

# B737 NG



# Electrical

## Introduction

### Aircraft equipped with Single Battery

Primary electrical power is provided by two engine integrated drive generators (IDGs) which supply three-phase, 115 volt, 400 cycle alternating current. Each IDG supplies its own bus system in normal operation and can also supply essential and non-essential loads of the opposite side bus system when one IDG is inoperative. Transformer rectifier (TR) units and a battery/battery charger supply DC power. The battery also provides backup power for the AC and DC standby system. The APU operates a generator and can supply power to both AC transfer busses on the ground or in flight.

There are two basic principles of operation for the 737 electrical system:

- There is no paralleling of the AC sources of power.
- The source of power being connected to a transfer bus automatically disconnects an existing source.

The electrical power system may be categorized into three main divisions: the AC power system, the DC power system, and the standby power system.

### Aircraft equipped with Dual Battery

Primary electrical power is provided by two engine integrated drive generators (IDGs) which supply three-phase, 115 volt, 400 cycle alternating current. Each IDG supplies its own bus system in normal operation and can also supply essential and non-essential loads of the opposite side bus system when one IDG is inoperative. Transformer rectifier (TR) units and the main battery/battery charger supply DC power. The main and auxiliary batteries also provide backup power for the AC and DC standby system. The APU operates a generator and can supply power to both AC transfer busses on the ground or in flight.

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## **Electrical Power Generation**

### **Engine Generators**

Primary power is obtained from two engine IDGs. The IDG maintains a constant generator speed throughout the normal operating range of the engine. An integral electro–mechanical disconnect device provides for complete mechanical isolation of the IDG.

### **APU Generator**

The APU generator can supply power to both AC transfer busses on the ground or in flight. As the only power source, the APU generator can meet electrical power requirements for all ground conditions and most flight conditions.

### **External Ground Power**

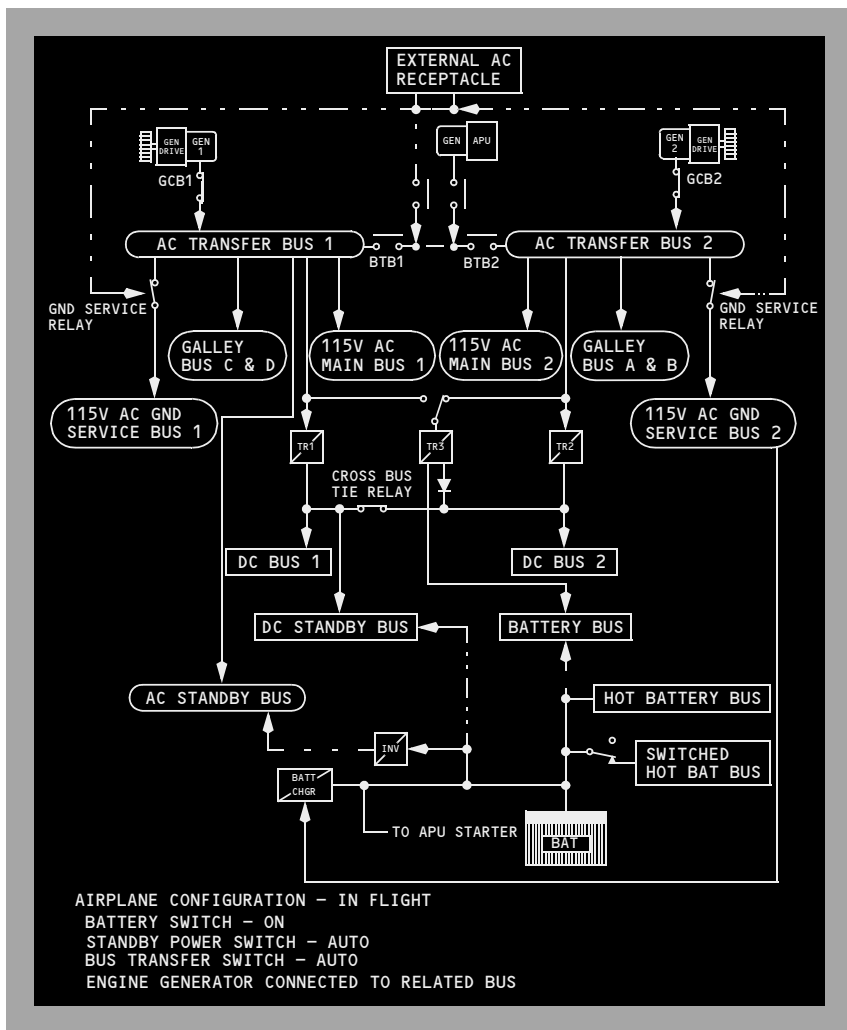
An external AC power receptacle located near the nose gear wheel well, on the lower right side of the fuselage, allows the use of an external power source. Status lights on a panel adjacent to the receptacle permit the ground crew to determine if external power is being used. When connected, external power can supply power to both transfer busses.

### **Ground Service**

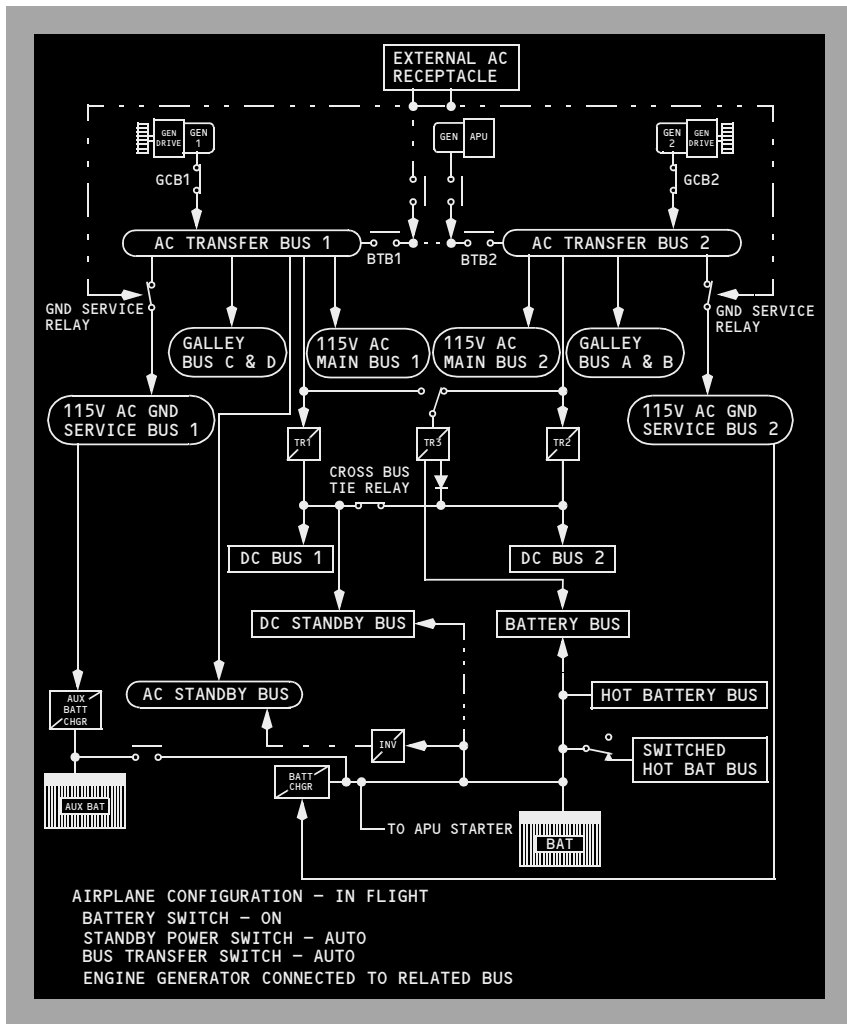
For ground servicing, a ground service switch is on the forward attendant's panel. The switch provides ground power directly to the AC ground service busses for utility outlets, cabin lighting and the battery charger without powering all airplane electrical busses. The ground service switch is a momentary push button and is overridden when both AC transfer busses are powered.

# Electrical Power Schematic

[Option - Single battery aircraft]



[Option – Dual battery aircraft]



## AC Power System

Each AC power system consists of a transfer bus, a main bus, two galley busses, and a ground service bus. Transfer bus 1 also supplies power to the AC standby bus. If the AC source powering either transfer bus fails or is disconnected, the transfer bus can be powered by any available source through the tie bus with the bus tie breakers (BTBs).

