G650
POWERPLANT

[Diagram of G650 powerplant system]

- Pitot Static SAT Airspeed
- ADM
- Throttle Resolver
- Electronic Engine Control
- Channel A
- Channel B
- FMU
- Fuel
- BR7100-725A1-12
- Dedicated Generator
- Permanent Magnet Alternator (PMA)
- Right Engine = ESS DC

** Note: Diagram details and connections are not fully transcribed due to the nature of the graphic representation.
Two (2) Rolls-Royce BR710-725A1-12
16,900 lbs thrust @ Sea Level @ ISA + 15°C
High bypass engines 4.18:1

FADEC-controlled
Engine Pressure Ratio (EPR) $EPR = \frac{\text{output}}{\text{input}}$

Titanium inlet cowling

Critical engine: Left engine
AFM - Performance, Section 5.01.10

HP and LP compressor sections are driven by their own coaxial shafts (shaft within a shaft)

High thrust-to-weight ratio $\Rightarrow$ fuel efficiency, noise reduction
FADEC SYSTEM

Full Authority Digital Engine Control (FADEC)

The sum of various systems

CONTROLS AND RespondS TO EPR REQUIREMENTS

DATA Entry Plug (DEP)

EEC

PMA

Pitot Static

SAT

Airspeed

ADM

Throttle Resolver

Electronic Engine Control

Channel A

Channel B

FMU

Fuel

>35% HP

<35% HP

L ESS DC

BR700-725A1-12

Dedicated Generator

* PERMANENT MAGNET ALTERNATOR (PMA)

** Right Engine = R ESS DC
FADEC SYSTEM

Each FADEC is powered by:

1. Initially by respective L ESS DC or R ESS DC bus
2. > 35% HP RPM by its own generator PMA

Each engine

controlled by

FADEC

The heart of FADEC

EEC

Powered by

< 35% HP
L ESS DC or R ESS DC

> 35% HP
PMA

channel A

channel B

* One active/controlling one back up

FMU

* Fuel control switch: changes channels
FADEC SYSTEM

- FADEC automatically performs a rotor bow avoidance procedure during start if engine has been shutdown

> 20 minutes < 5 hours

ENGINE START PROTECT

- FADEC provides engine start protection:
  1. On the ground only
  2. Switch only

- If a FADEC were to fail the engine would flame out

- Controls idle speed (Flight Idle x Approach Idle)

FL510 → Flight Idle (Flaps < 22°)

Approach Idle (Flaps > 22°)

FAF

Allows full spool up within 8 seconds

Ground idle

Landing remains high idle after wow + 5 seconds
ELECTRONIC ENGINE CONTROL

A COMPONENT OF THE FADEC SYSTEM AND ITS BRAIN
Electronic Engine Control

EEC Modes
- Primary Control Mode
  - EPR
    - HP RPM (@ idle)
- Alternate Control Mode
  - LP RPM
- Reverse Thrust Control Mode
  - LP RPM

- Independent Overspeed Protection (IOP)

- Both IOP Channels must agree for EEC to command FMU to shut off fuel to the engine
ENGINE IGNITION

- Two (2) ignition plugs (3,000V each) per engine
- Normal ground start uses one (1) igniter
- In-flight start uses two (2) igniters
- Manual ignition uses two (2) igniters

- Igniters are turned off automatically during an engine start at 42% HP RPM

- The EEC alternates channels and igniters as follows:

  1. EEC Channel A / Igniter 1
  2. EEC Channel B / Igniter 1
  3. EEC Channel A / Igniter 2
  4. EEC Channel B / Igniter 2

- When a normal ground start is aborted due to anomalies FADEC automatically selects the other igniter

- No time limit on the use of continuous ignition
ENGINE IGNITION

Ignition Modes

1. **Auto Start**
   - One igniter only
   - EEC: Alternates Channels
   - Fuel Control Switch: Changes igniter plugs

2. **Alternate Start**
   - Crank Master
   - Select Start
   - Manually select
   - L ENG R ENG

3. **Incremental Weather Mode**
   - T30 Probe senses moisture

4. **Auto-Relight Mode**
   - HP, LP or TGT Abnormality

5. **Quick-Restart Mode**
   - Inadvertent engine shutdown in flight
   - Return fuel control to run within 30 seconds
Engine Fuel System

Metered fuel from tanks, boost pumps to fuel spray nozzles. Introduction of fuel is controlled by FADEC.

