G650 Electrical System
- The Electrical Power System produces:

- 115 volts AC is generated in order to produce 28 volts DC via Transformer Rectifier Units (TRU)

- AC
  - Motors
  - Heaters
  - Chargers

- DC
  - Control functions or steady-state operations

- Two (2) separate systems/networks

L
- AC
- DC

R
- AC
- DC
- A split bus system prevents a short on one side from affecting the other side.

- Operational side can power the inoperative side.
- **Primary Power Distribution Boxes (PDBs)**

AC and DC power contactors and buses are located in PDBs.

On the PDBs there are circuit breakers (CB) to protect the individual buses.

From the PDBs power is distributed to the **Secondary Power Distribution System (SPDS)**.
- **Secondary Power Distribution System (SPDS)**

  The purpose of the SPDS is to take \textcolor{blue}{115 VAC} and \textcolor{red}{28 VDC} power from the primary power system and distribute it to the various aircraft loads.

  SPDS is comprised of:

  1. **Remote Interface Units (RIU):**
     - Brains of the SPDS
     - Dual channels
     - Perform system control functions and interface with other aircraft systems

  2. **Modular Power Tiles (MPT):**
     - MPTs perform power routing and circuit protection functions using AC and DC
     - Solid State Power Controllers (SSPC)
     - Four \textcolor{blue}{115 VAC} and four \textcolor{red}{28 VDC}
Electromechanical Circuit Breakers

Solid State Power Controllers (SSPC) (Virtual CBs)
- The Electrical Power System is controlled by two (2) Bus Power Control Units (BPCU)

- There are six (6) microprocessors:

- There are two (2) 60 Hz converters located in the tail compartment

- One (1) 60 Hz converter active and the other on standby

- = common household power
The AC system is generated by:

NORMAL

L IDG → APU GEN → EXT AC → R IDG

L MAIN AC → EMERGENCY AC BUS → R MAIN AC

EMERGENCY

RAT GEN

RAT
DC System

28 VDC is produced by:

Normal

Ess TRU

Main TRU

Aux TRU

Main TRU

Ess TRU

L

Main DC

L

Ess DC

R

Main DC

Ess DC

L

Main Batt

R

Main Batt

EBHA Battery

UPS Battery

Emergency
The Electrical Power System is controlled by two (2) identical and interchangeable microprocessors called BPCUs:

- The L\text{ BPCU} \hspace{5mm} \text{R BPCU} = \text{ The brains}

- They control and make all logical decisions for electrical distribution and protection.

- Traffic cops - Protectors of the buses

- Close and open contactors and/or relays to:
  - Efficiently supply power to the buses
  - Protect and isolate the electrical system from faults

- Output critical findings to the CAS

- Provides protection, power and logic to reset switch

- Monitor external AC \hspace{1mm} DC power

- Control the No Break Power Transfer (NBPT)
- Fault detection, protection and notification:

1. Fault detected by L BPCU
   - Bus contactor opened and locked out to protect the bus

2. L BPCU → Notifies the crew via CAS message
   - LAC Power Fail
   - LAC Reset

3. Can be reset by the crew via the switch if the fault is no longer present
   - AC
   - Control + Alt + Del

RESET
- BPCU logic: ESS before MAIN / L before R

- Located in:
  - **L BPCU**  \text{Left Electronic Equipment Rack (LEER)}
  - **R BPCU**  \text{Right Electronic Equipment Rack (REER)}
- Control the bus tie relays which allow operative side to power the inoperative side in the event of a short/fault on one side.

- Control and monitor:

  ![Diagram with L BPCU and R BPCU connected to external power sources]
- **No Break Power Transfer (NBPT)**

  - Controlled by BPCU
  - Power Transfer without a momentary interruption
  - Uses the **GCU** speed control to synchronize the frequency and phase of the IDGs to the previous or next AC source
  - **IDG available and no failure**
    - Two (2) sources connected at the same time
    - New source is connected first before previous source is disconnected
    - To and from an **IDG only** since its GCU has speed control
• Break Power Transfer (BPT)

