



CHAPTER 7

ELECTRICAL

CONTENTS

	Page
GENERAL	7-1
SYSTEM DESCRIPTION	7-1
AC System	7-1
DC System	7-10
Emergency AC and DC System	7-17
External Power	7-19
CONTROLS AND INDICATIONS	7-20
ELECTRICAL POWER SERVICES Panel	7-20
ADG AUTO DEPLOY CONTROL Panel	7-23
Flight Attendant Panel	7-24
External Service Panel	7-26
EICAS Primary Display—Primary Page	7-28
EICAS Secondary Display—Status Page	7-32
Circuit Breakers	7-49
Power Supply and Circuit-Breaker Summary	7-51
Electrical Distribution	7-57



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ILLUSTRATIONS

Figure	Title	Page
7-1	Electrical System	
	Major Component Locations	7-2
7-2	Air-Driven Generator	7-9
7-3	AC Ground-Power Receptacles	7-9
7-4	DC System Power Application	7-11
7-5	DC Ground-Power Receptacle.....	7-17
7-6	Electrical Power Service Panel	7-21
7-7	ADG Controls	7-23
7-8	Flight Attendant Panel	7-25
7-9	External Service Panel	7-27
7-10	EICAS Primary Display—Primary Page	7-29
7-11	EICAS Secondary Display—Status Page	7-33
7-12	EICAS Secondary Display— AC ELECTRICAL Page.....	7-34
7-13	EICAS Secondary Display— DC ELECTRICAL Page.....	7-43
7-14	Flight Deck Circuit-Breaker Panel Locations	7-49



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TABLES

Table	Title	Page
7-1	Generator Priority System.....	7-4
7-2	Normal AC Distribution	7-5
7-3	AC Load Distribution	7-5
7-4	AC Service Loads Distribution.....	7-6
7-5	TRU and AC/DC Bus Distribution	7-13
7-6	External Power Distribution	7-19
7-7	Electrical Page Color Logic	7-36
7-8	AC Bus Bar Outline Color Codes	7-38
7-9	DC Bus Bar Outlines	7-44
7-10	TRU Digital Readouts and Outlines	7-45
7-11	Power Supply and Circuit-Breaker Summary	7-51
7-12	DC Distribution Loads	7-57



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CHAPTER 7

ELECTRICAL

GENERAL

This chapter describes the various electrical systems, their power sources, and operation within automated and manual control capabilities. The major electrical systems include the following:

- DC system
- AC system
- Emergency AC and DC systems

The electrical systems are designed to sustain operation after major component failures. This reversionary operation is normally automatic and maintains electrical power to essential equipment even after multiple failures.

SYSTEM DESCRIPTION

AC SYSTEM

The primary electrical system (Figure 7-1) consists of two engine-driven, 115-volt/200-volt, 400-Hz, 3-phase, 30-kVA, AC power generators. An APU generator provides an alternate source of electrical power. The distribution systems furnish power to the following buses:

- AC bus 1 and AC bus 2
- AC essential bus
- AC utility bus 1 and AC utility bus 2
- AC service bus

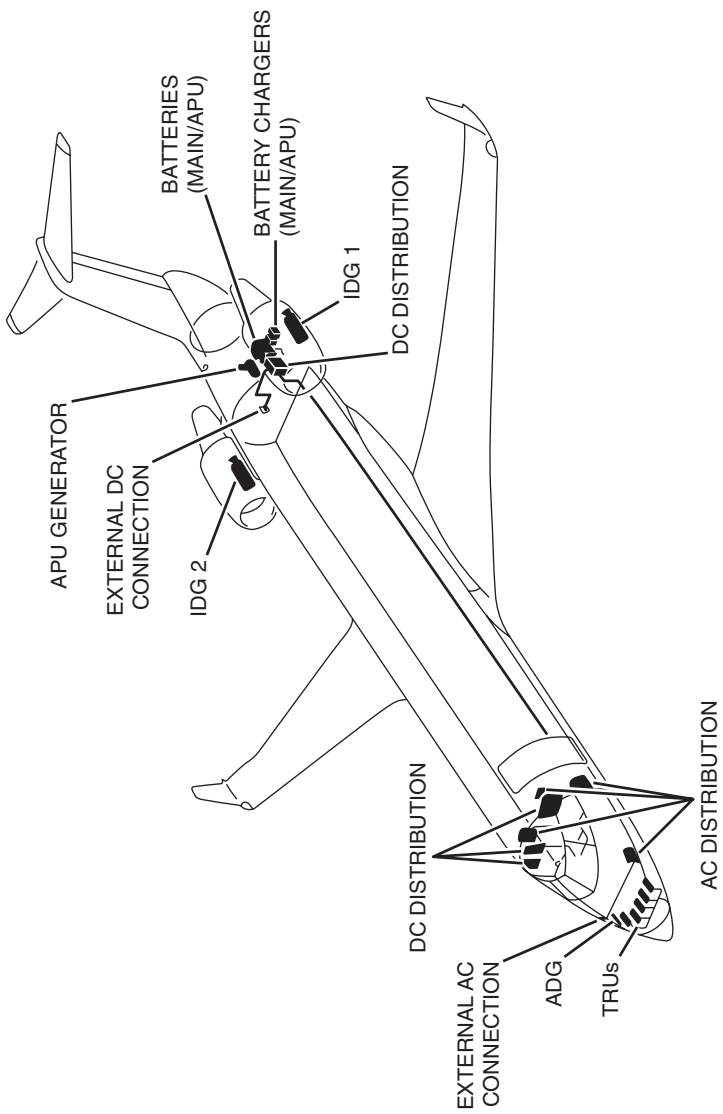


Figure 7-1 Electrical System Major Component Locations



The AC electrical page is accessed through a single push of the ELEC key on the EICAS control panel. It contains digital readouts of the following:

- Generator output (voltage, frequency, and load in kVA)
- Input/output flow on the bus bars
- General status indications via color logic
- System messages

AC Generation System

AC power is normally supplied by any two of three AC generators: one on each engine and one on the APU. Each generator is rated at 30-kVA continuous output. Each is capable of supplying more than sufficient power for main systems operation if the other two generators are lost.

The engine-driven, integrated-drive generators (IDG) convert engine variable speeds to a constant speed and produce 3-phase, AC power at 400 Hz. Each IDG uses a constant-speed drive to hydromechanically govern and control the rotational speed of the generator at 12,000 rpm.

Each IDG has a IDG DISC disconnect switch in the cockpit, which decouples the IDG from the engine's reduction gearbox in the event of an IDG failure. The IDG automatically disconnects when an overtemperature or overtorque condition occurs. Once disconnected, the IDG must be engaged manually at the engine after engine shutdown. There is fault protection in each generator control unit (GCU). The GCU removes the generator from its bus and deenergizes the generator during a malfunction. The generators may be reset (GEN switch to RESET) when the malfunction is corrected.

The APU generator is mounted on the APU and driven at a constant speed of 12,000 rpm, maintaining the generator's frequency output at 400 Hz.



Generator Priority System

The IDGs and APU generator power the airplane AC buses using a generator priority system. If an IDG fails, the operating generator picks up the failed generator's load through the generator-tie contactors. When available, the APU generator picks up the failed generator's load. Generator switching priority is as follows:

- No. 1 AC bus—IDG 1, then the APU generator, then IDG 2, then external power
- No. 2 AC bus—IDG 2, then the APU generator, then IDG 1, then external power

The generator priority system is shown in Table 7-1.

Table 7-1 GENERATOR PRIORITY SYSTEM

IDG 1	APU GENERATOR	IDG 2
Failed	Not available	Both AC bus 1 and 2
Failed	AC bus 1	AC bus 2
Both AC bus 1 and 2	Not available	Failed
AC bus 1	AC bus 2	Failed
Failed	Both AC bus 1 and 2	Failed

AC Distribution System

The No. 1 and No. 2 generators supply power directly to the No. 1 and No. 2 AC buses for distribution to the respective systems. Power from the APU generator is routed to either AC bus, or to both when both engine-driven generators are not operating, or directly to the AC service bus when in the service configuration. The AC essential bus can be powered by either of the two main buses by operating the AC ESS XFER switchlight. AC normal distribution is shown in Table 7-2.

AC load distribution is shown in Table 7-3.



Table 7-2 NORMAL AC DISTRIBUTION

AC BUS 1	AC BUS 2
AC essential bus	AC service bus
AC utility bus 1	AC utility bus 2
NOTE: Should a bus fault exist on AC bus 1, AC bus 2 can feed the AC essential bus independently from AC bus 1.	

Table 7-3 AC LOAD DISTRIBUTION

AC ESSENTIAL (3)	AC BUS 1	AC BUS 2
Horizontal Stab Trim Actuator (HSTA) (channel 2)		HSTA (Channel 1)
	Hydraulic pumps (3B and 2B)	Hydraulic pumps (3A and 1B)
Bleed leak controllers (left and right)		
Window heater (L)	Windshield heater (L)	Windshield/window heaters (R)
Probe heaters (L) (AOA and pitot)	Probe heaters (R) (AOA and pitot) and TAT	
Ice detector (1)		Ice detector (2)
Engine ignition (A)		
Instrument lights (pilot's and center)	Navigation, landing and taxi lights (L)	Instrument lights (copilot's and overhead), landing and taxi lights (R)
CB panel lights	(EGPWS)	
TCAS	Flight data recorder	



Table 7-3 AC LOAD DISTRIBUTION (Cont)

AC ESSENTIAL (3)	AC BUS 1	AC BUS 2
ARINC chassis and display cooling fans (L)	Hydraulic system fan, exhaust and flight deck fan, and display cooling fan (R)	ARINC display fan (R), galley and cabin fan
	Flap power drive unit (1)	Flap power drive unit (2)
	Engine vibration monitor	
	ADG deploy sensor	ADG deploy sensor
Essential TRU 1	TRU 1, DC essential bus	TRU 2, DC essential bus
ADG BUS: AC essential feed Essential hydraulic pump (3B) EICAS voltage and frequency indications		

The AC service bus supplies power to those circuits necessary for ground servicing operations, without having to energize the remainder of the electrical system. Power to the AC service bus is supplied directly from the external power receptacle or APU generator. This is provided that the APU SERV BUS switch, on the attendant panel, is on. The AC service loads distribution is shown in Table 7-4.

Table 7-4 AC SERVICE LOADS DISTRIBUTION

AC SERVICE BUS	AC UTILITY BUS 1	AC UTILITY BUS 2
Service TRU Vacuum cleaner Toilet motor and pump	Galley (1) and coffee maker Main battery charger Power sensing relay	Galley (2) and water system APU battery charger Power sensing relay
NOTE: Both battery chargers are shed when the No. 1 and No. 2 utility buses are shed.		



The AC utility buses is powered from the main AC buses or AC service bus. In flight, the AC utility buses are automatically shed if only one generator is operational. On the ground, both utility buses are shed if external AC power is connected and the flaps are $>0^\circ$.

There is priority control of AC power distribution. If the APU generator is supplying power to a bus, and an engine-driven generator is applied on the respective bus, the APU generator is automatically taken off the bus. If external power is supplying power to a bus and either the APU or main generator is placed on the bus, the external power is automatically taken off the bus and the other generator takes the load for that bus. Shutting down a generator, for any reason other than a fault on that generator bus, automatically transfers the load from that generator to the operative generator.

