MOTOROLA

POWER SUPPLY MODULE

INCLUDES MODELS:
CPN1049F (265W w/o Battery Charger; AC Input)
CPN1050G (265W with Battery Charger; AC Input)

1 DESCRIPTION

The Models CPN1049F / CPN1050G Power Supply Modules are described in this section. A general description, performance specifications, identification of controls, indicators, and inputs/outputs, a functional block diagram, and functional theory of operation are provided. The information provided is sufficient to give service personnel a functional understanding of the module, allowing maintenance and troubleshooting to the module level. (Refer also to the Maintenance and Troubleshooting section of this manual for detailed troubleshooting procedures for all modules in the station.)

General Description

The Models CPN1049 / CPN1050 Power Supply Modules each accept an ac input (90−264 V ac, 47−63 Hz) and generate +14.2V dc and +5.1V dc operating voltages to power the station modules. Each power supply module is comprised of three circuit boards which provide several switching-type power supply circuits, power factor correction circuitry, battery charger/revert circuitry (CPN1050 only), and diagnostics and monitoring circuitry, all contained within a slide-in module housing.

The power supply module provides the following features:

- **Auto-ranging for input voltage and frequency** — circuitry automatically adjusts for input ranges of 90−264 V ac and 47−63 Hz; no jumpers, switches, or other settings are required
- **Input transient and EMI protection** — MOV, gas discharge, and filter devices protect the power supply circuitry from ac line voltage transients and electro-magnetic interference
- **Internal voltage and current limiting** — circuitry continually monitors critical voltages and currents and shuts supply down if preset thresholds are exceeded
- **Temperature protection** — module contains built-in cooling fan; supply shuts down if temperature exceeds preset threshold
- **Diagnostic monitoring** — critical internal parameters are continually monitored and reported to the Station Control Module, which can automatically provide correction for certain operating conditions

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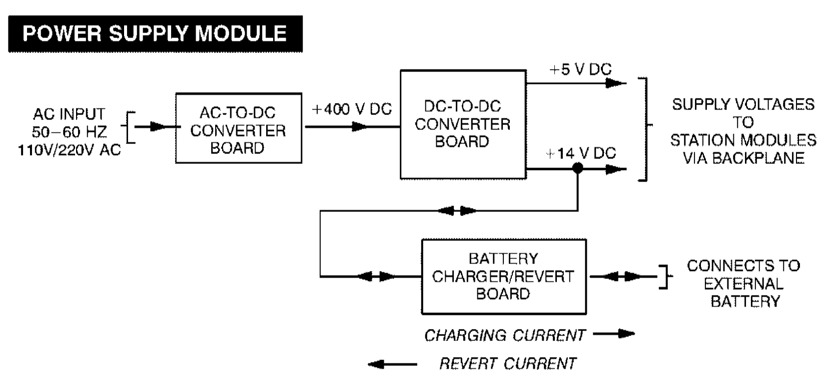
General Description (continued)

- **Fan Failure Protection** — Power Supply enters shutdown mode in event of cooling fan failure
- **Battery Reverse Polarity Protection** — Charger circuitry is protected against connecting the external battery in reverse polarity (CPN1050 only)
- **Auto Switchover to/from Battery** — If AC input fails, station is automatically switched over to battery operation; when AC input is restored, station is automatically switched back to power supply operation (CPN1050 only)
- **Auto Recovery from Shutdown** — Power Supply automatically recovers from shutdown mode if the cause of the shutdown no longer exists
- **Software-Controlled Battery Charging Voltage** — The battery charging voltage and current is controlled based on the ambient temperature (CPN1050 only)
- **Limited In-Rush Current** — Circuitry limits in-rush current to less than 30 A in all conditions

The Models CPN1049 and CPN1050 differ only in the inclusion of battery charger/revert board (CPN1050 only). Unless otherwise noted, the information provided in this section applies to both models.

Power Supply Module Simplified Block Diagram

The illustration below provides a simplified block diagram of a Power Supply Module (with battery charger) showing how the three circuit boards interconnect. A detailed block diagram and functional theory of operation for each board is provided later in this section (beginning on page 6).



Overview of Circuitry

The power supply module is comprised of three circuit boards, connected together via cables. These boards contain circuitry as follows:

AC-to-DC Converter Board (CPN6065D)

- **Input Conditioning Circuitry** — consists of ac line transient protection, EMI filtering, front panel on/off switch, startup-delayed relay, and a full-wave rectifier.
- **Startup Delay Circuitry** — provides a delay of approximately 1.5 seconds from time on/off switch is turned on until the power supply becomes functional (allows pre-charge of high-capacity filter capacitors to limit in-rush current on power up).
- **Boost/Power Factor Correction Circuitry** — consists of switching-type power supply that generates +400V dc for use by DC-to-DC Converter Board, as well as providing power factor correction.
- **Battery Revert Trigger Circuitry** — Monitors +400 V dc and generates a signal to the Battery Charger/Revert Board to activate battery revert if the +400 V dc fails or drops below approximately +350 V dc.
- **VCC Supply Circuitry** — consists of switching-type power supply that generates the VCC supply voltage (approximately +13V dc) for use by circuitry on AC-to-DC Converter Board and DC-to-DC Converter Board.

DC-to-DC Converter Board (CPN6079E)

- **+14 V Supply Circuitry** — consists of switching-type power supply that generates the +14 V dc supply voltage and provides primary/secondary isolation.
- **+5 V Supply Circuitry** — consists of switching-type power supply that generates the +5 V dc supply voltage (from +14 V dc supply voltage).
- **Battery Charger Control Circuitry** — Provides buffering for signals related to battery charging/revert operation.
- **Reference Voltage Circuitry** — Generates +10V_SEC and +2.5V_SEC supply voltages for use by local circuitry.
- **Diagnostics Circuitry** — converts analog status signals to digital format for transfer to Station Control Module.
- **Address Decode Circuitry** — performs address decoding to provide chip select signal for the A/D converter.
- **Startup/Shutdown Control Circuitry** — Provides delay intervals for startup and shutdown of entire power supply module.

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Overview of Circuitry (Continued)

Battery Charger/Revert Board (CPN6074C)

- **Charger Supply Circuitry** — consists of switching-type power supply that generates charging current for the external storage battery.
- **Pulse Width Modulator Circuitry** — consists of pulse-width modulator, boost switch timer, and driver circuitry to provide variable-width pulses for the FET switches in the Charger Supply Circuitry.
- **Battery Revert Circuitry** — consists of signal monitoring circuitry which turns on the Battery Revert FET Switches for certain input signal conditions (such as AC Fail).
- **Current Mode Controller Circuitry** — consists of current and voltage feedback signal monitoring circuitry which controls the Pulse Width Modulator Circuitry to maintain the desired charger output current and voltage.
- **SPI Bus Interface Circuitry** — consists of a D/A converter which accepts charger control digital signals from the Station Control Module and converts these signals to analog dc voltages to control various operating characteristics of the battery charger circuitry.
- **Shutdown Circuitry** — consists of signal monitoring circuitry which shuts down the battery charger for certain input signal conditions (such as loss of BATT_WATCHDOG signal from the Station Control Module).
- **Local Supplies Circuitry** — Accepts +14V_RAW (from DC-to-DC Converter Board) and generates VCC (+10V) and +5V supply voltages for use by local circuitry.

2 PERFORMANCE SPECIFICATIONS

Table 1 shows the electrical performance specifications for the Models CPN1049 and CPN1050 Power Supply Modules.

Performance Specifications

Table 1. CPN1049 / CPN1050 Power Supply Modules Performance Specifications

Parameter	Specification
Weight	6.5 kg (14.3 lbs)
Operating Temperature Range	−30 to +60° C (no derating)
Input Voltage Range	90 to 264 V ac
Input Frequency Range	47 to 63 Hz
Maximum Input Current	8.5 A
Steady State Output Voltages	+14.2 V dc ±5% +5.0 V dc ±5%
Output Current Ratings	+14.2 12.5 A +5.1 9 A
Total Output Power Rating	265W* * *including 100W for battery charger*
Output Ripple	All outputs 150 mV p−p (measured with 20 MHz BW oscilloscope at 25°C).

3 CONTROLS, INDICATORS, AND INPUTS/OUTPUTS

Figure 1 shows the power supply module controls, indicators, and all input and output external connections.

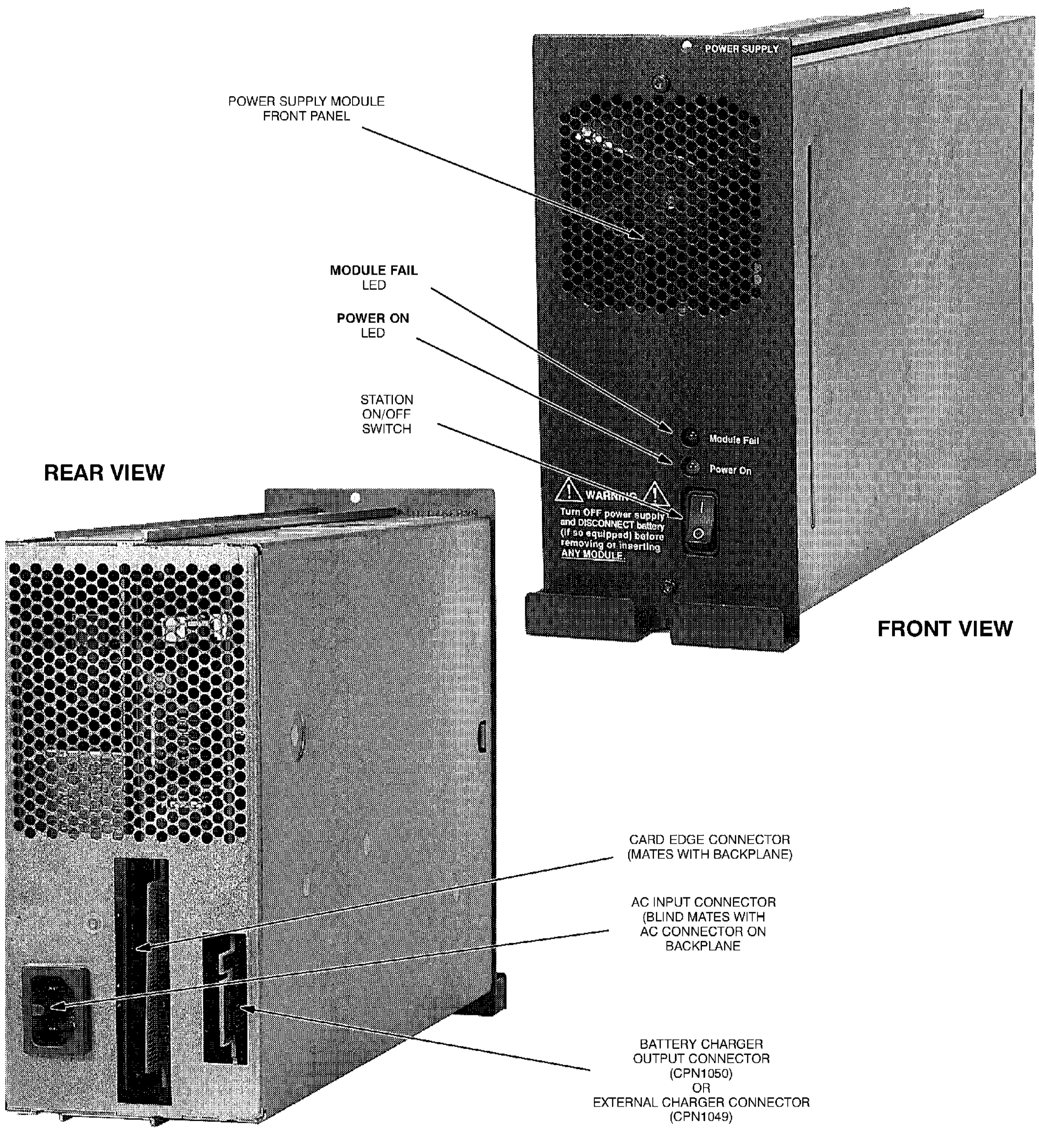

Figure 1. CPN1049 / CPN1050 Power Supply Module Controls, Indicators, and Inputs/Outputs

4 FUNCTIONAL THEORY OF OPERATION (AC-to-DC Converter Board)

The following theory of operation describes the operation of the CPN6065D AC-to-DC Converter Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 2 for a block diagram of the AC-to-DC Converter Board.

Input Conditioning Circuitry

Introduction

The AC-to-DC Converter Board accepts ac power from an external source, typically a 110V or 220/240V ac wall receptacle. AC power is connected to the board via a 3-wire line cord plugged into an ac receptacle mounted on the station backplane, into which the entire power supply module slides (blind mate connection).

Transient and EMI Protection

The ac line input is fed to the AC-to-DC Converter Board circuitry via transient protection and EMI filter circuits. The transient protection devices provide protection against voltage spikes by providing an effective short to ground under high voltage transient conditions. The EMI filter prevents electrical noise generated by the power supply module from interfering with other equipment connected to the same ac line circuit.

Front Panel On–Off Switch / Relay Circuitry

A rocker-type switch located on the power supply module front panel allows the power supply (and station) to be turned on and off. Note that the switch allows the filter circuitry (p/o Boost/Power Factor Correction Circuitry) to slowly charge (for approximately 1.5 seconds after switch is turned on) through two diodes and resistors. After the 1.5 second delay, the relay turns on and provides an ac input to the bridge rectifier. This 1.5 second pre-charge delay period limits in-rush current through the filter capacitors upon power up.

Rectifier Circuitry

The ac line voltage (via the relay) is rectified by a full-wave bridge rectifier and fed to the Boost/Power Factor Correction Circuitry.

Startup Delay Circuitry

This circuitry monitors the ac input (from the on/off switch) and provides a 1.5 second delay when switch is turn on before energizing the relay to turn on the power supply.

If the AC input is below approximately 85 V rms, the relay will not be turned on and the power supply outputs will be disabled. The red **Module Fail** LED on the front panel will light.

Boost/Power Factor Correction Circuitry

Overview

The Boost/Power Factor Correction Circuitry is comprised of a switching-type power supply which generates a +400 V dc voltage. This voltage is fed to the DC-to-DC Converter Board to be used as the source for the +14V and +5V Supply Circuits.

Switching Power Supply Operation

The switching power supply consists of a pulse width modulator (PWM) running at 67 kHz. The PWM output pulses are fed through driver transistors to control three power FETs which rapidly switch the Toroid Power Coil to ground. The result is a high induced current which charges the filter capacitors to approximately 400 V dc.

Note that the PWM output pulses are also controlled by voltage and current feedback signals. These feedback signals allow the average ac line current over switching cycles to be sinusoidal and in-phase with the ac input voltage (i.e., power factor corrected).

Battery Revert Trigger Circuitry

A comparator monitors the +400 V dc from the output of the Boost/Power Factor Correction Circuitry and a +5V reference signal. If the +400 V dc voltage should drop below approximately +350 V dc (considered an ac input failure), a BOOST_LOW signal is sent to the Battery Charger/Revert Board (via the DC-to-DC Converter Board) to activate battery revert mode.

VCC Supply Circuitry

This circuitry consists of a switching-type power supply which generates a +13 V dc supply voltage used as VCC by the local circuitry and the primary side of the DC-to-DC Converter Board.

The circuitry consists of a pulse width modulator (PWM) running at 67 kHz (from DC-to-DC Converter Board). The PWM output repetitively gates the +400 V dc (from the Boost/Power Factor Correction Circuitry) to the primary of the housekeeping transformer. The result is an induced voltage in the secondary winding which feeds a half-wave rectifier circuit. The output is a +13 V dc VCC supply voltage.

LED Status Indicators

Two LEDs located on the power supply module front panel indicate module status as follows:

- **AC On**— lights GREEN when On/Off switch is On and the AC input voltage is within operating range; LED turns off when module is turned off, ac power is removed, or AC input voltage is below approximately 85 V rms.
- **Module Fail**— lights RED when initially turning on or off the Power Supply (this is normal and does not indicate a failure), when the DC-to-DC Converter Board is not functioning properly, or when the Boost Circuitry is not functioning properly; LED turns off when module is functioning properly

Note *When in Battery Revert Mode (CPN1050 only), neither LED is lit. The cooling fan will continue to run.*

5 FUNCTIONAL THEORY OF OPERATION (DC-to-DC Converter Board)

The following theory of operation describes the operation of the CPN6079E DC-to-DC Converter Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 3 for a block diagram of the DC-to-DC Converter Board.

+14V Main Supply Circuitry

Overview

The +14V Main Supply Circuitry is comprised of two mirrored switching-type power supplies which generate the +14 V supply voltage. This voltage is used as the source for the +5V supply circuit, as well as the +14V supply voltage for the station modules (via the backplane) and

Switching Power Supply Operation

The +14V Main Supply Circuitry consists of two identical switching-type power supplies operating in parallel. Both supplies operate identically, as follows. A 133 kHz clock signal from the Sync Generator Circuitry is fed through a buffer to a Pulse Width Modulator (PWM). The PWM output pulses control a pair of power FETS (via a driver) to gate the +400 V dc (from the AC-to-DC Converter Board) to the primary of a power transformer. The induced voltage in the transformer secondary is half-wave rectified to charge the output filter circuitry, resulting in an output voltage of +14 V dc.

Since each supply receives a 133 kHz clock signal that is 180° out of phase with the other, each switching power supply alternately charges the output filter circuitry, resulting in an effective charging rate of 266 kHz.

Protection Circuitry

Peak/Average Current Limiting Circuitry — The peak current limiting circuitry accepts an output current feedback signal and a scaled +14V_RAW reference signal to control the PWMs. This effectively maintains a constant output voltage for varying output current demands.
The average current limiting circuitry monitors the +14 V dc output and generates a shutdown signal (MAIN_SD_PRI) if the average output current reaches a predetermined limit.

Overvoltage Protection Circuitry — This circuitry monitors the +14V output voltage and generates a shutdown signal (MAIN_SD_SEC) to shut down the entire power supply module if the +14 V output voltage exceeds a preset threshold.

+5 V Supply Circuitry

Overview

The +5 V Supply Circuitry is comprised of a switching-type power supply which generates a +5 V dc supply voltage. This voltage is used as the +5 V supply voltage for the station modules (via the backplane).

Switching Power Supply Operation

The +5 V switching power supply consists of a pulse width modulator (PWM) running at 133 kHz. The PWM output pulses are fed through a driver to control a power FET which repetitively gates the +14V_RAW (from the +14V Main Supply Circuitry) to a power coil. The result is a high induced voltage which charges the filter capacitors to approximately +5 V dc. A current sense comparator provides a feedback signal to the PWM to maintain a constant output voltage.

Protection Circuitry

An overvoltage detect circuit monitors the output voltage and, if preset thresholds are exceeded, turns on a FET crowbar circuit which immediately discharges the output to protect other modules in the station.

An overcurrent detect circuit monitors the current draw from the +5V Supply Circuitry and, if a preset threshold is exceeded, generates a MAIN_SD_SEC signal which shuts down the entire power supply module.

Battery Charger Control Circuitry

The AC_FAIL signal (from the AC-to-DC Converter Board) is buffered and fed to 1) the diagnostics circuitry as AC_GOOD_DIAG, and 2) the Battery Charger/Revert Board as BATTERY_REVERT. This signal activates battery revert mode.

Reference Voltage Circuitry

This circuitry accepts +14V_RAW (from the +14V Main Supply Circuitry) and generates +10V_SEC and +2.5V_SEC supply voltages for use by local circuitry.

Diagnostics Circuitry

Overview

The diagnostics circuitry consists of an 11-channel A/D converter which converts analog status signals from critical points in the power supply module to digital format for transfer to the Station Control Module via the SPI bus. Most of the status signals are generated by detect circuits to indicate the status of dc supply voltages and references.

Temperature Monitor and Control Circuitry

A thermistor mounted on the power supply module heatsink provides a varying resistance input to the Heatsink Temp Detect Circuitry. If the heatsink temperature exceeds a preset limit, the circuitry generates a MAIN_SD_SEC shutdown signal which shuts down the entire power supply module. A HEATSINK_DIAG signal is also sent to the Station Control Module via the A/D converter and SPI bus.

