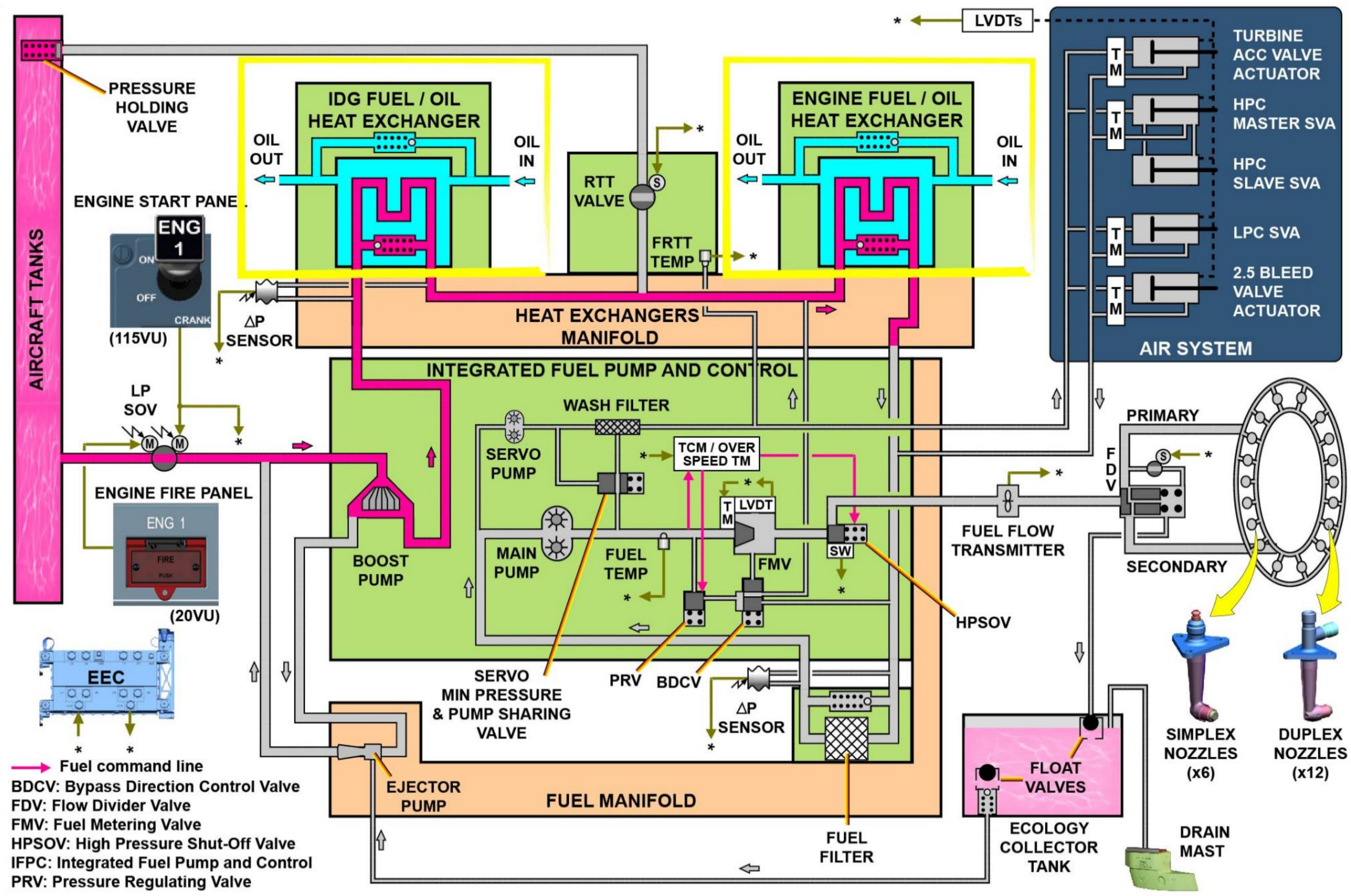
In turn, fuel is heated and de-iced.

Fuel from the engine FOHE is then sent to the fuel filter.

The Fuel Return-To-Tank (FRTT) module contains the Fuel Return Valve (FRV) and the FRTT Temperature sensor.

The FRV controls fuel to flow back to the aircraft tanks from downstream of the IDG FOHE and before it enters the engine FOHE as part of the fuel heat management system.

The FRV is controlled by the Electronic Engine Control (EEC) depending on the fuel temperature.



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INTEGRATED FUEL PUMP AND CONTROL

The IFPC is an electronically controlled unit which integrates the fuel metering components and the fuel pumps in a single unit to limit the space and the number of external tubes required for the system.

The IFPC uses dual coil torque motors and solenoids to control hydro-mechanical valves in relation to the fuel flow.

The Main Gearbox (MGB) turns the IFPC input shaft which drives the fuel pump boost-stage, the main fuel pump and servo pump.

FUEL FILTER AND MAIN PUMP

The heated fuel from the engine FOHE is directed through the fuel filter.

The filter element is a disposable filter located in a housing attached on the fuel manifold.

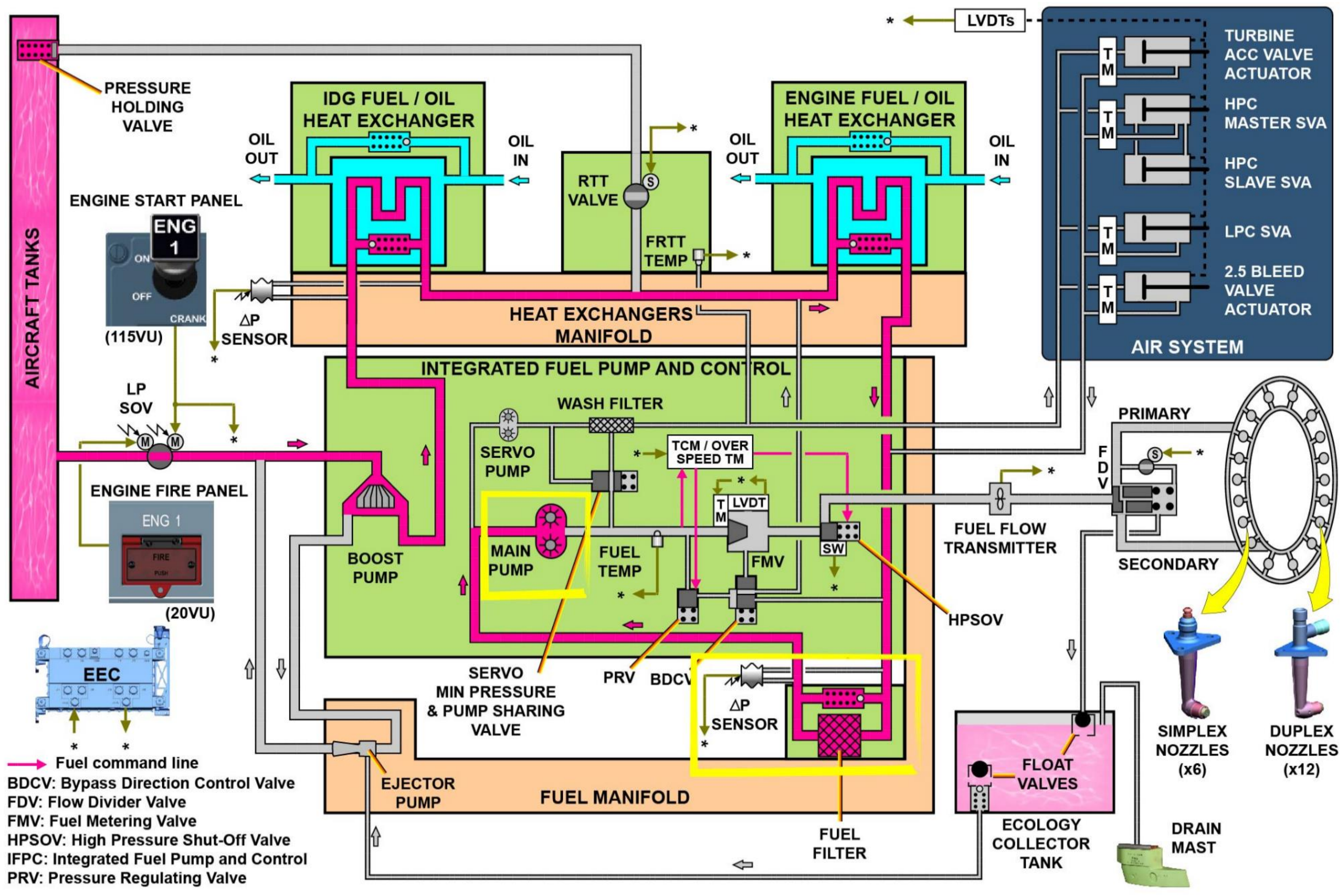
The filter is monitored by a differential pressure transmitter.

The filter housing is fitted with a bypass valve in case of filter element clogging.

The filter element is a disposable 25-micron filter.

The fuel exits the fuel filter and flows to the inlet port of the main fuel pump.

The main fuel pump is a single-stage gear pump, which increases the fuel pressure and sends the pressurized fuel to the Fuel Metering Valve (FMV).



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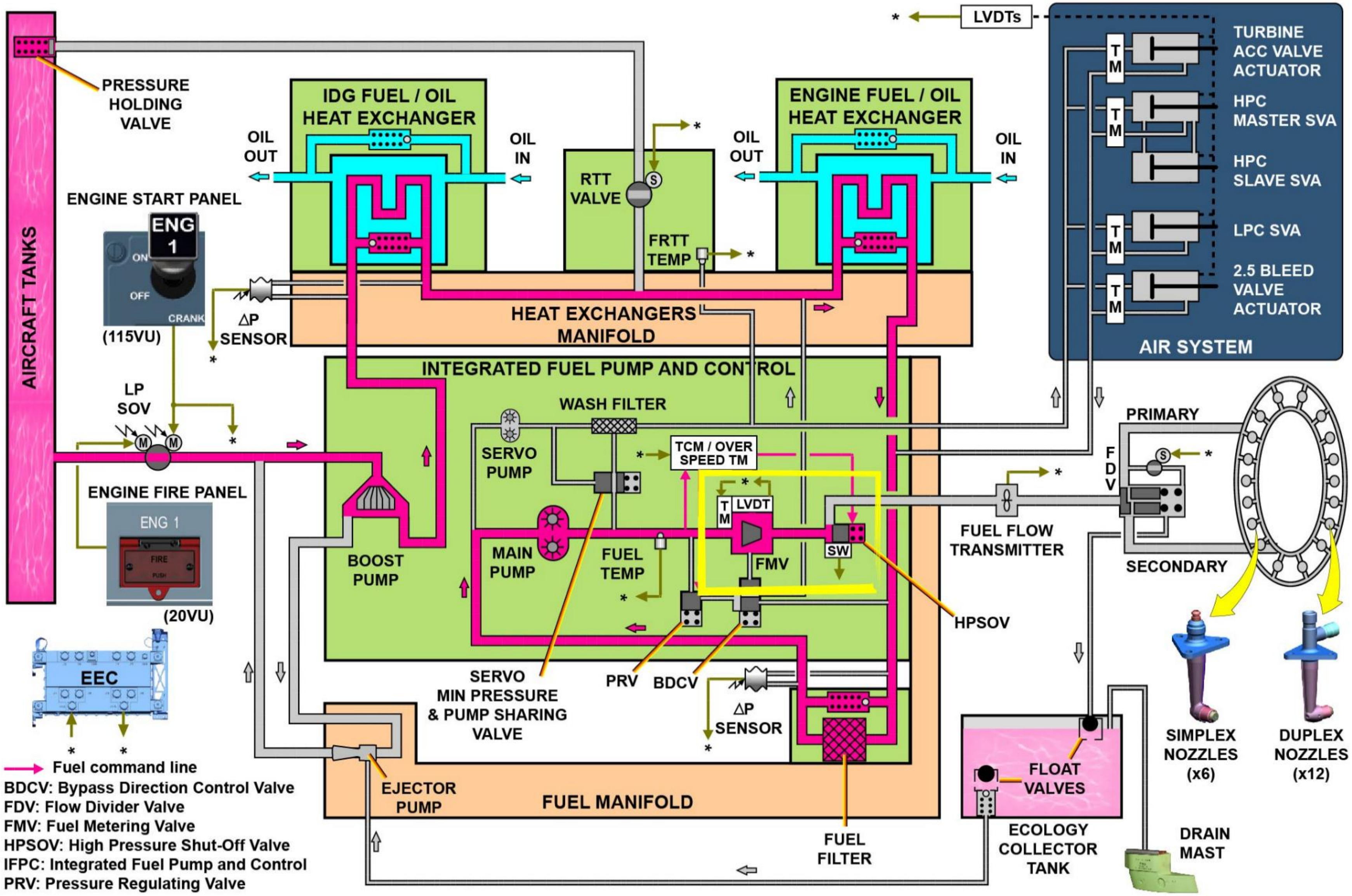
FUEL METERING VALVE AND HIGH PRESSURE SHUT-OFF VALVE

The EEC controls a dual Torque Motor (TM) which positions the FMV in the desired position.

The close loop monitoring is ensured by the EEC using the valve LVDT feedback signals.

The fuel from the FMV is directed to the High Pressure Shut-Off Valve (HPSOV).

The fuel pressure at the back side of the HPSOV is controlled by the Thrust Control Malfunction (TCM)/Overspeed TM and allows the valve to open or close.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PRESSURE REGULATING VALVE AND BYPASS DIRECTIONAL CONTROL VALVE

Inside the IFPC, the fuel from the main pump is directed to the FMV and to the Pressure Regulating Valve (PRV).

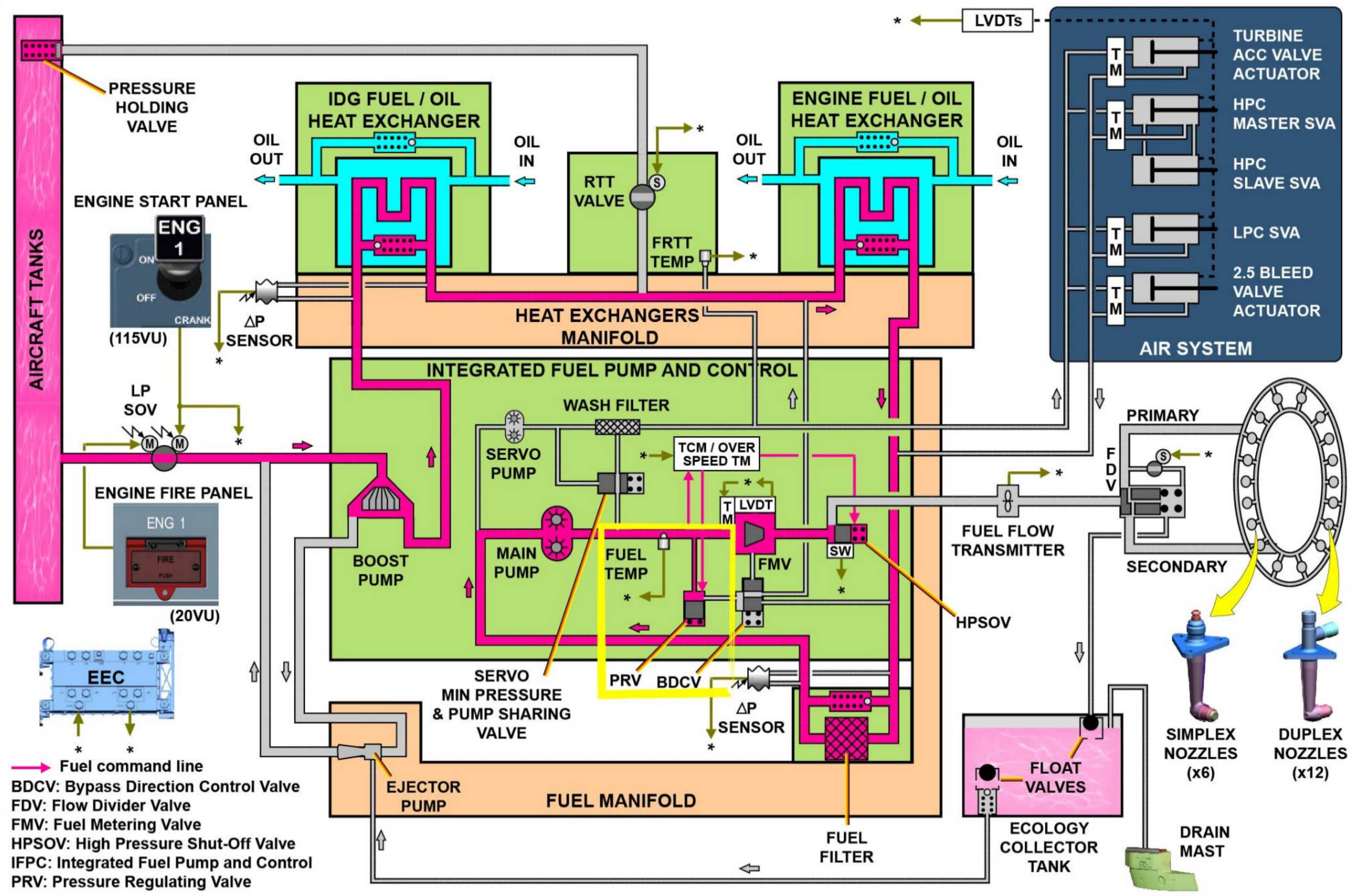
The purpose of the PRV is to maintain a constant fuel pressure drop across the FMV to ensure the correct fuel flow and acceleration for the engine.

The TCM/Overspeed TM controls the fuel pressure to the back side of the PRV to modulate fuel flow between the FMV and the Bypass Directional Control Valve (BDCV).

Pressurized fuel that passes through the PRV is directed to the BDCV.

The BDCV directs fuel by-passed by the PRV to the engine FOHE at low engine power or when the fuel temperature is low to help in maintaining the engine oil and fuel within operating limits.

At high power, the BDCV returns the recirculation flow downstream of the FOHE.



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EEC CONTROL

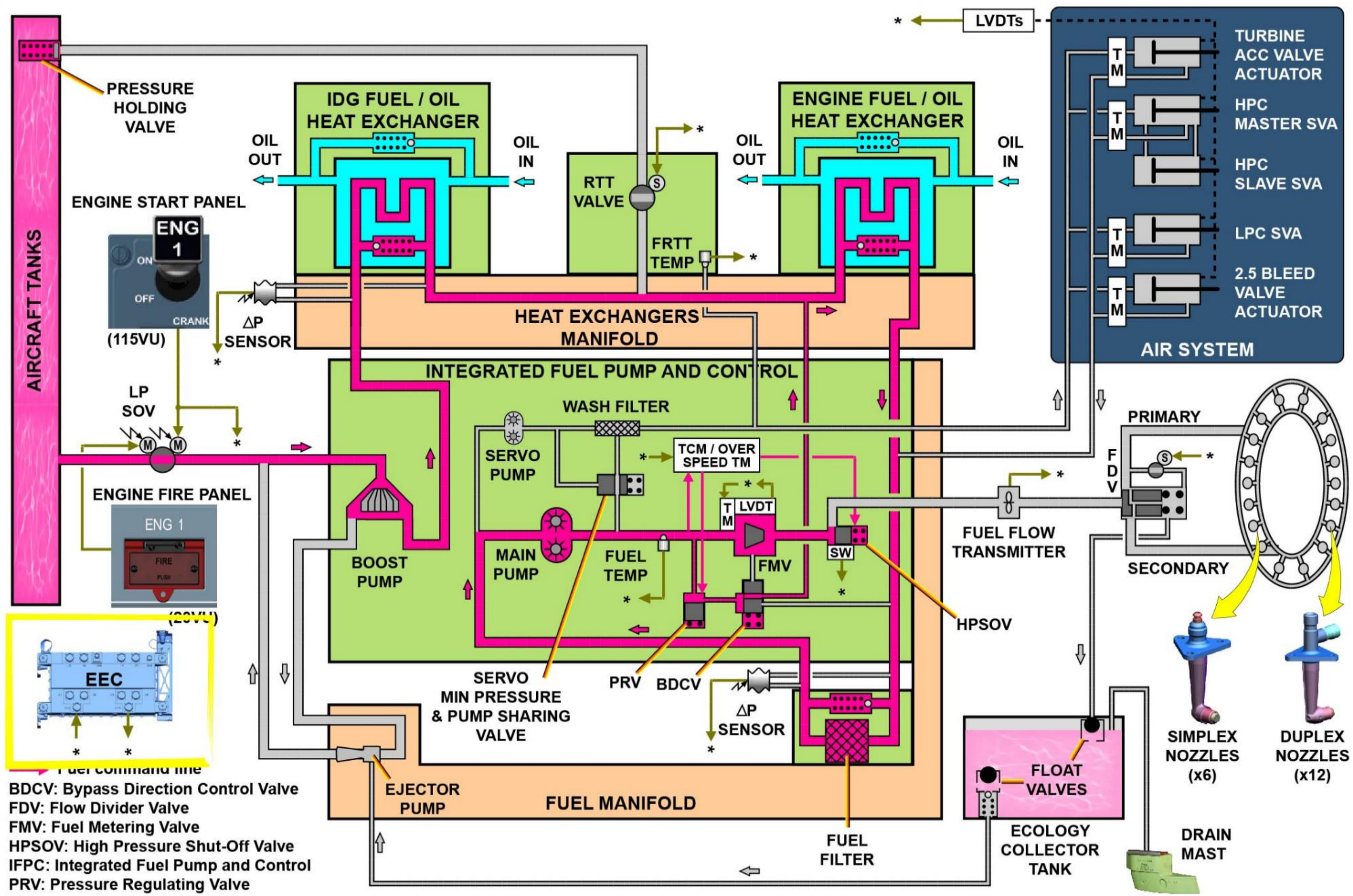
The EEC controls the dual TCM/Overspeed TM for HPSOV positioning.

It monitors the valve fully closed position with the two proximity switches.

The EEC also controls the FMV position via a dual channel Torque Motor (TM).

A dual channel Linear Variable Differential Transducer (LVDT) provides the FMV position to the EEC.

For the air system, the EEC controls the fuel-operated actuators with dual channel TMs and it monitors their position thanks to LVDT position feedbacks.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FUEL FLOW TRANSMITTER, FLOW DIVIDER VALVE AND FUEL NOZZLES

The metered fuel from the FMV crosses the HPSOV and flows to the fuel flow transmitter.

The fuel flow transmitter sends the fuel flow rate to the EEC channel A and directs fuel to the Flow Divider Valve (FDV).

The EEC commands the FDV opening during starting to improve fuel atomization.

During engine start, the FDV sends most of fuel to the primary manifold.

Above idle, the FDV evenly divides metered fuel flow between the primary and secondary fuel manifolds.

At shutdown, the FDV is spring loaded closed to allow primary and secondary manifold drainage.

The FDV is fitted with a metal screen strainer that can be bypassed in case of blockage.

There are 18 fuel nozzles mounted to the outer diffuser case. All the nozzles atomize fuel inside the combustor.

Twelve of them are duplex nozzles featuring both a primary and a secondary fuel flow paths while six others are simplex nozzles providing only a secondary fuel flow path.

Operation:

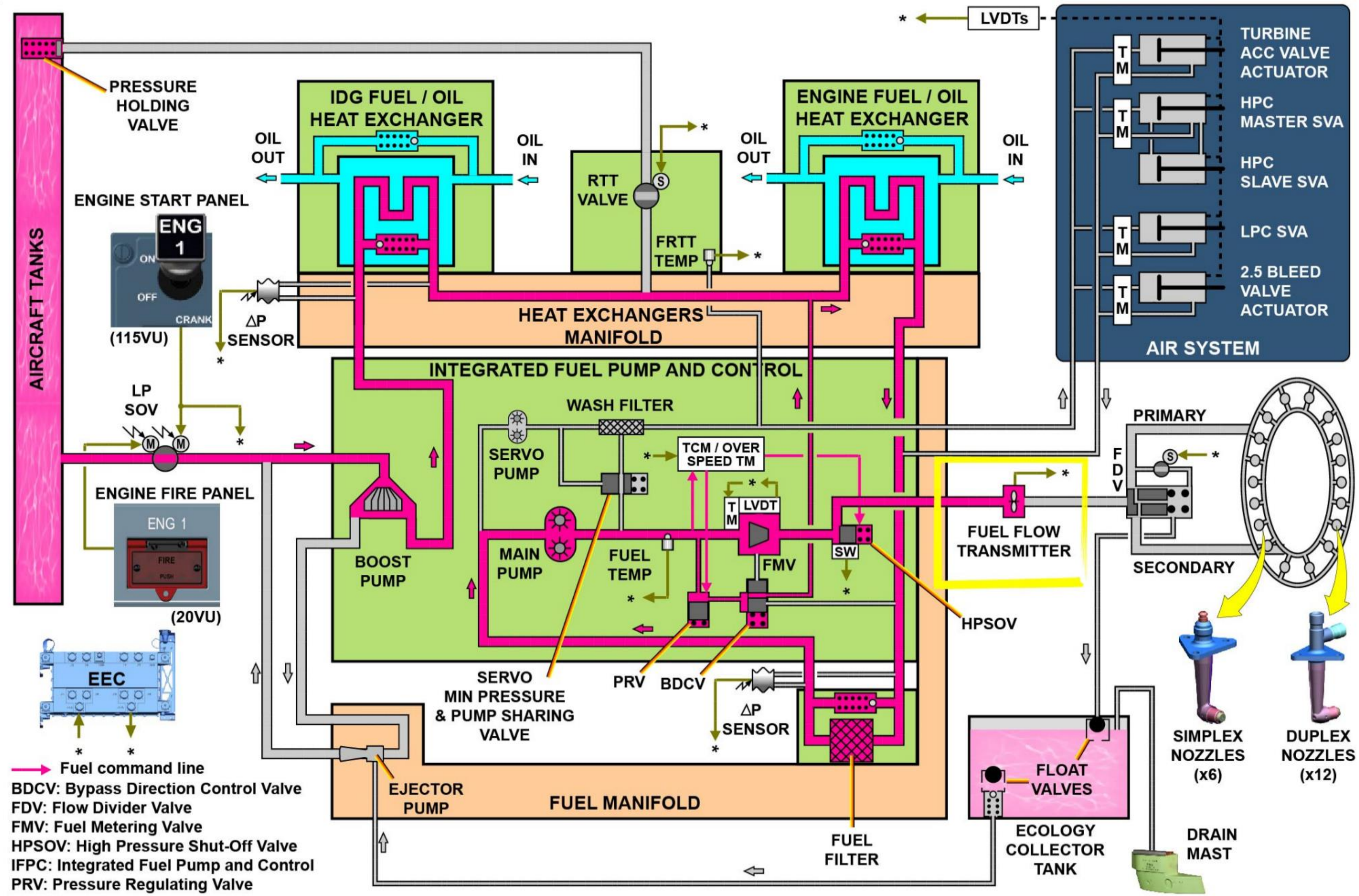
The FDV solenoid controls a high- and low-pressure drop capability from primary to secondary fuel nozzles.

1. During engine start, the FDV is in the high differential pressure mode with the solenoid de-energized. This creates a high pressure drop across the secondary fuel circuit, allowing more primary fuel to flow for ignition and combustor acoustic mitigation at sub-cruise power.

2. Inlet fuel pressure forces the piston to move against the spring, opening the FDV. At higher power settings the FDV is in the low differential pressure mode with the solenoid energized. This closes off the primary circuit to the backside of the piston to create a low pressure drop across the secondary fuel circuit.

3. The change in pressure between primary and secondary circuits allows the spring to move the piston to an intermediate position, providing even fuel flow to both the primary and secondary fuel nozzles. The low differential pressure mode is used to reduce combustor pattern factor at and above cruise.

4. At shutdown, fuel pressure is reduced and the spring moves the piston closed. The FDV shuts off the inlet, preventing fuel in the IFPC-to-FDV line from entering the combustor. The shutoff action also provides a drain path for remaining fuel in both lines to enter the ecology collector tank.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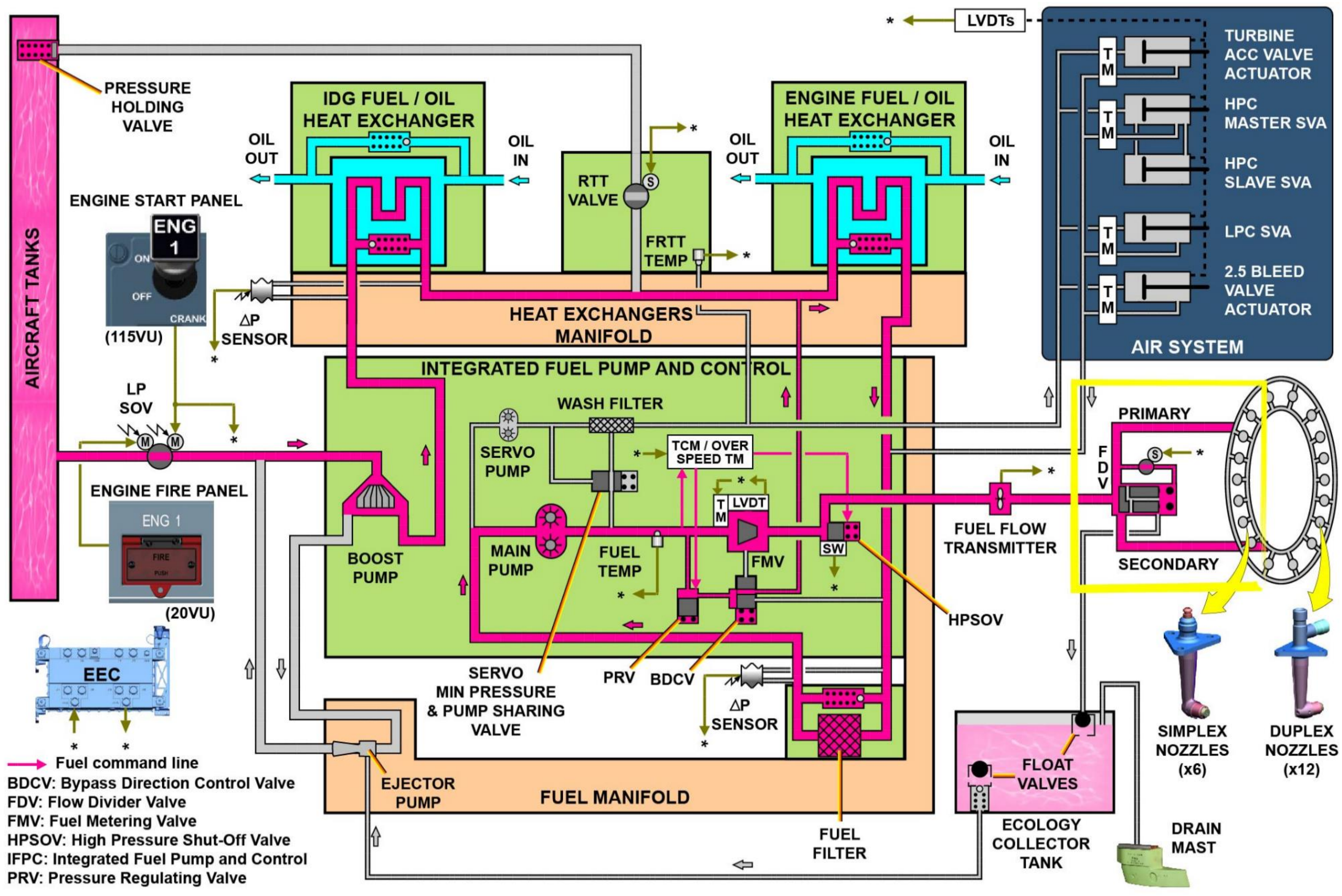
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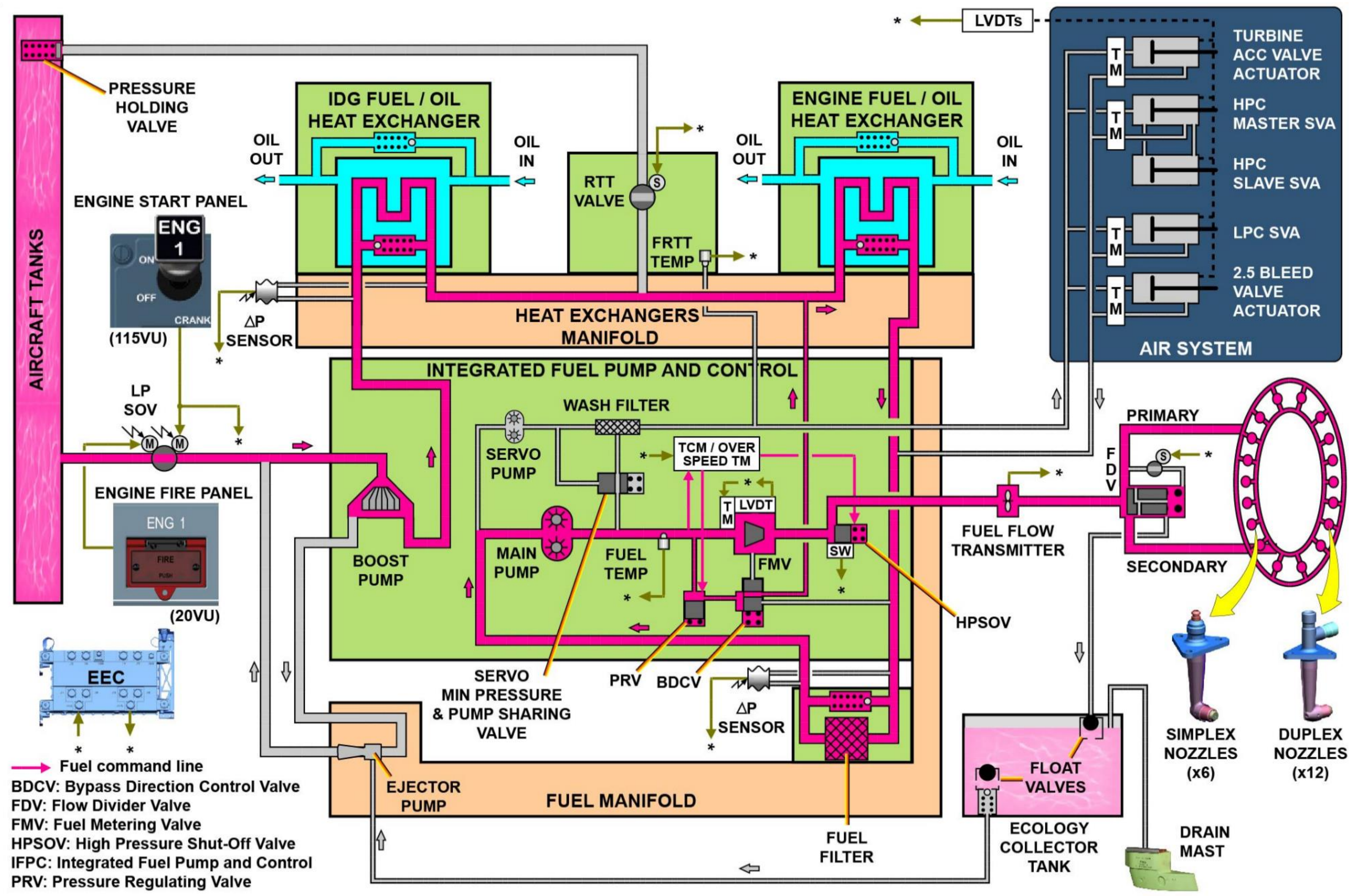

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ECOLOGY SYSTEM

At engine shutdown, residual fuel in the manifolds downstream of the FDV is drained back through the FDV to an ecology collector tank.

The collected fuel remains in the ecology collector tank until the next engine start when the fuel is drawn back into the fuel system.

During shutdown, the fuel pressure from the IFPC is reduced and the FDV closes to prevent fuel from entering the combustor and to drain any fuel remaining in both the primary and secondary fuel lines to the ecology collector tank.

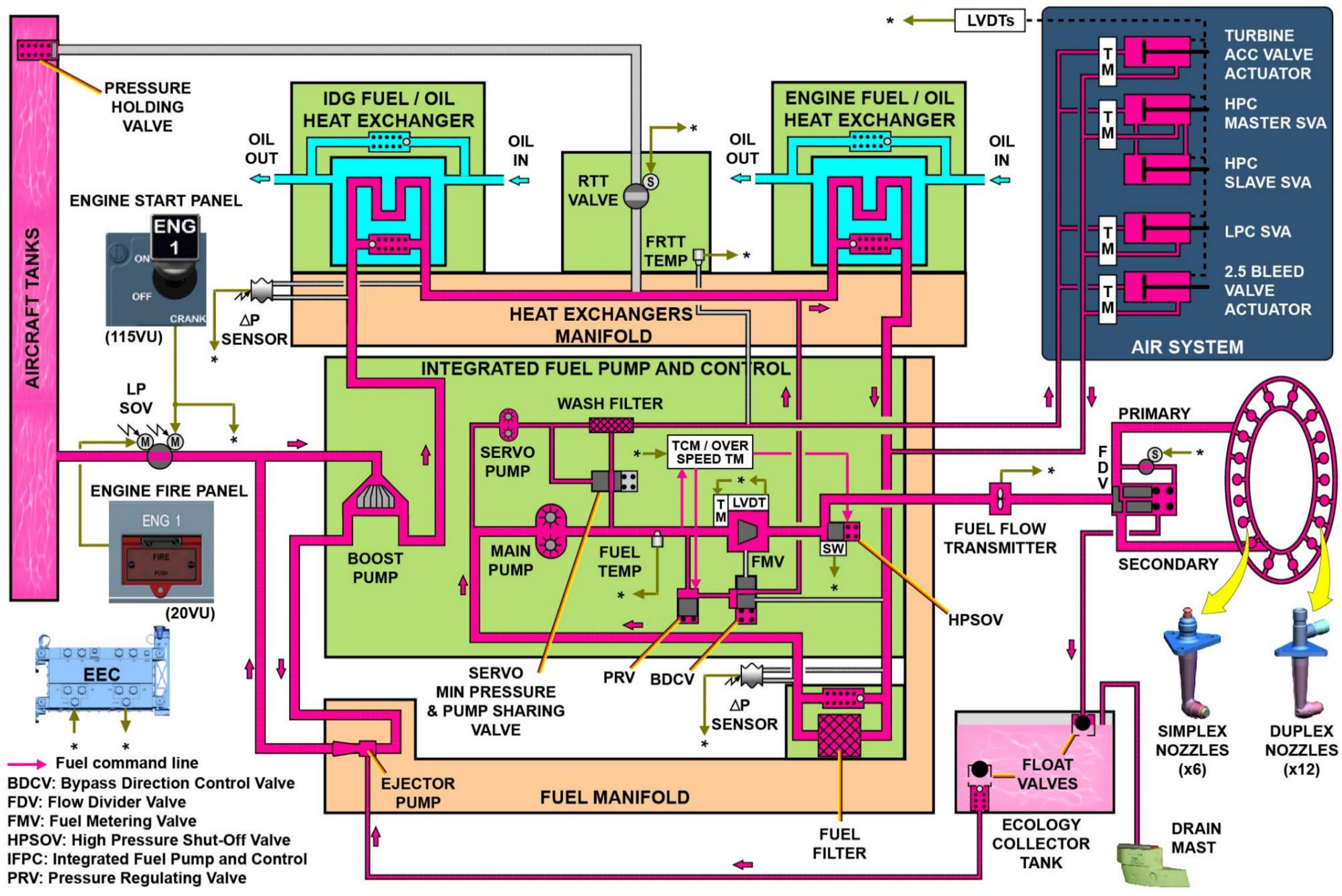
The ecology collector tank has enough space to receive fuel from a single engine shutdown.

The tank has an inlet float valve which closes when the tank has reached its maximum capacity.

This prevents the tank from overfilling and spilling fuel out following an aborted start.

At next engine start up, the ejector pump draws the fuel from the ecology collector tank back to the IFPC boost pump.

The tank has an outlet float valve which closes when the tank has reached its minimum capacity and a check valve to avoid fuel transfer from the suction line.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CRANK
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
PRIMARY
FDV
FUEL FLOW TRANSMITTER
SECONDARY
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
HPSOV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
FLOAT VALVES
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
ECOLOGY COLLECTOR TANK
DRAIN MAST
Fuel command line
BDCV: Bypass Direction Control Valve
FDV: Flow Divider Valve
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

STARTING INITIATION

During starting, the servo pump fuel pressure is not enough to control the air system actuators and to close the Servo Minimum Pressure and Pump Sharing Valve.

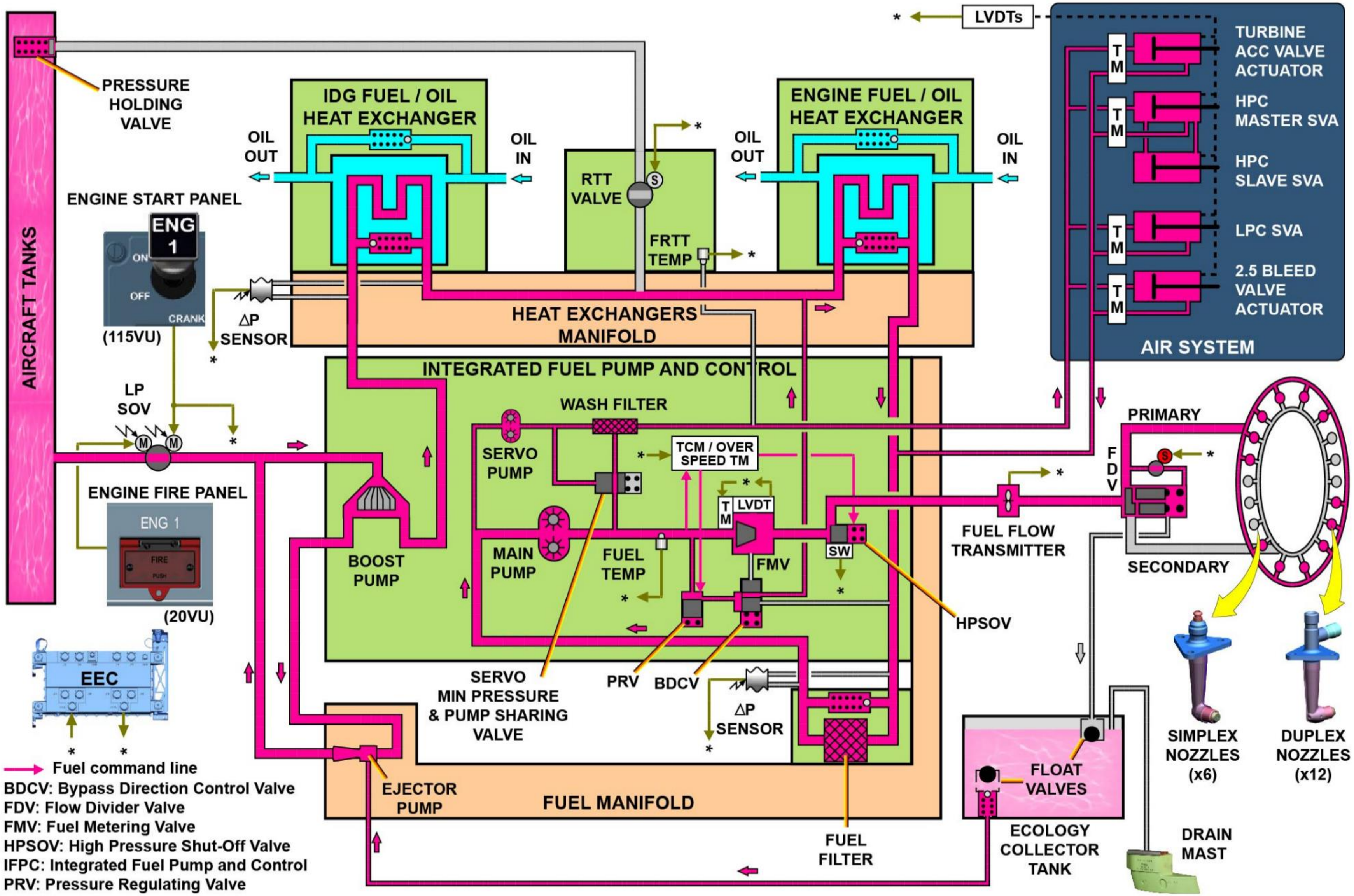
In this position, the Servo Minimum Pressure and Pump Sharing Valve directs a portion of pressurized fuel from the main pump to the five actuators.

