

Section - III SYSTEMS DESCRIPTION

Sub-section 9 ELECTRICAL POWER

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GENERAL

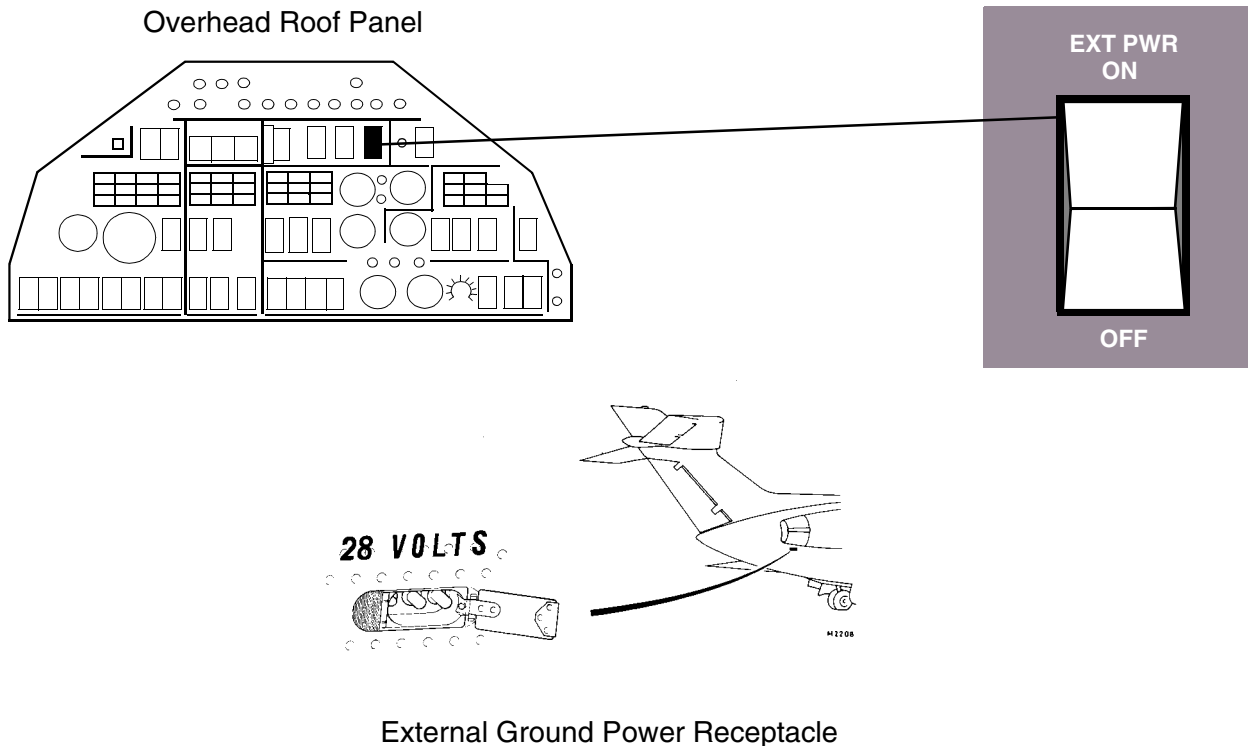
The airplane utilizes both DC and AC systems with emergency systems available for certain instrument and avionics requirements. The 28 VDC system uses a tied-busbar powered from engine driven starter/generators and backed-up by batteries. A third starter/generator driven from the Auxiliary Power Unit (if installed) is also available.

Power from the engine-driven generators and the APU generator is distributed by two essential busbar systems, PS1 and PS2. In normal flight conditions the two PS busbars are tied in parallel by a bus tie controlled by a BUS TIE switch, selected to CLOSE. Each generator circuit contains a voltage regulator which stabilizes the busbars at 28 ± 0.75 VDC. With a generator on line, selecting the BUS TIE switch to CLOSE connects the two PS busbars in parallel. A start busbar links the start power source (either the ground supply contactor or the internal start contactor) with the individual engine 1 and 2 start contactor or the APU start contactor. AC power is supplied through two systems, one using inverters, the other engine driven alternators.

CONTROLS and INDICATIONS

EXTERNAL POWER

A standard three pin 28 VDC external power receptacle is located at the right rear fuselage. For external starts, a ground power unit capable of supplying 28 VDC with a minimum output of 42 kW (short term capability of 28 VDC x 1500 AMPS) and having a limiter operating at 1100 AMPS must be used.



External power is connected to the airplane busbars through a ground power contactor. Contactor operation is controlled by the EXT PWR switch supplied from the third pin of the external power receptacle. With external power available and the EXT PWR switch ON and the EXT BATT CHG switch OFF, the No. 1 and No. 2 batteries are disconnected from the busbars. Selecting the BATT switch to ON has no effect.

CAUTION: NO. 1 BATTERY MAY BE EXCESSIVELY DISCHARGED AND DAMAGED IF THE ROOF SWITCH ON PANEL DA AND THE ENTRY LIGHT SWITCH ON THE FORWARD CABIN BULKHEAD ARE LEFT ON FOR LONG PERIODS WHILE EXTERNAL POWER IS APPLIED.

THE VESTIBULE ROOF LIGHT AND THE ENTRY LIGHT ARE CONNECTED VIA THEIR SWITCHES DIRECTLY TO NO. 1 BATTERY AND WILL COME ON IRRESPECTIVE OF THE POSITION OF THE EXT PWR, EXT BATT CHG OR BATT SWITCHES.

With the EXT BATT CHG switch ON, each battery is connected to its associated busbar (PS1 and PS2) and charged from the external power supply. The external power cannot be paralleled with the airplane generators.

BATTERY SUPPLIES

Two 24 VDC, 28 ampere-hour sealed lead acid main batteries, No. 1 and No. 2, are located in the rear equipment bay. These batteries provide internal power for engine starting and also maintain essential services in the event of a double generator failure.

NOTE: When the correct emergency drill is carried out together with prompt shedding of non-essential loads, the batteries can maintain essential services for a minimum of 60 minutes.

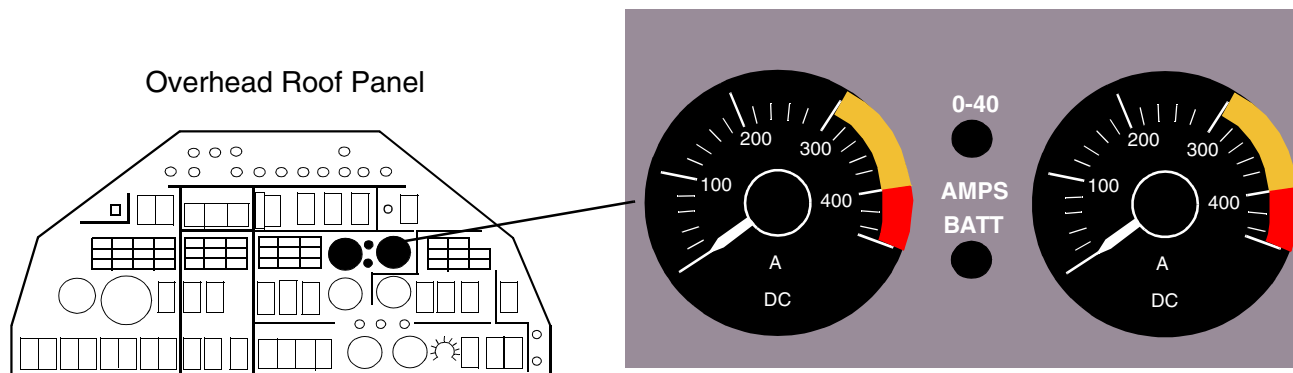
In addition to the main battery supplies, three 24 VDC 4 ampere-hour sealed lead acid batteries Nos. 3, 4 and 5 are located in the rear equipment bay. These batteries provide electrical power for the emergency lighting and essential services during emergency conditions.

Also, one 24 VDC 4 ampere-hour sealed lead acid battery No. 6 is located in the avionics shelf of the aft cabin. This battery provides electrical power to the Electronic Standby Instrument System (ESIS) in the event of a double generator failure and the output of the PE busbar being less than 21 VDC.

AMMETERS

Two ammeters are provided in the flight compartment on the overhead roof panel and provide generator load and battery charge current. Display selection is by operation of push switches labelled AMPS BATT and 0-40, located between the ammeters. The scale of 0-450A has a yellow segment from 300 to 400A, and a red segment from 400 to 450A. Each ammeter normally indicates its related generator load. When the AMPS BATT switch is operated, the battery charge currents are displayed.

If a low charge current (below 40A) cannot easily be read, the 0-40 push switch may also be operated to select an ammeter range of 0-40A. Release of both switches will revert the ammeter displays to their respective generator loads on the 0-450A scales.