Fan Monitor and Control Circuitry

The cooling fan in the power supply module is powered from the +14V Supply Circuitry and runs continuously. If the fan fails, the Fan Fault Detect circuit generates a fail signal (FAN_FAIL_DIAG) which is fed to the A/D converter. The fail signal also triggers a 50 second delay circuit which (after 50 seconds) generates a MAIN_SD_SEC signal which shuts down the entire power supply.

Address Decode Circuitry

The address decode circuitry allows the Station Control Module to use the address bus to select either the D/A converter (Battery Charger/Revert Board) or the A/D converter (Diagnostics Circuitry) for communications via the SPI bus. Typical communications include reading status signals from the Diagnostics Circuitry and providing charger output control signals to the Battery Charger/Revert Board.

Startup/Shutdown Control Circuitry

Shutdown Delay Circuitry

Upon receiving a shutdown signal (MAIN_SD_PRI) from the +14V Main Supply Circuitry, this circuit passes the signal through the Soft Start Circuitry for a 1 second interval to allow the entire power supply module to shutdown. The module then restarts (if the on/off switch is in **On** position). If the MAIN_SD_PRI signal is still active, the shutdown process will repeat.

Startup/Shutdown Delay Circuitry

When the power supply module is first turned on, the RELAY_ON signal is low and the output of the Startup/Shutdown Delay Circuitry keeps the supply in shutdown mode. After about 1.5 seconds RELAY_ON goes high, and the Startup/Shutdown Delay Circuitry provides a 1 second delay before releasing the shutdown signal and allowing the power supply to operate.

When the power supply module is turned off, the RELAY_ON signal goes low and the Startup/Shutdown Delay Circuitry keeps the supply in operating mode for 1 second to allow Battery Revert Mode to activate.

Soft Start Circuitry

Each time the Soft Start Circuitry receives a startup signal (i.e., MAIN_SD_PRI is inactive and the output of the Startup/Shutdown Delay Circuitry is high), the Soft Start Circuitry provides a gradually increasing output signal to "soft start" the Pulse Width Modulators (p/o +14V Main Supply Circuitry). This action minimizes the surge current when charging the output filter capacitors.

6 FUNCTIONAL THEORY OF OPERATION (Battery Charger/Revert Board)

The following theory of operation describes the operation of the CPN6074C Battery Charger/Revert Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 4 for a block diagram of the Battery Charger/Revert Board.

Note *Model CPN1049F Power Supply Modules (without battery charging capabilities) are equipped with a CPN6078B External Charger Connect Board in place of the CPN6074C Battery Charger/Revert Board. The External Charger Connect Board provides a direct electrical path from the +14V Main Supply Circuitry (p/o the DC-to-DC Converter Board) to the card edge connector used to connect to an external charger and battery. The external charger is responsible for 1) charging the external battery and 2) detecting an AC power fail condition and initiating battery revert mode.*

Charger Supply Circuitry

Overview

The Charger Supply Circuitry is comprised of a switching-type power supply which generates the charging current necessary to charge an external storage battery.

Switching Power Supply Operation

The charger switching power supply accepts +14V (from the DC-to-DC Converter Board) which is fed through a filter and a Buck FET Switch to a Power Coil. This coil is controlled by the Buck FET Switch and a Boost FET Switch to produce an induced output voltage of approximately +12 to +16 V dc. This charging voltage is filtered and fed through a pair of Reverse Battery FET Switches to the output terminals (card edge connector that extends from the rear of the Power Supply Module). Connections to an external storage battery are made to this card edge connector.

Protection against connecting the battery in reverse polarity is provided by the Charger Output Control Circuitry and the Reverse Battery FET Switches.

A thermistor mounted near the battery and connected to the station via a backplane connector provides an input to a comparator. The comparator output (BATT_T_DIAG) provides a dc voltage proportional to the battery temperature. This signal is sent to the Station Control Module via the Diagnostics Circuitry on the DC-to-DC Converter Board.

Pulse Width Modulator Circuitry

A 133 kHz clock signal (from the DC-to-DC Converter Board) is fed through a buffer/driver to a Pulse Width Modulator (PWM). The 133 kHz PWM output pulses are fed 1) directly to the Buck FET Switch via a driver, and 2) to the Boost FET Switch via a Boost Switch Timer and Driver. The two signals control the respective FET switches to control the Power Coil in the Charger Supply Circuitry so that it produces an approximately +12 to +16 V dc output to be filtered and charge the external battery.

Battery Revert Circuitry

Overview

The Battery Revert Circuitry accepts various inputs and determines when to activate battery revert mode by turning on the Battery Revert FET Switches. Battery Revert Mode will be activated or deactivated in the following conditions:

- If the AC_FAIL signal (from the DC-to-DC Converter Board) goes low (indicating that AC power has failed), the Battery Revert FET Switches will be turned on (via the FET Driver).
- If the battery voltage is too low, the Undervoltage Detect circuit detects the condition and disables the battery revert circuitry.
- If the battery voltage is too high, the Overvoltage Detect circuit detects the condition and disables the battery charger and the battery revert circuitry.
- If a fault condition exists (e.g., +5V Overcurrent), the shutdown detect circuitry detects the condition and disables the battery charger and the battery revert circuitry.

Current Mode Controller Circuitry

Overview

The Current Mode Controller Circuitry performs two major functions:

- The PWR_CUT signal (from the DC-to-DC Converter Board) is fed through a Voltage Scaling Circuit and reduces the battery charger output current during periods of heavy current draw by the station.
- The Voltage Scaling Circuitry accepts V_BC_RAW (voltage feedback signal from battery) and BATT_VOLT_RANGE and BATT_VOLT_SELECT signals (from the Station Control Module via the D/A Converter) which combine to set the charger output voltage (in a range of +12 V dc to +16 V dc).

SPI Bus Interface Circuitry

This circuitry consists of a D/A Converter that accepts digital signals from the Station Control Module and converts them to analog signals which control the operation of the Battery Charger/Revert Board. These signals:

- Control the charger voltage to the battery (BATT_VOLT_RANGE and BATT_VOLT_SELECT)
- Disable the Undervoltage Detect Circuitry (UVLO_DISABLE) to allow the station to continue operation even though the battery voltage is below the desired level
- Provide a watchdog signal to refresh the Watchdog Timer Circuitry (BATT_WATCHDOG)

Shutdown Circuitry

This circuitry accepts four input signals and generates a shutdown signal to shut down the battery charger for certain input signal conditions, A shutdown signal will be generated for any of the following conditions:

- The BATT_WATCHDOG signal (from the Station Control Module) is not present (indicating that the Station Control Module has failed, or the station's *Battery Type* field has been programmed (via RSS) for "NONE"
- The OVLO_LCKOUT signal is high (indicating that the battery voltage is too high)
- The MAIN_SD_SEC signal is low (indicating that one of the various monitoring points indicates a fault, such as overcurrent condition for +14V or +5 V supplies, overcurrent condition for entire Power Supply Module, etc.
- The AC_FAIL signal is high (indicating that the AC power to the Power Supply Module has been interrupted)

Local Supplies Circuitry

This circuitry contains two voltage regulators which accept +14V_RAW (from the +14V Main Supply Circuitry) and generate VCC (+10 V dc) and +5 V supply voltages for use by local circuitry.

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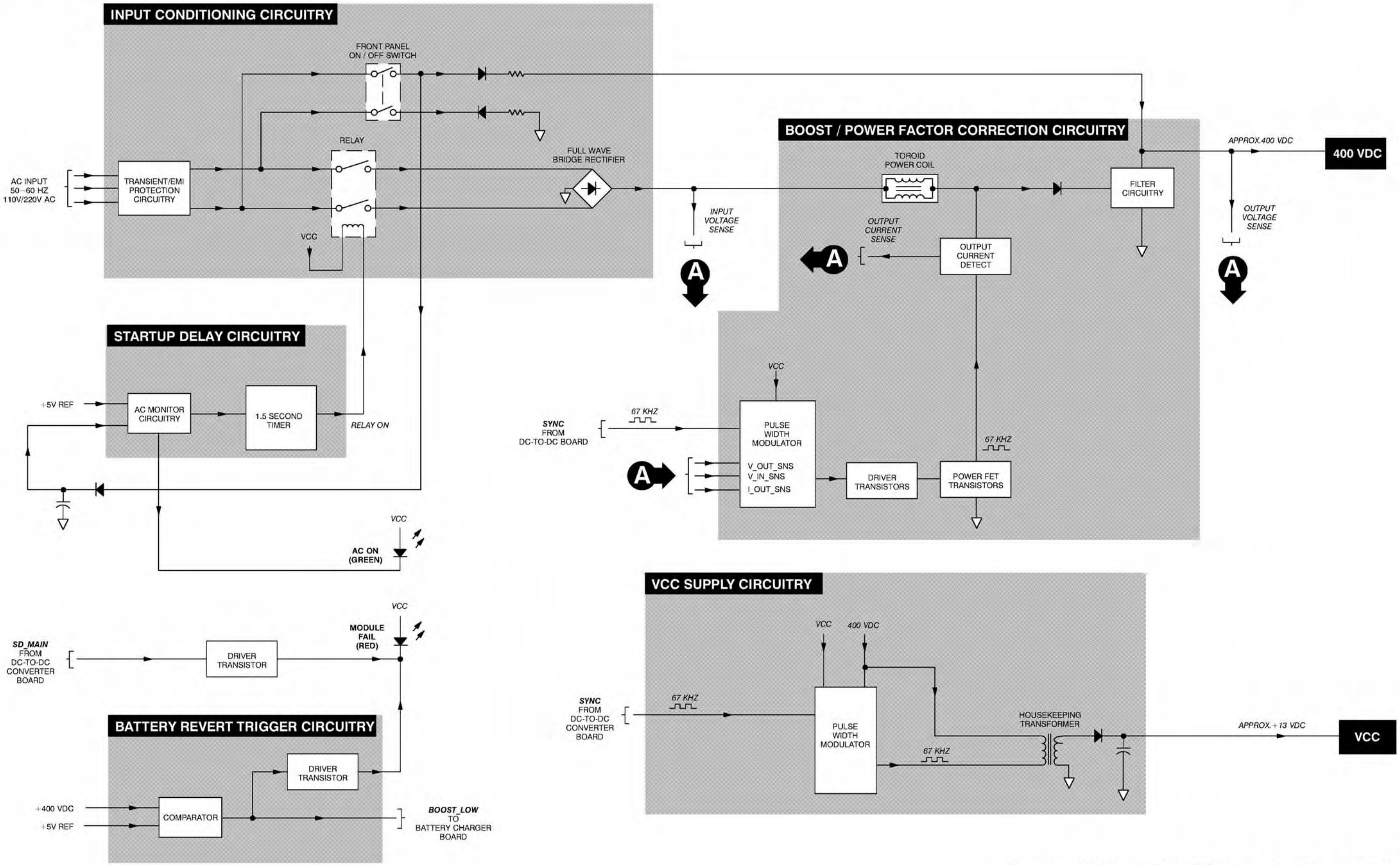
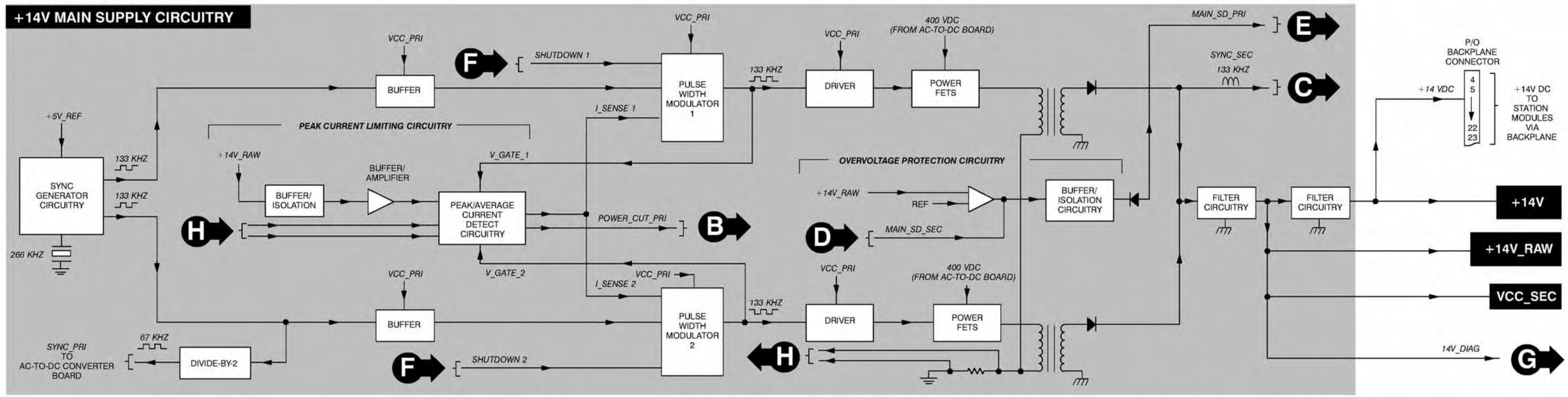


Figure 2. CPN6065D AC-to-DC Converter Board Functional Block Diagram



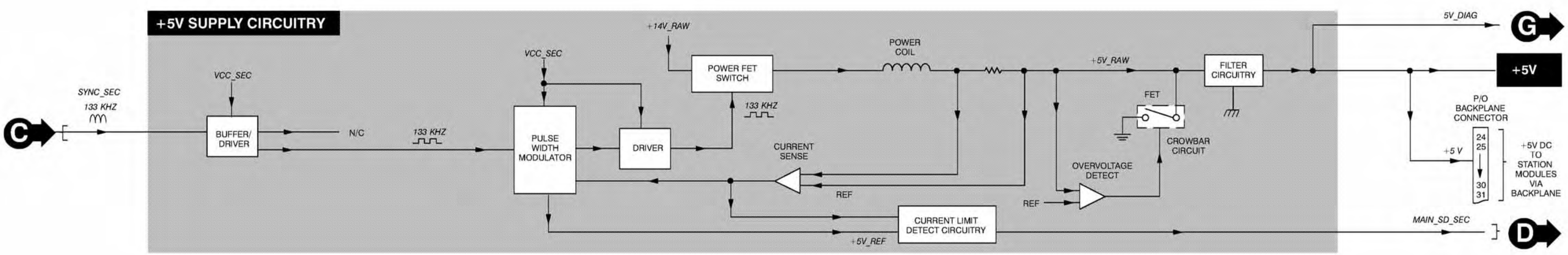


Figure 3. CPN6079E DC-to-DC Converter Board Functional Block Diagram (1 of 2)

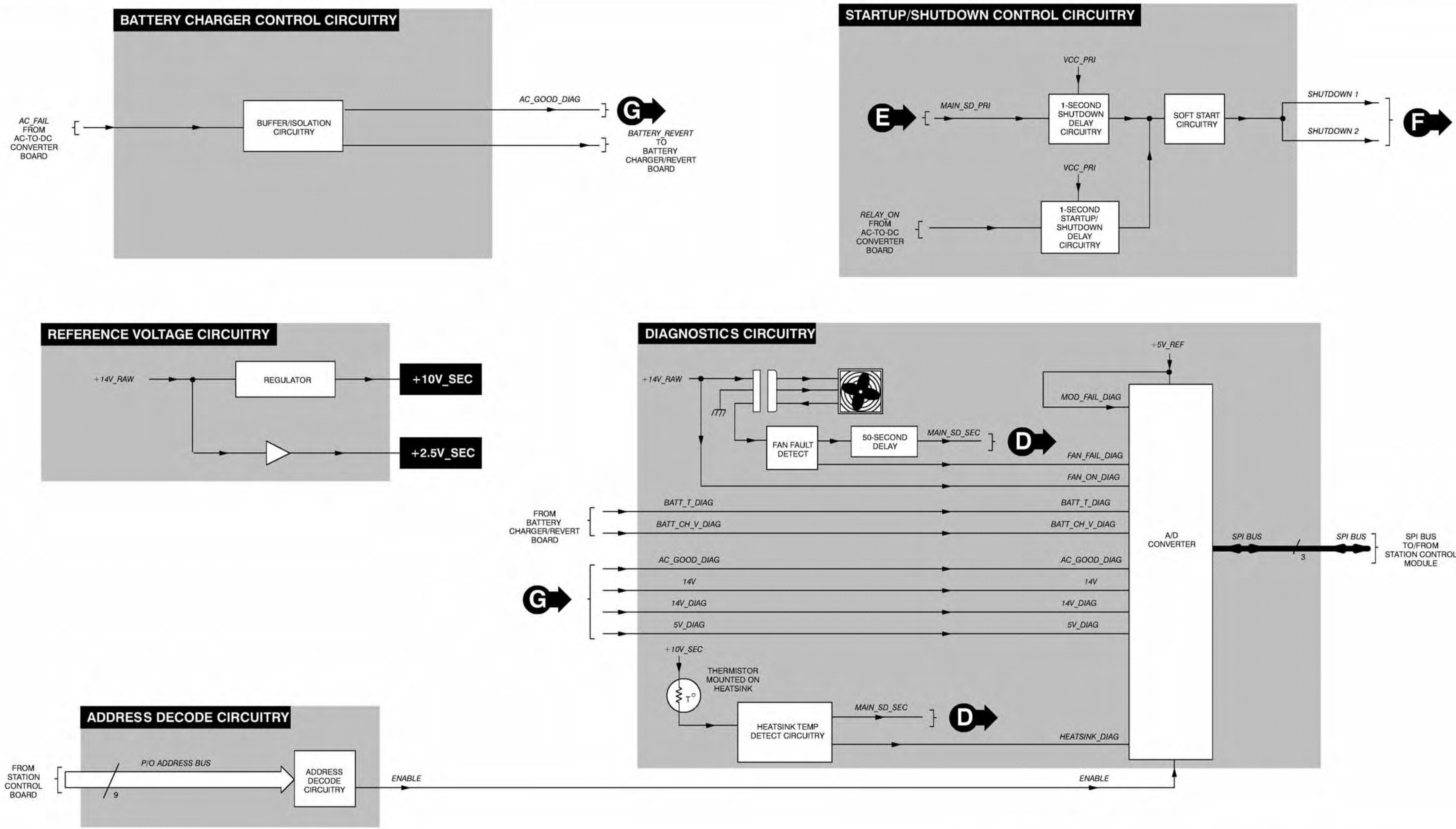


Figure 3. CPN6079E DC-to-DC Converter Board Functional Block Diagram (2 of 2)

