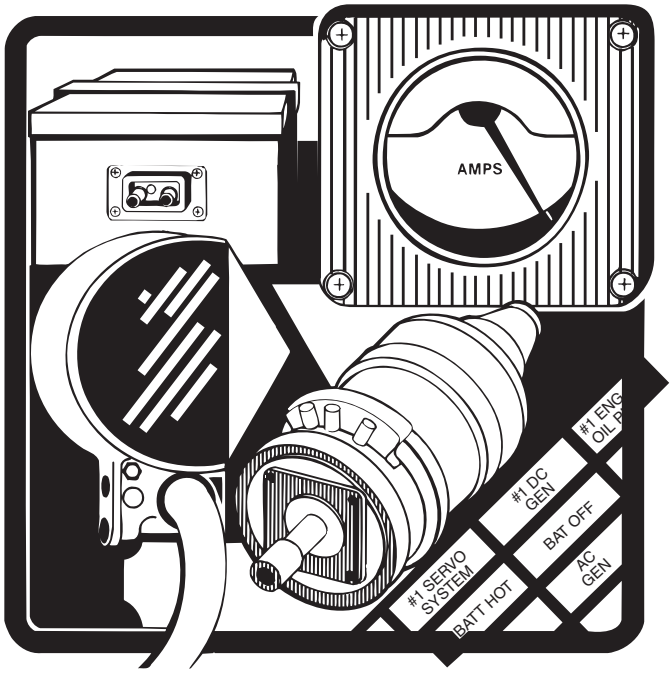
CHAPTER 2
ELECTRICAL POWER SYSTEMS



INTRODUCTION

This chapter provides a description of the electrical power system on Citation Mustang aircraft (Figure 2-1). The DC system consists of storage, generation, distribution, and system monitoring. Provision is also made for a limited supply of power during emergency conditions in flight and connection of a ground power unit (GPU) while on the ground.

GENERAL

Direct current provides the principal electrical power for the Citation Mustang. Normal aircraft system voltage is 28.5 VDC. Two generators are the primary power sources (one generator is capable of supplying all standard requirements). Secondary sources (battery or external power) may also be used.

Normal distribution of DC power is via a left and right feed bus connected by a crossfeed bus. This arrangement allows either generator to power the entire system or, working in parallel, to share the system load.

The battery and emergency buses normally tie to the main system, but they may isolate to only the battery or external power sources. When the aircraft is on the ground, an external DC power unit may supply electrical power to all buses.