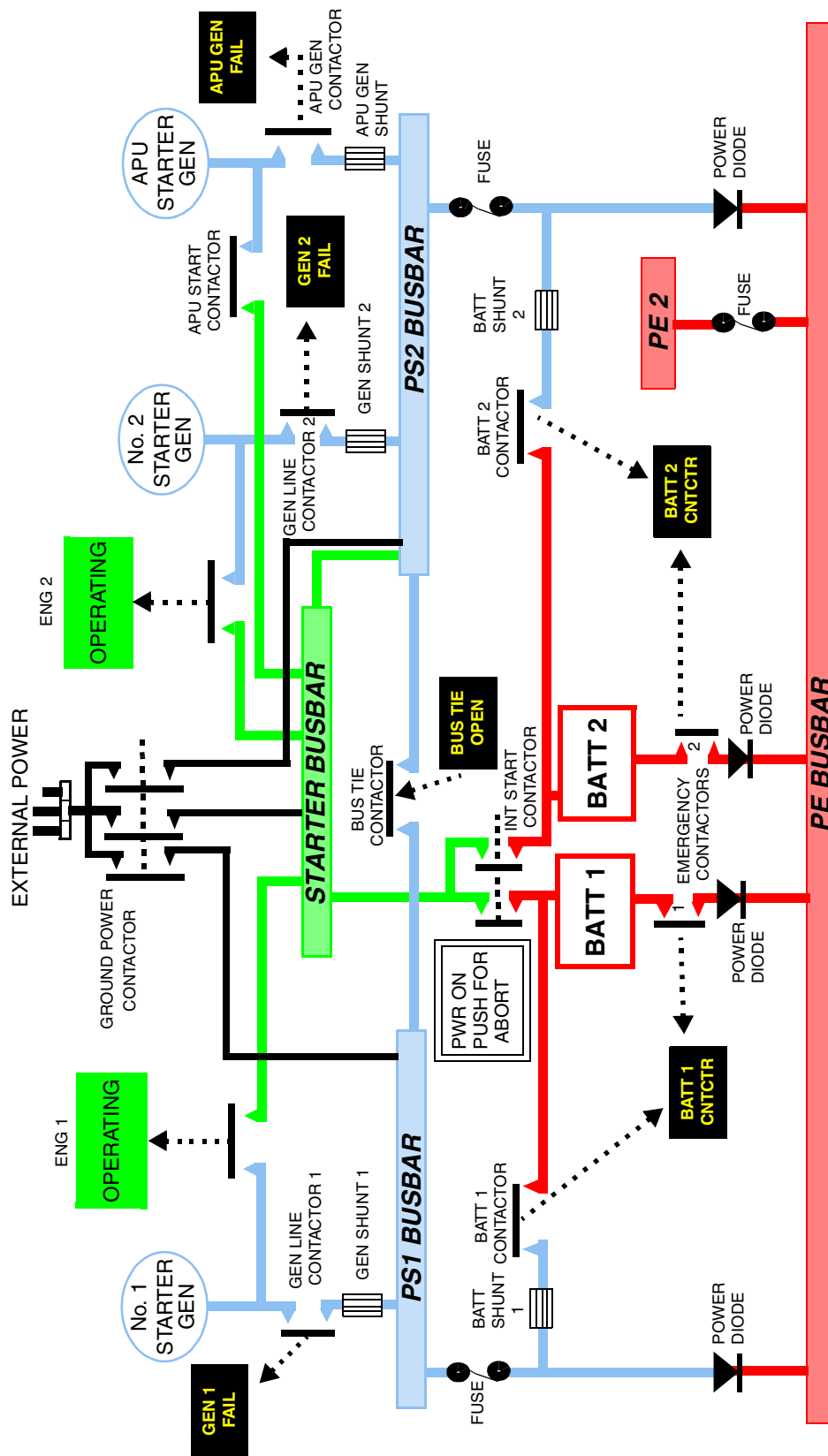
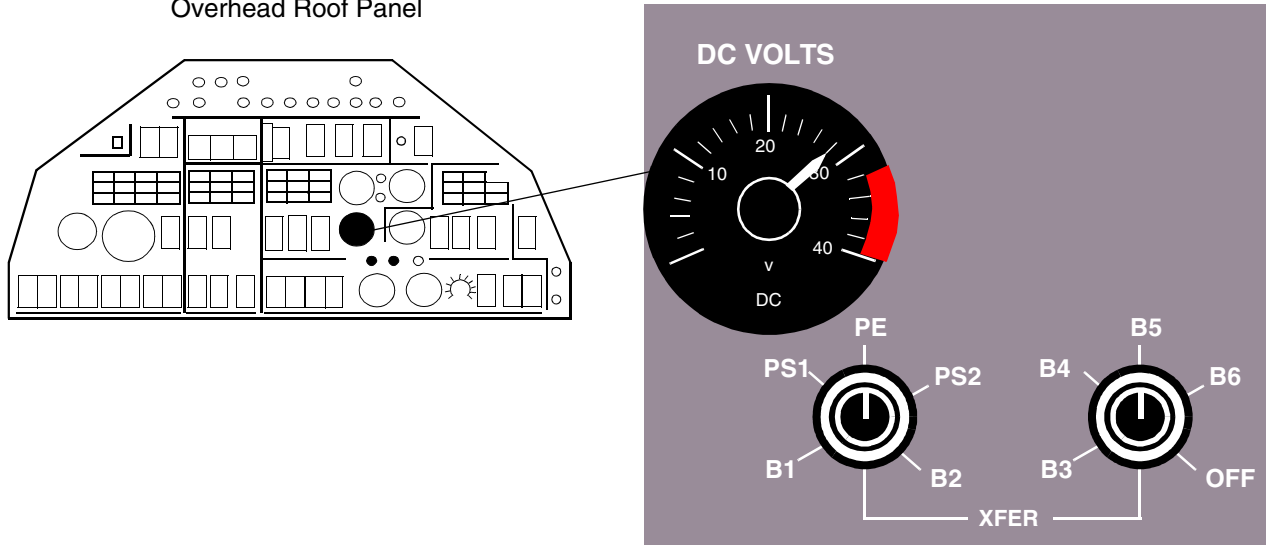


Figure 1
DC Electrical System De-energized

VOLTMETER

A 0-40V voltmeter and selector switches are provided in the flight compartment on the overhead roof panel. The voltmeter scale has a red segment between 32V and 40V. The voltmeter may display, by selection on the switches, the voltage of the batteries (1 thru 6), busbars PE, PS1 or PS2. The positions on the switches are labelled B1, PS1, PE, PS2, B2, XFER and B3, B4, B5, B6, OFF.

Overhead Roof Panel



EXT BATT CHG ON/OFF switch

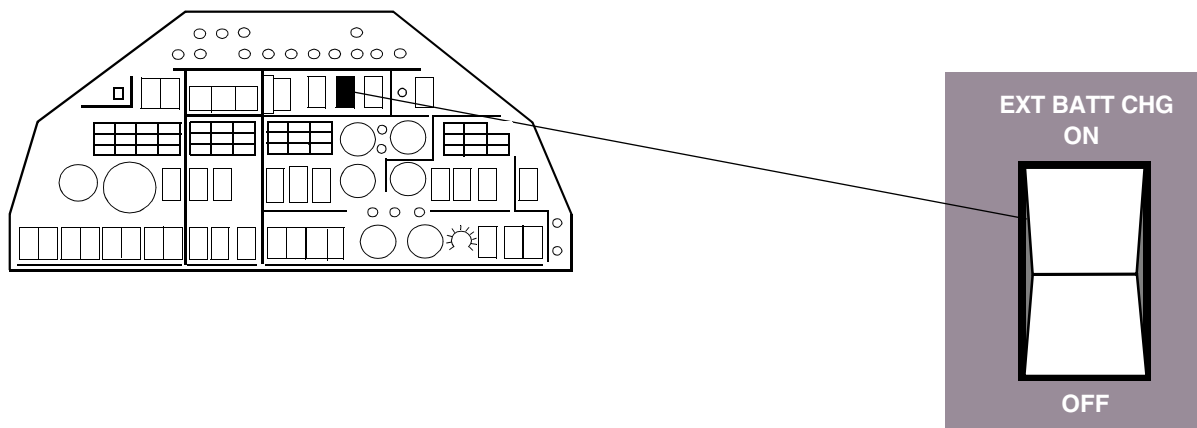
The No. 1 battery is charged from the PS1 busbar, and No. 2 battery is charged from the PS2.

As a generator comes on-line, the associated battery contactor closes automatically and the charge begins. The batteries may also be charged from an external power source by selecting the EXT BATT CHG switch to ON.

Rates of charges should be monitored on the generator ammeters during external charging and when the charge rate drops to less than 5 AMPS the EXT BATT CHG switch should be selected OFF.

During external charging, if the power supply voltage rises or falls beyond preset limits, the charging will automatically terminate.

