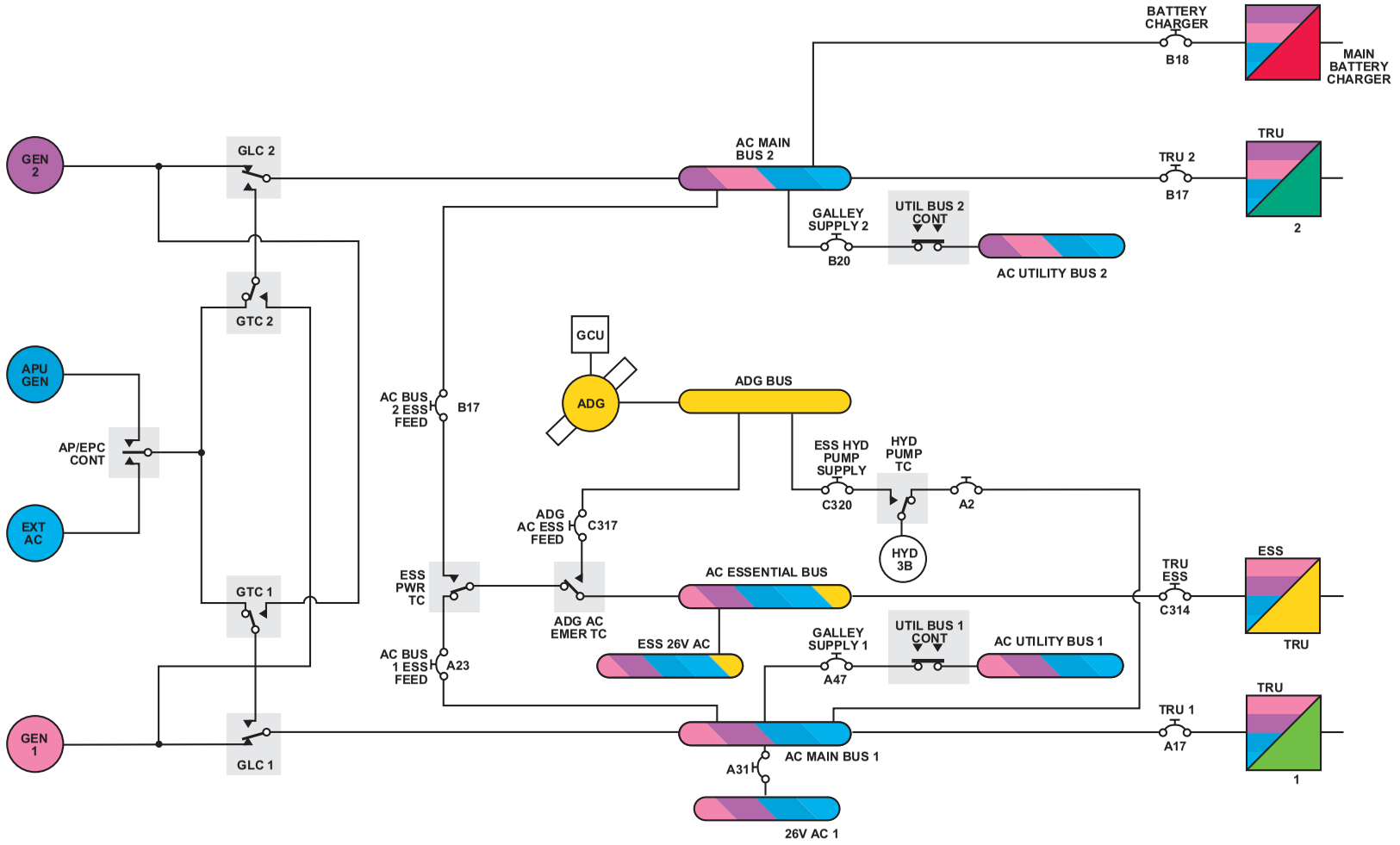