The status of the AC essential bus is shown on the EICAS secondary display (AC ELECTRICAL page) as ESS BUS. The ESS BUS indication is shown only when the bus is operational and on-line. The ESS BUS power source is shown by a flow line from the available power source (AC BUS 1 or AC BUS 2).

AC Essential-Bus Transfer

AC essential-bus transfer is automatically controlled by the AC voltage and frequency sensor. If an out-of-tolerance voltage or frequency condition occurs on AC bus 1, which energizes the AC essential bus, the AC essential bus source is automatically transferred to AC bus 2. This occurs when the voltage on any phase of the AC essential bus is less than 90 volts, or during a complete loss of power to the AC essential bus.

AC System Components

Integrated-Drive Generators

The main generators are 30-kVA, 115-VAC, three-phase, 400-hertz, integrated-drive generators (IDGs), mounted on each engines accessory gearbox. Each IDG is driven by a constant speed drive mechanism, which maintains the generator at a constant rpm. An IDG is automatically disconnected from its accessory gearbox if it



experiences an overtemperature or overtorque condition. An IDG can be disconnected via the respective IDG DISC switch on the ELECTRICAL SERVICES panel. IDG faults and disconnects are indicated on an EICAS display.

Generator Control Units

The generator-control units (GCUs) monitor and control generator output and provide circuit protection.

APU Generator

The APU generator is a 30-kVA, 115-volt, three phase, 400-hertz generator.

APU Generator-Control Unit

The APU generator-control unit monitors and controls generator output and provides circuit protection.

Air-Driven Generator

The air-driven generator (ADG), located on the forward lower fuselage (Figure 7-2), contains a ram-air turbine (RAT) that turns an AC generator. The turbine has a governed, two-blade, variable-pitch impeller, which controls the generator frequency.

The ADG is automatically deployed if there is a complete AC power failure. It is manually deployed by pulling the ADG handle on the pedestal.

The ADG is pushed into the airstream, where ram air turns the turbine. After the ADG is lowered, it can be retracted only on the ground with the restow pump. Two weight-on-wheels (WOW) signals from the proximity sensor electronic unit prevent the ADG AUTO DEPLOY CONTROL unit from operation on the ground.

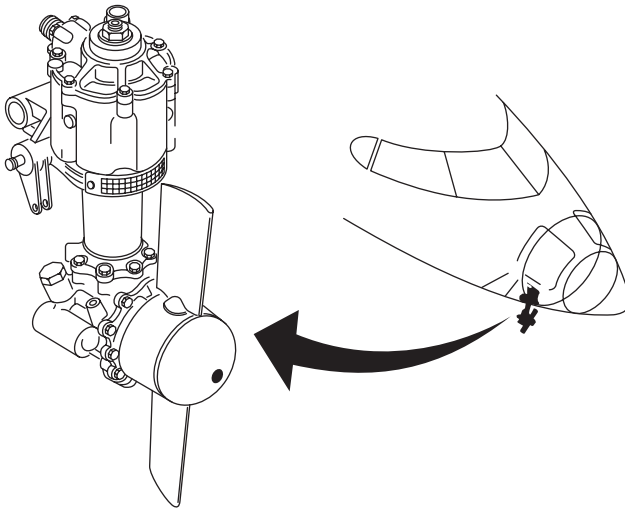


Figure 7-2 Air-Driven Generator

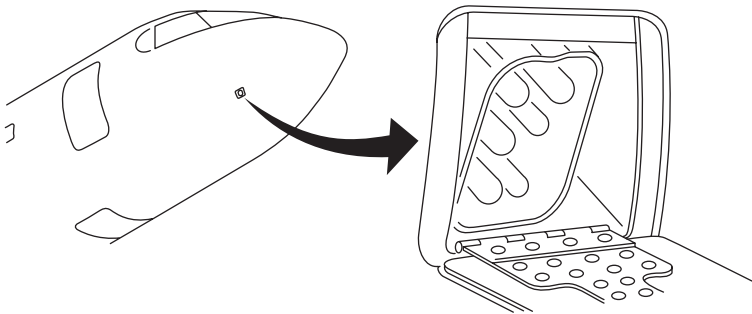


Figure 7-3 AC Ground-Power Receptacles

AC Ground-Power Receptacle

The AC ground-power receptacle (Figure 7-3) is on the right side of the aircraft above the nose landing gear.



DC SYSTEM

For load devices requiring DC power, 115-VAC power is converted to 28-VDC power by transformer-rectifiers. The 28-VDC power is distributed on the following buses (Figure 7-4):

- DC bus 1 and DC bus 2
- DC essential bus
- DC battery bus
- DC utility bus 1 and DC utility bus 2
- DC service bus

The 17-ampere hour, 24-volt, main battery provides the following:

- Backup power, through the standby power contactor, to the attitude heading reference system (AHRS), proximity sensor electronics unit (PSEU), and APU electronic control unit (ECU)
- Backup power to the EICAS data concentrator units (DCUs) and airplane clocks
- Battery power to the flight compartment lighting system

Cranking power for starting the APU is provided by the 43-ampere hour, 24-volt, APU battery.

Battery buses are as follows:

- Left and right battery bus
- Main battery-direct bus
- APU battery-direct bus.

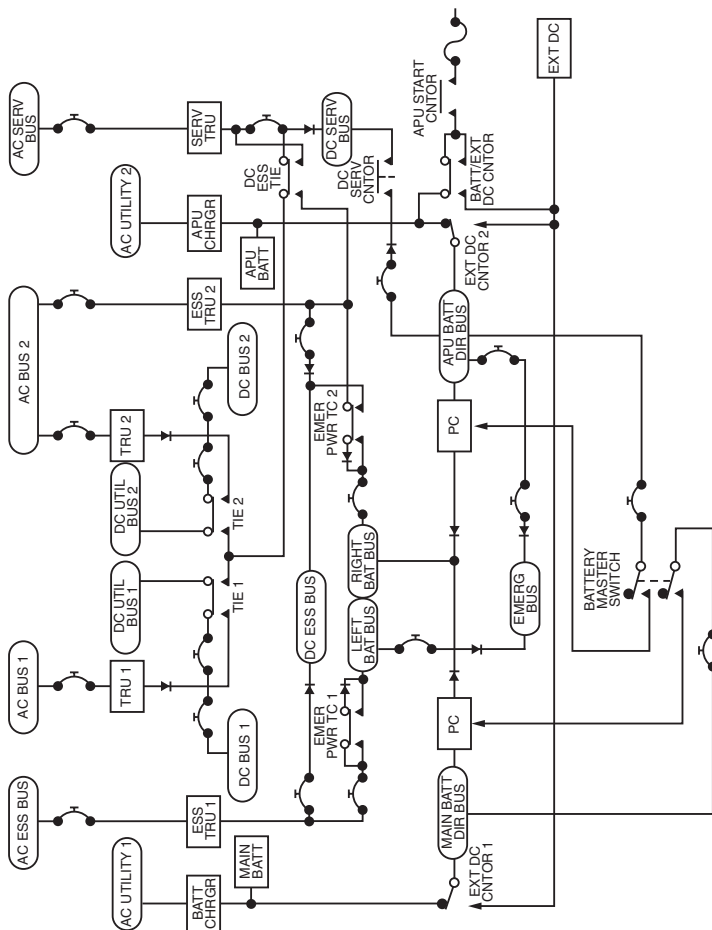


Figure 7-4 DC System Power Application



Battery chargers, powered by the AC utility buses, maintain the main and APU batteries in a charged condition. The main airplane battery and the APU battery are bridged during a complete AC system failure (GEN 1, GEN 2, and APU GEN failure).

Emergency electrical DC power is available on the following buses:

- DC essential bus
- Left and right battery bus
- APU battery-direct bus
- Main battery-direct bus

Electrical system warnings and cautions are presented on the EICAS primary display. Status and advisory messages are presented on the EICAS secondary display. General views of airplane electrical systems (AC or DC) are presented through synoptic diagrams on the EICAS secondary display.

The DC electrical page is accessed through a double push of the ELEC key on the EICAS control panel. It displays the following:

- Digital readouts of TRU and battery output (voltage and ampere output)
- Input/output flow on the bus bars
- General status information via color logic
- System messages

DC Generation System

Five 100-ampere, transformer rectifier units (TRU) convert the AC supply to 28 VDC and power the airplane's DC buses. Distribution for the TRUs and AC and DC buses are shown in Table 7-5.



Table 7-5 TRU AND AC/DC BUS DISTRIBUTION

INPUT BUS	TRU	OUTPUT BUS
AC essential	Essential TRU 1	DC essential DC battery bus (L)
AC bus 1	TRU 1	DC bus 1 DC utility bus 1
AC bus 2	TRU 2	DC bus 2 DC utility bus 2
	Essential TRU 2	DC essential bus DC battery bus (R)
AC service bus	Service TRU	DC service bus

Flight compartment indications of TRU failures are as follows:

- ESS TRU 1 caution message—Output less than 18 VDC
- ESS TRU 2 caution message—Output less than 18 VDC
- Bus caution message (DC ESS BUS, BATTERY BUS, DC BUS 1 and 2, and DC SERV BUS)

The DC essential bus and the No.1 and No. 2 DC buses can be cross tied by operating the appropriate bus-tie switchlights. Two 24-VDC batteries (main and APU) connect through their battery-direct buses (main battery-direct bus and APU battery-direct bus) to the DC battery buses (left and right). This connection is dependent upon the following conditions:

- BATTERY MASTER switch ON
- Airplane airborne with no AC generator operating
- ADG deployed



DC Battery System

Battery charge control is automatic and starts when the battery voltage decreases to 26 VDC. When the battery is fully charged the charger shuts off. The charger monitors the battery voltage and temperature to control the charge current and prevent a battery overheat or thermal runaway.

Application of Power to the Battery System During In-Flight Operations

Normal Operation

During normal operation when the BATTERY MASTER switch is set to ON, the main and APU batteries supplies 24-VDC power to the main and APU battery-direct buses. The main and APU batteries can also power the following buses:

- Left and right battery buses
- Emergency bus
- DC essential bus

Emergency Operation

During emergency operation, the air-driven generator is lowered into the airstream. When this occurs, DC emergency power-tie contactors 1 and 2 energize. This permits the essential DC bus, APU bus, and main battery bus to tie together.



Application of External Power to the Battery System

Connecting external DC power to the aircraft energizes the external DC contactor. This automatically disconnects the main and APU batteries from the battery-direct buses.

DC System Components

Transformer-Rectifier Units

There are five TRUs in the forward electronics compartment:

- TRU 1
- TRU 2
- ESS TRU
- ESS TRU 2
- SERV TRU

Bus-Tie Contactors

There are three bus-tie contactors in the ELECTRICAL POWER SERVICES panel designated:

- TIE 1
- TIE 2
- ESS TIE

Under normal conditions, the tie contactors are controlled by bus sensing relays. The TIE 1 and TIE 2 contactors automatically close the respective tie if power is lost on a bus. They can also be operated manually by switches on the ELECTRICAL POWER SERVICES PANEL. The ESS TIE can only be closed manually.



