- **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**
  - Everything else

- **Two (2) separate systems/networks**

- A split bus system prevents a short on one side from affecting the other side
Operative side can power the inoperative side.

Power Distribution Buses (PDBs):

AC power is first sent to the PDBs which is where the Main AC buses are located.
- The Electrical Power System is controlled by two (2) Bus Power Control Units (BPCU)

- There are six (6) computers:

- 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
115 VAC is generated by:

NORMAL

L IDG  APU GEN  EXT AC  R IDG

OPEN BUS TIE RELAY

L MAIN AC  R MAIN AC

EMERGENCY AC BUS

RAT GEN

RAT
- DC System

28 VDC is produced by:

NORMAL

L ESS TRU ➔ L MAIN TRU ➔ AUX TRU ➔ R MAIN TRU ➔ R ESS TRU

L MAIN DC ➔ L AUX DC ➔ R AUX DC ➔ EXT DC ➔ R MAIN DC ➔ GSB

L ESS DC ➔ L MAIN BATT ➔ EBHA BATT ➔ UPS BATT ➔ R MAIN BATT ➔ R ESS DC

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

- The \( \text{L BPCU R BPCU} \) 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 \( \text{AC DC} \) switch
- Monitor external \( \text{AC DC} \) 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**

   **RESET**

   **AC** = **CTRL** + **ALT** + **DEL**
- BPCU logic: \[ \text{ESS before MAIN} / \text{L before R} \]

- Located in:

  - **Left Electronic Equipment Rack (LEER)**
  - **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:

  - **L BPCU**: NBPT function
    - External 115 VAC Power
  - **R BPCU**: External 28 VDC Power
- **No Break Power Transfer (NBPT)**

  - Controlled by [L BPCU]
  - Power transfer without a momentary interruption
  - Matches the phases of the IDGs and/or APU GEN

- **No Break**
  - IDG
  - No failure

- **Break**
  - No IDG
  - And/or failure

- **Failure**
  - Eng
  - A Fire
  - Handle pulled

- EXT AC ↔ APU GEN

- GEN
  - R IDG Failure
  - Failure
INTEGRATED DRIVE GENERATORS (IDG)

- Two (2) Engine-driven IDGs

- Located on the engine's accessory gearbox

- IDG \( \leftarrow \) Constant Speed Drive (CSD)
  
  - Oil-cooled generator (oil is cooled by fan air)

- IDG \( \leftarrow \) 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       |     | R GEN ON       |
+----------------+     +----------------+
     | L IDG          |     | R IDG          |
+----------------+     +----------------+
   | L MAIN AC      |     | R MAIN AC      |
+----------------+     +----------------+
    | Pressed in     |     | Pressed in     |
|      and        |     |      and       |
|      IDGs power |     |      failed/isolated |
|      respective|     |      from       |
|      AC bus    |     |      respective|
|                |     |      AC bus    |
+----------------+     +----------------+

L GEN OFF

Pushed out and unpowered

L Generator off

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 rated at 40 kVA 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 system]

- L-6 AC Power Fail
- L-9 AC Power Fault
- APU Power Fail
- RAT Generator On
- 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 Rated at 15 kVA, produces: 115 VAC, 400 Hertz, 3-phase.
**Operating Envelope:**

- **≥ 180 kts** — **≤ M0.925** (Mmo)
- Sea Level → FL510

- **< 180 kts** the **RAT GEN** drops offline and the power the **buses**

- Rotates counter clockwise

- Six (6) percent fuel penalty

- RAT TEST = maintenance function only

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

- Guidance Panel: no vertical modes (ADS 4)

- Land with flaps **20°** (as per the QRH) so that in the event of a go-around the **AUX** are not used to power the **pump** to retract the flaps from **39°** to **20°** (save the batteries)
GENERATOR CONTROL UNITS (GCU)

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

- There are (4) GCUs:

  - IDG
  - APU GEN
  - IDG
  - RAT GEN

  - IDENTICAL
  - INDEPENDENT
  - INTERCHANGEABLE
  - NON-INTERCHANGEABLE

- GCUs are located in the LEER and REER.
- If GEN parameters are outside limits:
  - GCU takes GEN offline
  - GCU notifies BPCU
  - BPCU notifies CREW via CAS:
    - L AC Power FAIL
    - L Generator FAIL
  - GCU can be reset by cycling associated generator switch
EXTERNAL AC/DC Power

- External AC power
  - Receptacle is located on the right side of the fuselage
  - 30 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.