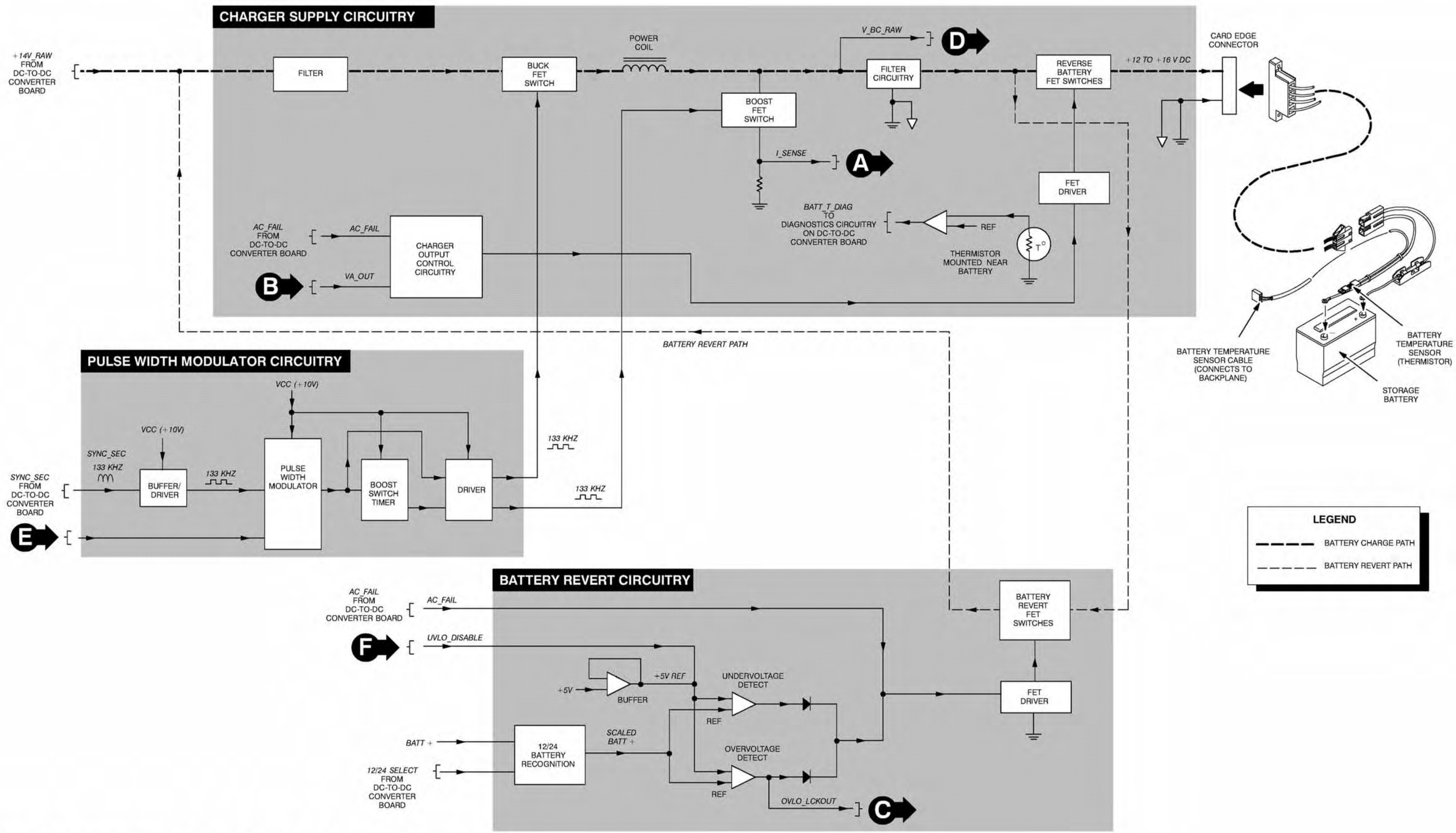


Figure 4. CPN6074C Battery Charger/Revert Board Functional Block Diagram (1 of 2)

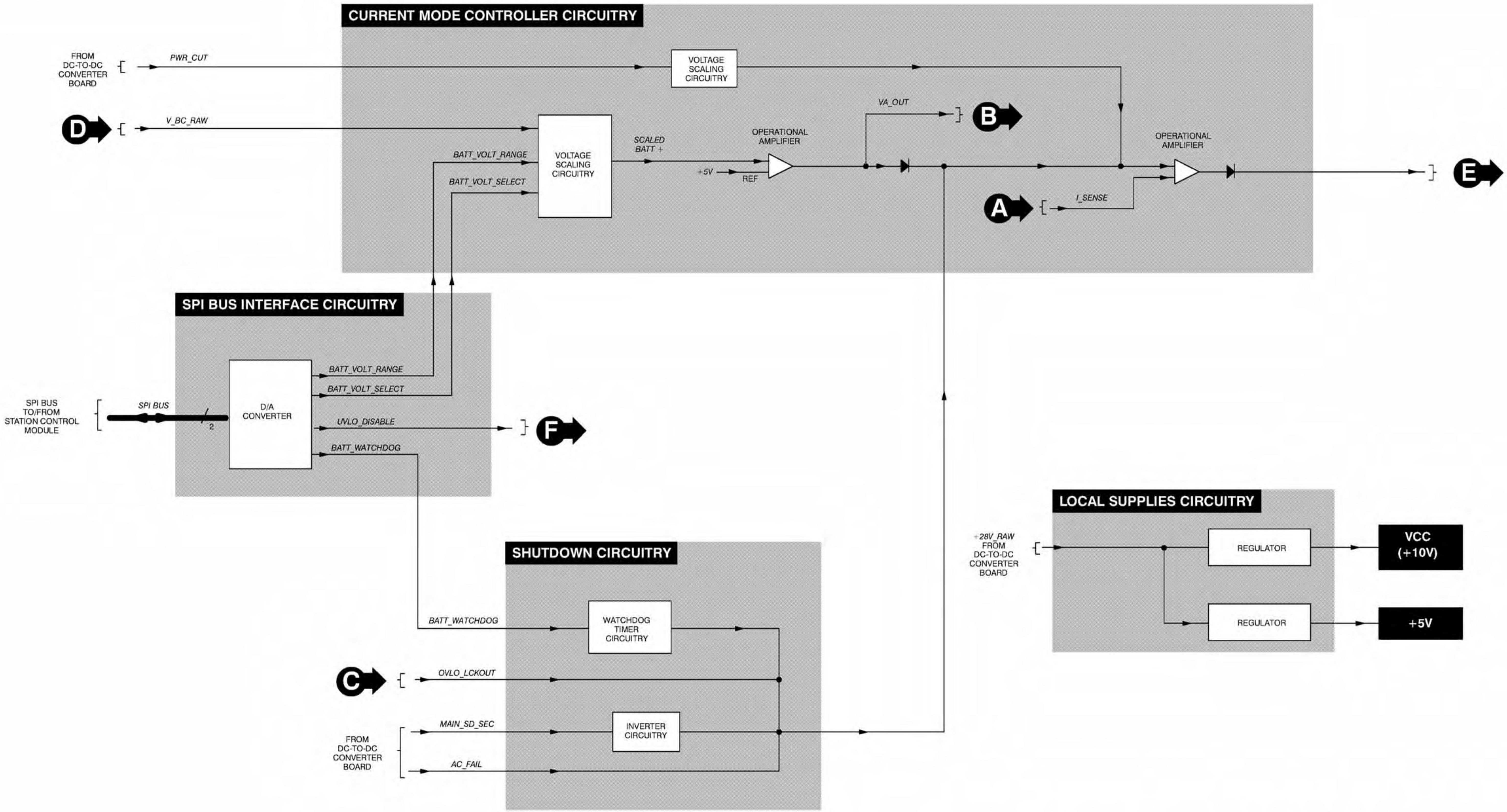


Figure 4. CPN6074C Battery Charger/Revert Board Functional Block Diagram (2 of 2)

MOTOROLA

POWER SUPPLY MODULE

INCLUDES MODELS:
CPN1047A (625W w/o Battery Charger; AC Input)
CPN1048A (625W with Battery Charger; AC Input)

1 DESCRIPTION

The Models CPN1047A/CPN1048A Power Supply Modules are described in this section. A general description, performance specifications, identification of controls, indicators, and inputs/outputs, a functional block diagram, and functional theory of operation are provided. The information provided is sufficient to give service personnel a functional understanding of the module, allowing maintenance and troubleshooting to the module level. (Refer also to the Maintenance and Troubleshooting section of this manual for detailed troubleshooting procedures for all modules in the station.)

General Description

The Models CPN1047A/CPN1048A Power Supply Modules each accept an ac input (90−264 V ac, 47−63 Hz) and generate +28.6V dc, +14.2V dc, and +5.1V dc operating voltages to power the station modules. Each power supply module is comprised of three circuit boards which provide several switching-type power supply circuits, power factor correction circuitry, battery charger/revert circuitry (CPN1048A only), and diagnostics and monitoring circuitry, all contained within a slide-in module housing.

The power supply module provides the following features:

- **Auto-ranging for input voltage and frequency** — circuitry automatically adjusts for input ranges of 90−264 V ac and 47−63 Hz; no jumpers, switches, or other settings are required
- **Input transient and EMI protection** — MOV, gas discharge, and filter devices protect the power supply circuitry from ac line voltage transients and electro-magnetic interference
- **Internal voltage and current limiting** — circuitry continually monitors critical voltages and currents and shuts supply down if preset thresholds are exceeded
- **Temperature protection** — module contains built-in cooling fan; supply shuts down if temperature exceeds preset threshold
- **Diagnostic monitoring** — critical internal parameters are continually monitored and reported to the Station Control Module, which can automatically provide correction for certain operating conditions

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Commercial Government and Industrial Solutions Sector
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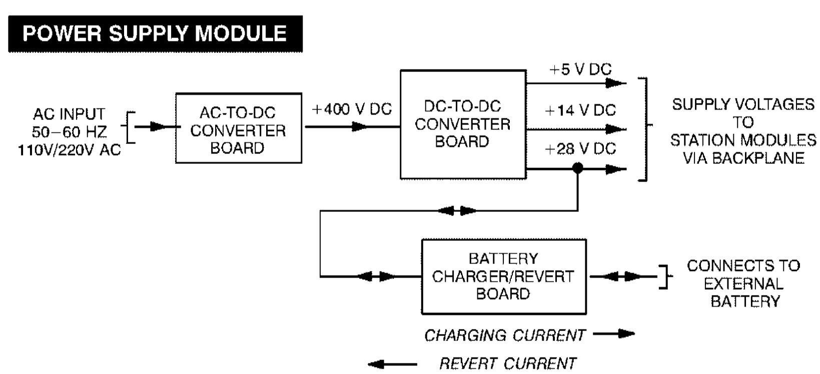
General Description (continued)

- **Fan Failure Protection** — Power Supply enters shutdown mode in event of cooling fan failure
- **Battery Reverse Polarity Protection** — Charger circuitry is protected against connecting the external battery in reverse polarity (CPN1048 only)
- **Auto Switchover to/from Battery** — If AC input fails, station is automatically switched over to battery operation; when AC input is restored, station is automatically switched back to power supply operation (CPN1048 only)
- **Auto Recovery from Shutdown** — Power Supply automatically recovers from shutdown mode if the cause of the shutdown no longer exists
- **Software-Controlled Battery Charging Voltage** — The battery charging voltage and current is controlled based on the ambient temperature (CPN1048 only)
- **Limited In-Rush Current** — Circuitry limits in-rush current to less than 30 A in all conditions

The Models CPN1047A and CPN1048A differ only in the inclusion of battery charger/revert board (CPN1048A only). Unless otherwise noted, the information provided in this section applies to both models.

Power Supply Module Simplified Block Diagram

The illustration below provides a simplified block diagram of a Power Supply Module (with battery charger) showing how the three circuit boards interconnect. A detailed block diagram and functional theory of operation for each board is provided later in this section (beginning on page 6).



Overview of Circuitry

The power supply module is comprised of three circuit boards, connected together via cables. These boards contain circuitry as follows:

AC-to-DC Converter Board (CPN6065B)

- **Input Conditioning Circuitry** — consists of ac line transient protection, EMI filtering, front panel on/off switch, startup-delayed relay, and a full-wave rectifier.
- **Startup Delay Circuitry** — provides a delay of approximately 1.5 seconds from time on/off switch is turned on until the power supply becomes functional (allows pre-charge of high-capacity filter capacitors to limit in-rush current on power up).
- **Boost/Power Factor Correction Circuitry** — consists of switching-type power supply that generates +400V dc for use by DC-to-DC Converter Board, as well as providing power factor correction.
- **Battery Revert Trigger Circuitry** — Monitors +400 V dc and generates a signal to the Battery Charger/Revert Board to activate battery revert if the +400 V dc fails or drops below approximately +350 V dc.
- **VCC Supply Circuitry** — consists of switching-type power supply that generates the VCC supply voltage (approximately +13V dc) for use by circuitry on AC-to-DC Converter Board and DC-to-DC Converter Board.

DC-to-DC Converter Board (CPN6067A)

- **+28 V Main Supply Circuitry** — consists of switching-type power supply that generates the +28 V dc supply voltage and provides primary/secondary isolation.
- **+14 V Supply Circuitry** — consists of switching-type power supply that generates the +14 V dc supply voltage (from +28 V dc supply voltage).
- **+5 V Supply Circuitry** — consists of switching-type power supply that generates the +5 V dc supply voltage (from +28 V dc supply voltage).
- **Battery Charger Control Circuitry** — Provides buffering for signals related to battery charging/revert operation.
- **Reference Voltage Circuitry** — Generates +10V_SEC and +2.5V_SEC supply voltages for use by local circuitry.
- **Diagnostics Circuitry** — converts analog status signals to digital format for transfer to Station Control Module.
- **Address Decode Circuitry** — performs address decoding to provide chip select signal for the A/D converter.
- **Startup/Shutdown Control Circuitry** — Provides delay intervals for startup and shutdown of entire power supply module.

— continued on next page —

Overview of Circuitry (Continued)

Battery Charger/Revert Board (CPN6074B)

- **Charger Supply Circuitry** — consists of switching-type power supply that generates charging current for the external storage battery.
- **Pulse Width Modulator Circuitry** — consists of pulse-width modulator, boost switch timer, and driver circuitry to provide variable-width pulses for the FET switches in the Charger Supply Circuitry.
- **Battery Revert Circuitry** — consists of signal monitoring circuitry which turns on the Battery Revert FET Switches for certain input signal conditions (such as AC Fail).
- **Current Mode Controller Circuitry** — consists of current and voltage feedback signal monitoring circuitry which controls the Pulse Width Modulator Circuitry to maintain the desired charger output current and voltage.
- **SPI Bus Interface Circuitry** — consists of a D/A converter which accepts charger control digital signals from the Station Control Module and converts these signals to analog dc voltages to control various operating characteristics of the battery charger circuitry.
- **Shutdown Circuitry** — consists of signal monitoring circuitry which shuts down the battery charger for certain input signal conditions (such as loss of BATT_WATCHDOG signal from the Station Control Module).
- **Local Supplies Circuitry** — Accepts +28V_RAW (from DC-to-DC Converter Board) and generates VCC (+10V) and +5V supply voltages for use by local circuitry.

2 PERFORMANCE SPECIFICATIONS

Table 1 shows the electrical performance specifications for the Models CPN1047A and CPN1048A Power Supply Modules.

Performance Specifications

Table 1. CPN1047A/CPN1048A Power Supply Modules Performance Specifications

Parameter	Specification
Weight	6.5 kg (14.3 lbs)
Operating Temperature Range	−30 to +60° C (no derating)
Input Voltage Range	90 to 264 V ac
Input Frequency Range	47 to 63 Hz
Maximum Input Current	8.5 A
Steady State Output Voltages	+28.6 V dc ±5% +14.2 V dc ±5% +5.0 V dc ±5%
Output Current Ratings	+28.6 12.5 A +14.2 8 A +5.1 3 A
Total Output Power Rating	625W* * *including 100W for battery charger*
Output Ripple	All outputs 150 mV p−p (measured with 20 MHz BW oscilloscope at 25°C).

3 CONTROLS, INDICATORS, AND INPUTS/OUTPUTS

Figure 1 shows the power supply module controls, indicators, and all input and output external connections.

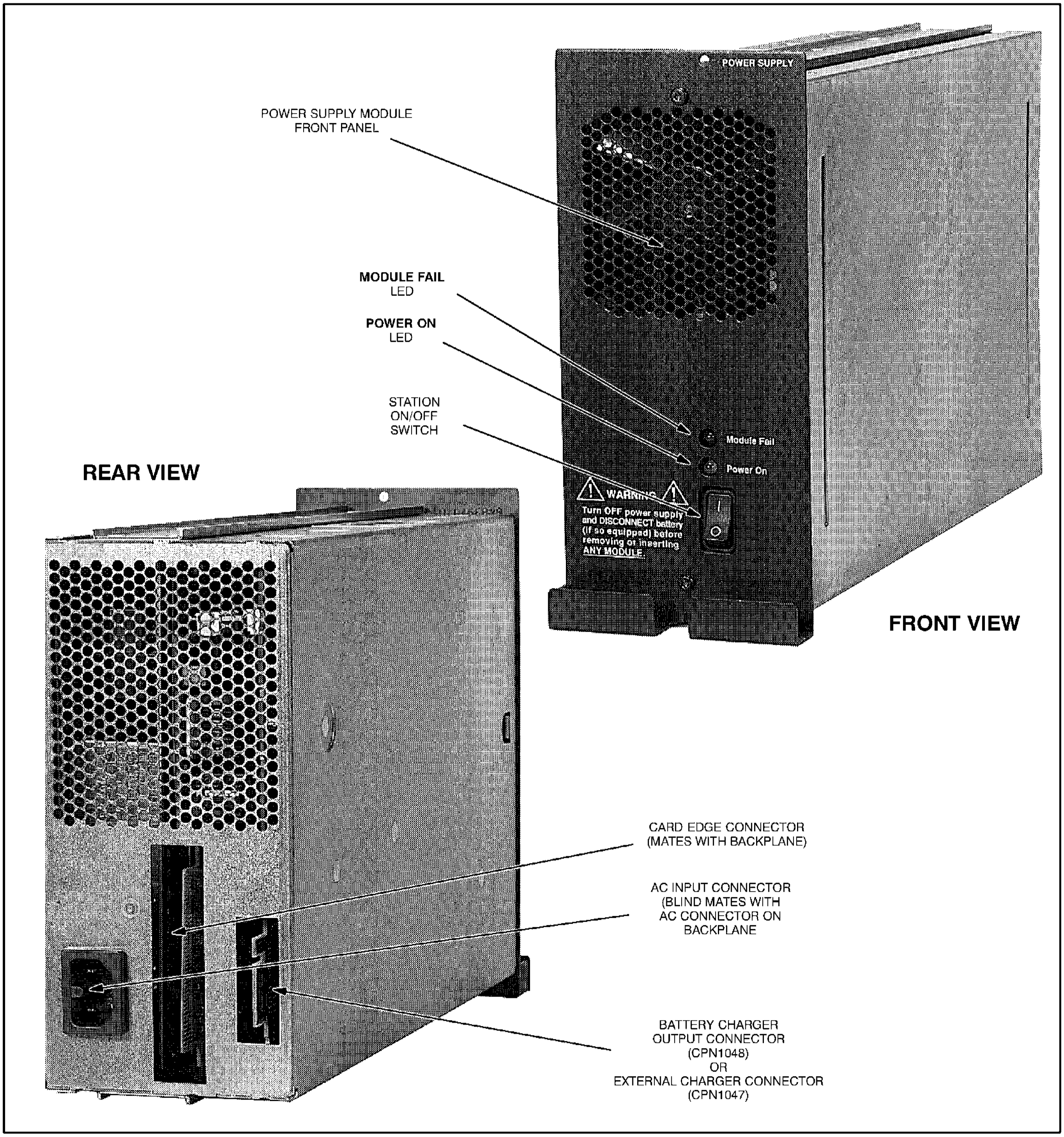


Figure 1. CPN1047A/CPN1048A Power Supply Module Controls, Indicators, and Inputs/Outputs

4 FUNCTIONAL THEORY OF OPERATION (AC-to-DC Converter Board)

The following theory of operation describes the operation of the CPN6065B AC-to-DC Converter Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 2 for a block diagram of the AC-to-DC Converter Board.

Input Conditioning Circuitry

Introduction

The AC-to-DC Converter Board accepts ac power from an external source, typically a 110V or 220/240V ac wall receptacle. AC power is connected to the board via a 3-wire line cord plugged into an ac receptacle mounted on the station backplane, into which the entire power supply module slides (blind mate connection).

Transient and EMI Protection

The ac line input is fed to the AC-to-DC Converter Board circuitry via transient protection and EMI filter circuits. The transient protection devices provide protection against voltage spikes by providing an effective short to ground under high voltage transient conditions. The EMI filter prevents electrical noise generated by the power supply module from interfering with other equipment connected to the same ac line circuit.

Front Panel On–Off Switch / Relay Circuitry

A rocker-type switch located on the power supply module front panel allows the power supply (and station) to be turned on and off. Note that the switch allows the filter circuitry (p/o Boost/Power Factor Correction Circuitry) to slowly charge (for approximately 1.5 seconds after switch is turned on) through two diodes and resistors. After the 1.5 second delay, the relay turns on and provides an ac input to the bridge rectifier. This 1.5 second pre-charge delay period limits in-rush current through the filter capacitors upon power up.