With the airplane on the ground and both generator control switches OFF, or with both engines shut down, selecting the GRD PWR switch ON connects external power to both transfer busses. Likewise, selecting either APU GEN switch ON connects APU power to both transfer busses. Whichever source is selected last powers both busses. It is not possible to power one transfer bus with external power and one transfer bus with APU power.

The transfer busses can be powered from the engine generators by momentarily positioning the related generator switch to ON. This closes the related generator circuit breaker (GCB) and connects the generator to the transfer bus. Whenever external power or APU is powering both transfer busses, and engine generator power is applied to its onside transfer bus, external power or APU continues to supply power to the remaining transfer bus.

In flight, each engine generator normally powers its own transfer bus. If an engine generator is no longer supplying power, the BTBs automatically close to allow the other engine generator to supply both transfer busses through the tie bus and BTBs. The APU can power either or both busses through the BTBs.

The system also incorporates an automatic generator on-line feature in case the airplane takes off with the APU powering both transfer busses. If the APU is either shut down or fails, the engine generators are automatically connected to their related transfer busses. This action occurs only once in flight and only under the circumstances described above.

## Bus Tie System

Either generator or the APU can supply power to both transfer busses. If the BUS TRANS switch is in the AUTO position and the source powering the transfer bus is disconnected or fails, the source powering the opposite transfer bus automatically picks up the unpowered transfer bus through the BTBs.

## Flight Deck Auxiliary Power System

The system is composed of a power converter and AC outlets on the P6 and P18 panels to provide power for Flight Deck Personal Electronic Devices (PEDs). A protective device is a part of the safety aspect of the outlets to prevent tampering with foreign objects. PEDs that are plugged into the Flight Deck Auxiliary Power outlets must be fully inserted into the outlet with the prongs of the plug inserted simultaneously to activate the protective device. If a plug is not inserted correctly, electrical power will not be present at the outlet and the plug will need to be removed and reinserted.

**Note:** Plugs installed before power up will need to be removed and reinserted to achieve electrical power.

## Automatic Load Shedding (Engine Generators)

### [Option - CAB/UTIL Power Switch]

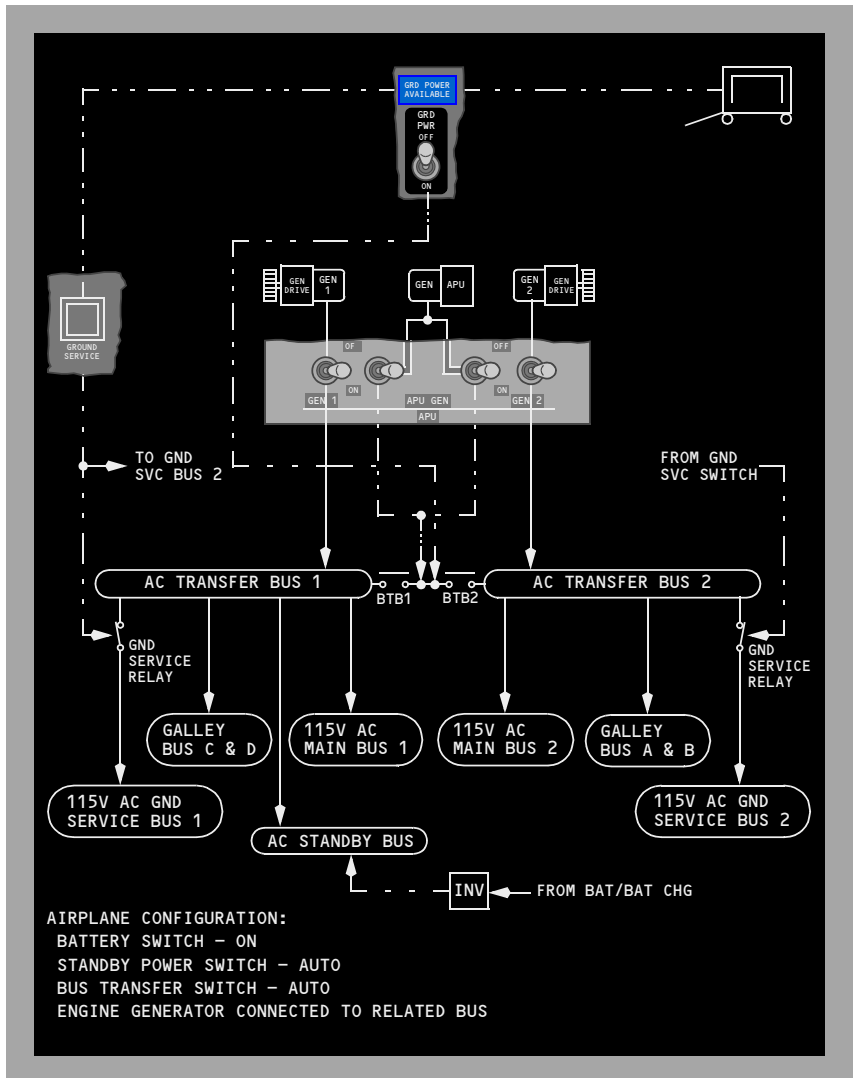
For single generator operation, the system is designed to shed electrical load incrementally based on actual load sensing. The galleys and main bus on transfer bus 2 are shed first; if an overload is still sensed, the galleys and main bus on transfer bus 1 are shed; if overload still exists, the IFE busses are shed. When configuration changes to more source capacity (two generator operation), automatic load restoration of the main busses, galley busses and IFE busses occurs; manual restoration of galley and main bus power can be attempted by moving the CAB/UTIL Power Switch to OFF, then back ON.

## APU Automatic Load Shedding

### [Option - CAB/UTIL Power Switch]

In flight, if the APU is the only source of electrical power, all galley busses and main busses are automatically shed. If electrical load still exceeds design limits, both IFE busses are also automatically shed. On the ground, the APU attempts to carry a full electrical load. If an overload condition is sensed, the APU sheds galley busses and main busses until the load is within limits. Manual restoration of galley and main bus power can be attempted by moving the CAB/UTIL Power Switch to OFF, then back ON.

## AC Power Schematic





## Electrical Power Controls and Monitoring

### Generator Drive

The IDGs contain the generator and drive in a common housing, and are lubricated and cooled by a self-contained oil system. An integral electro-mechanical disconnect device provides for complete mechanical isolation of the IDG.

The generator drive (DRIVE) amber caution light is illuminated when low oil is sensed in the IDG. IDG low oil pressure is caused by one of the following:

- IDG failure
- engine shutdown
- IDG automatic disconnect due to high oil temperature
- IDG disconnected through generator drive DISCONNECT switch.

A generator drive disconnect switch is installed. This switch disconnects the generator from the engine in the event of a generator drive malfunction. Reactivation of the generator may be accomplished only on the ground by maintenance personnel.

### AC Voltmeter, Ammeter and Frequency Meter

AC voltage and frequency may be read on the AC voltmeter and frequency meter for standby power, ground power, generator No. 1, APU generator, generator No. 2 and the static inverter. Frequency is indicated only when the generator is electrically excited. The voltage regulator automatically controls the generator output voltage.

Current readings for the two engine IDGs and the APU generator may be read on the AC ammeter.

The TEST position is used by maintenance and connects the voltage and frequency meter to the power systems test module for selection of additional reading points.