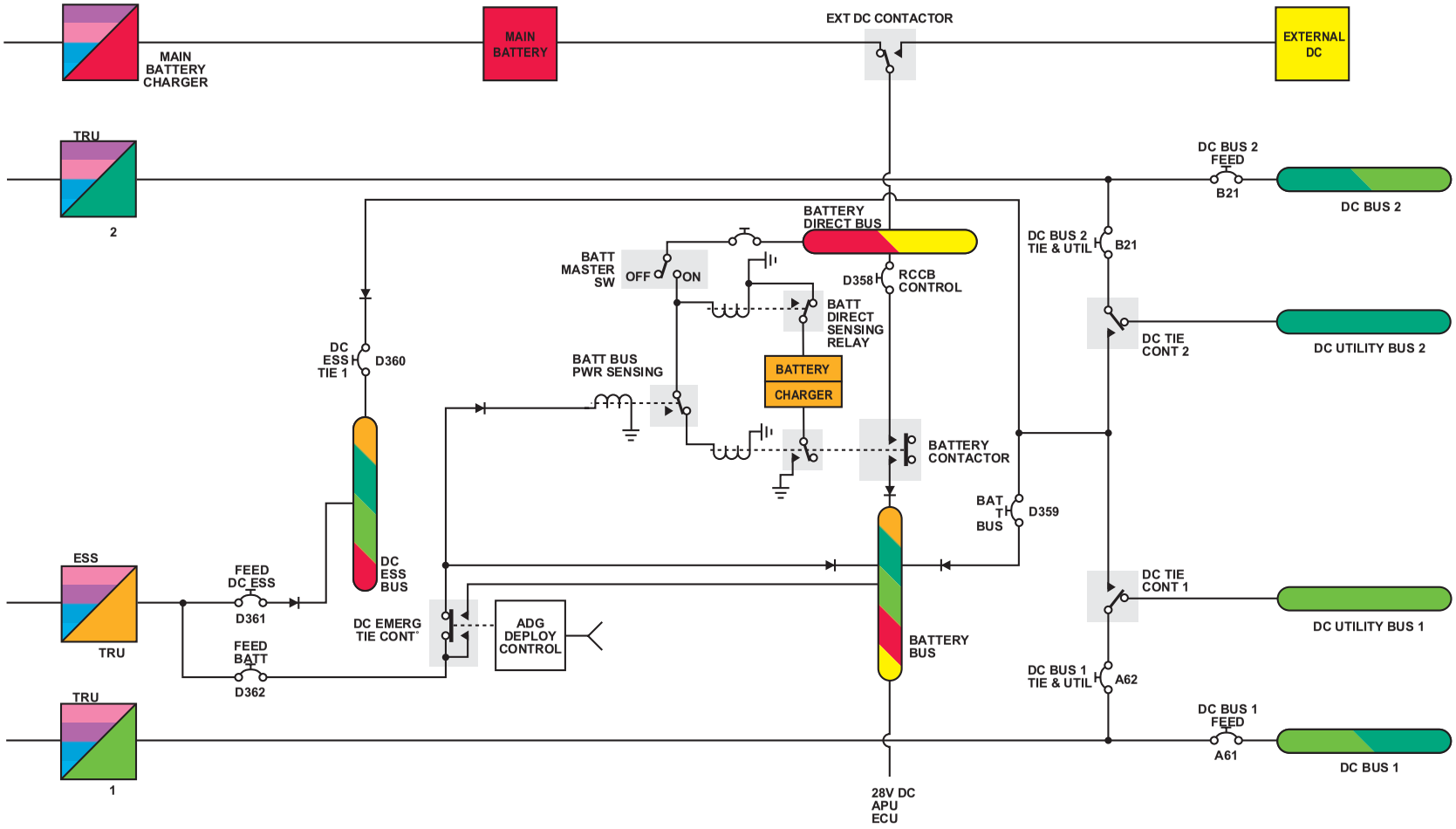
AC Electrical System