Low (LP) Pressure Pump driven by Engine's Accessory Gearbox.

FCOC extracts heat from HOT oil.

LP Pump can suction feed the engine < 20,000'.
Engine Fuel System

- Fuel Control Switches shut off fuel at the pylon
- Fire Handles shut off fuel at the fuel tanks

- Fire Handles valve position indicator:

- Wheelwell (Aft Wall)

- Crossflow Valve
- Inter Tank Valve
**Engine Oil System**

Total capacity: 21 pints
One (1) pressure pump
Four (4) scavenging pumps
Max consumption allowed: 0.42 pints/hour
Normal consumption is 0.1 pints/hour

**Diagram:**
- Oil Tank
- Oil Pump
- Oil Filter
- FCOC (Fuel Cooled Oil Cooler)
- Accessory Gearbox
- Front Bearing Chamber
- Rear Bearing Chamber
- (1) Pressure (4) Scavenging Pumps

**Additional Notes:**
- Engine oil servicing
- Conventional gravity
- Pressure filling
- Remote replenishment system
Engine Limitations

Engine Oil Temperature
-40°C Start
+20°C Taxi/Takeoff
+160°C Maximum

Engine Fuel Temperature
-40°C
+140°C
+165°C (15 Minutes)

Engine Start Cycles
3 Minutes / 15 Seconds
3 Minutes / 15 Seconds
3 Minutes / 15 Minutes

Cycle COoling PERIOD

Engine TGT Temperature
150°C Introduce Fuel
700°C Start (Ground)
850°C Start (Inflight)
900°C Takeoff (5 Minutes)
885°C MCT

Engine Oil Check
5 Minutes to 24 Hours from Shutdown
Engine Limitations - Start

- Minimum Oil Temperature: -40°C
- Minimum Bleed Air Pressure: 40 PSI
- Maximum TGT < Fuel: +150°C
- Maximum TGT: +700°C

Engine Start Cycle:
- 3 minutes/15 sec
- 3 minutes/15 sec
- 3 minutes/15 minutes

Engine Limitations - Static Ground Run

> Idle RPM

Max Crosswind:
- 30 KTS
- 25 KTS

Max Tailwind:
- 20 KTS
- 20 KTS
Exhaust Danger Area

Idle Thrust

Takeoff Thrust

275'

750'
Engine Limitations - Takeoff

Takeoff in ALT mode (LP) is prohibited

Minimum Oil Temperature for Takeoff: +20°C

Maximum TGT 900°C

5 minutes \(\rightarrow TO/EA\) \(\rightarrow\) 10 minutes

\[OEI > V_1\]
**Engine Limitations - Inflight**

**Maximum Continuous Thrust (MCT)**

885°C TGT

**Start Envelope**

\[ \leq 30,000' \]

- Starter Assist
- Windmill Start

\[ \leq 250 \text{ KCAS} \quad \geq 251 \text{ KCAS} \]

**Maximum TGT**

850°C

**Note:** No FADEC Protection

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**Engine Limitations - Landing**

**Thrust Reversers**

78.1% LP - 30 seconds

Idle reverse by 60 KCAS

**Note:** It is recommended to operate engines at idle for 3 minutes before shutdown

Static = 30% LP Maximum
DO NOT ATTEMPT RESTART IF:
- Fire
- FOD
- Frozen

RESTART OR NOT?

YES:
- Airstart - Automatic ✓ List ✗ ✗
- Airstart - Windmilling ✓ List ✗ ✗
  ✗ No FADEC Available during Start
  ✗ Icing Conditions

NO: - Engine shutdown in flight ✓ List

ENGINE FAILURE:

1. Open Crossflow Valve

2. Re-arm E-Batts

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X-flow
Open

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Questions, comments or errors?
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Thank you!