The other portion of fuel from the main pump is sent to the PRV and to the FMV.

The PRV opens partly and directs the excess of fuel flow to the BDCV which is spring loaded to send it to the engine FOHE.

The EEC opens the FMV and let the fuel to flow to the HPSOV which also opens and sends fuel to the fuel flow transmitter.

The pressurized fuel opens the FDV. The FDV partly opens and sends most of fuel to the primary fuel nozzles.



Fuel command line
BDCV: Bypass Direction Control Valve
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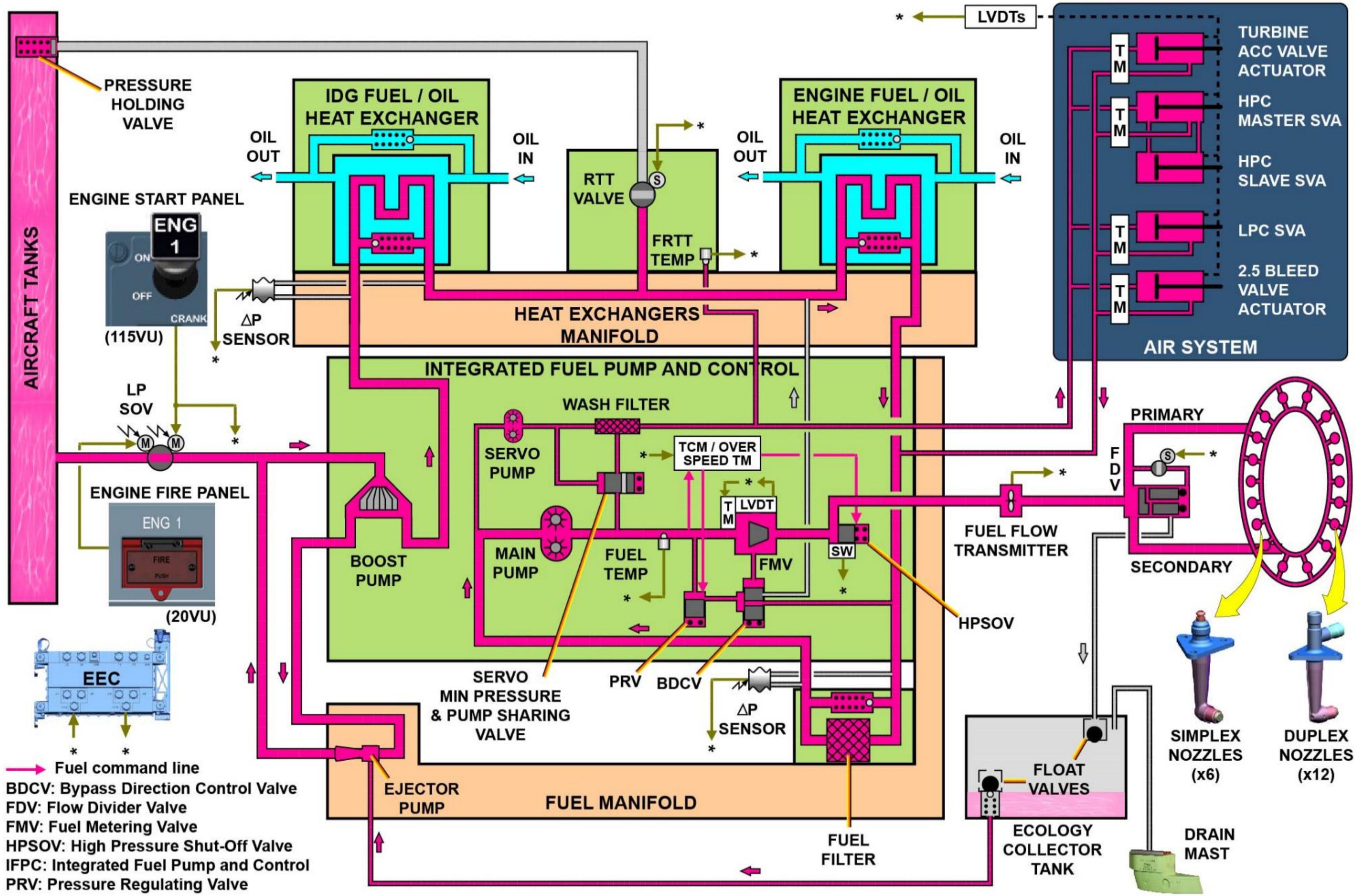
ACCELERATION

As the pumps rotation speed increases with the engine acceleration, the fuel pressure also increases.

The FMV opens more and therefore the fuel pressure pushes the BDCV out of its rest position to direct the excess fuel flow to the fuel filter.

The FDV also opens more and evenly divides metered fuel flow between the primary and secondary fuel nozzles.

In parallel, the fuel pressure from the servo pump increases and pushes the Servo Minimum Pressure and Pump Sharing Valve, segregating the burn flow from the servo fuel.



LVDTs
TURBINE ACC VALVE ACTUATOR
HPC MASTER SVA
HPC SLAVE SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
T M
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE START PANEL
ENG 1
ON
OFF
CRANK
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
AIRCRAFT TANKS
INTEGRATED FUEL PUMP AND CONTROL
WASH FILTER
LP SOV
SERVO PUMP
TCM / OVER SPEED TM
LVDT
PRIMARY
FDV
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
FUEL FLOW TRANSMITTER
SECONDARY
HPSOV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
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SIMPLEX NOZZLES (x6)
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NORMAL SHUTDOWN

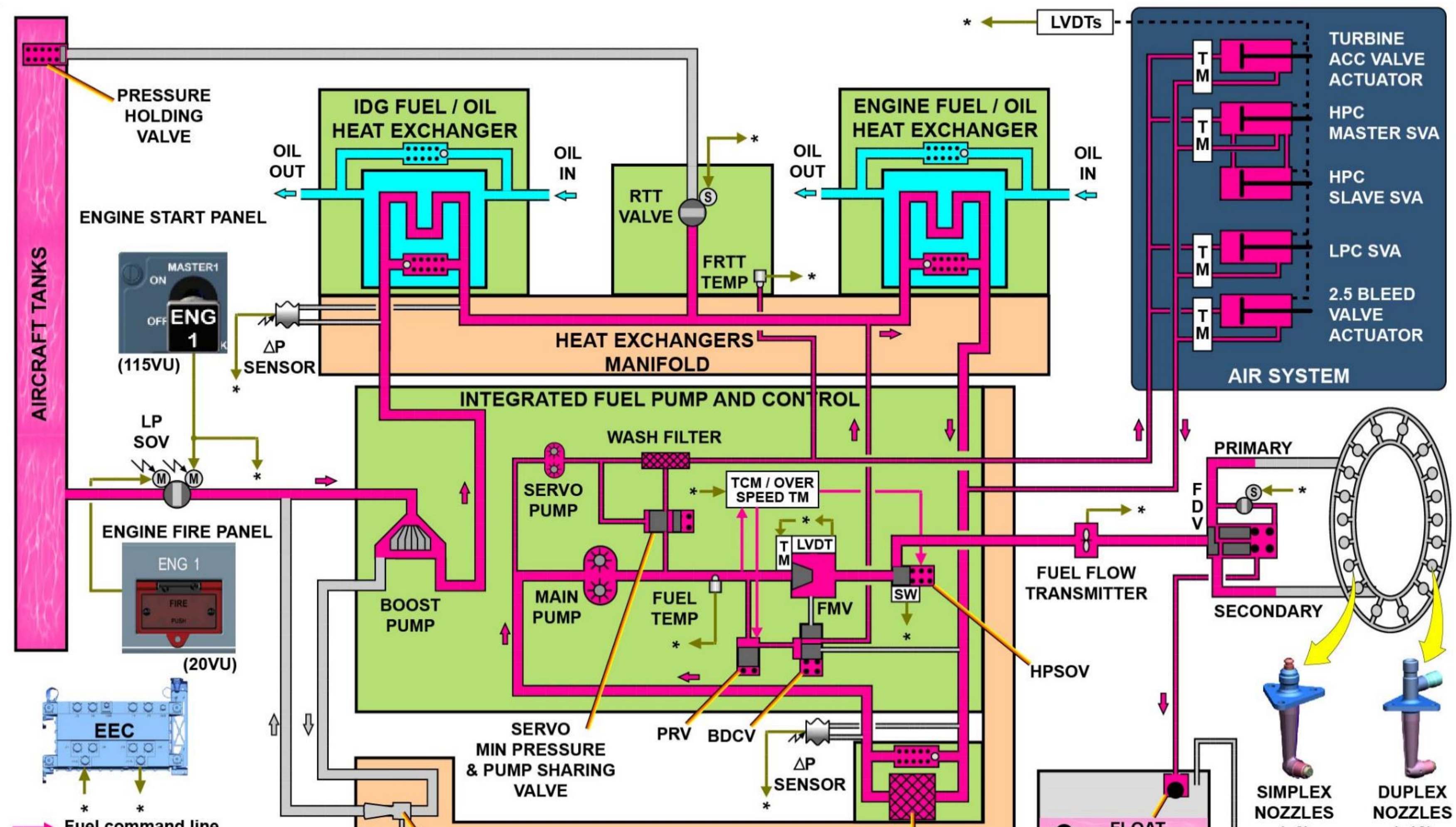
During a normal engine shutdown, the Master Lever controls the LPSOV to close and sends a shutdown signal to the EEC.

As a consequence, the EEC controls the TCM/overspeed TM that directs fuel pressure to the back side of the HPSOV to close it and stop the fuel flow to the engine.

In the same time, the PRV is controlled fully open to bypass the main pump fuel flow away from the FMV to the FOHE.

In turn when the related fuel pressure drops, the FDV closes to let the remaining fuel in the nozzle manifolds to drain in the ecology drain tank, and the Servo Minimum Pressure and Pump Sharing Valve reopens.

After the HPSOV is confirmed closed by the proximity switches, the EEC tests the FMV via its TM then closes it.



Fuel command line
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IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

ABNORMAL SHUTDOWN

The abnormal shutdown is initiated in case of an overspeed (N1 or N2), shaft shear (fan, LP or HP) or Thrust Control Malfunction (TCM) event detected on ground.

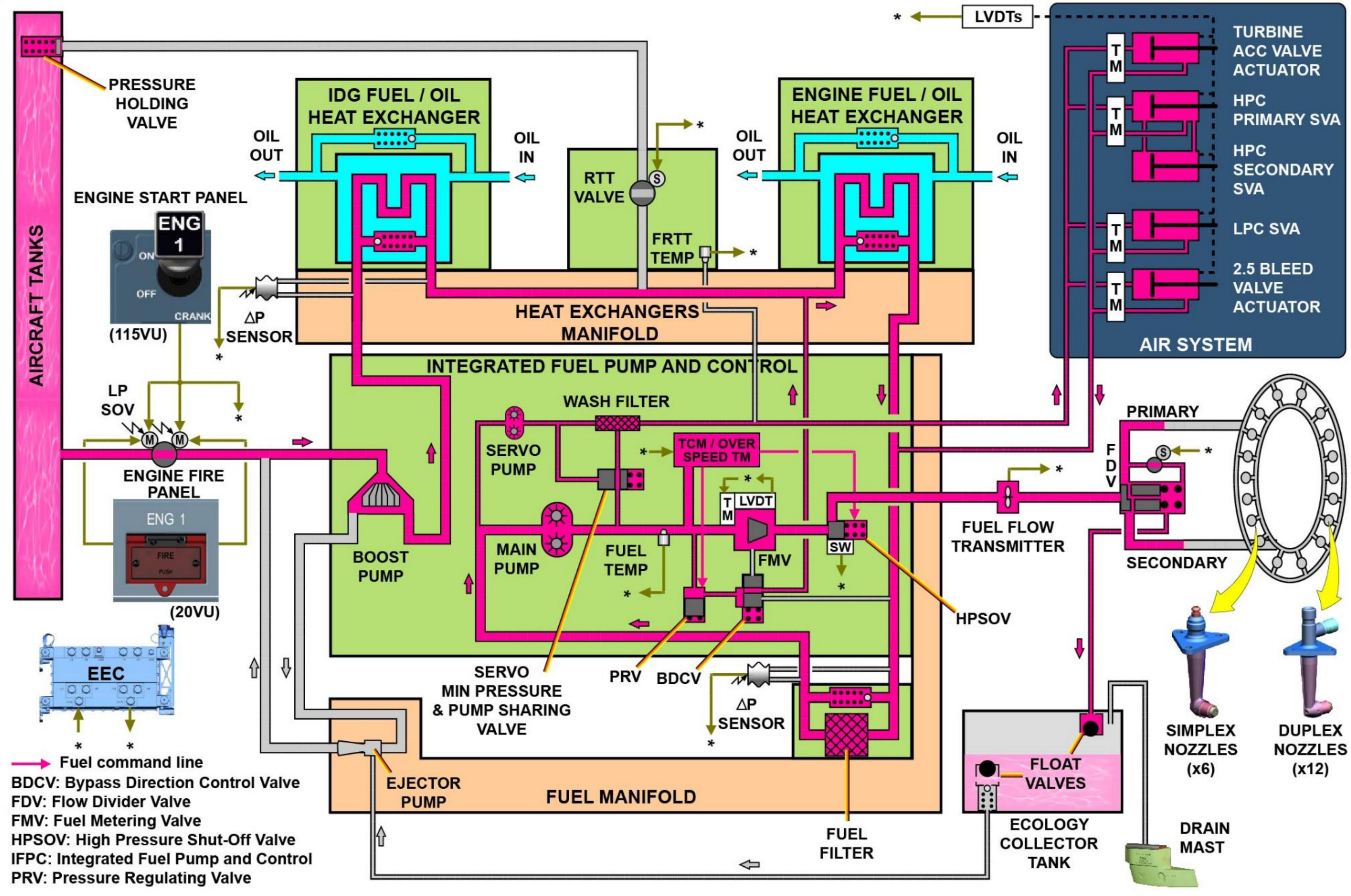
In such case, the TCM/overspeed TM directs fuel pressure to the back side of the HPSOV and of the PRV.

This causes the PRV to open and stop fuel flow to the FMV, allowing rapid closure of the HPSOV and rapid engine shutdown.

Fuel flow through the PRV is directed to the BDCV and then to the engine FOHE.

This shutoff method is independent from the FMV control.

In flight, if a TCM event malfunction occurs, the engine keeps running.


AIRCRAFT TANKS
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
LVDTs
TURBINE ACC VALVE ACTUATOR
HPC PRIMARY SVA
HPC SECONDARY SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
T M
ENGINE START PANEL
ENG 1
ON
OFF
CRANK
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
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WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
MAIN PUMP
FUEL TEMP
FMV
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SECONDARY
FUEL FLOW TRANSMITTER
HPSOV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
EJECTOR PUMP
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FLOAT VALVES
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DRAIN MAST
SIMPLEX NOZZLES (x6)
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PRV: Pressure Regulating Valve

FUEL INDICATING

The engine fuel indicating monitors the system condition and provides the system status to the cockpit displays.

The fuel flow transmitter sends signals to the EEC which enables the calculation of the fuel flow to the combustor.

The fuel flow is a primary engine parameter and is displayed on the EWD permanently.

The EEC also sends this data for the fuel used computation and display on the System Display (SD).

The Fuel Filter Differential Pressure (FFDP) sensor measures the differential pressure across the fuel filter.

This helps to detect if the filter is partially or totally clogged.

According to the received value, the EEC will generate various warnings on the EWD: ENG X FUEL FILTER DEGRAD or ENG X FUEL FILTER CLOG or ENG X FUEL SENSOR FAULT and on the SD: CLOG.

The IDG Fuel-Oil Heat Exchanger (FOHE) differential pressure sensor is used to sense the differential pressure on the fuel side of the FOHE and send a signal to the EEC in case of clogging detection.

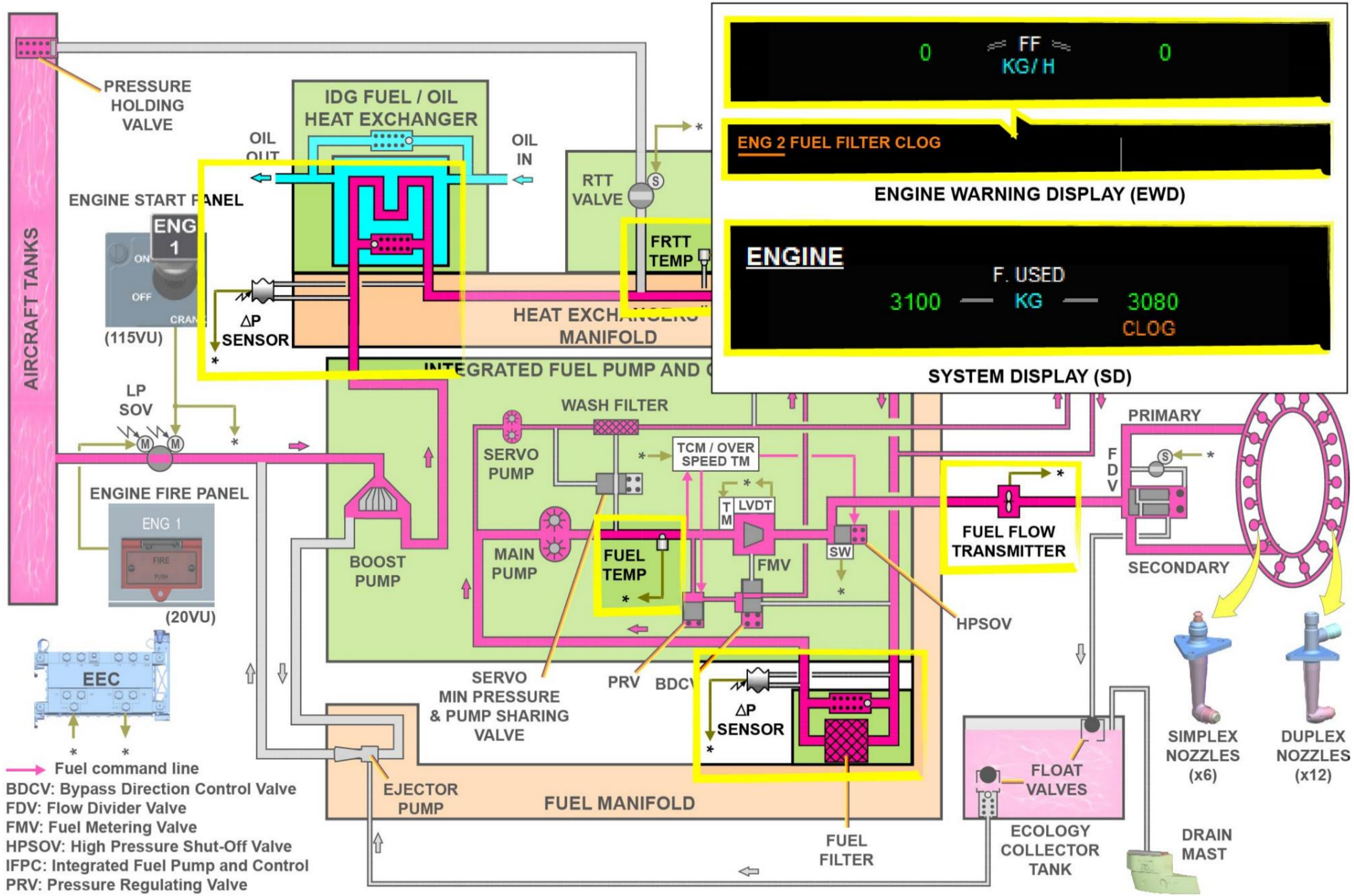
According to the status, the EEC will generate various warnings on the EWD: ENG X HEAT EXCHANGR CLOG or ENG X FUEL SENSOR FAULT.

For monitoring and Thermal Management System control by the EEC, the fuel temperature is sensed by two dual channel temperature sensors.

The fuel temperature sensor is used for the control of the heat exchangers (Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV)) and BDCV.

The Fuel Return To Tank (FRTT) temperature sensor is used for the RTTV control.

The engine fuel temperature is not directly displayed in the cockpit but, according to the status, the EEC will generate various warnings on the EWD: ENG X HOT FUEL or ENG X FUEL HEAT SYS or ENG X HEAT SYS DEGRADED or ENG X HEAT SYS FAULT.



PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
ENGINE START PANEL
ENG 1
ON
OFF
(115VU)
ΔP SENSOR
RTT VALVE
FRTT TEMP
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
FF KG/H
0
0
ENG 2 FUEL FILTER CLOG
ENGINE WARNING DISPLAY (EWD)
ENGINE
F. USED
3100
KG
3080
CLOG
SYSTEM DISPLAY (SD)
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
TM
MAIN PUMP
FUEL TEMP
FMV
SW
HPSOV
FUEL FLOW TRANSMITTER
PRIMARY
FDV
SECONDARY
ENGINE FIRE PANEL
ENG 1
(20VU)
BOOST PUMP
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
EEC
Fuel command line
BDCV: Bypass Direction Control Valve
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PRV: Pressure Regulating Valve
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
FLOAT VALVES
ECOLOGY COLLECTOR TANK
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
DRAIN MAST

INTEGRATED FUEL PUMP AND CONTROL (IFPC)

Purpose:

The IFPC supplies metered fuel flow to the engine as scheduled by the EEC, and supplies pressurized fuel to engine component actuators.

Location:

The IFPC is attached with bolts to the Fuel Manifold on the right side of the Main Gearbox at 3:00.

Description:

The IFPC's internal fuel pumping section is comprised of single stage boost, main, and servo pumps.

The boost pump is an impeller and the main and servo pumps are gear pumps.

Dual-channel torque motors for the fuel metering valve and the LVDT are contained within the IFPC housing, as are the torque motor for the shutoff valve and the valve's two proximity sensors.

The components are wired internally to two electrical connectors on the IFPC, one for each of the EEC channels.

Fuel from the boost pump provides initial pressurization of fuel received from the aircraft tank.

Fuel is sent in two directions to the fuel return pump and to the heat exchanger manifold.

The single-stage main pump further increases fuel pressure and directs the pressurized fuel to the metering valve within the fuel control section of the IFPC.

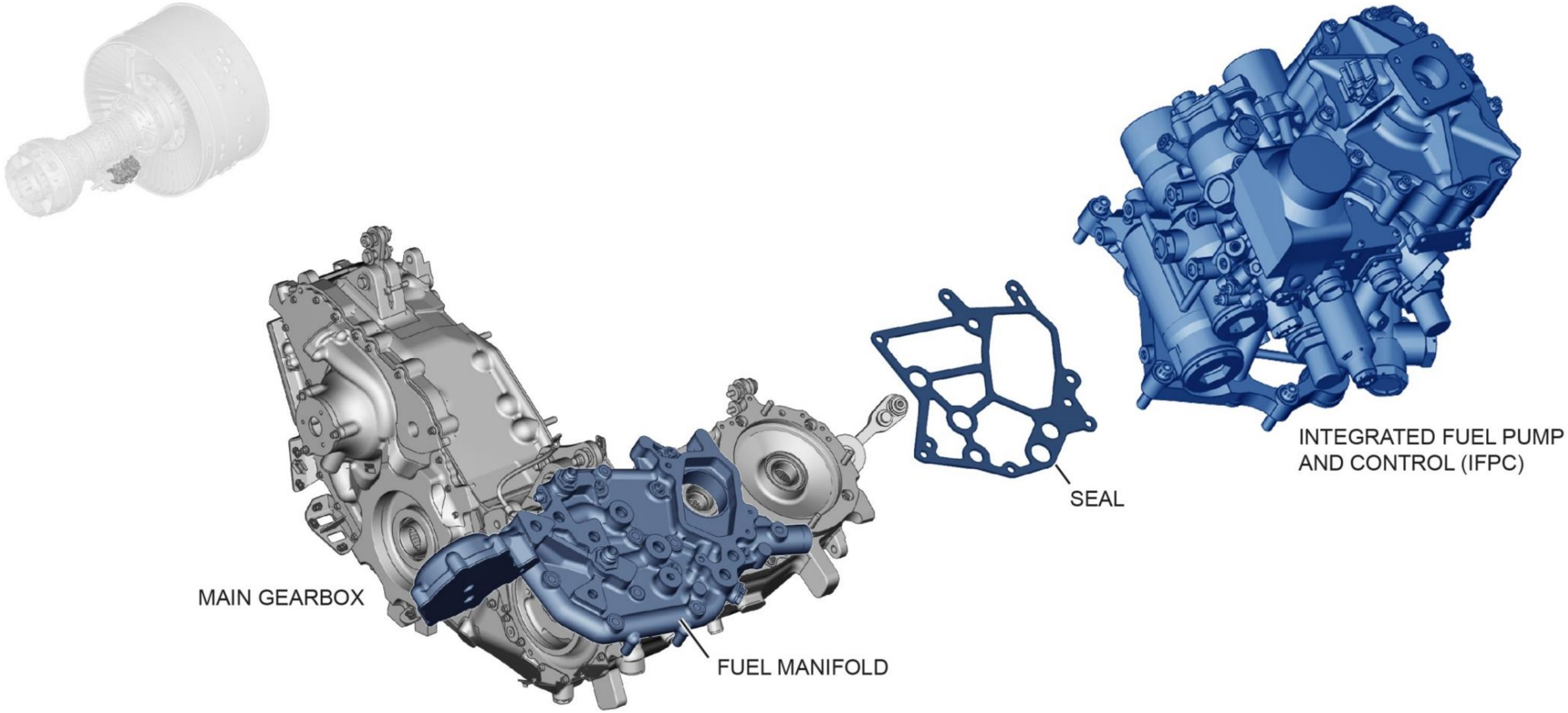
The servo pump further increases the fuel pressure, directing the pressurized fuel through a wire mesh wash filter.

Then it sends the fuel on to five engine component actuators, where it is used as muscle pressure to move the actuator pistons.

The main and servo pumps each have pressure relief valves that limit the developing absolute pressure to a pre-set design value.

The valves are spring-loaded closed, opening when fuel pressure exceeds a predetermined limit.

Fuel that flows past the pressure relief valves bypasses the fuel pump exit and is recirculated back to the fuel filter.


INTEGRATED FUEL PUMP AND CONTROL (IFPC)
SEAL
MAIN GEARBOX
FUEL MANIFOLD

FUEL MANIFOLD (FM)

Purpose:

The Fuel Manifold supplies mounting and sealing of the IFPC, the fuel return pump, the Fuel Filter Differential Pressure (FFDP) sensor and the fuel filter housing assembly.

It also transfers fuel between the components and serves as the connection point for external fuel lines.

Location:

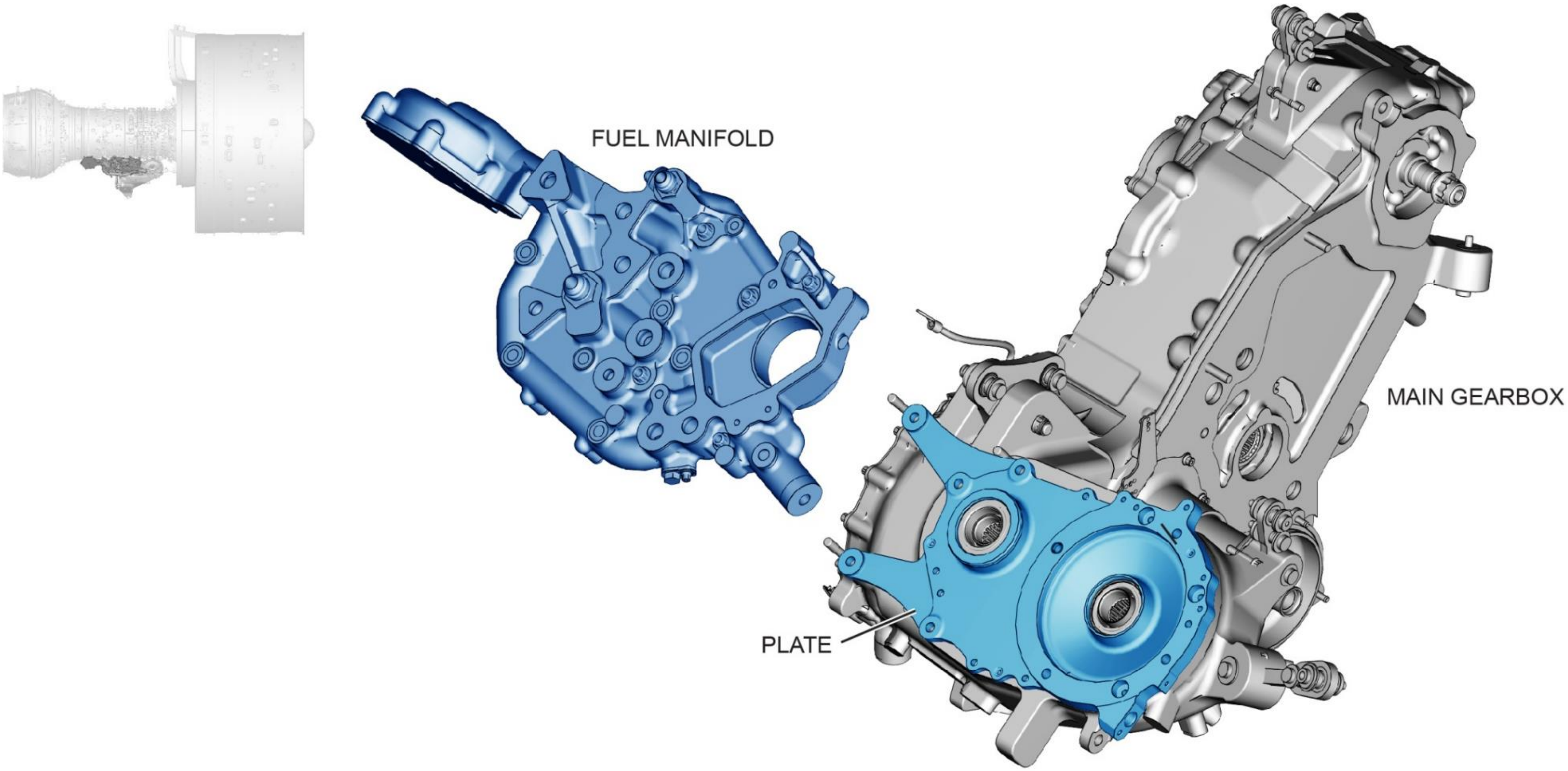
The Fuel Manifold is located on the right side of the engine and is attached to the Main Gearbox.

Description:

The manifold is made of aluminium and is attached to the MGB with five nuts.

Operation:

Fuel transfer through the manifold is conducted through internal passages, reducing the need for external fuel tubes.


FUEL MANIFOLD
MAIN GEARBOX
PLATE

FUEL FILTER ASSEMBLY

Purpose:

The fuel filter assembly removes solid contaminants from the pressurized fuel sent from the IFPC.

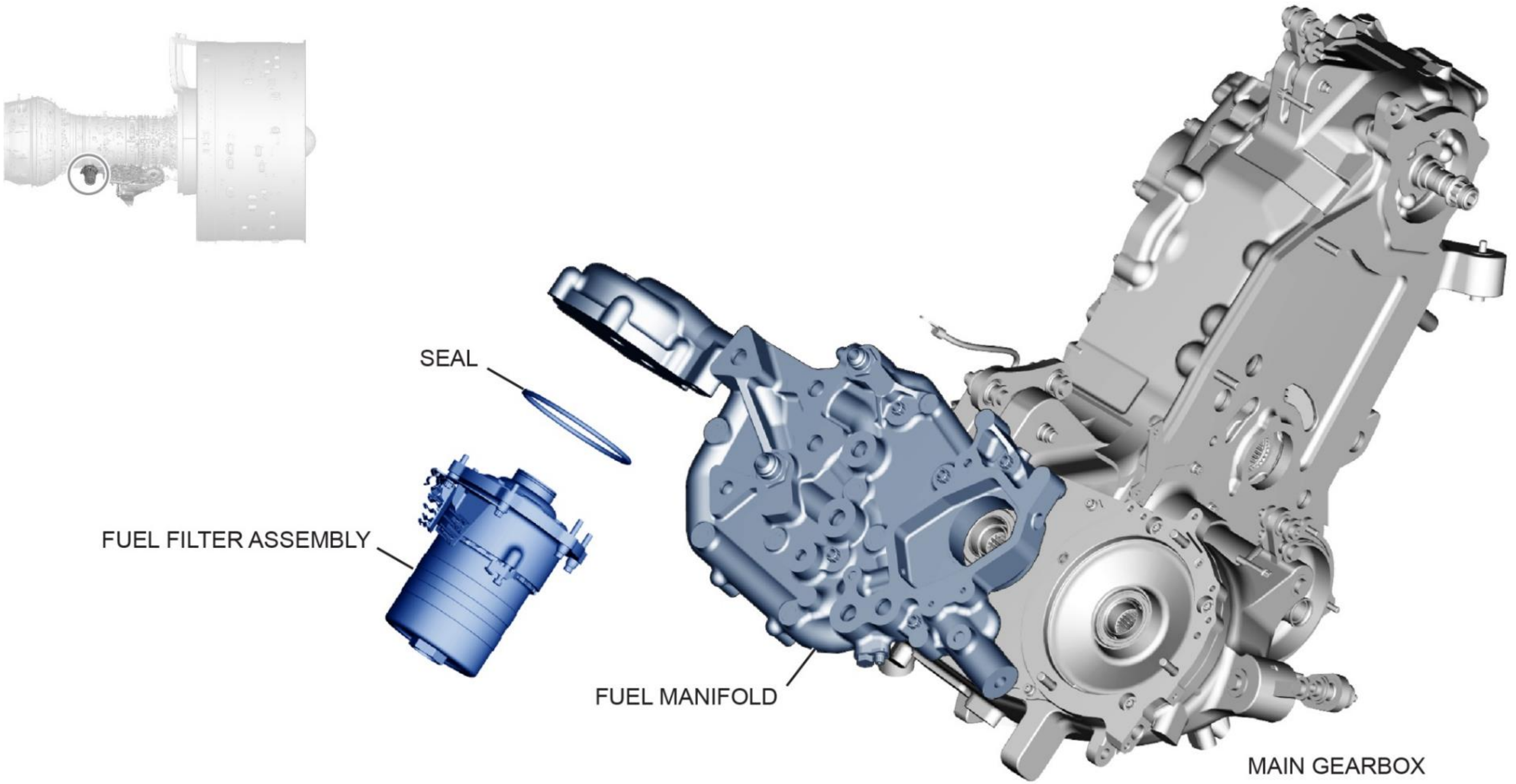
Location:

The assembly is attached to the Fuel Manifold at 3:00 on the right side of the engine.

Description:

The fuel filter assembly consists of these components:

housing and adapter
filter element
maintenance shutoff valve
bypass valve.


SEAL
FUEL FILTER ASSEMBLY
FUEL MANIFOLD
MAIN GEARBOX

FUEL FILTER HOUSING AND ADAPTER

The fuel filter housing and adapter contain the fuel that flows through the fuel filter element.

An O-ring provides sealing between the adapter and the threaded mating bore in the Fuel Manifold.

A face seal packing provides sealing between the adapter mount flange and the Fuel Manifold.

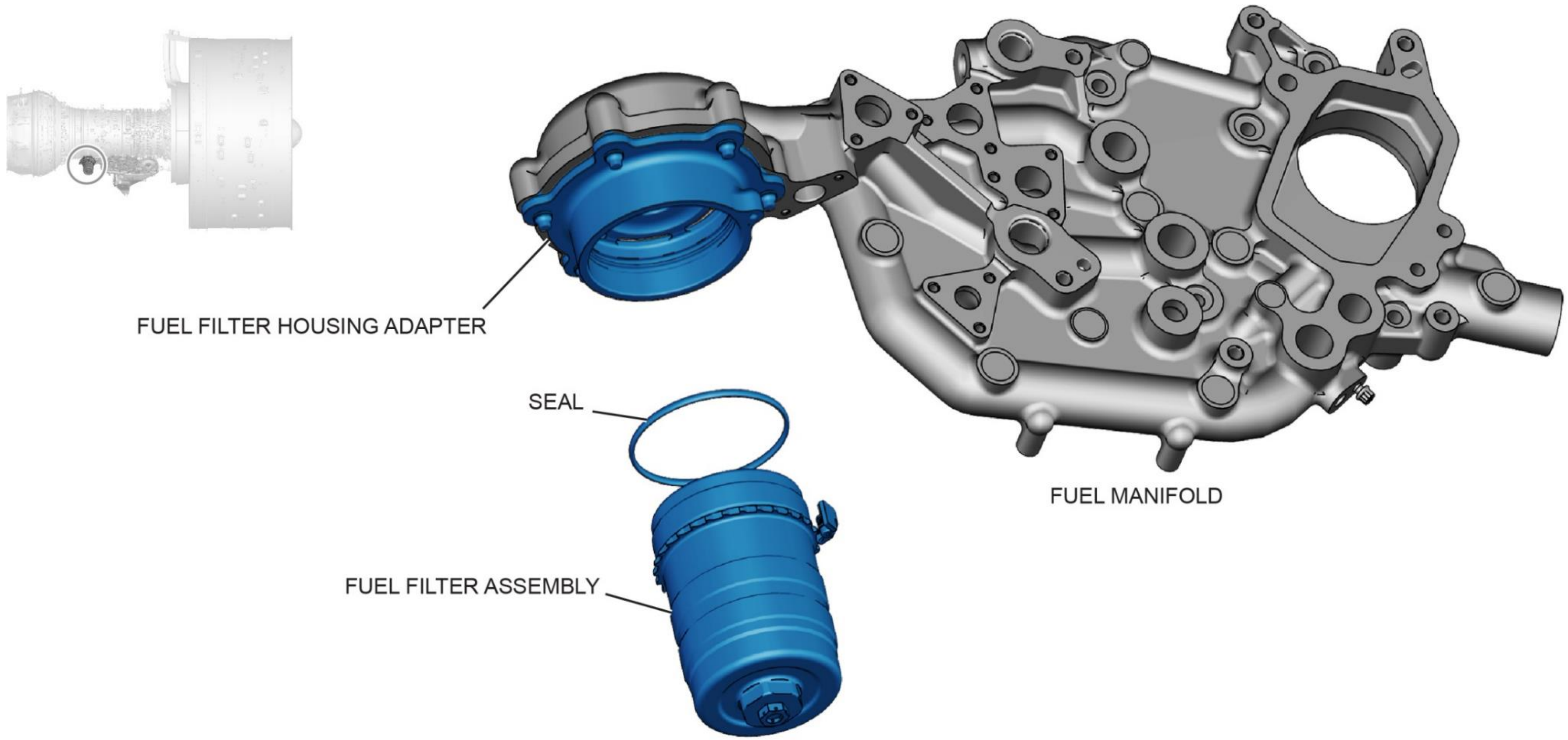
A drain plug is installed and threaded into the fuel filter housing for fuel drainage before the housing is removed.

An O-ring on the drain plug prevents fuel leakage.

Safety Conditions

WARNING

MAKE SURE THE FUEL SYSTEM IS SHUT OFF BEFORE REMOVING THE FUEL FILTER HOUSING. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.


FUEL FILTER HOUSING ADAPTER
SEAL
FUEL MANIFOLD
FUEL FILTER ASSEMBLY

FUEL FILTER ELEMENT

The fuel filter element is an 80-micron filter that removes solid contaminants from the pressurized fuel sent to the IFPC.

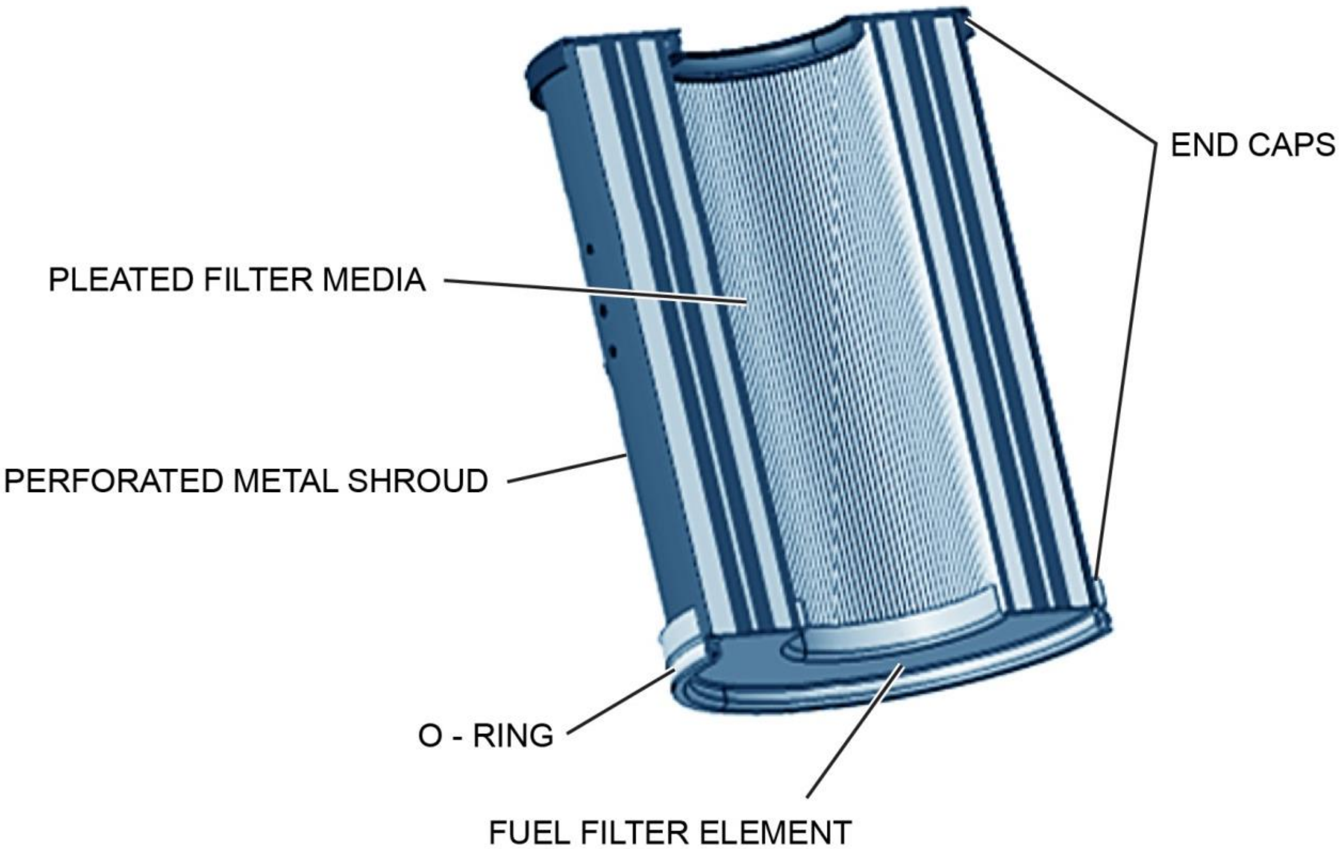
Fuel is delivered to the inside of the filter and then flows outward through the filter media.

The filter is a disposable type constructed of multiple pleated paper media.

Safety Conditions

WARNING

MAKE SURE THE FUEL SYSTEM IS SHUT OFF BEFORE REMOVING THE FUEL FILTER ELEMENT. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.


END CAPS
PLEATED FILTER MEDIA
PERFORATED METAL SHROUD
O - RING
FUEL FILTER ELEMENT

FUEL FILTER MAINTENANCE SHUT-OFF VALVE

The fuel filter maintenance shutoff valve is a spring-loaded mechanical valve installed in the adapter.

During filter change, the valve closes the port for fuel flow, limiting drainage.

When the fuel filter is installed, it pushes the valve against the spring to open the port for fuel flow.

Fuel Filter Bypass Valve

The fuel filter bypass valve allows fuel to bypass the filter element if it should become clogged.