Overhead Roof Panel



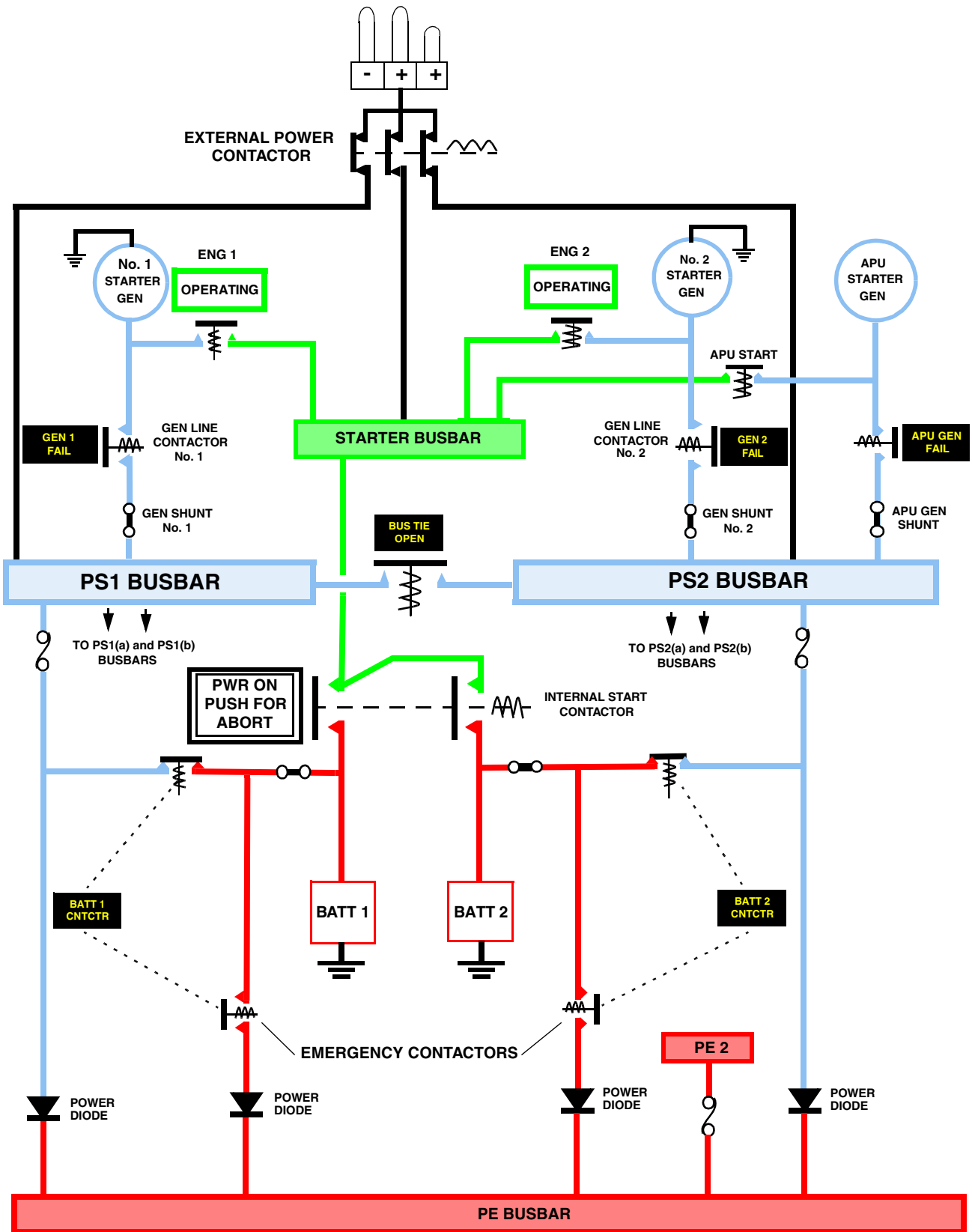


Figure 2
Ground Power Connected with External Battery Charge Switch ON

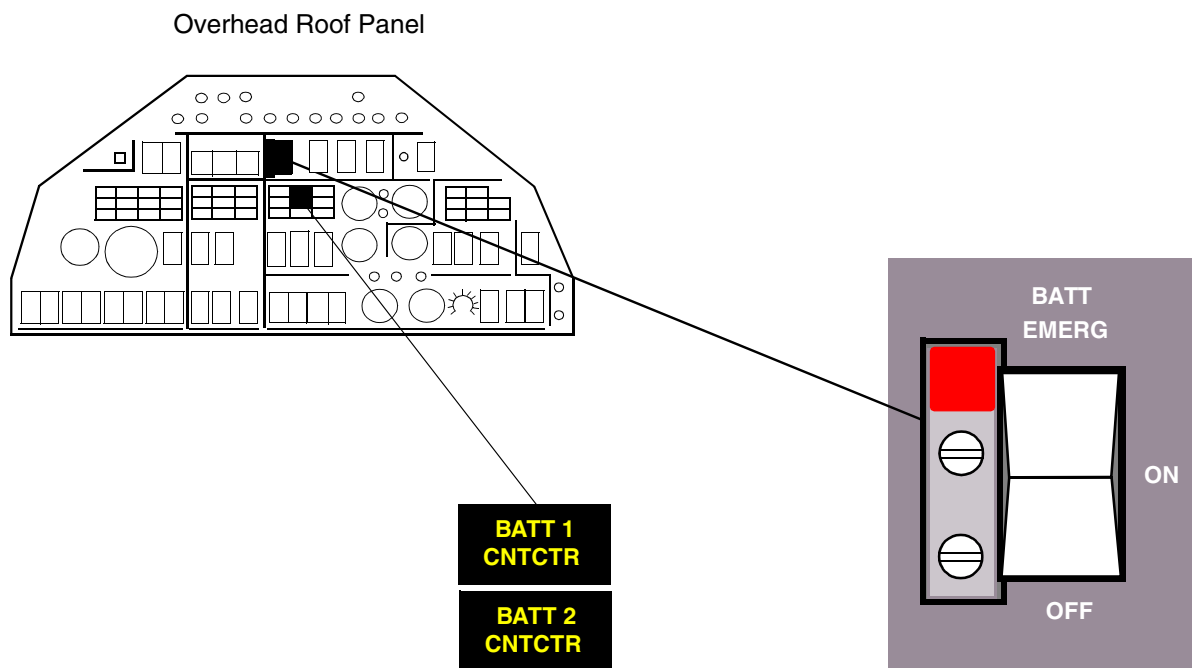
BATT EMERG-ON-OFF switch

With no generators or external power supplying the busbars, selection of the BATT switch to ON will connect both batteries in parallel to busbar PE via the emergency contactors.

When any generator comes on-line both emergency contactors remain closed. The generator fed PS busbar is connected to its related battery to commence charging, by closure of the associated battery contactor.

Both batteries may be charged from one generator by selecting the BUS TIE switch momentarily to the CLOSE position.

EMERG selection energizes both emergency contactors via independent circuits and connects both batteries to the PE busbar powering the essential services.



EMERG selection - annunciator illuminated

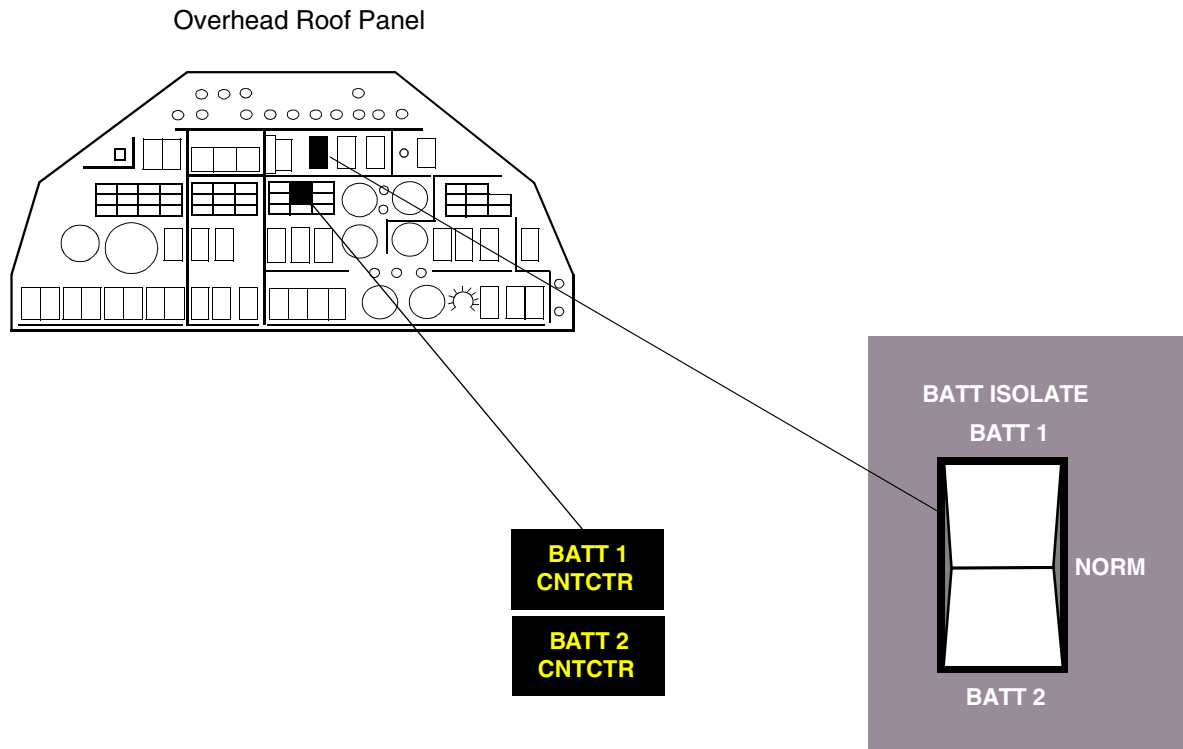
ON selection - annunciator extinguished

BATT ISOLATE BATT 1-NORM-BATT 2 switch

NORM selection closes both battery contactors to permit batteries to charge when the generators come on line, or external power is available.

Selecting the switch to either BATT 1 or BATT 2 will open the associated battery contactor, to isolate the battery from its charge source.

The relevant BATT CNTCTR annunciator will illuminate and the ELECT repeater on the MWS will flash.



NORM selection - annunciator extinguished

BATT 1 or BATT 2 selection - annunciator illuminated and the repeater annunciator flashes