Bus-Sensing Relays

The bus-sensing relays monitor TRU output and control tie contactor operation.

Main Battery

The main battery provides 24-VDC power to the main battery-direct bus. During emergency conditions, the main battery also supplies DC power to the following buses:

- Left and right battery bus
- Emergency DC bus
- DC essential bus

The main battery is charged by a charging system supplied from the No. 1 AC utility bus. Charging is automatically shutoff if a main battery fault is detected and MAIN BAT CHGR appears on an EICAS display.

APU Battery

The 24-volt APU battery provides power to start the APU when the AC generator (IDG) or ground power is not available. It supplies power through the APU battery-direct bus to the left and right battery busses, emergency DC bus, or DC service bus through the DC distribution system.

During emergency conditions the APU battery also supplies DC power to the following:

- Left and right battery busses
- Emergency DC bus.
- DC essential bus



APU battery charging is supplied from the No. 2 AC utility bus. Battery charging is automatically shutoff if a battery fault is detected and APU BATT CHGR appears on an EICAS display.

DC Ground-Power Receptacle

The DC ground power receptacle (Figure 7-5) is on the right side of the aircraft, adjacent to the batteries in the tail section. Ground power through the receptacle is controlled by the DC switchlight on the ELECTRICAL POWER SERVICES panel and supplies 28 VDC to both battery-direct buses.

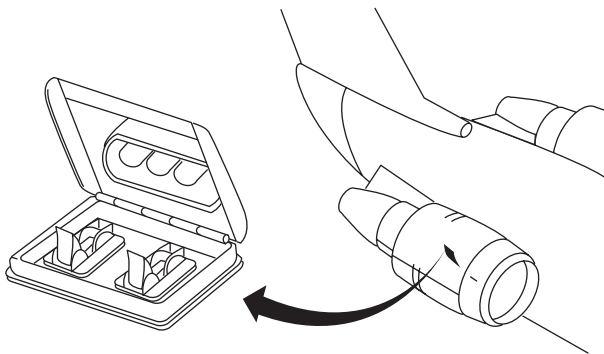


Figure 7-5 DC Ground-Power Receptacle

EMERGENCY AC AND DC SYSTEM

During normal operation:

- The AC essential bus receives 3-phase AC power from the No. 1 AC bus.
- The DC essential bus receives power from essential TRU 1 (on AC essential bus) and essential TRU 2 (on the No. 2 AC bus).



The loss of power from the left engine's generator (No. 1 AC bus) automatically transfers the AC essential bus to the right engine's generator (No. 2 AC bus). Manual control over essential bus load transfer is provided through the AC ESS XFER switchlight. With the loss of power from one or both engine generators, the APU generator can supply both buses.

During a complete loss of AC power, the ADG auto-deploys, powering the AC essential bus and hydraulic pump. The ADG deploy system monitors the three main AC generators and the main AC buses for a complete AC power failure. If a complete power failure occurs, an ADG uplock and release unit automatically deploys the ADG (ram-air turbine and generator) into the airstream. If the auto-deploy feature fails, the cable-operated ADG PULL handle manually releases the uplock and deploys the ADG. During total ADG failure, operating the manual deployment handle enables the Main and APU battery-direct buses to supply the DC essential bus. On the ground, when the parking brake is set, AGD automatic deploy is inhibited.

The airplane main battery and APU battery provide emergency DC power if the battery master switch is at ON and the airplane has lost AC power (ADG deployed). The DC battery bus (left and right portions) are then powered from both the main battery-direct bus and the APU battery-direct bus. This provides battery power to essential airplane systems for approximately 30 minutes.

NOTE

The battery is automatically connected to the battery bus should ESS TRU 1 and ESS TRU 2 fail.

DC Emergency Bus

The DC emergency bus is powered directly by the APU battery bus and left battery bus. The DC emergency bus load distribution is as follows:

- No. 1 fire extinguisher (left and right engine)
- No. 2 fire extinguisher (left and right engine)



- APU fire extinguisher (squib 1 and 2)
- Fuel-shutoff valves (left and right engine and APU)
- Hydraulic shutoff valves (left and right engine)

Battery Charging

The main battery charger and APU battery charger are in a charging configuration at all times when the battery master switch is on and the applicable AC utility bus is powered as follows:

- 115-volt to the No. 1 AC utility bus for the main battery charger
- 115-volt to the No. 2 AC utility bus for the APU battery charger

NOTE

In flight, both chargers are shed during single generator operations. On the ground, both chargers are shed if external power is connected and flaps more than 0°, and the passenger and service doors are locked.

EXTERNAL POWER

External AC power, supplied through the AC receptacle in the forward part of the airplane, provides power to the airplane as shown in Table 7-6.

Table 7-6 EXTERNAL POWER DISTRIBUTION

MAIN BUS CONFIGURATION	GROUND SERVICE CONFIGURATION
No.1 AC bus No.2 AC bus AC service bus No. 1 and No. 2 AC utility bus (with WOW and flaps at 0°)	AC service bus No. 1 and No. 2 AC utility bus

External DC power, through the receptacle at the right engine pylon, supplies the APU battery-direct bus, main battery-direct bus, and left and right battery bus. External DC power can start the APU. The



main airplane and APU batteries cannot be charged through external DC power. External power is controlled by the EXT DC switchlight on the ELECTRICAL POWER SERVICES panel.

CONTROLS AND INDICATIONS

ELECTRICAL POWER SERVICES PANEL

DC SERVICE Switch

This ON–OFF switch (Figure 7-6) controls power to the DC service bus.

BATTERY MASTER Switch

This ON–OFF switch connects the main battery and APU battery to battery bus.

DC External Power Switchlight

AVAIL—This green light element illuminates if DC power polarity and voltage is correct.

IN USE—This white light element illuminates if external DC power is supplying the APU and main battery-direct buses.

AC External Power Switchlight

AVAIL—This green light element illuminates if external power phase, voltage, and frequency are correct.

IN USE—This white light element illuminates if external power is supplying the AC buses.

IDG 1/2 DISC Switchlights

FAULT—This amber light illuminates if the respective IDG mal-functions (low oil pressure or high oil temperature).

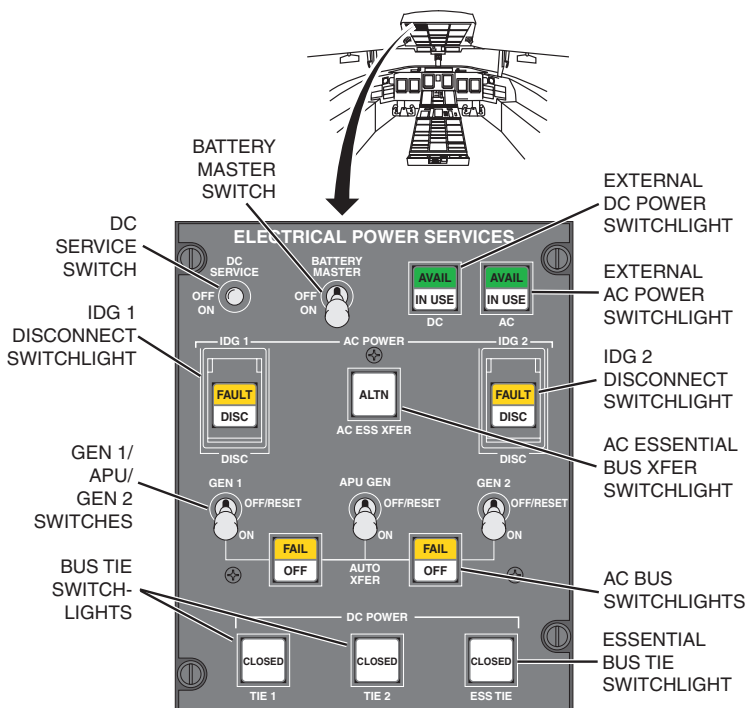


Figure 7-6 Electrical Power Service Panel

DISC—Pressing the switchlight disconnects the respective IDG from the engine accessory drive. The white DISC light then illuminates. Once disconnected, the IDG cannot be reset in flight or on the ground with the engines running.

AC POWER AC ESS XFER Switchlight

The switchlight illuminates white when a manual or automatic power transfer of the essential AC bus occurs. Manual transfer is accomplished by pushing the switchlight. The resulting essential bus power source is shown by a flow line from the available power source on the EICAS AC ELECTRICAL synoptic page.



Cycling the switchlight again removes power from the essential AC bus if previously accomplished by manual selection.

GEN 1/2/APU Switches

ON—This switch connects the respective generator to the airplane bus, provided all conditions are satisfactory.

OFF/RESET—This switch disconnects the respective generator from the airplane bus or rearms the generator control circuit.

CAUTION

Do not operate the passenger door during power switching (APU GEN to external power).

NOTE

After a generator reset, intermittent failure of the air-data systems may occur. These failures may result in uncommanded changes to the flight instruments. Flight crews should check/reset the barometric altimeter setting, altitude preselector, Vspeed, and speed bug settings after every generator switching event.

AC AUTO XFER Switchlights

FAIL—This amber light illuminates if an AC bus fault or a generator overcurrent condition occurs.

OFF—When pressed, automatic bus tie disabled. The white OFF light then illuminates. When pressed again, the switchlight enables bus transfer operation.

DC POWER TIE 1/2 CLOSED Switchlight

The white CLOSED light illuminates when the corresponding tie is closed. The respective tie is manually closed by pressing this switchlight.



DC POWER ESS TIE CLOSED Switchlight

This switchlight controls the essential DC bus tie. When pressed, the white CLOSED light illuminates when the tie closes. There is no automatic closing of this tie.

ADG AUTO DEPLOY CONTROL PANEL

LAMP UNIT Switch

This switch (Figure 7-7) facilitates testing of the panel and indicator light.

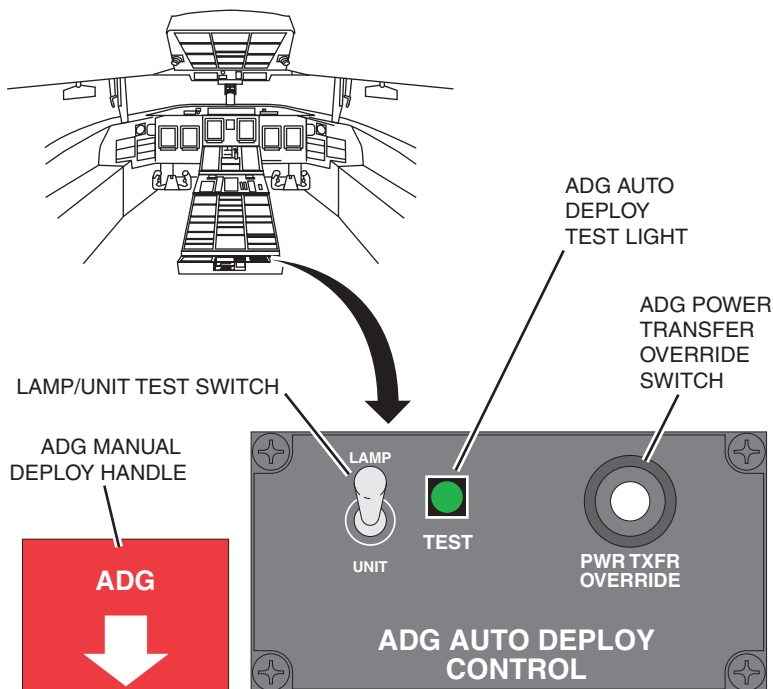


Figure 7-7 ADG Controls



LAMP—This switch position tests the TEST light and WOW circuit.