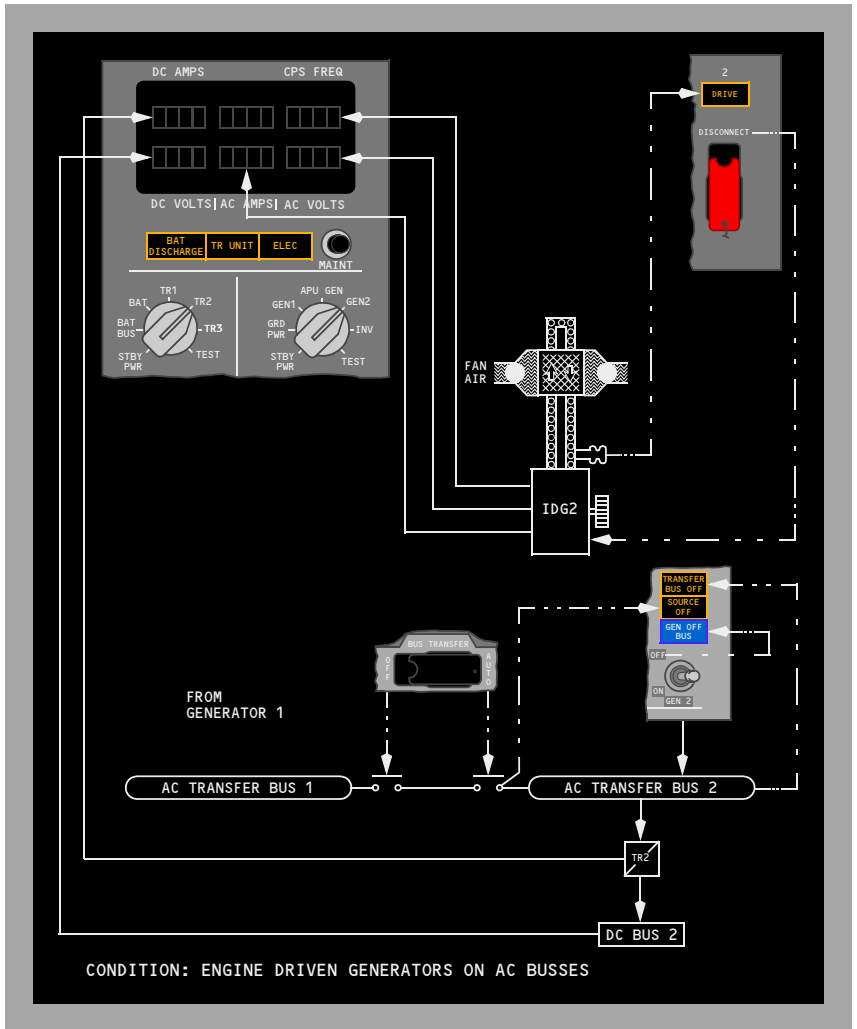
### DC Voltmeter and Ammeter

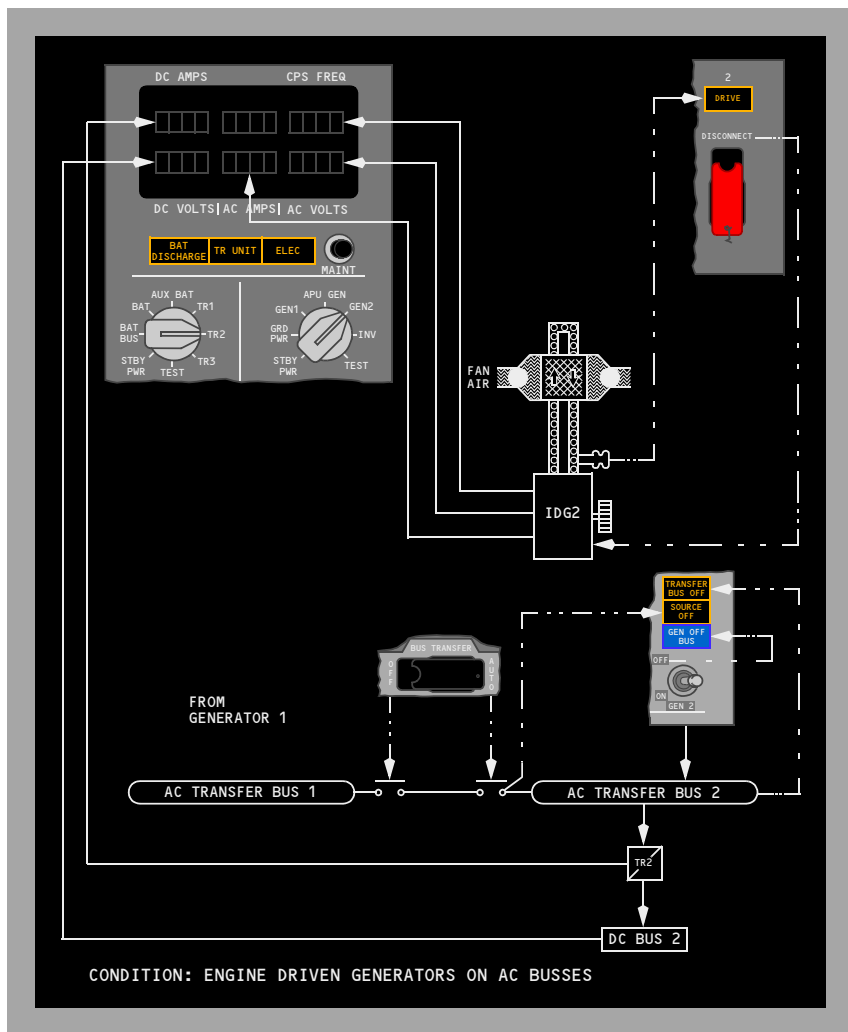
DC voltage and amperage may be read on the DC voltmeter and ammeter for the battery and each of the three TRs. The standby power and battery bus displays only DC voltage.

The TEST position is used by maintenance.

# Electrical Power Controls and Monitoring Schematic

[Option - Single battery aircraft]





## DC Power System

28 volt DC power is supplied by three TR units, which are energized from the AC transfer busses. The battery provides DC power to loads required to be operative when no other source is available.

On the ground, an amber ELEC light comes on to indicate that a fault exists in DC power system or standby power system. The ELEC light is inhibited in flight.

### Transformer Rectifier Units

The TRs convert 115 volt AC to 28 volt DC, and are identified as TR1, TR2, and TR3.

TR1 receives AC power from transfer bus 1. TR2 receives AC power from transfer bus 2. TR3 normally receives AC power from transfer bus 2 and has a backup source of AC power from transfer bus 1. Any two TRs are capable of supplying the total connected load.

Under normal conditions, DC bus 1, DC bus 2, and the DC standby bus are connected via the cross bus tie relay. In this condition, TR1 and TR2 are each powering DC bus 1, DC bus 2, and the DC standby bus. TR3 powers the battery bus and serves as a backup power source for TR1 and TR2.

The cross bus tie relay automatically opens, isolating DC bus 1 from DC bus 2, under the following conditions:

- At glide slope capture during a flight director or autopilot ILS approach. This isolates the DC busses during approach to prevent a single failure from affecting both navigation receivers and flight control computers
- Bus transfer switch positioned to OFF.

In-flight, an amber TR UNIT light illuminates if TR1, or TR2 and TR3 has failed. On the ground, any TR fault causes the light to illuminate.

## Battery Power

### Single Battery Aircraft

A 24 volt nickel-cadmium battery is located in the electronics compartment. The battery can supply part of the DC system. Battery charging is automatically controlled. A fully charged battery has sufficient capacity to provide standby power for a minimum of 30 minutes. Battery voltage range is 22–30 volts.

DC busses powered from the battery following a loss of both generators are:

- battery bus
- DC standby bus
- hot battery bus
- switched hot battery bus.

The switched hot battery bus is powered whenever the battery switch is ON.

The hot battery bus is always connected to the battery. There is no switch in this circuit. The battery must be above minimum voltage to operate units supplied by this bus. An amber BAT DISCHARGE light comes on when excessive battery discharge is detected.

### **Dual Battery Aircraft**

Two 24 volt nickel-cadmium batteries, main and auxiliary, are located in the electronics compartment. The batteries can supply part of the DC system. The auxiliary battery operates in parallel with the main battery when the battery is powering the standby system. At all other times, the auxiliary battery is isolated from the power distribution system. Battery charging is automatically controlled. Two fully charged batteries have sufficient capacity to provide standby power for a minimum of 60 minutes. Battery voltage range is 22–30 volts.

DC busses powered from the battery following a loss of both generators are:

- battery bus
- DC standby bus
- hot battery bus
- switched hot battery bus.

The switched hot battery bus is powered whenever the battery switch is ON.

The hot battery bus is always connected to the battery. There is no switch in this circuit. The battery must be above minimum voltage to operate units supplied by this bus. An amber BAT DISCHARGE light comes on when excessive battery discharge is detected.

### **Battery Charger Transformer/Rectifier**

#### **Single Battery Aircraft**

The purpose of the battery charger is to restore and maintain the battery at full electrical power. The battery charger is powered through AC ground service bus 2.