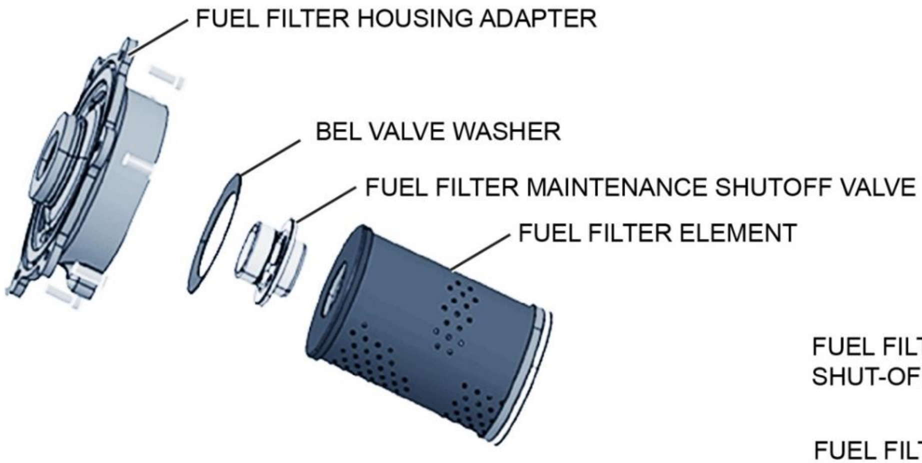
The valve has a Bel Valve® washer design and is installed between the adapter and the fuel filter maintenance shutoff valve.

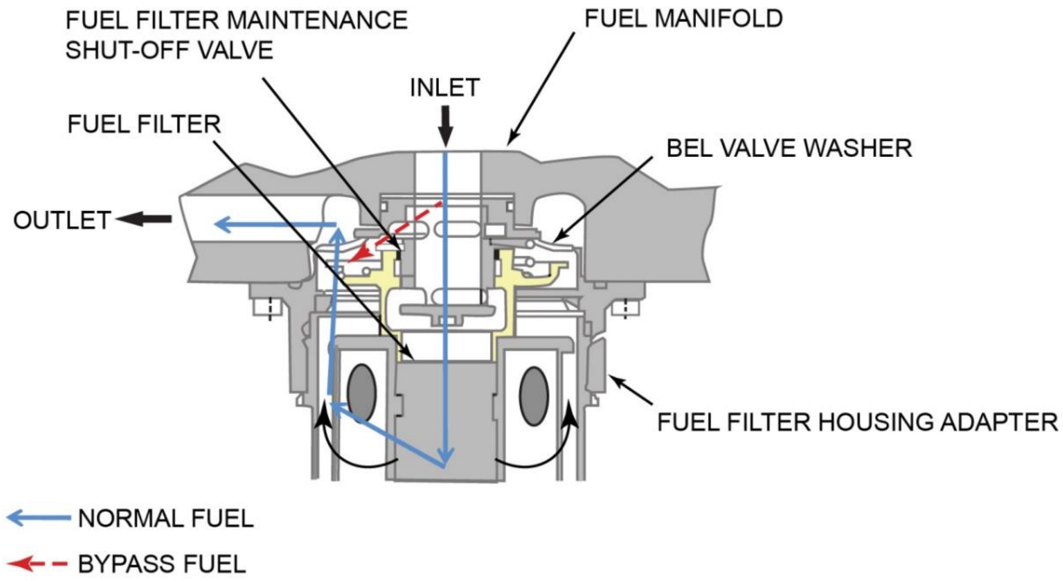
During normal engine operation, the bypass valve covers an internal passage between the adapter and the fuel manifold that is connected to the outlet port of the adapter.

When the fuel filter becomes clogged, sufficient fuel pressure is built up to push the valve open, allowing unfiltered fuel to port directly to the outlet port of the adapter.

The pressure upstream and downstream of the fuel filter is measured by the Fuel Filter Differential Pressure sensor and sent to the EEC.

The EEC will send a “Fuel filter degraded” or “Fuel filter clogged” message to the Engine Interface Unit (EIU) at specific differential pressure values.


FUEL FILTER HOUSING ADAPTER
BEL VALVE WASHER
FUEL FILTER MAINTENANCE SHUTOFF VALVE
FUEL FILTER ELEMENT


FUEL FILTER MAINTENANCE
SHUT-OFF VALVE
FUEL MANIFOLD
INLET
FUEL FILTER
BEL VALVE WASHER
OUTLET
FUEL FILTER HOUSING ADAPTER
NORMAL FUEL
BYPASS FUEL

FLOW DIVIDER VALVE (FDV)

Purpose:

The Flow Divider Valve is an EEC-controlled valve that directs metered fuel flow to the primary fuel nozzles during start up, and more evenly divides metered fuel flow between primary and secondary fuel nozzles above ground idle.

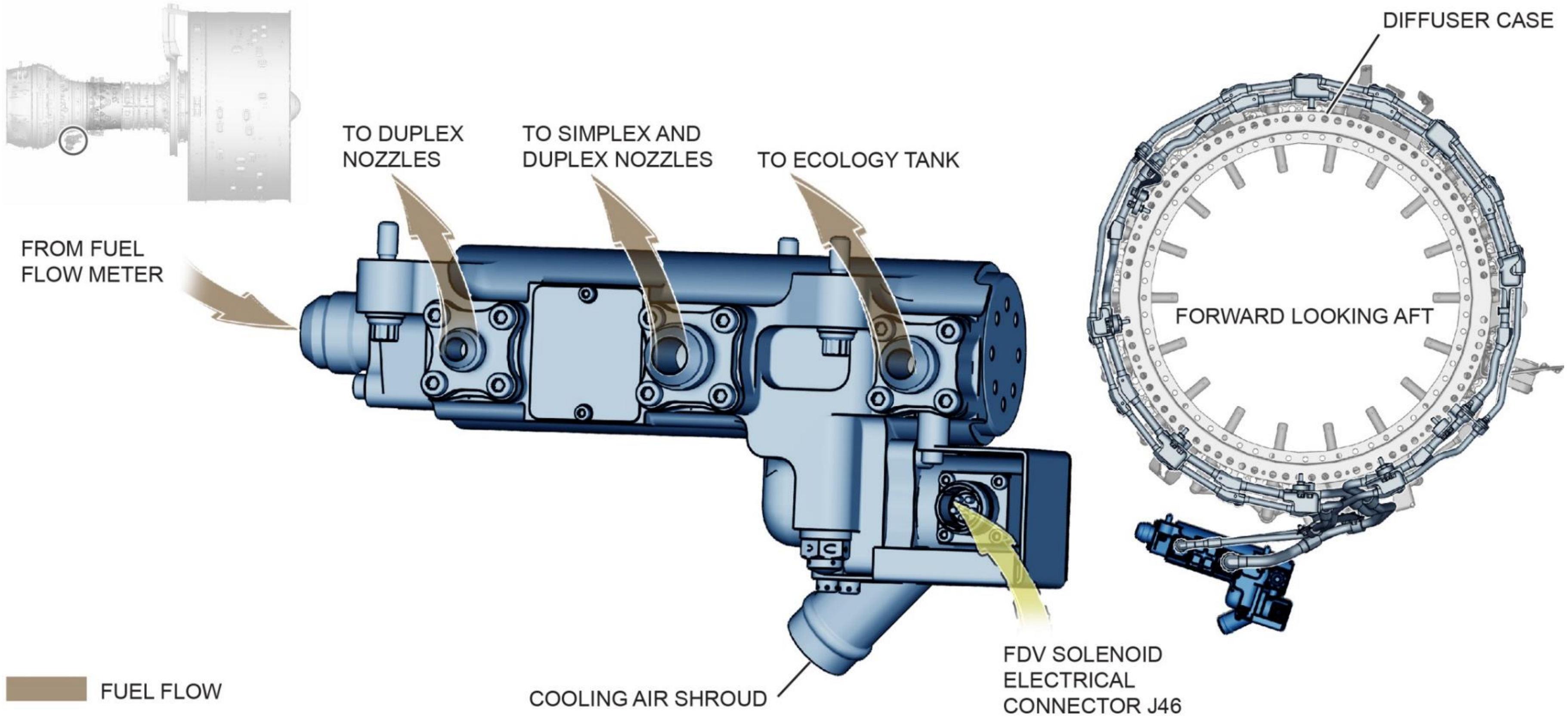
Location:

The FDV is mounted to a bracket at 6:00 just aft of the diffuser case.

Description:

The FDV consists of a dual-channel solenoid that is controlled by the EEC, and a spring and piston within the FDV housing. Fuel entering the FDV passes through a wire mesh inlet screen that captures any large debris present in the fuel.

A two-piece metal shroud covers the FDV solenoid. Cool bypass air is directed to the cavity between the FDV solenoid and the two-piece metal shroud to prevent overheating due to its proximity to the diffuser case.


DIFFUSER CASE
TO DUPLEX NOZZLES
TO SIMPLEX AND DUPLEX NOZZLES
TO ECOLOGY TANK
FROM FUEL FLOW METER
FORWARD LOOKING AFT
FUEL FLOW
COOLING AIR SHROUD
FDV SOLENOID ELECTRICAL CONNECTOR J46

FUEL NOZZLE SUPPLY MANIFOLDS

Purpose:

Fuel nozzle supply manifolds send fuel from the Fuel Manifold to the fuel nozzles.

Location:

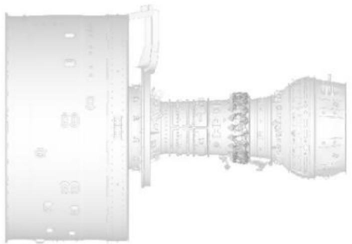
The supply manifolds are attached around the diffuser case.

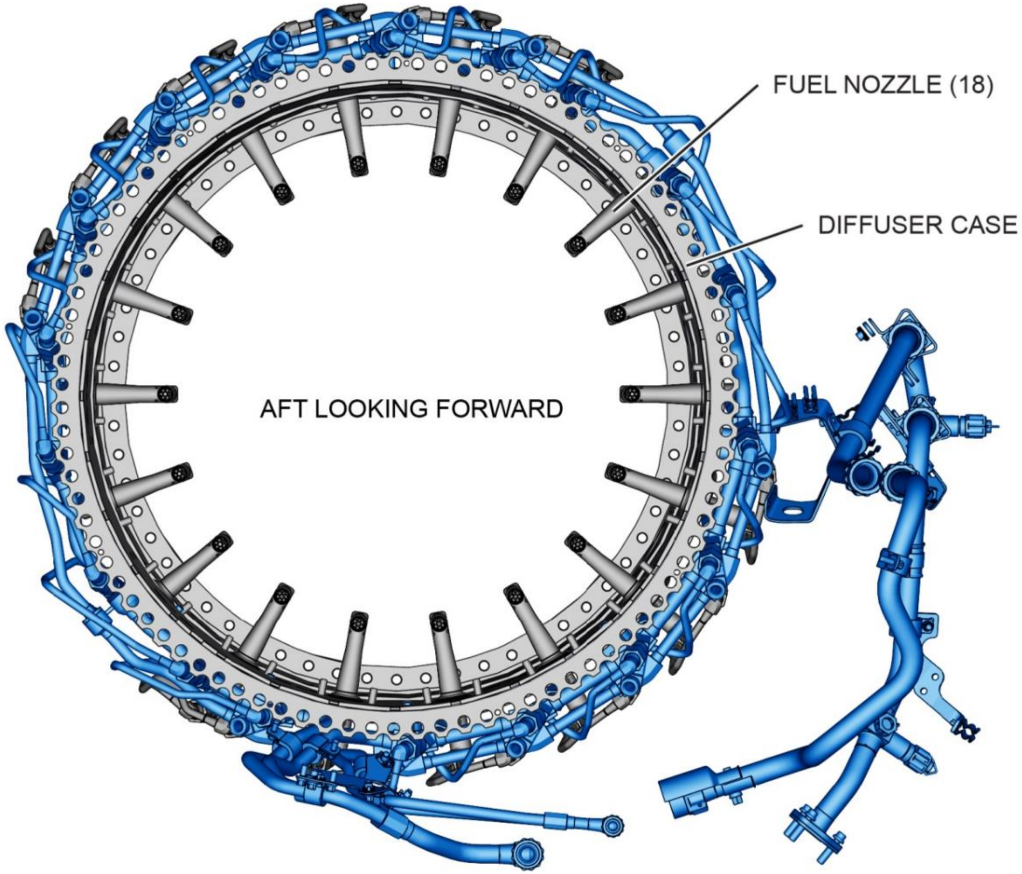
Description:

One supply manifold provides primary fuel supply and the other provides secondary supply.

Operation:

The supply manifolds send fuel from the IFPC fuel divider ports to the fuel nozzles.




FUEL NOZZLE (18)
DIFFUSER CASE
AFT LOOKING FORWARD

FUEL NOZZLES

Purpose:

Eighteen fuel nozzles atomize fuel for combustion inside the combustor.

Location:

Fuel nozzles are mounted to the outer diffuser case.

Description:

Twelve of the eighteen nozzles are duplex nozzles with both a primary and secondary fuel flow path. The remaining six are simplex nozzles that provide only a secondary fuel path.

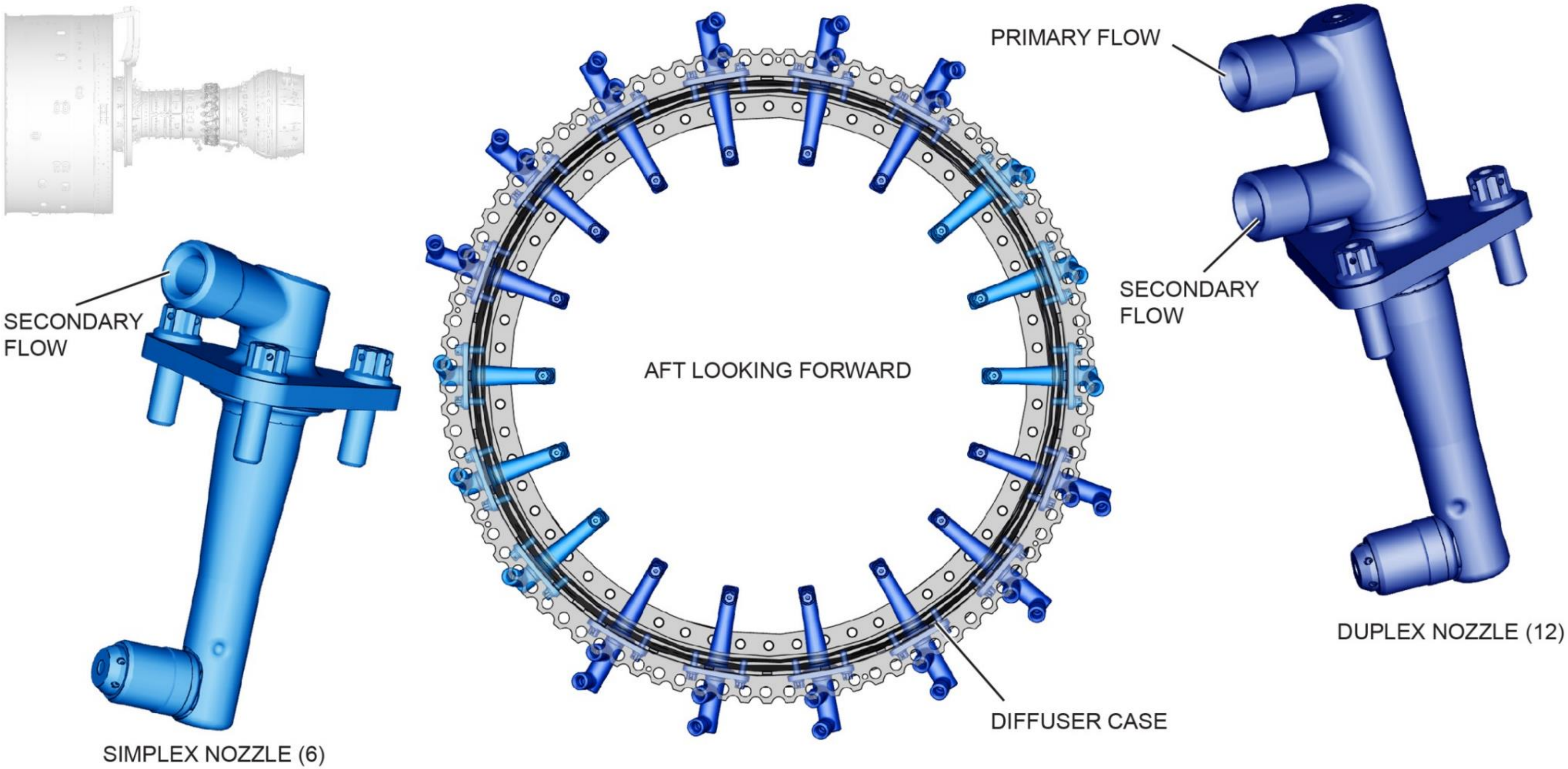
Operation:

At start, only the 12 duplex nozzles will deliver fuel from the primary flow port. During all other power operations, the secondary flow ports on all 18 nozzles will deliver fuel.

At one end of each duplex fuel nozzle is an atomizer installed in the combustion chamber that features a single, primary orifice and six radial jet secondary orifices, which use combustor inlet air to atomize the fuel.

Simplex fuel nozzles have only the six radial jet secondary orifices.

All fuel nozzles have their own support housing and no individual metering or check valves.


SECONDARY
FLOW
SIMPLEX NOZZLE (6)
AFT LOOKING FORWARD
DIFFUSER CASE
PRIMARY FLOW
SECONDARY
FLOW
DUPLEX NOZZLE (12)

ECOLOGY COLLECTOR TANK

Purpose:

The ecology collector tank collects the fuel from the primary and secondary fuel lines that have drained from the Flow Divider Valve (FDV) after engine shutdown.

Location:

The ecology collector tank is located at the rear of the fan case at 6:00.

Description:

Combustor pressure and gravity provide the motive force to push the fuel from the primary and secondary fuel lines into the tank.

Operation:

The outlet port of the ecology collector tank has a one-way check valve (internal to the tank) that is spring-loaded closed.

The check valve is covered by an outlet float valve. The two valves work together to drain fuel from the tank.

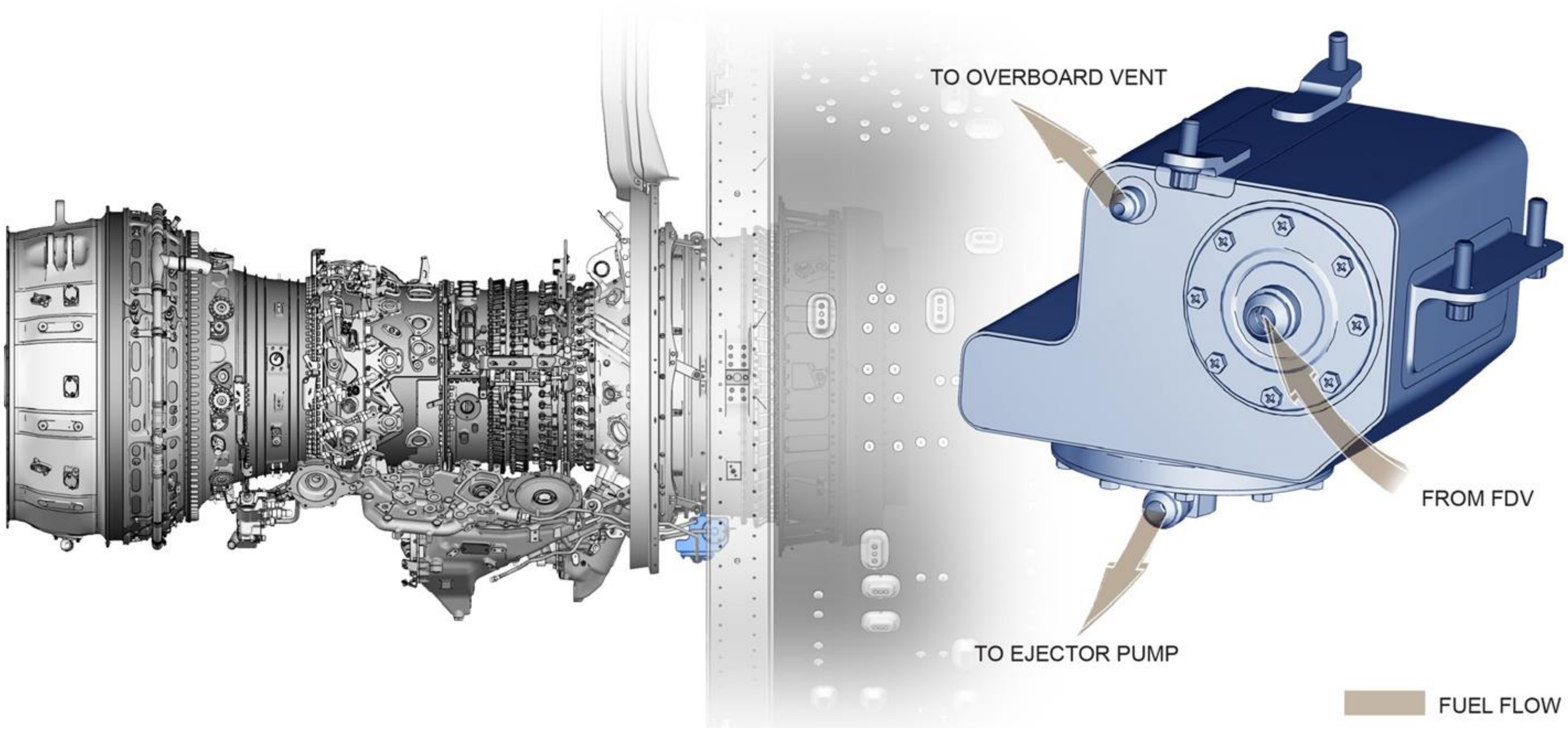
1. During engine start the boost pump in the IFPC directs pressurized fuel to the fuel return pump.

2. The fuel return pump opens the check valve and draws the fuel from the ecology collector tank, back into the boost pump fuel flow.

3. As fuel level decreases inside the ecology collector tank, the outlet float drops until it reaches the bottom, sealing the tank outlet.

The check valve remains open if the engine is running.

4. At shutdown the check valve closes and the outlet float valve rises with the fuel level in the tank.


TO OVERBOARD VENT
FROM FDV
TO EJECTOR PUMP
FUEL FLOW

FUEL RETURN PUMP

Purpose:

The fuel return pump draws the fuel from the ecology collector tank back to the boost pump at engine start up.

Location:

The pump is mounted on the Fuel Manifold, which is attached to the Main Gearbox on the right side of the engine at 4:00.

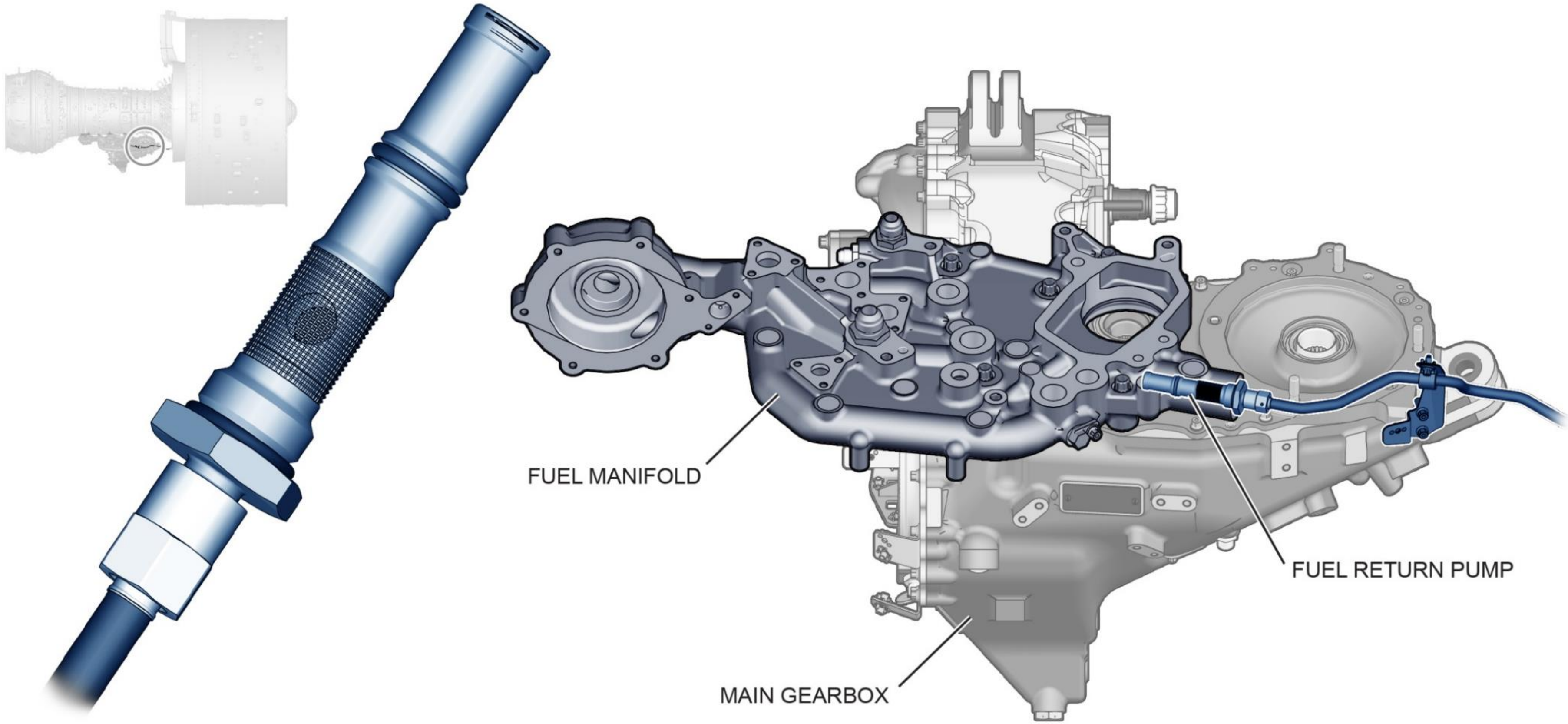
Description:

The fuel return pump receives pressurized fuel from the boost pump during engine operation.

Operation:

Pressurized fuel flows through the pump, creating the motive flow in a Venturi effect to draw the fuel from the ecology collector tank.

The combined fuel is returned to the inlet of the boost pump.


FUEL MANIFOLD
FUEL RETURN PUMP
MAIN GEARBOX

RETURN-TO-TANK VALVE

Purpose:

The Return-to-Tank (RTT) valve controls fuel flow back to the aircraft tank from downstream of the Integrated Drive Generator Fuel/Oil Heat Exchanger (IDG FOHE), and before it enters the engine Fuel/Oil Heat Exchanger as part of the Thermal Heat Management System.

Location:

The valve is attached to the TMS manifold at 9:00.

Description:

The RTT valve is an assembly consisting of a dual-channel solenoid valve, two fuel temperature sensors that are Resistance Temperature Devices (RTDs) and two proximity sensors, all contained within a housing.

The housing has one electrical connector, a fuel inlet port and a fuel outlet port.

The RTT valve is controlled by the EEC and is actuated based on aircraft altitude, ambient temperature, and fuel flow.

Operation:

The RTD sends the fuel temperature signal to the EEC.

At a specific fuel temperature, the EEC will energize the solenoid valve to open, directing some fuel back to the aircraft tank and bypassing the Fuel/Oil Heat Exchanger.

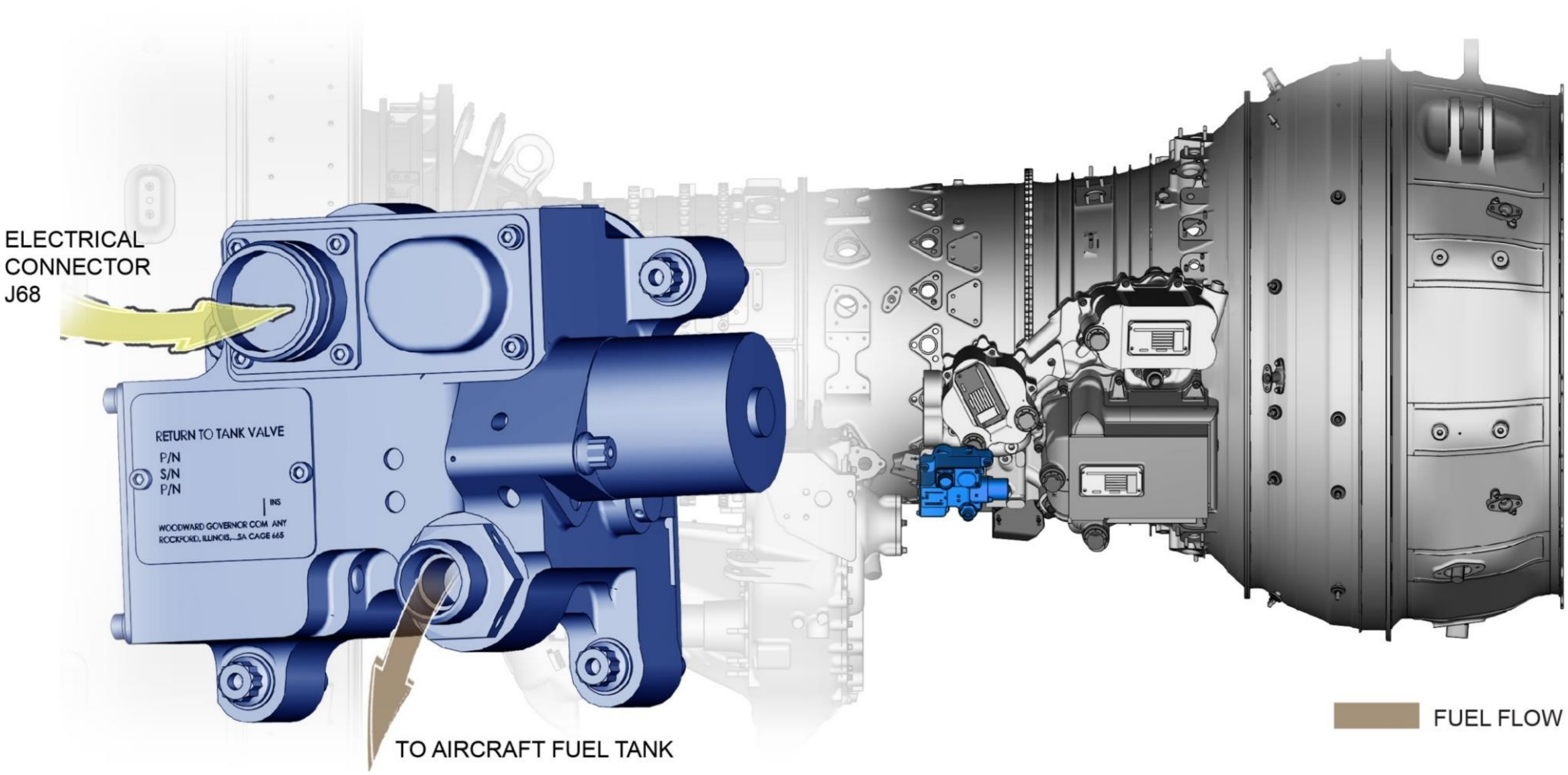
Proximity sensors monitor the solenoid valve position and send an “open” signal as position feedback to the EEC.

When the fuel temperature has decreased to a specific temperature, the EEC will de-energize the solenoid, directing the fuel back to the engine Fuel System.

When the RTT valve is open, it helps to cool IDG oil by increasing fuel flow through the IDG FOHE, removing additional heat.

This heated fuel is then directed back to the aircraft tank, where the heat dissipates.

This effect helps to maintain a lower overall fuel temperature, which in turn keeps the engine oil temperature lower when the fuel passes through the FOHE.

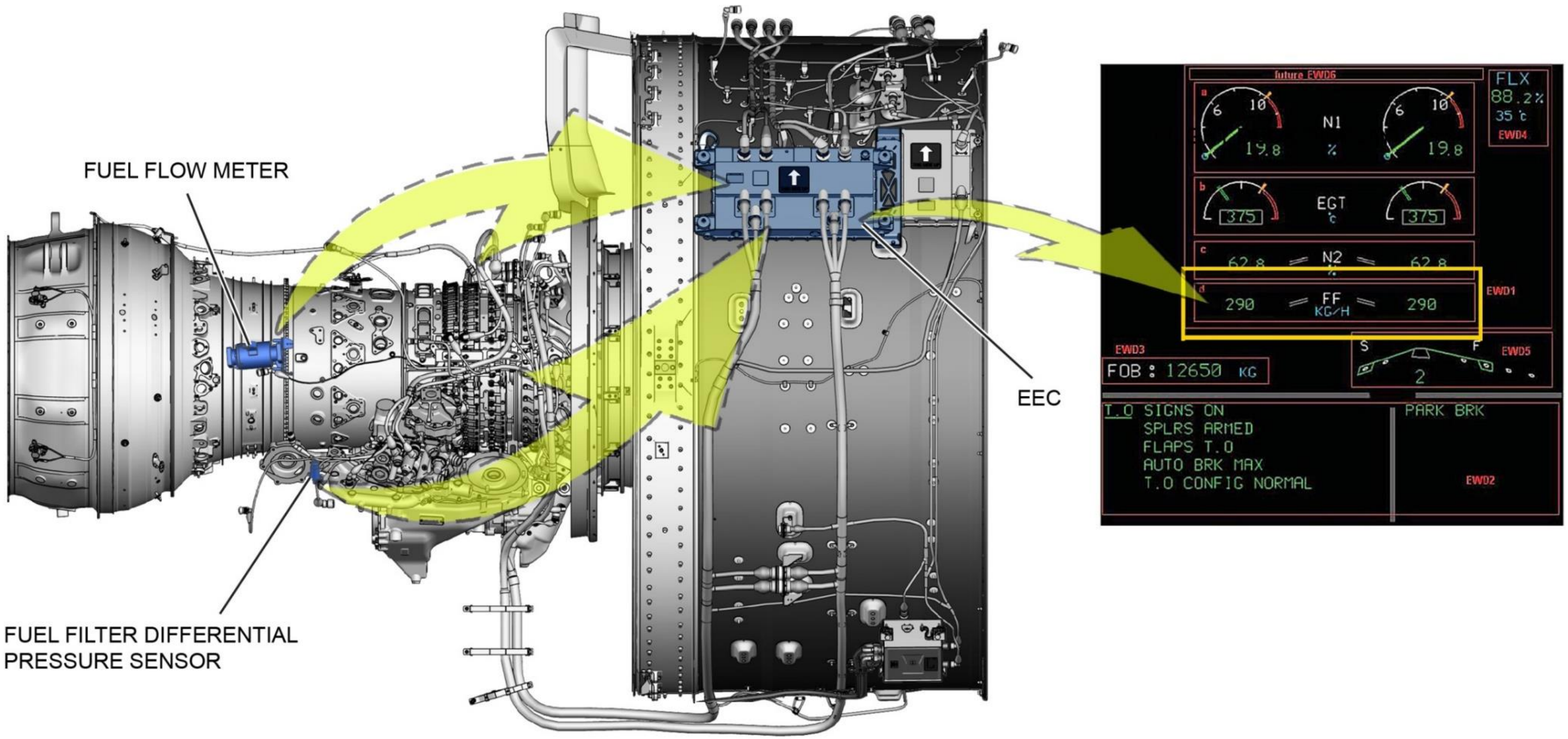

ELECTRICAL
CONNECTOR
J68
RETURN TO TANK VALVE
P/N
S/N
P/N
TO AIRCRAFT FUEL TANK
FUEL FLOW

FUEL INDICATING SYSTEM

The Fuel Indicating System monitors fuel flow and sends messages to the flight deck display about the system status and possible fuel filter clogs.

The system consists of the components shown below.

Fuel Flow Meter FFM
Fuel Filter Differential Pressure sensor FFDP
Fuel temperature sensor TF
IDG Fuel/Oil Heat Exchanger differential pressure sensor


FUEL FLOW METER
FUEL FILTER DIFFERENTIAL
PRESSURE SENSOR
EEC
FLX
88.2%
35 °C
N1
EGT
N2
FF
KG/H
290
290
FOB : 12650 KG
T.O SIGNS ON
SPLRS ARMED
FLAPS T.O
AUTO BRK MAX
T.O CONFIG NORMAL
PARK BRK

FUEL FLOW METER (FFM)

Purpose:

The Fuel Flow Meter sends the EEC a signal that is used to calculate fuel flow to the combustor.

Location:

The Fuel Flow Meter is at 3:00 on the right side of the engine.

Description:

The FFM is a single element device wired to Channel A of the EEC.

The signal is hardwired to Channel B internal to the EEC. The FFM is an in-line sensor located between the IFPC and the Flow Divider Valve.

Operation:

1. Fuel enters the driver assembly which provides the torque to rotate the shaft, drum and impeller. The vanes straighten the fuel flow and direct it to the rotating impeller.

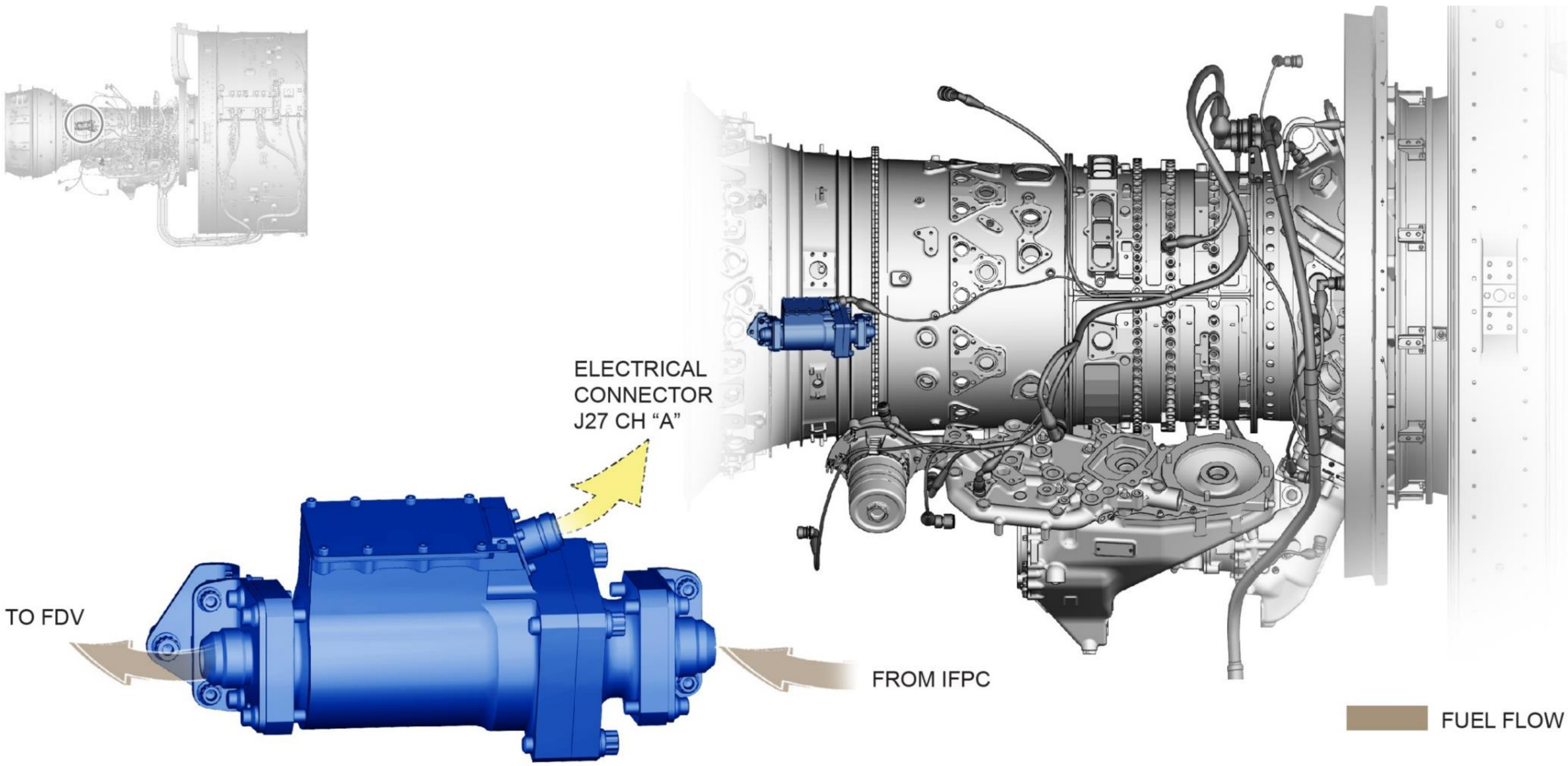
2. The fuel flowing through the rotating impeller causes it to deflect proportionally against a spring. Impeller deflection relative to the drum is measured by pulses generated by magnets attached to the drum and impeller.

3. The pulses are converted at the electrical connector to an electronic signal that is sent to the EEC.

The EEC then transmits the signal, in the form of fuel flow.

4. The EEC also computes fuel flow based on the fuel metering valve position and fuel temperature, and compares this calculated value to the value measured by the FFM.

If the fuel flow measured by the FFM is determined to be invalid, the fuel flow indication in the cockpit is replaced by amber crosses.


ELECTRICAL
CONNECTOR
J27 CH "A"
TO FDV
FROM IFPC
FUEL FLOW

FUEL DIFFERENTIAL PRESSURE SENSOR (FFDP)

Purpose:

The Fuel Filter Differential Pressure sensor alerts the crew of an impending filter clog by providing a signal to the EEC, which sends a ECAM message to the flight deck.

Location:

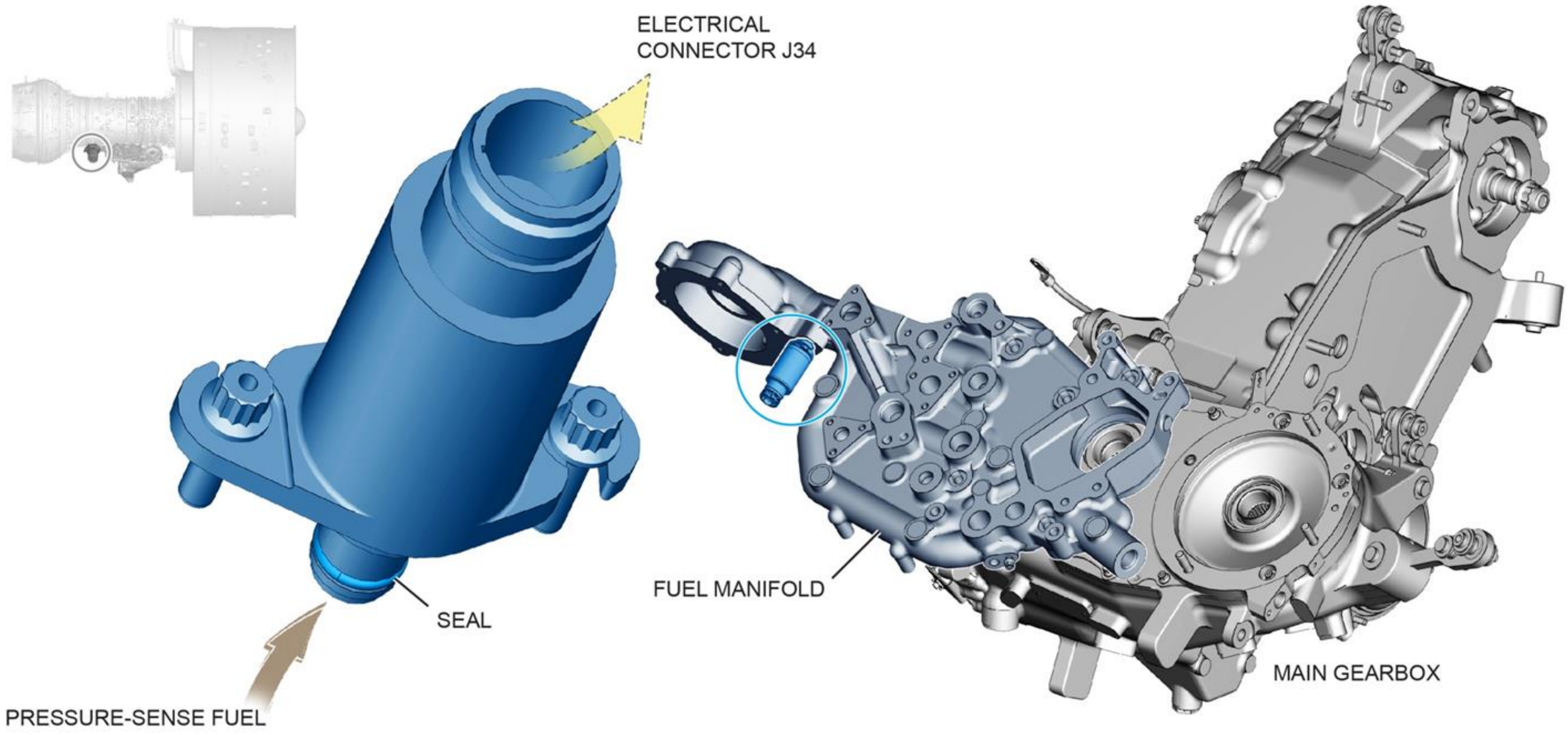
The sensor is mounted on the forward side of the Fuel Manifold next to the fuel filter at 5:00.