UNIT—This switch position tests continuity of the ADG autocontrol release system and related control circuit.

NOTE

The UNIT test can only be done with two generators selected ON and both AC buses powered.

ADG AUTO DEPLOY TEST Light

The green TEST light illuminates when the tests performed with the LAMP-UNIT switch in the UNIT position are correct.

PWR TXFR OVERRIDE Switch

When pressed, this switch removes ADG power to the AC essential bus when power is restored to AC bus 1 or 2.

ADG Manual Deploy Handle

Pulling the handle manually deploys the ADG.

NOTE

When aircraft speed is reduced and ADG output is below limits, the battery bus will power the essential DC bus.

FLIGHT ATTENDANT PANEL

APU SERVICE BUS Switchlight

ON—The switchlight (Figure 7-8) illuminates ON and the APU generator is connected to the AC service bus.

OFF—The switchlight illuminates OFF and the APU generator is disconnected from the AC service bus.

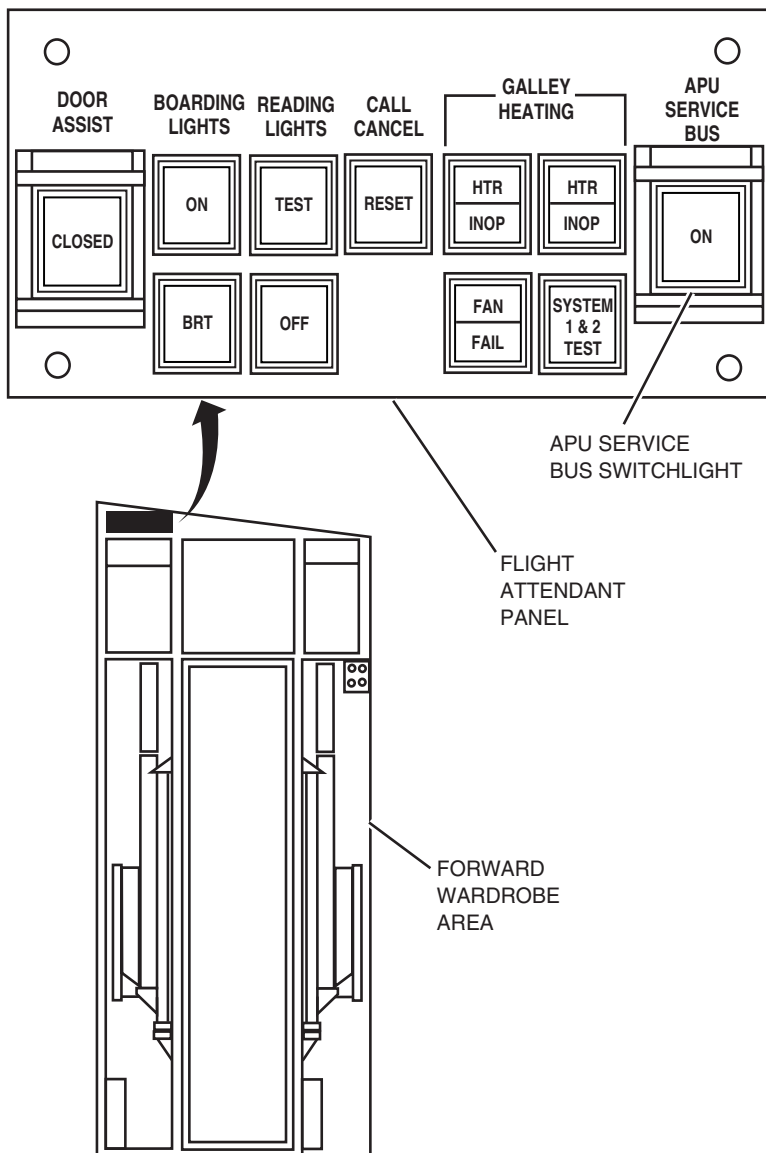


Figure 7-8 Flight Attendant Panel



EXTERNAL SERVICE PANEL

EXT AC PUSH Switchlight

AVAIL—The green AVAIL light (Figure 7-9) illuminates when the connected AC power phase, voltage, and frequency are correct.

IN USE—The white IN USE switchlight indicates external AC power is supplied to the airplane.

APU SHUT-OFF switch—This red switch is used to shutdown the APU during ground servicing.

BATT ON indicator light—This amber indicator light indicates the BATTERY MASTER switch is ON.

LAMP TEST switch—This switch tests the external service panel lights.

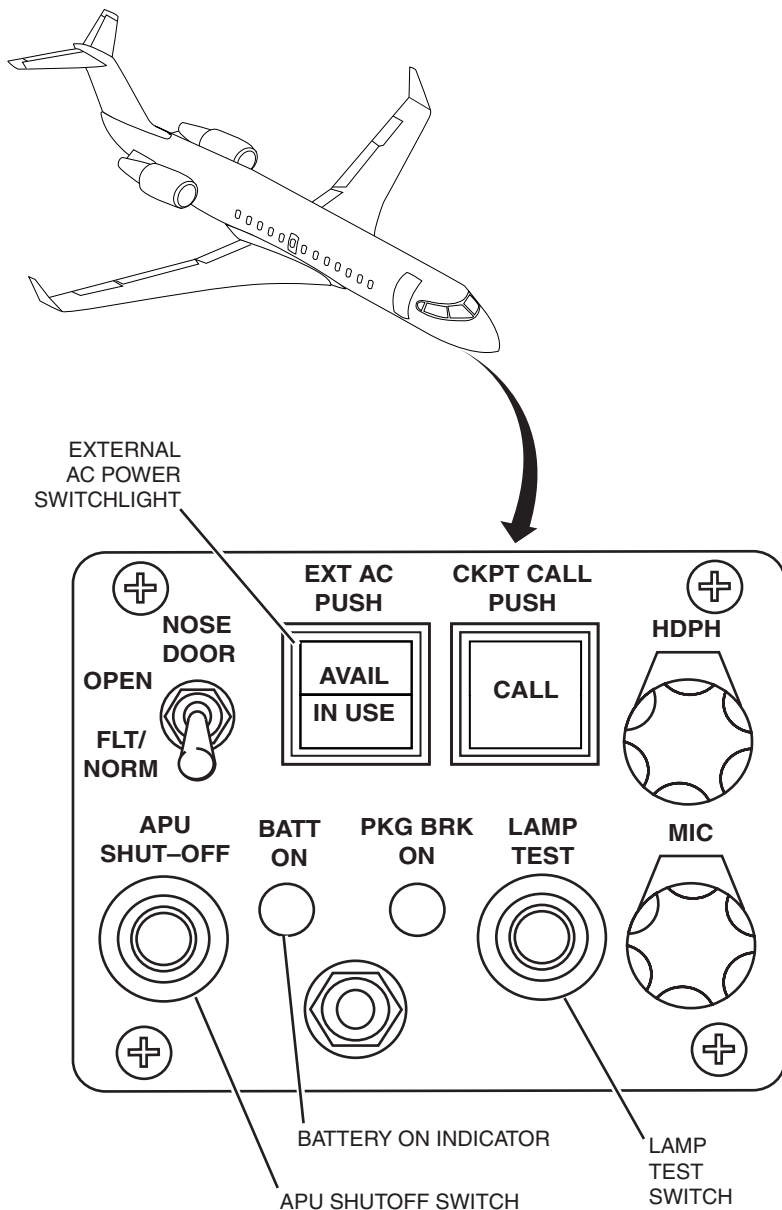


Figure 7-9 External Service Panel



EICAS PRIMARY DISPLAY—PRIMARY PAGE

Warning Message

EMER PWR ONLY

This red warning message (Figure 7-10) indicates the ADG has deployed.

Caution Messages

AC 1/2 AUTOXFER

The amber AC 1/2 AUTOXFER caution messages indicate the corresponding automatic bus transfer failed. The message is accompanied by illumination of the associated AUTOXFER FAIL light on the ELECTRICAL POWER SERVICE panel.

AC BUS 1/2

These amber caution messages indicate the associated bus is not powered.

AC ESS BUS

The amber AC ESS BUS caution message indicates the AC essential bus is inoperative.

NOTE

With the ADG deployed, the AC ESS BUS is powered; however, AC ESS BUS caution messages may be displayed intermittently.

AC SERV BUS

This amber caution message indicates the AC service bus is not powered.

APU BATT OFF

This amber caution message indicates the APU battery voltage is less than 18 VDC.

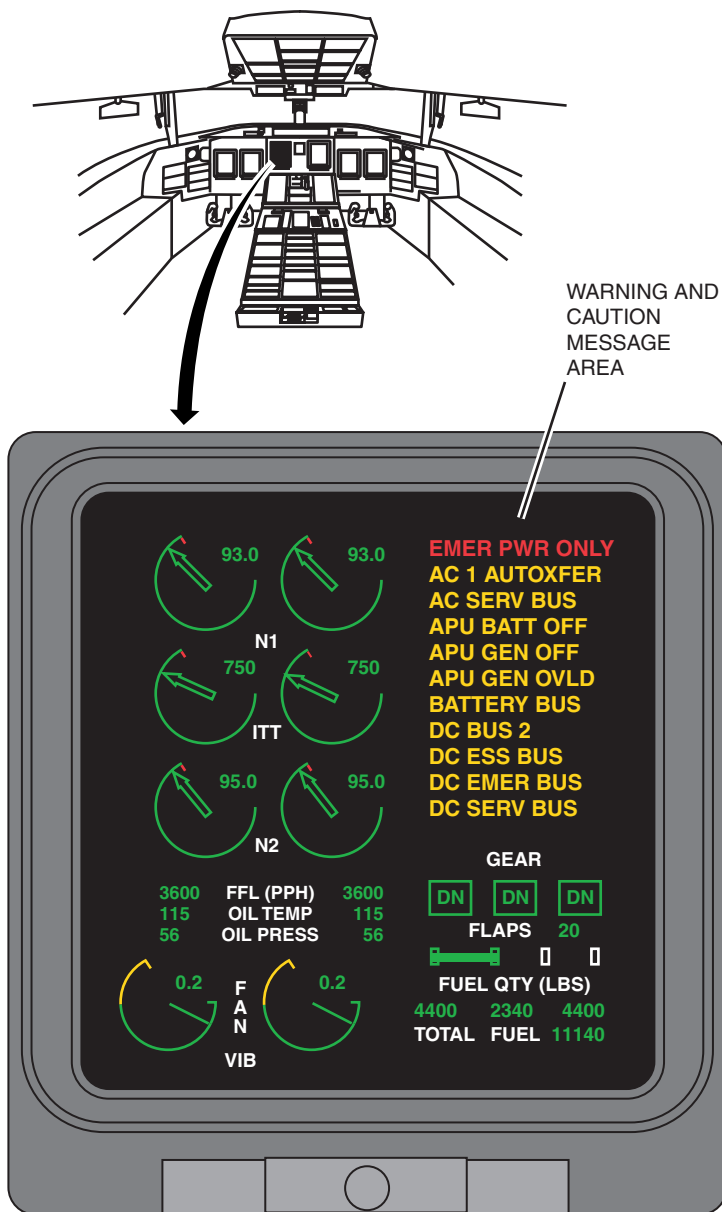


Figure 7-10 EICAS Primary Display—Primary Page



APU GEN OFF

The amber APU GEN OFF caution message indicates the APU generator is off.