**An IDG failure**

**An engine failure**

**A fire handle pulled**
AN IDG NOT AVAILABLE
- Two (2) Engine-driven IDGs

- Located on the engine's accessory gearbox

- IDG < CONSTANT SPEED DRIVE (CSD)
  - Oil-cooled generator (oil is cooled by fan air)

- IDG < Rated at 40 kVA
  - Produces: 115 VAC, 400 Hertz, 3-phase

- CSD converts variable engine speed to constant speed at the generator (12,000 RPM)
Dispatch with an IDG u/s not permitted due to AFM 015 G650ER-2016-03 APU SEALANT

Generator switches:

L GEN

ON

L IDG

L MAIN AC

Pressed in and
IDGs power respective AC bus

R GEN

ON

R IDG

R MAIN AC

L GEN

OFF

Pushed out and unpowered

L GENERATOR OFF

R GEN

OFF

Pressed in and failed/isolated from respective AC bus

R AC POWER FAIL
**Auxiliary Power Unit (APU) Generator**

- The APU provides an auxiliary source of:
  1. Electrical AC power - Ground
  2. Backup Electrical AC power - Air

- The APU can be started with L MAIN BATT and R MAIN BATT power.

- When the APU reaches 99% RPM + two (2) seconds, the APU generator comes online and can power all AC and DC buses.

- APU GEN is rated at 40 kVA and produces 115 VAC, 400 Hertz, 3-phase.

- Refer to AFM OIS G650ER-2016-03 APU Sealant for APU inflight operation limitations.
RAM Air Turbine (RAT)

- Backup AC Generator

![Diagram of Electrical Power Control and RAT Turbine]
- The RAT, once deployed by the crew, converts airstream energy to electrical energy.

- RAT GEN must be switched OFF prior to deploying the RAT. Then, wait **30** seconds for RAT to stabilize prior to switching its GEN on.

```
RAT GEN
OFF
```

```
Twist & Pull
```

```
RAT GEN
```

```
RAT GEN
```

```
Rated at **15 kVA**
```

```
Produces: 115 VAC
```

```
400 Hertz
```

```
3-phase
```

```
RAT GENERATOR ON
```
- Operating envelope:
  - \( \geq 180 \text{ kts} \) \( \leq 0.925 \) (Mmo)
  - Sea level \( \rightarrow \) FL510

- \( < 180 \text{ kts} \) the \textit{RAT GEN} drops offline and the power the \textit{ESS DC} buses

- Rotates counter clockwise

- Six (6) percent fuel penalty

- RAT \textit{TEST} = maintenance function only

- Once deployed the RAT can't be stowed in flight

- Land with flaps 20° (as per the QRH) so that in the event of a go-around the \textit{AUX} \textit{BATT} are not used to power the pump to retract the flaps from 39° to 20° (save the batteries)
No vertical speed or altitude hold modes

Only FPA available
GENERATOR CONTROL UNITS (GCU)

- GCUs are microprocessors that control generator output (quality assurance) and provide fault protection.

- There are 4 GCUs:
  
  - Identical
    - Independent
    - Interchangeable
  
  - Non-interchangeable

- GCUs are located in the LEER and REER.
- If GEN
  - Voltage
  - Frequency
  - Amperage

  \[ \Rightarrow \]

  Outside Parameters =

  - Takes GEN offline
  - Notifies L BPCU

  \[ \Rightarrow \]

  - L BPCU

  \[ \text{Notifies crew via CAS:} \]
  - L AC Power Fail
  - L Generator Fail

---

- Takes GEN offline
  - Notifies R BPCU

  \[ \Rightarrow \]

  - R BPCU

  \[ \text{Notifies crew via CAS:} \]
  - R AC Power Fail
  - R Generator Fail

---

- GCU
  - Can be reset by cycling the OFF switch
EXTERNAL AC/DC POWER

- **EXTERNAL AC power**
  - Receptacle is located on the right side of the fuselage
  - 40 kVA, 115 VAC, 400 Hz, 3 phase
  - Can power all AC buses and through the TRUs all DC buses are powered
  - BPCU checks quality of power before allowing onto aircraft

- **EXTERNAL DC power**
  - Receptacle is located on the right side of the fuselage
  - Powers all DC buses
  - Can be used to power the GSB
  - Use of external DC power to start the APU is prohibited
A Static Inverter converts DC to AC power in order to power Channel 1 of the Cabin Pressure Controller (CPC).
- In the unlikely event that normal (IDG) or back up AC power (APU GEN) is not available the RAT GEN can continue to power CPC 1.