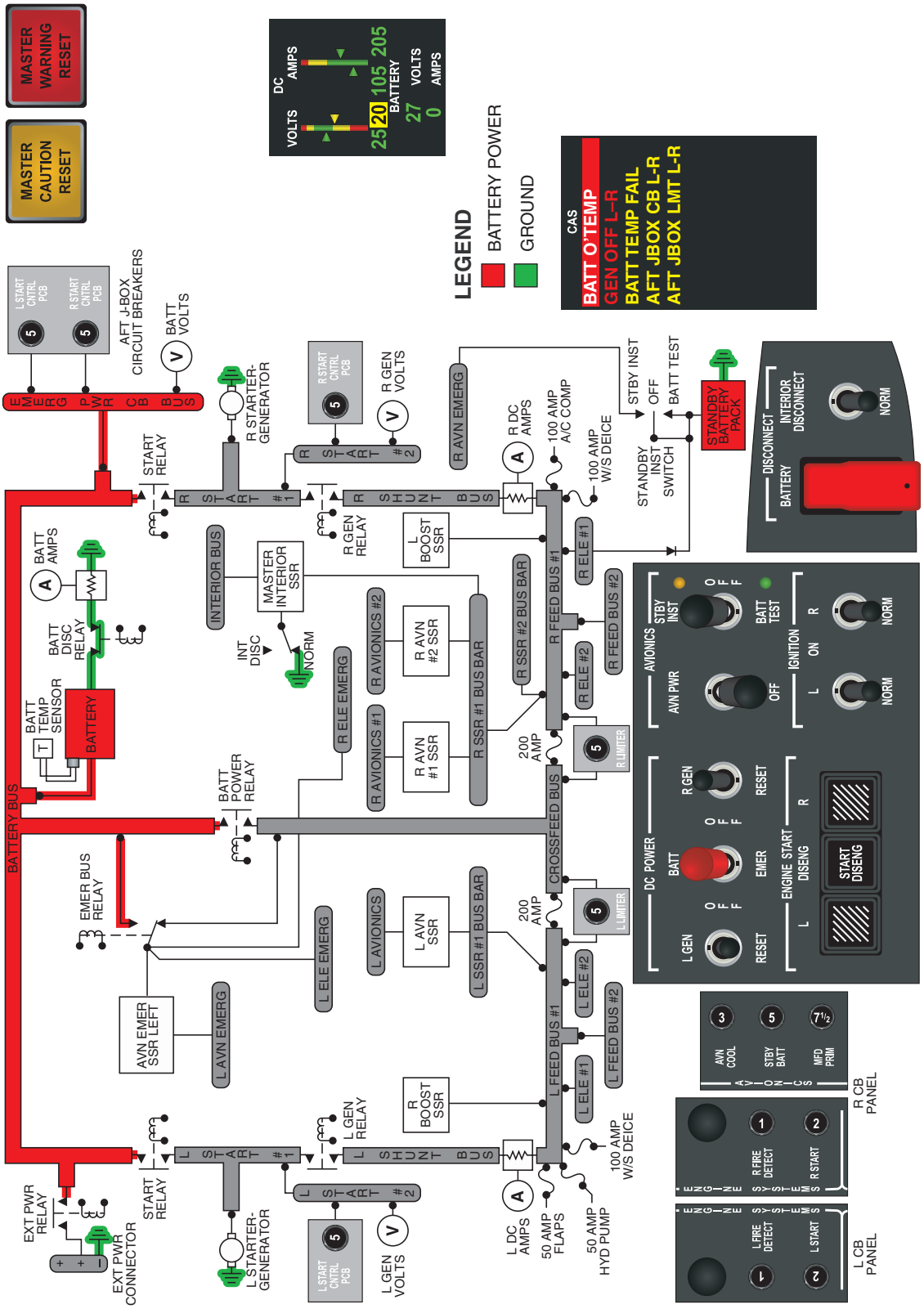


Figure 2-1. Electrical System Schematic

DESCRIPTION

The Mustang electrical system primarily provides 28-VDC power to operate electrical devices throughout the aircraft.

A starter-generator is used to start its respective engine, with starting power coming from the battery or from a GPU. Additionally, the starter-generator of a functioning engine (with battery assistance) can be used to start the opposite side engine.

One generator is capable of supplying all standard electrical requirements if a generator fails.

DC power is routed from each J-box feed bus through individual circuit breakers to each of the circuit-breaker buses in the cockpit CB panels. Cockpit circuit breakers control power to individual systems. Battery power is supplied to a hot battery bus and then through the battery relay to the crossfeed bus and the left and right feed buses.

Emergency DC power is supplied from the battery bus through the emergency power relay, to emergency bus circuit breakers on each cockpit CB panel when the battery switch is in the EMER position. If the battery switch is in the BATT position, generator power is supplied through the battery relay to the hot battery bus to charge the battery and from the crossfeed bus through the emergency relay to the emergency power buses.

The external power receptacle is underneath the right engine nacelle.

First engine start is performed from the battery unless using external power. The second engine start may be powered three different ways:

- With external power (if the first generator switch is OFF)
- From the battery (if the first generator switch is OFF and external power is not connected)
- From the battery with assistance from the first generator (ground only) if the first generator is online

Normally, when both engines are operating, the starter-generator in each engine provides 28-VDC power to the main bus system in the tail cone. This bus system and its associated relays provide connections and power management for the battery and provide for connection to GPUs. This bus system also allows either starter-generator to assist the other during starting and allows the two starter-generators to operate “in parallel” to share the electrical load evenly.

From the main bus system in the tail cone, power is distributed through circuit breakers in the tail cone directly to a few electrical devices in or near the tail cone. More power is routed forward from the main buses through feeder cables to the cockpit buses. Buses on each side of the cockpit (behind the CB panels) supply power through the cockpit circuit breakers and panel controls to most of the aircraft electrical devices.

Cockpit indicators monitor electrical system status and performance. Cockpit panel controls allow the crew to directly manage the generation and distribution of electrical power. Relays, solid state relays (SSRs), circuit breakers, current limiters, and generator control units (GCUs) protect the electrical system, and assist the crew in managing the supply and flow of electrical power.

COMPONENTS

BATTERY

A standard lead acid battery provides 24 volts rated at 28 amp hours. An optional NiCad battery provides 24 volts rated at 28 amp hours. The battery is in the tail cone compartment (Figure 2-2). It has a manual quick-disconnect, and is accessible through the tail cone door.