Rectifier Circuitry

The ac line voltage (via the relay) is rectified by a full-wave bridge rectifier and fed to the Boost/Power Factor Correction Circuitry.

Startup Delay Circuitry

This circuitry monitors the ac input (from the on/off switch) and provides a 1.5 second delay when switch is turn on before energizing the relay to turn on the power supply.

If the AC input is below approximately 85 V rms, the relay will not be turned on and the power supply outputs will be disabled. The red **Module Fail** LED on the front panel will light.

Boost/Power Factor Correction Circuitry

Overview

The Boost/Power Factor Correction Circuitry is comprised of a switching-type power supply which generates a +400 V dc voltage. This voltage is fed to the DC-to-DC Converter Board to be used as the source for the +28V, +14V, and +5V Supply Circuits.

Switching Power Supply Operation

The switching power supply consists of a pulse width modulator (PWM) running at 67 kHz. The PWM output pulses are fed through driver transistors to control three power FETs which rapidly switch the Toroid Power Coil to ground. The result is a high induced current which charges the filter capacitors to approximately 400 V dc.

Note that the PWM output pulses are also controlled by voltage and current feedback signals. These feedback signals allow the average ac line current over switching cycles to be sinusoidal and in-phase with the ac input voltage (i.e., power factor corrected).

Battery Revert Trigger Circuitry

A comparator monitors the +400 V dc from the output of the Boost/ Power Factor Correction Circuitry and a +5V reference signal. If the +400 V dc voltage should drop below approximately +350 V dc (considered an ac input failure), a BOOST_LOW signal is sent to the Battery Charger/Revert Board (via the DC-to-DC Converter Board) to activate battery revert mode.

VCC Supply Circuitry

This circuitry consists of a switching-type power supply which generates a +13 V dc supply voltage used as VCC by the local circuitry and the primary side of the DC-to-DC Converter Board.

The circuitry consists of a pulse width modulator (PWM) running at 67 kHz (from DC-to-DC Converter Board). The PWM output repetitively gates the +400 V dc (from the Boost/Power Factor Correction Circuitry) to the primary of the housekeeping transformer. The result is an induced voltage in the secondary winding which feeds a half-wave rectifier circuit. The output is a +13 V dc VCC supply voltage.

LED Status Indicators

Two LEDs located on the power supply module front panel indicate module status as follows:

- **AC On**— lights GREEN when On/Off switch is On and the AC input voltage is within operating range; LED turns off when module is turned off, ac power is removed, or AC input voltage is below approximately 85 V rms.
- **Module Fail**— lights RED when initially turning on or off the Power Supply (this is normal and does not indicate a failure) or when the DC-to-DC Converter Board is not functioning properly; LED turns off when module is functioning properly

Note *When in Battery Revert Mode (CPN1048 only), neither LED is lit. The cooling fan will continue to run.*

5 FUNCTIONAL THEORY OF OPERATION (DC-to-DC Converter Board)

The following theory of operation describes the operation of the CPN6067A DC-to-DC Converter Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 3 for a block diagram of the DC-to-DC Converter Board.

+28V Main Supply Circuitry

Overview

The +28V Main Supply Circuitry is comprised of two mirrored switching-type power supplies which generate the +28 V supply voltage. This voltage is used as the source for the +14V and +5V supply circuits, as well as the +28V supply voltage for the station modules (via the backplane) and

Switching Power Supply Operation

The +28V Main Supply Circuitry consists of two identical switching-type power supplies operating in parallel. Both supplies operate identically, as follows. A 133 kHz clock signal from the Sync Generator Circuitry is fed through a buffer to a Pulse Width Modulator (PWM). The PWM output pulses control a pair of power FETS (via a driver) to gate the +400 V dc (from the AC-to-DC Converter Board) to the primary of a power transformer. The induced voltage in the transformer secondary is half-wave rectified to charge the output filter circuitry, resulting in an output voltage of +28 V dc.

Since each supply receives a 133 kHz clock signal that is 180° out of phase with the other, each switching power supply alternately charges the output filter circuitry, resulting in an effective charging rate of 266 kHz.

Protection Circuitry

Peak/Average Current Limiting Circuitry — The peak current limiting circuitry accepts an output current feedback signal and a scaled +28V_RAW reference signal to control the PWMs. This effectively maintains a constant output voltage for varying output current demands.
The average current limiting circuitry monitors the +28 V dc output and generates a shutdown signal (MAIN_SD_PRI) if the average output current reaches a predetermined limit.

Overvoltage Protection Circuitry — This circuitry monitors the +28V output voltage and generates a shutdown signal (MAIN_SD_SEC) to shut down the entire power supply module if the +28 V output voltage exceeds a preset threshold.

+14 V Supply Circuitry

Overview

The +14 V Supply Circuitry is comprised of a switching-type power supply which generates a +14.2 V dc supply voltage. This voltage is used as the +14.2 V supply voltage for the station modules (via the backplane).

Switching Power Supply Operation

The +14 V switching power supply consists of a pulse width modulator (PWM) running at 133 kHz. The PWM output pulses are fed through a driver to control a power FET which repetitively gates the +28V_RAW (from the +28V Main Supply Circuitry) to a power coil. The result is a high induced voltage which charges the filter capacitors to approximately +14.2 V dc. A current sense comparator provides a feedback signal to the PWM to maintain a constant output voltage.

Protection Circuitry

An overvoltage detect circuit monitors the output voltage and, if preset thresholds are exceeded, turns on a FET crowbar circuit which immediately discharges the output to protect other modules in the station.

An overcurrent detect circuit monitors the current draw from the +14V Supply Circuitry and, if a preset threshold is exceeded, generates a MAIN_SD_SEC signal which shuts down the entire power supply module.

+5 V Supply Circuitry

The +5 V Supply Circuitry operates identically to the +14 V Supply Circuitry (described above) to generate a +5.1 V dc supply voltage. This voltage is used as the +5 V supply voltage for the station modules (via the backplane).

Battery Charger Control Circuitry

The POWER_CUT_PRI signal (from the Peak/Average Current Detect Circuitry) is buffered and fed to the Battery Charger/Revert Board as POWER_CUT_SEC. This signal reduces the current supplied by the battery charger circuitry to divert maximum power to the power supply outputs (+28V, +14V, and +5V) during times of heavy current draw.

The AC_FAIL signal (from the AC-to-DC Converter Board) is buffered and fed to 1) the diagnostics circuitry as AC_GOOD_DIAG, and 2) the Battery Charger/Revert Board as BATTERY_REVERT. This signal activates battery revert mode.

Reference Voltage Circuitry

This circuitry accepts +28V_RAW (from the +28V Main Supply Circuitry) and generates +10V_SEC and +2.5V_SEC supply voltages for use by local circuitry.

Diagnostics Circuitry

Overview

The diagnostics circuitry consists of an 11-channel A/D converter which converts analog status signals from critical points in the power supply module to digital format for transfer to the Station Control Module via the SPI bus. Most of the status signals are generated by detect circuits to indicate the status of dc supply voltages and references.

Temperature Monitor and Control Circuitry

A thermistor mounted on the power supply module heatsink provides a varying resistance input to the Heatsink Temp Detect Circuitry. If the heatsink temperature exceeds a preset limit, the circuitry generates a MAIN_SD_SEC shutdown signal which shuts down the entire power supply module. A HEATSINK_DIAG signal is also sent to the Station Control Module via the A/D converter and SPI bus.

Fan Monitor and Control Circuitry

The cooling fan in the power supply module is powered from the +14V Supply Circuitry and runs continuously. If the fan fails, the Fan Fault Detect circuit generates a fail signal (FAN_FAIL_DIAG) which is fed to the A/D converter. The fail signal also triggers a 50 second delay circuit which (after 50 seconds) generates a MAIN_SD_SEC signal which shuts down the entire power supply.

Address Decode Circuitry

The address decode circuitry allows the Station Control Module to use the address bus to select either the D/A converter (Battery Charger/Revert Board) or the A/D converter (Diagnostics Circuitry) for communications via the SPI bus. Typical communications include reading status signals from the Diagnostics Circuitry and providing charger output control signals to the Battery Charger/Revert Board.

Startup/Shutdown Control Circuitry

Shutdown Delay Circuitry

Upon receiving a shutdown signal (MAIN_SD_PRI) from the +28V Main Supply Circuitry, this circuit passes the signal through the Soft Start Circuitry for a 1 second interval to allow the entire power supply module to shutdown. The module then restarts (if the on/off switch is in **On** position). If the MAIN_SD_PRI signal is still active, the shutdown process will repeat.

Startup/Shutdown Delay Circuitry

When the power supply module is first turned on, the RELAY_ON signal is low and the output of the Startup/Shutdown Delay Circuitry keeps the supply in shutdown mode. After about 1.5 seconds RELAY_ON goes high, and the Startup/Shutdown Delay Circuitry provides a 1 second delay before releasing the shutdown signal and allowing the power supply to operate.

When the power supply module is turned off, the RELAY_ON signal goes low and the Startup/Shutdown Delay Circuitry keeps the supply in operating mode for 1 second to allow Battery Revert Mode to activate.

Soft Start Circuitry

Each time the Soft Start Circuitry receives a startup signal (i.e., MAIN_SD_PRI is inactive and the output of the Startup/Shutdown Delay Circuitry is high), the Soft Start Circuitry provides a gradually increasing output signal to "soft start" the Pulse Width Modulators (p/o +28V Main Supply Circuitry). This action minimizes the surge current when charging the output filter capacitors.

6 FUNCTIONAL THEORY OF OPERATION (Battery Charger/Revert Board)

The following theory of operation describes the operation of the CPN6074B Battery Charger/Revert Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 4 for a block diagram of the Battery Charger/Revert Board.

Note *Model CPN1047A Power Supply Modules (without battery charging capabilities) are equipped with a CPN6078A External Charger Connect Board in place of the CPN6074B Battery Charger/Revert Board. The External Charger Connect Board provides a direct electrical path from the +28V Main Supply Circuitry (p/o the DC-to-DC Converter Board) to the card edge connector used to connect to an external charger and battery. The external charger is responsible for 1) charging the external battery and 2) detecting an AC power fail condition and initiating battery revert mode.*

Charger Supply Circuitry

Overview

The Charger Supply Circuitry is comprised of a switching-type power supply which generates the charging current necessary to charge an external storage battery.

Switching Power Supply Operation

The charger switching power supply accepts +28V (from the DC-to-DC Converter Board) which is fed through a filter and a Buck FET Switch to a Power Coil. This coil is controlled by the Buck FET Switch and a Boost FET Switch to produce an induced output voltage of approximately +21 to +31 V dc. This charging voltage is filtered and fed through a pair of Reverse Battery FET Switches to the output terminals (card edge connector that extends from the rear of the Power Supply Module). Connections to an external storage battery are made to this card edge connector.

Protection against connecting the battery in reverse polarity is provided by the Charger Output Control Circuitry and the Reverse Battery FET Switches.

A thermistor mounted near the battery and connected to the station via a backplane connector provides an input to a comparator. The comparator output (BATT_T_DIAG) provides a dc voltage proportional to the battery temperature. This signal is sent to the Station Control Module via the Diagnostics Circuitry on the DC-to-DC Converter Board.

Pulse Width Modulator Circuitry

A 133 kHz clock signal (from the DC-to-DC Converter Board) is fed through a buffer/driver to a Pulse Width Modulator (PWM). The 133 kHz PWM output pulses are fed 1) directly to the Buck FET Switch via a driver, and 2) to the Boost FET Switch via a Boost Switch Timer and Driver. The two signals control the respective FET switches to control the Power Coil in the Charger Supply Circuitry so that it produces an approximately +21 to +31 V dc output to be filtered and charge the external battery.

Battery Revert Circuitry

Overview

The Battery Revert Circuitry accepts various inputs and determines when to activate battery revert mode by turning on the Battery Revert FET Switches. Battery Revert Mode will be activated or deactivated in the following conditions:

- If the AC_FAIL signal (from the DC-to-DC Converter Board) goes low (indicating that AC power has failed), the Battery Revert FET Switches will be turned on (via the FET Driver).
- If the battery voltage is too low, the Undervoltage Detect circuit detects the condition and disables the battery revert circuitry.
- If the battery voltage is too high, the Overvoltage Detect circuit detects the condition and disables the battery charger and the battery revert circuitry.
- If a fault condition exists (e.g., +5V Overvurrent), the shutdown detect circuitry detects the condition and disables the battery charger and the battery revert circuitry.

Current Mode Controller Circuitry

Overview

The Current Mode Controller Circuitry performs two major functions:

- The PWR_CUT signal (from the DC-to-DC Converter Board) is fed through a Voltage Scaling Circuit and reduces the battery charger output current during periods of heavy current draw by the station.
- The Voltage Scaling Circuitry accepts V_BC_RAW (voltage feedback signal from battery) and BATT_VOLT_RANGE and BATT_VOLT_SELECT signals (from the Station Control Module via the D/A Converter) which combine to set the charger output voltage (in a range of +21 V dc to +31 V dc).

SPI Bus Interface Circuitry

This circuitry consists of a D/A Converter that accepts digital signals from the Station Control Module and converts them to analog signals which control the operation of the Battery Charger/Revert Board. These signals:

- Control the charger voltage to the battery (BATT_VOLT_RANGE and BATT_VOLT_SELECT)
- Disable the Undervoltage Detect Circuitry (UVLO_DISABLE) to allow the station to continue operation even though the battery voltage is below the desired level
- Provide a watchdog signal to refresh the Watchdog Timer Circuitry (BATT_WATCHDOG)

Shutdown Circuitry

This circuitry accepts four input signals and generates a shutdown signal to shut down the battery charger for certain input signal conditions, A shutdown signal will be generated for any of the following conditions:

- The BATT_WATCHDOG signal (from the Station Control Module) is not present (indicating that the Station Control Module has failed, or the station's *Battery Type* field has been programmed (via RSS) for "NONE"
- The OVLO_LCKOUT signal is high (indicating that the battery voltage is too high)
- The MAIN_SD_SEC signal is low (indicating that one of the various monitoring points indicates a fault, such as overcurrent condition for +14V or +5 V supplies, overcurrent condition for entire Power Supply Module, etc.
- The AC_FAIL signal is high (indicating that the AC power to the Power Supply Module has been interrupted)

Local Supplies Circuitry

This circuitry contains two voltage regulators which accept +28V_RAW (from the +28V Main Supply Circuitry) and generate VCC (+10 V dc) and +5 V supply voltages for use by local circuitry.

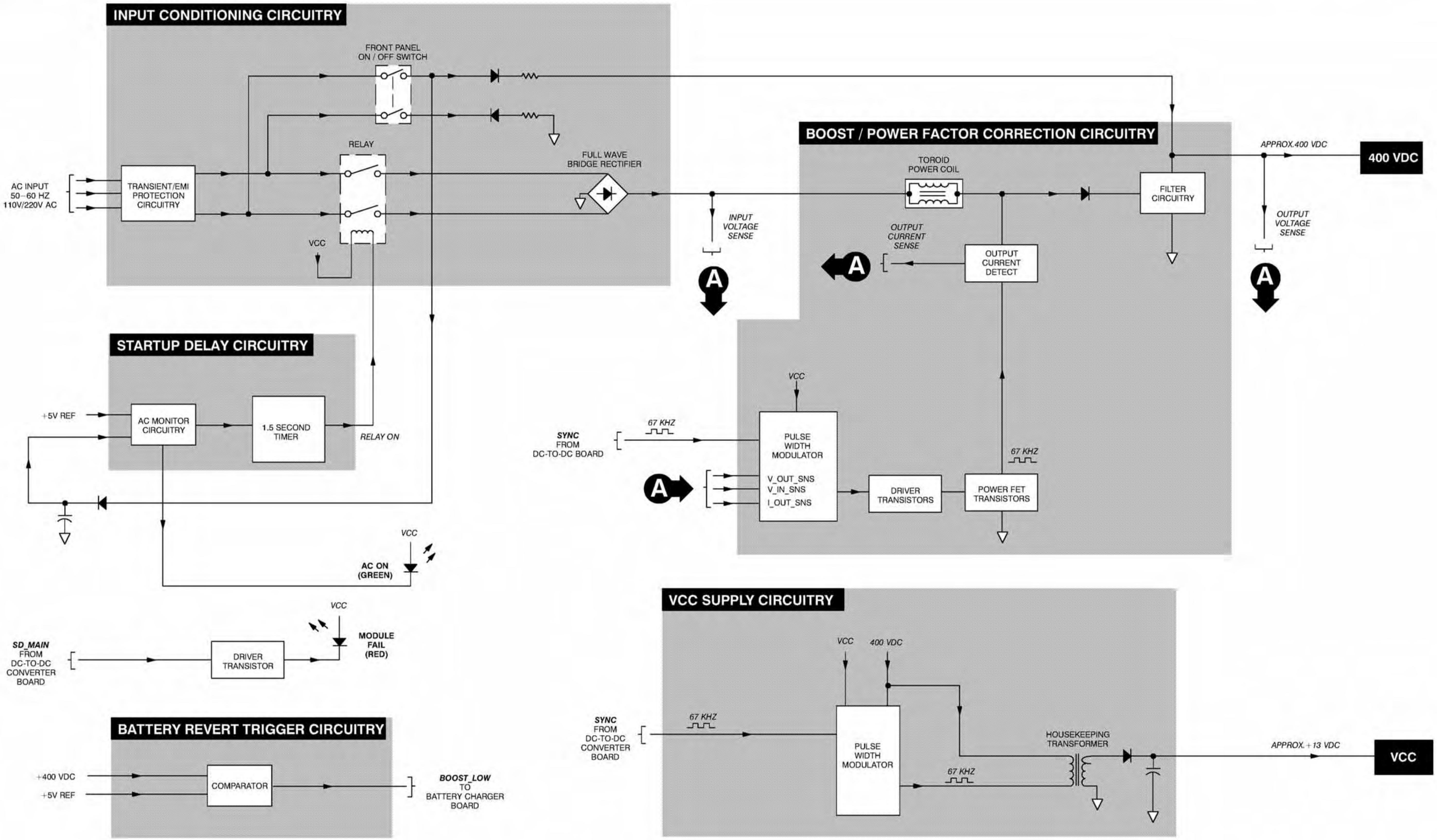


Figure 2. CPN6065B AC-to-DC Converter Board Functional Block Diagram

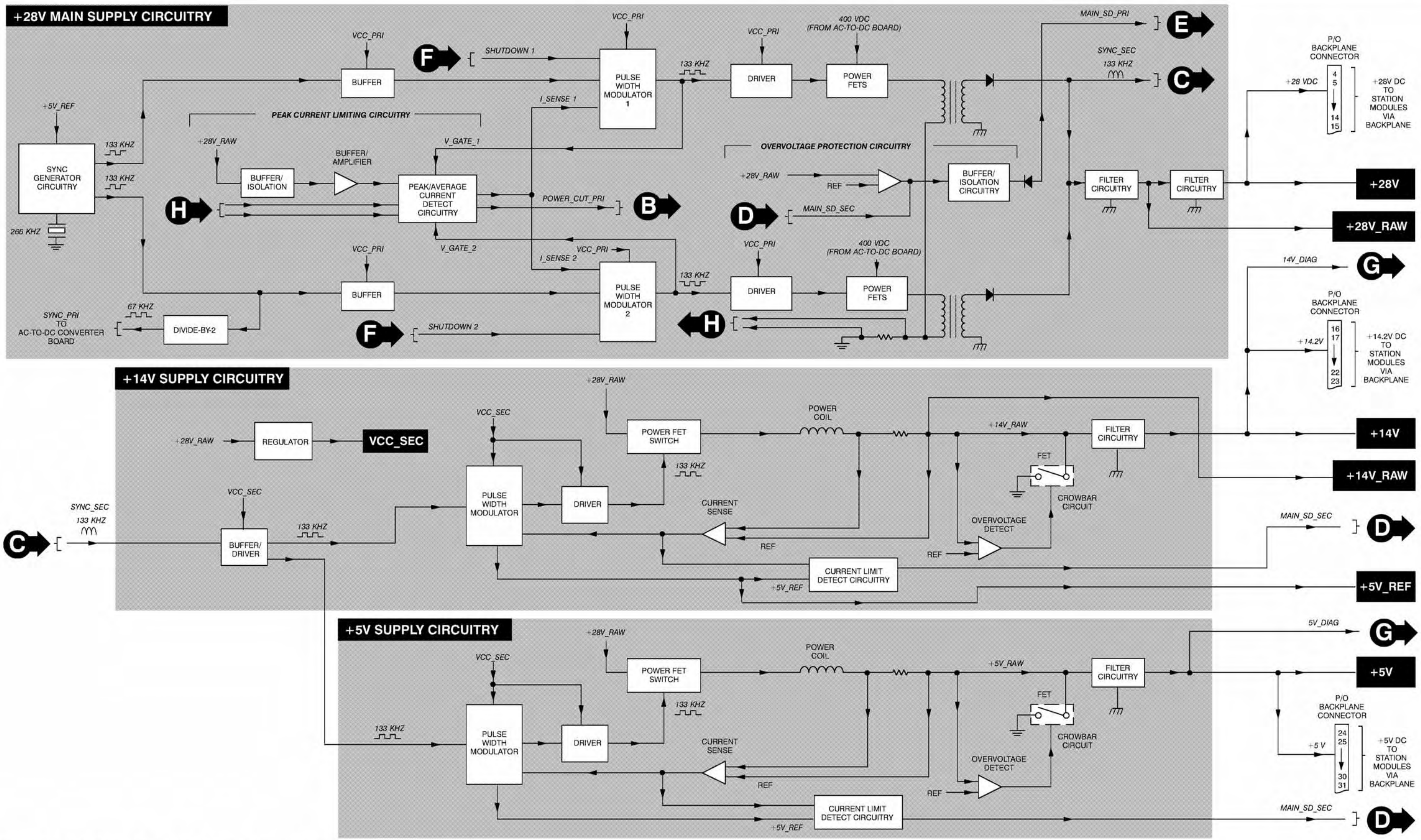


Figure 3. CPN6067A DC-to-DC Converter Board Functional Block Diagram (1 of 2)