- The STATIC INVERTER is located in the REER.

- RAT GEN
- APU GEN
- IDG

- L IDG
- APU GEN
- R IDG

- L ESS DC
- STATIC INVERTER

- TROV MOTOR 1

- 28VDC
- 115VAC

- EMERGENCY

- RAT
TRANSFORMER RECTIFIER UNITS (TRU)

- TRUs are powered by the buses
- A TRU converts 115 VAC to 28 VDC

- TRUs are located underneath the floor
- L ESS TRU L MAIN TRU R MAIN TRU R ESS TRU power their own buses

- AUX TRU powers the \( L_{\text{AUX DC}} \) \( R_{\text{AUX DC}} \) buses and will take over the duties of a failed \( \times \text{ESS or } \times \text{MAIN TRU} \) using the following priority process:

1. sheds \( L_{\text{AUX DC}} \) \( R_{\text{AUX DC}} \) buses
2. \( L_{\text{ESS DC}} \)
3. \( R_{\text{ESS DC}} \)
4. \( L_{\text{MAIN DC}} \)
5. \( R_{\text{MAIN DC}} \)
TRUs are rated at 250 amps. Ground ops - TRU load limits:

- 80% for L ESS TRU, L MAIN TRU, R MAIN TRU, and R ESS TRU
- 40% for AUX TRU
Ground Service Bus

- When you don't want to wake up the beast

- Ground Operations (APU shutdown)
  
  - Refueling
  - Engine oil
  - Potable water servicing
  - Hydraulic fluid servicing
  - Wheelwell lights

- Four (4) GSB switches
  
  - Security/Ground Service Panel
  - REER Maintenance Panel
  - Tail compartment
  - Fuel panel

- Power Sources (Priority)
- Rotating beacon light is powered by the **GSB** when the **Main Batt** is the source of power.

- At least one of the following must be open when using one of the **GSB** switches:

  **Fuel Panel (other side)**

  **Security/Ground Service Panel**

  **Main Entrance Door**

**Electrical Power Control**

- **L Bus Tie**
- **R Bus Tie**
- **Reset**
- **L GEN**
- **APU GEN**
- **Ext Pwr**
- **R GEN**
- **ON**
- **GND SYC BUS**
- **Main Batteries**
  - **Left**
  - **Right**
MAIN BATTERIES

- Two (2) Main Batteries:
  
  ![L Main Batt] ![R Main Batt]

  - Located in the Tail compartment
  - Nicad, 21 cells, 95 pounds
  - 28 VDC, 53 amp/hour
  
  - Purpose:

  1. Start the APU - uses only but both switches must be selected on

     **NOTE:** Minimum 22 volts on both batteries to start the APU

  2. Operate aux hyd pump -

  3. Power ESS DC buses - (if no other source of power)

Main Batteries

ON ON

LEFT RIGHT 

Switchlights illuminate
(Discharging)
• 16 minutes with two (2) APU start attempts

• Must be removed from aircraft in cold soaked conditions (≤ -20°C) and stored in a location warmer > -20°C and cooler than +40°C

• If ≤ 22 volts but not less than 7 volts the batteries can be recharged as follows:
  - Ext AC power connected
  - Batt switches **ON** **ON**

  ![Diagram](image)

  - The **L MAIN BATT** and **R MAIN BATT** are normally recharged by the **MAIN AC** buses
Flight Control Batteries

There are two (2) Flight Control System (FCS) batteries:

1. Electrical Backup Hydraulic Actuator (EBHA) battery

2. Uninterruptible Power Supply (UPS) battery

The FCS batteries can power the flight controls for thirty (30) minutes.