The battery connects to the battery bus. A battery disconnect relay between the battery and its ground provides an electrical disconnect during certain conditions. A BATTERY disconnect switch (Figure 2-3) is in the cockpit on the left side console panel. This switch opens the battery disconnect relay. Use this

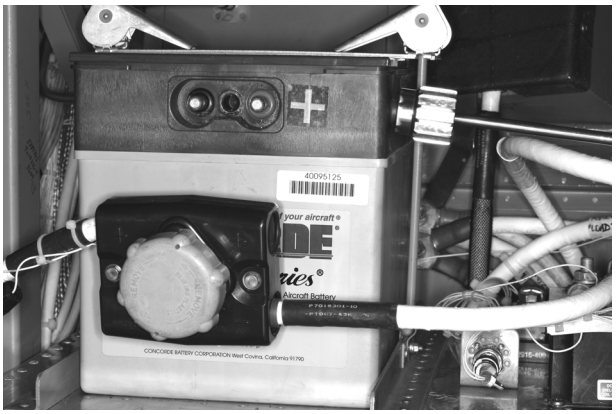


Figure 2-2. Battery

switch in case of a battery overheat or stuck start relay.

NOTE

The optional NiCad battery is susceptible to, and must be protected from, overheat due to excessive charging or discharging.

During an external power start cycle, to prevent battery discharge, the battery disconnect relay automatically disconnects the battery from its ground. A GPU start is not a battery start.

Starting the engines with an external power source is recommended practice to prolong the life of the batteries and conserve battery power for times when battery starts must be accomplished. When it is anticipated the aircraft will be idle for more than 2 days, it is advisable to disconnect the battery to prevent frequency memory circuits, or other equipment that may be powered by the battery bus, from draining the batteries.

A battery in good condition supplies power to all buses for a minimum of 10 minutes with maximum load. If powering only the battery and emergency buses, battery life should be a minimum of 30 minutes.

An INTERIOR DISCONNECT switch is on the pilot side console panel (Figure 2-3). When the switch is selected to the up position, the master interior relay opens, shutting off all electrical power in the cabin. When the switch is in the NORM position, the master interior relay closes, and electrical power flows to the cabin normally (when DC power is available and the other electrical controls are in the appropriate positions).

STANDBY BATTERY

The standby instrument battery is a 1.2 amp-hour sealed lead-acid battery. The standby battery is controlled with the AVIONICS STBY INST switch.

The standby instrument battery is in the radome on the avionics shelf assembly. The battery automatically supplies electrical power to the standby airspeed, attitude, and altitude instruments and the lighting for the whiskey compass when normal electrical power is not available.

STARTER-GENERATORS

Two engine-driven DC starter-generators (one on each engine accessory gearbox) are the

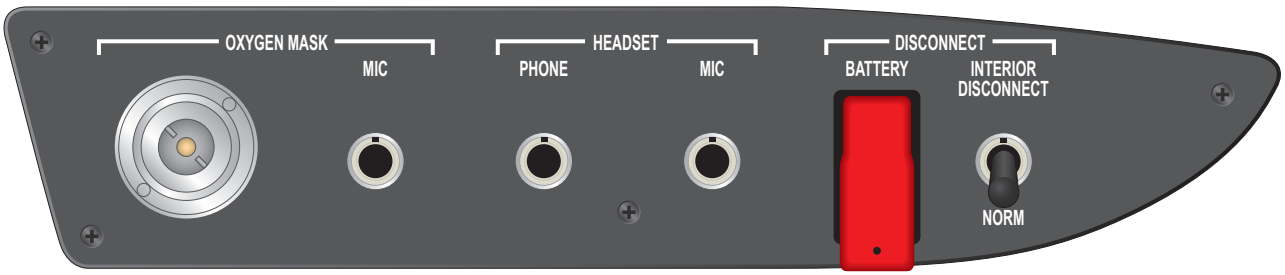


Figure 2-3. Battery Disconnect Switch

primary source of aircraft electrical power and supply power to all DC buses. Each generator is air cooled, rated at 29 VDC, and regulated to 28.5 volts.

The generators are engine-starting motors that revert to generators at the completion of the start cycle. Each generator system operates independently, but power distributes evenly through bus systems that are in parallel except during fault conditions.

DC power from the engine-driven generators distributes to two feed buses (see Figure 2-1). Each feed bus connects through a 200-amp current limiter to the crossfeed bus, allowing each feed bus to parallel the other.

During normal operation, the generators share loads equally (within ±10% of the total load) via the crossfeed bus. Each starter-generator is regulated by its own generator control unit (GCU).

Generator power routes from the crossfeed bus through the battery relay (when it is closed) to the battery bus. This provides power to charge the battery, and during generator operation powers the items on the battery bus.