Description:

The dual-channel, differential pressure strain gage sensor has an offset clawfoot mount for fast, error-free maintenance.

Operation:

The FFDP measures differential pressure across the fuel filter. If the difference goes beyond design limits, the sensor issues an advisory signal to the flight deck display through the EEC.


ELECTRICAL
CONNECTOR J34
SEAL
PRESSURE-SENSE FUEL
FUEL MANIFOLD
MAIN GEARBOX

IDG FUEL/OIL HEAT EXCHANGER DIFFERENTIAL PRESSURE SENSOR

Purpose:

The IDG Fuel/Oil Heat Exchanger differential pressure sensor measures the difference in fuel pressure upstream and downstream of the heat exchanger.

Location:

The sensor is located at 9:00 on the heat exchanger manifold.

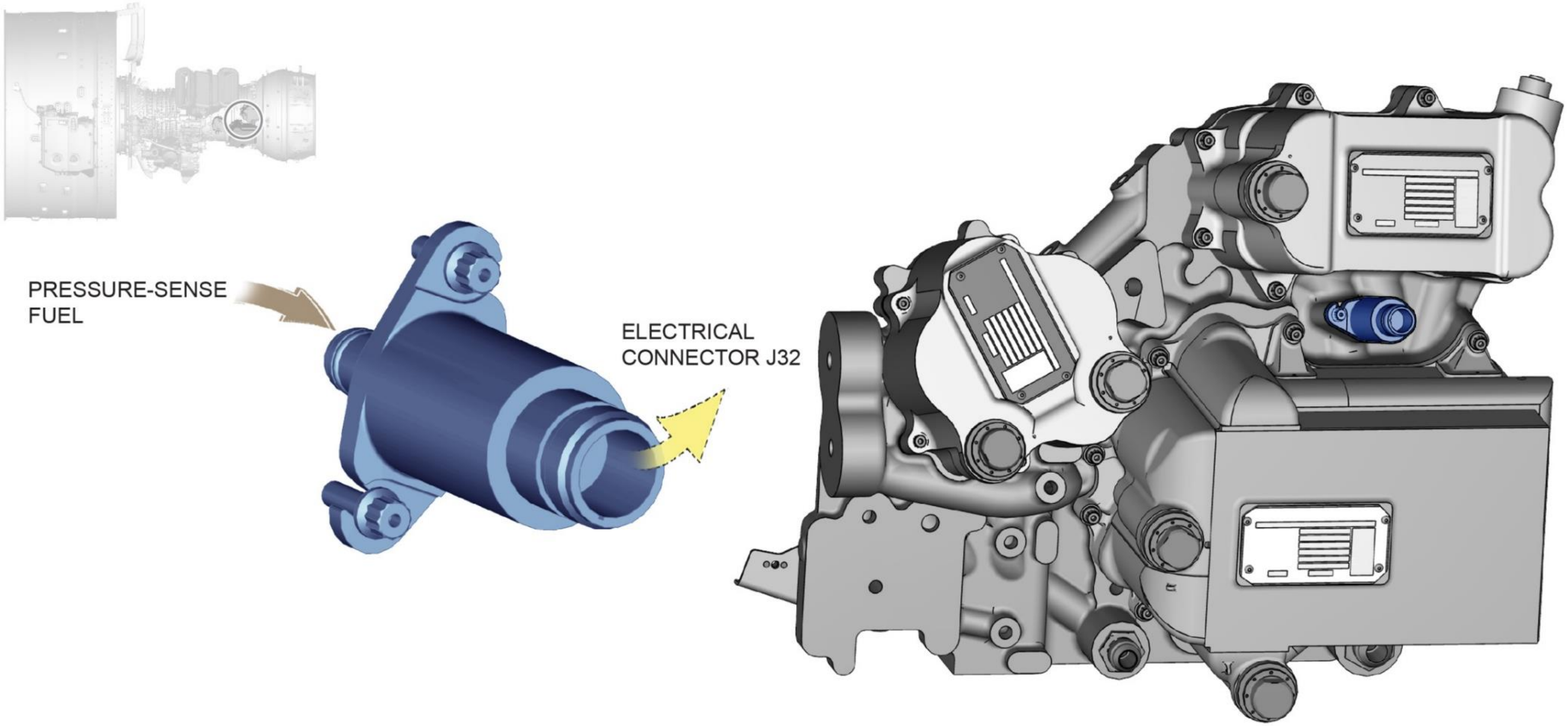
Description:

The sensor is dual channel.

Operation:

When pressure is applied, the strain gages change resistance, altering the output voltage. The output voltage for each sensing element correlates directly to fuel pressure and is sent to the EEC.

The EEC uses the differential pressure signal to send an IDGFOHE impending bypass message. The message is dependent on the differential pressure value.


PRESSURE-SENSE
FUEL
ELECTRICAL
CONNECTOR J32

FUEL TEMPERATURE SENSOR (Tfuel)

Purpose:

The sensor provides fuel temperature to the EEC.

Location:

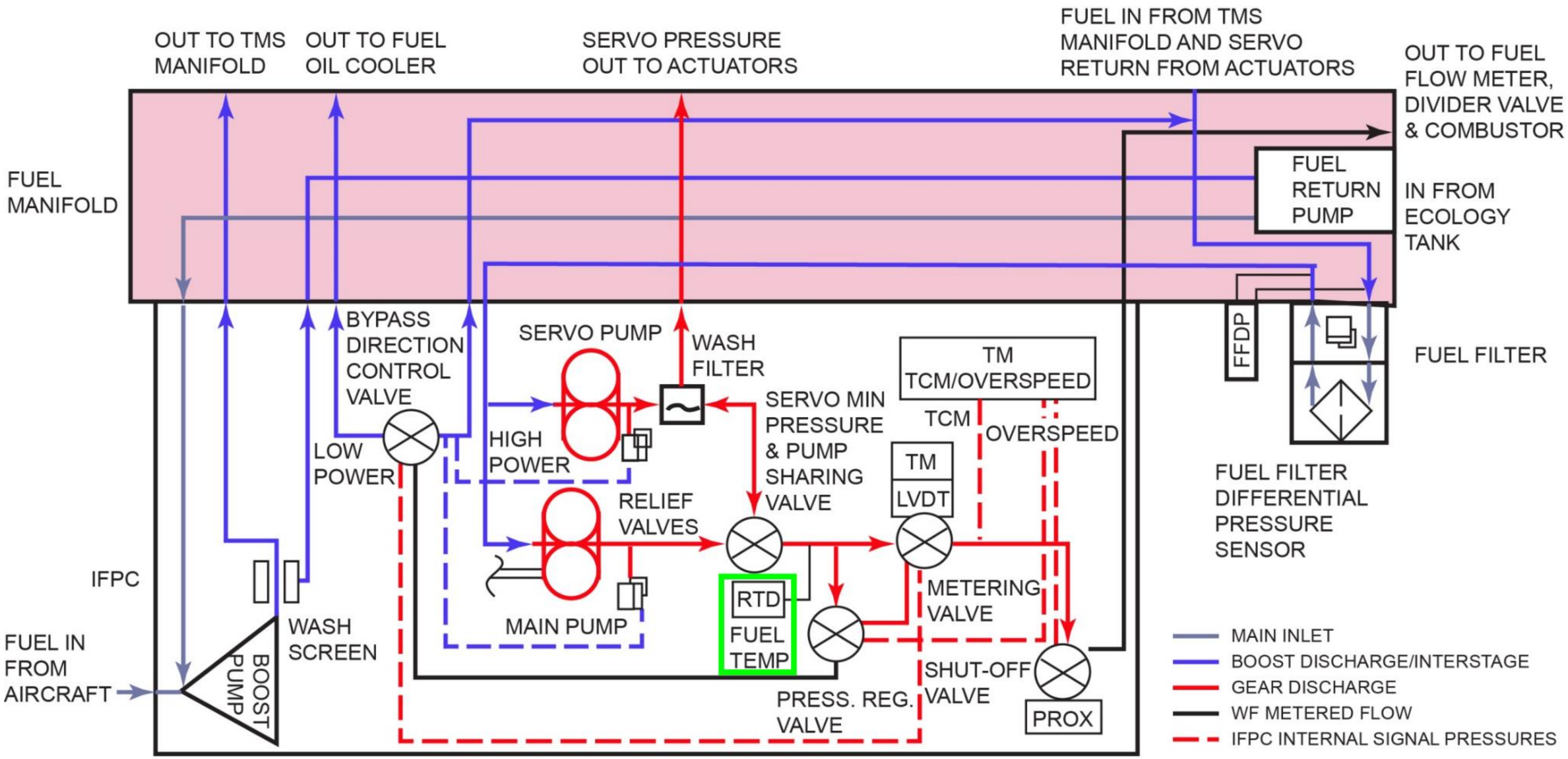
The sensor is built into the IFPC mounted on the Main Gearbox at 4:00.

Description:

The sensor is a dual channel Resistive Temperature Device (RTD) with an independent sensing element per channel. The sensor is integral to the IFPC.

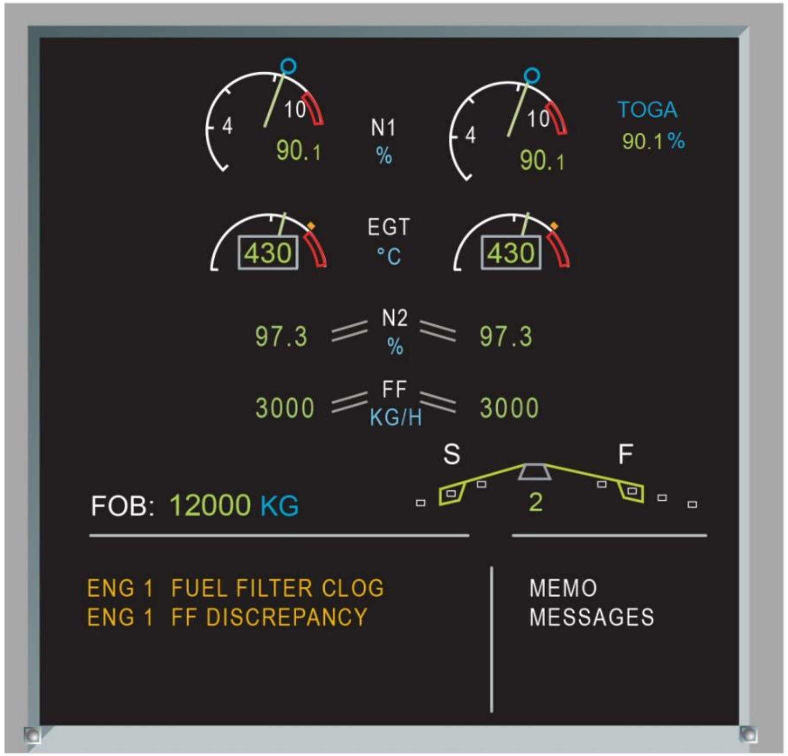
Operation:

The sensor monitors fuel temperatures prior to metering, and provides feedback to the EEC for positioning the FOHE oil bypass valve.


OUT TO TMS MANIFOLD
OUT TO FUEL OIL COOLER
SERVO PRESSURE OUT TO ACTUATORS
FUEL IN FROM TMS MANIFOLD AND SERVO RETURN FROM ACTUATORS
OUT TO FUEL FLOW METER, DIVIDER VALVE & COMBUSTOR
FUEL MANIFOLD
FUEL RETURN PUMP
IN FROM ECOLOGY TANK
FFDP
FUEL FILTER
BYPASS DIRECTION CONTROL VALVE
SERVO PUMP
WASH FILTER
SERVO MIN PRESSURE & PUMP SHARING VALVE
TM TCM/OVERSPEED
TCM
OVERSPEED
TM
LVDT
HIGH POWER
LOW POWER
RELIEF VALVES
METERING VALVE
FUEL FILTER DIFFERENTIAL PRESSURE SENSOR
IFPC
RTD
FUEL TEMP
MAIN PUMP
WASH SCREEN
FUEL IN FROM AIRCRAFT
BOOST PUMP
SHUT-OFF VALVE
PRESS. REG. VALVE
PROX
MAIN INLET
BOOST DISCHARGE/INTERSTAGE
GEAR DISCHARGE
WF METERED FLOW
IFPC INTERNAL SIGNAL PRESSURES

INTENTIONALLY BLANK

FLIGHT CREW INITIAL WARNING



ENGINE/WARNING DISPLAY

INTERACTIVE MODE FOR MAINTENANCE ACTION

MULTIPURPOSE CENTRALIZED DISPLAY UNIT (MCDU)

SAMPLE ECAM MESSAGES FOR ATA 73

INTENTIONALLY BLANK

ENGINE CONTROL (FADEC)

ENGINE CONTROL SYSTEM

The Engine Control System regulates and monitors engine operations using the Full Authority Digital Electronic Control (FADEC). FADEC is a computer-based system that acts as the primary interface between the engine and aircraft.

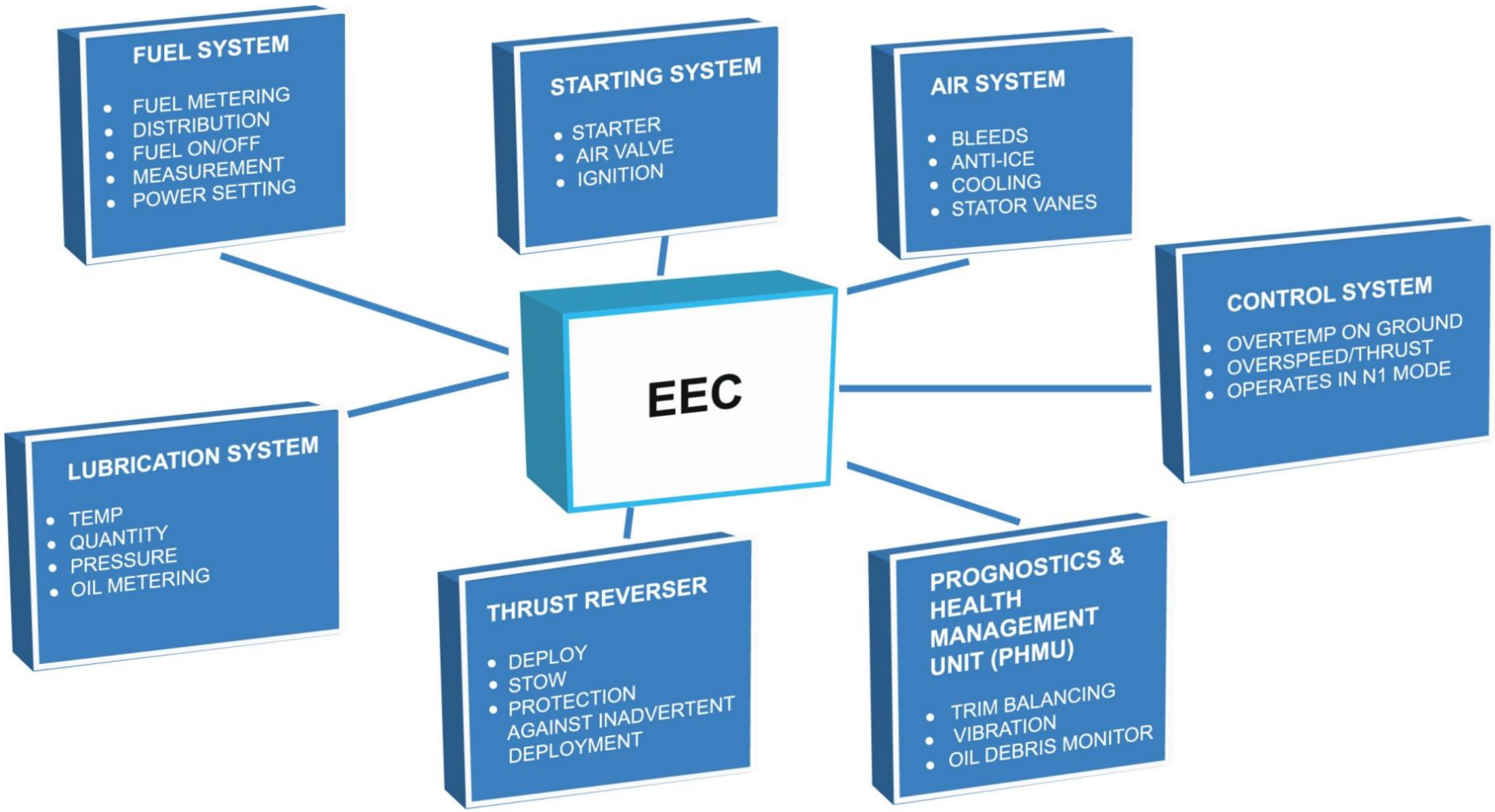
Found in both aircraft and engine systems, FADEC components work together to improve efficiency, enhance control functions, protect the engine, and provide operational reliability.

Numerous FADEC aircraft and engine components are overseen by the Electronic Engine Control (EEC), which is itself a component of the FADEC system.

The EEC sends, receives, and interprets information between aircraft and engine systems, while controlling and monitoring engine functions in systems including Fuel, Air, Starting, Oil, Thrust Reverser and Thermal Heat Management.

In conjunction with the engine's Prognostics and Health Management Unit (PHMU), the EEC analyses the condition of the engine based on operating parameters such as rotor rpm, fuel flow and exhaust gas temperatures.

Engine condition information is recorded and sent in real time to ground maintenance stations, and to the aircraft in the form of maintenance, caution, warning and status messages.


FUEL SYSTEM
FUEL METERING
DISTRIBUTION
FUEL ON/OFF
MEASUREMENT
POWER SETTING
STARTING SYSTEM
STARTER
AIR VALVE
IGNITION
AIR SYSTEM
BLEEDS
ANTI-ICE
COOLING
STATOR VANES
CONTROL SYSTEM
OVERTEMP ON GROUND
OVERSPEED/THRUST
OPERATES IN N1 MODE
EEC
LUBRICATION SYSTEM
TEMP
QUANTITY
PRESSURE
OIL METERING
THRUST REVERSER
DEPLOY
STOW
PROTECTION AGAINST INADVERTENT DEPLOYMENT
PROGNOSTICS & HEALTH MANAGEMENT UNIT (PHMU)
TRIM BALANCING
VIBRATION
OIL DEBRIS MONITOR

Components found on the right side of the engine are listed below.

Electronic Engine Control EEC

Pressure and temperature probe at Station 2.5 (P2.5/T2.5)

Data Storage Unit DSU

Wiring harnesses

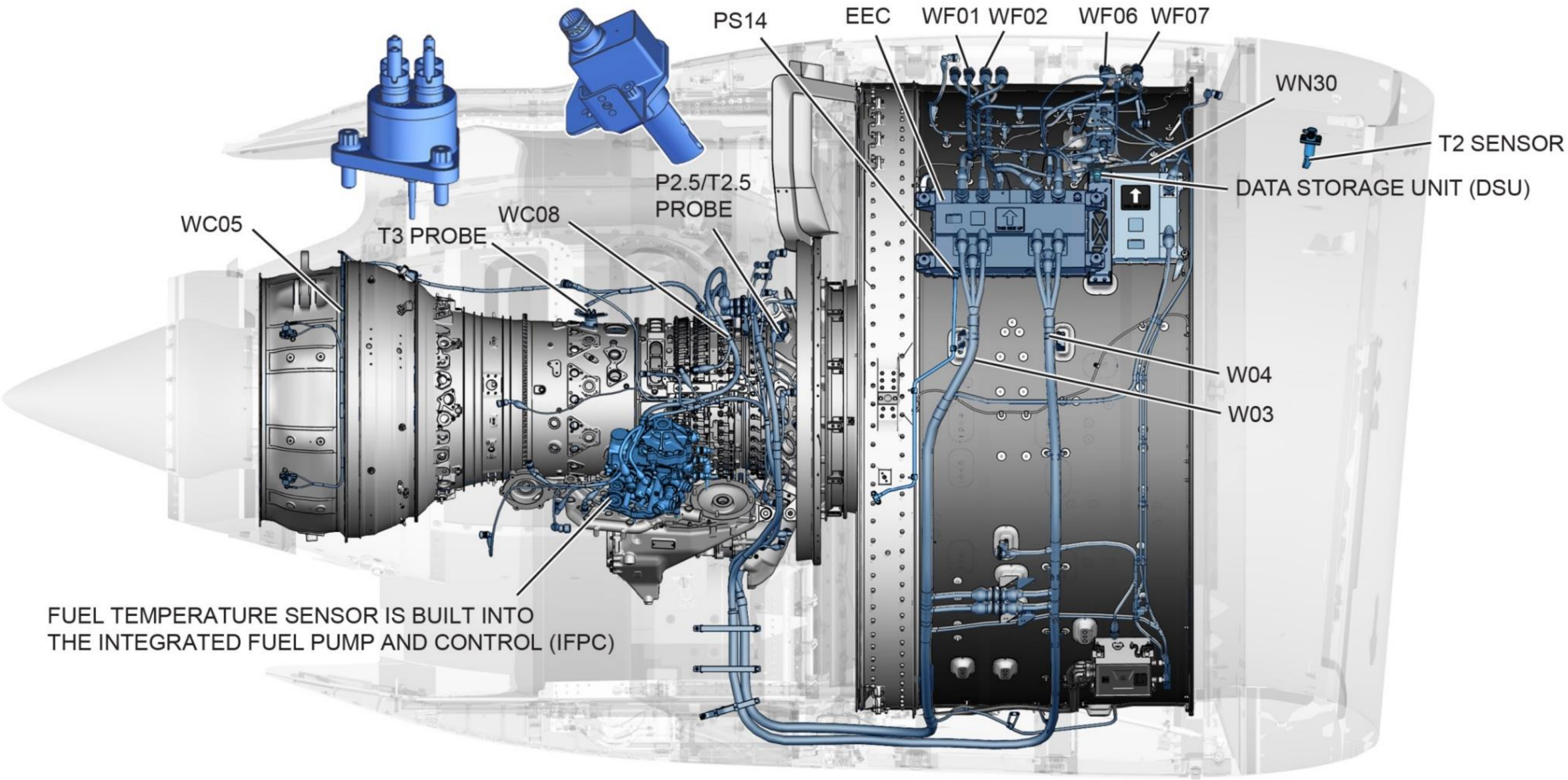
Fan: WF01, WF02, WF06, WF07, WN30
Core: WC05, WC08

Ambient pressure sensor Pamb

Temperature sensor at Station 2 T2

Temperature sensor at Station 3 T3

Pressure sensor at Station 14 PS14


PS14
EEC
WF01 WF02
WF06 WF07
WN30
T2 SENSOR
DATA STORAGE UNIT (DSU)
P2.5/T2.5
PROBE
WC08
WC05
T3 PROBE
W04
W03
FUEL TEMPERATURE SENSOR IS BUILT INTO
THE INTEGRATED FUEL PUMP AND CONTROL (IFPC)

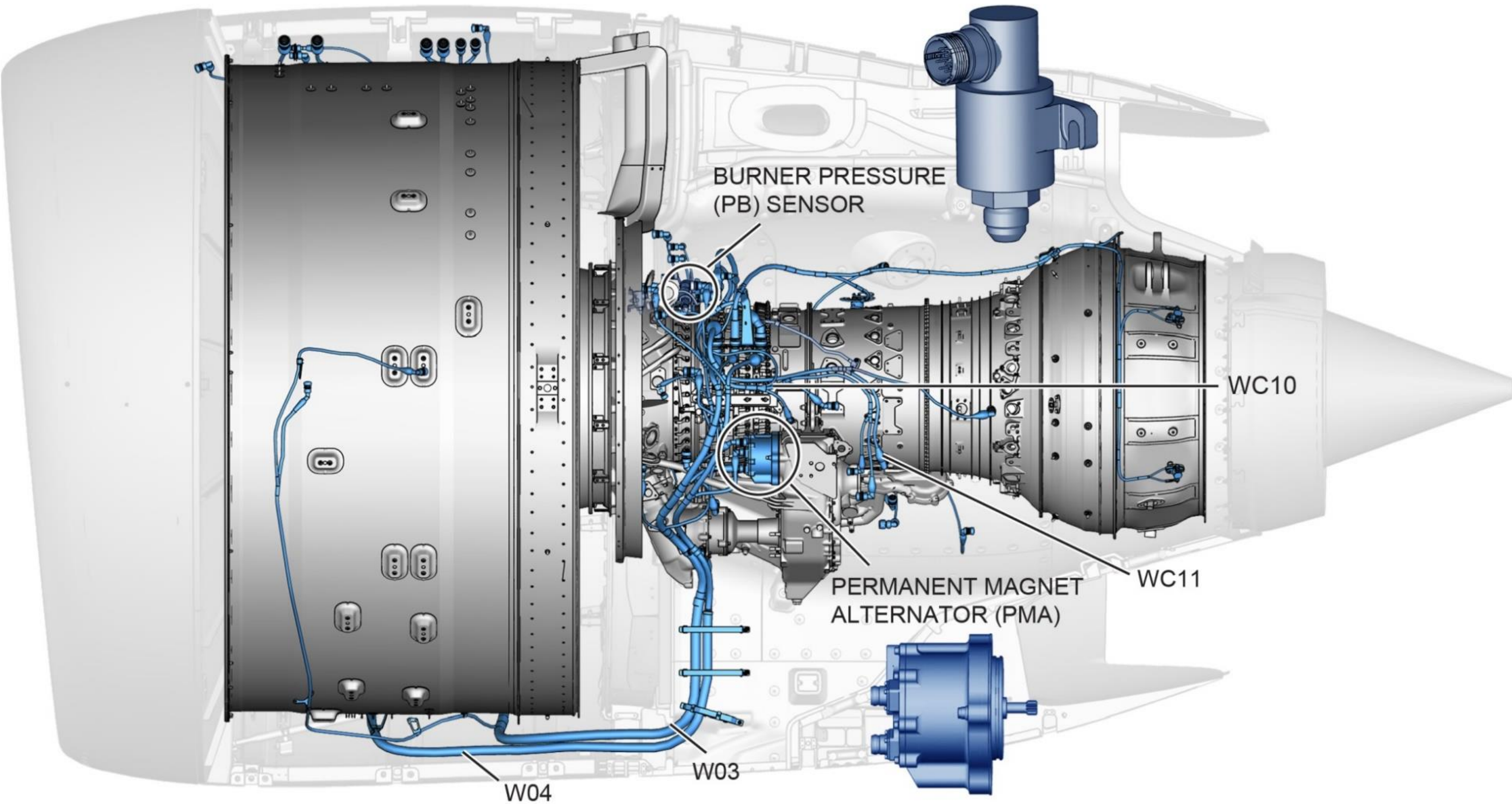
Components found on the left side of the engine are listed below.

Burner pressure sensor Pb

Permanent Magnet Alternator PMA

Wiring harnesses

Core: WC10, WC11, W03, W04


BURNER PRESSURE
(PB) SENSOR
WC10
PERMANENT MAGNET
ALTERNATOR (PMA)
WC11
W03
W04

Engine Electronic Control (EEC)

Purpose:

The EEC sends command signals from the FADEC System and receives and interprets FADEC signals in turn.

It energizes and deenergizes solenoids, and performs parameter calculations to control and monitor engine systems including Fuel, Air, Oil, Starting/Ignition, and thrust and limits controls.

The EEC also controls the Nacelle Anti-Ice System and monitors the Thrust Reverser System. It sends signals to the cockpit to communicate the status of the FADEC System and its interfacing components.

Location:

The EEC is attached to the Fan Case Assembly at 2:30.

Safety Conditions

CAUTION

DO NOT BEND OR TWIST THE WIRING HARNESS TOO MUCH. IF YOU DO, DAMAGE TO THE WIRING HARNESS CAN OCCUR.

MAKE SURE THAT THERE IS NO POWER TO THE EEC DURING THEREPLACEMENT OF THE EEC AND WHEN YOU REMOVE THE DATASTORAGE UNIT (DSU). IF THERE IS POWER TO THE EEC DURING THISTASK, DAMAGE TO THE EEC OR DSU CAN OCCUR.

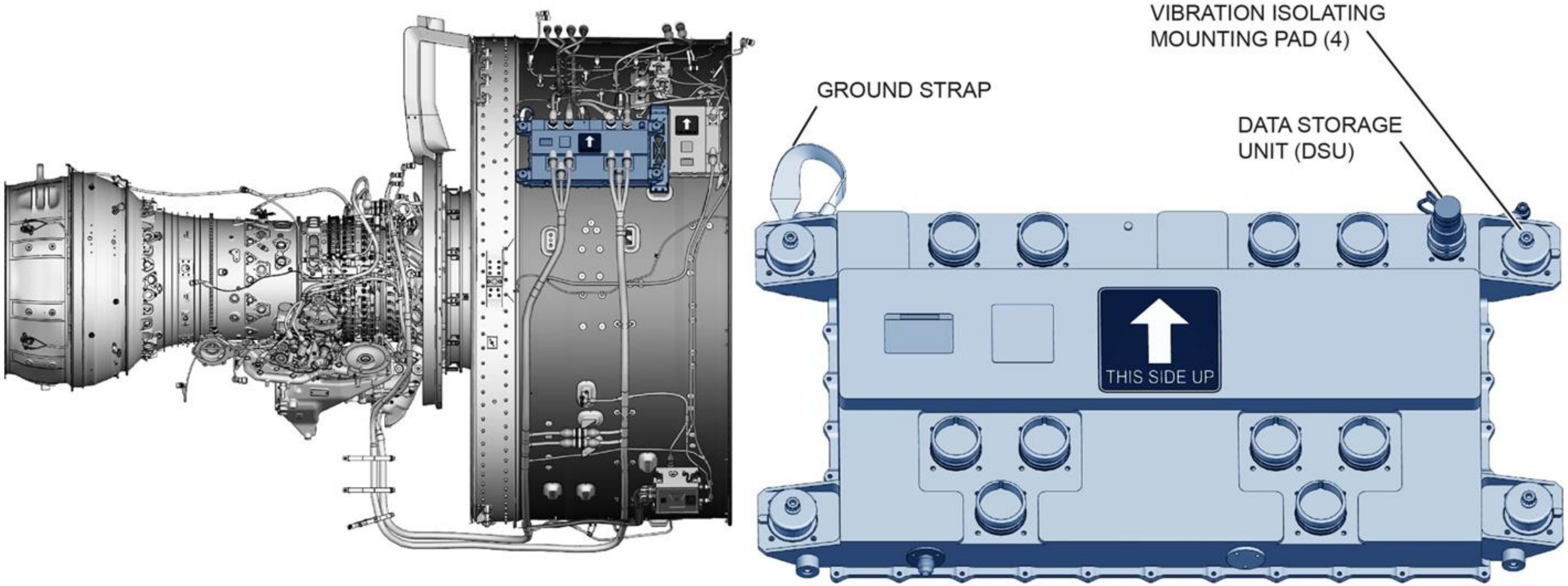
MAKE SURE THE DATA STORAGE UNIT REMAINS WITH THE ENGINE WHEN THE EEC IS REMOVED. IF YOU DO NOT OBEY THIS CAUTION AND AN INCORRECT DSU IS INSTALLED,

ENGINE OPERATION CAN BE AFFECTED.

IF ONLY THE EEC WAS REPLACED, MAKE SURE THAT THE DATA STORAGE UNIT (DSU) INSTALLED ON THE ENGINE IS REINSTALLED IN THE REPLACEMENT EEC. IF YOU DO NOT OBEY THIS, ENGINE OPERATION MAY BE AFFECTED.

PUT CAPS OR COVERS ON ALL OPEN PORTS OF ENGINE COMPONENTS TO PREVENT CONTAMINATION OF THE INTERNAL SURFACES.

MAKE SURE YOU HOLD THE EEC WHILE YOU REMOVE THE BOLTS. IF YOU DO NOT HOLD THE EEC, IT CAN FALL AND CAUSE DAMAGE TO THE EEC AND OTHER ENGINE PARTS.


VIBRATION ISOLATING
MOUNTING PAD (4)
GROUND STRAP
DATA STORAGE
UNIT (DSU)
THIS SIDE UP

Engine Electronic Control (EEC)

Description:

The EEC receives power from the Permanent Magnet Alternator (PMA) or from the aircraft as a backup supply.

Redundant A and B channels incorporate processors that respond to and process information based on the logic and data stored in program memory.

The processors, program memory, and power supply are contained in an aluminium housing with 11 external electrical receptacles.

Each channel has five electrical receptacles to send command signals and receive signals.

One electrical receptacle provides attachment for the Data Storage Unit (DSU).

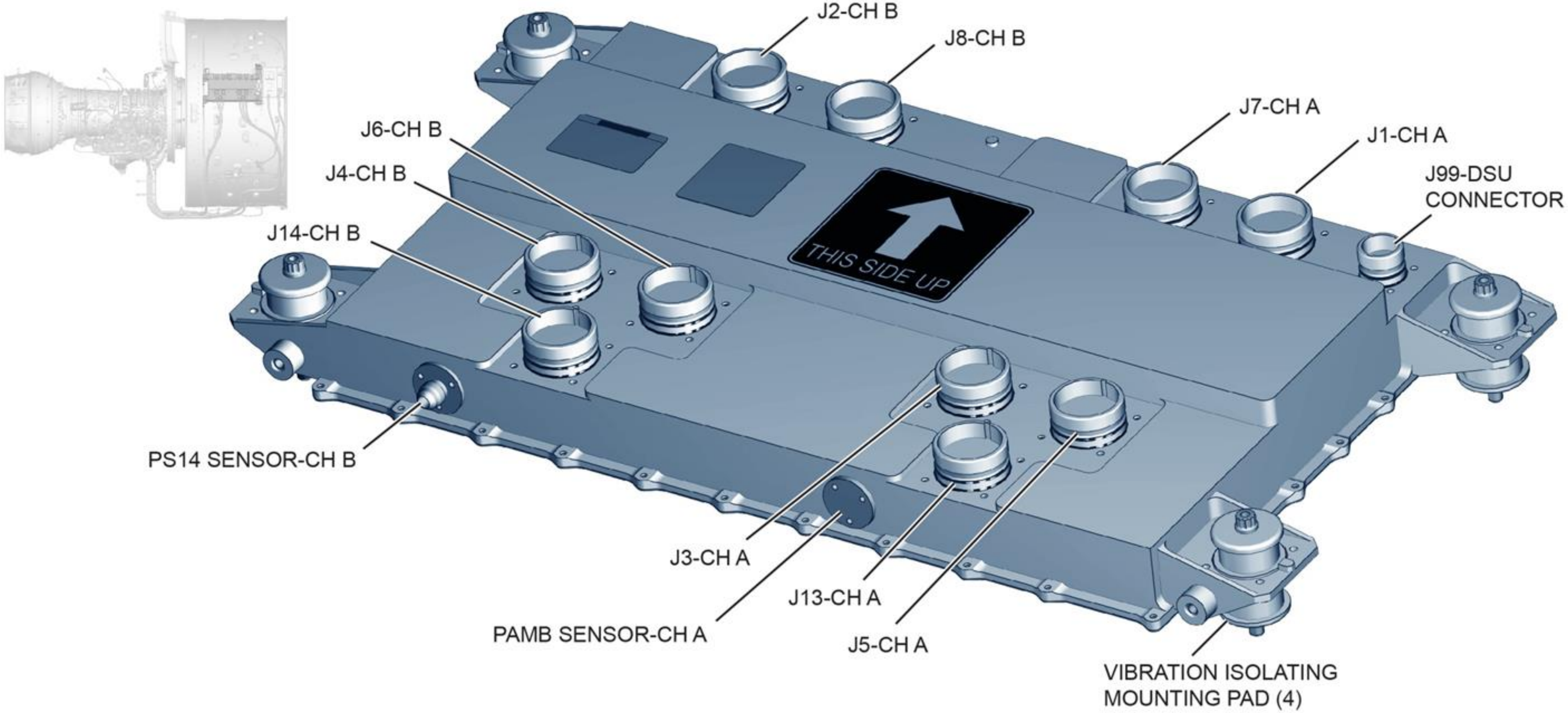
Two internal pressure sensors are also contained within the aluminium housing, one to measure fan exit air pressure (PS14) and another to measure ambient air pressure (Pamb).

Each time the EEC powers up, it conducts an automatic built-in test to verify its integrity.

If the EEC fails the built-in test, it will send an Electronic Centralized Aircraft Monitor (ECAM) warning to the flight deck.

The EEC is re-programmable on-wing using a portable software loader.

Channel	Connector	Wiring
A	J1	Aircraft/engine
	J3, J5, J13	Engine
	J7	Nacelle
	J99	DSU connector
B	J2	Aircraft/engine
	J4, J6, J14	Engine
	J8	Nacelle


J2-CH B
J8-CH B
J7-CH A
J1-CH A
J99-DSU
CONNECTOR
J6-CH B
J4-CH B
J14-CH B
THIS SIDE UP
PS14 SENSOR-CH B
J3-CH A
PAMB SENSOR-CH A
J13-CH A
J5-CH A
VIBRATION ISOLATING
MOUNTING PAD (4)

PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

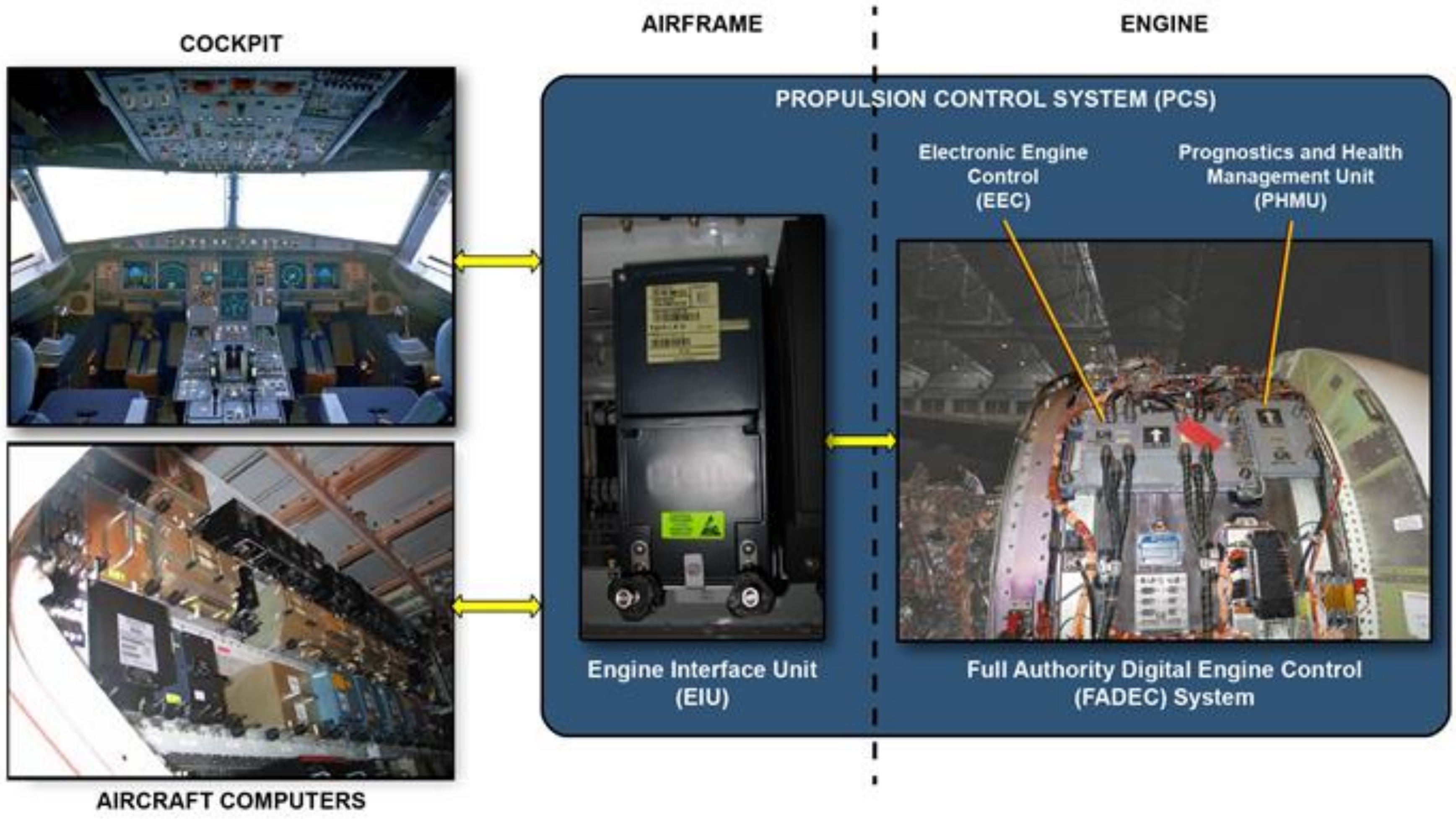
GENERAL

The Propulsion Control System (PCS) consists in Engine Interface Unit (EIU) and FADEC System which includes Electronic Engine Control (EEC) and Prognostics and Health Management Unit (PHMU).

Each EIU is dedicated to an engine. EIU 1 and 2 are located in the aircraft avionics bay 80VU.

The EEC and PHMU are attached to the engine fan case assembly at 2:30.

Both EEC & PHMU are vibration-isolated units, which are cooled by natural convection.


