

FADEC System Overview

The FADEC System controls the ignition spark and fuel mixture in the engine. Automatic mixture eliminates manual mixture control and optimizes engine performance.

The FADEC System includes the following components:

- Two Master Power Control Units (referred to herein as MPC 1 and MPC 2)
- Various Sensors
- High Voltage Harness
- Low Voltage Harness
- Cabin Harnesses
- Health Status Annunciator (HSA)
- Fuel Injection System

The FADEC System monitors fuel and ignition conditions via a sensor set (made up of a network of sensors). The MPC Units receive information from the sensor set transmitted through the Low Voltage Harness which interfaces with the MPC Units via connectors. The Low Voltage Harness connects to the cabin harness via two, firewall-mounted bulkhead fittings or connectors.

These sensors provide input to the two microprocessor control channels in each MPC. Each control channel is assigned to control an engine cylinder. For redundancy, each control channel is capable of operating its assigned cylinder and a cylinder assigned to the second control channel within the same MPC Unit.

Each control channel monitors the current operating conditions and manages its cylinder in a manner that will yield operation within specified parameters. As operating conditions change, the control channel adjusts both the fuel mixture and ignition timing to maintain the normal operating parameters. For example, as the throttle is opened, manifold pressure increases. The sensor detects that change and the MPC Unit adds the appropriate amount of fuel.

It is important to note that the FADEC controlled engine is different from a standard engine in that an individual cylinder can be leaned or enriched by its control channel without affecting the other cylinders. There is no fuel mixture control lever in the FADEC equipped system.

Chapter 3, FADEC Description, covers more operational theory and descriptive details of the FADEC System.

FADEC SYSTEM DESCRIPTION

The FADEC System controls the ignition spark and fuel mixture of the engine. Refer to Figure 3-1. The FADEC System is a redundant system which includes the following components that will be installed on the engine or airframe:

- Two Master Power Control Units (referred to herein as “MPC 1” and “MPC 2”)
- Sensors for Manifold Pressure and Temperature
- Cylinder Head Temperature (CHT) Sensor
- Exhaust Gas Temperature (EGT) Sensors
- Speed Sensors
- Fuel Pressure Sensors
- Low Voltage Harness (Figure 3-1)
- High Voltage Harness (Figure 3-2)
- Throttle Body Assembly
- Health Status Annunciator (HSA) (installed in the cockpit)
- Fuel Injection System (Figure 3-4)

Each MPC Unit has a lower portion and an upper portion. The lower portion contains an electronic circuit board; the upper portion houses the ignition coils. The electronic circuit board contains two, independent microprocessor controllers called “control channels.”

Each control channel is assigned to a single engine cylinder. Since there are two control channels in each MPC, a single MPC Unit can operate two engine cylinders. (There are no shared electronic components between the two control channels.)

For redundancy, each control channel is capable of operating its assigned cylinder and a cylinder assigned to the second control channel within the same MPC Unit.

Each control channel monitors the current operating conditions and manages its cylinder in a manner that will yield maximum operating performance and efficiency within specified operating parameters. If operating conditions change, the control channel adjusts both the fuel mixture and ignition timing to return the cylinder to normal operating parameters.

The control channels also receive input from the pilot via the throttle control thereby eliminating manual mixture control. Primary/secondary power is supplied by the Cabin Harness through the Bulkhead Connectors. Information from the MPC Units is conveyed to the HSA and the cockpit-mounted data port through the same Cabin Harness/Bulkhead Connector Assembly.

The FADEC System continuously monitors fuel and ignition conditions. The MPC Units receive information from sensors via the Low Voltage Harness which interfaces with the MPC Units via 50-pin DIN connectors. The Low Voltage Harness connects to the Cabin Harness via firewall-mounted Bulkhead Connectors.

The status of the FADEC System is conveyed to the pilot by the HSA. Discrete lamps in the HSA will illuminate upon detection of system faults and during some normal control actions.

Sensor input to each control channel includes engine speed, crank position, fuel pressure, intake manifold air pressure, intake manifold air temperature and **Wide Open Throttle** (WOT) position. In addition, each control channel also receives exclusive signals for measuring its cylinder's head temperature and exhaust gas temperature.

The control channels in the MPC Units use the signals from the sensors to determine the required fuel mixture and ignition timing for its cylinder's next combustion event. The required fuel quantity is injected into each cylinder intake port at the appropriate time, with respect to crank position, by a solenoid style fuel injector. The injector's control coil is driven directly by the associated control channel.

All critical sensors are redundant with one sensor from each pair connected to channels in different MPC Units. Synthetic software default values are also used if both sensors of a redundant pair should fail. This arrangement supports the functional redundancy of the FADEC System.

The FADEC System is electrically powered and not self-excited. As such, the system requires two, independent power supply sources. Typically, one source will be the aircraft's primary electrical buss, referred to as Primary Power. The second source, referred to as Secondary Power, may be a second aircraft buss, an engine driven generating device, or a battery. Electrical power to the FADEC System is controlled from the cockpit by two switches used to interrupt the Primary Power and Secondary Power.

Using a conventional aircraft-style Ignition Switch, the pilot controls the enabling, starting, and disabling of the FADEC System.