CL-601-1A



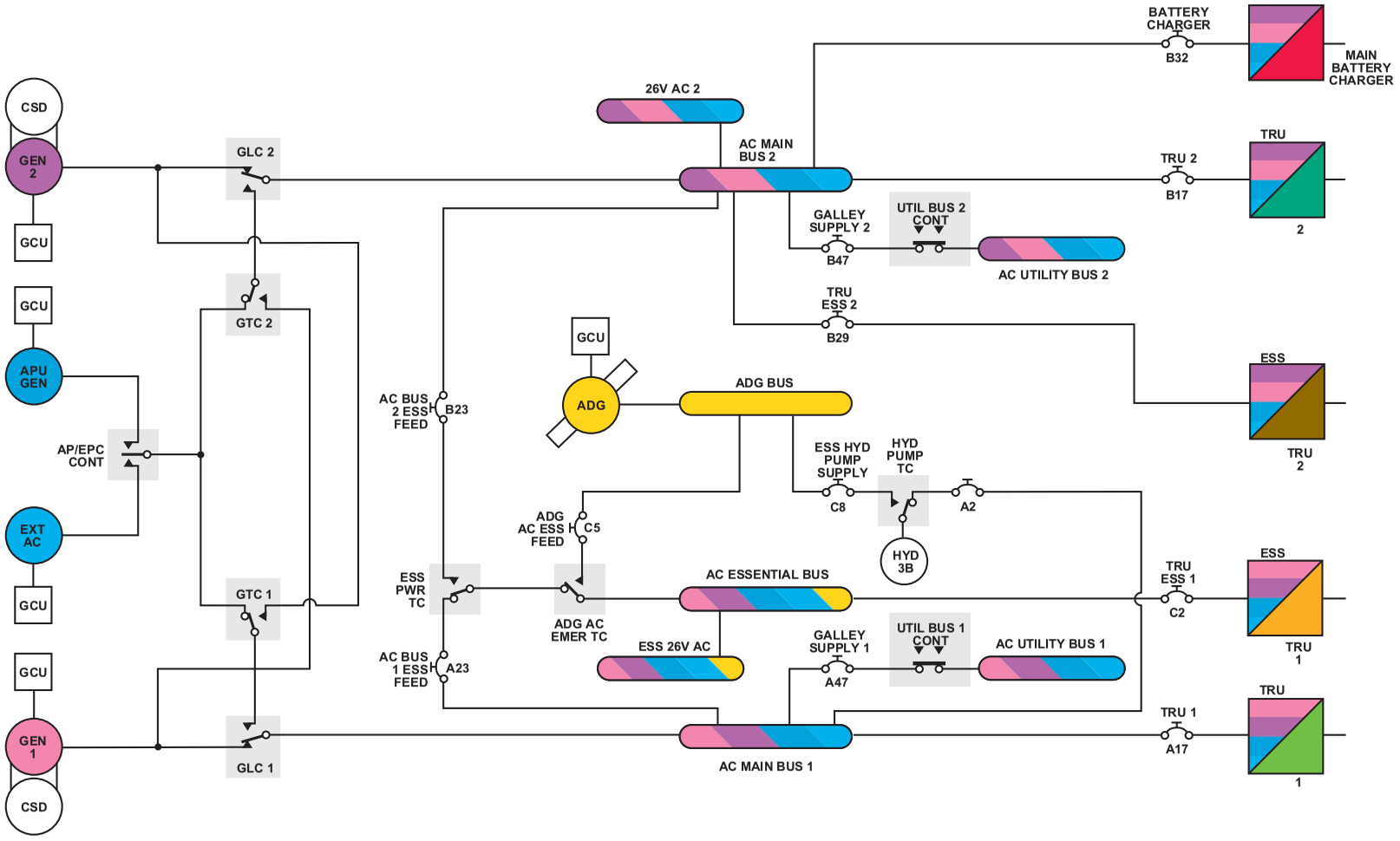
DC Electrical System

CL-601-1A



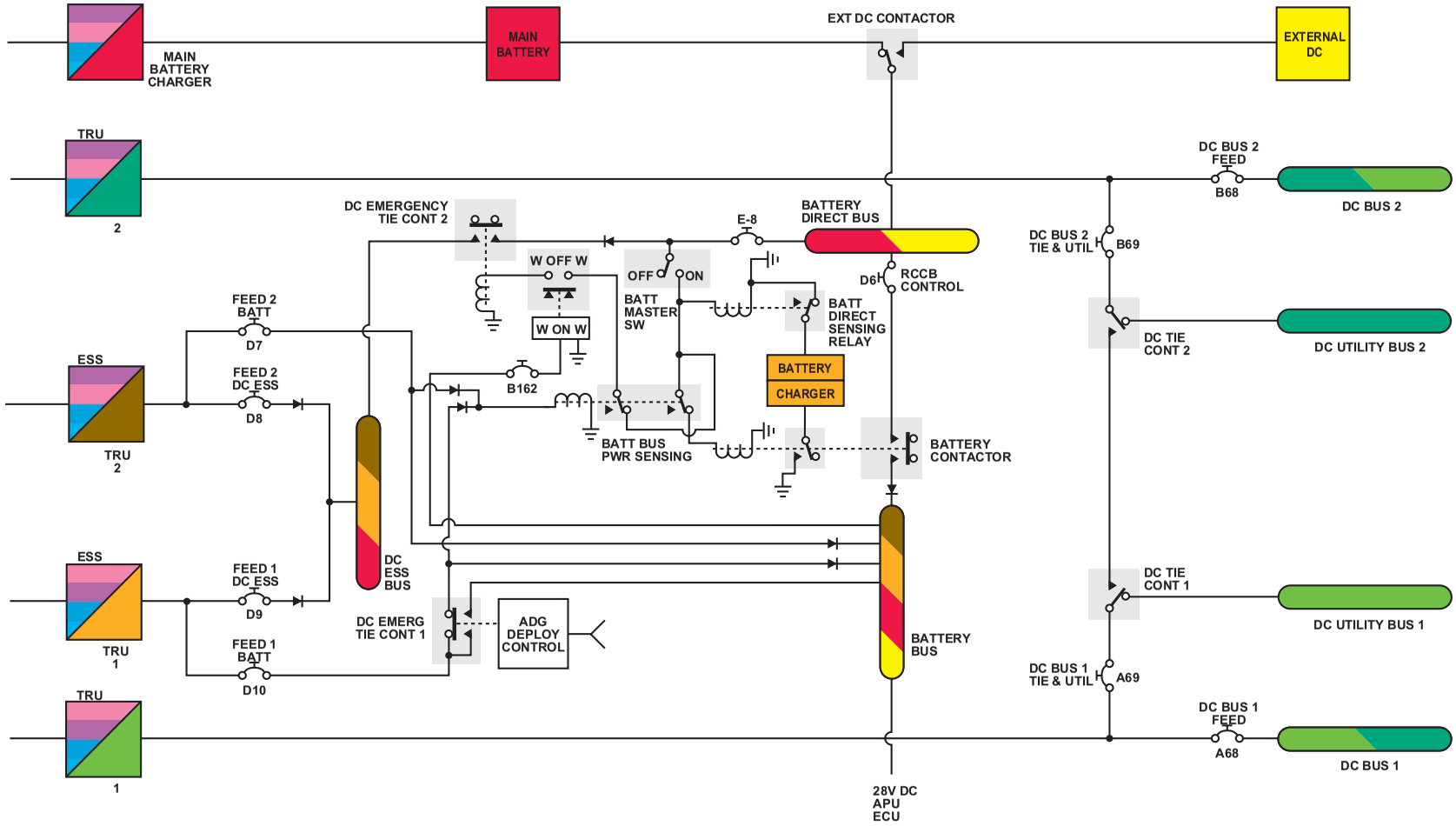
AC Electrical System

CL-601-3A/3R



DC Electrical System

CL-601-3A/3R



AC System

Two engine-driven integrated drive generators (IDGs) are the aircraft's primary source of AC power. An APU-driven generator supplies auxiliary power for ground operations and, within the operating limitations of the APU, also provides AC power in flight. All three generators are essentially identical; each provides 115V/200V AC, 400 Hz, three-phase (A-B-C rotation) power and has a 30 kVA power rating.

If the generators fail and the main AC buses lose power, an air-driven generator (ADG) in the right forward nose automatically deploys into the air stream. This generator, powered by a ram air turbine, provides emergency 115V/200V AC, 400 Hz power. The ADG has a 15 kVA power rating.

When none of the generators are on line during ground operations, an AC external power system may supply the AC buses. The system consists of a receptacle near the nosewheel well, monitoring circuits, and a ground power control switch. When selected ON, AC external power connects the aircraft's AC buses to the AC ground power unit if voltage, frequency, and phase rotation are within limits. A green ground power AVAIL light is illuminated on the overhead panel to indicate the external AC power is within tolerances.

A bus distribution system supplies the various systems requiring 115V/200V AC through circuit breakers. These buses include:

- AC Bus 1 and AC Bus 2
- Essential AC bus
- AC Utility Bus 1 and AC Utility Bus 2.

AC Bus 1 supplies AC Utility Bus 1 and the Essential AC bus while AC Bus 2 supplies AC Utility Bus 2. AC Bus 2 can also supply the AC Essential bus if AC Bus 1 loses power.

On the 601-1A, there are two 26V AC buses. Essential 26 V AC is supplied through a step-down transformer from Essential AC and an additional 26V AC bus is powered from Main AC Bus 1. **The 601-3A** is similar except the additional 26V AC is powered from Main AC Bus 2.