COCKPIT
AIRFRAME
ENGINE
PROPULSION CONTROL SYSTEM (PCS)
Electronic Engine Control (EEC)
Prognostics and Health Management Unit (PHMU)
Engine Interface Unit (EIU)
Full Authority Digital Engine Control (FADEC) System
AIRCRAFT COMPUTERS

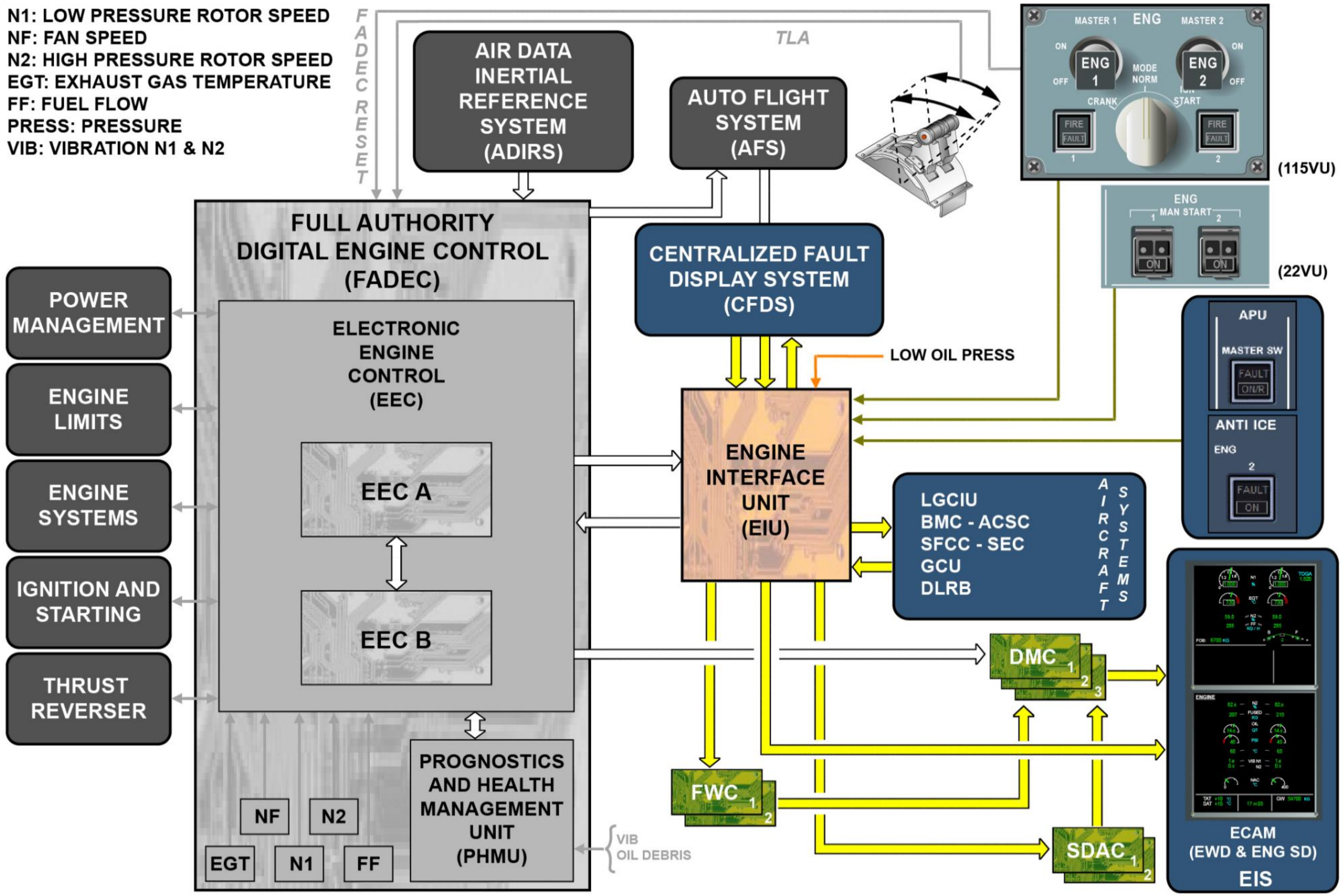
ENGINE INTERFACE UNIT

Each EIU is an interface concentrator between the airframe and the corresponding EEC on the engine.

It ensures the segregation of the 2 engines and aircraft electrical power supply to the FADEC.

It concentrates data from or to the cockpit panels and displays.

It gives logics and information to or from other aircraft systems as Flight/Ground from Landing Gear Control and Interface Unit (LGCIU).


N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
EGT: EXHAUST GAS TEMPERATURE
FF: FUEL FLOW
PRESS: PRESSURE
VIB: VIBRATION N1 & N2
FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
TLA
AUTO FLIGHT SYSTEM (AFS)
MASTER 1
ENG
MASTER 2
ON
OFF
MODE NORM
CRANK
START
FIRE
FAULT
(115VU)
ENG MAN START
ON
(22VU)
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
FAULT
ON
ENGINE INTERFACE UNIT (EIU)
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

FADEC

The FADEC consists in a dual channel EEC with crosstalk and failure detection, a PHMU and sensors used for control and monitoring.

The FADEC system manages the engine thrust and optimizes the performance.

The EEC interfaces with most of the A/C systems through the EIU.

The FADEC controls the engine parameters displayed in the cockpit.

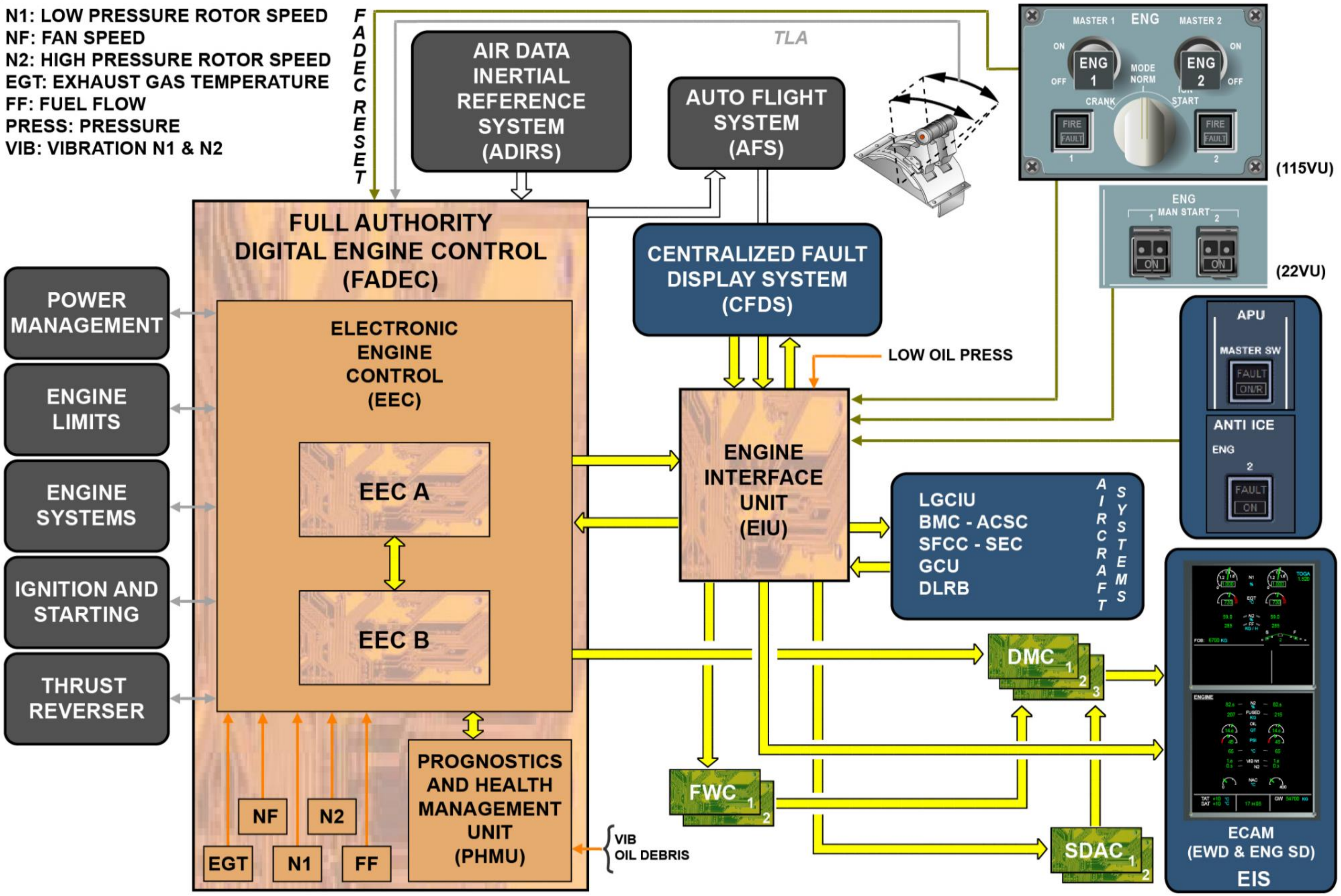
The primary parameters (N1, N2, Exhaust Gas Temperature (EGT) and Fuel Flow (FF)) are sent directly by the EEC to the ECAM via Display Management Computers (DMCs).

The engine system page shows secondary parameters: oil quantity, Oil pressure and Oil temperature, fuel used, and engine N1 and N2 vibration

The vibration figures are communicated by the PHMU to the EEC.

These secondary parameters are transmitted to the ECAM SD via the EIUs and the SDACS

The Flight Warning System (FWS) will gather necessary information directly from EEC, EIU, System Data Acquisition Concentrator (SDAC) and generates associated messages on Engine/Warning Display (EWD).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FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
AUTO FLIGHT SYSTEM (AFS)
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MODE
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CRANK
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ON
(22VU)
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
ON
ENGINE INTERFACE UNIT (EIU)
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

POWER MANAGEMENT

The FADEC provides automatic engine thrust control and thrust parameter limit computation.

The EEC uses air data parameters from Air Data/Inertial Reference System (ADIRS) for rating calculations.

The FADEC manages power according to two thrust modes:

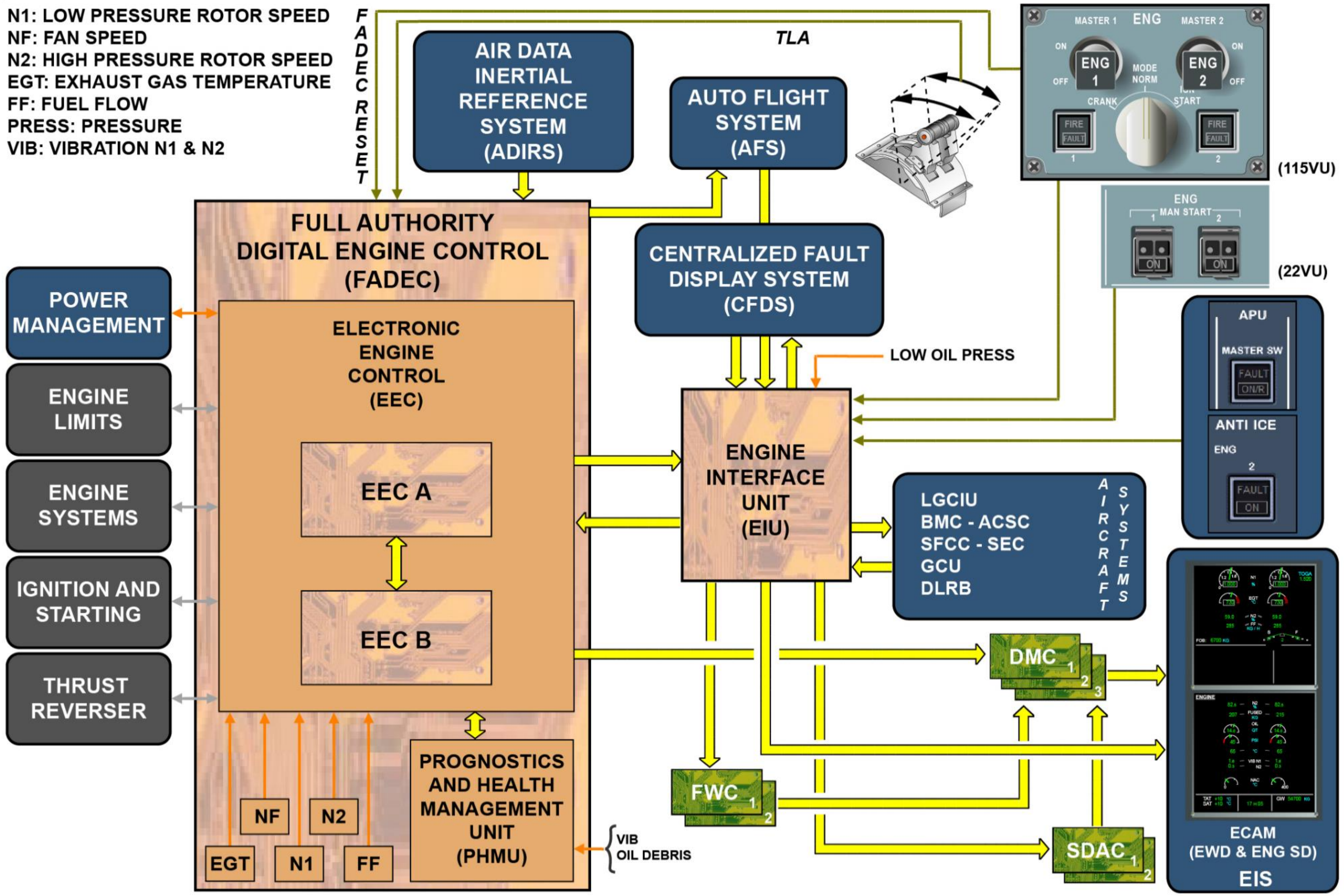
- manual mode depending on Throttle Lever Angle (TLA),
- autothrust mode depending on autothrust function generated by the Auto Flight System (AFS).

The FADEC also provides two idle mode selections: minimum idle and approach idle.

If the aircraft is on ground and extend the slats the engine will stay at minimum idle but in flight it will go to approach idle.

The idle can also be modulated up to approach idle depending on:

- Air conditioning demand,
- wing anti-ice demand,
- engine anti-ice demand
- oil temperature (for Integrated Drive Generator (IDG) cooling).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AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
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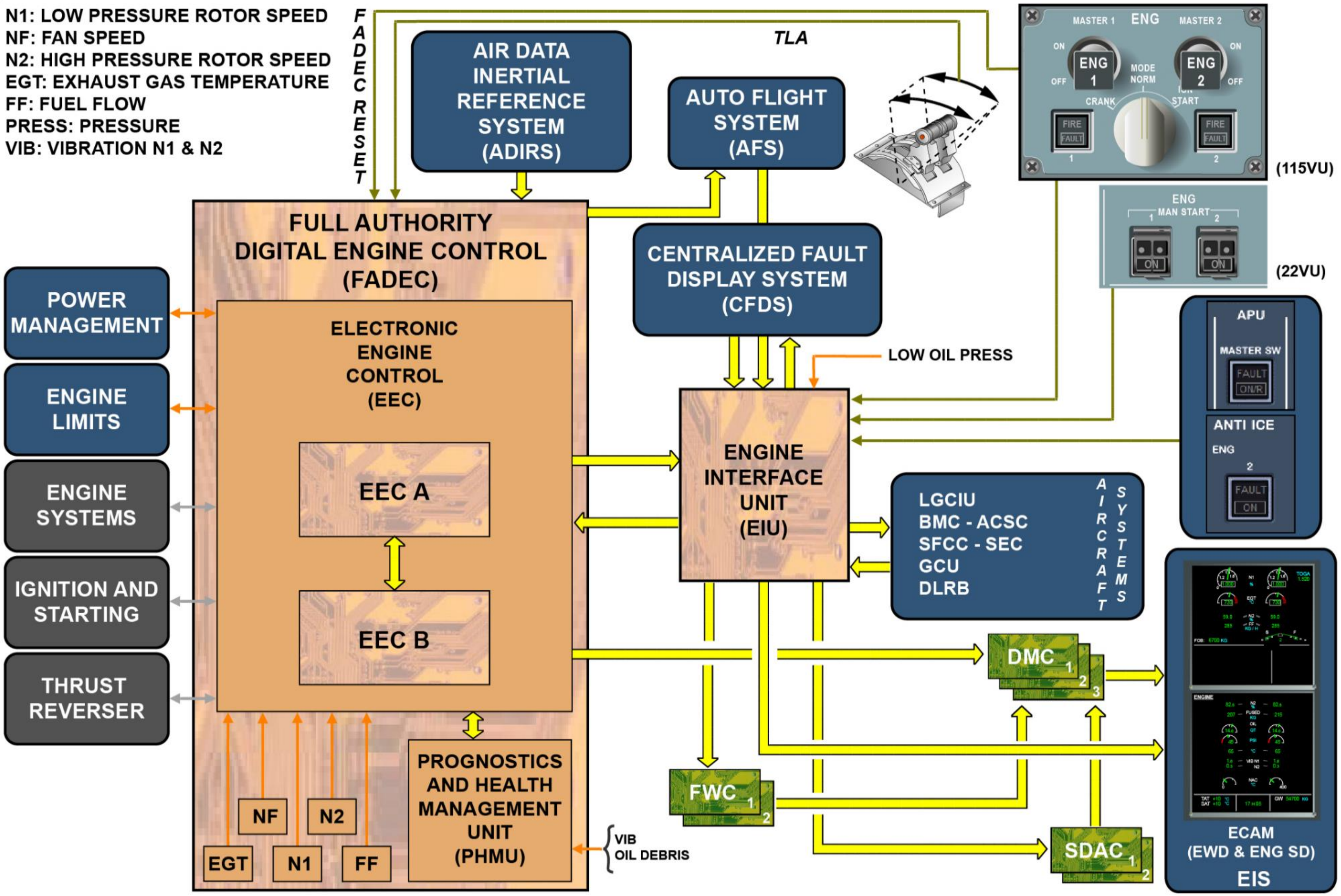
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
ENGINE INTERFACE UNIT (EIU)
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
FAULT
ON
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

ENGINE LIMIT PROTECTION

The FADEC ensures engine integrity protection. It provides overspeed protection for N1 and N2 or rotor shaft shear by driving to close the Thrust Control Malfunction (TCM)/Overspeed torque motor in the Integrated Fuel Pump and Control (IFPC).

Shaft shear detection logic is only active at high power settings.

It ensures overheat protection by monitoring EGT, nacelle and EEC temperature.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ENG MAN START
(22VU)
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
POWER MANAGEMENT
ELECTRONIC ENGINE CONTROL (EEC)
LOW OIL PRESS
APU
MASTER SW
ENGINE LIMITS
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ENGINE INTERFACE UNIT (EIU)
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EEC A
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GCU
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AIRCRAFT SYSTEMS
IGNITION AND STARTING
EEC B
DMC 1 2 3
THRUST REVERSER
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
NF
N2
FWC 1 2
VIB
OIL DEBRIS
SDAC 1 2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

ENGINE SYSTEM CONTROL

The FADEC provides optimal engine operation by controlling:

combustor metering valve and fuel flow,

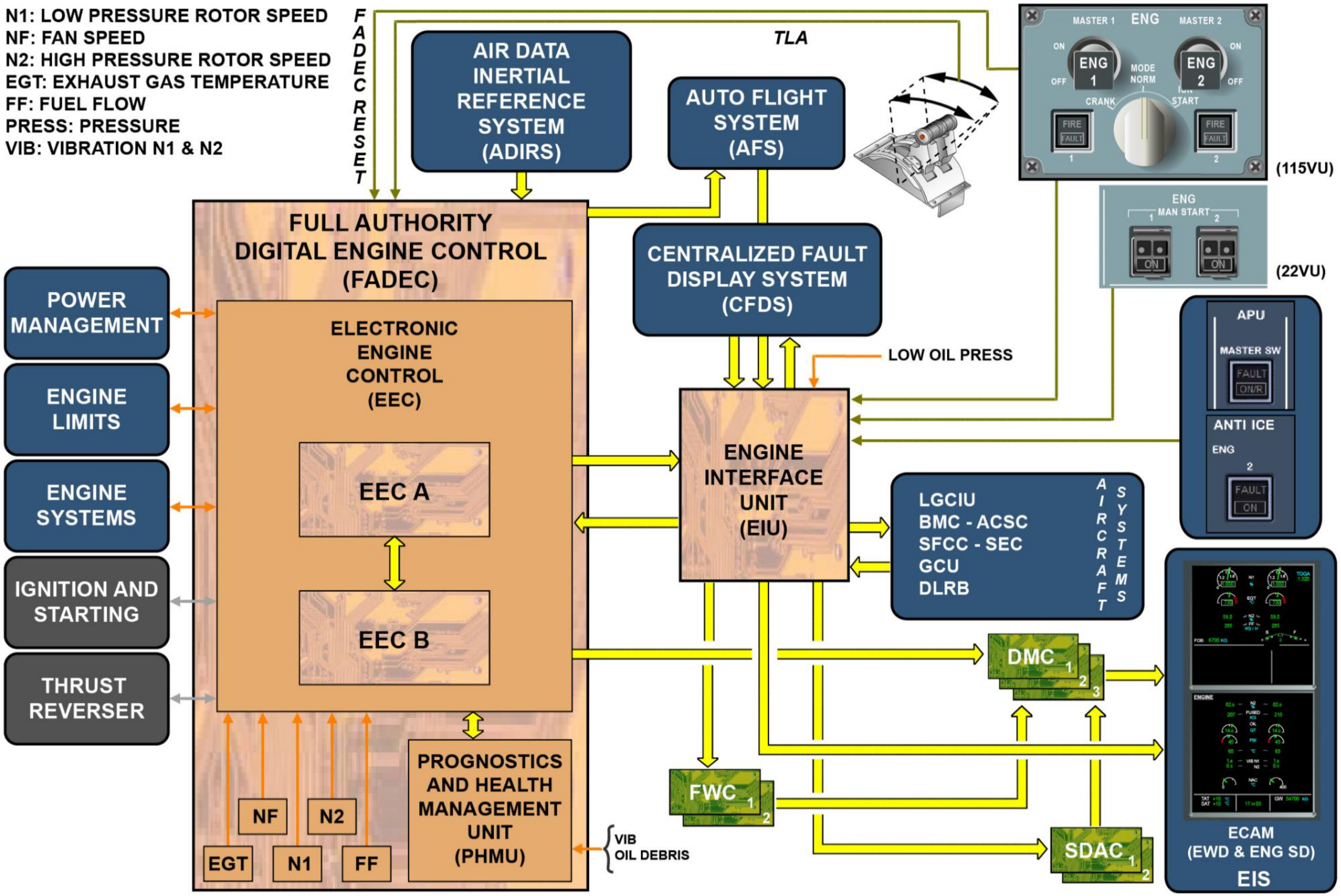
compressor airflow and turbine case cooling,

thermal management (oil cooling, fuel heating),

control and monitoring sensors,

BITE (fault detection, isolation, annunciation and transmission to the aircraft),

nacelle anti-ice.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FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
AUTO FLIGHT SYSTEM (AFS)
TLA
MASTER 1
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CRANK
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FIRE
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MAN START
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ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
APU
MASTER SW
FAULT
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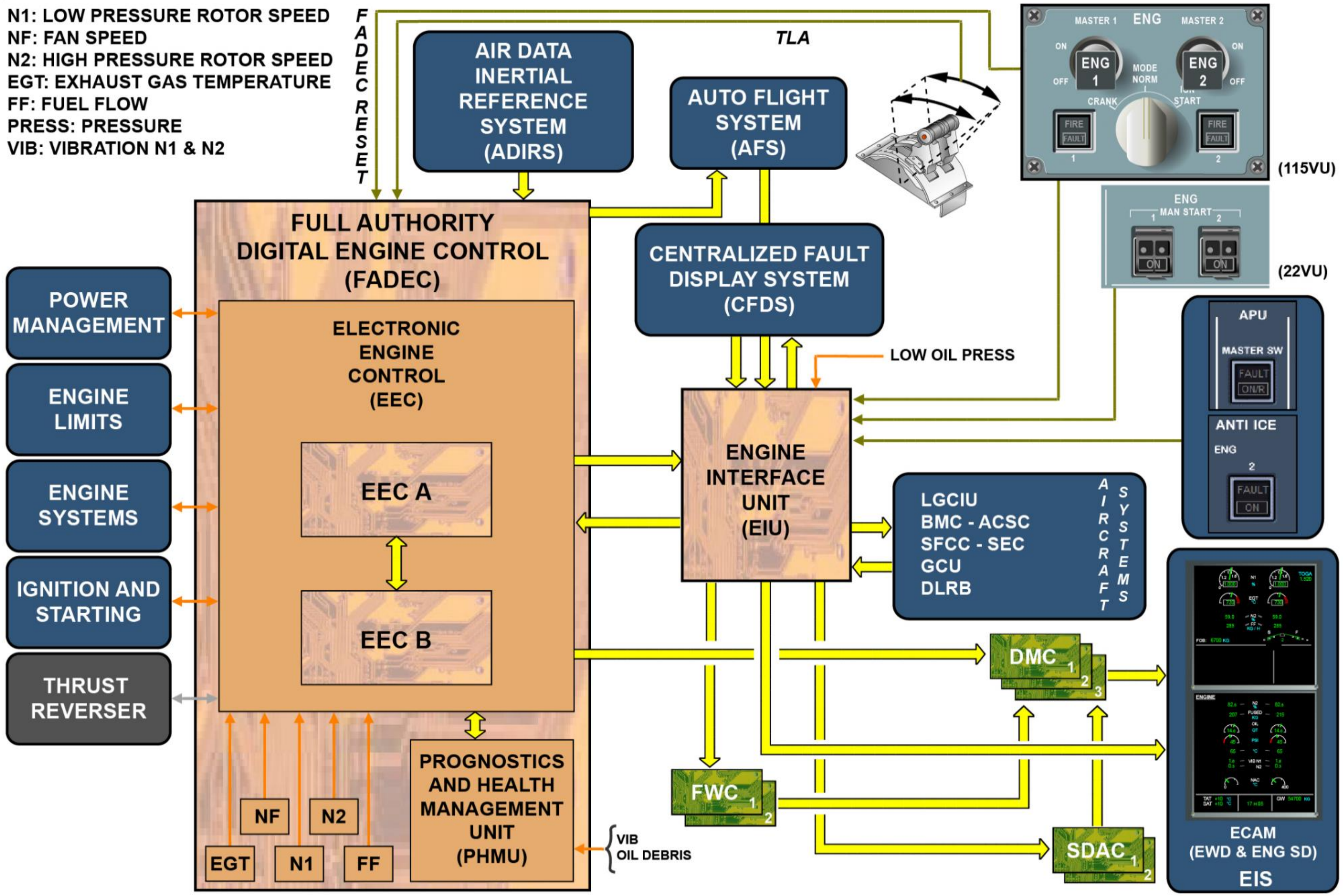
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
ENGINE INTERFACE UNIT (EIU)
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC
FWC
SDAC
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

STARTING AND IGNITION CONTROL

The FADEC controls the engine start sequence in automatic or manual mode when initiated from the control panels.

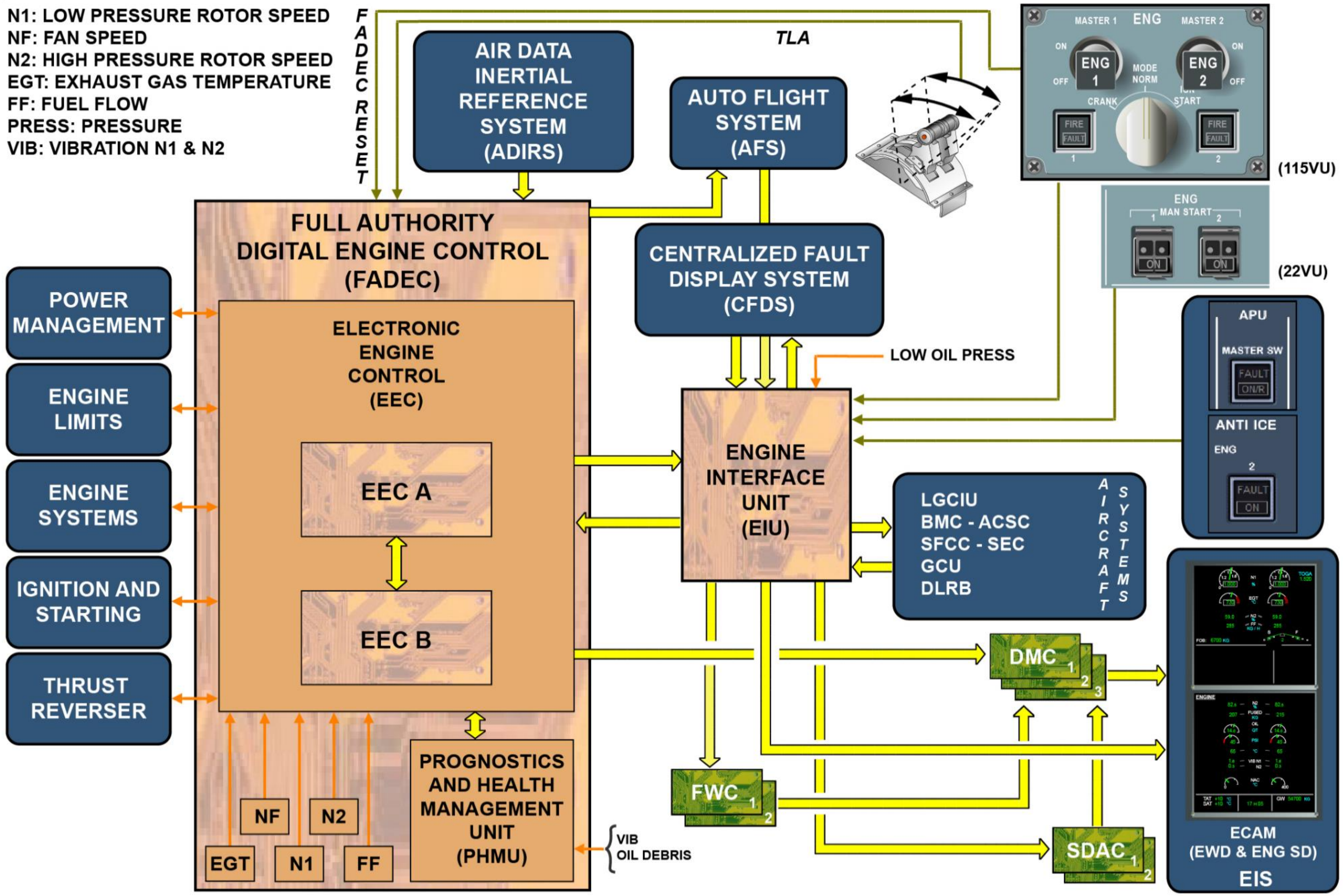
It monitors N1, N2, EGT and oil parameters and then can abort or recycle an engine start.



N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
EGT: EXHAUST GAS TEMPERATURE
FF: FUEL FLOW
PRESS: PRESSURE
VIB: VIBRATION N1 & N2
FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
TLA
AUTO FLIGHT SYSTEM (AFS)
MASTER 1 ENG MASTER 2
ON
OFF
ENG 1
ENG 2
MODE NORM
CRANK
START
FIRE FAULT
(115VU)
ENG MAN START
ON
(22VU)
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
FAULT
ON
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
ENGINE INTERFACE UNIT (EIU)
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
NF
N2
EGT
N1
FF
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
ECAM (EWD & ENG SD)
EIS

THRUST REVERSER

The FADEC supervises the thrust reverser operation.



N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
EGT: EXHAUST GAS TEMPERATURE
FF: FUEL FLOW
PRESS: PRESSURE
VIB: VIBRATION N1 & N2
FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
TLA
AUTO FLIGHT SYSTEM (AFS)
MASTER 1
ENG
MASTER 2
ON
OFF
MODE NORM
CRANK
IGN START
FIRE FAULT
(115VU)
ENG MAN START
ON
(22VU)
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
FAULT
ON
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
ENGINE INTERFACE UNIT (EIU)
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

FADEC ARCHITECTURE

ARCHITECTURE

The FADEC consists in the Electronic Engine Control (EEC), the Prognostic and Health Monitoring Unit (PHMU) and peripherals (sensors and output drivers).

EEC

The EEC is a microprocessor controlled digital unit with two independent control channels identified as channel A and B.

Each channel has its own processors, power supply, program memory, selected input sensors and output drivers.

In addition to input/output redundancy (for comparison and backup), data is sent internally between the two channels by a crosstalk data link.

Each channel receives inputs from the A/C and FADEC system sources.

Thus, each channel can monitor and control the operation of the engine and transmit engine data to the A/C and to engine subsystem duplicated controls (torque motors and solenoids).

EEC channels A and B are housed in one assembly but are physically divided by a two-piece modular design.

Each channel module has one printed circuit board module, the input/output interconnect modules and one pressure sensor.

Five electrical connectors are used in each channel module to connect wiring from the engine, aircraft and nacelle.

The EEC also has a connector to test the unit and a connector for the Data Storage Unit (DSU).

DSU

The DSU is a data memory plug attached to the engine case bracket by a lanyard and connected on the EEC channel A for engine identification and rating, engine trim data storage and detected failures storage.

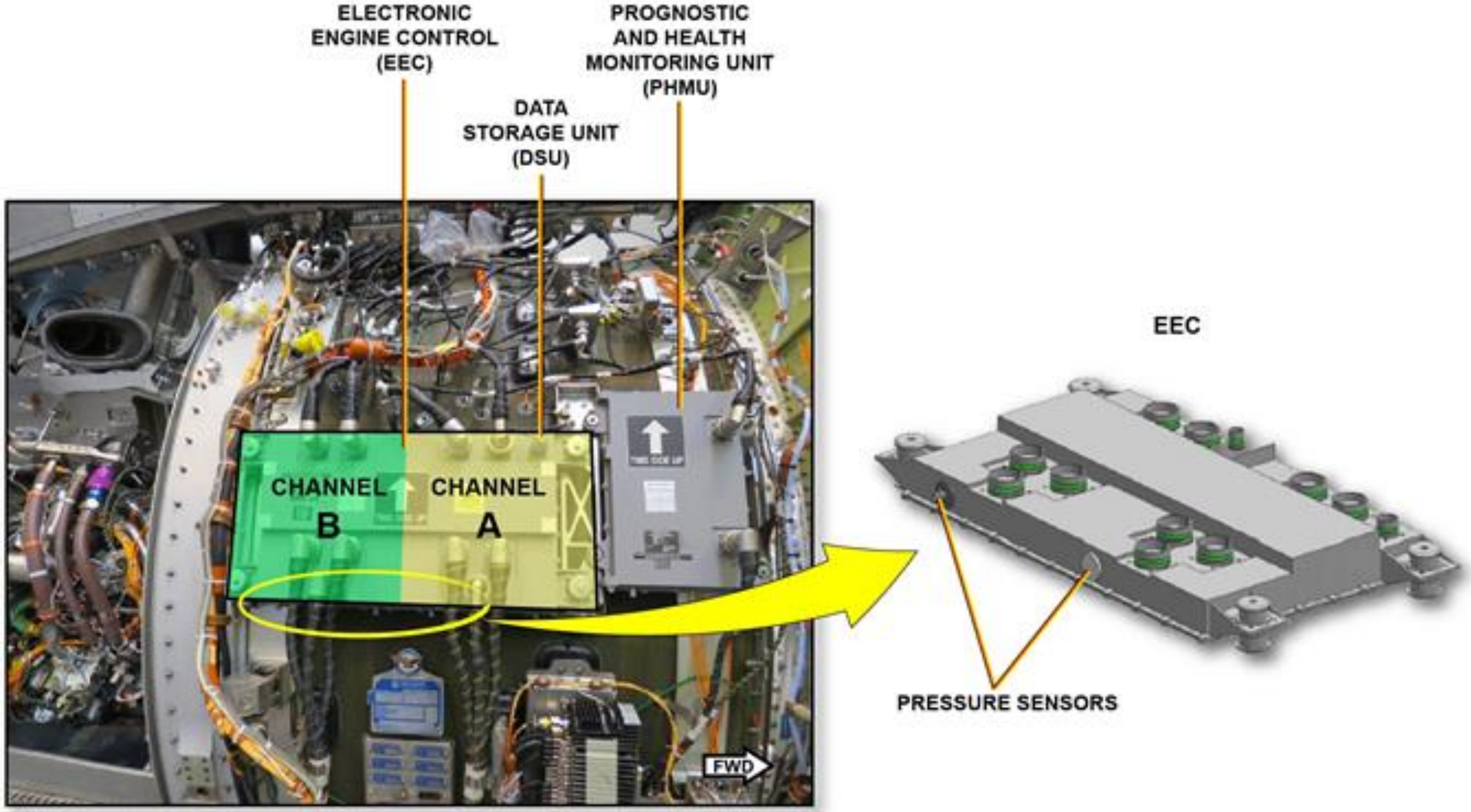
PHMU

The PHMU is a single channel component with internal software that performs the following engine health monitoring functions:

- Vibration analysis,
- Engine trim balance solution computation,
- Oil Debris Monitoring (ODM),
- Auxiliary Oil Pressure (AOP) signal conversion.

It uses data provided by several engine sensors and by the EEC and sends back the computed data to the EEC through CAN buses.

Two connectors are used for the data exchange.


ELECTRONIC ENGINE CONTROL (EEC)
PROGNOSTIC AND HEALTH MONITORING UNIT (PHMU)
DATA STORAGE UNIT (DSU)
CHANNEL B
CHANNEL A
FWD
EEC
PRESSURE SENSORS

PROCESS

Most of the FADEC operations are based on the same principle, they respond to a demand from the A/C or from the EEC internal schedules, and they take into account input parameters from the A/C and from the engine sensors.

Most of the sensors and output drivers are duplicated for redundancy and segregated to each EEC channel.

For a control loop, one EEC channel elaborates a single command signal sent to an engine subsystem control and it makes sure that its command has been followed by monitoring the dual feedback from this engine subsystem.

The EEC also continuously performs integrity test of its control circuits.

When fully operational, the EEC starts and operates in an Active-Standby mode.

Under this control scheme, only one channel of the EEC has full authority over all engine functions and is identified as the preferred channel.

The preferred channel is alternated upon every engine shutdown for the next engine start.

If a feedback fault is detected in the preferred channel, the data is retrieved from the standby channel via the crosstalk data link.

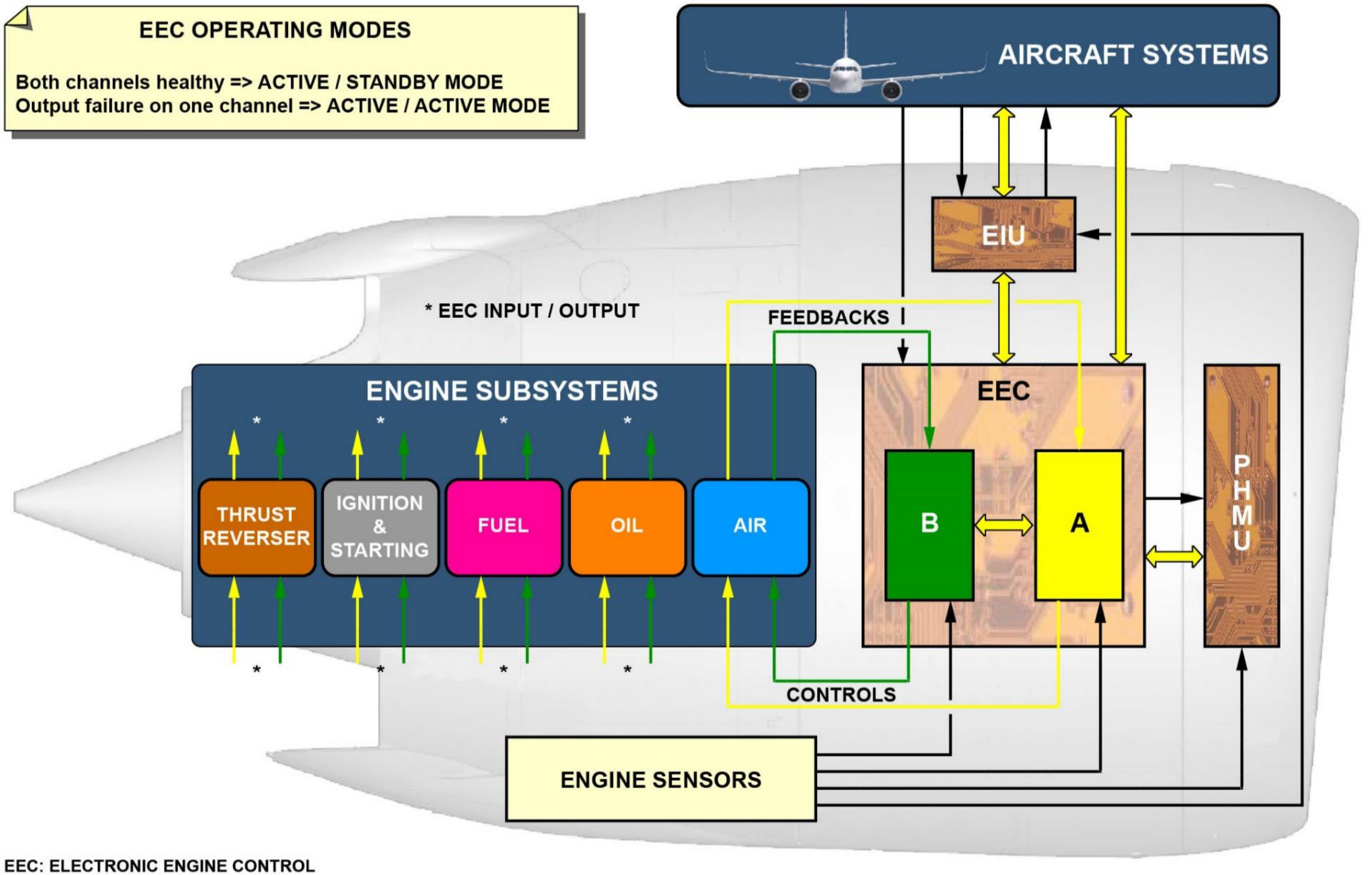
If an output driver fault is detected, the EEC switches from Active-Standby mode to Active-Active mode.

This allows either channel to control any of the output drivers independently, regardless of which channel is the preferred channel.

This control mode allows both channels to be engaged simultaneously and to manage different engine functions, providing an effective fault accommodation strategy.

If the crosstalk data link is lost, each channel maintains its current controls prior the failure.

If the engine subsystem control loop is no more possible (by any channel), the subsystem control is set to its failsafe position.



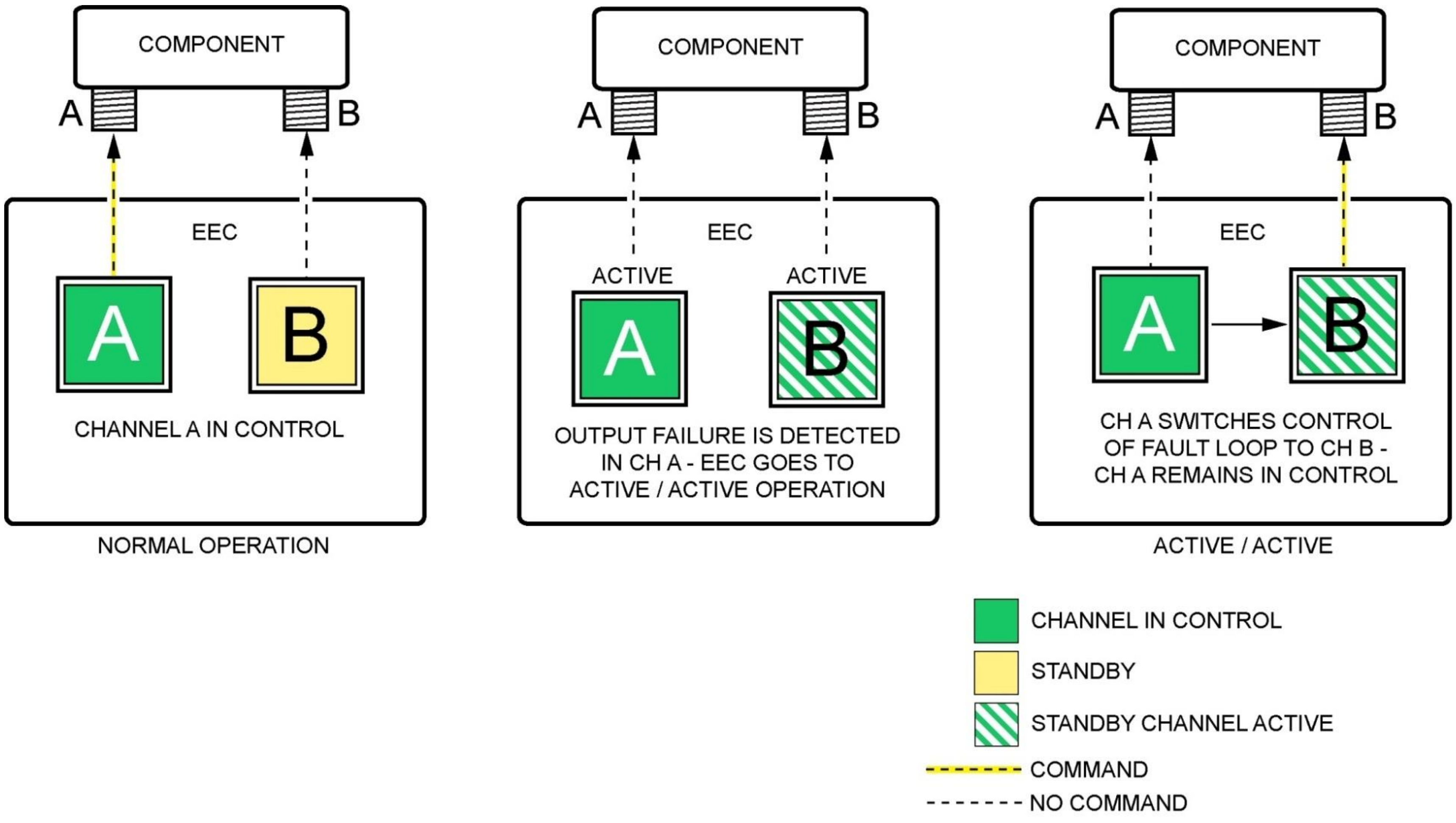
EEC: ELECTRONIC ENGINE CONTROL
EIU: ENGINE INTERFACE UNIT
PHMU: PROGNOSTIC AND HEALTH MONITORING UNIT

Operation:

During normal operation, the EEC is in active/standby mode, where all engine functions are controlled by the channel selected for the flight.