Normally (with the battery switch set to BATT), generator power routes from the crossfeed bus through the emergency relay to power the cockpit emergency buses and through the battery relay to power the emergency bus in the J-box. The battery and emergency relays are operated with the battery switch.

GROUND POWER UNIT

A GPU can be connected to the aircraft DC system through a receptacle in the fuselage below the right engine nacelle (Figure 2-4). External power is routed through the external power relay to the battery bus. The battery charges from the GPU, regardless of the battery switch position.

A GPU providing a maximum voltage of 29 VDC may be used. The left and right start controllers monitor GPU voltage and open the external power relay to disconnect the GPU from the aircraft if voltage exceeds approximately 32.5 VDC.

Figure 2-4. GPU Receptacle

Before connecting a GPU, ensure that the voltage of the GPU is regulated to 28–29 volts the amperage output between 800 and 1,100 amps. When using external power for prolonged ground operation (over 30 minutes), disconnect the battery to preclude overheating the battery. Do not use the battery disconnect switch.

CAUTION

Some GPUs do not have reverse-current protection. If the GPU is powered off while connected to the aircraft, the battery may be rapidly discharged and/or damaged. Always disconnect the GPU from the aircraft when not in use.

Connecting the external power source energizes the external power relay, which connects the external power source to the battery bus. Setting the battery switch to the BATT position energizes the battery relay, which allows the connection of external (or battery) power from the battery bus to the emergency buses, and through the crossfeed bus to the left and right feed buses.

When either the left or right generator power relay closes, the external power relay deenergizes to remove external power from the battery bus. This prevents the aircraft generators and the GPU from simultaneously applying power to the aircraft buses.

CAUTION

If the battery is charged using the GPU, it must be monitored. Current from most GPUs is not regulated and a battery overheat may occur.

DISTRIBUTION

DC power is distributed throughout the aircraft though several buses (see Figure 2-1) via the main junction box (aft J-box) and cockpit buses (behind CB panels).

Main Junction Box (Aft J-Box)

The main junction box (aft J-box) (Figure 2-5) in the tail cone compartment contains:

- Two feed buses:
  - Left feed bus No. 1
  - Right feed bus No. 1
- Two start buses:
  - Left start bus No. 1
  - Right start bus No. 1
- Two shunt buses:
  - Left shunt bus
  - Right shunt bus
- Crossfeed bus
- Battery bus

Main Feed Buses

Each generator (left and right) normally supplies power through its respective generator relay to its respective main feed bus (left feed bus No. 1 and right feed bus No. 1). These buses are tied together through the crossfeed bus.

Start Buses

The left and right start buses provide power to the left and right start No. 2 buses and those provide power to the controllers and related systems. In order for the start relay to close, the battery switch must be in the BATT position.

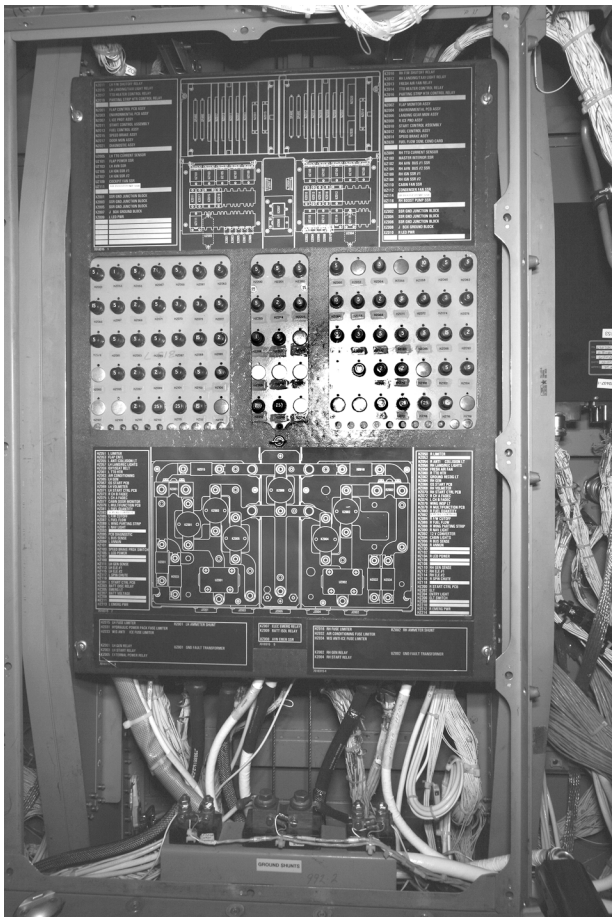


Figure 2-5. Aft J-Box

When the respective start relay closes, the start bus is connected to the battery bus, which supplies power from the battery or a GPU.