NOTE

During ground operations, switching power from the APU to the No. 2 engine generator, and vice versa, causes a momentary loss of the No. 2 DC bus, which disengages the No. 2 yaw damper. To reengage the yaw damper, wait 30 seconds with the airplane stationary, then press the YD 2 switchlight.

APU GEN OVLD

This amber caution light comes on to indicate the generator control unit has detected an overload.

BATTERY BUS

The amber BATTERY BUS caution message comes on to indicate the left or right portion of the battery bus is not powered.

DC BUS 1/2

This amber caution message comes on to indicate the corresponding DC bus is not powered with either the No. 1 or No. 2 AC bus on line.

DC ESS BUS

The amber DC ESS BUS message indicates the DC essential bus is not powered. Both AC buses or both essential TRUs are failed.

DC EMER BUS

This amber caution message indicates the DC emergency bus is not being powered.



DC SERV BUS

The amber DC SERV BUS caution message indicates the DC service bus is not powered with either the No.1 or No. 2 AC bus on line.

ESS TRU1/2

These amber caution messages indicate the respective essential TRU voltage is less than 18 VDC, with the AC essential bus not failed.

GEN 1/2 OVLD

The amber GEN 1/2 OVLD caution messages indicate the respective generator-control unit detected an overload.

GEN 1/2 OFF

These amber caution messages indicate the respective generator is off.

IDG 1/2

The amber IDG 1/2 caution messages indicate the respective IDG has low oil pressure or excessive oil temperature.

MAIN BATT OFF

The amber MAIN BATT OFF caution message indicates the main battery is at less than 18 VDC.



EICAS SECONDARY DISPLAY—STATUS PAGE

Status Messages

AC ESS ALTN

This white status message indicates the AC essential bus has transferred to the alternate (automatically or manually) (Figure 7-11).

AC UTIL 1/2 OFF

The white AC UTIL 1/2 OFF status messages indicate the corresponding AC utility bus is not powered.

AC 1/2 AUTOXFER OFF

These white status messages indicate that transfer to the corresponding AC bus is inhibited.

APU BATT CHGR

The white APU BATT CHGR caution message indicates an APU battery charger fault. The message also comes on as part of the power-up self-test after the AC utility bus 2 comes on line.

DC BUS TIE 1/2

The white DC TIE 1/2 CLSD status messages indicate the corresponding ELECTRICAL POWER SERVICE panel TIE 1 or TIE 2 switchlight is positioned to CLOSED.

ESS DC TIE

This white status message indicates the ELECTRICAL POWER SERVICE panel ESS TIE switchlight is position to CLOSED.

IDG 1/2 DISC

These white status messages indicate the respective IDG is disconnected.

MAIN BATT CHGR

This white status message indicates shutdown of the main battery charger. This message also comes on as part of the power-up self-test after the No.1 AC utility bus comes on line.

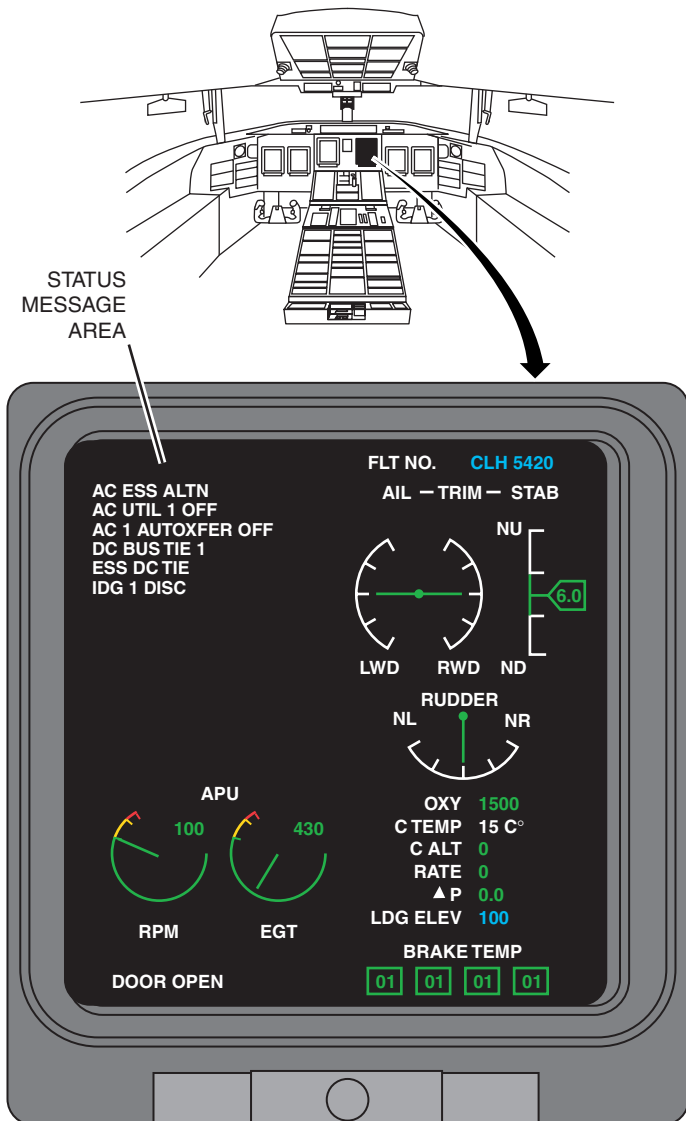


Figure 7-11 EICAS Secondary Display—Status Page



EICAS Secondary Display—AC Electrical Synoptic Page

Generator 1/2 Output Line (Upper)

Green—A green line (Figure 7-12) indicates the generator line contactor is closed.

Blank—A blank line indicates the generator line contactor is open.

Generator 1/2 Load, Voltage, and Frequency Readouts

Load displays in kVA. Voltage displays VAC. Frequency displays in Hz.

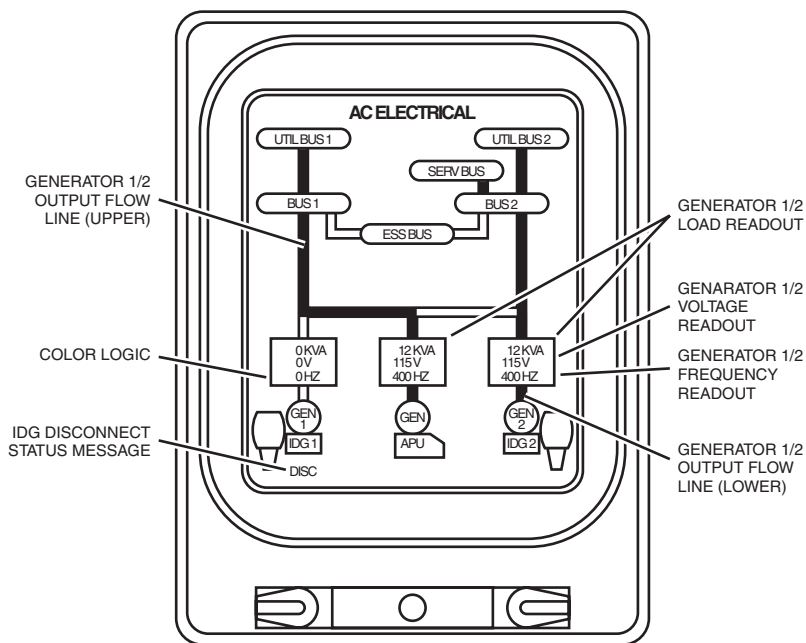


Figure 7-12 EICAS Secondary Display—
AC ELECTRICAL Page (1 of 4)



Generator 1/2 Output Line (Lower)

Green—A green line indicates the generator is on line.

Blank—A blank line indicates the generator is off line.

Utility Bus 1/2 SHED Message

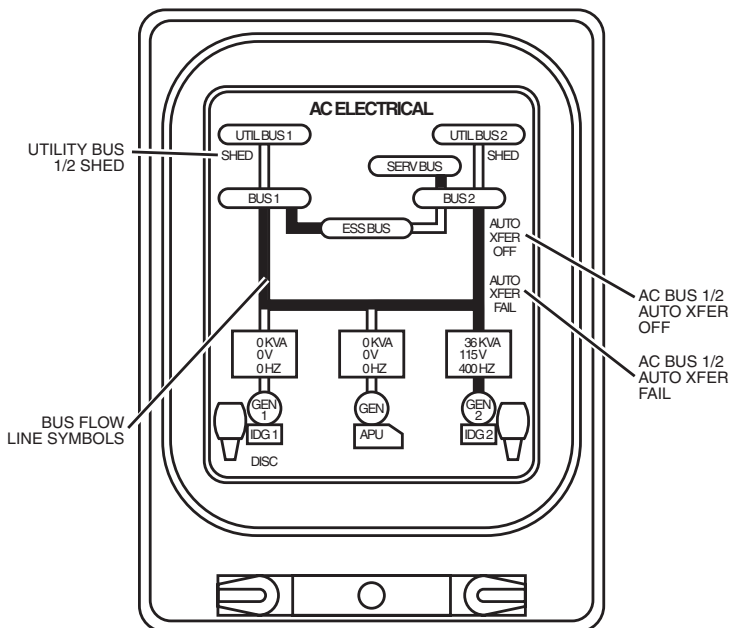
This white status message indicates the corresponding utility bus has automatically shed from the electrical system (corresponding DC BUS TIE switchlight comes on CLOSED).

NOTE

SHED also comes on when single generator on-line (airborne) or single generator on-line and flaps out of zero detent (on ground).

AC Bus Flow Line Symbols:

- Green—Bus is energized
- Blank—Bus has been deenergized



**Figure 7-12 EICAS Secondary Display—
AC ELECTRICAL Page (2 of 4)**



AC BUS 1/2 AUTO XFER OFF Message

This white status message indicates the corresponding ELECTRICAL POWER SERVICE panel AUTO XFER switchlight is selected to OFF.

AC BUS 1/2 XFER FAIL

Message—Comes on to indicate that the corresponding automatic bus tie contactor has failed

Color Logic

The color logic for the presented information is shown in Table 7-7.