The battery charger provides a voltage output tailored to maximize the battery charge. Following completion of the primary charge cycle, the battery charger reverts to a constant voltage TR mode. In the TR mode, it powers loads connected to the hot battery bus and the switched hot battery bus. The battery charger TR also powers the battery bus if TR3 fails. With loss of AC transfer bus 1 or the source of power to DC bus 1, the AC and DC standby busses are powered by the battery/battery charger.

## **Dual Battery Aircraft**

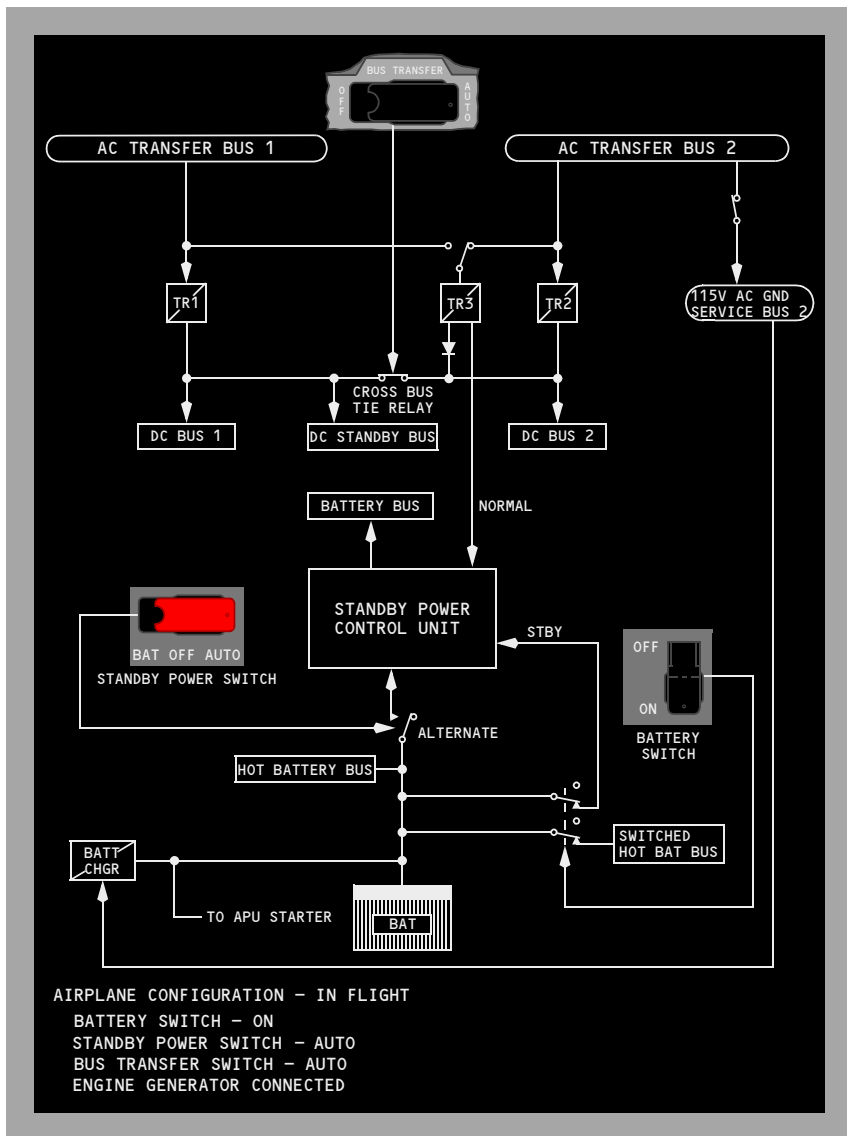
The purpose of the battery chargers is to restore and maintain the batteries at full electrical power. The main battery charger is powered through AC ground service bus 2. The auxiliary battery charger is powered through AC ground service bus 1.

The battery chargers provide a voltage output tailored to maximize the battery charge. Following completion of the primary charge cycle, the main battery charger reverts to a constant voltage TR mode. In the TR mode, it powers loads connected to the hot battery bus and the switched hot battery bus. The main battery charger TR also powers the battery bus if TR3 fails. With loss of AC transfer bus 1 or the source of power to DC bus 1, the AC and DC standby busses are powered by the main and auxiliary battery/battery chargers.

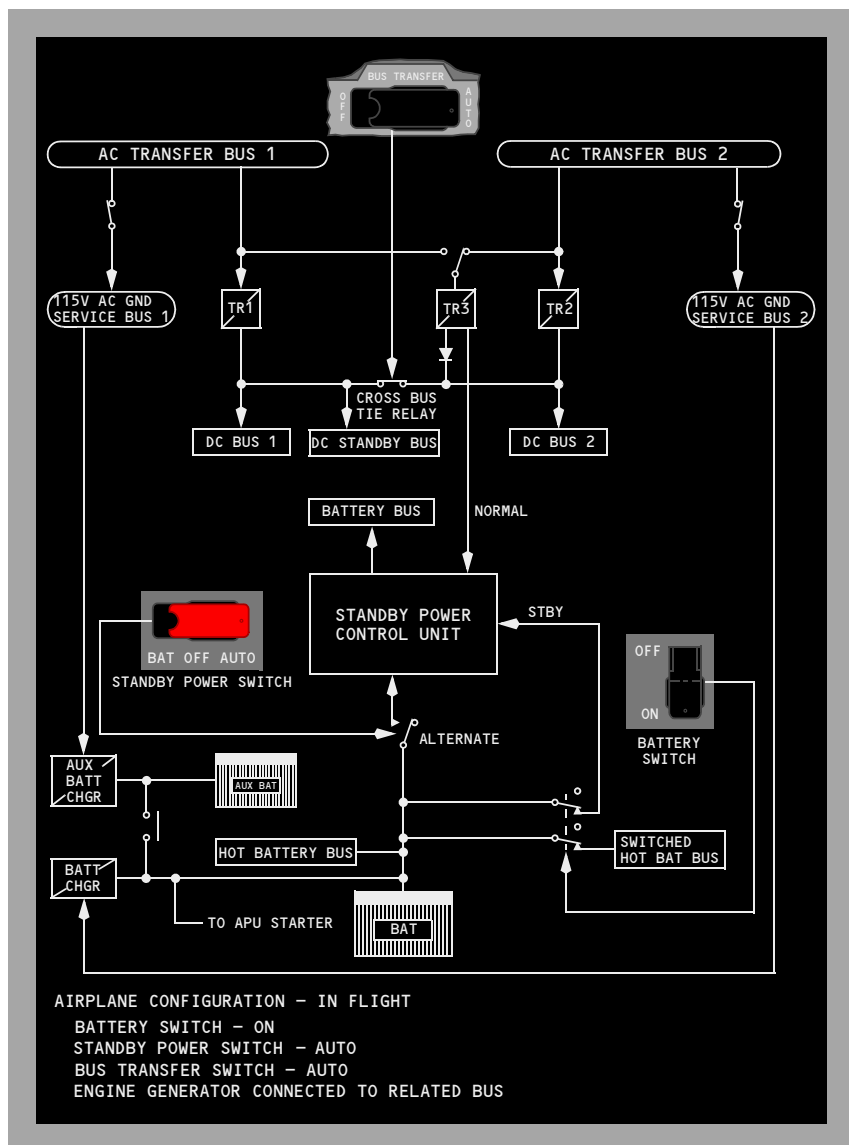
The auxiliary battery charger and battery are isolated from the power distribution system under normal operation. When the main battery is powering the standby system, the auxiliary battery is connected to operate in parallel with the main battery.

## DC Power System Schematic

[Option - Single battery Aircraft]



### [Option – Dual battery Aircraft]





## Standby Power System

### Normal Operation

The standby system provides 115V AC and 24V DC power to essential systems in the event of loss of all engine or APU-driven AC power. The standby power system consists of:

- static inverter
- AC standby bus
- DC standby bus
- battery bus
- hot battery bus
- switched hot battery bus
- main battery

### [Option - Dual battery aircraft]

- auxiliary battery.