The ADG bus, supplied by the air-driven generator only, supplies 115V/200V AC power directly to the No. 3B hydraulic pump and through the AC Essential bus to other flight critical systems.

IDGs

Each integrated drive generator consists of a generator coupled to the output shaft of a constant speed drive (CSD). The hydro-mechanical CSD, driven by the engine's accessory gearbox (AGB), drives the generator at a constant 12,000 RPM when the engine is operating.

Each IDG's generator control unit (GCU) regulates generator output to 115 ±3V AC and 290 ±30A. The GCU also provides:

- undervoltage protection if generator output voltage drops below 100 ±5V AC
- overload indication by illuminating OVLD light when GCU overload monitor circuit senses generator overload (>100 ±5A more than 3 seconds) without an undervoltage condition
- overvoltage protection with an inverse time delay if generator output exceeds 125V (10 seconds at 125V and 0.1 second at 150V)
- underfrequency (<375 ±5 Hz) and overfrequency (>425 ±5 Hz) protection
- overcurrent protection at 187 ±13A
- tie bus overcurrent protection at 130 ±8A
- differential current protection at 20 ±5A.

If a voltage, frequency, or curent fault occurs, the generator control relay (GCR) de-energizes. After the GCR de-energizes, the GEN OFF light illuminates, the generator line control relay (GLCR) de-energizes, and the generator drops off-line.

APU Generator

When running at its normal operating speed, the APU turns its generator at a relatively constant 12,000 RPM through a generator drive adapter. The adapter provides a mechanical interface between the APU and generator and supplies cooling and lubricating oil for the generator.

The APU's generator control unit (GCU) is identical to and interchangeable with the engine-driven generator GCU. The APU's GCU provides the same protection functions as those provided for the IDGs. If a voltage, frequency, or current fault occurs, the GCU disconnects APU generator output from the electrical system by de-energizing the APU's generator control relay (GCR). After the GCR de-energizes, the generator line control relay (GLCR) de-energizes. The auxiliary power contactor (APC) opens to take the APU generator off-line. When the generator is off-line and the APU is above 95% RPM, the respective GEN OFF light illuminates.

Air-Driven Generator

The air-driven generator (ADG) consists of a constant-speed ram air turbine connected to a small 15 kVA, 115V/200V AC generator. ADG deployment is controlled through an auto deploy control unit connected to the generator line contactors (GLCs), auxiliary power contactor (APC), and main AC buses. Deployment occurs automatically if the generators fail and the main AC buses lose power in flight. If the automatic deployment system fails, pulling the ADG handle manually deploys the ADG.

The ADG's generator control unit (GCU) provides limited protection functions compared to the IDG and APU GCUs. This protection includes:

- overvoltage (130V for 2 seconds)
- overfrequency (450 Hz for more than 2 seconds)
- underfrequency (250 Hz for more than 2 seconds).

If an electrical fault occurs, the GCU opens the output contact to remove essential systems from the ADG bus. When the ADG returns to normal operation, the system automatically resets, the contactor closes, and the ADG bus begins supplying the essential systems.

Operation

Connecting an external AC power source to the ground power receptacle supplies power to the external power contactor and external power monitor (EPM). If external power is within 106 to 124V, 370 to 430 Hz, and A-B-C phase rotation, the EPM's external power ready relay (EPPR) energizes and the green AVAIL light illuminates.

Before using external AC power, place the AC metering selector in the EXT POWER position to verify supplied AC power is within normal voltage and frequency operating range (115 ±9V AC and 400 ±25 Hz).

Placing the GPWR switch in the ON position directs 28V DC from the Battery Direct bus or the EPM monitor through the closed APU power (APU PR) and another relay to the external power contactor (EPC). The EPC closes and AC power flows from the external AC power receptacle to the main AC bus transfer contactors. Closing of the EPC also illuminates the amber IN USE light and extinguishes the AVAIL light. The MAIN BUS OFF lights then extinguish.

With the APU running, placing the APU generator switch in the ON position energizes the generator control relay (GCR) and generator line control relay (GLCR); the APU's GEN OFF light extinguishes. When the GLCR energizes, the APU power relay (APU PR) opens. The external power contactor (EPR) then opens to disconnect external AC power from the aircraft. The IN USE light extinguishes and the AVAIL light illuminates.