Table 7-7 ELECTRICAL PAGE COLOR LOGIC

EICAS READOUT /OUTLINE	GREEN	AMBER	WHITE	HALF-INTENSITY MAGENTA	AMBER ---	HALF-INTENSITY CYAN
XXX KVA	Gen loaded	Gen over-loaded	Gen not on line	Invalid data		
XX V	100 to 125 VAC		≤ 100 VAC or ≥ 125 VAC		Invalid data	
XX HZ	375 to 425 Hz		≥ 375 Hz or ≤ 425 Hz		Invalid data	
	Gen on	Gen off with engine or APU running	Gen and engine off	Invalid data		



Table 7-7 ELECTRICAL PAGE COLOR LOGIC (Cont)

EICAS READOUT /OUTLINE	GREEN	AMBER	WHITE	HALF- INTENSITY MAGENTA	AMBER ---	HALF- INTENSITY CYAN
	CSD on	Fault. Low oil press or high oil temp	IDG and Engine off	Invalid data		
			Engine off	Invalid data		Engine running and ready to load
			APU off	Invalid data		APU running and ready to load

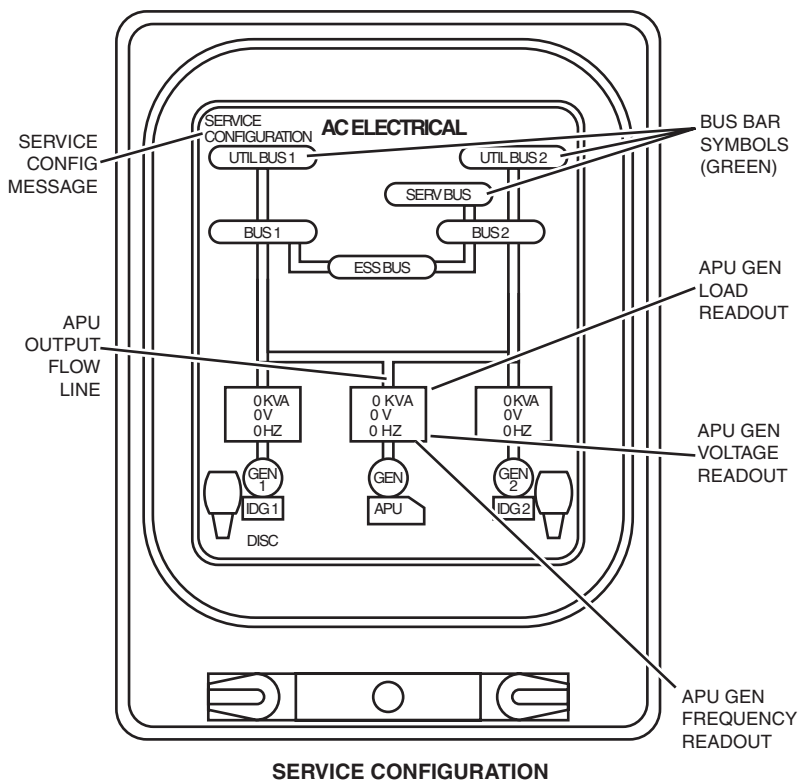


AC Bus Bar Outlines

See Table 7-8.

Table 7-8 AC BUS BAR OUTLINE COLOR CODES

BUS BAR	GREEN	AMBER	WHITE	HALF-INTENSITY MAGENTA
BUS 1	Powered (gen line contactor 1)	Bus fault	Not powered	Invalid data
BUS 2	Powered (gen line contactor 2)	Bus fault	Not powered	Invalid data
ESS BUS	Powered	Inoperative (essential bus fail)		Invalid data
SERV BUS	Powered	Inoperative AC service bus fail)		Invalid data
UTIL BUS 1	Powered		Not powered (shed)	Invalid data
UTIL BUS 2	Powered		Not powered (shed)	Invalid data



**Figure 7-12 EICAS Secondary Display—
AC ELECTRICAL Page (3 of 4)**

APU Generator Output Flow Line (Upper)

Green—The generator line contactor is closed.

Blank—The APU generator is open.

APU Generator Output Flow Line (Lower)

The flow line displays in green when the APU is on line.



SERVICE CONFIGURATION Message

This message appears if the APU is available, but no power source is selected, and the APU SERVICE BUS switchlight on the attendant's forward miscellaneous panel is pressed in (ON). The AC service buses, DC service buses, and AC utility buses are powered (Figure 7-12, 3 of 4).

Bus Bar Symbols (Service Configuration)

Green—The APU is connected to the service bus and both utility buses.

Blank—The buses are not energized.

APU Generator Load, Voltage, and Frequency Readouts

Load displays in kVA. Voltage displays in VAC. Frequency displays in Hz.

External AC Outline

The outline displays in green when the connected external AC is correct.

External Voltage Readout

Green—Voltage is correct.

White—Voltage is too low or too high.

External AC Input Outline

Green—External AC is available.

White—External AC is in use.

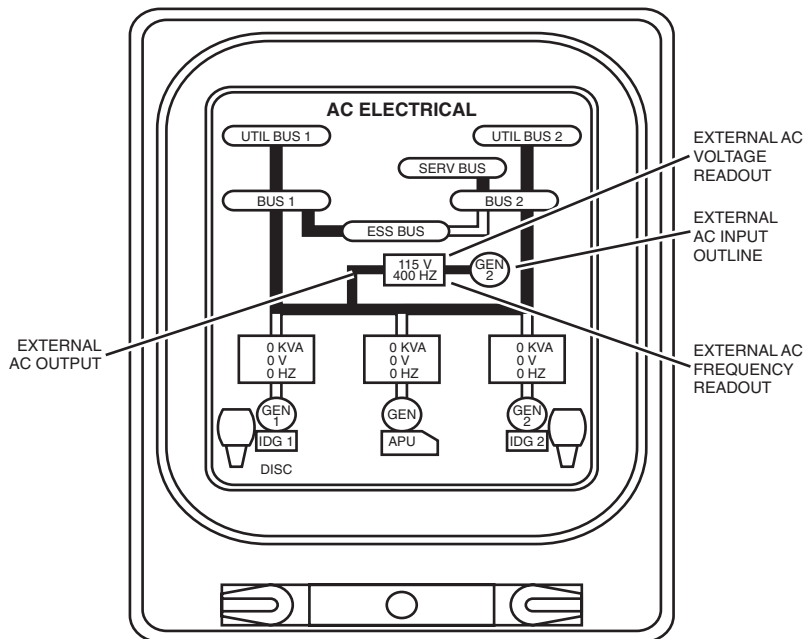


Figure 7-12 EICAS Secondary Display—AC ELECTRICAL
Page (4 of 4)

External AC Frequency Readout

Green—Frequency is correct.

White—Frequency is too low or too high.



EICAS Secondary Display—DC Electrical Page

EMERG BUS Outline

Green—The bus (Figure 7-13) is only powered by the battery bus or APU battery direct bus.

Amber—The bus is not powered.

NOTE

During normal operation, when the DC emergency bus is powered by the battery bus and the APU battery direct bus, the DC EMERG BUS outline and respective flow lines are not displayed.

EMERG BUS Flow Lines

Green—The EMERG BUS is powered.

White—The EMERG BUS *is not* powered through the indicated flow line.

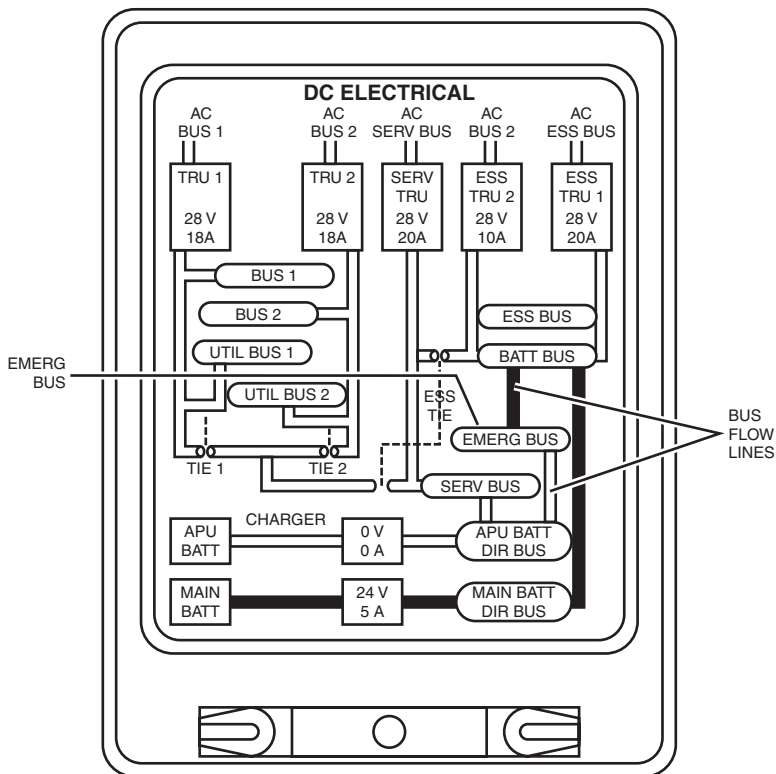


Figure 7-13 EICAS Secondary Display—DC ELECTRICAL
Page (1 of 4)



DC Bus Bar Outlines

DC bus bar flow line are shown in Table 7-9.

Table 7-9 DC BUS BAR OUTLINES

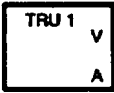
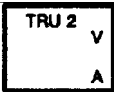
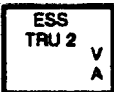
BUS BAR OUTLINE	GREEN	AMBER	WHITE	HALF-INTENSITY MAGENTA
BUS 1/2	Bus powered	Bus fault	Bus not powered	Invalid data
UTIL BUS 1/2	Bus powered		Bus not powered	Invalid data
ESS BUS	Bus powered	Bus fault	Bus not powered	Invalid data
BATT BUS	Bus powered	Bus fault	Bus not powered	Invalid data
SERV BUS	Bus powered	Bus fault	Bus not powered	Invalid data
APU BATT DIR BUS	Battery ≥ 18 VDC	Battery ≤ 18 VDC		Invalid data
MAIN BATT DIR BUS	Battery ≥ 18 VDC	Battery ≤ 18 VDC		Invalid data
	Battery ≥ 18 VDC	Battery < 18 VDC	External DC in use	Invalid data
	Battery ≥ 18 VDC	Battery < 18 VDC	External DC in use	Invalid data
 (Batt direct bus status)	Always displayed between 18 VDC and 32 VDC		≤ 18 VDC or ≥ 32 VDC	



TRU Digital Readouts and Outlines

TRU digital readout and bus bar outline information is shown in Table 7-10.