During normal operation the guarded standby power switch is in AUTO and the battery switch is ON. This configuration provides alternate power sources in case of partial power loss as well as complete transfer to battery power if all normal power is lost. Under normal conditions the AC standby bus is powered from AC transfer bus 1. The DC standby bus is powered by TR1, TR2, and TR3; the battery bus is powered by TR3; the hot battery bus and switched hot battery bus are powered by the battery/battery charger.

### Alternate Operation

#### Single Battery Aircraft

The alternate power source for standby power is the battery. With the standby power switch in the AUTO position, the loss of all engine or APU electrical power causes the battery to power the standby loads, both in the air and on the ground. The AC standby bus is powered from the battery via the static inverter. The DC standby bus, battery bus, hot battery bus, and switched hot battery bus are powered directly from the battery.

The standby power switch provides for automatic or manual control of power to the standby buses.

In the AUTO position, automatic switching from normal to alternate power occurs if power from either AC transfer bus 1 or DC bus 1 is lost.

Positioning the switch to BAT overrides automatic switching and places the AC standby bus, DC standby bus, and battery bus on battery power. The battery switch may be ON or OFF. If the battery switch is OFF, the switched hot battery bus is not powered.

Positioning the standby power switch to OFF de-energizes both the AC standby bus and the DC standby bus and illuminates the STANDBY PWR OFF light.

### **Dual Battery Aircraft**

The alternate power sources for standby power are the main battery and auxiliary battery. With the standby power switch in the AUTO position, the loss of all engine or APU electrical power causes the batteries to power the standby loads, both in the air and on the ground. The AC standby bus is powered from the batteries via the static inverter. The DC standby bus, battery bus, hot battery bus, and switched hot battery bus are powered directly from the batteries.

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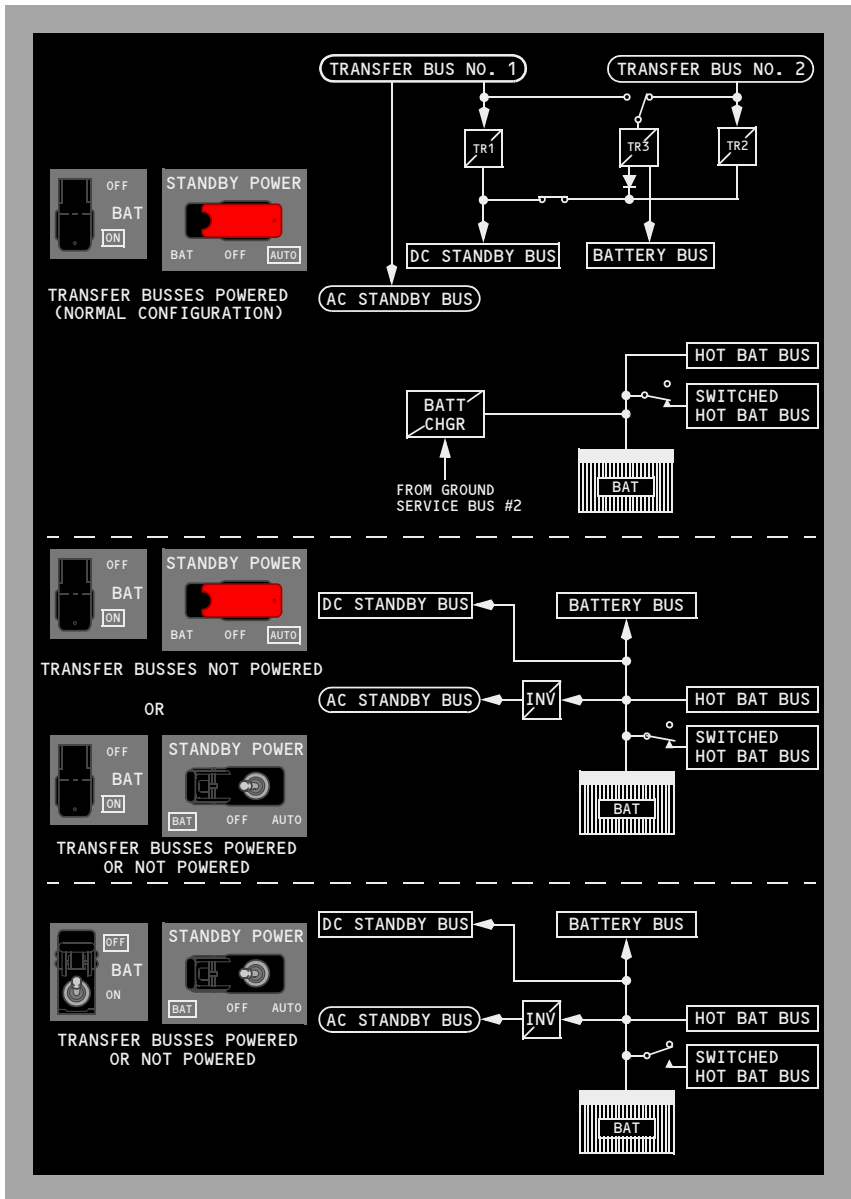
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### **Static Inverter**

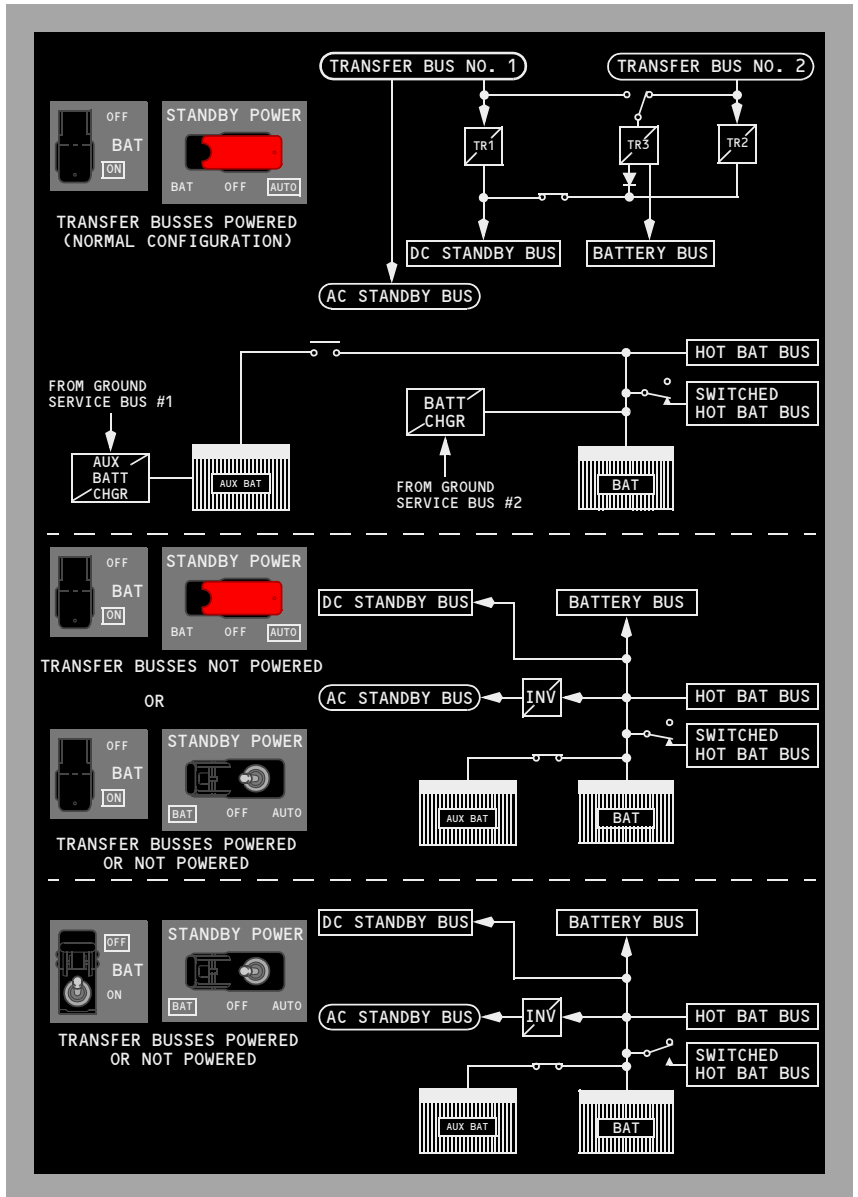
The static inverter converts 24 volt DC power from the battery to 115V AC power to supply the AC standby bus during the loss of normal electrical power. The power supply to the inverter is controlled by the standby power switch and the battery switch on the overhead panel.