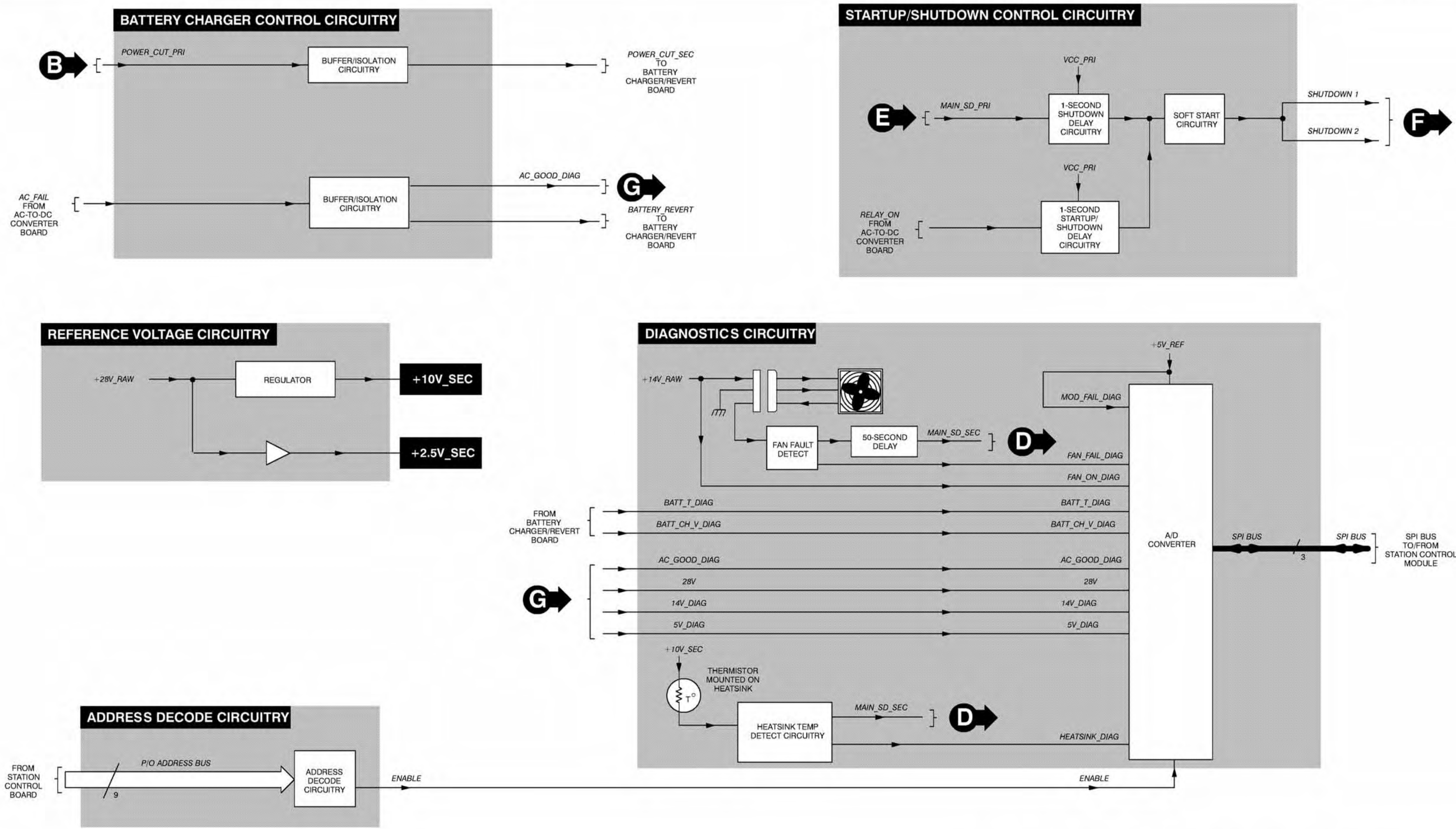


Figure 3. CPN6067A DC-to-DC Converter Board Functional Block Diagram (2 of 2)

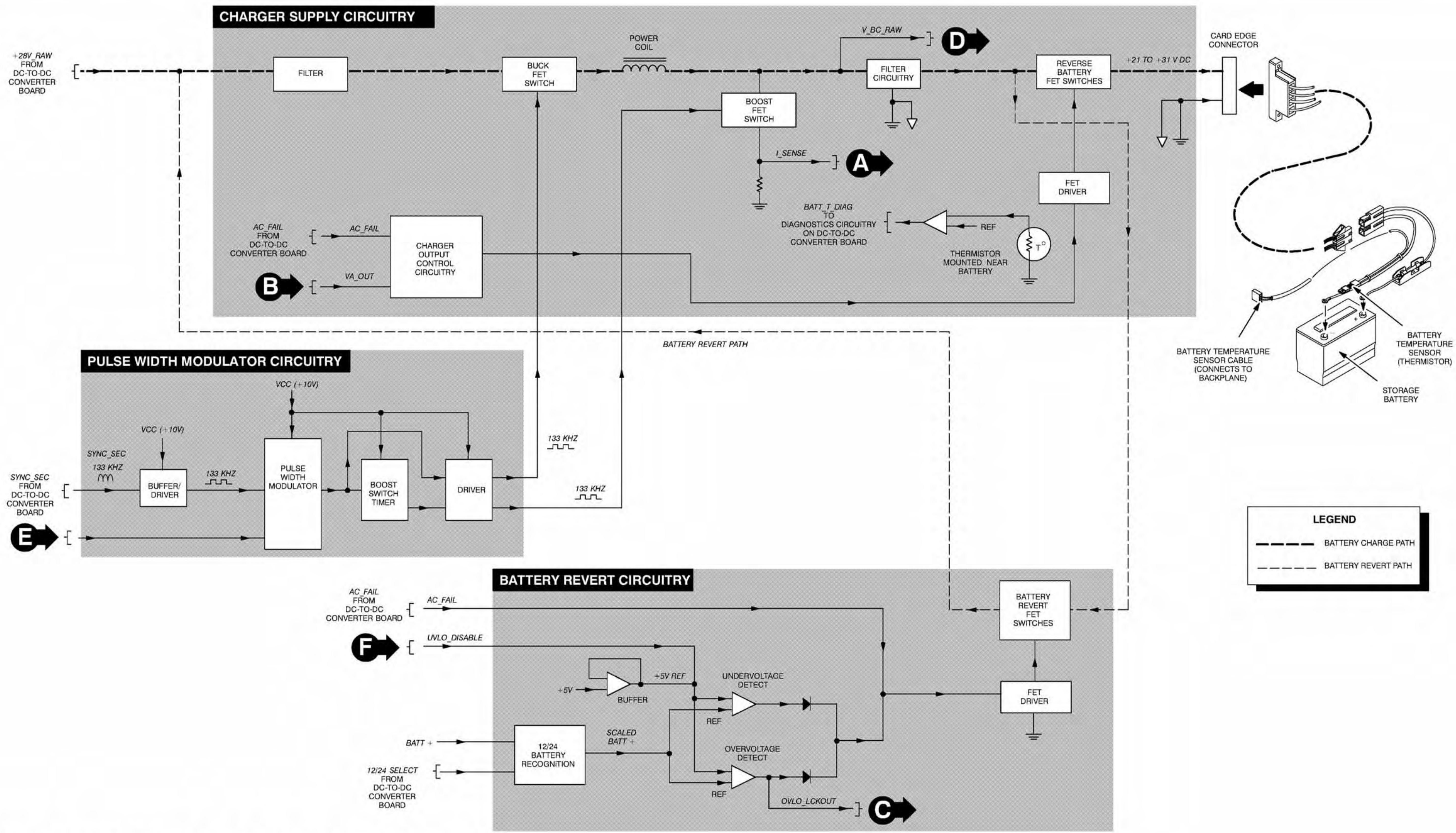


Figure 4. CPN6074B Battery Charger/Revert Board Functional Block Diagram (1 of 2)

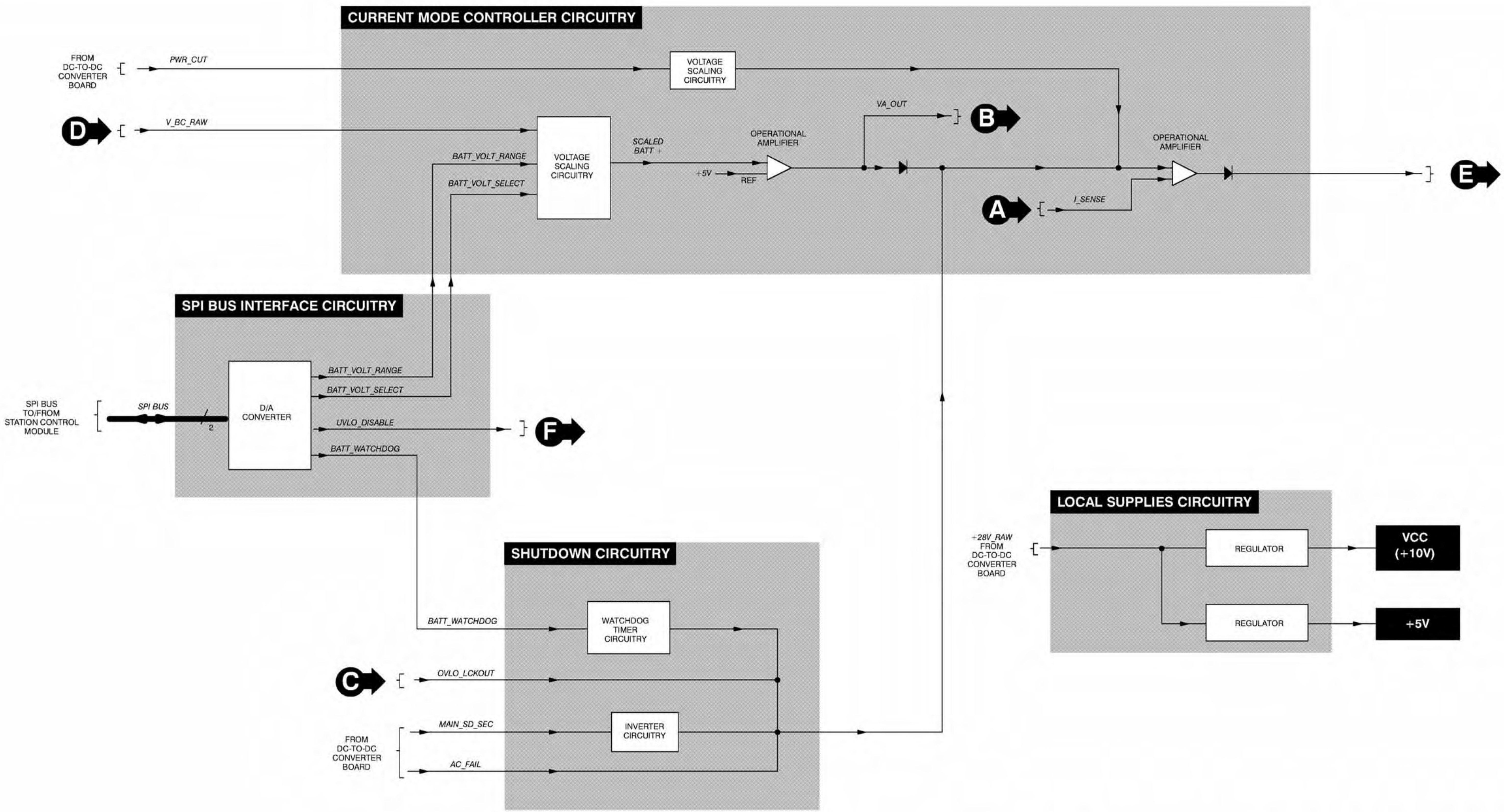


Figure 4. CPN6074B Battery Charger/Revert Board Functional Block Diagram (2 of 2)

MOTOROLA

POWER SUPPLY MODULE

INCLUDES MODELS:
TRN7802A (210W; 12/24V DC Input)
TRN7803A (210W; 48/60V DC Input)

1 DESCRIPTION

The Models TRN7802A/TRN7803A Power Supply Modules are described in this section. A general description, performance specifications, identification of controls, indicators, and inputs/outputs, a functional block diagram, and functional theory of operation are provided. The information provided is sufficient to give service personnel a functional understanding of the module, allowing maintenance and troubleshooting to the module level. (Refer also to the Maintenance and Troubleshooting section of this manual for detailed troubleshooting procedures for all modules in the satellite receiver or station.)

General Description

The Model TRN7802A Power Supply Module accepts an input of either 12 V dc or 24 V dc, while the Model TRN7803A Power Supply Module accepts an input of either 48 V dc or 60 V dc. Each module generates +5V dc and +14.2V dc operating voltages to power the satellite receiver or station modules. Each power supply module is comprised of several switching−type power supply circuits and diagnostics and monitoring circuitry, all contained within a slide−in module housing.

The power supply module provides the following features:

- Internal voltage and current limiting — circuitry continually monitors critical voltages and currents and shuts supply down if preset thresholds are exceeded
- Temperature protection — module contains built−in cooling fan which is thermostatically controlled; supply shuts down if temperature exceeds preset threshold
- Diagnostic monitoring — critical internal parameters are continually monitored and reported to the Station Control Module, which can automatically provide correction for certain operating conditions
- Front panel On/Off switch with built−in circuit breaker (30A for TRN7802A, 10A for TRN7803A)

The Models TRN7802A and TRN7803A differ only in the required dc input voltage. Unless otherwise noted, the information provided in this section applies to both models.

Commercial Government and
Industrial Solutions Sector
1301 E. Algonquin Road, Schaumburg, IL 60196

1 DESCRIPTION (Continued)

Overview of Circuitry

The power supply module contains the following circuitry:

- Startup Inverter Circuitry — provides VCC for power supply circuitry during initial power–up
- Main Inverter Circuitry — consists of switching–type power supply that generates the +14.2V dc supply voltage
- +5 V Inverter Circuitry — consists of switching–type power supply that generates the +5 dc supply voltage
- Clock Generator Circuitry — generates 267 kHz and 133 kHz clock signals used by pulse width modulators in the three inverter circuits
- Diagnostics Circuitry — converts analog status signals to digital format for transfer to Station Control Module
- Address Decode Circuitry — performs address decoding to provide chip select signals for the A/D and D/A converters

2 PERFORMANCE SPECIFICATIONS

Table 1 shows the electrical performance specifications for the Models TRN7802A and TRN7803A Power Supply Modules.

Performance Specifications

Table 1. TRN7802A/TRN7803A Power Supply Modules Performance Specifications

Parameter	Specification
Weight	6.5 kg (14.3 lbs)
Operating Temperature Range	−30 to +60° C
Input Voltage Range	TRN7802A 10.5 – 34.5 V dc TRN7803A 41 – 72 V dc
Maximum Input Current	8.5 A
Steady State Output Voltages	+14.2 V dc ±5% +5.1 V dc ±5%
Output Current Ratings	+14.2 12.5 A +5.1 9 A
Total Output Power Rating	no derating 225 W
Output Ripple	All outputs 50 mV p−p (measured with 20 MHz BW oscilloscope at 25°C). High Frequency individual harmonic voltage limits in 10 kHz−100 MHz frequency band: 14.2 V 1.5 mV p−p 5V 5 mV p−p
Short Circuit Current	0.5 A avg. max

3 CONTROLS, INDICATORS, AND INPUTS/OUTPUTS

Figure 1 shows the power supply module controls, indicators, and all input and output external connections.

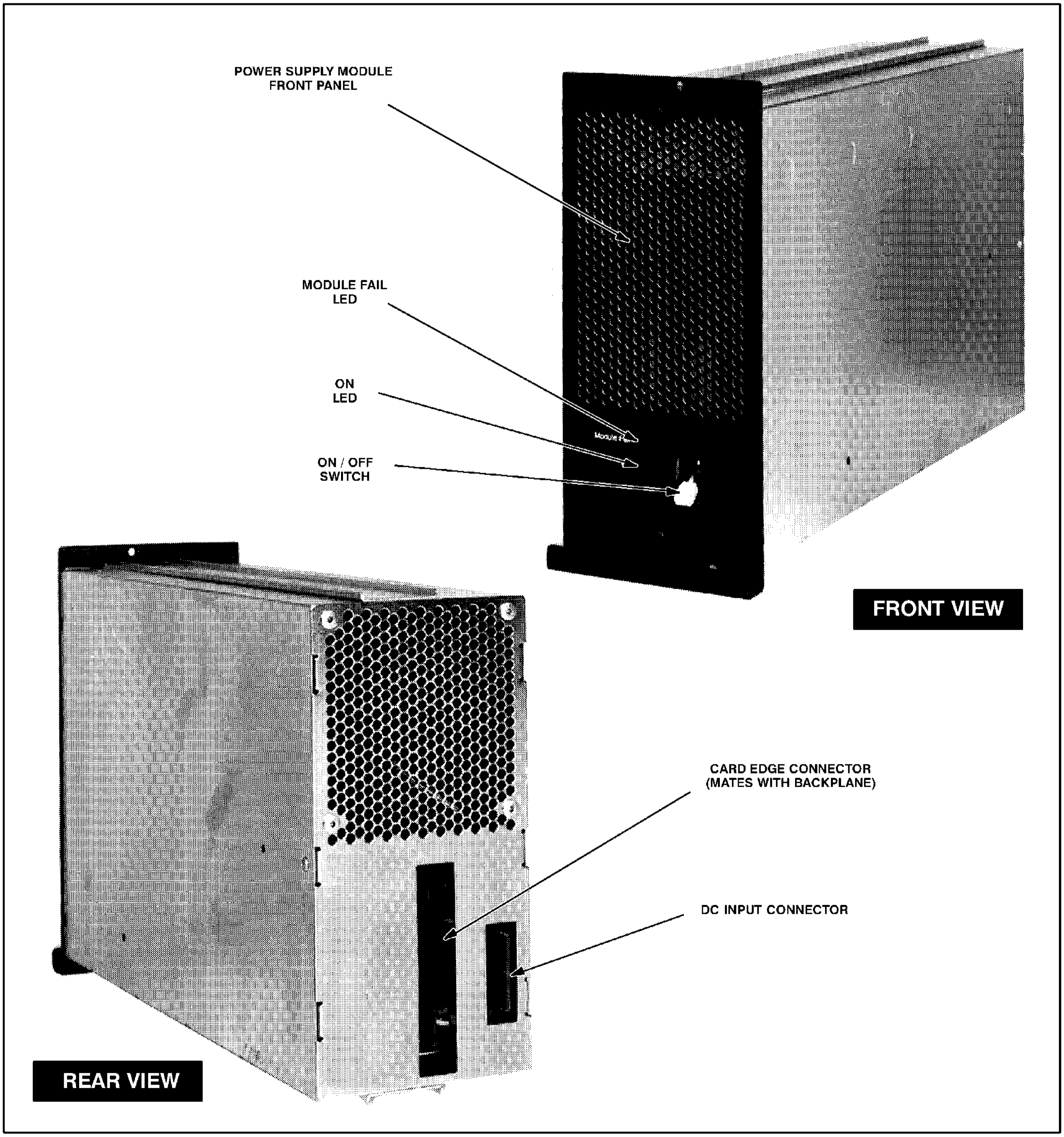


Figure 1. Power Supply Module Controls, Indicators, and Inputs/Outputs

4 FUNCTIONAL THEORY OF OPERATION

The following theory of operation describes the operation of the power supply circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 2 for a block diagram of the power supply module.