AC power from the APU generator then flows through the closed auxiliary power contactor (APC), generator transfer contactors, and generator line contactors (GLCs) to the main AC buses.

After an engine reaches idle speed and the associated generator tested, placing the generator's control switch in the ON position energizes the IDG's generator control relay (GCR); the GEN OFF light then extinguishes. If no electrical faults exist and generator voltage, frequency, and current are within normal operating limits, the generator line control relay (GLCR) energizes.

After the second engine is at idle speed and the associated generator tested, placing the second engine's generator control switch in the ON position energizes its GCR and extinguishes its GEN OFF light. The GLCR closes; IDG output supplies the associated main AC bus. The generator tie contactors (GTCs) open when each IDG supplies its own main AC bus.

When the GLCR closes to connect the second IDG output to the associated main AC bus, the APU PR energizes to disconnect APU generator power from the aircraft and the APU GEN OFF light illuminates.

Failure of engine and APU-driven generators in flight initiates the air-driven generator (ADG) automatic deploy sequence. If, after a two second delay, AC Bus 1 and 2 lose power, the ADG auto-deploy control unit supplies 28V DC to fire the ADG uplock actuator. The ADG then deploys into the airstream and begins supplying AC power within approximately four seconds. If ADG fails to automatically deploy, pulling the ADG handle manually deploys the ADG. If extended operation is necessary with the ADG deployed, aircraft performance (distance) is reduced by approximately 8%.

When the ADG generator comes on-line, the control unit energizes the hydraulic pump transfer contactor to connect the No. 3B hydraulic pump to the ADG bus. After hydraulic pump transfer, the AC and DC transfer contactor automatically energize to connect essential aircraft systems to the ADG bus.

If a main generator comes on-line after ADG deployment, pressing the PWR TXFR OVERRIDE button with the ADG handle stowed de-energizes the electric hydraulic 3B pump and AC and DC transfer contactors. This allows transfer of power from the ADG bus to the normal AC and DC buses.

If AC Bus 1 voltage drops below 90V AC or loses power completely, the FAIL light illuminates. Transfer of AC Essential bus to AC Bus 2 is automatic and the AC Essential FAIL light momentarily illuminates during power transfer. If AC Bus 1 voltage returns to normal after automatic power transfer, the AC Essential bus transfers back to AC Bus 1 as its power source. Pressing the ALTN switchlight connects the AC Essential bus to AC Bus 2, extinguishes the FAIL light, and illuminates the ALTN light. If the AC Essential bus power source was manually transferred and AC Bus 1 voltage returns to normal, the system will not automatically transfer the AC Essential bus back to AC Bus 1 as its power source.

DC System

A single ni-cad battery supplies power for APU starting and, if the normal DC electrical system fails, provides essential DC power in parallel with an essential transformer-rectifier unit. Additional ni-cad batteries supply power for the emergency lighting system. Some aircraft have an auxiliary battery for APU cold starting.

Three (**S/Ns 3001 to 3066**) or four (**S/N 5001 and subsequent**) transformer rectifier units (TRUs), powered by 115/200V AC power, provide 28V DC to the aircraft electrical system.

An external DC power system allows a ground power unit (GPU) to supply DC power for ground operation and maintenance.

The DC bus distribution system consists of:

- DC Bus 1 and DC Bus 2
- DC Essential bus
- DC Utility Bus 1 and 2
- Battery bus
- Battery Direct bus.

Batteries

A 24V DC, 36 or 43 amp-hour (AH) ni-cad battery provides power for APU starting. In addition, two small emergency batteries provide DC power for the emergency lighting system.

If a battery fault develops with the BATTERY MASTER switch in the ON position, the battery charger's fault detection circuits illuminate the CHARGER light and trigger the MASTER CAUTION lights. These battery faults include:

- cell short
- battery temperature exceeds 60°C (140°F)
- temperature drops to -29°C (-20°F)
- temperature sensors shorts or an open circuit
- battery charger loses AC power input.

On S/Ns 3001 to 3066 with SB 601-0099 and S/Ns 5001 to 5134, an auxiliary battery supplies power to the APU electronic control unit (ECU) for cold weather starting. The battery's FAIL light illuminates with:

- open battery
- shorted cell
- open or shorted battery temperature sensor
- no charger operation
- no battery output with APU START/STOP switch in ON position.

S/N 5135 and subsequent, an IRS battery provides auxiliary power for the APU's ECU.