# Standby Power System Schematic

[Option - Single battery aircraft]



[Option – Dual battery aircraft]



## All Generators Inoperative

The following list identifies the significant equipment that operates when the main battery and the auxiliary battery are the only source of electrical power.

### Airplane General

- standby compass light
- white dome lights
- emergency instrument flood lights
- flight crew oxygen
- passenger oxygen

### [Option]

- standby forward airstair interior/exterior operation

### Air Systems

- A/C pack valves
- BLEED TRIP OFF lights
- manual pressurization control
- altitude warning horn

### [B737-600/700]

- PACK TRIP OFF lights

### [B737-800/900]

- PACK lights

### Anti-Ice

### [Option]

- Captain's pitot probe heat

### Communications

- flight interphone system
- service interphone system
- passenger address system
- VHF No. 1

### Electrical

- STANDBY POWER OFF light

### Engines, APU

- upper display unit  
N1, N2, fuel flow, EGT, fuel quantity, oil pressure, oil temperature, oil quantity
- upper display unit

N1, N2, fuel flow, EGT, fuel quantity, oil pressure, oil temperature, oil quantity, hydraulic pressure, hydraulic quantity

- thrust reversers
- starter valves
- right igniters
- APU operation (start attempts not recommended above 25,000 feet)

### **Fire Protection**

- APU and engine fire extinguisher bottles
- APU and engine fire detection system
- Cargo fire extinguisher bottle

### **Flight Instruments**

- Captain's outboard display unit (compact EFIS or PFD format)

#### **[Option]**

- Captain's outboard and inboard display units (EFIS/MAP or PFD/ND format)
- clocks
- left EFIS control panel
- Standby instruments  
radio magnetic indicator (RMI), standby airspeed/altimeter, standby attitude indicator, standby magnetic compass

### **Flight Management, Navigation**

- FMC
- left CDU
- heading/track indications
- VHF NAV No. 1
- ILS No. 1
- left IRS
- left GPS
- marker beacon

#### **[Option]**

- ADF No. 1

#### **[Option]**

- IFF No. 1

#### **[Option]**

- transponder No. 1

#### **[Option]**

- DME No. 1

## **Fuel**

- crossfeed valve
- engine fuel shutoff valves
- spar fuel shutoff valve
- FUEL VALVE CLOSED lights
- fuel quantity indicators

## **Hydraulic Power**

- engine hydraulic shutoff valves
- standby rudder shutoff valves

## **Landing Gear**

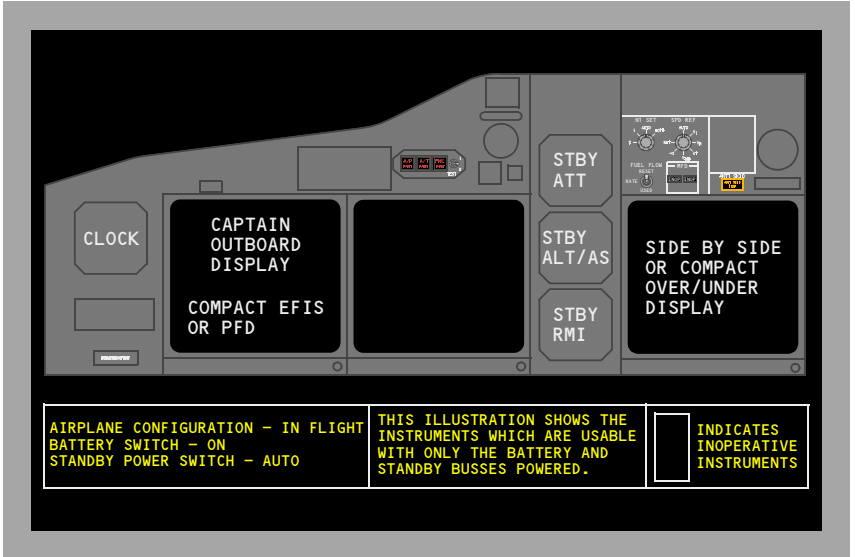
- inboard antiskid system
- ANTISKID INOP light
- parking brake
- air/ground system
- landing gear indicator lights

## **Warnings**

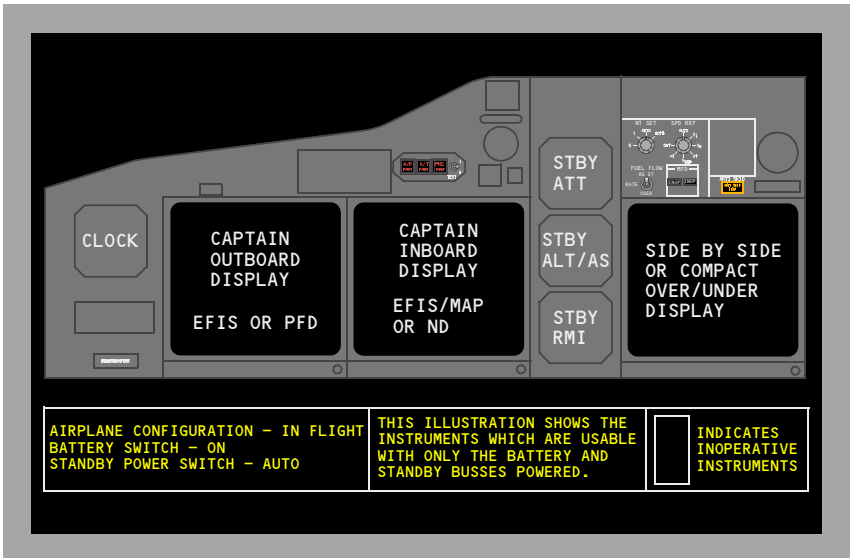
- stall warning system
- aural warnings
- master caution light recall

## **Basic Equipment Operating – Captain Instrument Panel**

The standby power system utilizes the battery as a source of power to supply the below depicted flight instruments. All of the Captain's instruments that are powered by standby power are integrally lighted on standby power