MWS panel

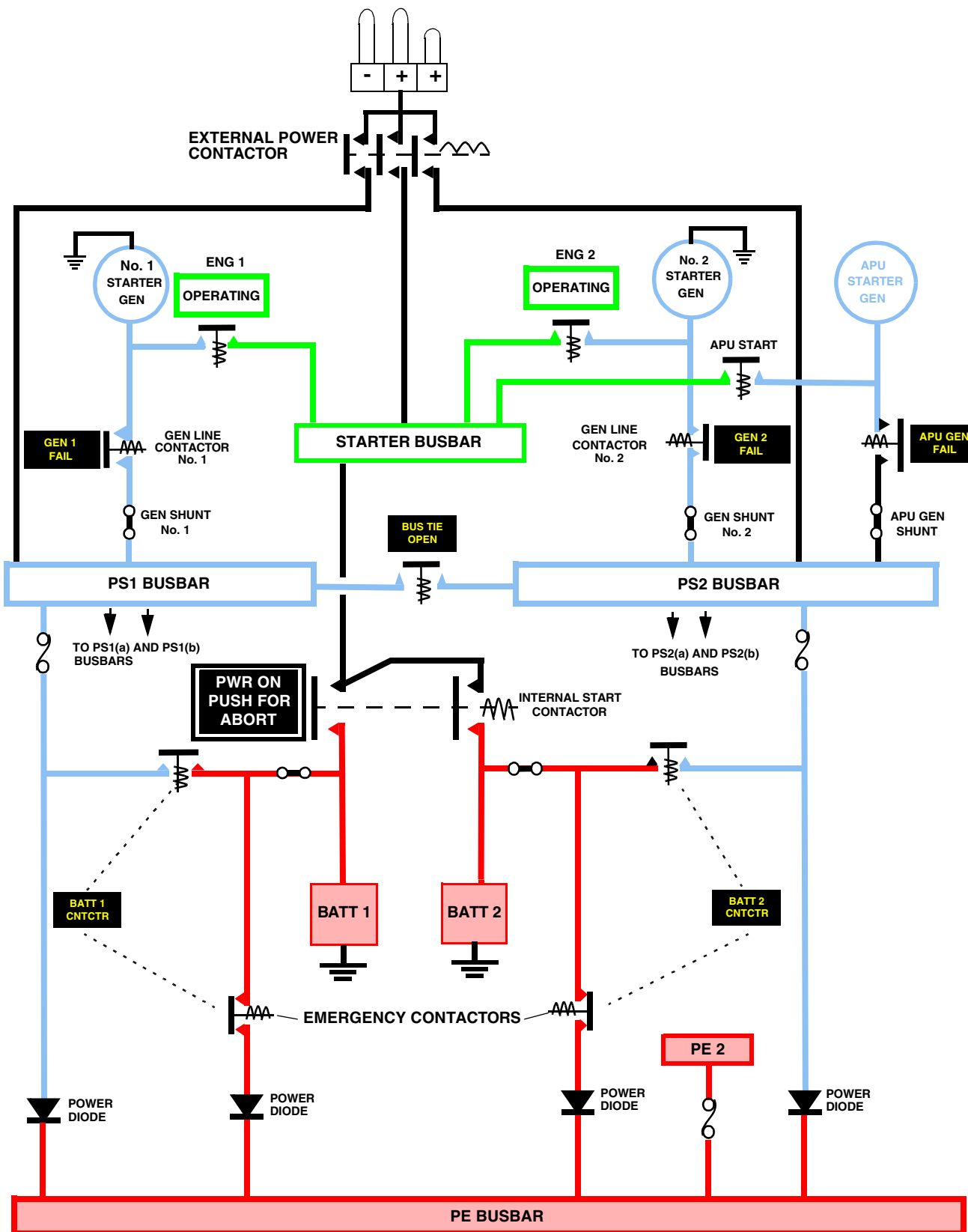
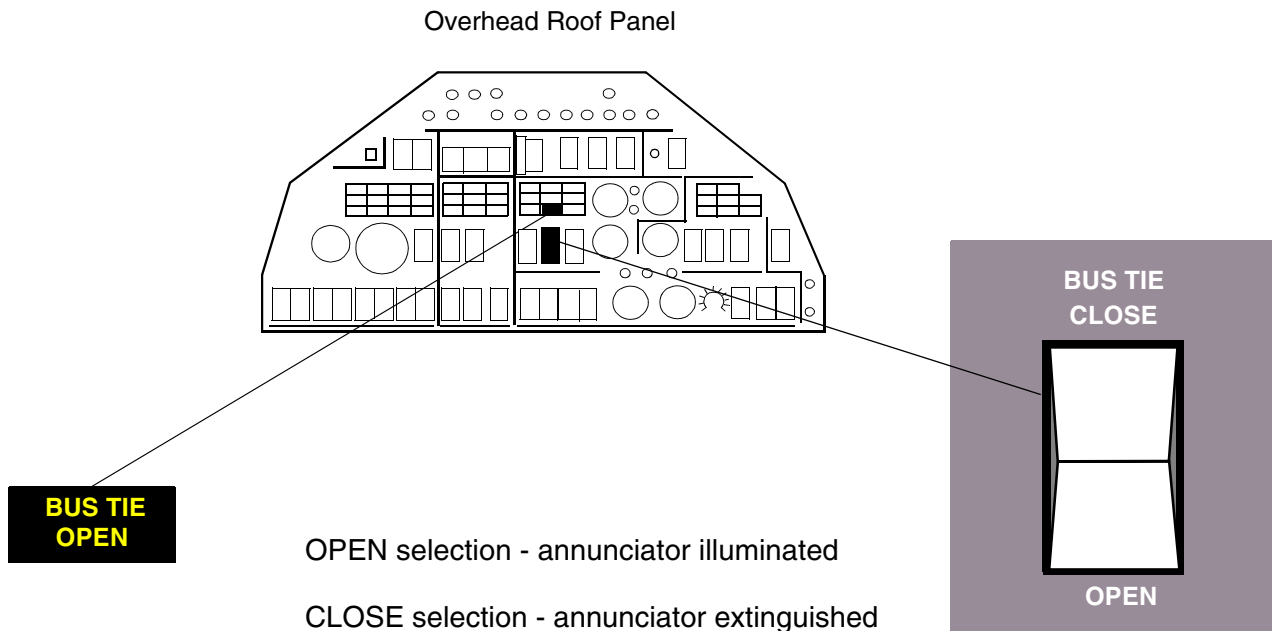


Figure 3
Battery Switch ON

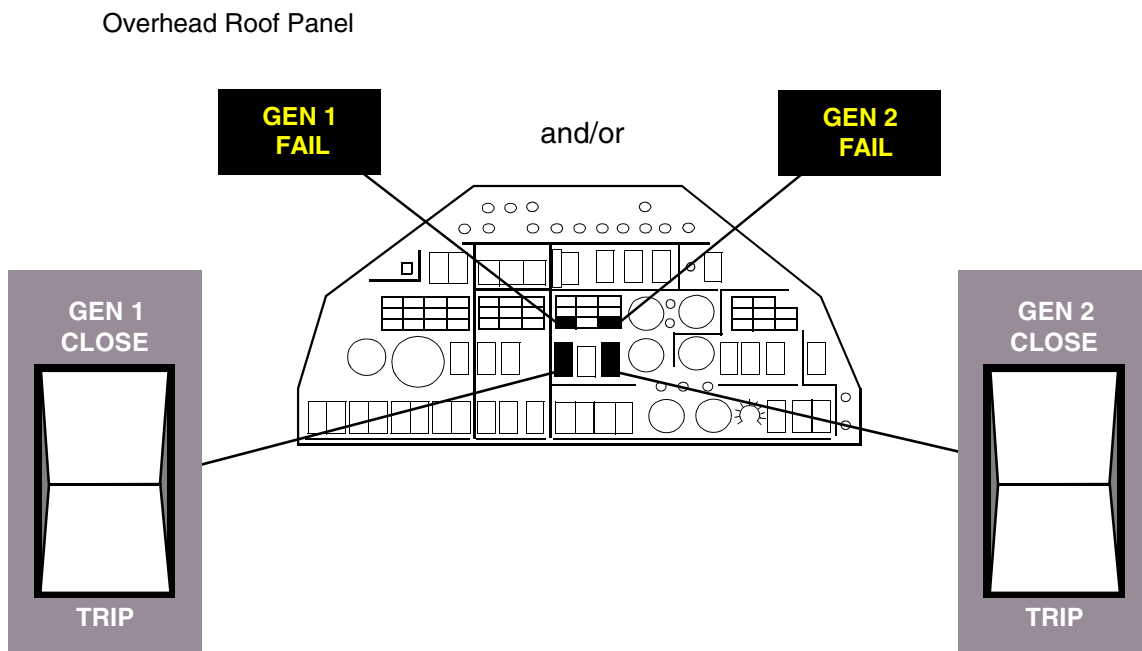
BUS TIE CLOSE-OPEN switch

Following an abnormal electrical condition, selecting the BUS TIE switch to OPEN splits the busbar system into two single-channel busbars.



GEN 1 and GEN 2 CLOSE-TRIP switches

A three position, spring-loaded to center, generator control switch labelled GEN 1 or GEN 2 CLOSE/TRIP is connected into each generator circuit. Operated momentarily to the TRIP position, it will disconnect its associated generator from the busbars and isolate its field circuit and illuminate the following annunciators. Operated to the CLOSE position, and held for 5 seconds, will reset the generator field circuit, and subsequent release to the center position will allow the Generator Line Contactor (GLC) to close, provided that no fault exists, to connect the generator to the busbars.