TRUs

Two main and one or two essential transformer-rectifier units convert 115V/200V AC, 400 Hz, three-phase power into unregulated 28V DC for various aircraft systems. Each TRU operates when its AC bus power is available (see **Table 4-A**).

On S/Ns 3001 to 3066 without SB 601-0107, the main TRUs are 100A units while the essential TRU is a 50A unit. **On S/Ns with SB 601-0107**, all three TRUs are 100A units. **On S/N 5001 and subsequent**, all four TRUs are 100A units. The load on Essential TRUs 1 and 2, although rated at 100A, is limited to 30A each.

Connecting a 28V DC GPU to the DC receptacle on the right aft fuselage energizes the external DC contactor. The contactor, in turn, disconnects the battery from the Battery Direct bus, supplies external power to the Battery Direct bus and the APU starting circuit, and illuminates the overhead panel IN USE light.

Care must be taken when connecting DC external power to the aircraft to ensure proper voltage and amperage settings. There are no safeguards to protect the aircraft from an out of tolerance external DC power supply.

Placing the Battery Master switch in the ON position allows external DC power to the Battery bus.

Without external DC power, the battery supplies the Battery Direct bus through the normally open external DC contactor. Placing the Battery Master switch in the ON position energizes the battery contactor and battery direct sense relay. The BATTERY light extinguishes, the CHARGER and ELEC lights illuminate, and the MASTER CAUTION lights flash. Battery power then flows through the closed battery contactor to the Battery bus. The BATT BUS OFF light extinguishes.

With AC power supplying AC Bus 1, AC Bus 2, and the AC Essential bus, the transformer-rectifier units (TRUs) supply power to their respective DC buses (see **Tables 4-B** and **4-C**). The bus sense relays then open and the MAIN BUS 1 OFF, MAIN BUS 2 OFF, and ESS BUS OFF lights extinguish. Because essential TRU power supplies the Battery bus, the battery contactor opens to disconnect battery power.

With the TRUs operating and AC power available, the battery charger operates and the CHARGER light extinguishes.

If the No. 1 or 2 TRU fails and its associated main DC bus loses power, the bus sensing relay opens to illuminate the associated MAIN BUS OFF light. Pressing both DC BUS TIE CLOSED switchlight closes the bus tie relays to connect the main DC buses. The failed bus sensing relay closes and the MAIN BUS OFF light extinguishes. With the DC main buses tied, power is automatically shed from the DC Utility buses.

On S/Ns 3001 to 3066 if the essential TRU fails, the bus sensing relay opens to illuminate the ESS BUS OFF light. With the Battery Master switch in the ON position, the battery contactor closes to connect the Battery bus to the battery.

Pressing either BUS TIED CLOSED switchlight closes the associated bus tie relay to supply DC power from a main DC bus to the DC Essential bus. The ESS BUS OFF light extinguishes and the battery contactor opens to disconnect the battery from the Battery bus and supply power from the DC Essential bus to the Battery bus.

On S/N 5001 and subsequent if an essential TRU fails, the respective essential TRU 1/2 OFF light illuminates. If the opposite essential TRU is operating, it automatically powers the DC Essential bus.

Unit	Power Source	
	3001 to 3066	5001 and Sub.
TRU 1	AC Bus 1	AC Bus 1
TRU 2	AC Bus 2	AC Bus 2
TRU ESS 1	AC Essential bus	AC Essential bus
TRU ESS 2	N/A	AC Bus 2

Table 4-A; TRU Power Sources

Operating TRUs	TRU 1	TRU 2	ESS TRU
ALL	DC Bus 1 DC Utility 1	DC Bus 2 DC Utility 2	DC Essential
TRU 1 **ESS TRU**	DC Bus 1 DC Bus 2	NONE	DC Essential
TRU 2 **ESS TRU**	NONE	DC Bus 1 DC Bus 2	DC Essential
TRU 1	DC Bus 1 DC Bus 2 DC Essential	NONE	NONE
ESS TRU	NONE	NONE	DC Essential

Table 4-B; TRU Power Distribution (S/Ns 3001 to 3066)

