G650 POWERPLANT

THROTTLE RESOLVER

Air Data System (ADS)

Electronic Engine Controller (EEC)
Channel A, Channel B

Modular Avionics Units (MAU)

Fuel Metering Unit (FMU)

Low Pressure Shutoff Valve (LP Sov)

ESS DC BUS

>35% Permanent Magnet Alternator (PMA)

<35%

Fuel Spray Nozzles (SN)

Diagram showing the flow of power and control systems in a G650 powerplant.
Two (2) Rolls-Royce BR700-725A1-12

BR700 - 725 A 1 - 12

- 16,900 lbs of Thrust @ ISA + 15°C
- High bypass Turbopfan - 4.18:1

- FADEC - Controlled
- Engine Pressure Ratio (EPR) \( EPR = \frac{\text{output}}{\text{input}} \)
- Titanium inlet cowling
- High Thrust-to-Weight Ratio \( \rightarrow \) Fuel Efficiency
- High Thrust-to-Weight Ratio \( \rightarrow \) Noise Reduction
- Left engine is designated as the critical engine
  (AFM - Performance, Section 5.01.10)
• HP and LP compressor sections are driven by their own coaxial shafts (shaft within a shaft)

- Twin-spool

  • Low pressure rotor
    
    Single-stage fan driven by three (3) stage turbine

  ![Diagram of low pressure rotor]

  ![Diagram of HP compressor and HP turbine]

• High pressure rotor

  Ten (10) stage compressor driven by a two (2) stage turbine

  ![Diagram of HP compressor and HP turbine]
- **Accessory Gear Box (AGB)**

Uses power extracted from the HP compressor shaft to drive the following **accessories**:

- Integrated Drive Generator (IDG)
- **Fuel** metering unit (FMU)
- **Fuel** pump
- Oil pump and breather
- Permanent Magnet Alternator (PMA)
- Hydraulic pump
- **Full Authority Digital Electronic Control (FADEC):**
  Mounted on outside, upper portion of the engine.
  Consists of three (3) major components:

  ![Diagram of FADEC components: EEC, DEP, PHA]

- FADEC provides engine start protection:
  1. **On the Ground only**
  2. **ON switch only**

- Controls and responds to EPR requirements

- The FADEC provides:
  - Engine protection
  - Improved handling
  - Better fuel efficiency
  - Prolonged engine life
- FADEC automatically performs a rotor bow (uneven heating of the engine's core) avoidance procedure during start if engine has been shutdown within:

  > 20 minutes < 5 hours

  The crew is notified via the following CAS message:

  ! Engine START PROTECT

- If FADEC were to fail the engine would flame out.
Electronic Engine Controller (EEC)

- **Brains of the FADEC**
- **Dual channels** - one active and one standby
- **Fuel control switch:** changes channels
- **ECC controls engine idle speed**

  Idle Speed Control is based on EPR with thrust levers at idle. There are **three (3) modes:**

  1. **Flight Idle**
  2. **Approach Idle**
  3. **Ground Idle**
1. **Flight Idle:**
   - Flaps < 22°

2. **Approach Idle:**
   - Flaps > 22°
   - WOW - Air
   - Wheel speed < 53 knots

3. **Ground Idle:**
   - Aircraft WOW (Ground)
   - Touchdown + five (5) seconds
   - Delay allows for full and rapid spool up
Primary control mode
Alternate control mode
Reverse thrust control mode

Primary control mode
Alternate control mode
Reverse thrust control mode

• Independent Overspeed Protection (IOP)

* Both EEC channels must agree for EEC to command FMU to shut off fuel to the engine
The DEP contains engine trim data. This trim data is utilized by the EEC to make all engines produce the same thrust.
Permanent Magnet Alternator (PMA)

Primary source of EEC power once the engine accelerates > 35% HP RPM

FADEC

Electronic Engine Controller (EEC)

Data Entry Plug (DEP)

Permanent Magnet Alternator (PMA)

HP RPM

>35%  <35%  <35%  >35%

Permanent Magnet Alternator (PMA)  ESS DC BUS  ESS DC BUS  Permanent Magnet Alternator (PMA)
Engine Ignition System

- Dual channel Ignition Exciter (A and B) on each engine
- Controlled by dual channel EEC and powered by 28 VDC
- Generates high voltage pulse transmitted through ignition leads to ignition plugs in combustor

- **Ground starts** → One (1) igniter
- **Airstarts** → Two (2) igniters (high sparking rate)
- Manual ignition → Two (2) igniters
- Igniters are turned off automatically at 92% RPM HP during engine start
- EECs alternate 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

  ![L-R Autostart Abort]

- There is no time limit on the use of continuous ignition
  ![Cont Ign]
  ON
- Ignition modes:

1. Auto Start
2. Alternate Start
3. Inclement Weather Mode
4. Auto-Relight Mode
5. Quick Restart Mode

1. Auto Start

   - Start Master: On
   - Select Start: On
   - L Eng: On
   - R Eng: On

   - One (1) igniter only
   - EEC alternates channels
   - Fuel control switches change igniter plugs
② **ALTERNATE START**
- Select START
- Two (2) igniters
- No FADEC protection

③ **Inclément weather mode**
- T3O 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 tank's boost pumps to fuel nozzles
- Introduction of fuel is controlled by FADEC
- Low (LP) and High (HP) pressure pumps are driven by engines' accessory gearbox
- Exports heat from hot engine oil
- LP pump can suction feed the engine ≤ 20,000'
- Each engine has its own **Fire Handle**

- Pulling a **Fire Handle** shuts off fuel at the tank
Engine Oil System

Engine oil tank: **16.8 U.S quarts / 15.9 liters**

One (1) pressure pump

Four (4) scavenge pumps
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**) (Darker blue)

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**Engine Start Cycles**

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Cooling Period</th>
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<tbody>
<tr>
<td>3 minutes / 15 seconds</td>
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<td>3 minutes / 15 seconds</td>
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<tr>
<td>3 minutes / 15 minutes</td>
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**Engine TGT Temperature**

- 150°C **Introduce Fuel**
- 700°C **Start - Ground**
- 850°C **Start - Inflight**
- 900°C **Takeoff (5 minutes)**
- 900°C **OEI (10 minutes)**
- 885°C **Max Continuous**

**Engine Oil Level Check**
- 5 minutes to 24 hours from engine shutdown
Engine Limitations - Start

Minimum Oil Temperature: -40°C

Minimum Bleed Air: 40 psi

Maximum TGT Fuel: 150°C

Maximum TGT: 700°C

Engine Start Cycles: 3 minutes / 15 seconds

Engine Limitations - Static Ground Run

> Idle RPM

Max Crosswind: 30 knots

Max Tailwind: 20 knots

Max Crosswind: 25 knots

Max Tailwind: 20 knots
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 \(\xrightarrow{\text{TO/GA}}\) 10 Minutes

OEI > V₁
Engine Limitations - Inflight

Maximum Continuous Thrust (MCT) 885°C TGT
Start envelope
≤ 30,000'
Starter assist Windmilling
≤ 250 KCAS ≥ 251 KCAS
Maximum TGT 850°C
Note: No FADEC protection

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:
- FIRE
- FOD
- FROZEN

RESTART - YES OR NO?

YES:
- AIRSTART - AUTOMATIC ✓- list
- AIRSTART - windmilling ✓- list

* No FADEC PROTECTION during START
* icing conditions

NO: - Engine Shutdown in Flight ✓- list
Questions, comments or errors...please send me an email: ivan@code7700.com

Thank you!