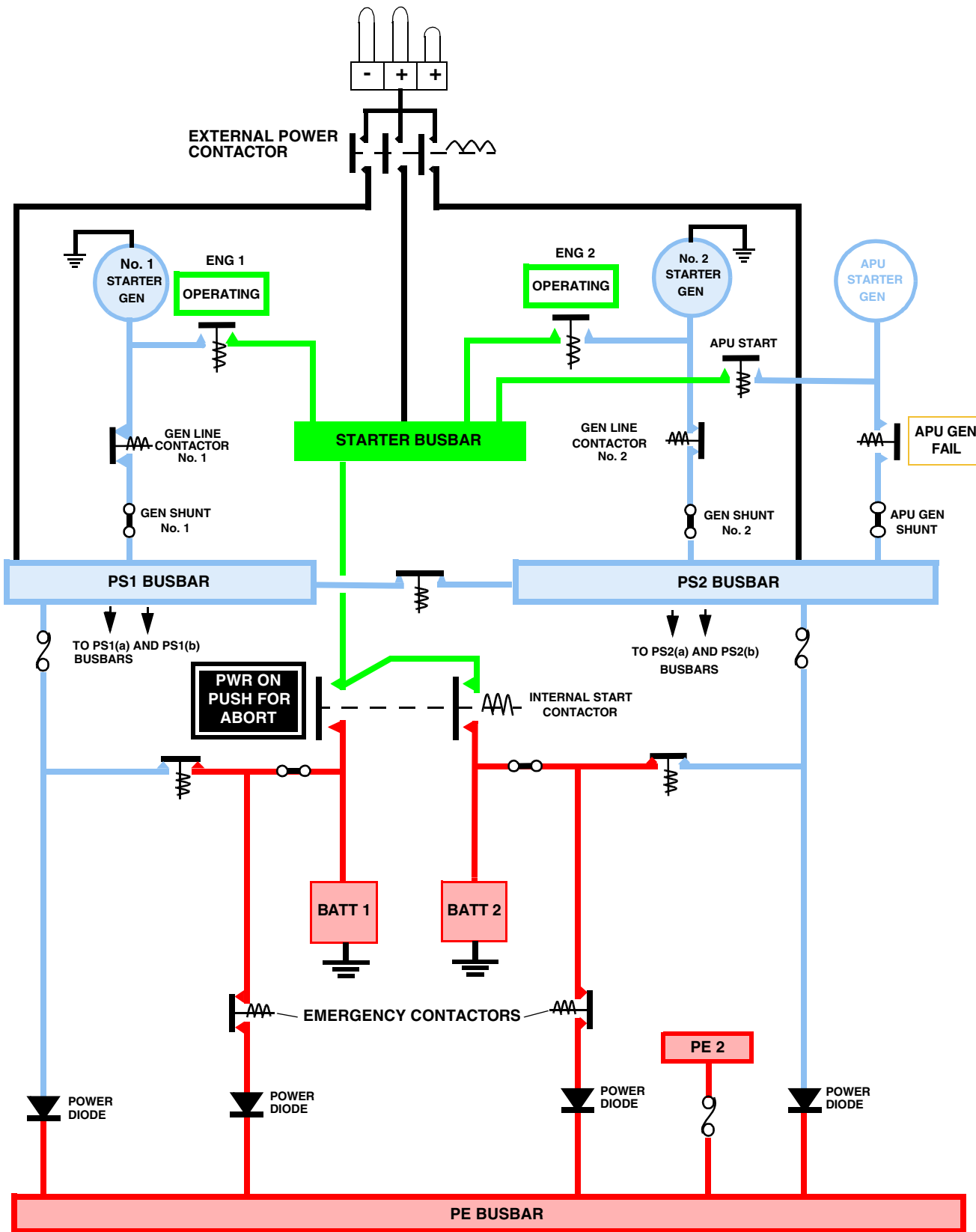


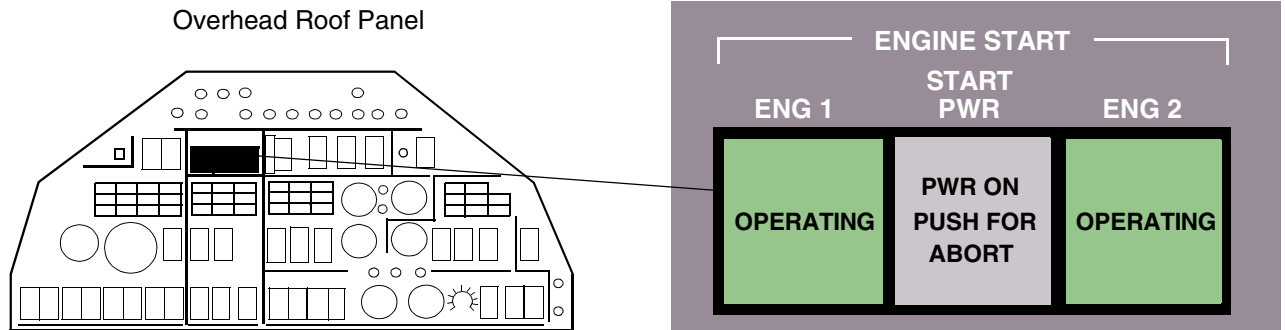
Figure 4
Normal Flight Conditions

ENGINE START USING EXTERNAL POWER

Selecting the EXT PWR switch to ON with a suitable external power supply unit will energize all busbars including the start busbar providing that internal start power has not been previously selected.

Operation of the START PWR push switch illuminates the PWR ON/PUSH FOR ABORT annunciator and brings the start circuit to a state of readiness for ENGINE START switch selection. This push switch operation also inhibits an internal start.

A warning horn will sound if the switch is operated and the LANDING GEAR selector is not in the down position.



NOTES:

1. No. 1 avionics and other essential loads should only be used prior to engine starting.
2. No. 2 engine is started first and then its generator is used as detailed below.

At ENGINE START switch operation (ENG 1 or 2) the Generator Control Unit (GCU) initiates the start cycle. Illumination of the OPERATING annunciator indicates completion of the start hold-on circuit, allowing release of the ENGINE START switch.

With the start busbar connected to the starter/generator, the engine motors. When N_2 RPM reaches 10% or more and N_1 is indicating, the HP cock is selected open to supply fuel to the engine and also energizes the igniter unit through the HP cock microswitch.

As the engine reaches self sustaining speed, the GCU initiates a start cut-off sequence. At cut-off, the OPERATING annunciator extinguishes.

ABORT START

The starting sequence may be aborted at any time by a second operation of the START PWR switch.

This initiates a start cut-off sequence by removing the supply to the GCU and extinguishes the PWR ON/PUSH FOR ABORT and OPERATING annunciators.

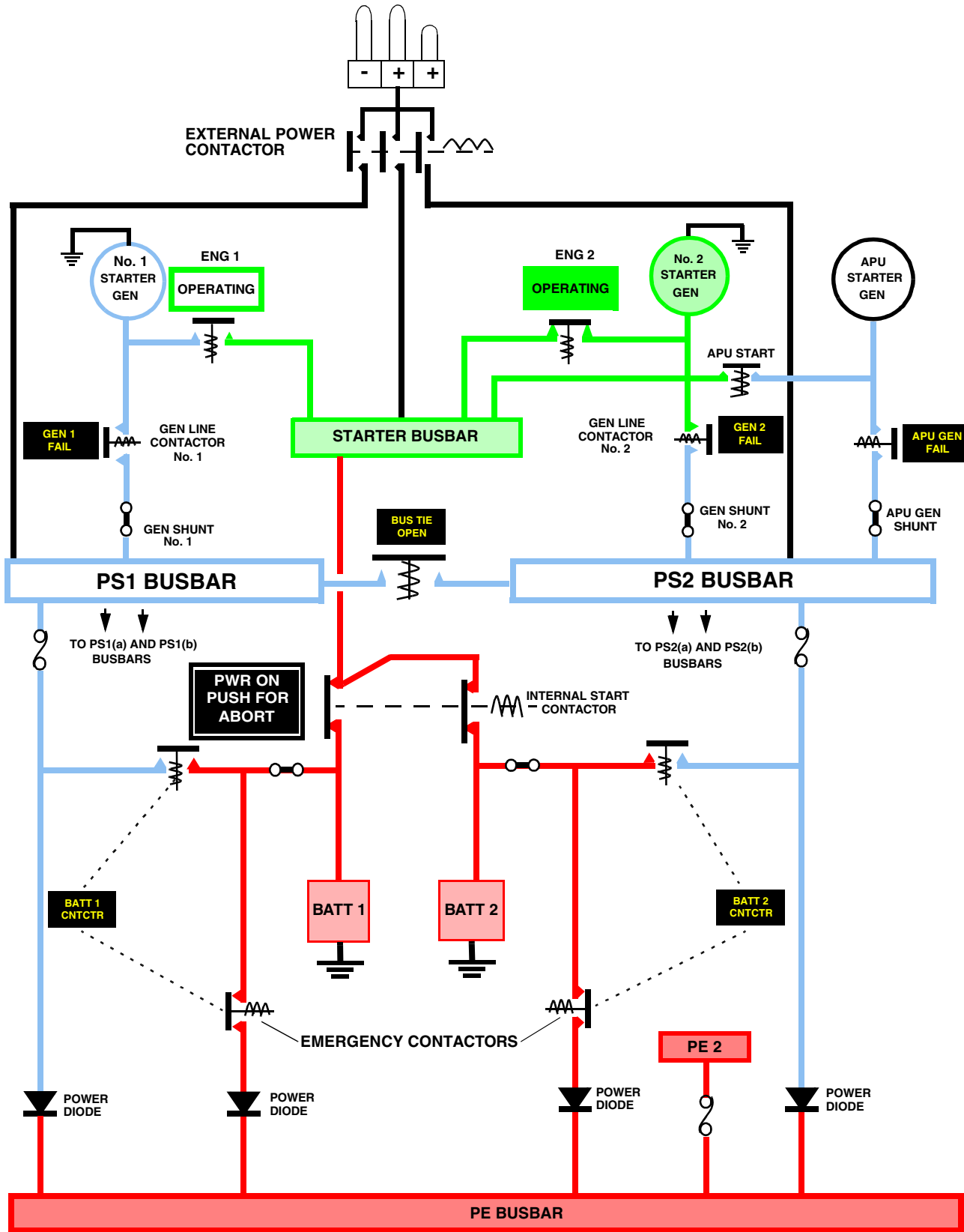


Figure 5
Internal Start with No. 2 Engine Selected

ENGINE START USING BATTERY POWER (Figure 5)

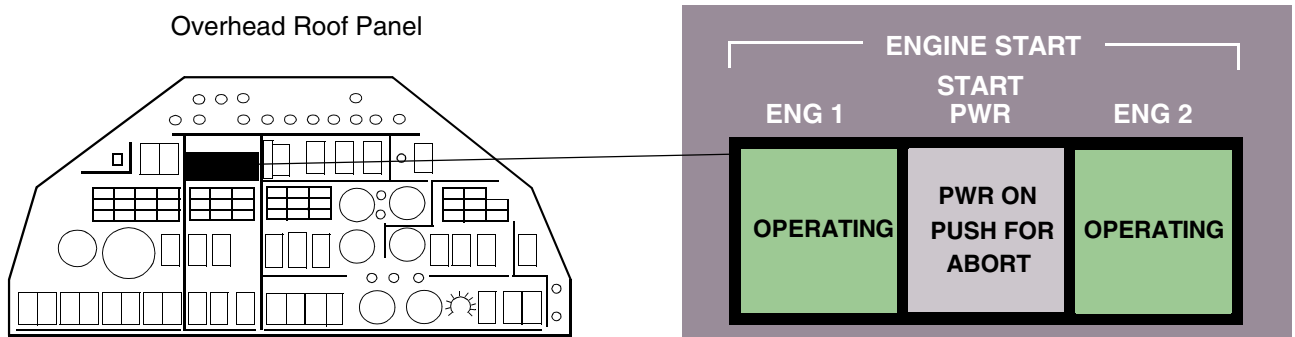
Selecting the BATT switch to ON energizes PE busbar and makes the battery power available at the internal start contactor. Operation of the START PWR energizes the internal start contactors which connect both batteries to the start busbar and brings the system to a state of readiness for ENGINE START.

When the START PWR switch is operated the integral PWR ON PUSH FOR ABORT annunciator illuminates and the generator fed busbars and both batteries are connected to the start busbar.