Shunt Buses

The left and right shunt buses connect the starter-generators to the electrical system. The GCUs and starter-generators manage the connection of the start buses through the left and right start relay and the left and right generator relay. With the exception of a cross-generator start, normally only one relay at a time (either start relay or generator relay) is closed on each side to connect the corresponding start bus to the electrical system.

Crossfeed Bus

The crossfeed bus functions solely as a bus tie connecting the battery bus, the emergency buses, and the two main feed buses into one integral system.

If the battery switch is selected to BATT, the battery power relay closes, which connects the battery bus to the crossfeed bus. Power extends from the crossfeed bus through 200-amp current limiters to each main feed bus. Power also extends from the crossfeed bus to the cockpit emergency power circuit-breaker buses and (through the avionics power switch) to the avionics buses.

Battery Bus

The battery bus is connected directly to the battery. It may receive power from a GPU and during normal operation, receives its power from either or both generators.

Cockpit Distribution and CB Panels

Various feed-extension buses, avionics buses, emergency buses, and the interior buses are in the cockpit.

Feed Extension Buses

From each main feed bus (left feed No. 1 and right feed No. 1) in the tail cone, various extension feed buses distribute power to components through controls and circuit breakers in the cockpit. The main left and right feed-extension buses are behind the pilot and copilot CB panels respectively (Figure 2-6). Other feed-extension buses are also behind the corresponding CB panels and are powered through 25-amp circuit breakers.

Avionics Buses

Avionics buses (left and right) are powered from the respective main feed buses through solid-state relays (SSRs) when the AVN MASTER switch is selected ON. These buses provide power to the aircraft avionics, except the avionics that are on the emergency buses.

Emergency Buses

Emergency bus items are listed in Table 2-1. The aircraft has five emergency buses:

- Emergency power circuit-breaker bus
- Left electrical emergency bus
- Right electrical emergency bus
- Left avionics emergency bus
- Right avionics emergency bus (with standby battery)

Table 2-1. EMERGENCY BUS ITEMS

• Standby altimeter	• Cockpit floodlights
• COM 1	• Pilot pitot-static heat
• NAV 1	• Audio panel 1 and 2
• ADC 1	• Autopilot control panel
• AHRS 1	• Standby airspeed indicator
• Landing gear lights	• Standby attitude indicator
• Cabin dump	• PFD 1–Reversion mode

The emergency power circuit-breaker bus is directly connected to the battery bus at all times.

Other buses are powered from either the crossfeed bus, the battery bus, or the standby battery.

With the battery switch in the BATT position, power to the emergency buses is from the crossfeed bus.

Because the crossfeed bus normally feeds the emergency buses, the pilot must use the battery switch to energize the emergency power relay to the EMER position, which switches all emergency buses from the disabled crossfeed bus to the battery bus.

With the battery switch in the EMER position, the following aural warnings are available:

- Terrain awareness and warning system (TAWS) alert
- Autopilot disconnect
- Check altitude
- Decision height
- Vertical track
- Marker beacon

Figure 2-6. CB Panels

CAUTION

With the battery switch in the EMER position, some aural warnings are NOT available, including:

- Stall warning
- Landing gear
- Overspeed
- Traffic information service (TIS)

SYSTEM PROTECTION

Generator Control Units

Two GCUs regulate, parallel, and protect the generators. The GCUs are in the tail cone, with one unit dedicated to each starter-generator. Each GCU controls a field and generator relay. Each generator relay connects the generator to its feed bus. The GCU permits the generator relay to close when the cockpit generator switch is in GEN and the

generator output is within 0.5 volts of normal system voltage (28.5 VDC).

When the GCU senses an internal feeder fault (short circuit) or an overvoltage, the respective side generator and field relays open. These relays also open when the ENGINE FIRE switchlight is selected.

A reverse current (10% of total load) or undervoltage opens only the generator relay, removing the generator from the system but leaving the field relay closed.

The GCU utilizes software and solid-state circuitry to perform the following operations:

- Control voltage regulation
- Load sharing
- Overvoltage/overexcitation protection
- Automatic generator line contactor control
- Reverse current protection
- Overload protection
- Overspeed protection
- Open ground protection
- Open shunt protection
- Open point of regulation (POR) protection
- Starter cutoff
- Field weakening
- Ground fault protection

Circuit Breakers and Current Limiters

Parallel feeder cables (between each DC feed bus in the tail cone and the corresponding feed-extension buses in the cockpit) receive protection from circuit breakers. Various other circuit breakers on the feed buses in the tail cone protect against overload.