When an output failure is detected in the active channel, the EEC operates in the active/active mode.

This mode permits the EEC to switch control of the fault loop to the standby channel, keeping control of the remaining functions with the original channel selected for that flight.


COMPONENT
A
B
EEC
A
B
CHANNEL A IN CONTROL
NORMAL OPERATION
COMPONENT
A
B
EEC
ACTIVE
ACTIVE
A
B
OUTPUT FAILURE IS DETECTED IN CH A - EEC GOES TO ACTIVE / ACTIVE OPERATION
COMPONENT
A
B
EEC
A
B
CH A SWITCHES CONTROL OF FAULT LOOP TO CH B - CH A REMAINS IN CONTROL
ACTIVE / ACTIVE
CHANNEL IN CONTROL
STANDBY
STANDBY CHANNEL ACTIVE
COMMAND
NO COMMAND

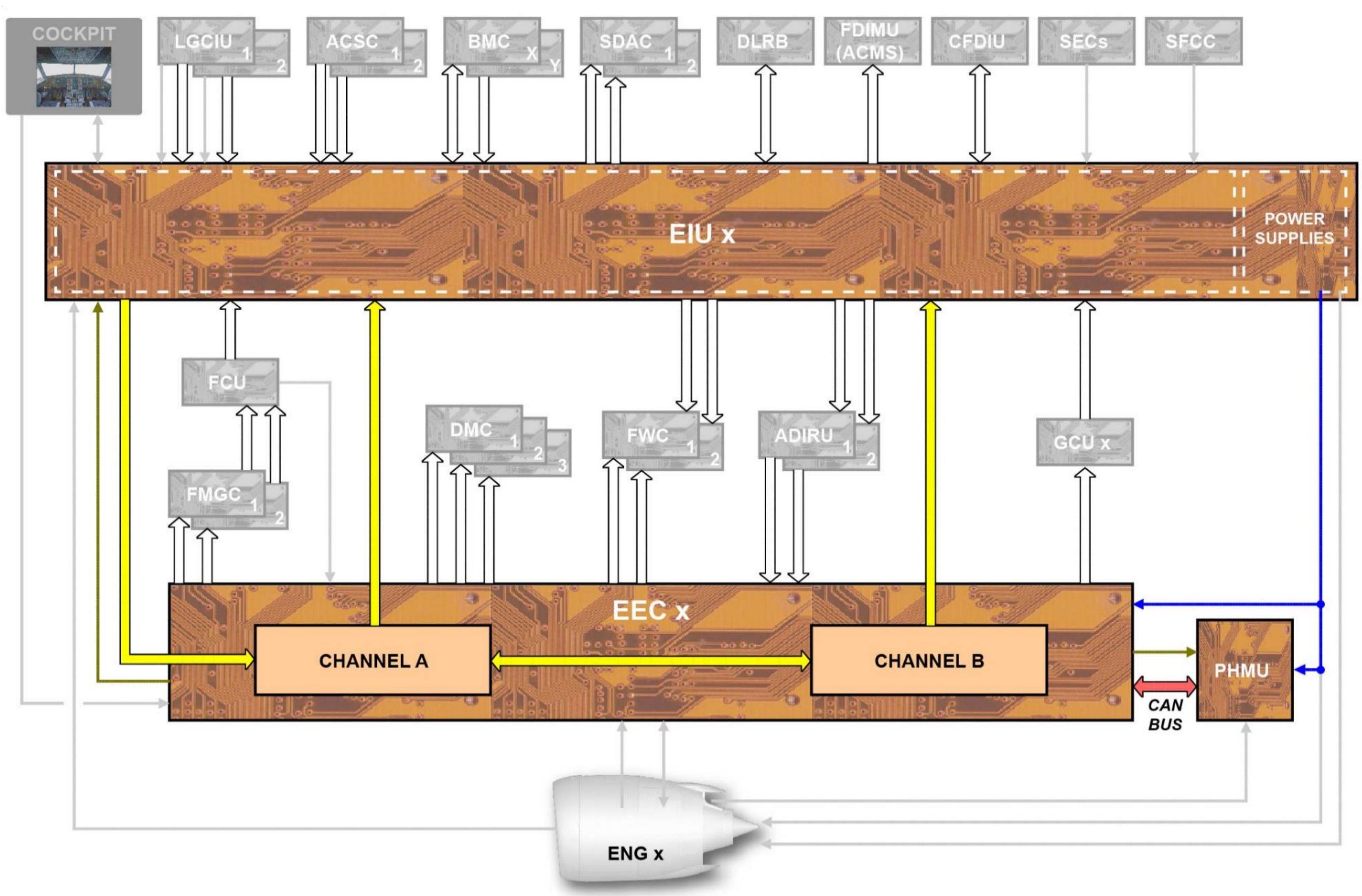
FADEC INTERFACES

GENERAL

In order to provide a full range of engine control and monitoring, the Propulsion Control System (PCS) exchanges data within its own computers (Engine Interface Unit (EIU), Electronic Engine Control (EEC), Prognostic and Health Monitoring Unit (PHMU)) and with the other aircraft systems computers.

The EIU is the main interface with the aircraft systems.

Inputs or outputs are transmitted on a digital, analogue or discrete format.


COCKPIT
LGCIU
1
2
ACSC
1
2
BMC
X
Y
SDAC
1
2
DLRB
FDIMU
(ACMS)
CFDIU
SECs
SFCC
EIU x
POWER
SUPPLIES
FCU
FMGC
1
2
DMC
1
2
3
FWC
1
2
ADIRU
1
2
GCU x
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN
BUS
ENG x

PCS INTERFACES

The EIU performs the following bus transfer.

EIU digital inputs from:

GCU #: for idle modulation based on Integrated Drive Generator (IDG) load.

DLRB: for EIU data-loading.

ACSC 1/2: for bleed decrement computation.

CFDIU: for BITE purposes (Normal Mode and Menu Mode).

BMC 1/2: for bleed computation.

LGCIU 1/2: for flight/ground status computation.

FCU: for Autothrust function and Thrust Control Malfunction (TCM) protection in flare.

EIU digital outputs to:

ADIRU 1/2: for air data correction.

CFDIU: for BITE purposes (Normal Mode and Menu Mode).

DLRB: for EIU data-loading.

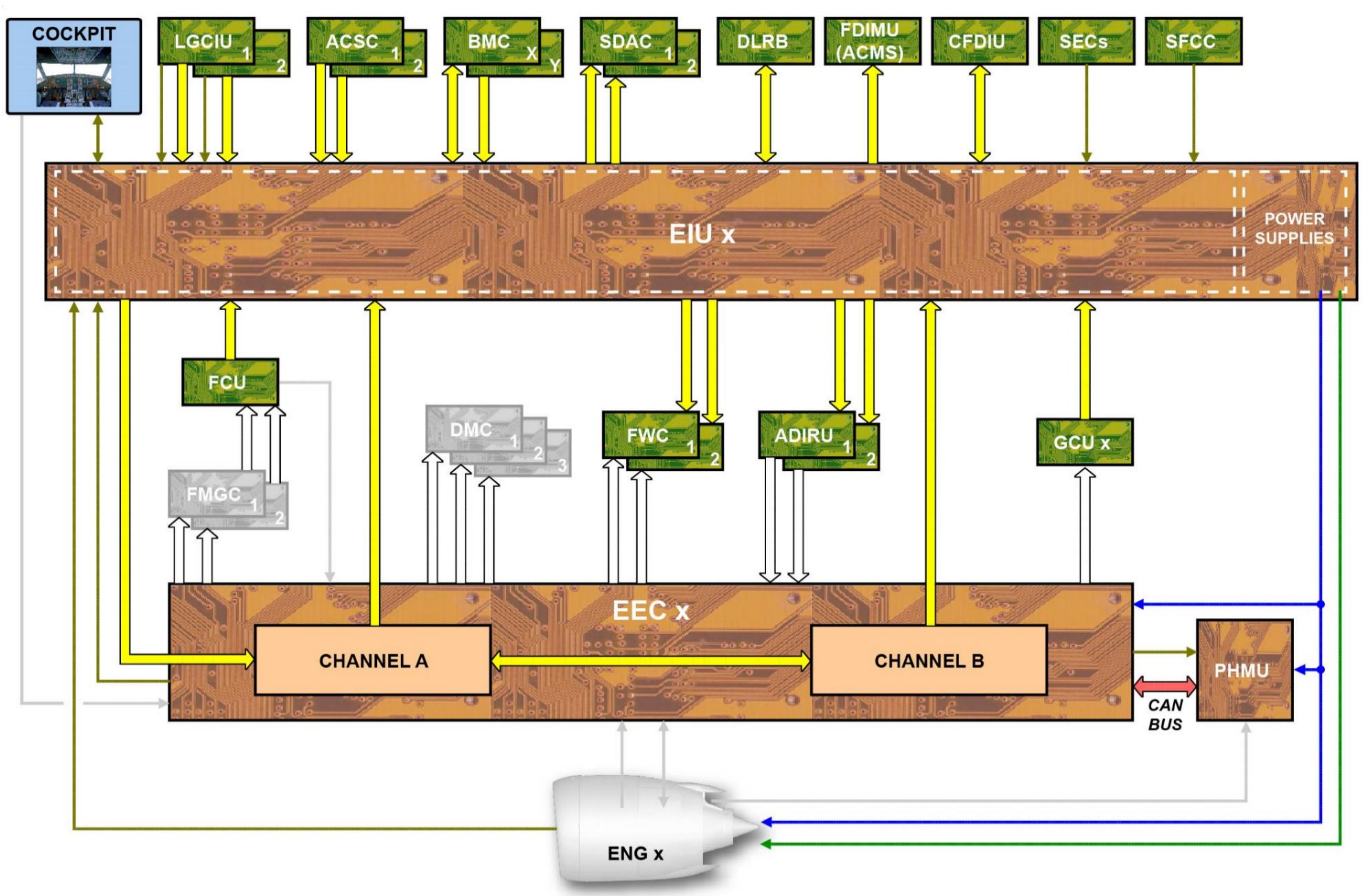
SDAC 1/2: for engine parameters acquisition.

FDIMU (ACMS): for condition monitoring and troubleshooting purpose.

BMC #: for bleed computation

FWC 1/2: for warnings display.

The EIU performs the following discrete exchange.


COCKPIT
LGCIU 1 2
ACSC 1 2
BMC X Y
SDAC 1 2
DLRB
FDIMU (ACMS)
CFDIU
SECs
SFCC
EIU x
POWER SUPPLIES
FCU
DMC 1 2 3
FWC 1 2
ADIRU 1 2
GCU x
FMGC 1 2
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN BUS
ENG x

EIU discrete inputs from:

From cockpit controls:

- Master lever ON/OFF
- Throttle position (switches): for thrust reverser operation.
- Rotary selector Ignition/Auto/Crank
- Wing De-Ice P/B OFF: for bleed decrement computation.
- Nacelle Anti-Ice P/B ON/OFF: for Nacelle Anti-Ice (NAI) control and bleed decrement computation.
- Fire handle ON: for engine isolation.
- Manual Engine Start P/B ON
- FADEC Ground Power ON
- Bump ON/OFF
- APU Master Switch ON/OFF: for bleed decrement computation.

From LGCIUs:

- LH Landing Gear compressed: for flight/ground status computation.
- RH Landing Gear compressed: for flight/ground status computation.
- Nose Landing Gear (NLG) compressed: for flight/ground status computation.

From SECs:

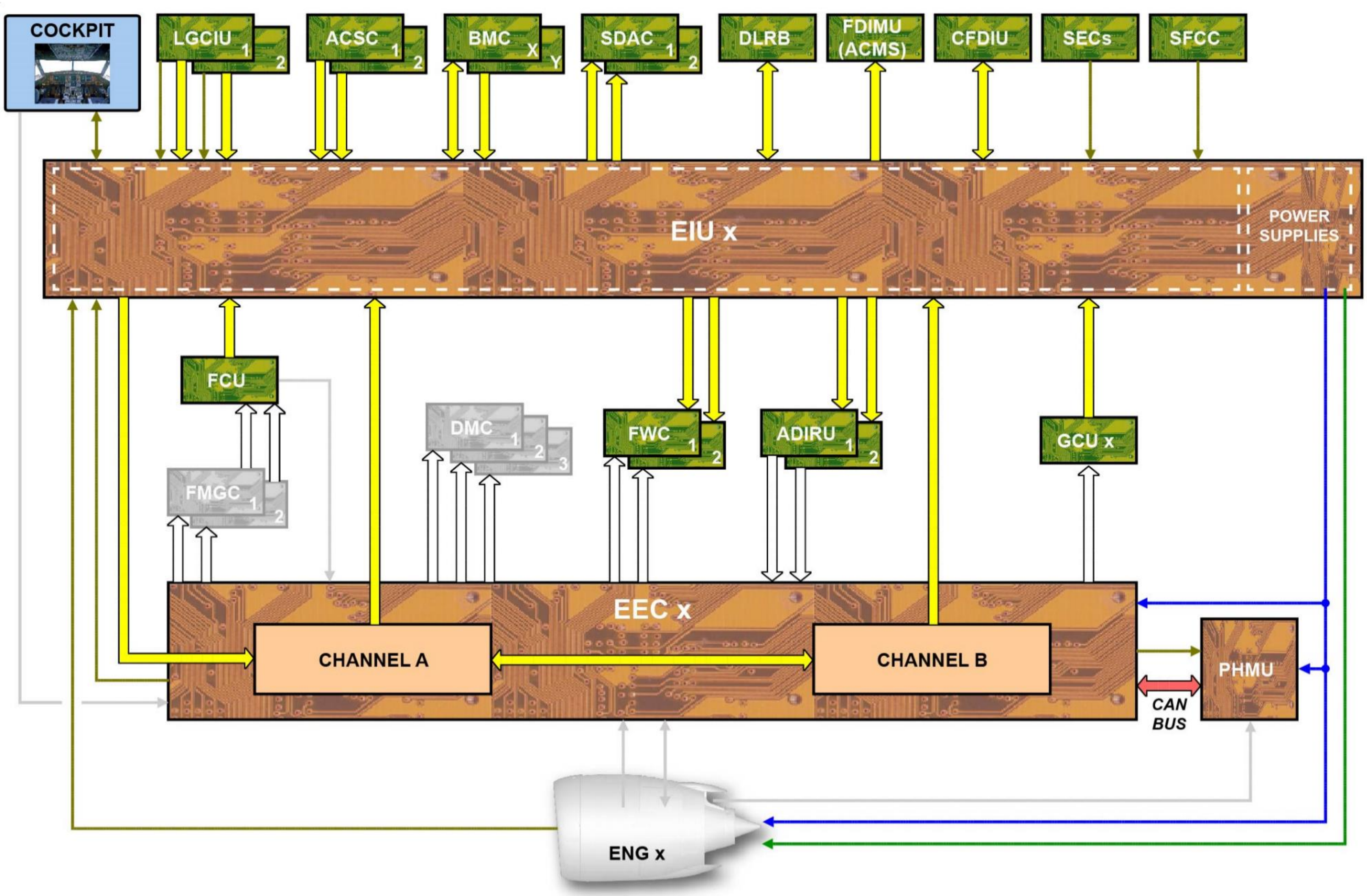
- Ground Spoiler OUT
- TLA < -3 deg

From SFCC:

- Flaps and Slats lever retracted

From engine:

- FRTTV Selected OFF (EEC)
- Low Oil Pressure sensor: for OIL LO PRES warning.
- Engine position and type
- Latch Door Monitoring Proximity Switches.


COCKPIT
LGCIU 1 2
ACSC 1 2
BMC X Y
SDAC 1 2
DLRB
FDIMU (ACMS)
CFDIU
SECs
SFCC
EIU x
POWER SUPPLIES
FCU
DMC 1 2 3
FWC 1 2
ADIRU 1 2
GCU x
FMGC 1 2
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN BUS
ENG x

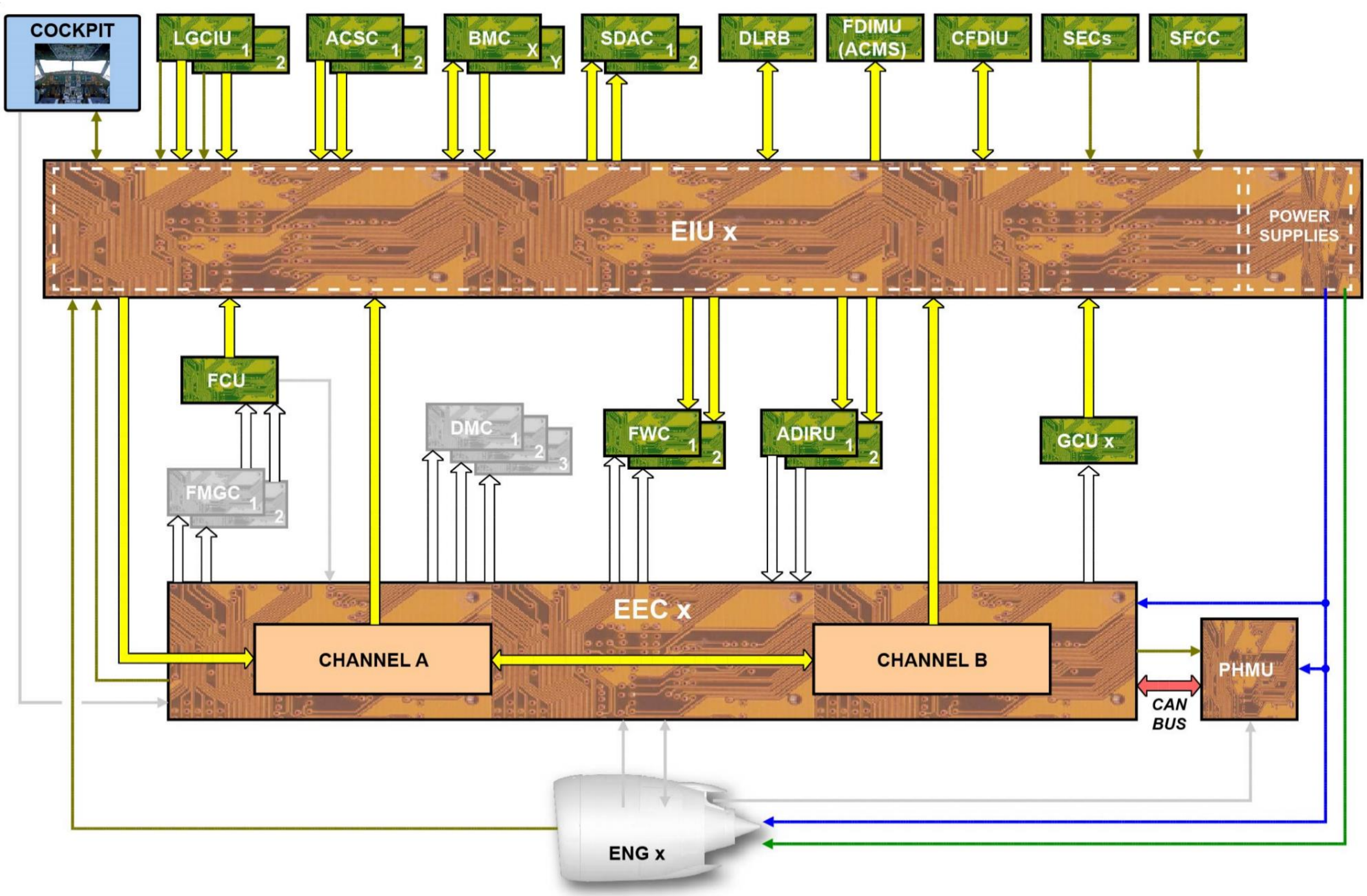
EIU discrete outputs:

- Fuel HPSOV Closed
- N2 Not Below Idle
- TLA in Take Off Position
- Start Valve Closure
- APU Boost Command
- Master Lever Fault Light
- Oil Low pressure and Ground
- NAI P/B Fault Light
- Latch Door Monitoring Proximity Switches
- The EIU provides the following power supplies.

EIU power supply outputs to:

- PHMU (28V DC).
- Hydraulic pump depressurization solenoid (28V DC).
- EEC channels (28V DC).
- Igniters (115V AC).
- Thrust reverser Valves (28V DC for ICV & DCV).

Unless specified differently, signals are dual (from/to both EEC channels).


COCKPIT
LGCIU
1
2
ACSC
1
2
BMC
X
Y
SDAC
1
2
DLRB
FDIMU
(ACMS)
CFDIU
SECs
SFCC
EIU x
POWER
SUPPLIES
FCU
DMC
1
2
3
FWC
1
2
ADIRU
1
2
GCU x
FMGC
1
2
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN
BUS
ENG x

The EEC performs the following bus transfer.

EEC digital inputs from:

- EIU # (channel A): for aircraft data exchange.
- ADIRU 1/2: for engine control (alt, TAT, PT, CAS, Mn).
- PHMU: for vibration monitoring and trim balancing.

EEC digital outputs to:

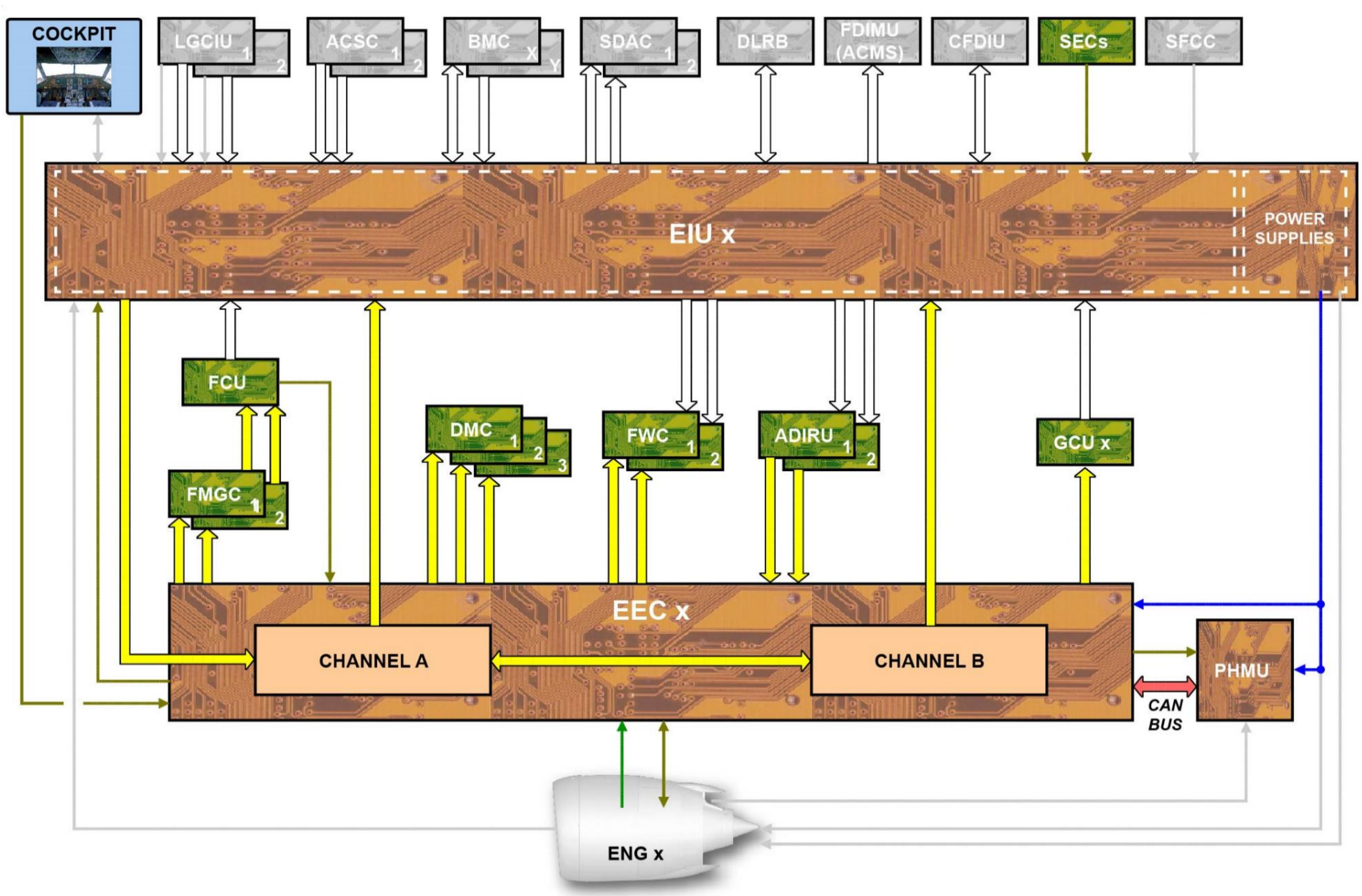
- EIU #: for engine data exchange and secondary parameters.
- FMGC 1/2: for Autothrust function and TCM protection in flare.
- PHMU: for vibration monitoring and trim balancing.
- DMC 1/2/3: for primary parameters, faults and warnings display.
- FWC 1/2: for warnings display.
- GCU #: for power supply management.

The EEC performs the following discrete/analogue exchange.

EEC discrete/analogue inputs from:

Cockpit controls:

- Master lever OFF: for shutdown and reset.
- Throttle position (resolvers): for manual and auto thrust control.
- Autothrust disconnect P/B (Ch. B)
- FADEC Ground Power OFF
- Nacelle Anti-Ice P/B ON/OFF: for NAI control and bleed decrement computation.


COCKPIT
LGCIU
1
2
ACSC
1
2
BMC
X
Y
SDAC
1
2
DLRB
FDIMU
(ACMS)
CFDIU
SECs
SFCC
EIU x
POWER
SUPPLIES
FCU
FMGC
1
2
DMC
1
2
3
FWC
1
2
ADIRU
1
2
GCU x
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN
BUS
ENG x

FCU:

Autothrust engagement (Ch. B)

SECs:

TCM ground operation

Engine:

Engine sensors and subsystems feedbacks

Engine position (Ch. A).

EEC discrete/analogue outputs to:

PHMU:

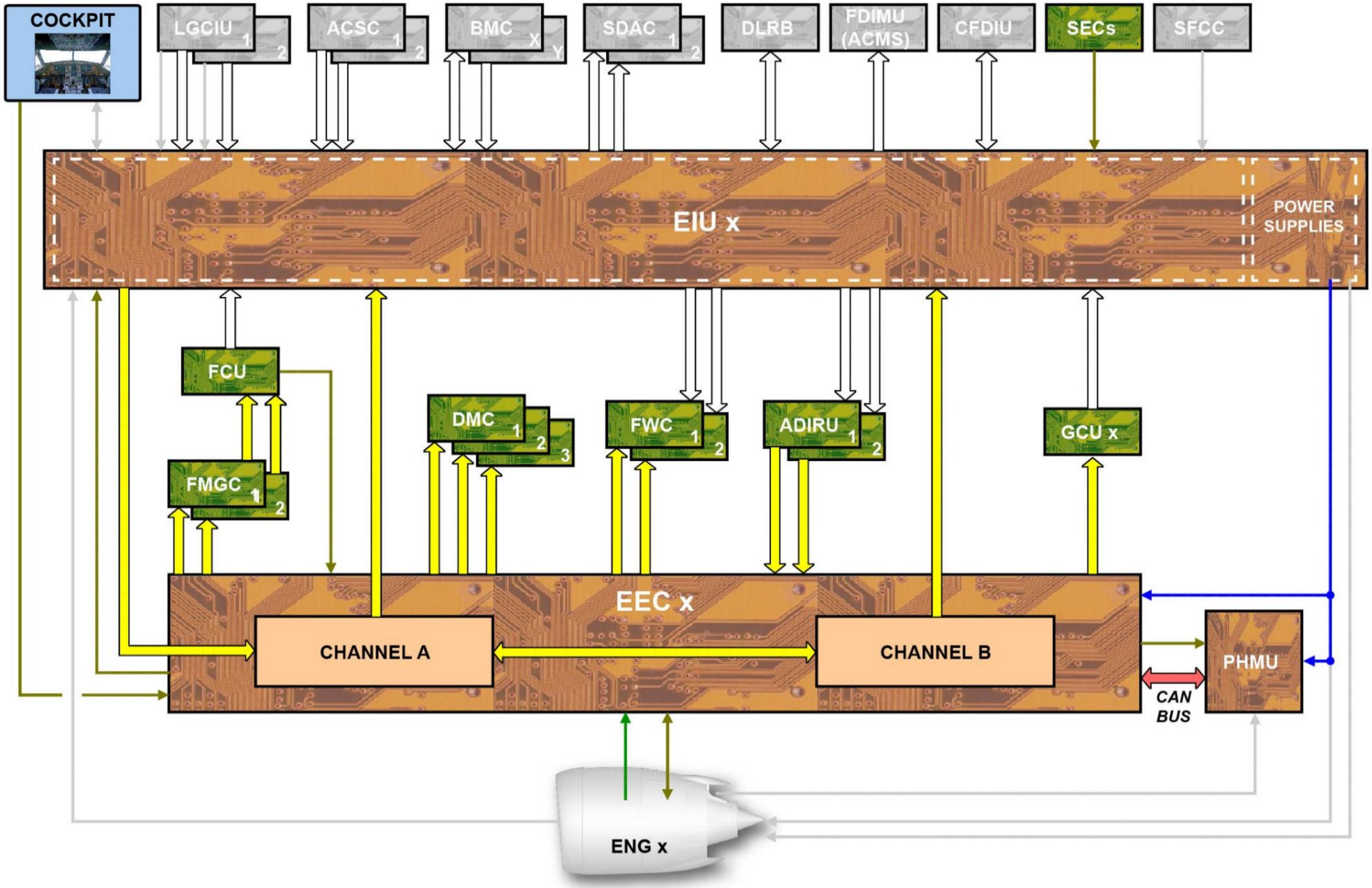
Nf (Ch. B), N1 (Ch. A), N2 (Ch. A)

Engine subsystems:

Control signals

EIU:

FRTTV Selected OFF.


COCKPIT
LGCIU 1 2
ACSC 1 2
BMC X Y
SDAC 1 2
DLRB
FDIMU (ACMS)
CFDIU
SECs
SFCC
EIU x
POWER SUPPLIES
FCU
FMGC 1 2
DMC 1 2 3
FWC 1 2
ADIRU 1 2
GCU x
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN BUS
ENG x

FADEC INTERFACES

Unless specified differently, signals are dual (from/to both EEC channels).

The EEC is the main controller and monitoring device over the engine subsystems.

AIR SYSTEM

For the air system management, the EEC sends and receives the following data.

Compressor Stator Vane Control System:

- LPC SVA TM control signal,
- HPC master SVA Torque Motor (TM) control signal,
- LPC SVA, HPC master and slave SVAs LVDT feedback signal.

Compressor Bleed Control System:

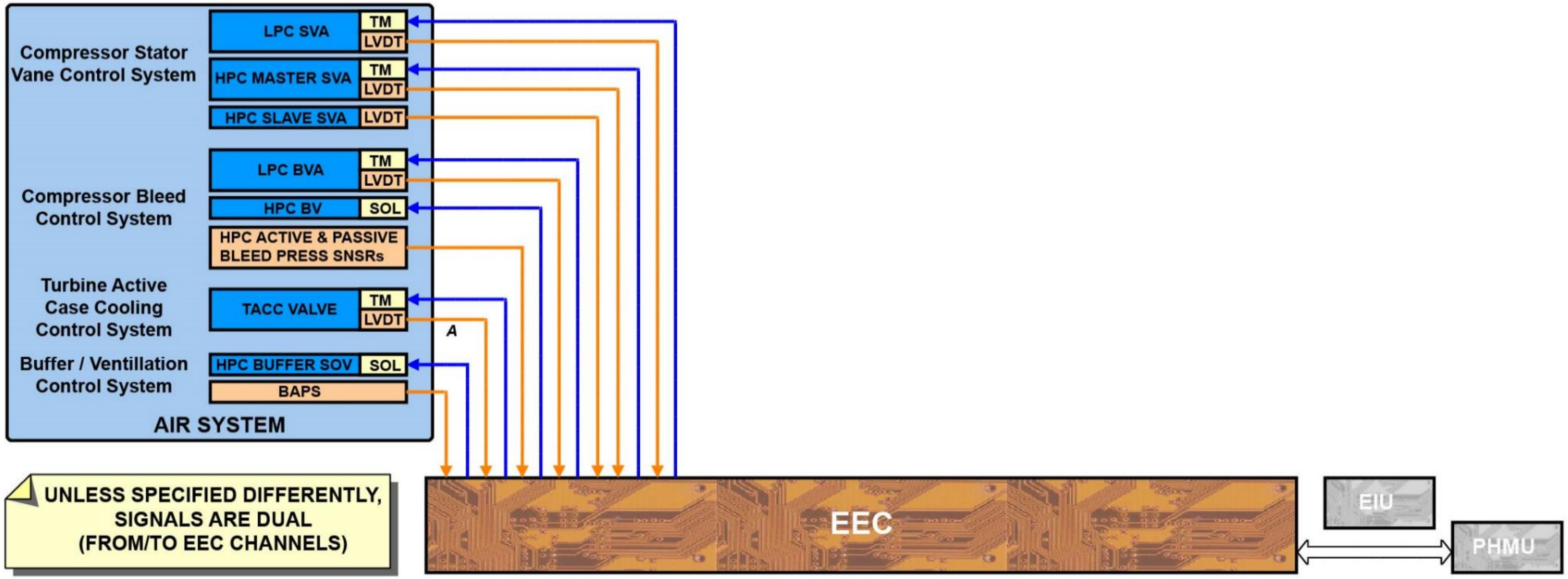
- LPC Bleed Valve Actuator (BVA) TM control signal,
- LPC BVA LVDT feedback signal,
- HPC BV solenoid control signal,
- HPC active and passive bleed pressure sensors.

Turbine Active Case Cooling Control System:

- TACC Valve TM control signal,
- TACCV LVDT feedback signal (Ch. A).

Buffer/Ventilation Control System:

- HPC Buffer Shut Off Valve (SOV) solenoid feedback signal,
- Buffer Air Pressure Sensor (BAPS) feedback signal.


Compressor Stator Vane Control System
LPC SVA
TM
LVDT
HPC MASTER SVA
TM
LVDT
HPC SLAVE SVA
LVDT
Compressor Bleed Control System
LPC BVA
TM
LVDT
HPC BV
SOL
HPC ACTIVE & PASSIVE BLEED PRESS SNSRs
Turbine Active Case Cooling Control System
TACC VALVE
TM
LVDT
A
Buffer / Ventillation Control System
HPC BUFFER SOV
SOL
BAPS
AIR SYSTEM
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU

FUEL SYSTEM

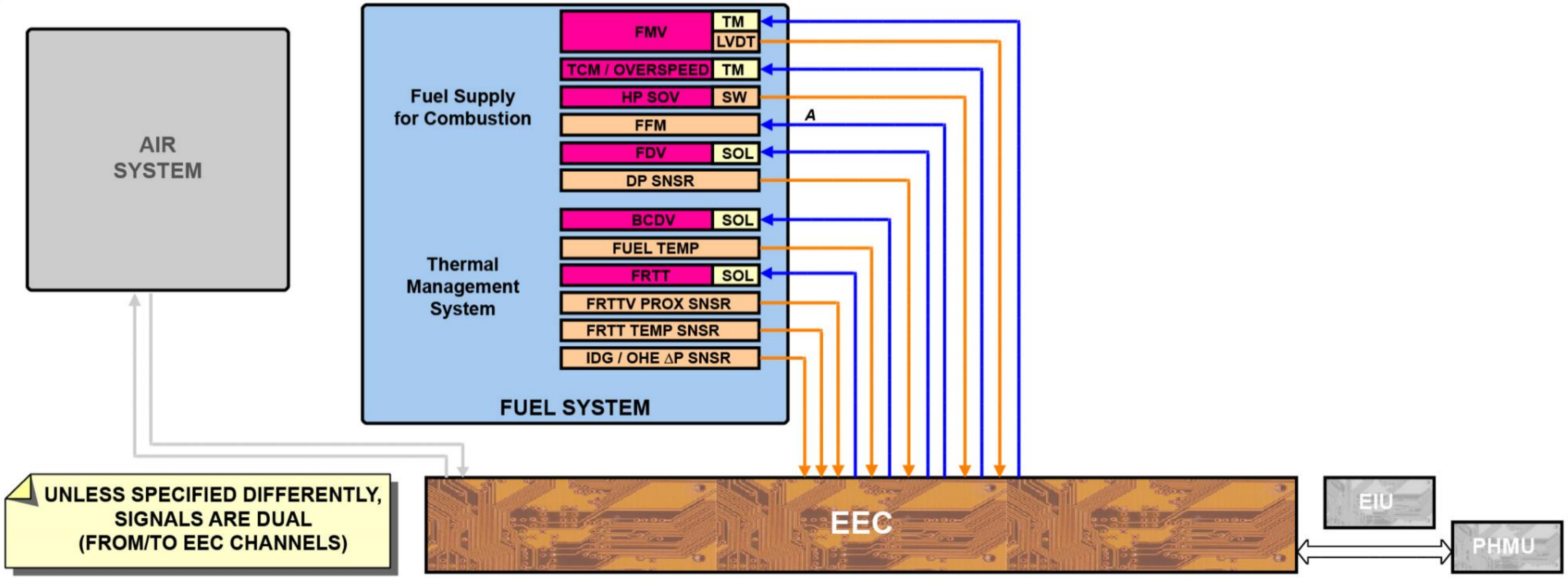
For the fuel system management, the EEC sends and receives the following data.

Fuel Supply for combustion:

- Fuel Metering Valve (FMV) TM control signal,
- FMV LVDT feedback signal,
- TCM / Overspeed TM control signal,
- HP Shut Off Valve proximity switch feedback signal,
- Fuel Flow Meter (FFM) control signal (ch A),
- Flow Divider Valve (FDV) solenoid control signal,
- Fuel Filter Differential Pressure Sensor feedback signal.

Thermal Management System:

- Bypass Direction Control Valve (BDCV) solenoid control signal,
- Fuel Temperature sensor feedback signal,
- Fuel Return To Tank (FRTT) Valve solenoid control signal,
- FRTTV Proximity Switch feedback signal,
- FRTT Temperature Sensor feedback signal,
- IDG Fuel/Oil Heat Exchanger Differential Pressure Sensor feedback signal.


AIR SYSTEM
Fuel Supply for Combustion
FMV
TM
LVDT
TCM / OVERSPEED
TM
HP SOV
SW
FFM
A
FDV
SOL
DP SNSR
Thermal Management System
BCDV
SOL
FUEL TEMP
FRTT
SOL
FRTTV PROX SNSR
FRTT TEMP SNSR
IDG / OHE ΔP SNSR
FUEL SYSTEM
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU

OIL SYSTEM

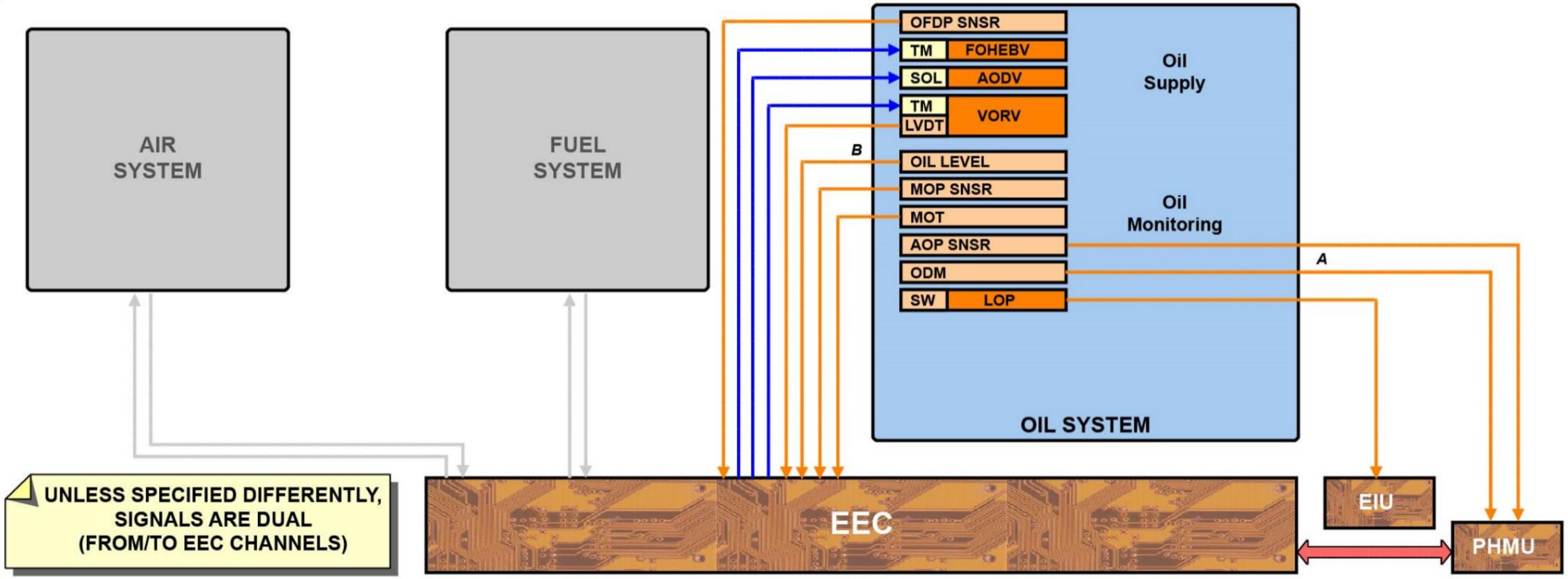
For the oil system management, the EEC sends and receives the following data:

Oil Supply:

- Oil Filter Differential Pressure sensor feedback signal,
- Fuel Oil Heat Exchanger Bypass Valve (FOHEBV) TM control signal,
- Active Oil Damper Valve (AODV) solenoid control signal,
- Variable Oil Reduction Valve (VORV) TM control signal,
- VORV LVDT feedback signal.

Oil Monitoring:

- Oil Level (OL) sensor feedback signal (Ch. B),
- Main Oil Pressure (MOP) sensor feedback signal,
- Main Oil Temperature (MOT) sensor feedback signal,
- Auxiliary Oil Pressure (AOP) sensor feedback signal via PHMU,
- Oil Debris Monitoring (ODM) sensor feedback signal (Ch. A) via PHMU:
- Low Oil Pressure (LOP) switch feedback signal to the EIU.