Pushing either ENGINE START switch (ENG 1 or 2) illuminates the OPERATING annunciator and busbars PS1 and PS2, with the generator, will be disconnected from the start busbar. The engine starter is then energized from the batteries.

WITH A GENERATOR ON LINE

With a main engine or APU generator on-line, and the BUS TIE closed, the generator and both batteries will be connected to busbars PS1, PS2 and PE.



DC POWER GENERATION

Two 28 VDC starter/generators, one driven from each engine, serve as the primary source of power for the airplane. The generators are self-exciting and each produce a rated power output of 9 kW when the engine reaches self-sustaining speed. A third starter/generator, driven from the APU (if installed) is also available. The output voltage of each generator is stabilized by an associated generator control unit (GCU). The GCUs provide load equalization when the generator outputs are paralleled.

For engine starting, the generator operates as a starter motor powered by a 28 VDC ground supply, or by the airplane main batteries connected in parallel. At starter cut-off, the generator control unit (GCU) voltage regulator assumes control of the starter/generator field. Provided the quality of generator output is satisfactory, an output from the GCU will close the generator line contactor (GLC) connecting the generator to its associated busbar (PS1 or PS2). When the GLC closes, the related GEN FAIL annunciator extinguishes.

NOTES:

1. Closure of the GLC is inhibited when busbar voltage is higher than generated voltage and when EXT POWER is ON.
2. Should the generator have been previously tripped manually, it will require to be manually reset.

In the event of reverse current, overvoltage, or over excitation faults being detected, the GCU will signal the GLC to open, thereby removing the faulty system from the busbars and illuminating the relevant GEN FAIL annunciator.

NOTE: An attempt to reinstate an off-line generator can be made using the GEN CLOSE-TRIP switch.

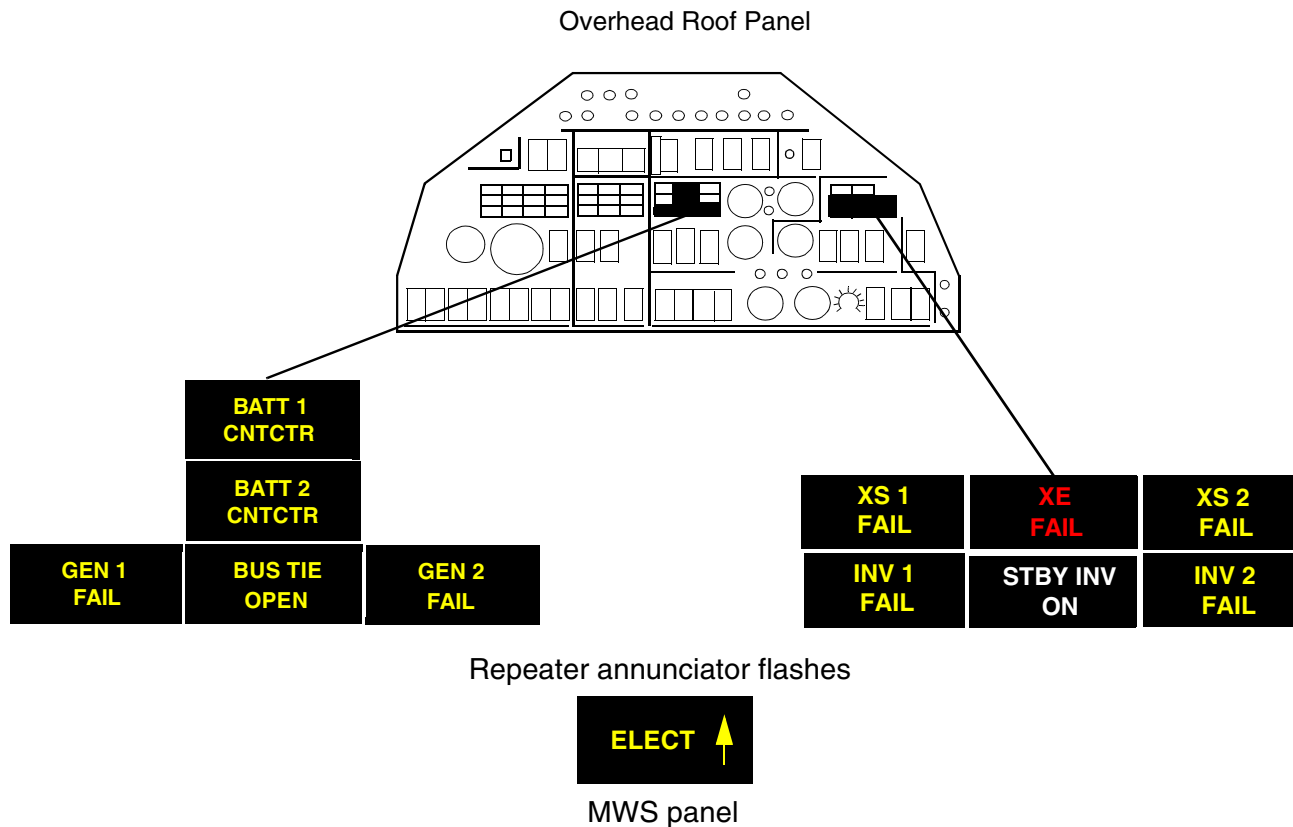
SINGLE GENERATOR FAILURE (Figure 6)

A faulty generator may be tripped off-line automatically by its GCU, or by operation of the GEN CLOSE-TRIP switch to the momentary TRIP position. With the unserviceable generator off-line, operating the BUS TIE switch to CLOSE closes the BUS TIE contactor so that the serviceable generator feeds busbars PS1 and PS2 as well as PE.

DOUBLE GENERATOR FAILURE (Figure 7)

Following a double generator failure, both generator contactors open. Both battery contactors also open to prevent the batteries from powering the non-essential loads on PS1 and PS2 busbars.

The following annunciators will illuminate.



Selection of the BATT switch to EMERG connects direct supplies from the batteries to the emergency contactors to make sure they remain energized closed. These supplies also make sure the battery contactors are opened, should they have failed to do so due to a fault in the automatic circuits. To achieve the maximum time on battery power, it is necessary that load-shedding is carried out.

Refer to the Pilot Checklist - EMERGENCY PROCEDURES - for DOUBLE GENERATOR FAILURE.