Table 7-10 TRU DIGITAL READOUTS AND OUTLINES

READOUT/ OUTLINE	GREEN	WHITE	AMBER	HALF- INTENSITY MAGENTA
XX V	Between 22 and 29 VDC	≤ 22 VDC or ≥ 29 VDC	Invalid data (amber dashes)	
XX A	Between 3 and 99 amps	≤ 3 amps or ≥ 99 amps	Invalid data (amber dashes)	
	≥ 18 VDC	< 18 VDC	TRU failure	Invalid data
	≥ 18 VDC	< 18 VDC	TRU failure	Invalid data
	≥ 18 VDC, load ≥ 2 amps	< 18 VDC, load < 2 amps	TRU failure	Invalid data
	≥ 18 VDC, load ≥ 3 amp	< 18 VDC, load 3 amp	TRU failure	Invalid data
	≥ 18 VDC, load ≥ 3 amp	< 18 VDC, load amp	TRU failure	Invalid data

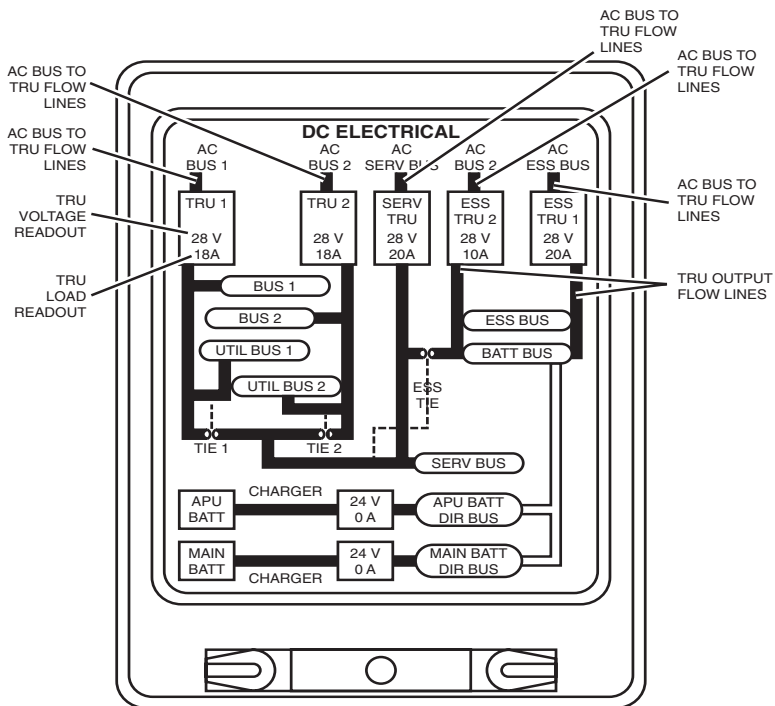


Figure 7-13 EICAS Secondary Display—DC ELECTRICAL
Page (2 of 4)

TRU Voltage and Load Readouts

TRU voltage displays in 1-volt increments. TRU load displays in 1-amp increments.

AC BUS Flow Line

When displayed in green, the bus is powering the TRU.

TRU Output Flow Lines

When displayed in green, the respective bus is on line.

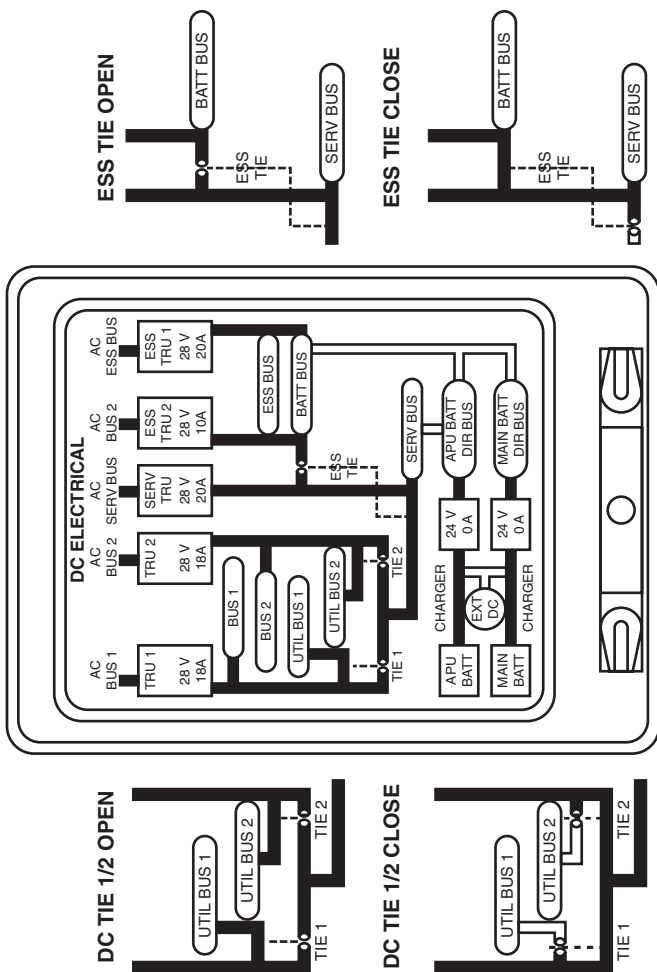


Figure 7-13 EICAS Secondary Page—DC ELECTRICAL
Page (3 of 4)



External DC Flow Line

The line displays with external DC power in use.

SERV BUS Bus Bar

The bus bar displays with external DC power connected to the DC service bus.

NOTE

The DC SERVICE switch must be selected OFF prior to selecting the BATTERY MASTER switch to OFF.

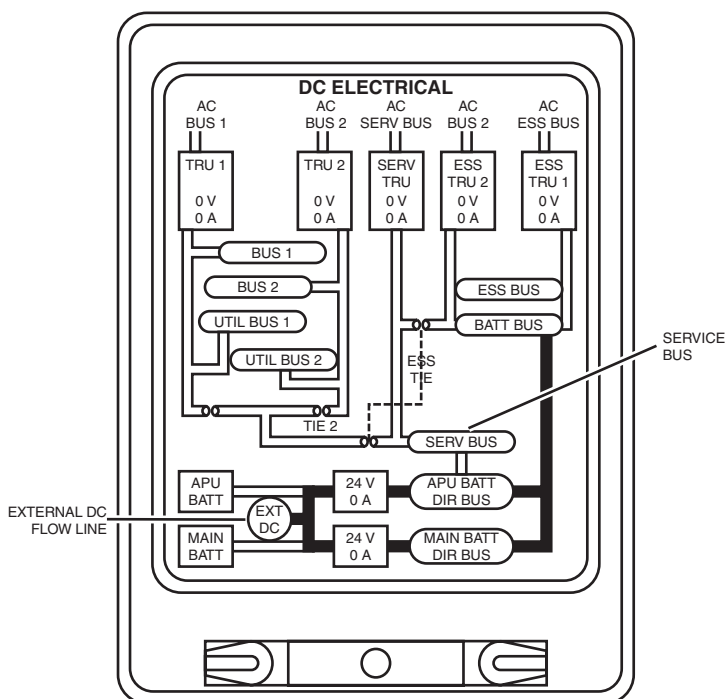


Figure 7-13 EICAS Secondary Display—DC ELECTRICAL
Page (4 of 4)



CIRCUIT BREAKERS

Electrical system flight deck circuit-breaker panels are in Figure 7-14.

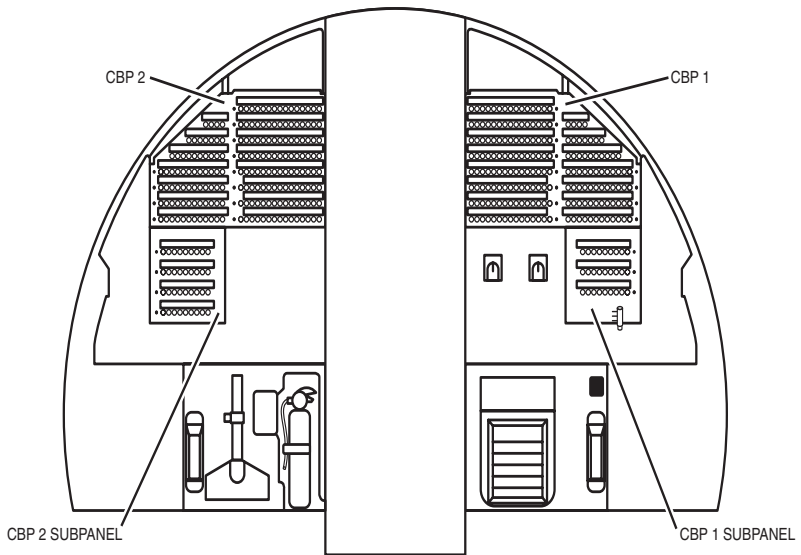


Figure 7-14 Flight Deck Circuit-Breaker Panel Locations (1 of 2)

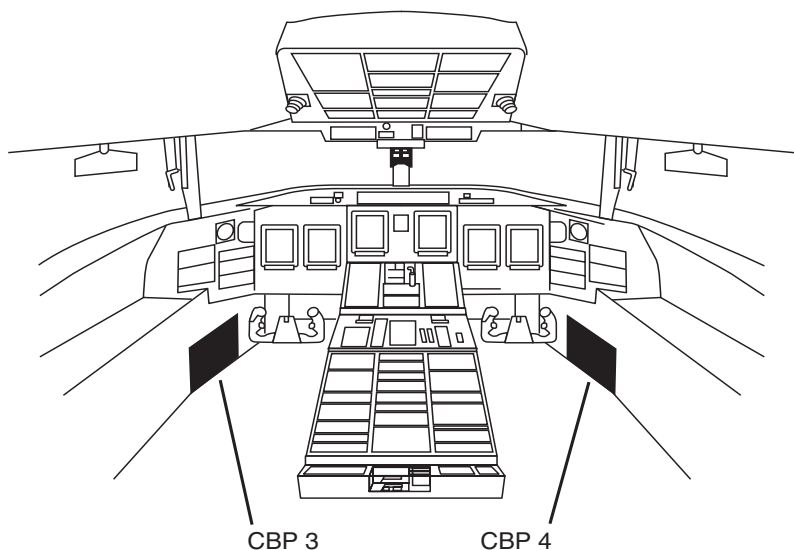


Figure 7-14 Flight Deck Circuit-Breaker Panel Locations (2 of 2)



POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY

The power supply and circuit-breaker summary is shown in Table 7-11.