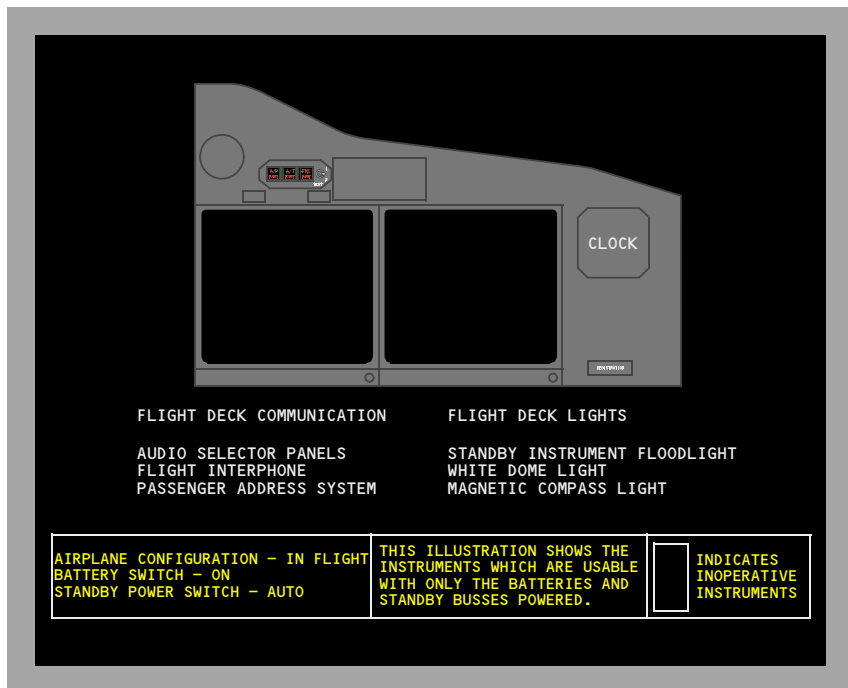


**[Option - Captain's Outboard and Inboard Display Units on Standby Power]**



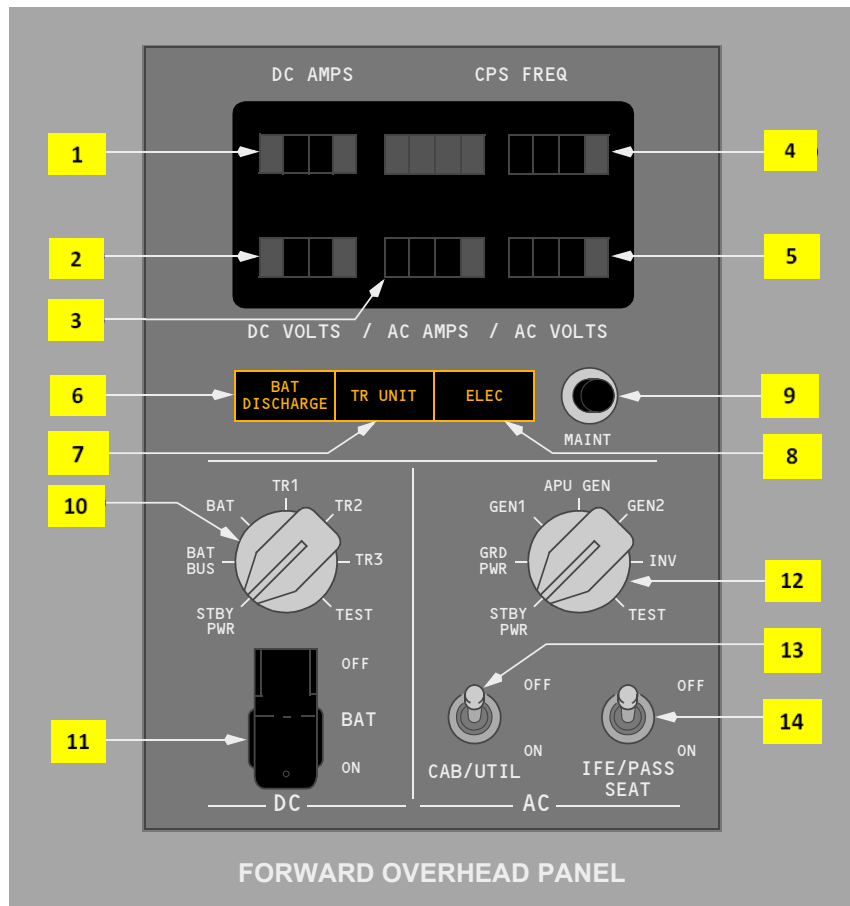


## Basic Equipment Operating – First Officer Instrument Panel

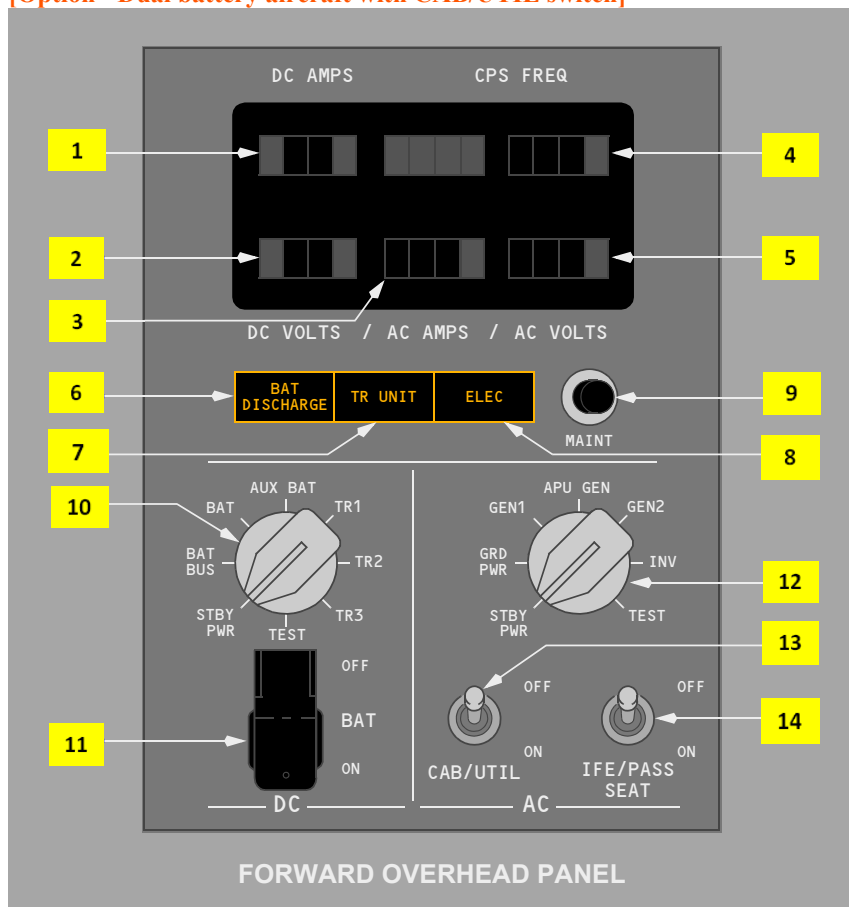


## AC and DC Metering Panel

[Option - Single battery aircraft with CAB/UTIL switch]



[Option - Dual battery aircraft with CAB/UTIL switch]



**1 DC Ammeter**

Indicates amperage of source selected by DC meters selector.

**2 DC Voltmeter**

Indicates voltage of source selected by DC meters selector.

**3 AC Ammeter**

Indicates amperage of source selected by AC meters selector.

**4 Frequency Meter**

Indicates frequency of source selected by AC meters selector.

**5 AC Voltmeter**

Indicates voltage of source selected by AC meters selector.

**6 Battery Discharge (BAT DISCHARGE) Light**

Illuminated (amber) – with BAT switch ON, excessive battery discharge detected.

**7 TR UNIT Light**

Illuminated (amber) –

- on the ground – any TR has failed.
- in flight –
  - TR1 failed; or
  - TR2 and TR3 failed.

**8 Electrical (ELEC) Light**

Illuminated (amber) – a fault exists in DC power system or standby power system.

**Note:** Operates only with airplane on ground.

**9 Maintenance Test (MAINT) Switch**

Used by maintenance.

**10 DC Meters Selector**

Selects DC source for DC voltmeter and DC ammeter indications.

TEST – used by maintenance.

**11 Battery (BAT) Switch**

OFF –

- removes power from battery bus and switched hot battery bus when operating with normal power sources available
- removes power from battery bus, switched hot battery bus, DC standby bus, static inverter, and AC standby bus when battery is only power source.

ON (guarded position) –

- provides power to switched hot battery bus
- energizes relays to provide automatic switching of standby electrical system to battery power with loss of normal power.

## 12 AC Meters Selector

Selects AC source for AC voltmeter, AC ammeter and frequency meter indications

TEST – used by maintenance.

## 13 CAB/UTIL Switch

OFF – removes electrical power from galley and cabin equipment systems including:

- all 115V AC galley busses

[B737-600/700]

- cabin recirculation fan

[B737-800/900]

- left & right recirculation fans
- fwd and aft door area heaters
- drain mast heaters
- lavatory water heaters
- logo lights
- potable water compressor
- 115V AC shaver outlets when installed

ON – supplies electrical power to galley and cabin equipment systems.

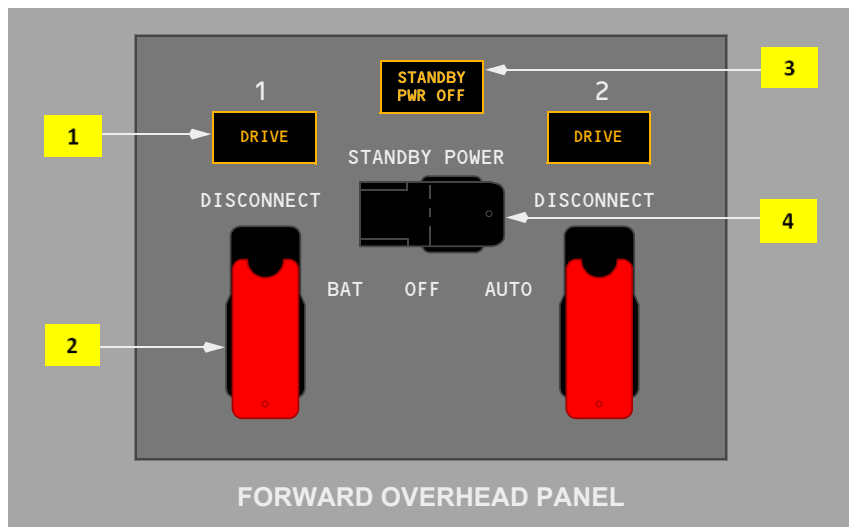
## 14 IFE/PASS SEAT Switch

OFF – removes electrical power from installed components of the passenger seats, in-flight entertainment systems, and other power systems including:

- 115V AC audio entertainment equipment
- 115V AC video entertainment equipment
- cabin telephone equipment
- FAX machine
- 28V DC video equipment and passenger seat electronic outlets
- 115V AC flight deck auxiliary power outlets

ON – supplies electrical power to installed components of the passenger seats, in-flight entertainment systems, and other power systems.