AIR
SYSTEM
FUEL
SYSTEM
OFDP SNSR
TM
FOHEBV
SOL
AODV
TM
LVDT
VORV
Oil
Supply
B
OIL LEVEL
MOP SNSR
MOT
Oil
Monitoring
AOP SNSR
ODM
A
SW
LOP
OIL SYSTEM
UNLESS SPECIFIED DIFFERENTLY,
SIGNALS ARE DUAL
(FROM/TO EEC CHANNELS)
EEC
EIU
PHMU

IGNITION AND STARTING SYSTEMS

For the ignition and starting systems management, the EEC sends and receives the following data:

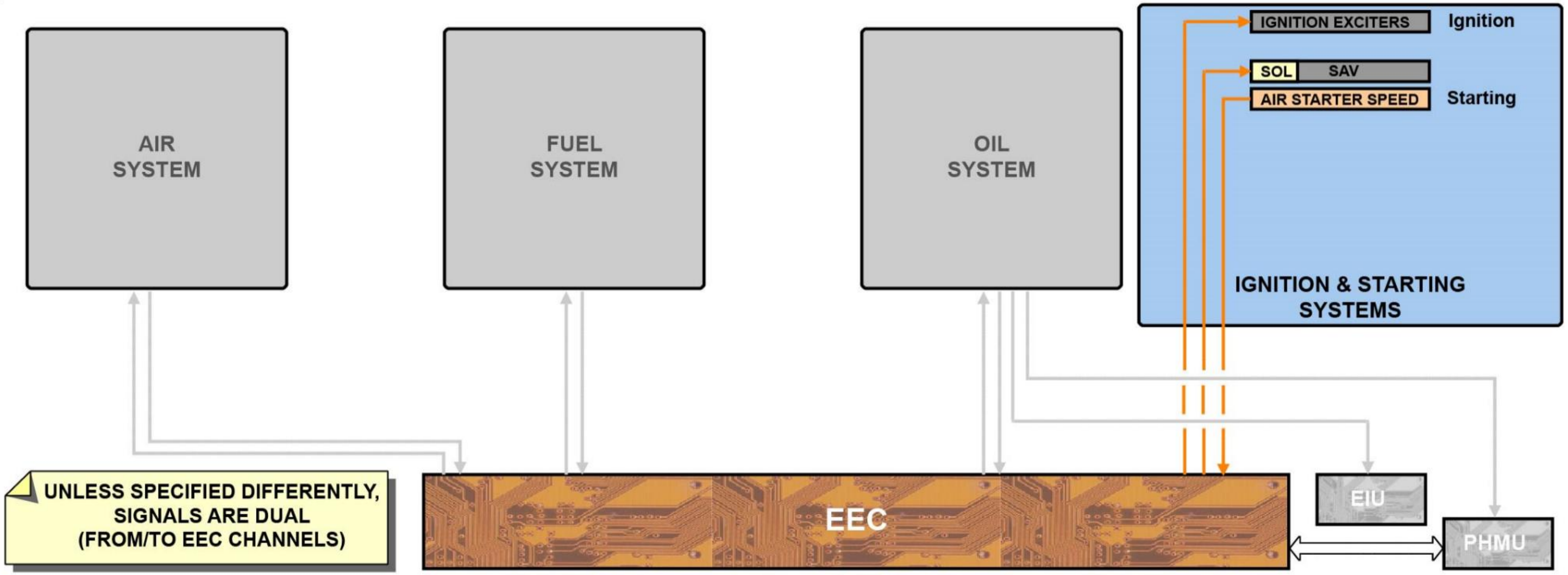
Ignition:

Ignition Exciter control signal (2 pairs).

Starting:

Starter Air Valve (SAV) solenoid control signal,

Air starter speed sensor feedback signal.



AIR SYSTEM
FUEL SYSTEM
OIL SYSTEM
IGNITION EXCITERS
Ignition
SOL
SAV
AIR STARTER SPEED
Starting
IGNITION & STARTING SYSTEMS
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU

NACELLE ANTI-ICE SYSTEM

For the Nacelle Anti Ice system management, the EEC sends and receives the following data:

NAI:

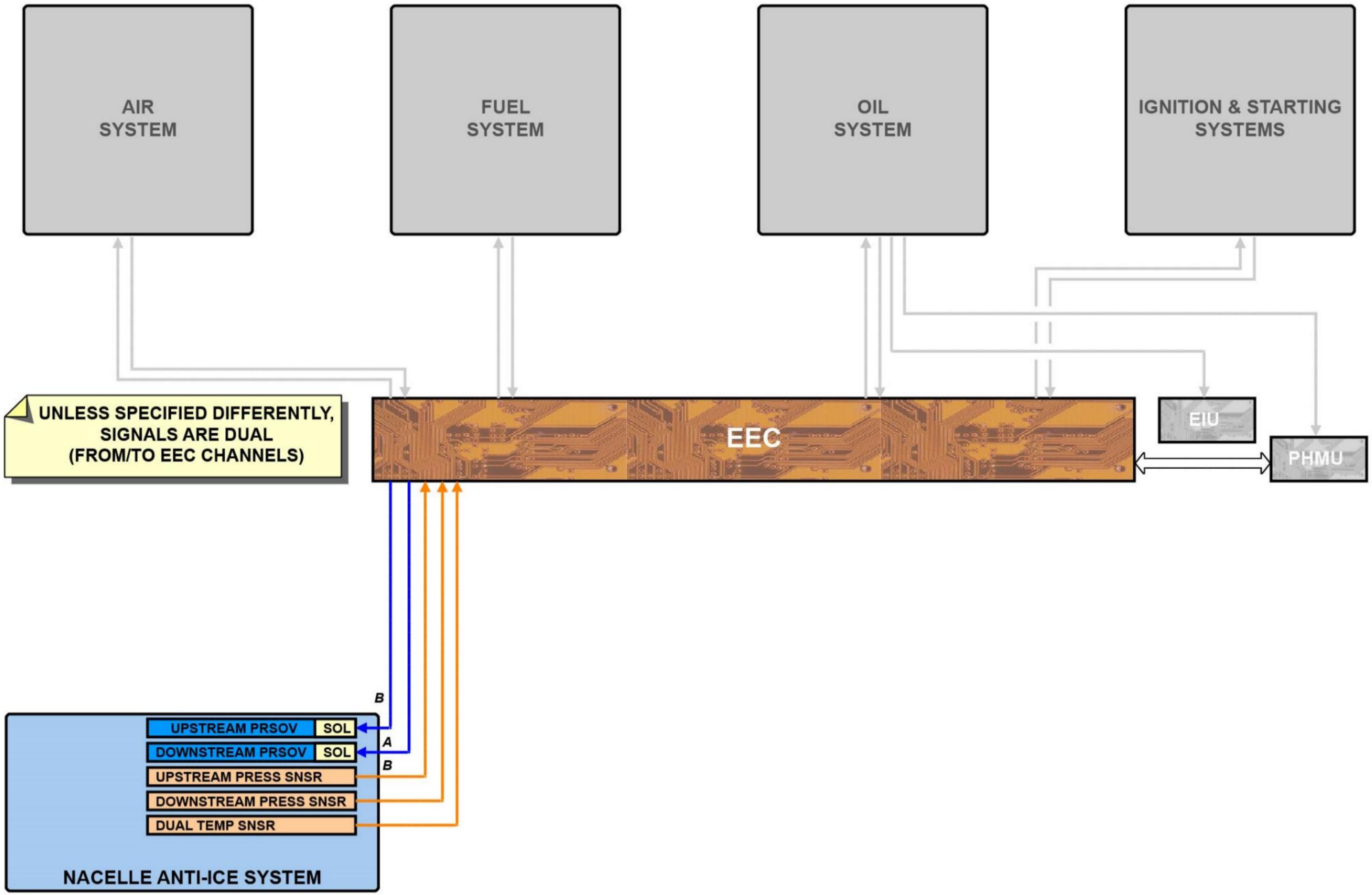
Upstream PRSOV solenoid control signal (Ch. B),

Downstream PRSOV solenoid control signal (Ch. A),

Upstream pressure sensor feedback signal (Ch. B),

Downstream pressure sensor feedback signal,

Dual temperature sensor feedback signal.


AIR
SYSTEM
FUEL
SYSTEM
OIL
SYSTEM
IGNITION & STARTING
SYSTEMS
UNLESS SPECIFIED DIFFERENTLY,
SIGNALS ARE DUAL
(FROM/TO EEC CHANNELS)
EEC
EIU
PHMU
B
UPSTREAM PRSOV
SOL
A
DOWNSTREAM PRSOV
SOL
B
UPSTREAM PRESS SNSR
DOWNSTREAM PRESS SNSR
DUAL TEMP SNSR
NACELLE ANTI-ICE SYSTEM

THRUST REVERSER SYSTEM

For the thrust reverser system management, the EEC sends and receives the following data.

Thrust Reverser:

Isolation Control Valve (ICV) solenoid control signal by EIU and EEC,

ICV pressurized proximity switch feedback signal,

ICV inhibition proximity switch feedback signal,

Directional Control Valve (DCV) solenoid control signal by EIU and EEC,

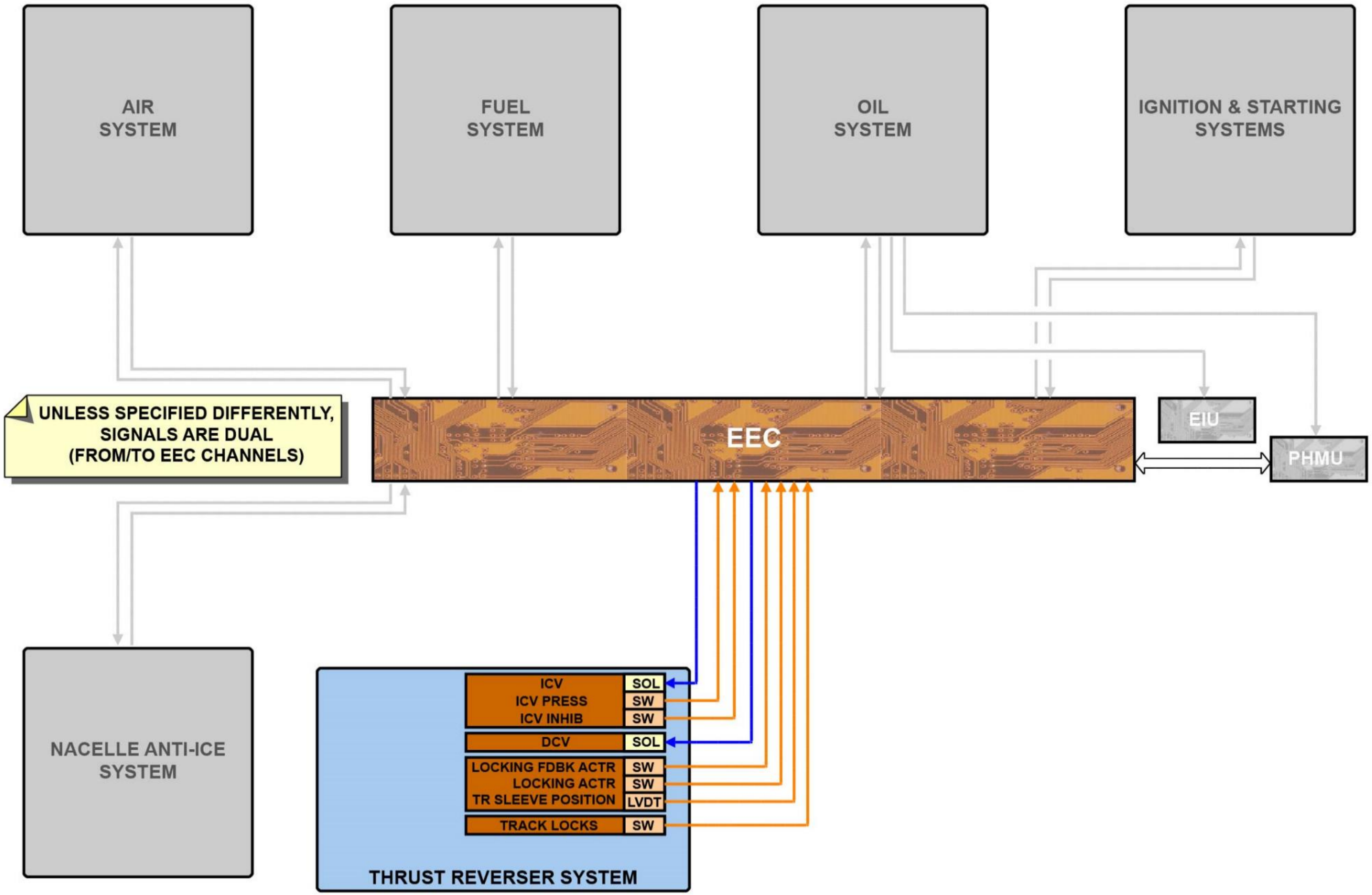
Locking Feedback Actuators primary lock proximity switch feedback signal,

Locking Actuators primary lock proximity switch feedback signal,

Locking Feedback Actuators LVDT feedback signal,

Track Locks proximity switch feedback signal.

Note: Tertiary Lock Valve (TLV) solenoids are controlled independently by SEC.


AIR
SYSTEM
FUEL
SYSTEM
OIL
SYSTEM
IGNITION & STARTING
SYSTEMS
UNLESS SPECIFIED DIFFERENTLY,
SIGNALS ARE DUAL
(FROM/TO EEC CHANNELS)
EEC
EIU
PHMU
NACELLE ANTI-ICE
SYSTEM
ICV
ICV PRESS
ICV INHIB
SOL
SW
SW
DCV
SOL
LOCKING FDBK ACTR
LOCKING ACTR
TR SLEEVE POSITION
SW
SW
LVDT
TRACK LOCKS
SW
THRUST REVERSER SYSTEM

ENGINE SENSORS

For the engine control and monitoring, the EEC receives the following data.

Engine Sensors:

N1 feedback signal,

Nf feedback signal,

N2 feedback signal,

P ambient feedback signal (Ch. A),

Ps14 feedback signal (Ch. B),

P2 feedback signal,

P25 feedback signal (Ch. A),

P3 feedback signal (2 pairs),

T2 feedback signal,

T25 feedback signal (Ch. A),

T3 feedback signal,

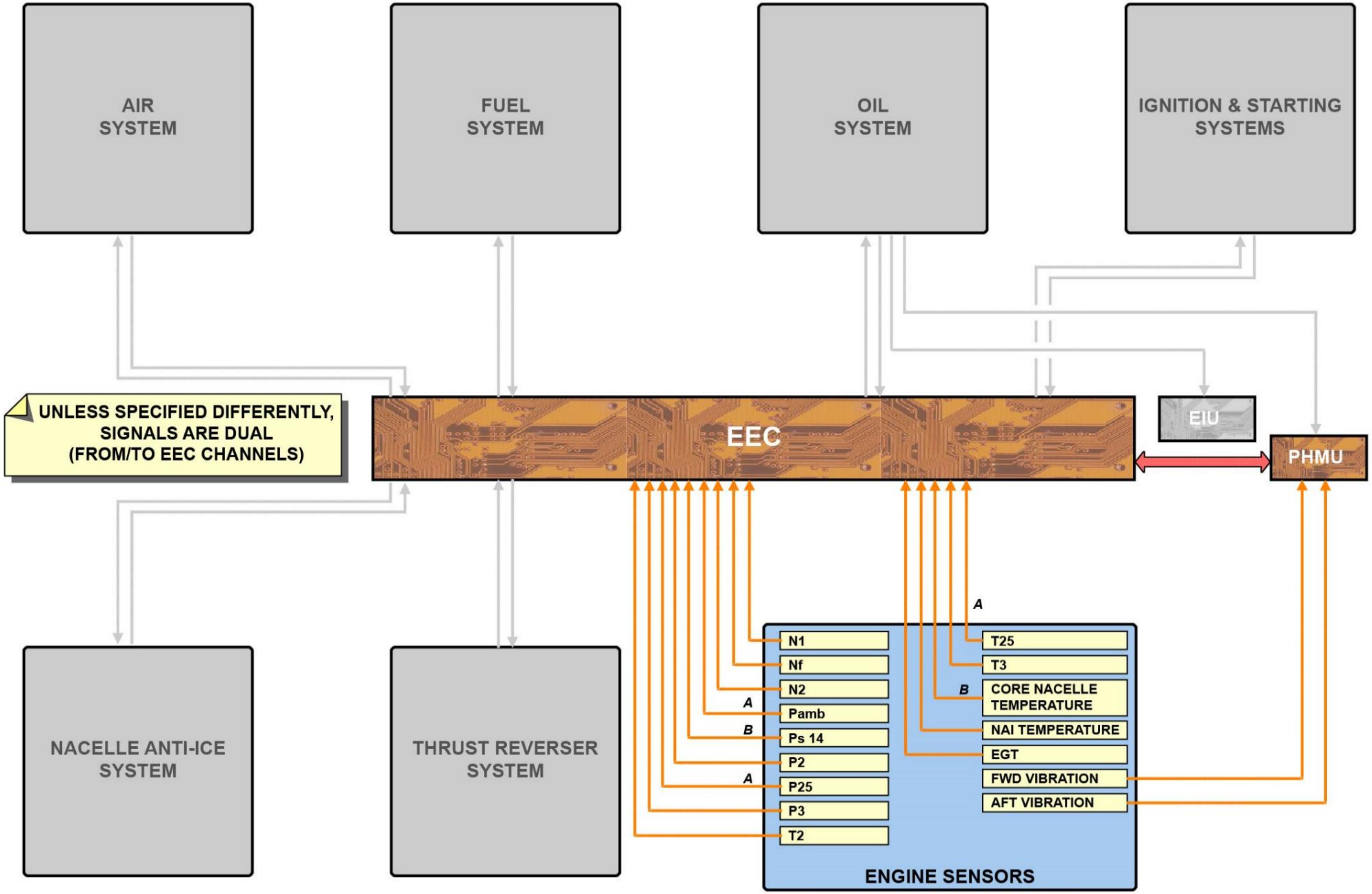
Core Nacelle Temperature feedback signal (Ch. B),

NAI Temperature feedback signal,

EGT feedback signal (2 pairs),

Forward Vibration feedback signal to PHMU,

Aft Vibration feedback signal to PHMU.



AIR SYSTEM
FUEL SYSTEM
OIL SYSTEM
IGNITION & STARTING SYSTEMS
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU
A
N1
Nf
N2
A
Pamb
B
Ps 14
P2
A
P25
P3
T2
T25
T3
B
CORE NACELLE TEMPERATURE
NAI TEMPERATURE
EGT
FWD VIBRATION
AFT VIBRATION
ENGINE SENSORS
NACELLE ANTI-ICE SYSTEM
THRUST REVERSER SYSTEM

COCKPIT CONTROLS

For the engine control, the EEC receives the following data.

Cockpit Controls:

Master Lever position,

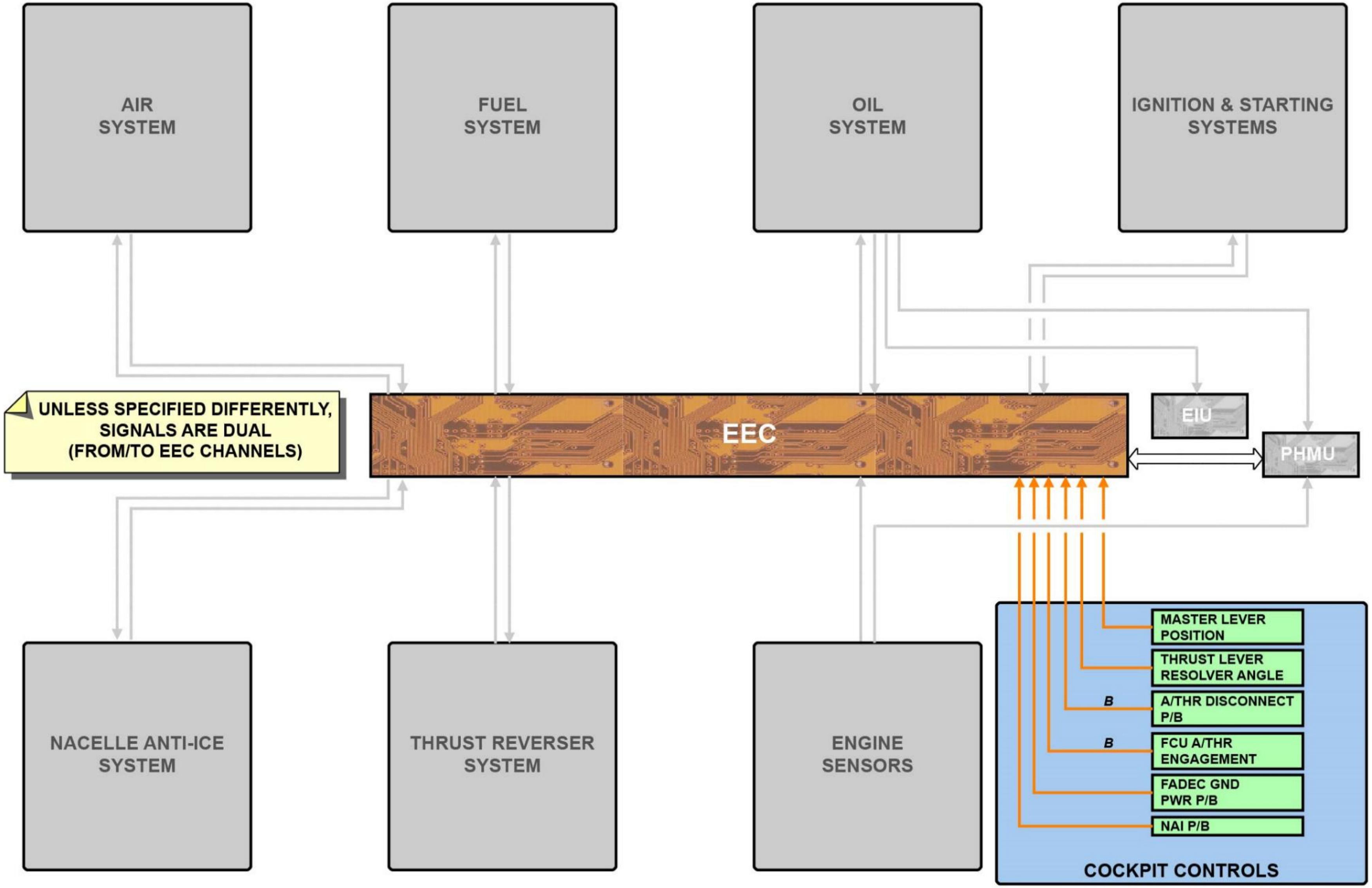
Thrust Lever resolver angle,

Auto Thrust (A/THR) Disconnect P/B (ch B),

Flight Control Unit (FCU) A/THR engagement (ch B),

FADEC Ground Power P/B,

NAI P/B.


AIR SYSTEM
FUEL SYSTEM
OIL SYSTEM
IGNITION & STARTING SYSTEMS
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU
NACELLE ANTI-ICE SYSTEM
THRUST REVERSER SYSTEM
ENGINE SENSORS
MASTER LEVER POSITION
THRUST LEVER RESOLVER ANGLE
B
A/THR DISCONNECT P/B
B
FCU A/THR ENGAGEMENT
FADEC GND PWR P/B
NAI P/B
COCKPIT CONTROLS

FADEC ELECTRICAL PWR SPLY CONTROL

EEC

The Electronic Engine Control (EEC) is electrically supplied by the A/C electrical network when high pressure rotor speed (N2) is below 10% or when the dedicated Permanent Magnet Alternator (PMA) has failed, and then by its dedicated PMA when N2 is above 10%.

AIRCRAFT POWER

The EEC is supplied by the A/C electrical power network when N2 is below 10%.

Each channel is independently supplied by the A/C 28V DC through the Engine Interface Unit (EIU).

The aircraft 28V DC permits the EEC to:

- automatic ground check of the Full Authority Digital Engine Control (FADEC) system when the engine is not running, that is to say FADEC GrouND PoWeR ON for interactive tests and data loading,
- control starting: MASTER lever ON or mode selector on IGNition or CRANK, Starter Air Valve (SAV),
- control reverser system.

NOTE: The EIU takes its power from the same bus bar as the EEC.

PMA SUPPLY

As soon as the engine is running above 10% of N2, its PMA directly supplies each EEC channel with three-phase AC power.

Two transformer rectifiers provide 28V DC power supply to channels A and B.

Switching between the A/C 28V DC supply and the dedicated alternator power supplies is done automatically by the EEC.

AUTO DEPOWERING

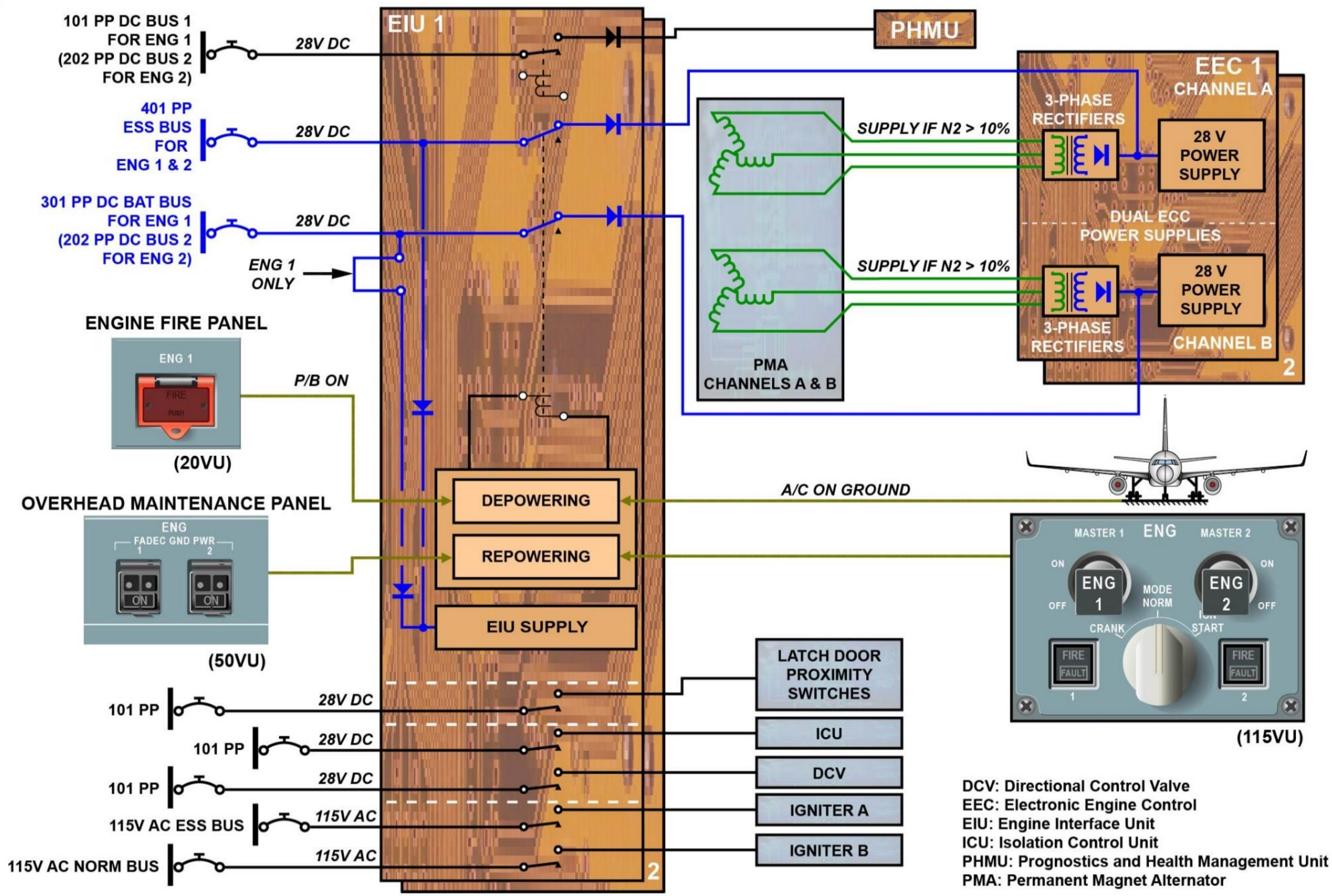
The FADEC is automatically depowered on the ground, through the EIU, after engine shutdown.

The EEC automatic depowering occurs on the ground:

- 5 min after A/C power-up,
- 5 min after engine shutdown.

Power is not cut-off if Centralized Fault Display System (CFDS) EEC menus are active or Data Loading going on (software upload/memory dump).

NOTE: An action on the ENGine FIRE P/B provides EEC power cut-off from the A/C network.



101 PP DC BUS 1
FOR ENG 1
(202 PP DC BUS 2
FOR ENG 2)
28V DC
401 PP
ESS BUS
FOR
ENG 1 & 2
28V DC
301 PP DC BAT BUS
FOR ENG 1
(202 PP DC BUS 2
FOR ENG 2)
28V DC
ENG 1
ONLY
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
(20VU)
P/B ON
OVERHEAD MAINTENANCE PANEL
ENG
FADEC GND PWR
1
2
ON
ON
(50VU)
EIU 1
2
PHMU
EEC 1
CHANNEL A
3-PHASE
RECTIFIERS
28 V
POWER
SUPPLY
DUAL ECC
POWER SUPPLIES
28 V
POWER
SUPPLY
3-PHASE
RECTIFIERS
CHANNEL B
2
SUPPLY IF N2 > 10%
SUPPLY IF N2 > 10%
PMA
CHANNELS A & B
DEPOWERING
REPOWERING
EIU SUPPLY
A/C ON GROUND
MASTER 1
ENG
MASTER 2
ON
ON
ENG
1
ENG
2
OFF
OFF
MODE
NORM
CRANK
START
FIRE
FAULT
FIRE
FAULT
1
2
(115VU)
101 PP
28V DC
101 PP
28V DC
101 PP
28V DC
115V AC ESS BUS
115V AC
115V AC NORM BUS
115V AC
LATCH DOOR
PROXIMITY
SWITCHES
ICU
DCV
IGNITER A
IGNITER B
DCV: Directional Control Valve
EEC: Electronic Engine Control
EIU: Engine Interface Unit
ICU: Isolation Control Unit
PHMU: Prognostics and Health Management Unit
PMA: Permanent Magnet Alternator

MANUAL REPOWERING

For maintenance purposes and Multipurpose Control and Display Unit (MCDU) engine tests, the ENGine FADEC GrouND PoWeR panel permits FADEC power supply to be restored on the ground with engines shut down.

When the corresponding ENGine FADEC GrouND PoWeR P/B is pressed ON the EEC recovers its power supply.

NOTE: The FADEC is also repowered as soon as the engine start selector is in IGNition/START or CRANK position, or the MASTER lever is selected ON.

SUBSYSTEMS POWER SUPPLY

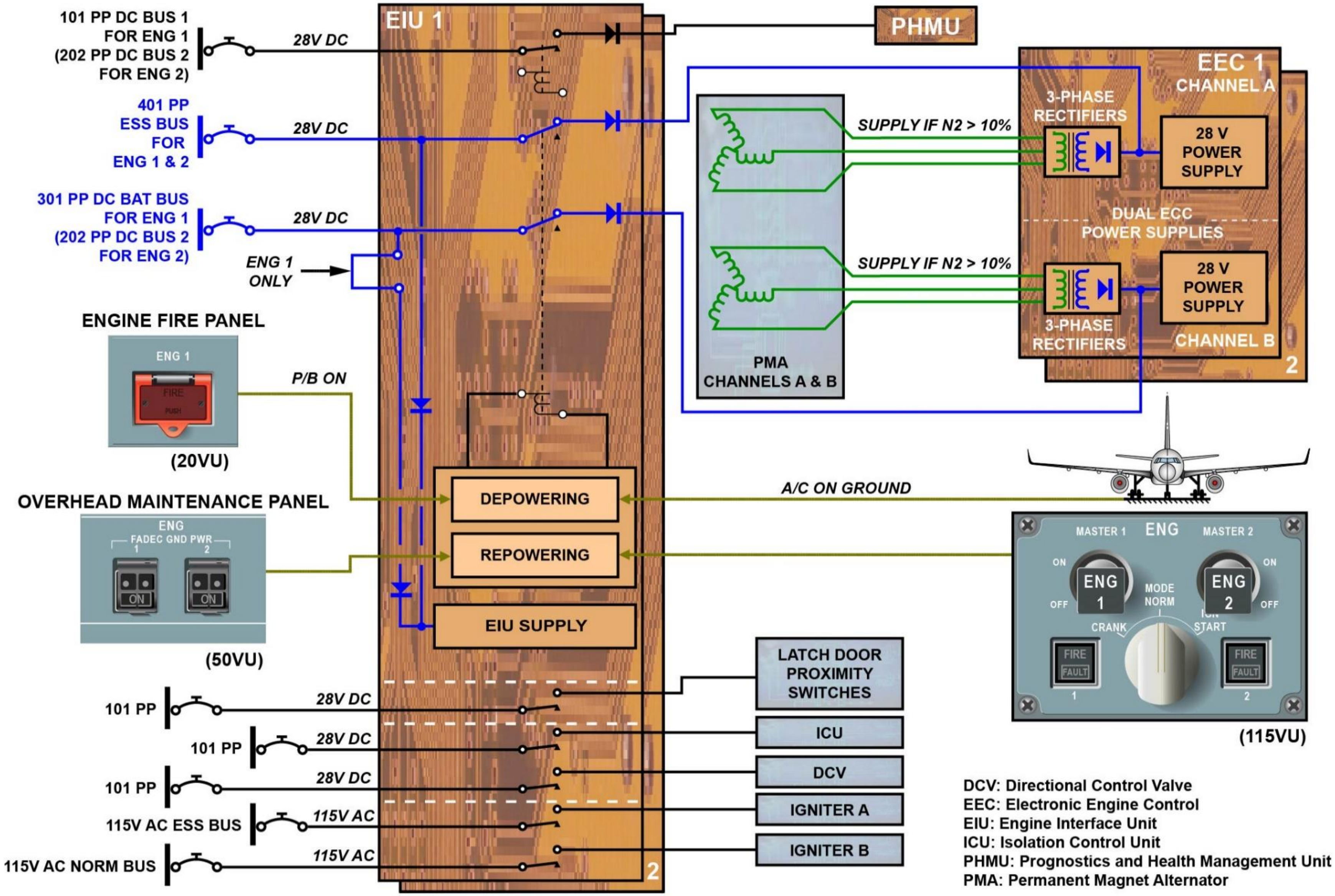
The Prognostics and Health Management Unit (PHMU) receives aircraft 28V DC directly from the aircraft normal DC power bus through the EIU.

The de-powering conditions are the same as the EEC.

The Fan cowl door proximity switches are supplied by another bus in 28V DC.

Power is also transferred to the reverser system valves for Directional Control and Isolation.

Each starting igniter is independently supplied with 115V AC.


101 PP DC BUS 1
FOR ENG 1
(202 PP DC BUS 2
FOR ENG 2)
28V DC
EIU 1
PHMU
401 PP
ESS BUS
FOR
ENG 1 & 2
28V DC
EEC 1
CHANNEL A
3-PHASE
RECTIFIERS
28 V
POWER
SUPPLY
SUPPLY IF N2 > 10%
301 PP DC BAT BUS
FOR ENG 1
(202 PP DC BUS 2
FOR ENG 2)
28V DC
DUAL ECC
POWER SUPPLIES
ENG 1
ONLY
SUPPLY IF N2 > 10%
28 V
POWER
SUPPLY
3-PHASE
RECTIFIERS
CHANNEL B
2
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
P/B ON
PMA
CHANNELS A & B
(20VU)
A/C ON GROUND
OVERHEAD MAINTENANCE PANEL
ENG
FADEC GND PWR
1
2
ON
ON
DEPOWERING
REPOWERING
EIU SUPPLY
MASTER 1
ENG
MASTER 2
ON
ON
OFF
OFF
ENG 1
ENG 2
MODE
NORM
CRANK
START
FIRE
FAULT
FIRE
FAULT
1
2
(50VU)
LATCH DOOR
PROXIMITY
SWITCHES
101 PP
28V DC
101 PP
28V DC
ICU
(115VU)
101 PP
28V DC
DCV
115V AC ESS BUS
115V AC
IGNITER A
115V AC NORM BUS
115V AC
IGNITER B
2
DCV: Directional Control Valve
EEC: Electronic Engine Control
EIU: Engine Interface Unit
ICU: Isolation Control Unit
PHMU: Prognostics and Health Management Unit
PMA: Permanent Magnet Alternator

P2.5/T2.5 Probe

Purpose:

The P2.5 / T2.5 probe detects LPC exit air pressure and temperature at Station 2.5.

Location:

The probe is located on the Compressor Intermediate Case at 1:00.

Description:

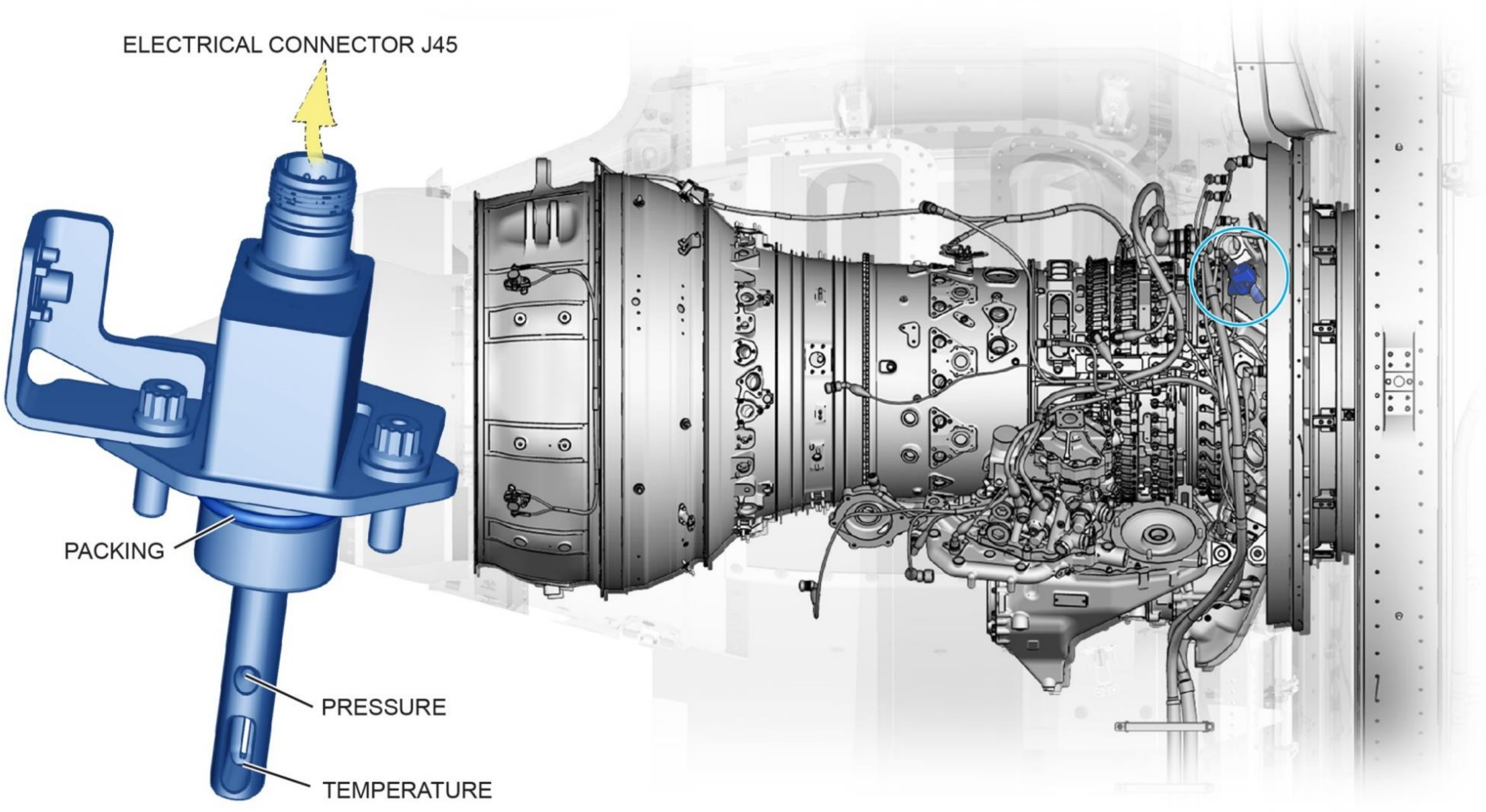
The probe contains two single-channel sensors. P2.5 is sent to EEC Channel B, and T2.5 is sent to Channel A. The EEC processes both signals to monitor engine health and analyse performance.

The probe consists of a stainless-steel housing, an internal strain gauge-type transducer for measuring air pressure, an RTD sensing element for measuring air temperature, and an electrical connector.

Operation:

The housing of the probe allows inlet air to contact the RTD sensing element. As air pressure is applied, the resistance of the strain gage changes, altering the output voltage in direct correlation.

The sensing element is connected to the electrical connector, which transmits the temperature signal to the EEC.


ELECTRICAL CONNECTOR J45
PACKING
PRESSURE
TEMPERATURE

Data Storage Unit (DSU)

Purpose:

The DSU provides 8 MB of non-volatile memory storage for engine identification, history, and ratings data. It is the master source for engine identification data.

Location:

The DSU is attached to a lanyard installed on the J99 electrical connector, located at the top right side of the EEC housing next to Channel A electrical connectors.

Description:

The DSU is a dual-channel memory device. Its lanyard is a threaded electrical connector like the engine wiring harnesses.

The lanyard is permanently bolted to the fan case, ensuring that identification data for the engine can be transferred to a new EEC if the old one is removed.

Operation:

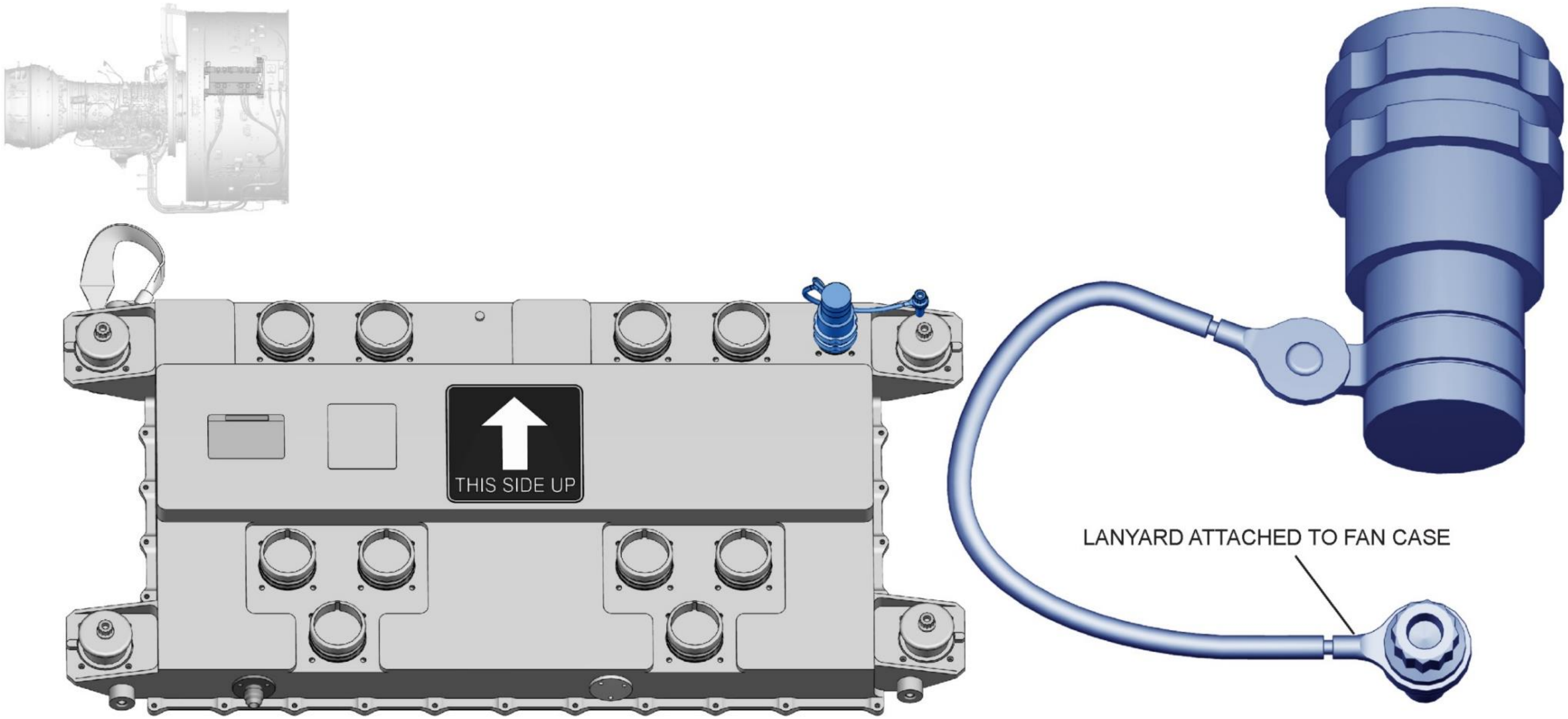
The DSU must be installed before the engine can start.