**Table 7-11 POWER SUPPLY AND CIRCUIT-BREAKER
SUMMARY**

SYSTEM	SUB-SYSTEM	CB	BUS BAR	CB PANEL	LOCATION
AC distribution	IDG	IDG 1 DISC	DC BAT	1	P9
		IDG 2 DISC			P10
	GCU	GCU 1			Q10
		GCU 2			Q11
		GCU 3			Q12
		ADG AUTO	APU BAT DIR BUS	5	B10
		ADG MAN			B11
		ADG AUTO DEPLOY	DC BAT	2	N6
		ADG MAN DEPLOY			N7
		ADG DEPLOY SENS	AC BUS 1	1	C10
		STBY PWR CONT	MAIN BAT DIR	5	A7



Table 7-11 POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY (Cont)

SYSTEM	SUB-SYSTEM	CB	BUS BAR	CB PANEL	LOCATION
AC distribution	AC essential bus	AC ESS FEED	ADG BUS	3	A8
		AC ESS FEED	AC BUS 1	1	C2
		ESS PWR CONT	APU BAT DIR	5	B13
		ESS AC XFER CONT	DC BAT	1	Q9
	AC utility bus 1	AC UTIL BUS FEED	AC UTIL 1		E2
		PWR SENS			E7
		AC UTILITY BUS CONT	DC BUS 2		J4
	AC utility bus 2	AC UTILITY BUS FEED		2	E2
		AC UTILITY BUS SENS	AC UTIL 2		E7
		AC UTILITY BUS CONT	DC BUS 1		J4
	AC service bus	AC SER BUS FEED	AC SERV		



Table 7-11 POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY (Cont)

SYSTEM	SUB-SYSTEM	CB	BUS BAR	CB PANEL	LOCATION
DC distribution	Battery bus	FEED 1 BAT BUS	DC BAT	2	M5
		FEED 2 BAT BUS	DC BAT		M7
		BAT BUS PWR SENS			M9, M10
	DC tie contactors	DC TIE CONTROL	DC BUS 1	1	E11
			DC BUS 2	2	E11
	TIE AND UTLY	E13			
	DC essential	ESS TRU 1	AC ESS	3	A2
		FEED 1 DC ESS	DC BAT	2	M4
		FEED 2 DC ESS			M6
		ESSTRU PWR 1 SENS	DC ESS		M3
		ESSTRU PWR 2 SENS			M4
		28 VDC ESS SENS		4	B3



Table 7-11 POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY (Cont)

SYSTEM	SUB-SYSTEM	CB	BUS BAR	CB PANEL	LOCATION
DC distribution	DC bus 1	TRU 1	AC BUS1	1	B2
		FEED	DC BUS 1		E12
		DC 1 PWR SENS			E14
		TRU 1 PWR SENS			E15
	DC bus 2	TRU 2	AC BUS 1	2	B2
		FEED	DC BUS 2		E12
		DC 2 PWR SENS			E14
		TRU 2 PWR SENS			E15
	DC utility bus 1	UTILY BUS 1 FEED	DC BUS 1	1	E13
		PWR SENS	DC UTIL 1		L10
	DC utility bus 2	TIE AND UTILY	DC BUS 2	2	E13
		PWR SENS	DC UTIL 2		L10



Table 7-11 POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY (Cont)

SYSTEM	SUB-SYSTEM	CB	BUS BAR	CB PANEL	LOCATION
DC distribution	DC service bus	SERV BUS FEED	APU BAT DIR	5	B3
		BUS FEED	DC SERVICE	2	T5
		SERVICE TRU	AC SERVICE		R5
		PWR SENS/ SERV BUS	DC SERVICE		T6
		PWR SENS/ SERV TRU	DC SERVICE		T7
	DC emergency bus	APU BATT DIRECT FEED	DC EMER BUS	1	S6



Table 7-11 POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY (Cont)

SYSTEM	SUB-SYSTEM	CB	BUS BAR	CB PANEL	LOCATION
Main and APU batteries	APU battery	APU BATT CONT	APU BAT DIR	5	B2
		EMER BUS FEED			B4
		RCCB CONT/ APU BATT		2	M12
		APU CHARGER	AC UTIL 2		E5
	Main battery	MAIN BATT CONT	MAIN BAT DIR	5	A2
		RCCB CONT/ MAIN BATT		2	M11
		MAIN BATT CHARGER	AC UTIL	1	E5



ELECTRICAL DISTRIBUTION

The bus load distribution is shown in Tables 7-12 .

Table 7-12 DC LOADS DISTRIBUTION

DC BUS 1 (CBP-1)	DC BUS 2 (CBP-2)	DC ESSENTIAL BUS (CBP-4)
Spoiler Electronic Unit	Horizontal Stabilizer Trim Control Unit (CH 1)	Horizontal Stabilizer Trim Control Unit (CH 2)
Spoiler Electronic Control System (PWR 1)	Spoiler Electronic Unit (2A)	Spoiler Electronic Unit (1A, 2B)
Heaters, Static (R) and ADS Controller (R)	Spoiler Electronic Control System (PWR 2)	Spoiler Electronic Control System 1–2 (PWR 3)
Cockpit Temperature Control	Clock 2	Heater, Static and ADS Heater Control (L)
Left Windshield Heat Controller	Cabin Temperature Controller and Manual Controller	Cabin Pressure Controllers (1 and 2) and Control Panel
14th-Stage Bleed-Air Isolation and Shutoff Valve (L)	Right Windshield and Window Heater Controller	Left Window Heater Control
10th-Stage Bleed-Air Isolation and Shutoff Valve (L)	14th-Stage Bleed-Air Isolation and Shutoff Valve (R)	10th-Stage Bleed-Air Isolation Valve
Anti-ice Automatic NORM (1)	10th-Stage Bleed-Air Isolation and Shutoff Valve (R)	Bleed-Air Leak Test
Proximity Sensor (Landing Gear Control/Door 1) (Weight-on-Wheels 1)	Anti-ice Automatic NORM (2)	Anti-ice Manual (L) STBY



Table 7-12 DC LOADS DISTRIBUTION (Cont)

DC BUS 1 (CBP-1)	DC BUS 2 (CBP-2)	DC ESSENTIAL BUS (CBP-4)
Lights (Cockpit Floor, Rear anti-collision, Wing Inspection)	Fuel Pump Control (R)	Thrust Reverser (Auto, Stow, 1 and 2)
Maintenance Diagnostic Computer	Proximity Sensor (Landing Gear Control/Door 2) (Weight-on-Wheels 2)	Fuel (Transfer Shutoff Valve and Control)
DME 1	Avionics Cooling (Controller 2, Cockpit Shutoff Valve, Overboard Shutoff Valve)	Oil Pressure (R)
Radio Altimeter	IAPS (AFCS) (Right Fan)	Passenger Door Control
Flight Data Recorder Control	EFIS Control Panel 2	Proximity Sensor (Landing Gear Control)
Weather Radar (Receiver, Transmitter and Control)	Audio Control Panel (Observer's)	Pilot's Floodlights
EICAS Primary Display	ADF 2	Emergency Lights
EICAS Secondary Display	DME 2	EFIS, CRT, Dimming Panel 1
Left Lamp Driver Unit	VHF Nav Radio 2	Avionic Cooling Controller (1)
Bright/Dim Power Supply Unit	VHF Comm Radio 2	Stall Protection (CH R)
Data Loader	PFD 2	DCU 1 (CH A, B)
Flap Control (CH 1)	MFD 2	EFIS Panel 1
Nose Landing Lights	RTU 2	Audio Control Panel (Copilot's)



Table 7-12 DC LOADS DISTRIBUTION (Cont)

DC BUS 1 (CBP-1)	DC BUS 2 (CBP-2)	DC ESSENTIAL BUS (CBP-4)
Brake Temperature Monitor	Air Data Computer (2)	ADC 1
FMS (CDU 1)	ATC Transponder 2	ADF 1
DC Tie Control	Brake Pressure Indicator	VHF Nav Radio (1)
Bus 1 Feed Utility	Anti-Skid	Cockpit Voice Recorder
Bus 1 Feed	Copilot's Wiper (Motor and Control)	PFD 1
DC 1 Power Sensing	Hydraulic System (AC Pump Control 1 and 3A, Indicator 1)	MFD 1
TRU 1 Power Sensing	DC Tie Control	RTU 1
AC Utility Bus Control	Bus 2 Feed Tie and Utility	Clock 1
Left Air Conditioning Unit	DC 2 Power Sensing	ATC Transponder 1
DME (1)	TRU 1 Power Sensing	IAPS (AFCS) (Left Fan)
Smoke Detector	AC Utility Bus Control	
Passenger Signs	Right Air Conditioning Unit	
Overboard Shutoff Valve	Flap Control (CH 2)	
Pilot's Wiper (Motor and Control)	Nose Wheel Steering	



Table 7-12 DC LOADS DISTRIBUTION (Cont)

DC BUS 1 (CBP-1)	DC BUS 2 (CBP-2)	DC ESSENTIAL BUS (CBP-4)
Anti-Skid	Clock 2	
GPS (1)	Lights (Copilot's Map and Wing Anti-Collision)	
Hydraulic System (AC Pump Control 2 and 3B, Fan Control, Indicator 2)		

BATTERY BUS (CBP-1)	BATTERY BUS (CBP-2)
Passenger Oxygen (Manual Deploy and Left Passengers)	Clock 1
Fuel System Control	Ram Air Shutoff Valve
Left Fuel Pump (Control and Power)	CPAM
Fuel X-Feed Control	Crew Oxygen Monitor
Left Engine Oil Pressure	Passenger Oxygen (Auto Deploy and Right Passengers)
Passenger Address	Anti-ice Valves (L and R Manual 2)
Lights (Standby Instrument and Compass, Map Dome, Chart Holder, Overhead and Copilot's Flood)	Proximity Sensor (Landing Gear Control/Door 1 and 2) (Weight-on-Wheels 1 and 2)
Fire Detector (A,B, Test)	EICAS Control Panel
Passenger Signs	DCU 1 and 2 (CH A and B)
EICAS/RTU Dimming	Standby Horizon Indicator
Stall Protection (Stick Pusher CH 1)	EICAS Display 1 (ED1)



Table 7-12 DC LOADS DISTRIBUTION (Cont)

BATTERY BUS (CBP-1)	BATTERY BUS (CBP-2)
Audio Control Panel (Pilot's)	EICAS Display 2 (ED2)
Air Data Computer (1 and 2) Alternate Power Supply	Lamp Driver Unit
VHF Comm Radio 1	Bright/Dim Power Supply Unit
Emergency Tuning Unit	Hyd System 3 (Gages)
IDG Disconnect (1 and 2)	ADG Controller (Auto and Manual)
Essential AC Transfer Control	Essential TRU (Power 1 and 2 Sensing)
GCU (1, 2, and 3)	Feed 1 (Battery and DC Essential)
DC Emergency Bus Feed	Feed 2 (Battery and DC Essential)
Engine Ignition (A and B) Control	Battery Bus (Power Sensing)
Engine Start (L and R)	RCCB Control (Main and APU Battery)
Transfer/APU (Manual X-flow, Fuel Pump, Controller, ECU)	Overheat Detector (Main Landing Gear Bay)

MAIN BATTERY DIRECT BUS (CBP-5)	APU BATTERY DIRECT BUS (CBP-5)	BATTERY BUS (CBP-5)
Main Battery Contactor	APU Battery Contactor	Engine Ignition System (B)
APU ECU	Service Bus Feed	
DCUs 1 and 2	Oil Bypass Indicator	
Standby Power Controller	Engine Oil Replenish- ment System	
Attitude Heading	ADG (Auto and Manual Deploy)	
Clocks 1 and 2	External DC Power	



Table 7-12 DC LOADS DISTRIBUTION (Cont)

MAIN BATTERY DIRECT BUS (CBP-5)	APU BATTERY DIRECT BUS (CBP-5)	DIRECT BUS (CBP-5)
PSEU	Essential Power Control	
Lights (Service, Boarding, and Maintenance)	Refuel/Defuel Panel	
	Emergency Refuel	

DC UTILITY BUS 1 (CBP-1)	DC UTILITY BUS 2 (CBP-2)	DC SERVICE BUS (CBP-2)
Left Cabin Reading Lights	Right Cabin Reading Lights	Lights (Navigation, Toilet, and Galley Dome)
Power Sensing	Power Sensing	Cabin Lighting, Upward and Downward (L and R)
		Service Bus Feed from CBP-5
		Power Sensing (Service Bus and TRU)