Operating TRUs	TRU 1	TRU 2	ESS TRU	ESS TRU
ALL	DC Bus 1 DC Utility 1	DC Bus 2 DC Utility 2	DC Essential Battery	DC Essential Battery
TRU 1 **ESS TRU 1** **ESS TRU 2**	DC Bus 1 DC Bus 2 (see Note 1)	NONE	DC Essential Battery	DC Essential Battery
TRU 2 **ESS TRU 1** **ESS TRU 2**	NONE	DC Bus 1 DC Bus 2 (see Note 1)	DC Essential Battery	DC Essential Battery
TRU 1 **ESS TRU 2**	DC Bus 1 DC Bus 2 (see Note 1)	NONE	NONE	DC Essential Battery
ESS TRU 1 **ESS TRU 2**	NONE	NONE	DC Essential Battery	DC Essential Battery
ESS TRU 1 (see Note 2)	NONE	NONE	DC Essential Battery	NONE
ESS TRU 2 (see Note 3)				DC Essential Battery

Table 4-C; TRU Power Distribution (S/N 5001 and Subsequent)

[1]Both BUS TIE CLOSED switchlights must be selected to the closed position.

[2]Essential TRU 1 is operational on ADG power. DC Essential is connected to the Battery bus.

[3]Essential TRU 2 is operational from AC Main bus 2. All other TRUs are failed.

Electrical System

Power Source	AC Integrated drive generators – 115V/200V AC, 400 Hz, three-phase, 30 kVA APU-driven generator 115V/200V AC 400 Hz, three-phase, 30 kVA Air-driven generator – 115V/200V AC 400 Hz, three-phase, 15 kVA External AC power – 115V/200V AC, 400 Hz, three-phase (A-B-C rotation) DC Transformer-rectifier units – 28V DC Ni-cad battery – 24V, 36 or 43AH Emergency and IRS batteries External DC power – 28V DC
Distribution	AC Buses 1, 2, and one 26V AC bus AC Essential bus – 115V and 26V AC Utility Buses 1 and 2 ADG bus DC Buses 1 and 2 DC Essential bus DC Utility buses 1 and 2 Battery bus Battery Direct bus
Control	Generator switches (ON/OFF-RESET/TEST) Generator control units (GCUs) GPWR switch BATTERY MASTER switch BUS TIED CLOSED switchlights ALTN switchlight

Electrical System (continued)

Monitor	AC voltage, frequency, and load meters DC voltage and amperage meters System lights 1/2 OFF ALTN (Essential AC) AUTO OFF/FAIL AVAIL/IN USE (external power) BATTERY/CHARGER BUS TIED CLOSED ELECT (master warning) ESS BUS OFF (Essential TRU) FAIL (Essential AC) GEN OFF/OVLD (generator) MAIN BUS 1/2 OFF (AC and DC)
Protection	Circuit breakers Generator control units (GCUs)

Lighting Systems

Cockpit

Light	Control	Power Source
Flood Lighting Pilot's Center Panel Copilot's	 FLOOD LTS FLOOD LTS FLOOD LTS	 Essential DC bus Battery bus Battery bus
Floor	FLOOR	DC Bus 1
Instrument Panel Pilot's Center Copilot's Overhead	 INST INST INST OVHD PNL	 Essential AC bus Essential AC bus AC Bus 1 AC Bus 2 Battery bus*
Map	LH MAP RH MAP	Battery bus DC Bus 1 Battery bus*
Standby Compass	STBY COMP	Battery bus
Standby Horizon	STBY COMP	DC Bus 2 Battery bus*
Standby Instruments		Battery Bus

*Secondary power source if primary power source fails.

Interior

Light	Control	Power Source
Dome	DOME	Battery bus
Boarding	BOARD/BOARDING	Battery Direct bus
Cabin Signs	NO SMKG SEAT BLTS Landing Gear Control	AC Bus 1 DC Bus 1
Cargo and Service	SERVICE (2) REAR FUSE SERVICE	Battery Direct bus

NOTE: Except for the above, passenger compartment lighting varies with the completion center interior.

Exterior

Light	Control	Power Source
Anti-Collision	ANTI-COLLISION or ANTI COLL*	DC Bus 1 (rear) DC Bus 2 (wing)
Emergency	Essential DC bus loss ARM/ON/OFF	Battery packs Essential DC bus
Landing Lights	LANDING LT or LH/RH LANDING LTS*	AC Bus 1 (left) AC Bus 2 (right)
Navigation	NAV	AC Bus 1
Recognition/ Taxi	RECOG/TAXI	AC Bus 1 (left) AC Bus 2 (right)
Wing Inspection	WING	DC Bus 1

*S/N 5001 and subsequent