Input Conditioning Circuitry

Introduction

The power supply module accepts dc power from an external source, typically a bank of storage batteries. DC power is connected to the module via a 4–wire dc input cable mounted on the satellite receiver or station backplane.

Transient and EMI Protection

The dc input is fed to the power supply module circuitry via transient protection and EMI filter circuits. The transient protection devices provide protection against voltage spikes by providing an effective short to ground under high voltage transient conditions. The EMI filter prevents electrical noise generated by the power supply module from interfering with other equipment connected to the same dc source.

Front Panel On–Off Switch and Breaker

A toggle–type switch located on the power supply module front panel allows the power supply (and satellite receiver or station) to be turned off by removing the dc input voltage. The switch controls a built–in circuit breaker (rated at 30A for TRN7802A, 10A for TRN7803A) to provide overload protection for the power supply and satellite receiver or station circuitry.

Startup Inverter Circuitry

This circuitry consists of a switching–type power supply which generates a +12 V dc supply voltage used by the power supply module circuitry as VCC at the time of initial power up. When all supply voltages have stabilized, this circuit is overridden by +14.2 V BULK which continues to supply VCC to the module circuitry.

The circuitry consists of a pulse width modulator (PWM) running at 133 kHz (internal circuitry provides clock signal during initial power up). The PWM output pulses control a transistor switch which repetitively gates voltage (divided down 400 V dc from the Input Conditioning Circuitry) to the primary of the startup isolation transformer. The result is an induced voltage in the secondary winding which feeds two half–wave rectifier circuits. One circuit provides the +12 V dc Startup Bias voltage (used by the module circuitry as initial VCC), and the other provides a BULK DETECT signal used by the Diagnostics Circuitry to generate the DC FAIL signal.

Main Inverter Circuitry

Overview

The main inverter circuitry is comprised of a switching–type power supply which generates a +14.2 V dc supply voltage. This voltage is used as the source for the +5 V inverter circuit in the power supply module, as well as the +14.2 V supply voltage for the satellite receiver or station modules (via the backplane).

Switching Power Supply Operation

The main inverter switching power supply consists of a pulse width modulator (PWM) running at 67 kHz. The PWM output pulses control a power FET bridge which alternately gate the input dc voltage (from the Input Conditioning Circuitry) to the primary of the main isolation transformer. The result is an induced voltage in the secondary windings of the transformer at 133 kHz rate.

Transformer Secondary Voltages

The main isolation transformer has two secondary windings, as follows:

- **Module Fail Winding** — operates in conjunction with a half–wave rectifier circuit to provide a dc signal (Mod Fail) to the A/D converter (p/o Diagnostics Circuitry); indicates that the main inverter circuitry is functioning properly.
- **+14.2 V Winding** — operates in conjunction with a full–wave rectifier circuit to generate a +14.2 V dc supply voltage. Overcurrent and overvoltage detect circuits monitor the circuit operation and, if preset thresholds are exceeded, generate a shutdown signal which is fed to the softstart circuitry to shutdown the main inverter.

+5 V Inverter Circuitry

Overview

The +5 V inverter circuitry is comprised of a switching−type power supply which generates a +5 V dc supply voltage. This voltage is used as the +5 V supply voltage for the satellite receiver or station modules (via the backplane).

Switching Power Supply Operation

The +5 V inverter switching power supply consists of a pulse width modulator (PWM) running at 133 kHz. The PWM output pulses control a power FET which repetitively gates the +14.2 V dc (from the Main Inverter Circuitry) to the filtering circuitry. The result is a +5 V dc supply voltage.

Protection Circuitry

An overvoltage detect circuit monitors the output voltage and, if preset thresholds are exceeded, generates a shutdown signal which is fed to the softstart circuitry to shutdown the main inverter. Upon an overvoltage detection, a FET crowbar circuit immediately discharges the output to protect other modules in the satellite receiver or station.

An overcurrent detect circuit monitors the current draw from the +5 V inverter circuit and, if a preset threshold is exceeded, shuts down the +5 V inverter. If the overcurrent condition lasts for a preset length (approx. 50 msec), the surge current delay circuit generates a shutdown signal which is fed to the softstart circuitry to shutdown the main inverter.

Diagnostics Circuitry

Overview

The diagnostics circuitry consists of a 11−channel A/D converter which converts analog status signals from critical points in the module to digital format for transfer to the Station Control Module via the SPI bus. Most of the status signals are generated by detect circuits to indicate the status of dc supply voltages and references.

Temperature Monitor and Control Circuitry

A thermistor mounted on the power supply module heatsink provides a varying resistance input to several detect and control circuits, as follows:

- **Heatsink Status Detect** — compares signal from thermistor to reference voltage to generate an output proportional to heatsink temperature; signal is sent to Station Control Board via A/D converter and SPI bus.
- **Hi−Temp Detect** — compares signal from thermistor to reference voltage to generate a high temperature signal if preset threshold is exceeded; signal is sent to softstart circuitry to shut down main inverter if overtemperature condition is detected.
- **Fan Control Circuitry**— compares signal from thermistor to reference voltage to generate a fan control signal to turn on cooling fan mounted in power supply module; also generated is a FAN ON status signal which is sent to Station Control Board via A/D converter and SPI bus.

  Note that a Fan Fault Detect circuit accepts a pulsed feedback signal from the cooling fan to indicate whether the fan is functioning (when turned on by Fan Control Circuitry); a FAN FAIL status signal is sent to Station Control Board via A/D converter and SPI bus

Note: *The cooling fan in the Power Supply Module is thermostatically controlled and may come on at any time during satellite receiver or station operation. Failure of the fan to rotate continuously does not indicate a failure of the module.*

Status LED Indicators

Two LEDs located on the power supply module front panel indicate module status as follows:

- **On**— lights GREEN when power supply module is turned on and functioning properly; LED turns off when module is turned off, input power is removed, or module startup circuitry is in fail mode
- **Module Fail**— lights RED when power supply module is in fail mode, or when a failure in another station module causes excessive current drain on any of the power supply output voltages; LED turns off when module is functioning properly

Address Decode Circuitry

The address decode circuitry allows the Station Control Board to use the address bus to select the A/D converter (Diagnostics Circuitry) for communications via the SPI bus. Typical communications include reading status signals from the Diagnostics Circuitry.

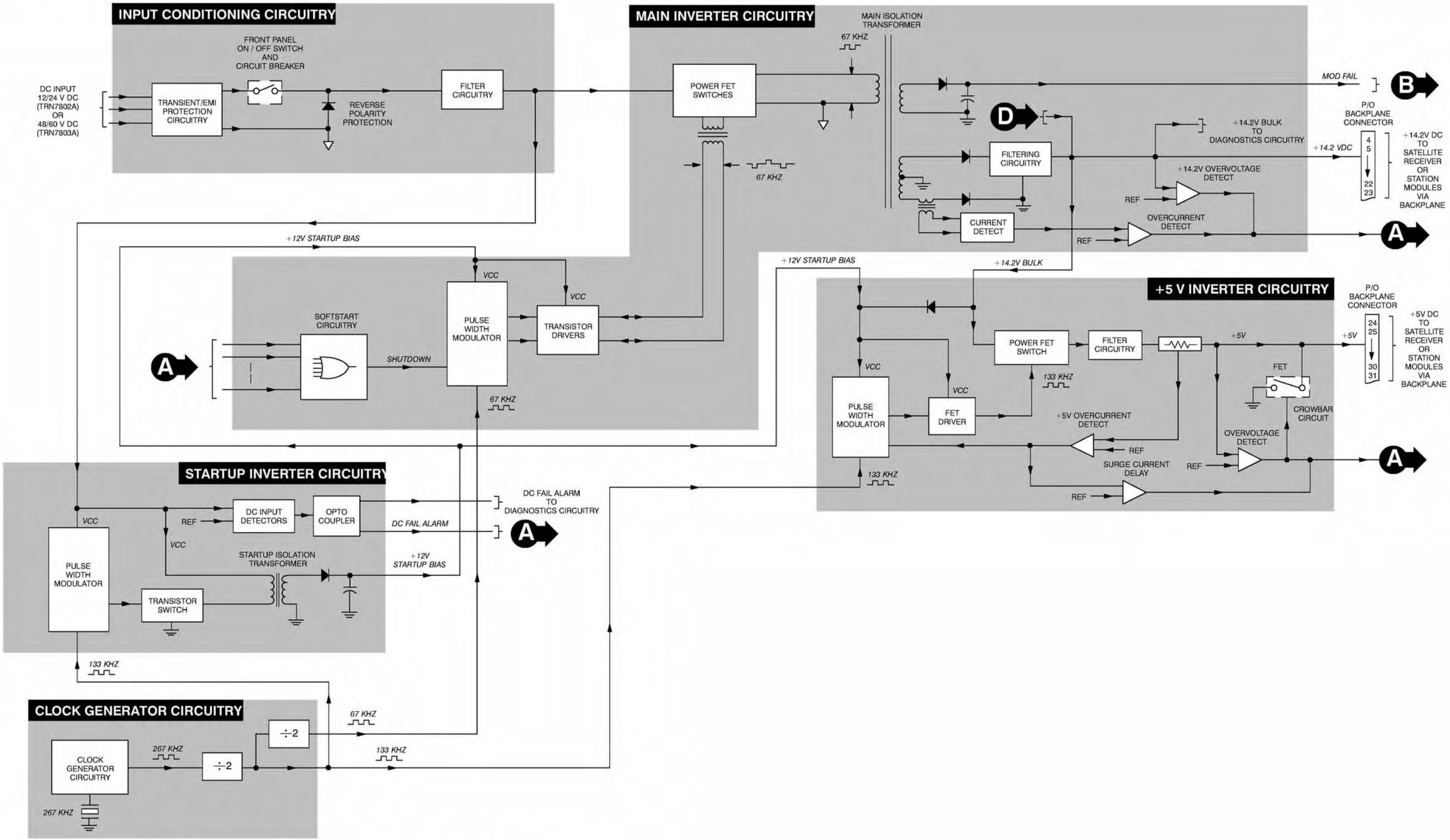


Figure 2. 210W DC/DC Power Supply Module Functional Block Diagram (Sheet 1 of 2)

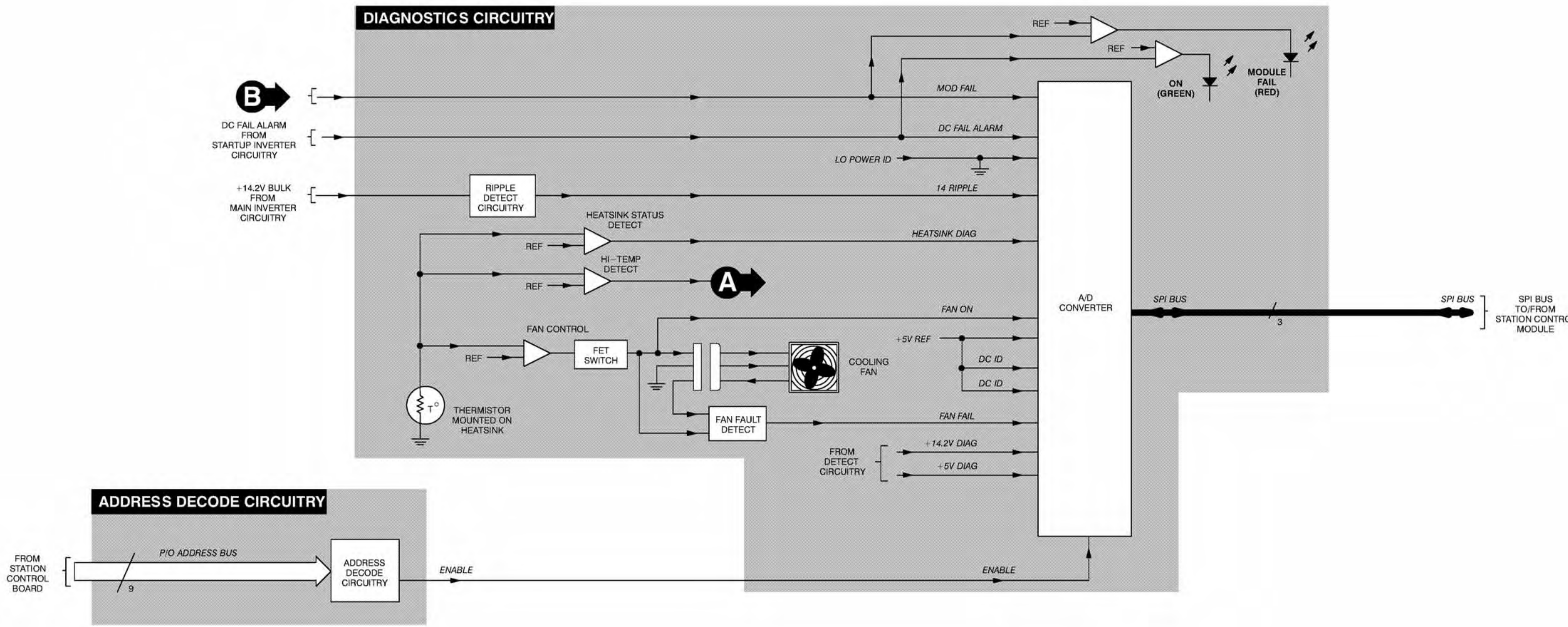


Figure 2. 210W DC/DC Power Supply Module Functional Block Diagram (Sheet 2 of 2)

POWER SUPPLY MODULE

Model TRN7801A (600W; 24 V DC Input)

1 DESCRIPTION

The Model TRN7801A Power Supply Module is described in this section. A general description, performance specifications, identification of controls, indicators, and inputs/outputs, a functional block diagram, and functional theory of operation are provided. The information provided is sufficient to give service personnel a functional understanding of the module, allowing maintenance and troubleshooting to the module level. (Refer also to the Maintenance and Troubleshooting section of this manual for detailed troubleshooting procedures for all modules in the station.)

General Description

The Model TRN7801A Power Supply Module accepts an input of 24 V dc and generates +28.6V dc, +5V dc, and +14.2V dc operating voltages to power the station modules. The power supply module is comprised of several switching-type power supply circuits and diagnostics and monitoring circuitry, all contained within a slide-in module housing.

The power supply module provides the following features:

- **Internal voltage and current limiting** — circuitry continually monitors critical voltages and currents and shuts supply down if preset thresholds are exceeded
- **Temperature protection** — module contains built−in cooling fan which is thermostatically controlled; supply shuts down if temperature exceeds preset threshold
- **Diagnostic monitoring** — critical internal parameters are continually monitored and reported to the Station Control Module, which can automatically provide correction for certain operating conditions
- Front panel On/Off switch with built-in 50A circuit breaker

1 DESCRIPTION (Continued)

Overview of Circuitry

The power supply module contains the following circuitry:

- Startup Inverter Circuitry — provides VCC for power supply circuitry during initial power−up
- Main Inverter Circuitry — consists of switching−type power supply that generates the +28V dc supply voltage
- +14.2 V Inverter Circuitry — consists of switching−type power supply that generates the +14.2V dc supply voltage
- +5 V Inverter Circuitry — consists of switching−type power supply that generates the +5 dc supply voltage
- Clock Generator Circuitry — generates 67 kHz and 133 kHz clock signals used by pulse width modulators in the four inverter circuits
- Diagnostics Circuitry — converts analog status signals to digital format for transfer to Station Control Module
- Address Decode Circuitry — performs address decoding to provide chip select signals for the A/D and D/A converters

2 PERFORMANCE SPECIFICATIONS

Table 1 shows the electrical performance specifications for the Model TRN7801A Power Supply Module.

Performance Specifications

Table 1. TRN7801A Power Supply Module Performance Specifications

Parameter	Specification
Weight	6.5 kg (14.3 lbs)
Operating Temperature Range	−30 to +45° C (no derating) −30 to +60° C (derated)
Input Voltage Range	21.0− 34.5 V dc
Maximum Input Current	40A
Steady State Output Voltages	+28.6 V dc ±5% @ 16A +28.6 V dc ±5% @ 12.8A (derated) +14.2 V dc ±5% @ 9A +5.1 V dc ±5% @ 9A
Output Current Ratings	+28.6 16A +14.2 9A +5.0 9A
Total Output Power Rating	no derating 630 W derated 540 W
Output Ripple	All outputs 50 mV p−p (measured with 20 MHz BW oscilloscope at 25°C). High Frequency individual harmonic voltage limits in 10 kHz−100 MHz frequency band: 28.6V 1.5 mV p−p 14.2 V 3.0 mV p−p 5V 5.0 mV p−p
Short Circuit Current	0.5 A avg. max

3 CONTROLS, INDICATORS, AND INPUTS/OUTPUTS

Figure 1 shows the power supply module controls, indicators, and all input and output external connections.