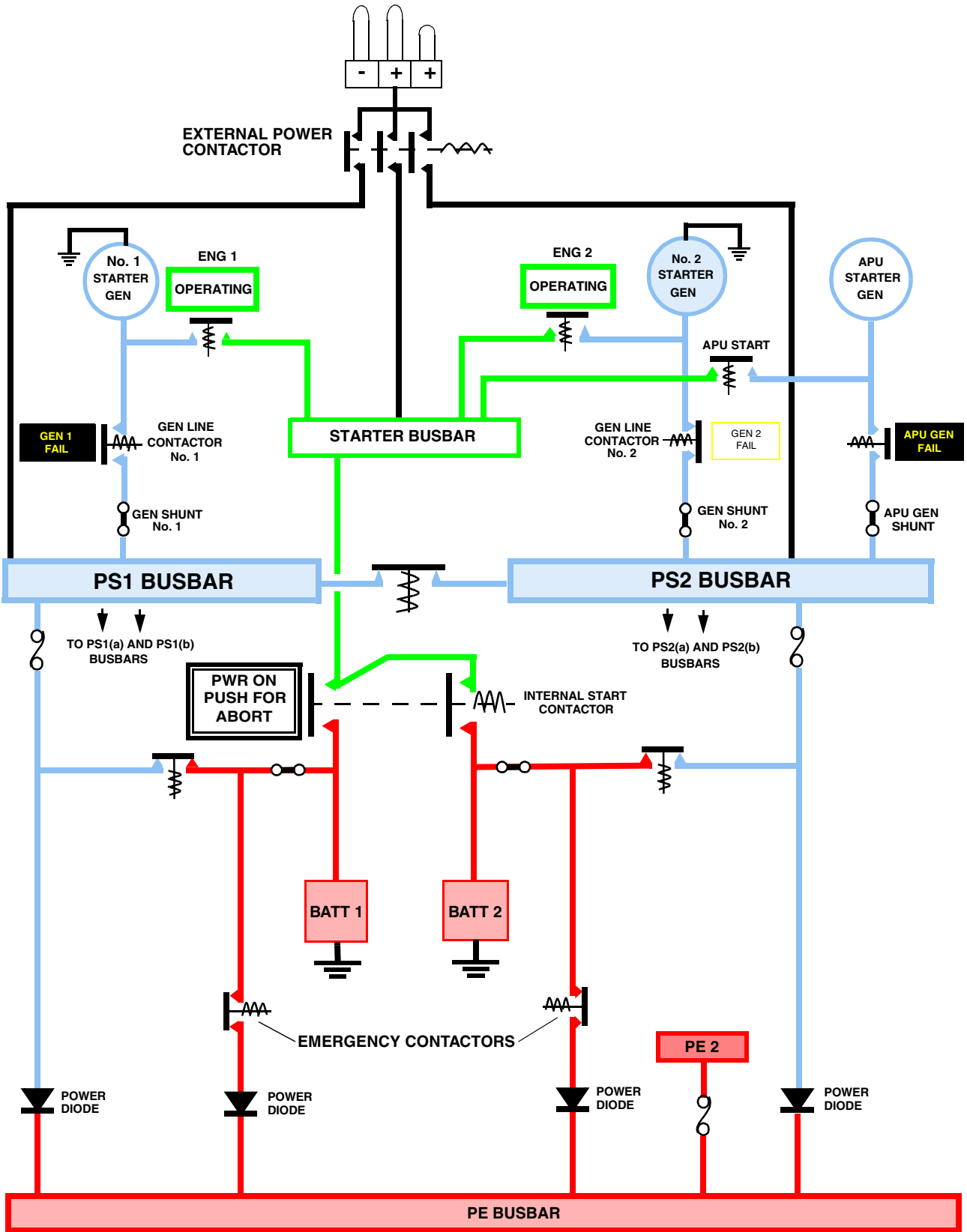


Figure 6
Single Generator Failure

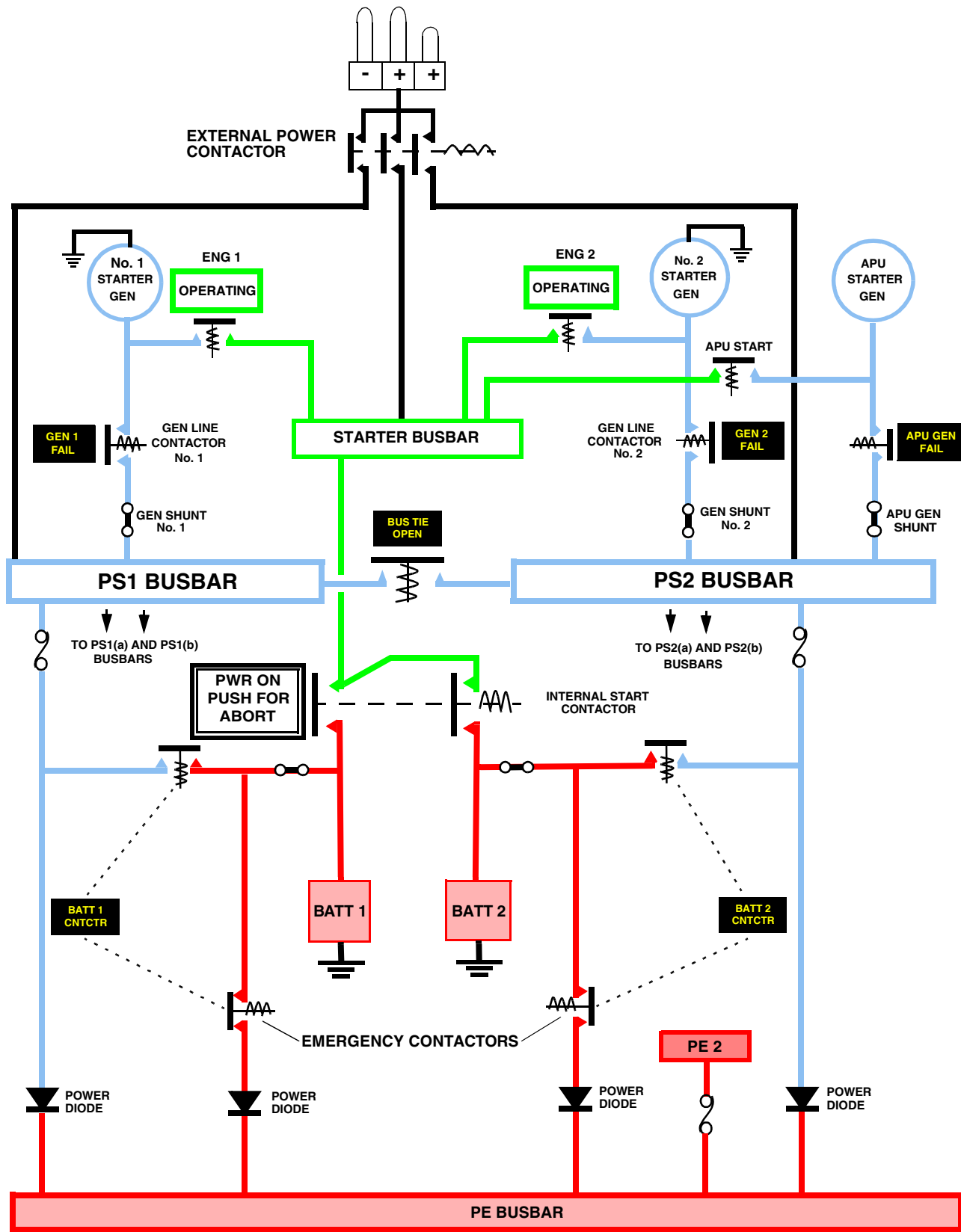


Figure 7
Double Generator Failure

APU GENERATOR (if APU installed)

The generator driven by the APU is rated at 28 VDC at 250 AMPS. When the APU is running, operating the APU GEN switch, located on the APU control panel - vestibule panel inner face, to CLOSE and held for 5 seconds causes the APU generator contactor to close. The electrical output of the APU is connected to PS2 busbar and selecting the BUS TIE switch to CLOSE also connects the APU output to PS1.

OVERVOLTAGE PROTECTION

The GCU overvoltage protection circuit operates when the generator terminal voltage rises above 32.5 VDC. This opens the generator field and signals the GLC to open, disconnecting the generator from its busbar.

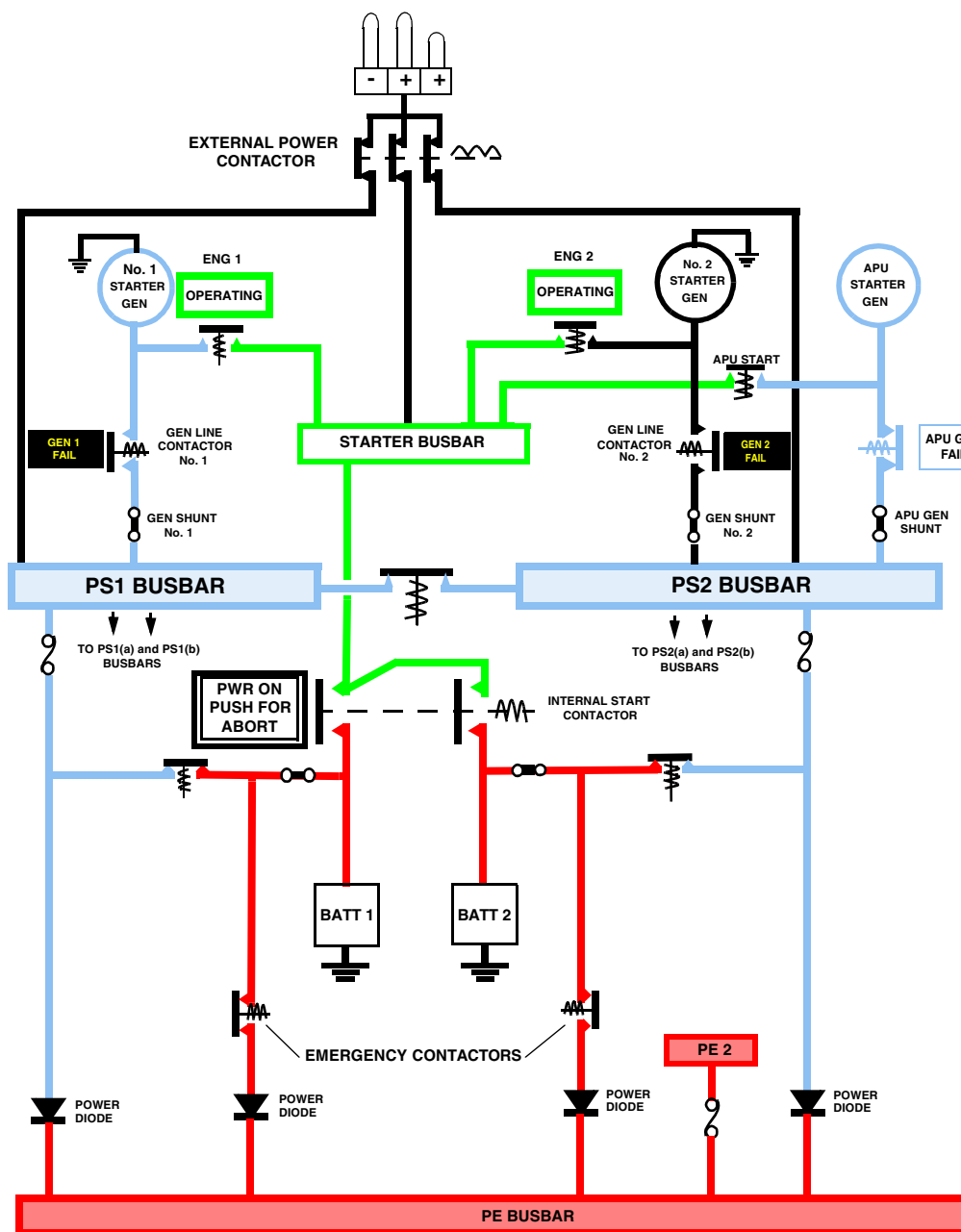


Figure 8
APU (if installed) Generator On-Line

AC POWER

AC power is supplied from two sources:

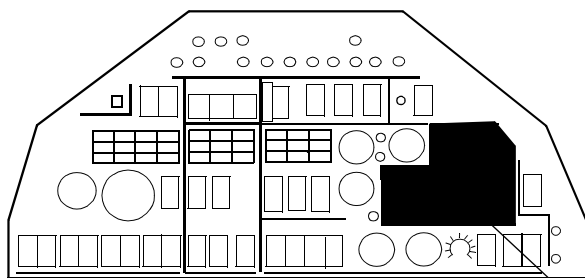
- DC driven static inverters
- Engine driven alternators

CONTROLS and INDICATIONS

All controls and indicators, with the exception of the ELECT repeater annunciator on the MWS panel, are located on the AC POWER section of the overhead roof panel. The main inverter START-STOP switches are three position switches, spring-loaded to the center position.