If the DSU becomes disconnected in flight, the EEC will use the programming information stored in its memory for continued operation.

The engine serial number is input via the DSU for use with the engine condition monitoring program.

The DSU can be reprogrammed if necessary and data can be downloaded through the aircraft's Central Maintenance Computer.

Both channels can access the DSU plug, and will access DSU data even if one channel's control processor has failed.


THIS SIDE UP
LANYARD ATTACHED TO FAN CASE

Wiring Harnesses

Purpose:

Wiring harnesses provide a pathway for electrical commands, for engine and airframe data, and for power between Electronic Engine Control, aircraft, and engine components.

Location:

The engine has three types of harnesses.

Fan case harnesses, designated with the letters *WF*, are attached to the left side of the case.

Core harnesses, designated as *W* or *WC*, are attached to the left side of the fan case and the left and right side of the engine core.

A nacelle harness designated as *WN30* is located on the inlet cowl.

Description:

Groups of two or three twisted, shielded harness wires are covered in grey, non-flammable, chafe-resistant Nomex® over braid.

Stainless steel connectors and stainless closed back-shells have anti-rotation features.

Operation:

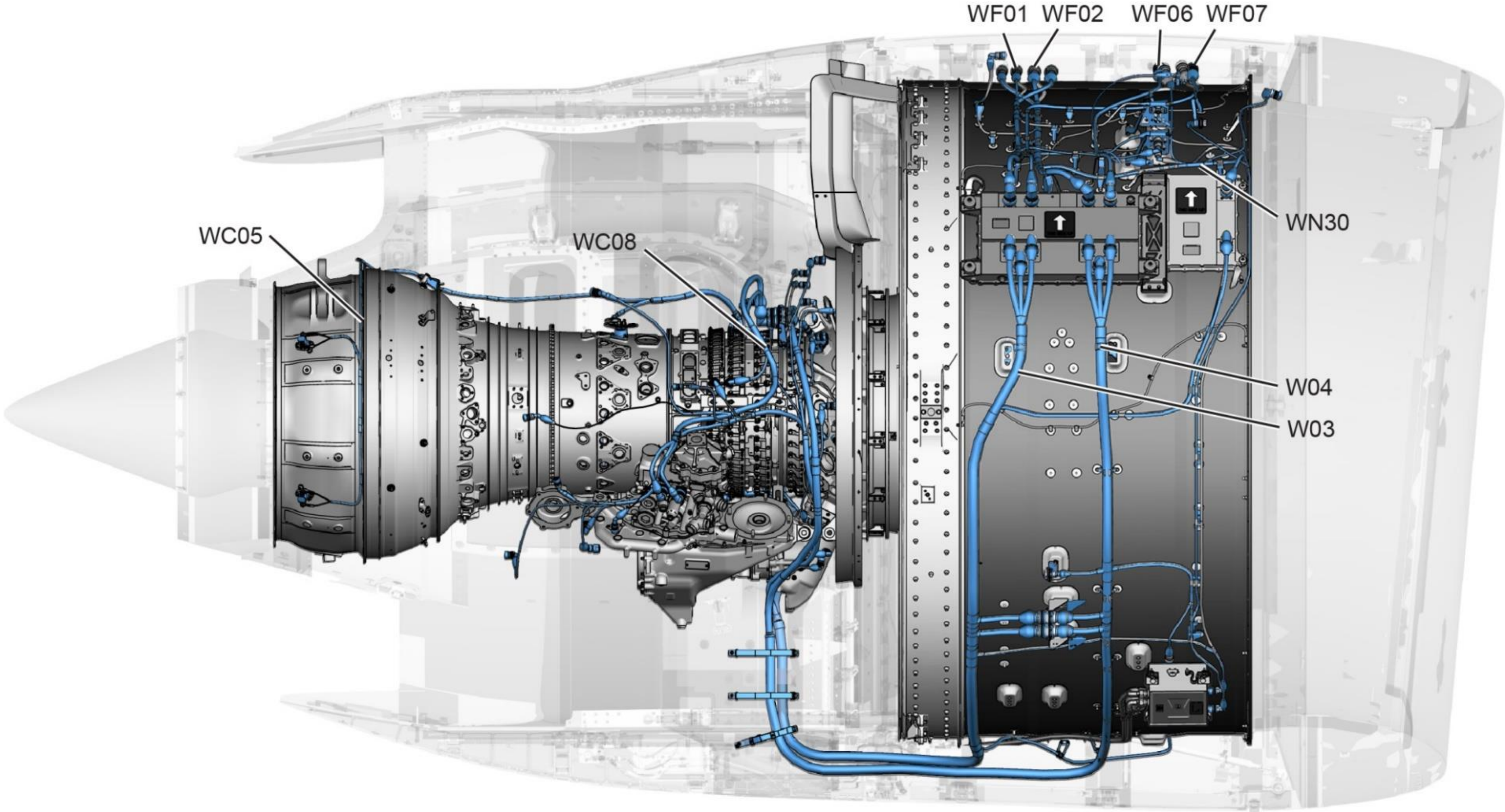
Connectors and back-shells have 360° shield termination for electromagnetic interference protection.

On-wing harness repair is limited to the Nomex over braid. Off engine repairs can be made by the vendor or an approved Federal Aviation Administration repair facility.

Harness Type	Designation
Fan case	• WF01, -02, -06, -07
Core	• W03, -04 • WC05, -08, -10, -11
Nacelle	• WN30

CAUTION:

DO NOT BEND OR TWIST THE WIRING HARNESS TOO MUCH. IF YOU DO, DAMAGE TO THE WIRING HARNESS CAN OCCUR


WF01
WF02
WF06
WF07
WN30
WC05
WC08
W04
W03

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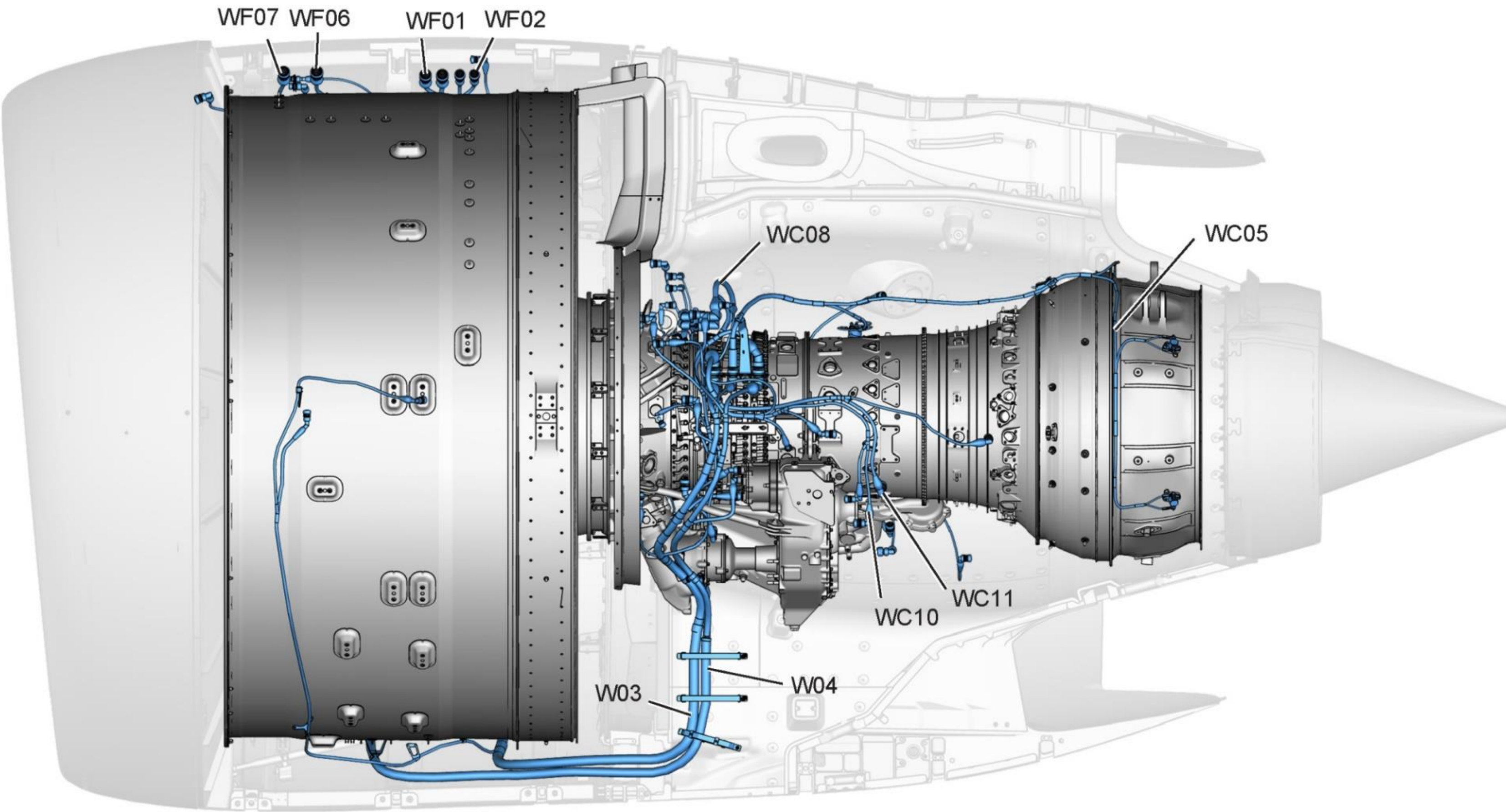

WF07
WF06
WF01
WF02
WC08
WC05
WC11
WC10
W04
W03

Pamb Sensor

Purpose:

The Pamb sensor is a single-channel probe that detects ambient air pressure.

Location:

The Pamb sensor is internal to the EEC housing and is located on the bottom right side below the Channel A electrical connectors.

Description:

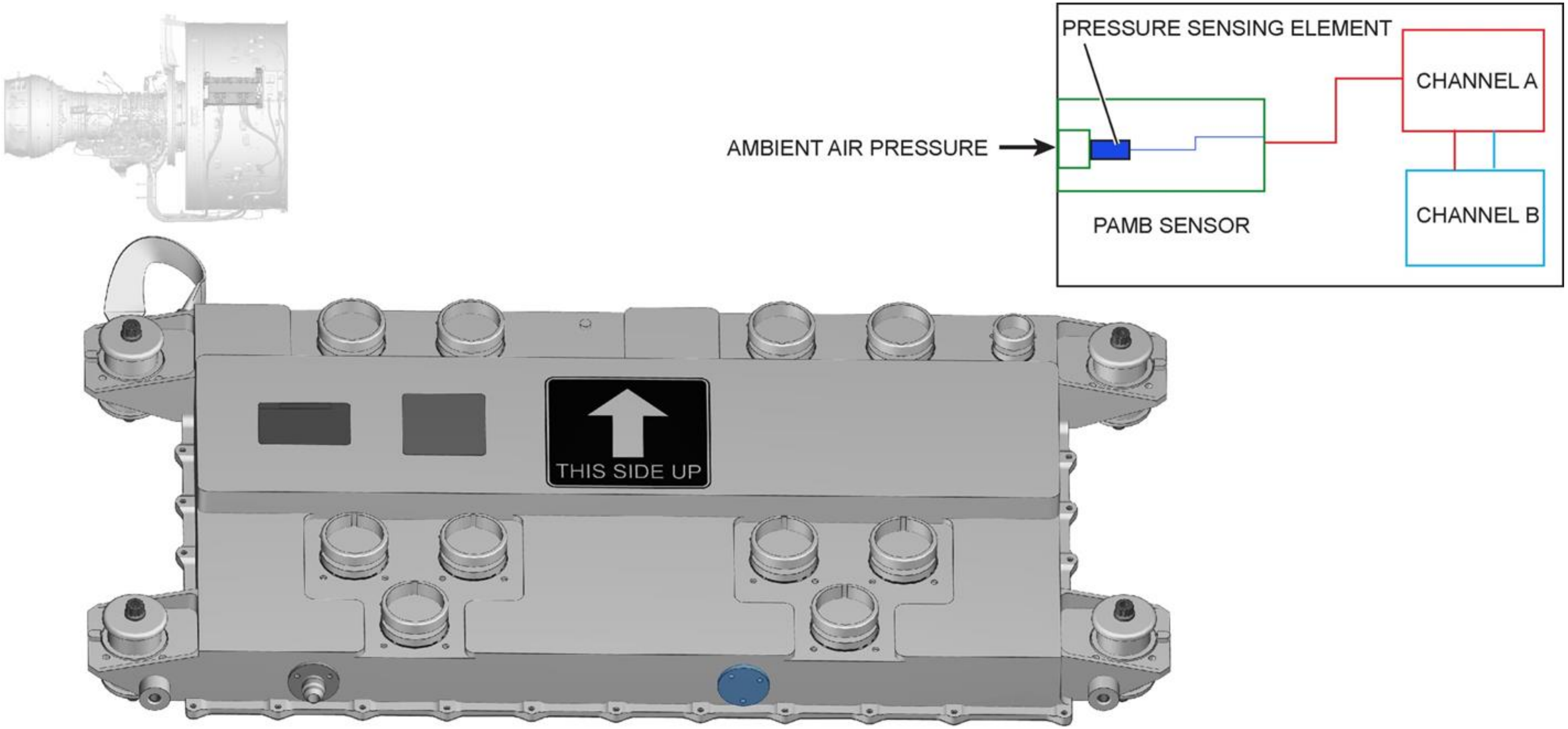
The sensor is wired to Channel A and detects ambient air pressure through a port in the EEC housing.

Operation:

When pressure is applied, a strain gauge alters its resistance, changing output voltage to the sensor in direct correlation to ambient air pressure.

Ambient air pressure is used by the EEC for many control scheduling functions, including engine rating and Mach number calculations.

The EEC also compares its Pamb signal with an independent ambient pressure signal from the aircraft to validate the health of each one.


PRESSURE SENSING ELEMENT
CHANNEL A
AMBIENT AIR PRESSURE
PAMB SENSOR
CHANNEL B
THIS SIDE UP

T2 Sensor

Purpose:

The T2 sensor detects engine inlet air temperature used for many control scheduling functions, including engine rating and Mach number calculations.

Location:

The sensor is located on the inlet cowl at 1:00. (Aft looking Fwd)

Description:

The dual channel sensor uses a single-element Resistance Temperature Device (RTD) that detects air temperature in the fan inlet. Resistance of the sensing element alters in response to a change in the surrounding air temperature.

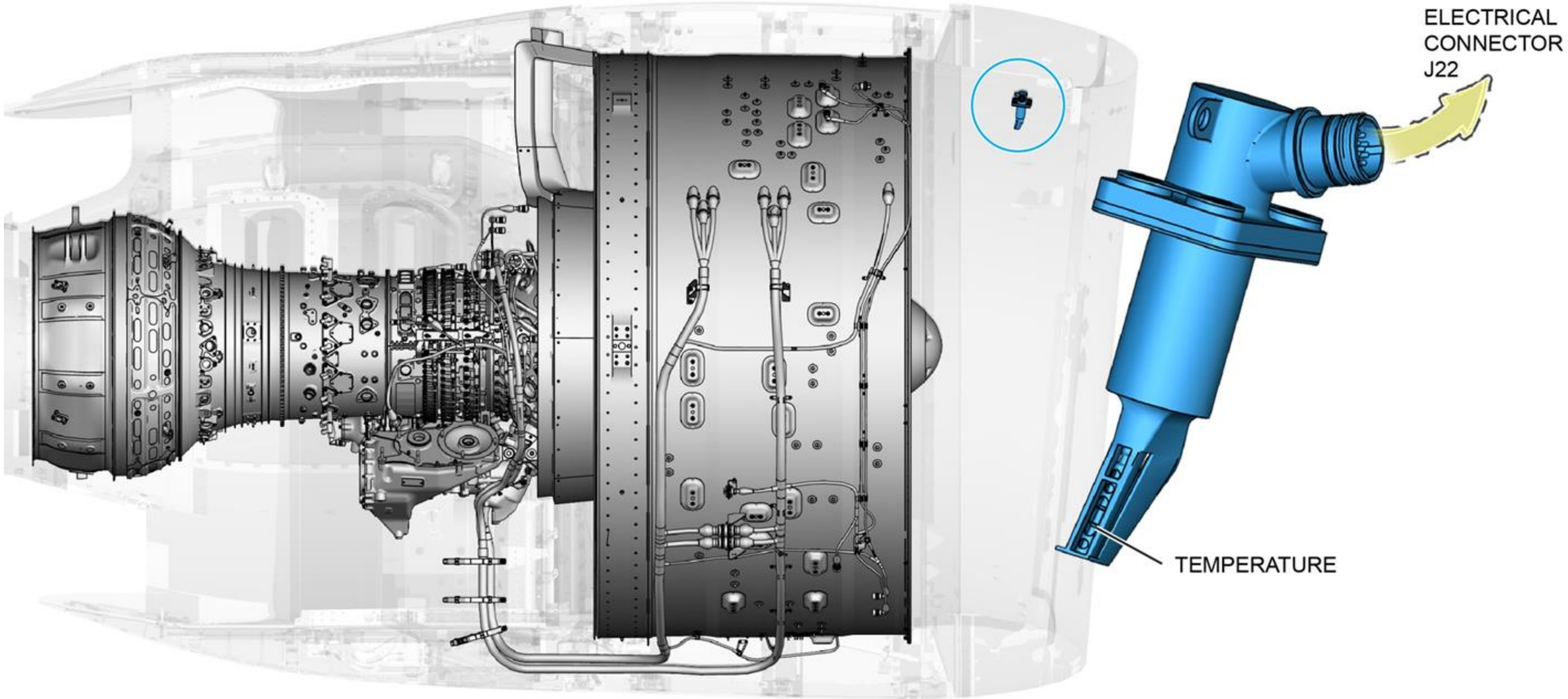
The constant relationship means a properly functioning sensor will always indicate the same resistance at any one temperature.

Operation:

The sensing element is connected to an electrical connector that transmits the temperature signal to the EEC.

The EEC processes the sensor signal and receives a total air temperature signal from the aircraft's Air Data Inertial Reference Unit (ADIRU).

The EEC compares the two inlet air temperature signals to validate the health of each signal.


ELECTRICAL
CONNECTOR
J22
TEMPERATURE

T3 Sensor

Purpose:

The T3 temperature sensor supplies data to the EEC for monitoring engine performance and High Pressure Compressor health.

Location:

The T3 sensor is secured to the diffuser case at 1:00.

Description:

The dual-channel T3 sensor transmits its analog signals to the EEC though the EGT/T3 harness assembly.

Operation:

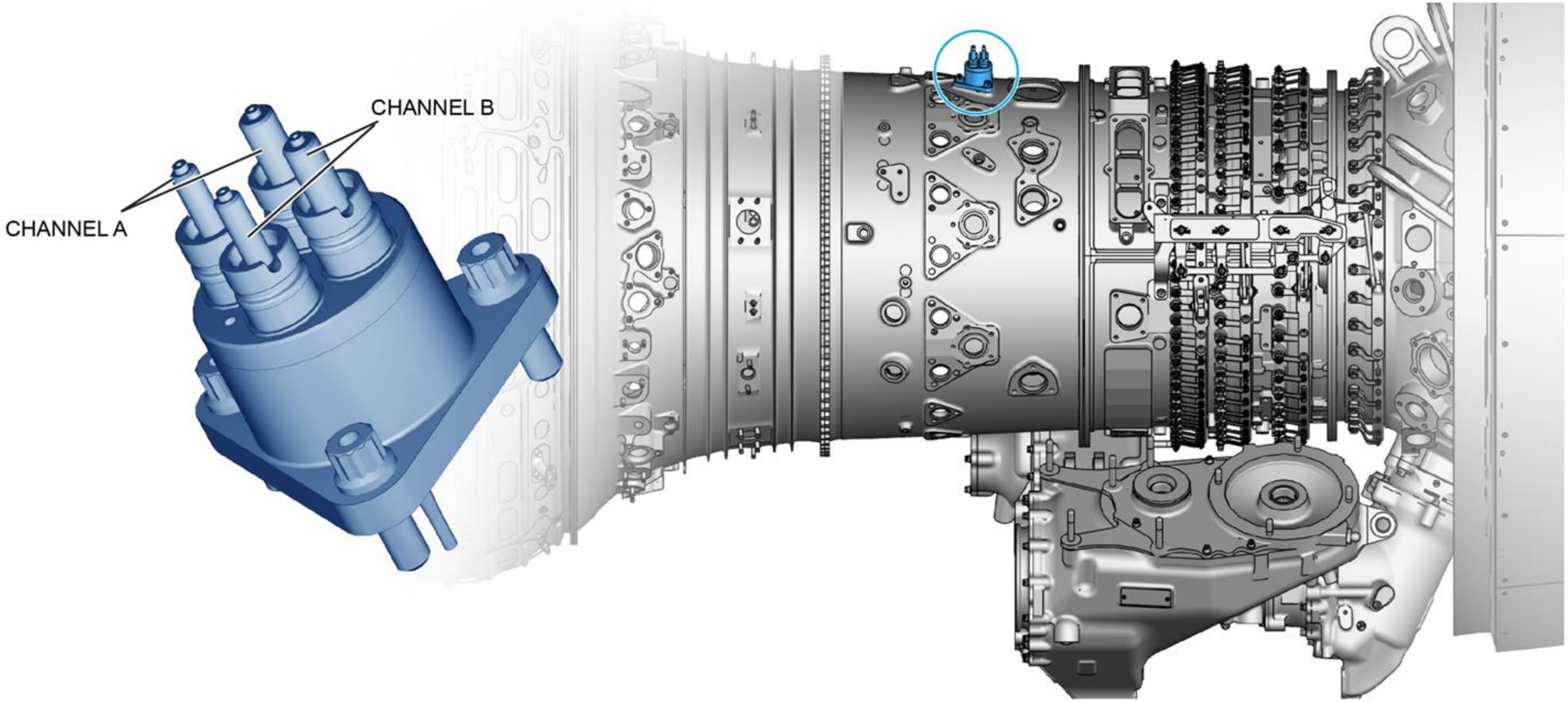
One set of terminal studs sends the signal to Channel A, and the other set sends the signal to Channel B.

CAUTION

Safety Conditions

DO NOT TORQUE THE STUD NUTS MORE THAN THE SPECIFIED TORQUE.

IF YOU DO, YOU CAN BREAK OR DAMAGE THE STUDS.


CHANNEL B
CHANNEL A

PS14 Sensor

Purpose:

The PS14 sensor detects air pressure at the fan exit.

Location:

The PS14 sensor is internal to the EEC, located on the bottom left of the EEC housing below the Channel B electrical connectors.

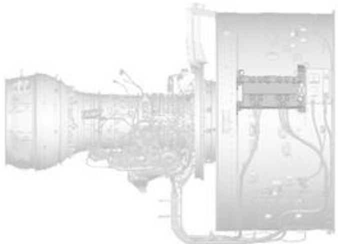
The PS14 tube attaches to the PS14 sensor at the rear fan case support at 3:30.

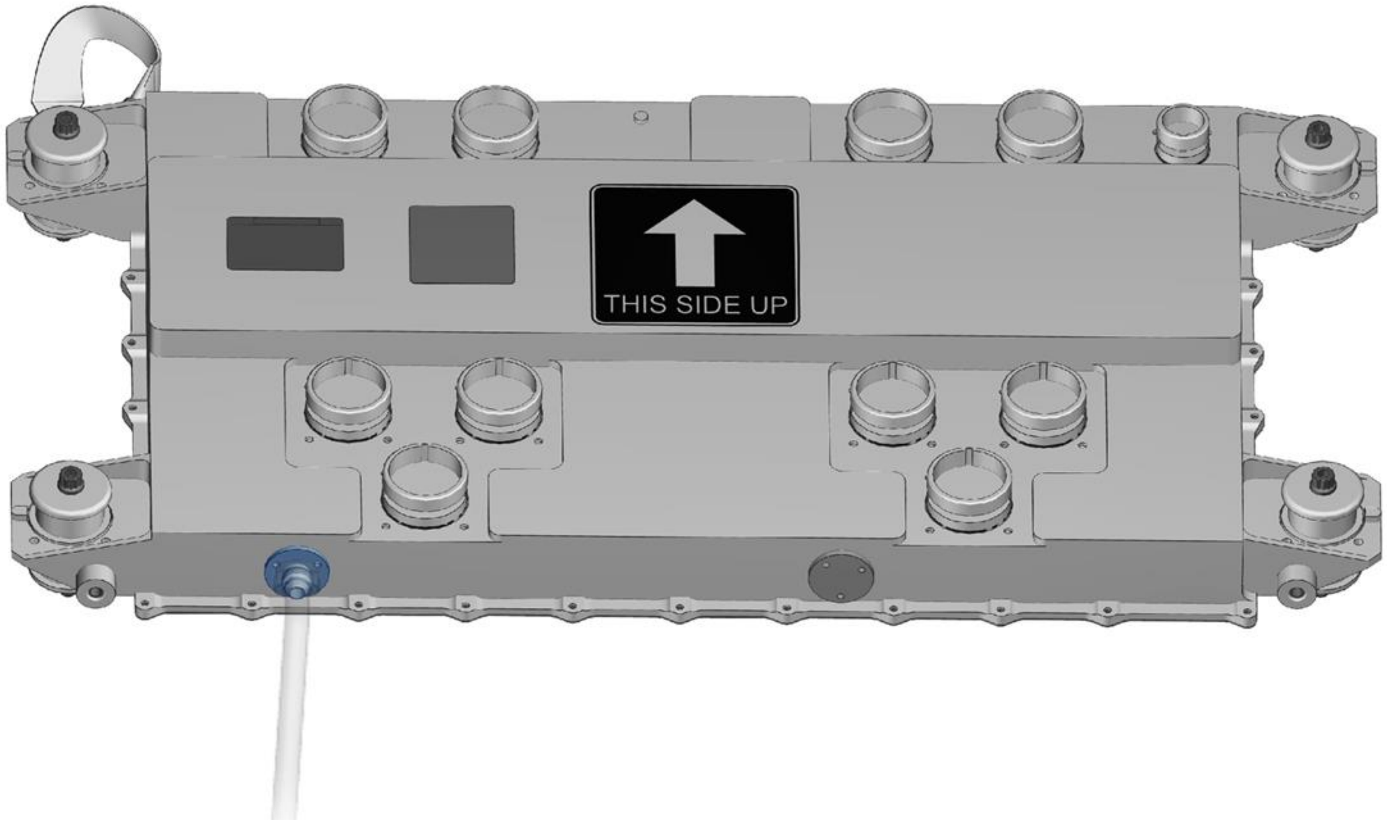
Description:

The single-channel sensor wired to Channel B detects fan exit air pressure through an external sense line.

The inlet port for the PS14 sense line is a plenum covered by a fan case liner between two fan exit guide vanes.

The plenum receives air pressure from unsealed locations aft of the fan exit guide vanes.




THIS SIDE UP

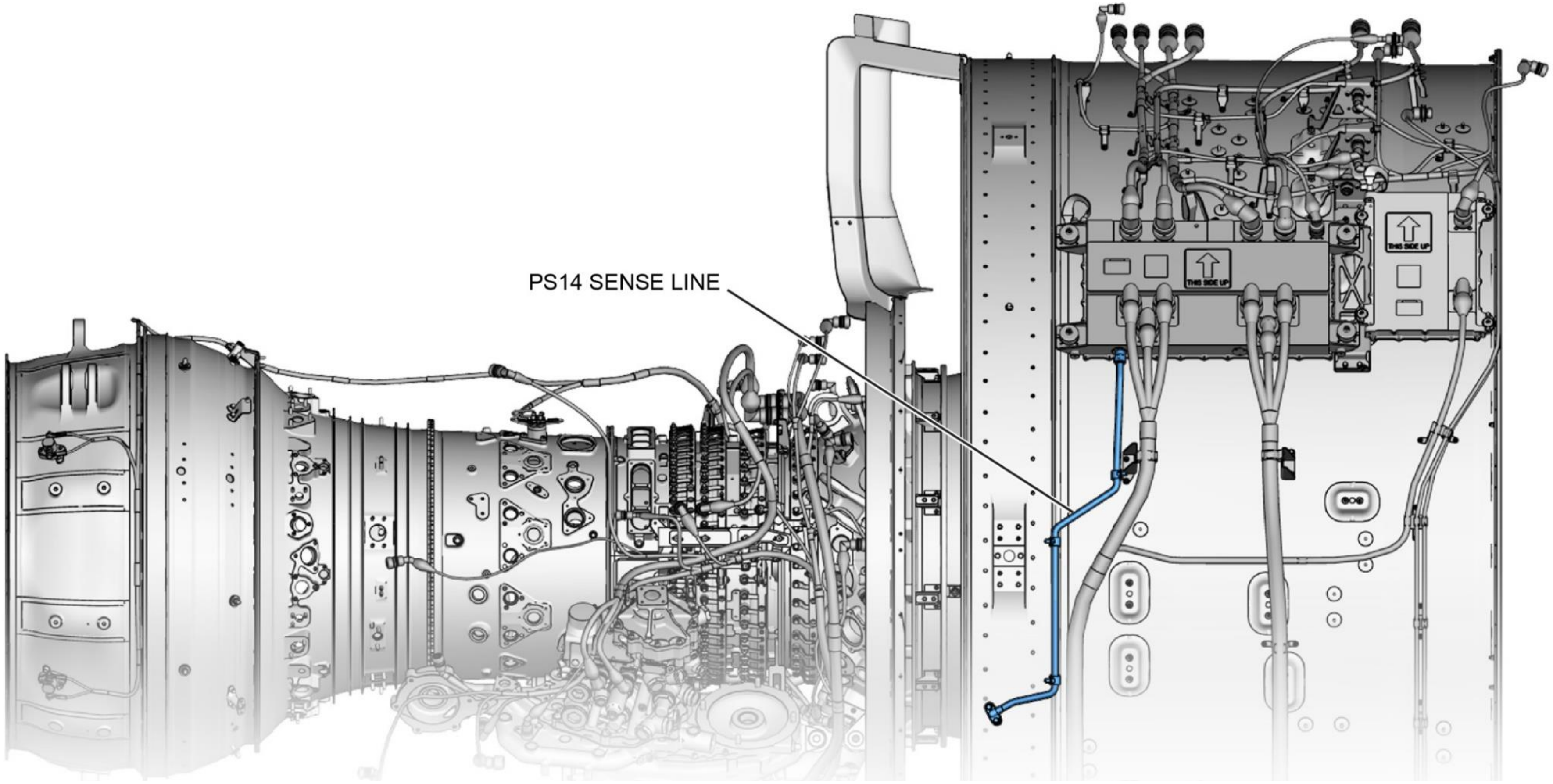
PS14 Sensor

Operation:

When pressure is applied, a strain gage alters its resistance, changing output voltage to the sensor.

The output voltage correlates directly to air pressure.

Fan exit pressure is used by the EEC to calculate engine inlet air pressure (P2) and to validate an independent air pressure reading from the aircraft.


PS14 SENSE LINE
THIS SIDE UP
THIS SIDE UP

Burner Pressure (Pb) Sensor

Purpose:

The Pb sensor provides burner pressure to the EEC for fuel scheduling, surge recovery, stall detection, fuel topping, auto start logic and shaft shear detection.

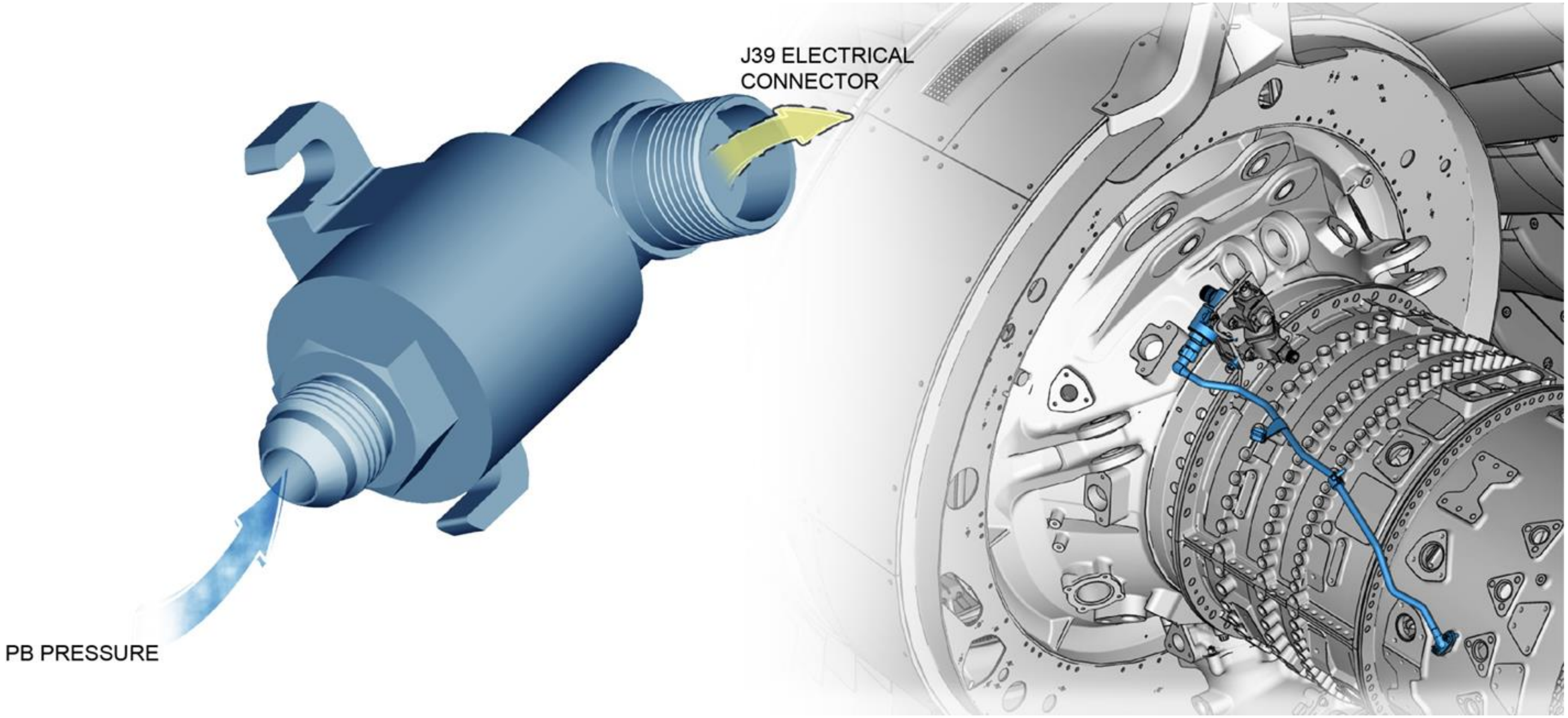
Location:

The sensor is attached to the Compressor Intermediate Case fire seal at 10:00.

Description:

The sensor is a dual-channel pressure transducer.

Operation:
The sensor converts air pressure from the diffuser case into an electrical signal and sends the signal to the EEC.


J39 ELECTRICAL
CONNECTOR
PB PRESSURE

Permanent Magnet Alternator (PMA)

Purpose:

The PMA rotor and stator generator provides electrical power to both channels of the EEC during engine operation.

Location:

The PMA is attached to a dedicated mounting pad on the front left side of the Main Gearbox.

Description:

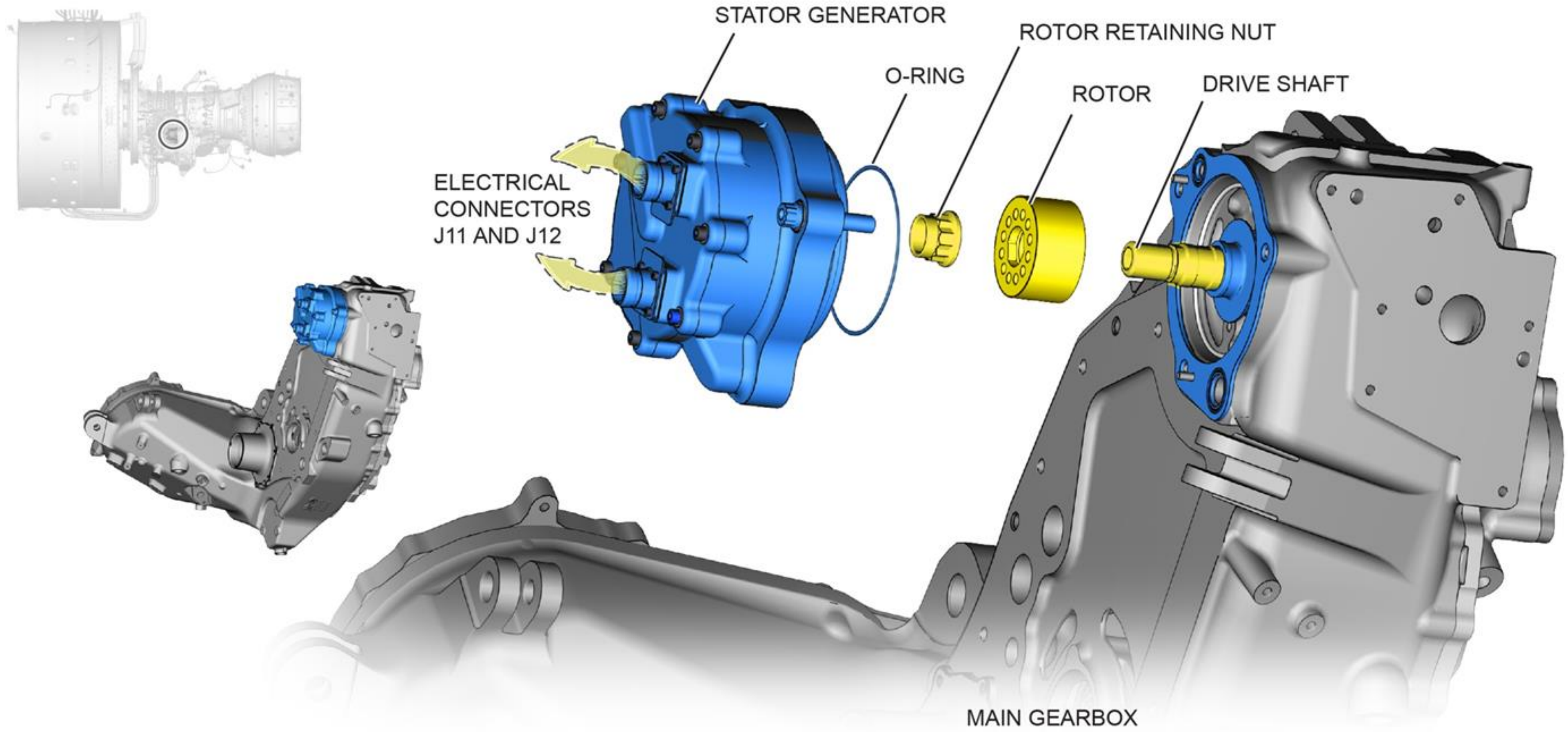
The PMA rotor consists of a high tensile steel magnet and an Inconel sleeve. The rotor houses the magnets, which are held in place by the sleeve. The rotor is installed on the PMA drive shaft on the Main Gearbox. Removal and installation of the rotor require special tooling.

Safety Conditions

CAUTIONS

THERE ARE STRONG MAGNETS IN THE ROTOR. MAKE SURE YOU KEEP THE ROTOR AWAY FROM OTHER METAL OBJECTS, PARTICLES, AND DUST. IF YOU DO NOT DO THIS, DAMAGE TO THE ROTOR CAN OCCUR.

The PMA stator consists of two electrical connectors; three captive fasteners; an O-ring; a face seal; and two sets of single-channel circuit windings contained in an oil-cooled aluminium housing.


STATOR GENERATOR
ROTOR RETAINING NUT
O-RING
ROTOR
DRIVE SHAFT
ELECTRICAL
CONNECTORS
J11 AND J12
MAIN GEARBOX

Operation:

Rotor

The PMA drive shaft is used to transmit torque from the Main Gearbox to the PMA rotor. A self-locking nut is installed to provide axial retention of the PMA rotor. As the rotor is spun by the drive shaft, the magnet rotates and induces a current in both sets of windings of the stator. This current provides the voltage that is used to power the EEC.

Stator

“In” and “out” ports that align with matching holes in the Main Gearbox direct engine oil in and out of the stator housing.

Movement of the oil through the housing’s internal passages allows the oil to cool the PMA.

Oil sealing is provided by a face seal at the “in” and “out” holes.

The seal is designed for maximum durability. Attachment features of the PMA to the Main Gearbox minimize relative motion between the mating interfaces, assuring that wear of the seal face is not

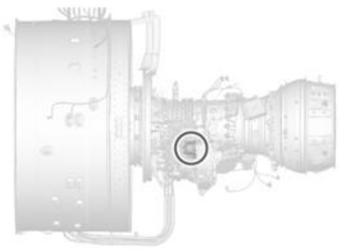
If the PMA becomes inoperable during engine operation, 28-VDC aircraft power automatically switches on to provide power to the FADEC System.

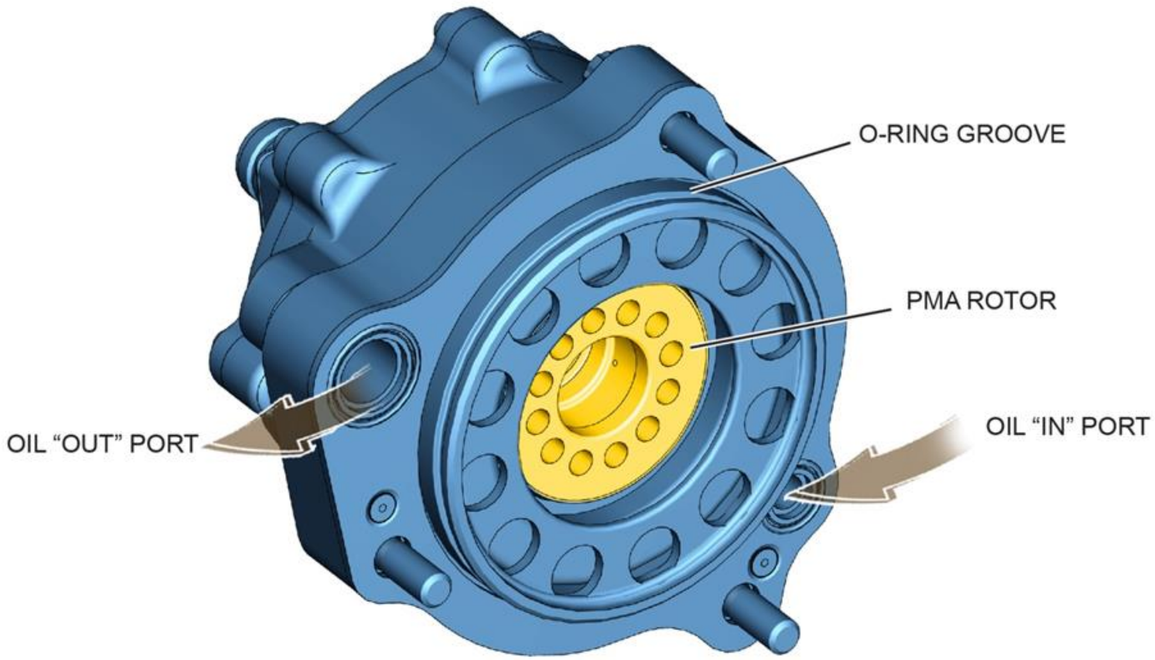
The two sets of windings are isolated from each other and are connected to separate Channel A and B electrical connectors on the outside of the PMA stator housing.

An O-ring provides oil sealing between the PMA stator housing and the Main Gearbox.

If the PMA is removed on-wing or during a shop visit, the O-ring is replaced.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS





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