Current limiters, also known as fuse limiters, are provided to protect against major electrical overload. A list of the protected buses and components is provided below:

- Left feed bus No. 1—200 amps
- Right feed bus No. 1—200 amps
- Air-conditioner compressor—100 amps
- Windshield heat (left)—100 amps
- Windshield heat (right)—100 amps
- Flaps—50 amps
- Hydraulic powerpack—50 amps
- HF radio (optional)—50 amps

Solid-State Relays

Solid-state relays (SSRs) serve as a combination circuit breaker and relay for numerous components. SSRs are individually controlled by cockpit system switches or, in some instances, by remotely mounted printed circuit boards (PCBs).

SSRs are installed in either a 25- or 10-amp size; however, they are resistor-adjustable for lower amperage trip points. The following buses and components are SSR-protected and controlled:

- Left avionics bus
- Right avionics bus (No. 1)
- Right avionics bus (No. 2)
- Left avionics emergency bus
- Master interior bus
- Cockpit fan
- Cabin fan
- Condenser fan
- Left fuel boost pump
- Right fuel boost pump
- Left ignitor No. 1
- Right ignitor No. 1
- Left ignitor No. 2
- Right ignitor No. 2

Relays and Engine Starting

For generator-assisted second engine starts, the battery power relay opens to prevent high-current flow from the crossfeed bus to the battery bus and protects the 200-amp current limiters. This causes starting current from the online generator and battery to flow through the two starter relays and battery bus to the starter. A blown 200-amp current limiter splits the feed buses, preventing generator paralleling.

Pressing the starter button for GPU starts, first opens the battery disconnect relay to prevent the battery cycles, then closes the start relay.

If GPU voltage is excessive, an overvoltage sensor opens the external power relay and breaks the circuit to the battery bus. External power disable relays also disconnect the GPU from the battery bus whenever a generator relay closes, bringing a generator online.

CONTROLS AND INDICATIONS

Control of DC power is maintained with a battery switch and two generator switches (Figure 2-7).

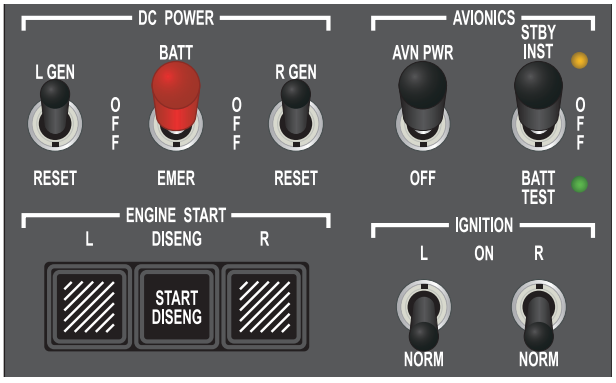


Figure 2-7. Battery, Generator, and Ignition Switches

BATTERY SWITCH

The battery switch is on the pilot DC POWER subpanel and has three positions: BATT, OFF, and EMER.

If the battery switch is in the OFF position, the battery bus isolates from all other buses in the system with the exception of the emergency power circuit-breaker bus.

When the battery switch is in the BATT position, the battery power relay closes, completing a circuit to the crossfeed bus. The emergency relay deenergizes while the battery relay is in the BATT position and completes a circuit to the emergency buses from the crossfeed bus.

In the EMER position, only the emergency power relay energizes, which connects the emergency buses to the battery bus. These buses receive power from the battery or external power. When external power is not applied to the aircraft and the generators are online, placing the battery switch in EMER or OFF isolates the battery from any charging source.

BATTERY DISCONNECT SWITCH

A guarded battery disconnect switch (see Figure 2-3) is above the pilot armrest on the left side console panel. The switch has two positions: BATTERY (disconnect) and NORM. It disconnects the battery and is used only for abnormal operations involving stuck start relay or battery overtemperature. Activating this switch uses battery power to open the battery disconnect relay on the ground side of the battery.

NOTE

The battery switch on the DC POWER subpanel must be in the BATT position for the battery disconnect switch to operate.

If the battery ground is open, the battery cannot supply electrical power to the aircraft or receive a charge from the generators.

CAUTION

Do not use the battery disconnect switch for an extended time. The battery disconnect relay will continue to draw a small current from the battery until the battery is discharged. The battery disconnect relay will then close, resulting in a very high charge rate and probable overheat.

AVIONICS STANDBY INSTRUMENT SWITCH

The avionics standby instrument switch is on the AVIONICS pilot switch panel in the cockpit. The switch can be set to the STBY INST, OFF, or BATT TEST position. The switch supplies power to the right avionics emergency bus.