- The Static Inverter is located in the REER.
- TRUs are powered by the main AC buses.
- A TRU converts 115 VAC to 28 VDC.
- TRUs are located underneath the floor.
- LTRU, LTRU, RTRU, RTRU power their own buses.

- AUX TRU powers the L AUX DC, R AUX DC buses and will take over the duties of a failed ESS or MAIN TRU using the following priority process:

ESS before MAIN

L before R

1. Sheds L AUX DC, R AUX DC buses
2. L ESS DC
3. R ESS DC
4. L MAIN DC
5. R MAIN DC
TRU switches allow opposite bus to power a TRU that lost power due to the failure of its own AC.

TRUs are rated at 250 amps.

GROUND ops - TRU load limits:

- 80%
  - L ESS TRU
  - L MAIN TRU
  - R MAIN TRU
  - R ESS TRU

- 40%
  - 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

- Three (3) GSB switches
  - Security/Ground Service Panel
  - REER Maintenance Panel
  - Tail Compartment

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

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

![Diagram of an airplane showing the main entrance door, security/ground service panel, and tail compartment.](image-url)

**ELECTRICAL POWER CONTROL**

![Diagram of electrical power control system showing bus ties, generator sources, and main batteries.](image-url)
Two (2) Main Batteries:

- 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 \( \leq -20^\circ C \) and stored in a location warmer \( > -20^\circ C \) and cooler than \( +40^\circ C \)

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

• The L MAIN Batt 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**
   
   ![EBHA Battery Diagram]

2. **Uninterruptible Power Supply (UPS) battery**
   
   ![UPS Battery Diagram]

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

- Illuminated **ON** if no AC power is being produced and they power their own buses (discharging)

![Diagram of EBHA and UPS Batteries with buses]
- **System Power ON Self Test (SPOST)**

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

- **FCS Batteries - Charger/Transformer Rectifier**

  ![Diagram](image)
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:

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

- **L Emergency**
- **R Emergency**
- **Flight Instrument**
- **FWD E-BATT**
- **AFT E-BATT**

• 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 and must be re-armed to avoid depletion.

- **BREAK**
  - No IDG
  - AND/OR
  - Failure

- **EXT AC ↔ APU GEN**
- **GEN IDG or R IDG Failure**
- **ENGINE 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**
• 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
**NORMAL - EMERGENCY**

**NORMAL**

- L IDG and R IDG → All AC/DC buses
- L IDG or R IDG → All AC/DC buses

**APU GEN**

**RAT GEN**

\( \geq 180 \text{ KTS} \)

**Emergy AC Bus**

- L LESS TRU
- L LESS DC
- R LESS TRU
- R LESS DC

**TR/CHRG**

- UPS BUS
- EBHA BUS

**L MAIN BATT** and **R MAIN BATT**

\( \geq 2 \text{ APU START ATTEMPTS} \)

**EBHA BATT** and **UPS BATT**

\( \geq 180 \text{ KTS} \)

**00:16 MINUTES**

**EBHA BUS**

**00:30 MINUTES**

**FWD E-BATT** and **AFT E-BATT**

(ESS DC buses < 20 Volts)

**EMERGENCY**

Standby Flight Instruments

IRUs

Comm Radio

Emerg. lights

**00:45 MINUTES**

(approximately)
Questions, comments or errors...please send me an email: ivan.luciani@gmail.com

Thank you!