The fuel system must be pressurized at start-up to suppress vapor. The mechanical engine driven Fuel Pump provides pressure for normal operation. For this reason, an Electric Boost Pump is required for starting. Once started, the engine will run at idle and low rpm without the Electric Boost Pump – however, efficiency will be reduced. The boost pump is controlled using the cockpit mounted Boost Pump Mode Switch (BPMS). The BPMS has three operating positions, **OFF**, **ON** and **AUTO**. With the BPMS in the **AUTO** position, the FADEC System can activate and deactivate the Electric Boost Pump as required. In the **ON** and **OFF** positions, the pilot has authority over the state of the Electric Boost Pump.

FADEC Ignition System

The ignition system is a waste-spark type. Each cylinder's spark plugs are fired twice per engine cycle, once on the compression stroke and again on the exhaust stroke.

The ignition spark is timed to the engine's crank position. The timing is variable depending on engine load conditions. The spark energy is also varied with respect to engine load.

NOTE: Engine ignition timing is established by the FADEC computers and cannot be adjusted.

Each of the two MPC Units of the FADEC System controls the ignition spark for two cylinders. Each MPC Unit contains a pair of high voltage coils that fire the spark plugs. MPC1 fires the top and bottom spark plugs for cylinders 1 & 2 and MPC2 fires the top & bottom spark plugs for cylinders 3 & 4. Refer to Figures 3-2 and 3-3 for diagrams of the MPC Unit high voltage circuit.

The High Voltage Ignition Leads connect directly to the MPC Unit spark towers. Each spark tower pair is connected to opposite ends of one of the MPC Unit's high voltage coil packs.

Each control channel within an MPC Unit commands one of the MPC's two coil packs. One of the two spark plugs for a given cylinder is connected to one of the MPC Unit coil packs. The other plug for the same cylinder is connected to the other coil pack within the same MPC Unit. This connection configuration is the same for the other cylinder to be controlled by the same MPC Unit.

For both spark plugs in a given cylinder to fire on the compression stroke, both control channels within an MPC Unit must fire their coil pack.

FADEC Fuel System

The FADEC System controls the fuel supplied to each cylinder using solenoid-actuated sequential port Fuel Injectors. The Fuel Injection System (Figure 3-4) is composed of:

- An engine-driven Fuel Pump
- Fuel Distribution Block and fuel lines
- Solenoid-controlled Fuel Injection Nozzles.

Changes in throttle position, engine speed, manifold pressure, and manifold temperature are observed by the FADEC System. The engine-driven Fuel Pump provides a quasi-constant fuel pressure at speeds above 1,200 rpm. Fuel pressure is constantly monitored by the MPC Units using dual redundant fuel pressure sensors that are mounted on the Fuel Distribution Block.

Fuel is metered to the cylinders under control of the MPC Units. The MPC Units monitor changes in air density and engine speed to determine how much fuel will be injected into the intake port of the cylinder. The Fuel Distribution Block distributes fuel to each of the four Fuel Injector Nozzles.

The Fuel Injector is responsible for atomizing fuel and is controlled by a solenoid. The solenoid actuates the spring loaded pintle valve by lifting the valve when current is supplied to it by the MPC Unit. The coil creates an electromagnetic field that provides the lifting force for the pintle. When the solenoid is inactive, the spring closes the pintle valve and shuts off fuel.

When the FADEC System detects the need for more fuel to be injected to a given cylinder, the solenoid holds the pintle valve open for a longer duration permitting more fuel to flow into that given cylinder.

Speed Sensor Assembly

The Speed Sensor Assembly (SSA) consists of a signal conditioner and speed sensor array. The signal conditioner filters both the power supplied to the speed sensor array and the signals from the sensors. The speed sensor array consists of four sensors that detect the speed and position of the timing gear. The SSA relays this information to the MPCs to coordinate spark and ignition events.

Low Voltage Harness

The Low Voltage Harness consists of wiring that connects all essential components. Except for the SSA and pressure sensors, all sensors are hardwired to this harness. Faults detected in sensors hardwired to the Low Voltage Harness constitute faults in the Low Voltage Harness and require repair or replacement of this harness.

High Voltage Harness

The High Voltage Harness conducts the high energy spark from the coils in the MPCs to the spark plugs.

Health Status Annunciator

The Health Status Annunciator (HSA) is a solid state annunciator panel that conveys information with regards to the FADEC System status to the pilot; HSA indications are driven directly by the FADEC control channels.

Throttle Body Assembly

The Throttle Body Assembly supplied with the FADEC kit takes the place of the carburetor and performs the air metering function for the engine. It is equipped with bosses to which the manifold air temperature and pressure sensors are installed.

Timing Gear

The timing gear (speed sensor gear) is modified to operate in conjunction with the cam shaft to control speed and timing. A series of holes drilled through the speed sensor gear web form a circular track of “targets”. When the cam rotates, the detectors sense the “targets” (drilled holes) as they pass by. The targets are arranged in an outer and inner “track” with the outer track having 16 targets and the inner track having one.

Aircraft Installation Requirements

Detailed interface limitations and requirements for the FADEC System are provided in Appendix A of this manual.