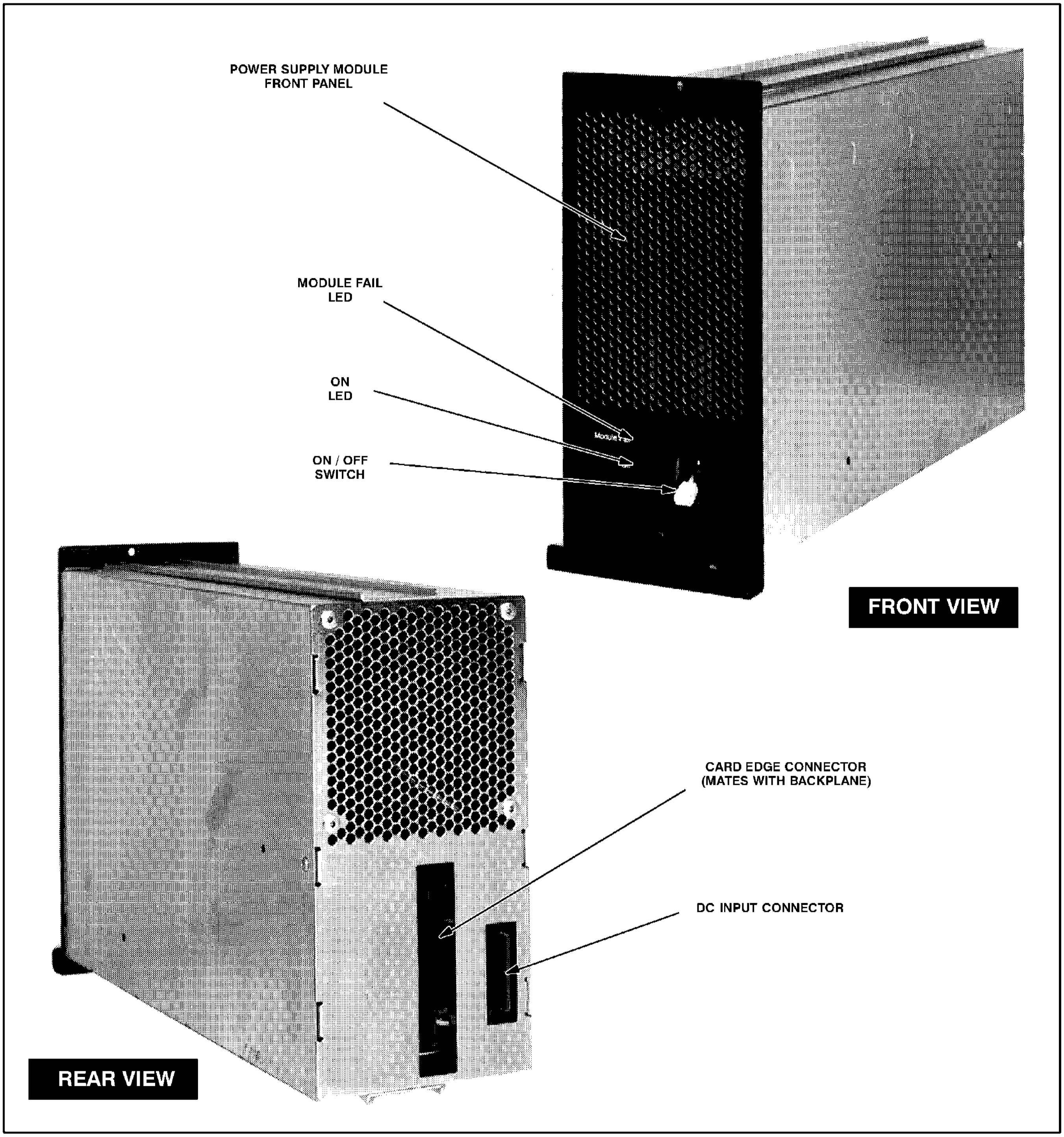


Figure 1. Power Supply Module Controls, Indicators, and Inputs/Outputs

4 FUNCTIONAL THEORY OF OPERATION

The following theory of operation describes the operation of the power supply circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 2 for a block diagram of the power supply module.

Input Conditioning Circuitry

Introduction

The power supply module accepts dc power from an external source, typically a bank of storage batteries. DC power is connected to the module via a 4–wire dc input cable mounted on the station backplane.

Transient and EMI Protection

The dc input is fed to the power supply module circuitry via transient protection and EMI filter circuits. The transient protection devices provide protection against voltage spikes by providing an effective short to ground under high voltage transient conditions. The EMI filter prevents electrical noise generated by the power supply module from interfering with other equipment connected to the same dc source.

Front Panel On–Off Switch

A toggle–type switch located on the power supply module front panel allows the power supply (and satellite receiver) to be turned off by removing the dc input voltage. The switch controls a built-in circuit breaker (rated at 50A) to provide overload protection for the power supply and station circuitry.

Startup Inverter Circuitry

This circuitry consists of a switching–type power supply which generates a +12 V dc supply voltage used by the power supply module circuitry as VCC at the time of initial power up. When all supply voltages have stabilized, this circuit is overridden by +14.2 V BULK which continues to supply VCC to the module circuitry.

The circuitry consists of a pulse width modulator (PWM) running at 133 kHz (internal circuitry provides clock signal during initial power up). The PWM output pulses control a transistor switch which repetitively gates voltage to the primary of the startup isolation transformer. The result is an induced voltage in the secondary winding which feeds two half–wave rectifier circuits. One circuit provides the +12 V dc Startup Bias voltage (used by the module circuitry as initial VCC), and the other provides a BULK DETECT signal used by the Diagnostics Circuitry to generate the AC FAIL signal.

Main Inverter Circuitry

Overview

The main inverter circuitry is comprised of a switching–type power supply which generates a +28.6 V dc supply voltage. This voltage is used as the source for the +14.2 V and +5 V inverter circuits in the power supply module, as well as the +28 V supply voltage for the station modules (via the backplane).

Switching Power Supply Operation

The main inverter switching power supply consists of a pulse width modulator (PWM) running at 67 kHz. The PWM output pulses control a power FET bridge which alternately gate the input dc voltage (from the Input Conditioning Circuitry) to the primary of the main isolation transformer. The result is an induced voltage in the secondary windings of the transformer at 133 kHz rate.

Transformer Secondary Voltages

The main isolation transformer has two secondary windings, as follows:

- **Module Fail Winding** — operates in conjunction with a half–wave rectifier circuit to provide a dc signal (Mod Fail) to the A/D converter (p/o Diagnostics Circuitry); indicates that the main inverter circuitry is functioning properly.
- **+28 V Winding** — operates in conjunction with a full–wave rectifier circuit to generate a +28 V dc supply voltage. Overcurrent and overvoltage detect circuits monitor the circuit operation and, if preset thresholds are exceeded, generate a shutdown signal which is fed to the softstart circuitry to shutdown the main inverter.

+14.2 V Inverter Circuitry

Overview

The +14.2 V inverter circuitry is comprised of a switching–type power supply which generates a +14.2 V dc supply voltage. This voltage is used as the +14.2 V supply voltage for the station modules (via the backplane).

Switching Power Supply Operation

The +14.2 V inverter switching power supply consists of a pulse width modulator (PWM) running at 133 kHz. The PWM output pulses control a power FET which repetitively gates the +28.6 V dc (from the Main Inverter Circuitry) to the filtering circuitry. The result is a +14.2 V dc supply voltage.

Protection Circuitry

An overvoltage detect circuit monitors the output voltage and, if preset thresholds are exceeded, generates a shutdown signal which is fed to the softstart circuitry to shutdown the main inverter. Upon an overvoltage detection, a FET crowbar circuit immediately discharges the output to protect other modules in the station.

An overcurrent detect circuit monitors the current draw from the +14.2 V inverter circuit and, if a preset threshold is exceeded, shuts down the +14.2 V inverter. If the overcurrent condition lasts for a preset length (approx. 50 msec), the surge current delay circuit generates a shutdown signal which is fed to the softstart circuitry to shutdown the main inverter.

+5 V Inverter Circuitry

Overview

The +5 V inverter circuitry operates identically to the +14.2 V inverter circuitry (described above) to generate a +5 V dc supply voltage. This voltage is used as the +5 V supply voltage for the station modules (via the backplane).

Diagnostics Circuitry

Overview

The diagnostics circuitry consists of an 11−channel A/D converter which converts analog status signals from critical points in the module to digital format for transfer to the Station Control Module via the SPI bus. Most of the status signals are generated by detect circuits to indicate the status of dc supply voltages and references.

Temperature Monitor and Control Circuitry

A thermistor mounted on the power supply module heatsink provides a varying resistance input to several detect and control circuits, as follows:

- **Heatsink Status Detect —** compares signal from thermistor to reference voltage to generate an output proportional to heatsink temperature; signal is sent to Station Control Board via A/D converter and SPI bus.
- **Hi−Temp Detect** — compares signal from thermistor to reference voltage to generate a high temperature signal if preset threshold is exceeded; signal is sent to softstart circuitry to shut down main inverter if overtemperature condition is detected.
- **Fan Control Circuitry**— compares signal from thermistor to reference voltage to generate a fan control signal to turn on cooling fan mounted in power supply module; also generated is a FAN ON status signal which is sent to Station Control Board via A/D converter and SPI bus.

  Note that a Fan Fault Detect circuit accepts a pulsed feedback signal from the cooling fan to indicate whether the fan is functioning (when turned on by Fan Control Circuitry); a FAN FAIL status signal is sent to Station Control Board via A/D converter and SPI bus

Note: *The cooling fan in the Power Supply Module is thermostatically controlled and may come on at any time during station operation. Failure of the fan to rotate continuously does not indicate a failure of the module.*

Status LED Indicators

Two LEDs located on the power supply module front panel indicate module status as follows:

- **Power On**— lights GREEN when power supply module is turned on and functioning properly; LED turns off when module is turned off, input power is removed, or module startup circuitry is in fail mode
- **Module Fail**— lights RED when power supply module is in fail mode, or if a failure in another station module causes excessive current drain on any of the power supply output voltages; LED turns off when module is functioning properly

Address Decode Circuitry

The address decode circuitry allows the Station Control Board to use the address bus to select the A/D converter (Diagnostics Circuitry) for communications via the SPI bus. Typical communications include reading status signals from the Diagnostics Circuitry.

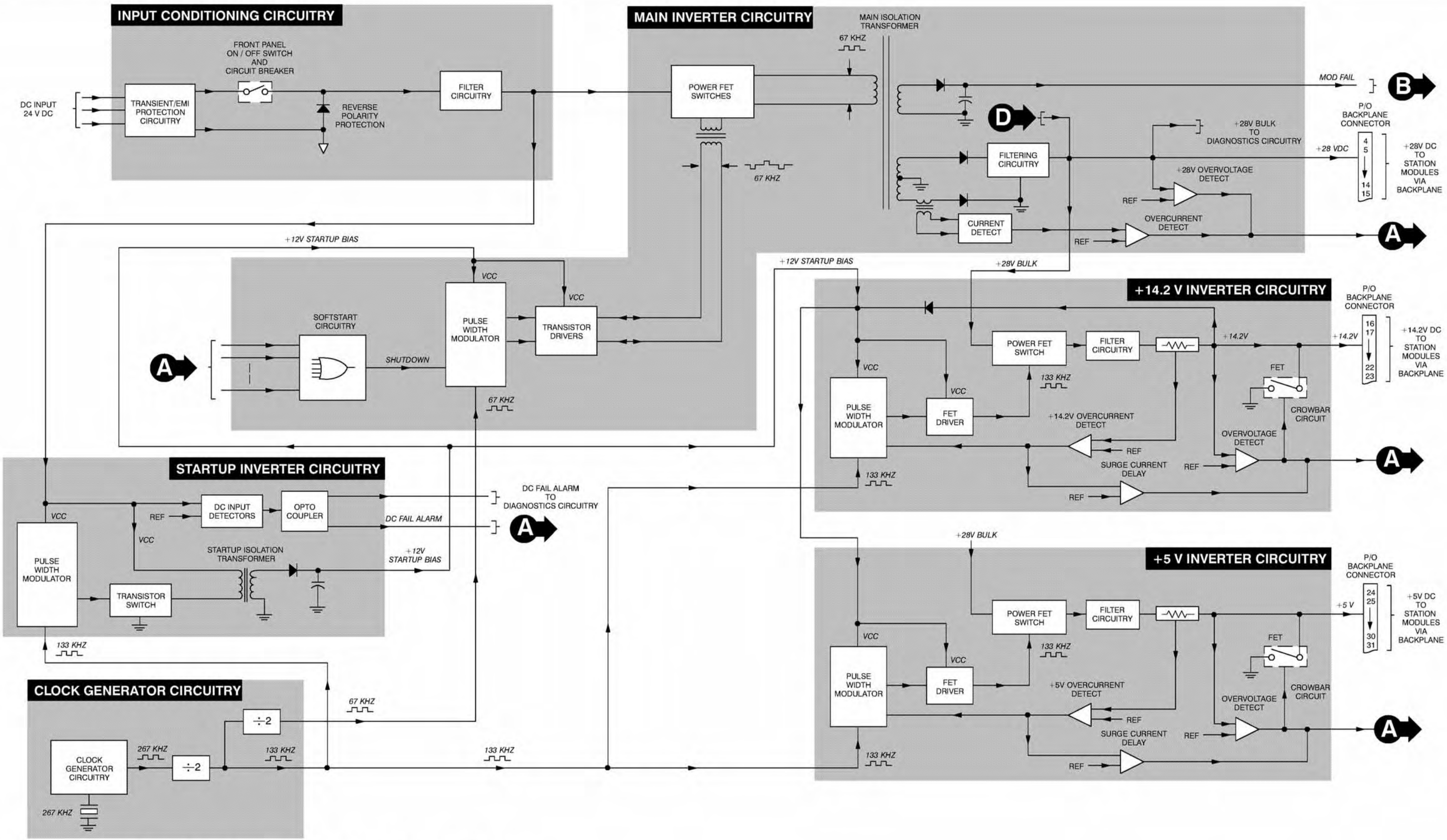


Figure 2. 600W DC/DC Power Supply Module Functional Block Diagram (Sheet 1 of 2)

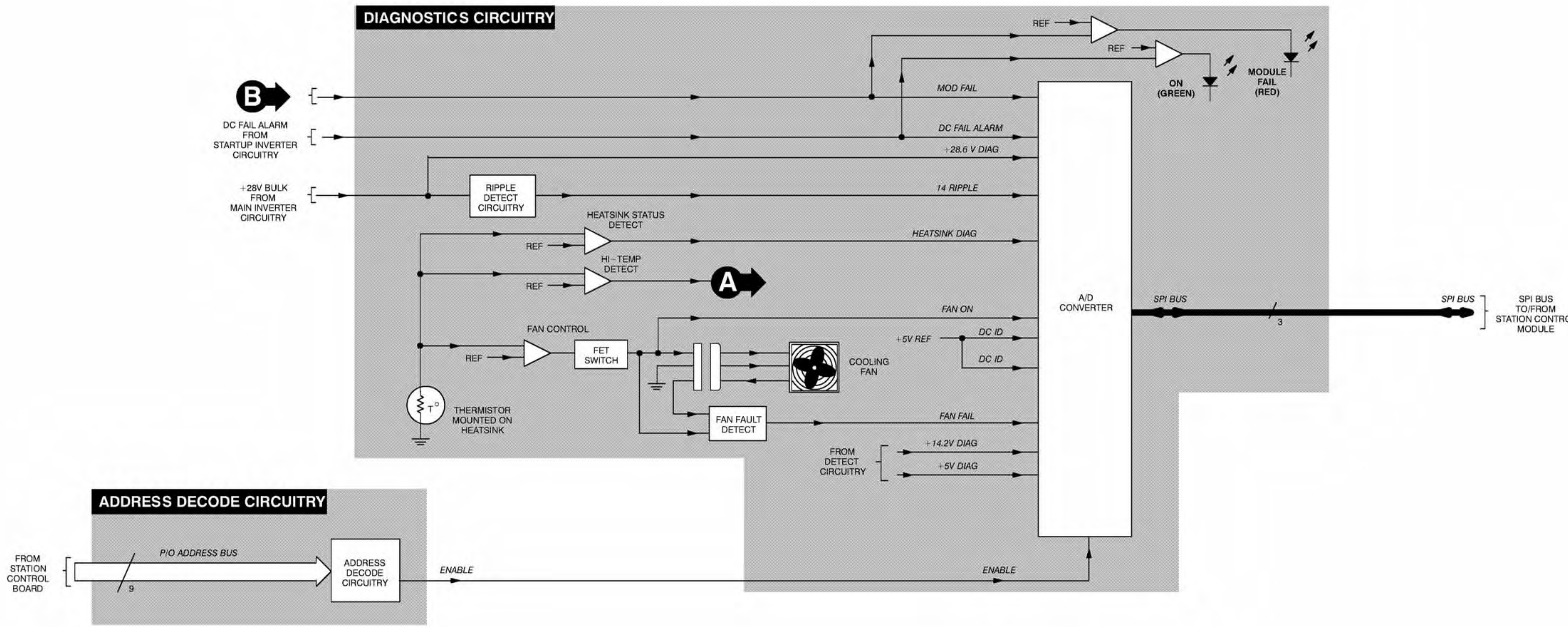


Figure 2. 600W DC/DC Power Supply Module Functional Block Diagram (Sheet 2 of 2)

MOTOROLA

POWER SUPPLY MODULE

CPN1031B (600W; 48/60V DC Input)

1 DESCRIPTION

The Model CPN1031B Power Supply Module is described in this section. A general description, performance specifications, identification of controls, indicators, and inputs/outputs, a functional block diagram, and functional theory of operation are provided. The information provided is sufficient to give service personnel a functional understanding of the module, allowing maintenance and troubleshooting to the module level. (Refer also to the Maintenance and Troubleshooting section of this manual for detailed troubleshooting procedures for all modules in the station.)

General Description

The Models CPN1031B Power Supply Module accepts a dc input of either 48 V dc or 60 V dc and generates +28.6V dc, +14.2V dc, and +5.1V dc operating voltages to power the station modules. The power supply module is comprised of two circuit boards which provide several switching-type power supply circuits and diagnostics and monitoring circuitry, all contained within a slide-in module housing.

The power supply module provides the following features:

- **Internal voltage and current limiting** — circuitry continually monitors critical voltages and currents and shuts supply down if preset thresholds are exceeded
- **Temperature protection** — module contains built-in cooling fan; supply shuts down if temperature exceeds preset threshold
- **Diagnostic monitoring** — critical internal parameters are continually monitored and reported to the Station Control Module, which can automatically provide correction for certain operating conditions
- **Fan Failure Protection** — Power Supply enters shutdown mode in event of cooling fan failure
- **Auto Recovery from Shutdown** — Power Supply automatically recovers from shutdown mode if the cause of the shutdown no longer exists
- **Limited In-Rush Current** — Circuitry limits in-rush current to less than 30 A in all conditions

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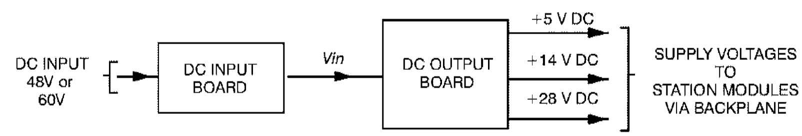
Power Supply Module Simplified Block Diagram

The illustration below provides a simplified block diagram of a Power Supply Module showing how the two circuit boards interconnect. A detailed block diagram and functional theory of operation for each board is provided later in this section (beginning on page 6).

POWER SUPPLY MODULE



Overview of Circuitry

The power supply module is comprised of two circuit boards, connected together via cables. These boards contain circuitry as follows:

DC Input Board (CPN6064B)

- **Input Conditioning Circuitry** — consists of: dc filtering components, reverse polarity circuitry to protect power supply circuitry from reverse polarity connection to external DC source, Startup Delay Circuitry
  - — Filter Circuitry to provide filtering of DC input voltage
  - — Reverse Polarity Circuitry to protect power supply circuitry from reverse polarity connection to external DC source
  - — Startup Delay Circuitry to provide a delay of approximately 1.5 seconds from time on/off switch is turned on until the power supply becomes functional (allows pre-charge of high-capacity filter capacitors to limit in-rush current on power up)
  - — Filter Circuitry to provide filtering of DC output voltage
- **Inverter Circuitry A and B** — consists of two inverter circuits that accept gating signals from the *Inverters A/B Control Circuitry* (on DC Output Board) to provide 133 kHz signal to *Output Filter Circuitry* and to the *+5V and +14V Power Supply Circuits* (on DC Output Board)
- **Output Filter Circuitry** — consists of dc filtering components to filter the +28 V dc output voltage supplied to the station modules

DC Output Board (CPN6068A)

- **Inverters A/B Control Circuitry** — consists of switching-type circuitry that generates the 133 kHz *V_GATE_1* and *V_GATE_2* signals to the *Inverter A* and *Inverter B* circuitry on the DC Input Board; also contains *Peak Current Limiting Circuitry* and *Overvoltage Protection Circuitry.*
- **+14 V Supply Circuitry** — consists of switching-type power supply that generates the +14 V dc supply voltage.
- **+5 V Supply Circuitry** — consists of switching-type power supply that generates the +5 V dc supply voltage.
- **Reference Voltage Circuitry** — Generates +10V_SEC and +2.5V_SEC supply voltages for use by local circuitry.
- **Diagnostics Circuitry** — converts analog status signals to digital format for transfer to Station Control Module.
- **Address Decode Circuitry** — performs address decoding to provide chip select signal for the A/D converter.
- **Startup/Shutdown Control Circuitry** — Provides delay interval for shutdown of entire power supply module.

2 PERFORMANCE SPECIFICATIONS

Table 1 shows the electrical performance specifications for the Model CPN1031B Power Supply Module.