When the standby battery is powering the standby instruments, the amber light adjacent to the switch illuminates. Selecting BATT TEST performs a capacity check on the standby battery. A successful test is indicated by a green light adjacent to the switch.

GENERATOR SWITCHES

Two generator switches (L GEN and R GEN) are on the pilot DC POWER subpanel (see Figure 2-7). The generator switches have three positions: L (or R) GEN, OFF, and RESET.

Setting the switch to L GEN or R GEN allows the GCU to close the generator relay and connects the generator to its feed bus. The ammeter indicates the generator output to the feed buses.

With the switch in the OFF position, the generator relay opens and the ammeter shows no generator load to the feed buses.

Placing the switch in the spring-loaded RESET position rebuilds field voltage to provide a means of resetting a generator that has tripped as a result of a fault condition.

ENGINE START BUTTONS

Two engine start buttons (L and R) (see Figure 2-7) on the pilot ENGINE START subpanel activate a circuit to close the associated start relay and allow starting current to flow from the battery bus to the starter. A starter disengage (DISENG) button between the starter buttons opens the start circuit if manual termination of the start sequence is desired (see Figure 2-7).

Pushing the engine start button illuminates a white light in the starter button as a direct indication that the start relay is closed.

INDICATIONS

The DC electrical system is monitored by:

- Crew alerting system (CAS) messages
- Engine indicating and crew alerting system (EICAS) display window
  - DC AMPs display
  - BATTERY AMPs display
  - BATTERY VOLTS display
- Engine start button light

CAS Messages

BATT O'TEMP

With the optional NiCad battery installed, a battery overtemperature warning system warns the pilot of abnormally high battery temperatures (Figure 2-8). An internal temperature of 63–70°C (145–156°F) displays an amber BATT O'TEMP message and steady MASTER CAUTION lights.

If the temperature reaches 71°C (160°F) a red BATT O'TEMP message displays and the MASTER WARNING lights flash.

BATT TEMP FAIL

An amber BATT TEMP FAIL message indicates the battery temperature sensor has failed (applies to NiCad battery-equipped aircraft only).

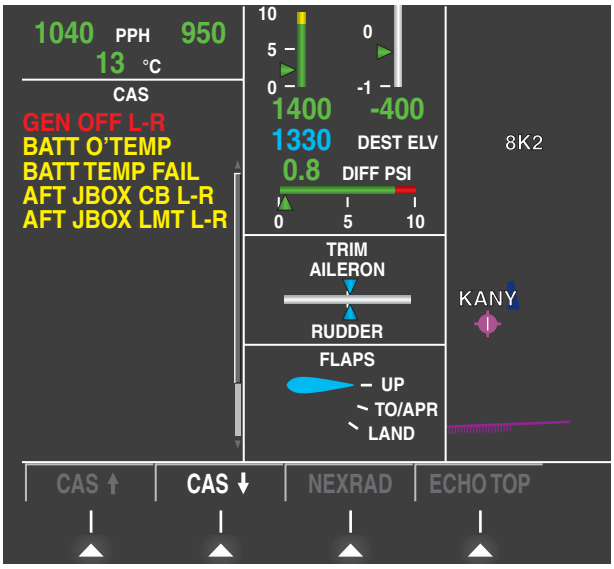


Figure 2-8. CAS Messages

GEN OFF L-R

Loss of a single generator or an open generator relay is indicated by an amber GEN OFF L or R message and triggers steady MASTER CAUTION lights.

Dual generator failure is annunciated with a red GEN OFF L-R message and flashing red MASTER WARNING lights.

AFT JBOX CB L-R

An amber AFT JBOX CB L-R message indicates the left or right start circuit breaker on the aft J-box has popped. The circuit breaker cannot be reset from the cockpit. Maintenance is required.

AFT JBOX LMT L-R

An amber AFT JBOX LMT L-R message indicates failure of a 200-amp current limiter.

EICAS Display Window

The DC window of the EICAS display provides dual generator indications (left and right) for both voltage (VOLTS) and current (AMPS), and also BATTERY voltage and current.

VOLTS Display

The left and right generator VOLTS displays are on the upper-left area of the DC window (Figure 2-9). Each VOLTS display indicates voltage at its respective generator. In reversionary mode, only the digits are displayed.