The illumination of the XE FAIL annunciator will also result in the red flashing MWS master warning lamps on the glareshield to operate. The ELECT repeater annunciator will flash when any of the following annunciators illuminate:

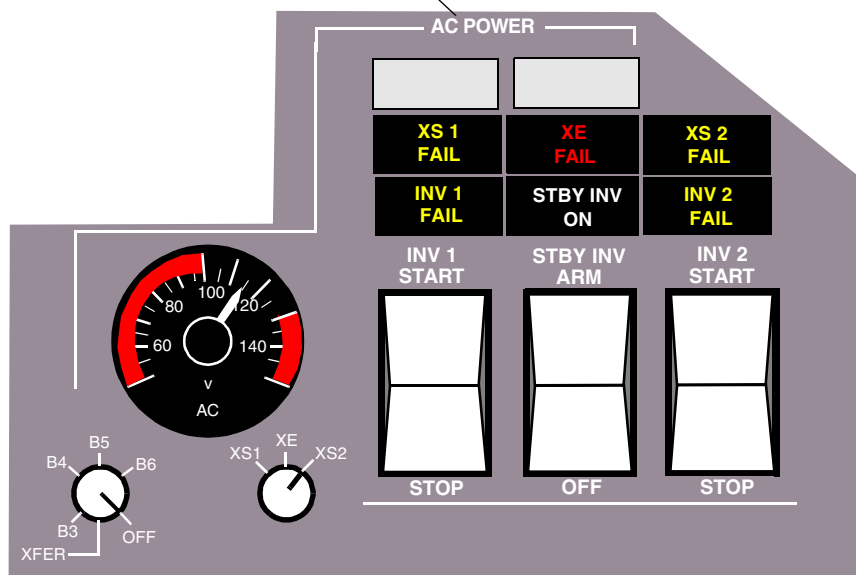
Overhead Roof Panel



Repeater annunciator flashes



MWS panel



The AC VOLTS indicator is calibrated to read from 50 to 150 VAC. Its face has a red segment from 50 volts to 100 volts and another red segment from 130 volts to 150 volts.

Voltage on busbars XS 1, XE and XS 2 may be displayed by selection of the associated voltmeter rotary switch.

STATIC INVERTERS

Two 1500VA, 115V, 400 Hz. main static inverters, designated No. 1 and No. 2, are installed in the rear equipment bay. Under normal operating conditions, these main inverters provide power to the airplane's AC busbars. A 250VA, 115V, 400Hz. standby inverter is installed in the rear equipment bay to power essential AC services in the event of failure of both main inverters.

Starting No. 1 Inverter

Momentarily selecting INV 1 switch to the START position causes the following actions:

- Energize No. 1 inverter and connect its output to XS 1 busbar.
- Busbars XE and XS 2 will be supplied from XS 1 via the auto transfer circuit.
- The following annunciators will extinguish: XS 1 FAIL, INV 1 FAIL, XE FAIL and XS 2 FAIL. The red MWS master warning lamps will also cease to operate.
- Annunciator INV 2 will remain illuminated.

Starting No. 2 inverter

With the No. 1 inverter on-line, momentarily selecting the INV 2 switch to START causes the following actions:

- Energizes No. 2 inverter.
- Disconnect busbar XS 2 from the output of No. 1 inverter.
- Connect No. 2 inverter output to XS 2 busbar.
- INV 2 FAIL annunciator and the ELECT repeater annunciator to go out.

Failure Of a Main Inverter

Failure of one main inverter results in the related INV FAIL annunciator and ELECT repeater to illuminate. The auto transfer circuit connects the remaining main inverter to all three busbars.

Failure Of Both Main Inverters

Provided the STBY INV switch is selected to ARM, failure of both main inverters results in the following actions:

- Energizes the standby inverter and connect its output to XE busbar.
- The STBY INV ON annunciator will illuminate.
- The XS 1, INV 1, XS 2 and INV 2 FAIL annunciators will illuminate, together with the ELECT repeater.

NOTE: If the standby inverter fails while operating, the XE FAIL annunciator will illuminate and the MWS master warning lamps will flash.

AC POWER DISTRIBUTION

Two main busbars XS 1 and XS 2 and an essential busbar XE are provided. During normal operation, busbars XS 1 and XE are fed by No. 1 inverter and XS 2 by No. 2 inverter.

In the event of a single main inverter failure, the remaining main inverter output will be automatically switched to supply all three busbars. If failure of both main inverters should occur, essential services supplied from busbar XE will be maintained by the standby inverter.

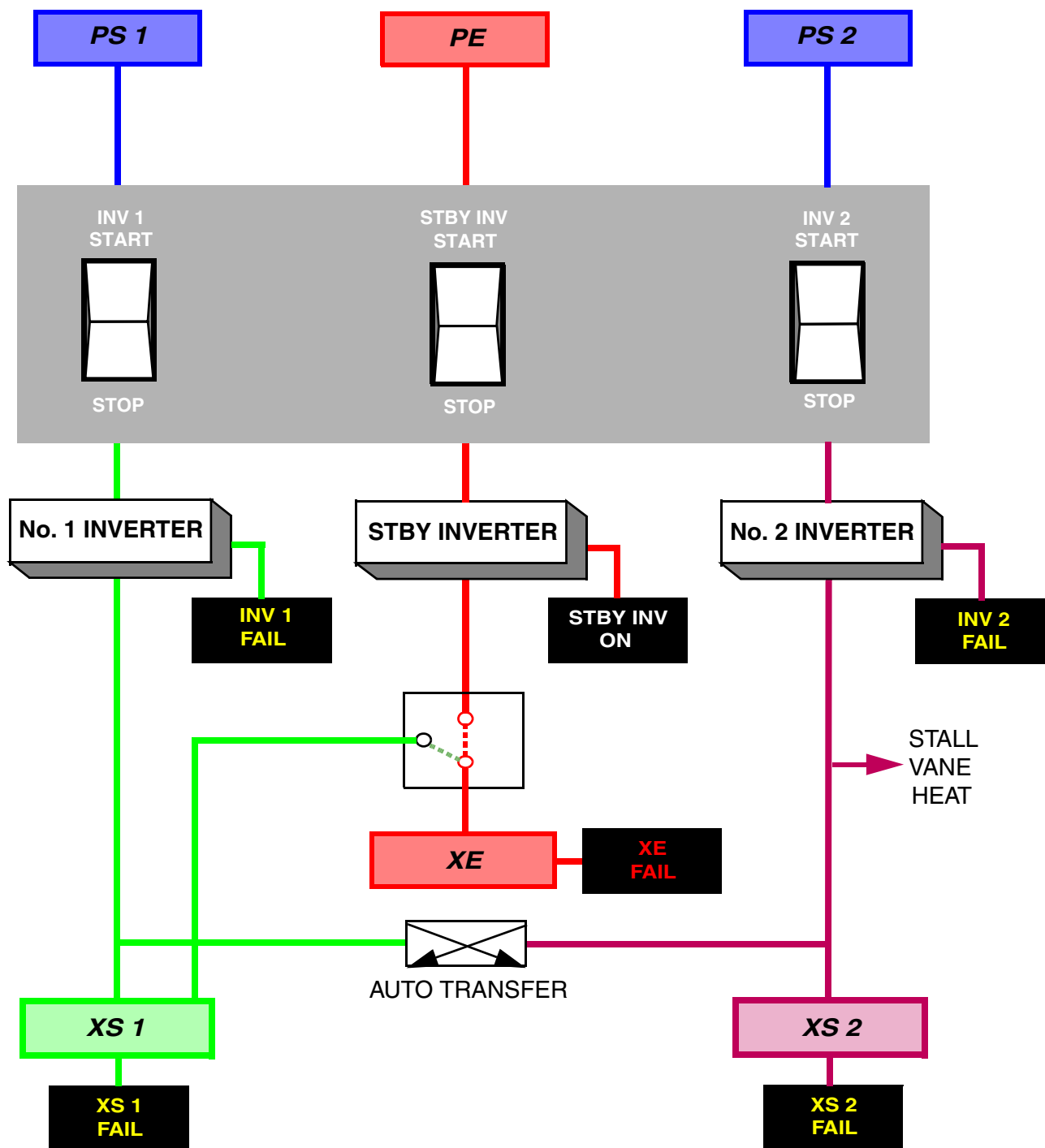


Figure 8
Inverter System Busbars - Simplified

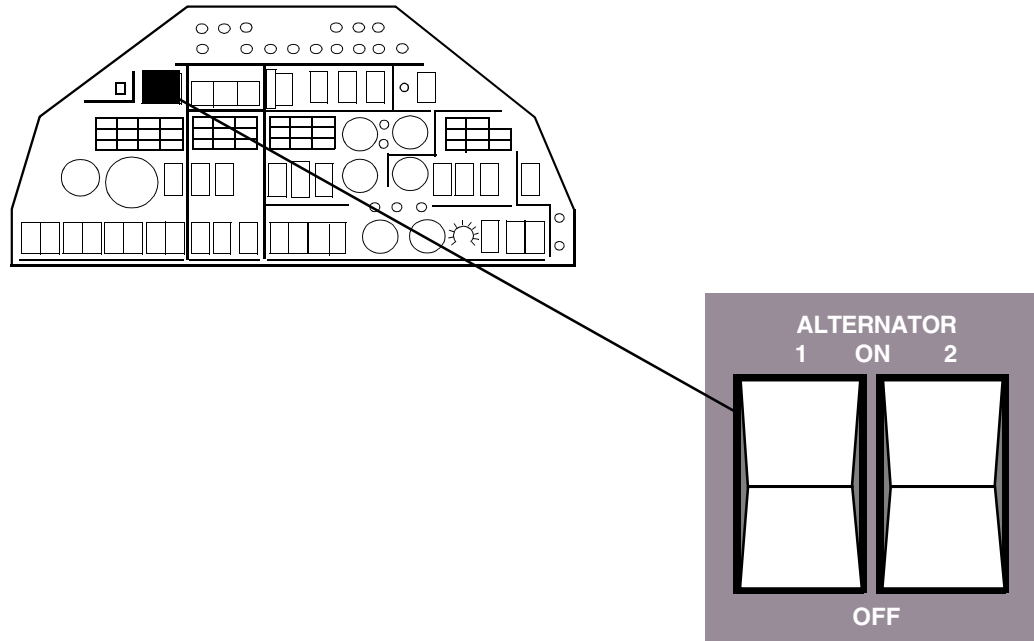
ALTERNATOR POWER SUPPLY

The AC generated power is supplied from two 208V, frequency wild, three phase alternators, one driven by each engine. This supply is used to power the windscreen and side screen heating and the vane heaters.

Each alternator is controlled by an ALTERNATOR 1 or 2 ON/OFF switch located at the top of the ICE PROTECTION section of the overhead roof panel.

Failure of an alternator is indicated by an ALTR 1 or 2 FAIL annunciator on the overhead roof panel.

Overhead Roof Panel



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