- Illuminated ON ON if no AC power is being produced and they power their own buses (discharging)
- System Power ON Self Test (SPOST)

- Selected ON first then selected ON
- Forty five (45) second test
- No electrical interruptions during SPOST or a complete power down is required

- FCS Batteries - Charger/Transformer Rectifier

* Dual function: Charger and TR
- **Electrical Backup Hydraulic Actuator**

- Nicad, **28 Volts**, **53 Amp/hour**
- Located in the tail compartment

- Powers seven (7) **EBHA Actuators**

- Can be charged by **RAT GEN** via the **RAT**

- Must be removed from aircraft in cold soaked conditions ($\leq -20^\circ C$) and stored in a location warmer $> -20^\circ C$ and cooler than $+40^\circ C$
Uninterruptible Power Supply (UPS)

- Lead acid, 24 volts, 10.5 amp/hour
- Located in the REER

- Powers flight control computers channels 1A and 2B

- Can be charged by RAT GEN via the emergency AC BUS
Emergency Batteries

- There are two (2) E-BATs
  - A Forward and an Aft E-Batt

- Located in:
  - LEER
  - FWD E-Batt
  - Aft E-Batt

- Sealed, lead acid with its own internal charger
- 24 Volts, 10.5 amp/hour
- Forty Five (45) minutes duration, approximately
• Power the following buses:

  - **Fwd E-Batt**
  - **Aft E-Batt**
  - **L Emergency**
  - **R Emergency**
  - **Flight Instrument**

• When "Armed" the E-batts come ON automatically when power to the **L ESS DC** and/or **R ESS DC** drops below 20 volts, even momentarily.

• After a break power transfer the E-batts will come on.

• Break: **No IDG** and/or **Failure**

• Ext AC ↔ APU GEN

• Engine Failure

• GEN IDG or R IDG Failure

• A Fire Handle pulled
• E-BATTs power the following equipment:

- Emergency Lighting
- Exterior Emergency Lights
- Standby Flight Displays (2)
- Inertial Reference Units (3)
- Three (3) Audio Control Panels (ACPs)
- MCDU 1 - STby Engine INSTRUMENTS
- MCDU 3 - Backup Radios (VHF1/NAV1)
- Two (2) clocks

• An integrated charger/transformer rectifier recharges the E-BATTs
① Both IDGs

② One IDG only
③ APU GEN only

④ RAT GEN only
The **E-Batt** can be used in an emergency to open the electric main entrance door (EMED) via three (3) switches: two (2) external and one (1) internal.

**External Switches:**

- Security/Ground Service Panel
- Main Entrance Door Emergency Switch

The EMED is opened via either one of these on the first flight of the day to confirm that the **E-Batt** has sufficient battery charge.

**Internal Switch:**

- Vestibule Switch
ELECTRICAL POWER CONTROL

L Bus Tie

L GEN ON

APU GEN

EXT PWR ON

R Bus Tie

R GEN

GND SRC BUS

RESET

Main Batteries

Two (2) Green

Two (2) Blue

Six (6) Black

Five (5) switchlights Pressed IN

Four (4) switchlights Pushed OUT
Normal - Emergency

Normal
\[
\begin{align*}
&\text{L IDG and R IDG} \\
&\text{or}
\end{align*}
\]
\[\text{All AC/DC buses}\]

APU GEN

RAT GEN
\[\geq 180\text{ KTS}\]

Emergency AC Bus
\[
\begin{align*}
&\text{TR/CHRG} \\
&\text{UPS BUS} \\
&\text{EBHA BUS}
\end{align*}
\]

\[
\begin{align*}
&\text{L ESS TRU} \\
&\text{L ESS DC} \\
&\text{R ESS TRU} \\
&\text{R ESS DC}
\end{align*}
\]

L MAIN BATT R MAIN BATT
\[
\begin{align*}
&\text{(2 APU START ATTEMPTS)}
\end{align*}
\]

EBHA BATT UPS BATT

00:16 MINUTES

(< 180 KTS)
00:30 MINUTES

FWD E-BATT AFT E-BATT
\[\text{(ESS DC buses < 20 Volts)}\]

Standby Flight Instruments
IRUs
Comm Radio
Emer. lights
00:45 MINUTES (approximately)
Questions, comments or errors...please send me an email: ivan@code7700.com

Thank you!