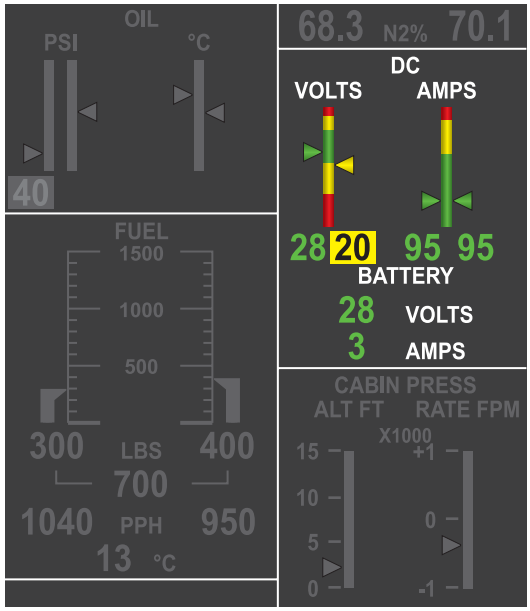


Figure 2-9. Electric Display (Normal)

AMPS Display

The left and right generator AMPS displays are on the upper-right area of the DC window (Figure 2-9). Each display indicates current flow from its respective generator to its respective DC feed bus. During normal operation, the indication should be parallel within ±10% of total load. Amperage between the starter-generator and the battery bus is not reflected on the AMPS displays. In reversionary mode, only the digits are displayed.

BATTERY–VOLTS Display

The BATTERY–VOLTS display is a digital display on the bottom-center area of the DC window. The display indicates voltage on the battery bus.

BATTERY–AMPS Display

The BATTERY–AMPS display is a digital display on the bottom of the DC window (Figure 2-9). The display indicates current into or from the battery. Positive amperage indicates battery charging. Negative amperage indicates battery discharge.

OPERATION

PREFLIGHT

During the interior preflight, place the generator switches to GEN if the intention is a battery start or to the OFF position if external power is desired. Place the battery switch to BATT and verify the voltage display for 24 volts minimum (22 volts minimum for NiCad).

After checking lights and pitot heat, turn the battery switch to the OFF position. During the exterior preflight, visually check the battery for signs of deterioration or corrosion. Do not connect external power until completing these checks.

STARTING (FIRST ENGINE)

Before starting the engines, recheck the generator switches for proper position and verify battery voltage. Ensure that the battery switch is in the BATT position.

Depressing the L or R ENGINE START button:

- Closes the respective start relay
- Activates the electric fuel boost pump

Closure of the start relay (indicated by illumination of the start button white light) connects battery bus power to the starter for engine rotation.

At approximately 8% turbine rpm (N_2):

- FADEC commands fuel flow to the start nozzles
- Ignition is activated by the full-authority digital engine control (FADEC)
- A green IGN appears on the multifunction display (MFD) at the upper interturbine temperature (ITT) scale and indicates current to one or both exciter boxes

Within 10 seconds, combustion should occur as evidenced by rising ITT.

As the engine accelerates through 48.6% N_2:

- The GCU starter overspeed sensor automatically terminates the start sequence.
- The start relay opens.
- The electric boost pump is deenergized.
- The GEN OFF message disappears from the CAS window(GEN switch ON).
- The green IGN indication extinguishes.
- N_2 digits change from white to green.

STARTING (SECOND ENGINE)

For a second engine start on the ground, the operating generator assists the battery in providing current to the starter. The operating engine must be at idle rpm.

When the remaining start button activates, both start relays close and the white light in each starter button illuminates.

When one generator relay closes and the other energizes as a starter, the battery disable relay causes the battery relay to open the circuit between the crossfeed bus and the battery bus in order to protect the 200-amp current limiter.

STARTING (IN FLIGHT)

An engine start in flight using the start button is a battery start only. The squat switch disables generator-assist capability when airborne. Only the associated start relay closes and the boost pump on that side activates.

The only difference between an in-flight start and a ground start with one generator online, is that the start relay on the same

side as the operating generator does not close and the battery power relay opens. This isolation of the start circuit from the operating generator and buses in flight is through left squat switch logic and is required by certification regulations.

The protection circuit for the 200-amp current limiter is the same as previously described. Refer to the "Airstart Envelope" graph in "Limitations" of the *Airplane Flight Manual (AFM)*.

STARTING (ASSISTED BY EXTERNAL POWER UNIT)

A GPU can be used for engine starts. Check for voltage regulation to a maximum of 29 VDC and 800/1,100 amps.

When external power starts are planned, the generator switches remain in the OFF position until the removal of external power from the aircraft. Otherwise, when the first generator comes online, the external power relay opens and the GPU automatically disconnects from the battery bus. The second engine start becomes a generator-assist battery start.

EMERGENCY/ ABNORMAL

For specific information on emergency/abnormal procedures, refer to the appropriate abbreviated checklists or the FAA-approved *AFM*.