## Generator Drive and Standby Power Panel



### 1 Generator Drive (DRIVE) Lights

Illuminated (amber) – Integrated drive generator (IDG) low oil pressure caused by one of the following:

- IDG failure
- engine shutdown
- IDG automatic disconnect due to high oil temperature
- IDG disconnected through generator drive DISCONNECT switch.

### 2 Generator Drive Disconnect (DISCONNECT) Switches (guarded)

Disconnects IDG if electrical power is available and engine start lever is in IDLE. IDG cannot be reconnected in the air.

### 3 STANDBY Power Off (PWR OFF) Light

Illuminated (amber) – one or more of the following busses are unpowered:

- AC standby bus
- DC standby bus
- battery bus.

#### 4 STANDBY POWER Switch

AUTO (guarded position) –

- In flight, or on the ground, and AC transfer busses powered:
  - AC standby bus is powered by AC transfer bus 1
  - DC standby bus is powered by TR1, TR2 and TR3
- In flight, or on the ground, loss of all AC power
  - AC standby bus is powered by battery through static inverter
  - DC standby bus is powered by battery
  - Battery bus is powered by battery.

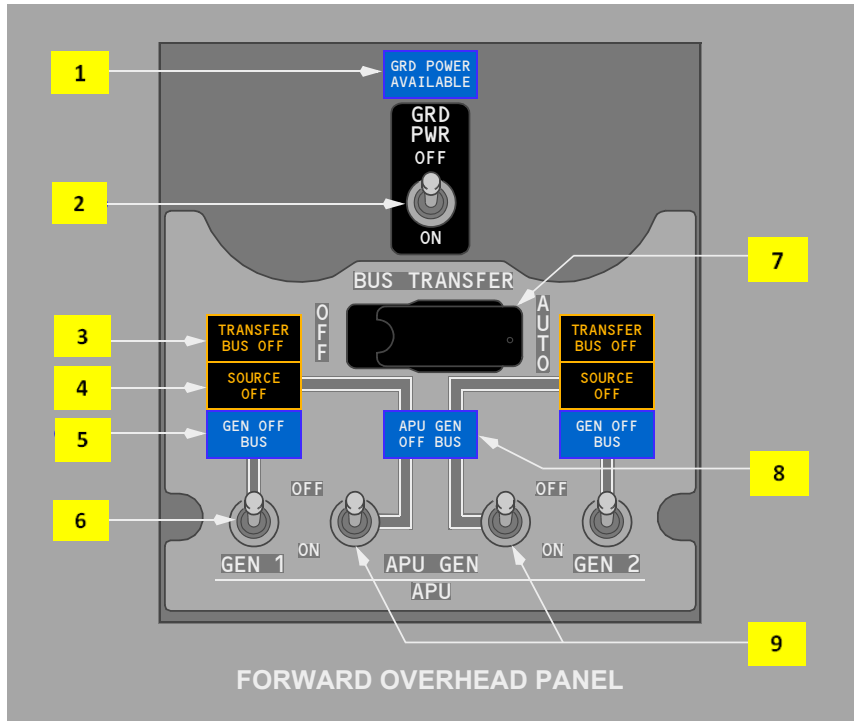
OFF (center position) –

- STANDBY PWR OFF light illuminates
- AC standby bus, static inverter, and DC standby bus are not powered.

BAT (unguarded position) –

- AC standby bus is powered by battery through static inverter
- DC standby bus and battery bus are powered directly by battery.

## Ground Power Panel and Bus Switching Panel



### 1 Ground Power Available (GRD POWER AVAILABLE) Light

Illuminated (blue) – ground power is connected and meets airplane power quality standards.

### 2 Ground Power (GRD PWR) Switch

Three position switch, spring-loaded to neutral

OFF – disconnects ground power from AC transfer busses.

ON – if momentarily moved to ON position and ground power is available:

- removes previously connected power from AC transfer busses
- connects ground power to AC transfer busses if power quality is correct.

### 3 TRANSFER BUS OFF Lights

Illuminated (amber) – related transfer bus is not powered.



#### 4 SOURCE OFF Lights

Illuminated (amber) – no source has been manually selected to power the related transfer bus, or the manually selected source has been disconnected

- if a source has been selected to power the opposite transfer bus, both transfer busses are powered.

#### 5 Generator Off Bus (GEN OFF BUS) Lights

Illuminated (blue) – IDG is not supplying power to the related transfer bus.

#### 6 Generator (GEN) Switches

Three position switch, spring-loaded to neutral.

OFF – disconnects IDG from related AC transfer bus by opening generator circuit breaker.

ON – connects IDG to related AC transfer bus by disconnecting previous power source and closing generator circuit breaker,

#### 7 BUS TRANSFER Switch

AUTO (guarded position) – BTBs operate automatically to maintain power to AC transfer busses from any operating generator or external power

- DC cross tie relay automatically provides normal or isolated operation as required.

OFF – isolates AC transfer bus 1 from AC transfer bus 2 if one IDG is supplying power to both AC transfer busses

- DC cross tie relay opens to isolate DC bus 1 from DC bus 2.

#### 8 APU Generator Off Bus (GEN OFF BUS) Light

Illuminated (blue) – APU is running and not powering a bus.

#### 9 APU Generator (GEN) Switches

Three position switch, spring-loaded to neutral.

OFF –

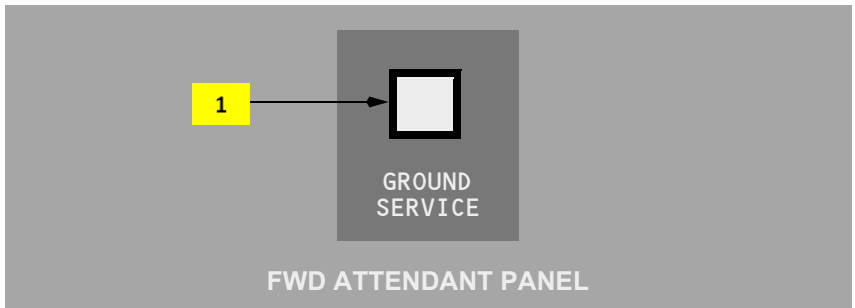
- APU generator powering both AC transfer busses
  - moving a single APU GEN switch to OFF illuminates related SOURCE OFF light. APU continues to power AC transfer busses
  - subsequently moving other APU GEN switch to OFF disconnects APU generator from tie bus and removes APU power from AC transfer busses
- APU generator powering one AC transfer bus; IDG powering one AC transfer bus

- moving related APU GEN switch to OFF disconnects APU generator from tie bus and AC transfer bus. IDG powers AC transfer busses.

ON –

- Neither AC transfer bus powered by IDG – moving a single APU GEN switch to ON:
  - connects both AC transfer busses to the APU generator
  - disconnects external power, if connected
  - opposite SOURCE OFF light illuminates until the other APU GEN switch is moved to ON.
- Both AC transfer busses powered by IDGs – moving an APU GEN switch ON:
  - powers the related AC transfer bus from the APU generator
  - other AC transfer bus continues to receive power from the IDG.

## Ground Service Switch



### 1 GROUND SERVICE Switch

Momentary push-button switch.

Provides manual control of ground service busses. Enables servicing airplane using external power without activating AC transfer busses.

Illuminated (white) –

- ON – connects external power to ground service busses
- OFF – disconnects external power from ground service busses.

## **Electrical Limitations**

The use of Flight Deck Auxiliary Power outlets in the flight deck requires operational regulatory approval.