Performance Specifications

Table 1. CPN1031B Power Supply Module Performance Specifications

Parameter	Specification
Weight	6.5 kg (14.3 lbs)
Operating Temperature Range	−30 to +60° C (no derating)
Input Voltage Range	+43.2 V dc to +62.4 V dc
Maximum Input Current	22 A
Steady State Output Voltages	+28.6 V dc ±5% +14.2 V dc ±5% +5.0 V dc ±5%
Output Current Ratings	+28.6 12.5 A +14.2 8 A +5.1 3 A
Total Output Power Rating	No Derating 600 W
Output Ripple	All outputs 50 mV p−p (measured with 20 MHz BW oscilloscope at 25°C). High Frequency individual harmonic voltage limits in 10 kHz−100 MHz frequency band: 28.6V 1.5 mV p−p 14.2 V 3.0 mV p−p 5V 5.0 mV p−p
Short Circuit Current	25.5 A ± 3 A

3 CONTROLS, INDICATORS, AND INPUTS/OUTPUTS

Figure 1 shows the power supply module controls, indicators, and all input and output external connections.

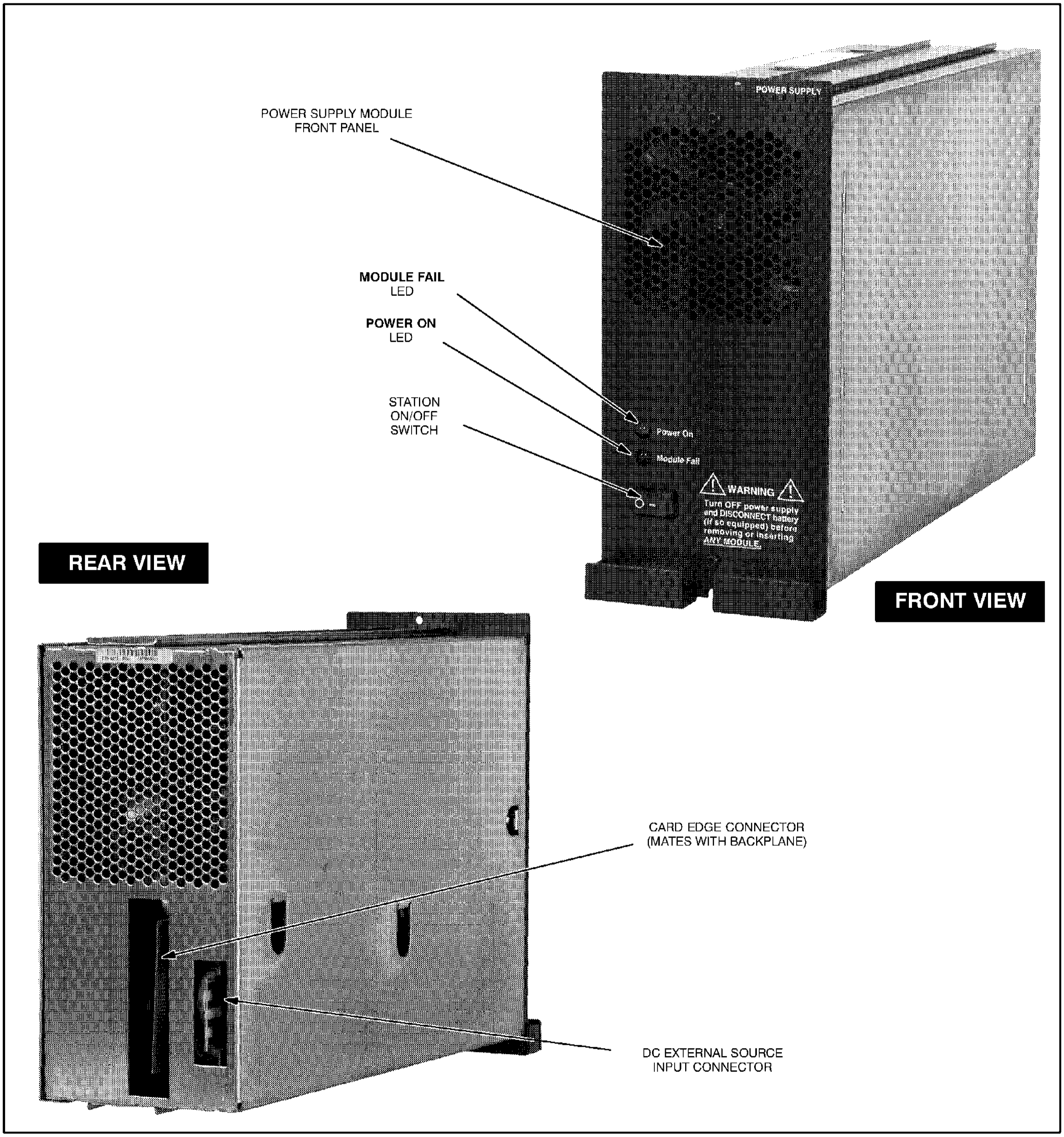


Figure 1. CPN1031B Power Supply Module Controls, Indicators, and Inputs/Outputs

4 FUNCTIONAL THEORY OF OPERATION (DC Input Board)

The following theory of operation describes the operation of the CPN6064B DC Input Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 2 for a block diagram of the DC Input Board.

Input Conditioning Circuitry

Introduction

The DC Input Board accepts dc power from an external source, typically a bank of storage batteries. DC power is connected to the board via a 4-wire dc input cable mounted on the station backplane.

Input Filter Circuitry

The DC input voltage is fed to filtering circuitry. This circuitry consists of filter capacitors that remove any ripple and/or transients from the input dc signal.

Front Panel On–Off Switch / Startup Delay Circuitry

A rocker-type switch located on the power supply module front panel allows the power supply (and station) to be turned on and off. Note that the switch allows the output filter circuitry to slowly charge (for approximately 1.5 seconds after switch is turned on) through two diodes and resistors. After the 1.5 second delay, the relay turns on and provides the full dc input voltage to the output filter circuitry. This 1.5 second pre-charge delay period limits in-rush current through the filter capacitors upon power up.

If the DC input is below approximately 43.2 V, the relay will not be turned on and the power supply outputs will be disabled. The red **Module Fail** LED on the front panel will light.

Output Filter Circuitry

The DC input voltage is fed to filtering circuitry. This circuitry consists of filter capacitors that remove any ripple or noise from the switching circuitry from the +28 V dc output.

Inverter Circuitry A and B

Inverter Circuitry A and Inverter Circuitry B are identical switching-type circuits that accept the gating signals (V_GATE_1 and V_GATE_2) from the DC Output Board and generate a 133 kHz output signal. This signal is fed to the Output Filter Circuitry (which provides a +28 V dc supply voltage to the station) and to the +5V and +14V Supply Circuits on the DC Output Board.

Output Filter Circuitry

This circuitry consists of a series of filter capacitors that filter the 133 kHz signal from Inverter Circuits A and B to provide a +28 V dc supply voltage for use by the station modules (via the backplane).

5 FUNCTIONAL THEORY OF OPERATION (DC Output Board)

The following theory of operation describes the operation of the CPN6068A DC Output Board circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the module in order to facilitate maintenance and troubleshooting to the module level. Refer to Figure 3 for a block diagram of the DC Output Board.

Inverters A/B Control Circuitry

Overview

The Inverters A/B Control Circuitry is comprised of two mirrored switching-type circuits which generate the V_GATE_1 and V_GATE_2 signals used by the Inverter Circuitry A and Inverter Circuitry B (located on the DC Input Board).

Switching Circuitry Operation

The switching circuitry consists of two identical switching-type circuits operating in parallel. Both circuits operate identically, as follows. A 67 kHz clock signal from the Sync Generator Circuitry is fed through a buffer to a Pulse Width Modulator (PWM). The PWM outputs a 133 kHz signal (V_GATE_1 or V_GATE_2) which is fed to Inverter Circuitry A (or Inverter Circuitry B) located on the DC Input Board.

Since Inverter Circuitry A and Inverter Circuitry B each receives a 133 kHz V_GATE signal that is 180° out of phase with the other, each circuit alternately charges the output filter circuitry, resulting in an effective charging rate of 133 kHz.

Protection Circuitry

Peak/Average Current Limiting Circuitry — The peak current limiting circuitry accepts an output current feedback signal and a scaled +28V_RAW reference signal to control the PWMs. This effectively maintains a constant output voltage for varying output current demands.
The average current limiting circuitry monitors the +28 V dc output and generates a shutdown signal (PRI_SHUTDOWN) if the average output current reaches a predetermined limit.

Overvoltage Protection Circuitry — This circuitry monitors the +28V_RAW voltage and generates a shutdown signal (PRI_SHUT_SEC) to shut down the entire power supply module if the +28 V output voltage exceeds a preset threshold.

+14 V Supply Circuitry

Overview

The +14 V Supply Circuitry is comprised of a switching-type power supply which generates a +14.2 V dc supply voltage. This voltage is used as the +14.2 V supply voltage for the station modules (via the backplane).

Switching Power Supply Operation

The +14 V switching power supply consists of a pulse width modulator (PWM) running at 133 kHz. The PWM output pulses are fed through a driver to control a power FET which repetitively gates the +28V_RAW (from the Output Filter Circuitry on the DC Input Board) to a power coil. The result is a high induced voltage which charges the filter capacitors to approximately +14.2 V dc. A current sense comparator provides a feedback signal to the PWM to maintain a constant output voltage.

Protection Circuitry

An overvoltage detect circuit monitors the output voltage and, if preset thresholds are exceeded, turns on a FET crowbar circuit which immediately discharges the output to protect other modules in the station.

An overcurrent detect circuit monitors the current draw from the +14V Supply Circuitry and, if a preset threshold is exceeded, generates a PRI_SHUT_SEC signal which shuts down the entire power supply module.

+5 V Supply Circuitry

The +5 V Supply Circuitry operates identically to the +14 V Supply Circuitry (described above) to generate a +5.1 V dc supply voltage. This voltage is used as the +5 V supply voltage for the station modules (via the backplane).

Reference Voltage Circuitry

This circuitry accepts +28V_RAW (from the +28V Main Supply Circuitry) and generates +10V_SEC and +2.5V_SEC supply voltages for use by local circuitry.

Diagnostics Circuitry

Overview

The diagnostics circuitry consists of an 11-channel A/D converter which converts analog status signals from critical points in the power supply module to digital format for transfer to the Station Control Module via the SPI bus. Most of the status signals are generated by detect circuits to indicate the status of dc supply voltages and references.

Temperature Monitor and Control Circuitry

A thermistor mounted on the power supply module heatsink provides a varying resistance input to the Heatsink Temp Detect Circuitry. If the heatsink temperature exceeds a preset limit, the circuitry generates a PRI_SHUT_SEC shutdown signal which shuts down the entire power supply module. A HEATSINK_DIAG signal is also sent to the Station Control Module via the A/D converter and SPI bus.

Overvoltage/Undervoltage Detect Circuitry

This circuitry monitors the VIN__FLTRD signal from the DC Input Board and generates a DC_GOOD_DIAG signal as long as the VIN__FLTRD signal remains within predetermined limits. The circuitry also drives the LED indicators (described below).

LED Status Indicators

Two LEDs located on the power supply module front panel indicate module status as follows:

- **Power On**— lights GREEN when On/Off switch is On and the AC input voltage is within operating range; LED turns off when module is turned off, ac power is removed, or AC input voltage is below approximately 85 V rms.
- **Module Fail**— lights RED when initially turning on or off the Power Supply (this is normal and does not indicate a failure) or when the DC-to-DC Converter Board is not functioning properly; LED turns off when module is functioning properly

Address Decode Circuitry

The address decode circuitry allows the Station Control Module to use the address bus to select either the D/A converter (Battery Charger/Revert Board) or the A/D converter (Diagnostics Circuitry) for communications via the SPI bus. Typical communications include reading status signals from the Diagnostics Circuitry.

Startup/Shutdown Control Circuitry

Shutdown Delay Circuitry

Upon receiving a shutdown signal (PRI_SHUTDOWN) from the +28V Main Supply Circuitry, this circuit passes the signal through the Soft Start Circuitry for a 1 second interval to allow the entire power supply module to shutdown. The module then restarts (if the on/off switch is in **On** position). If the PRI_SHUTDOWN signal is still active, the shutdown process will repeat.

Soft Start Circuitry

Each time the Soft Start Circuitry receives a startup signal (i.e., PRI_SHUTDOWN is inactive), the Soft Start Circuitry provides a gradually increasing output signal to “soft start” the Pulse Width Modulators (p/o +28V Main Supply Circuitry). This action minimizes the surge current when charging the output filter capacitors.

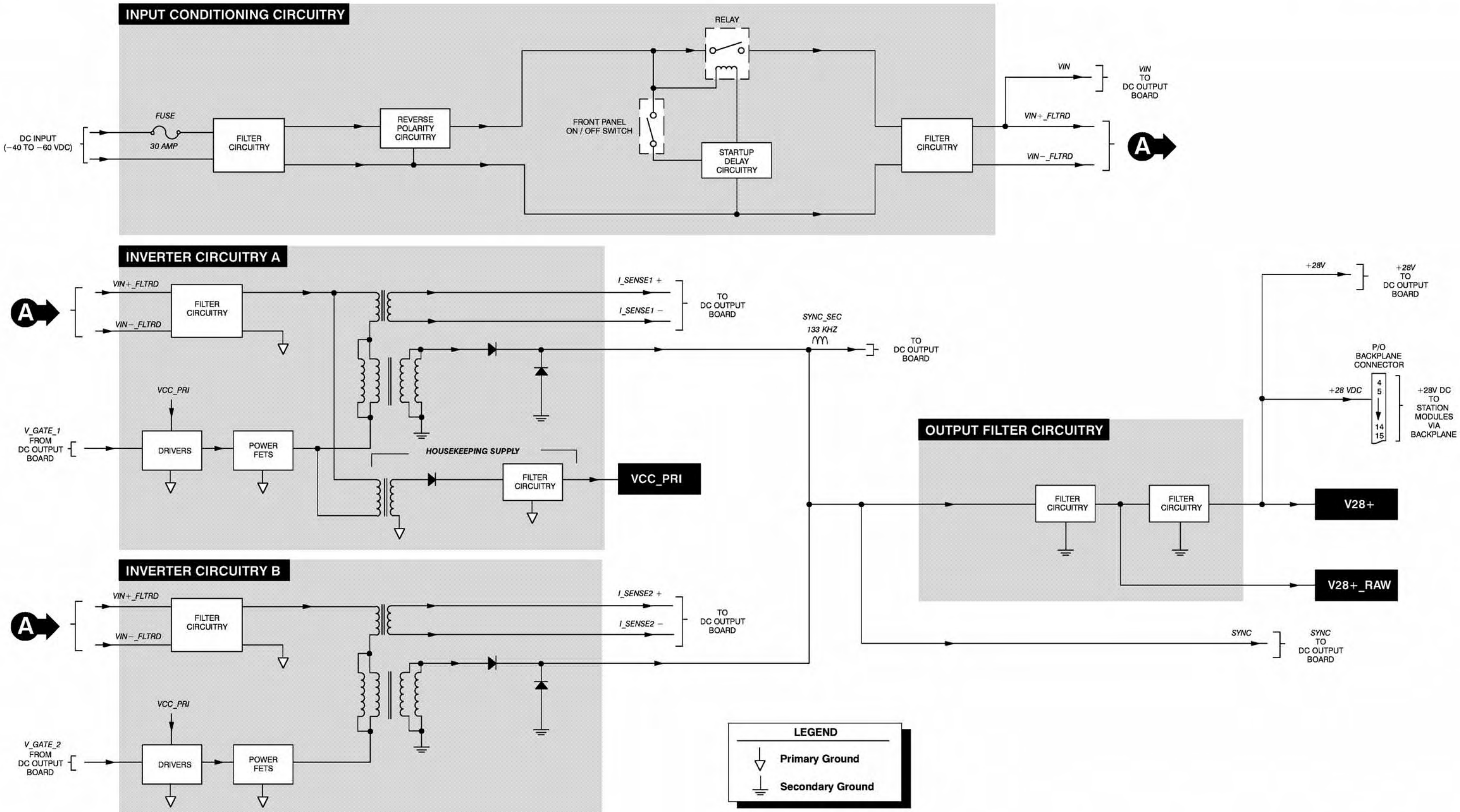


Figure 2. CPN6064B DC Input Board Functional Block Diagram

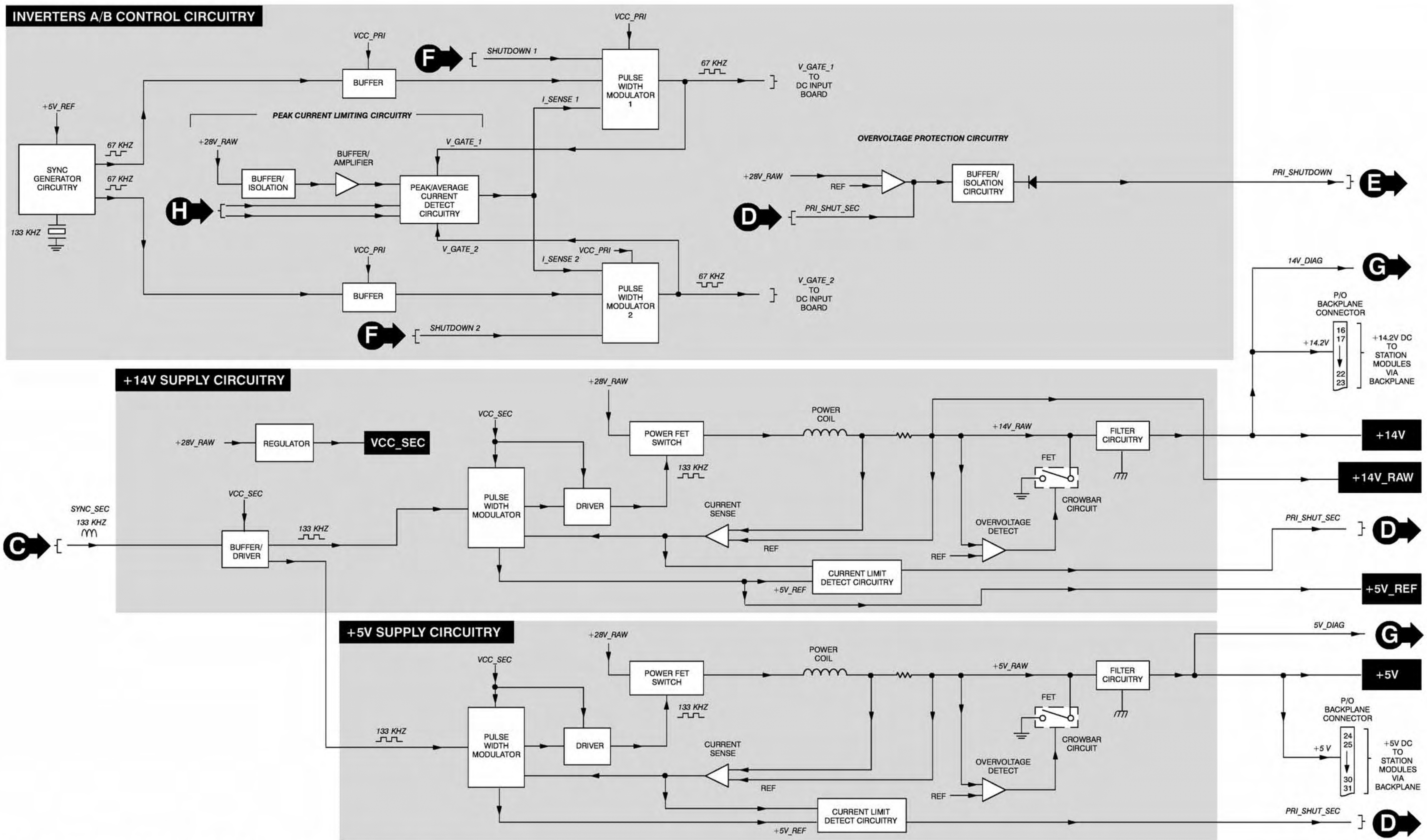


Figure 3. CPN6068A DC Output Board Functional Block Diagram (1 of 2)

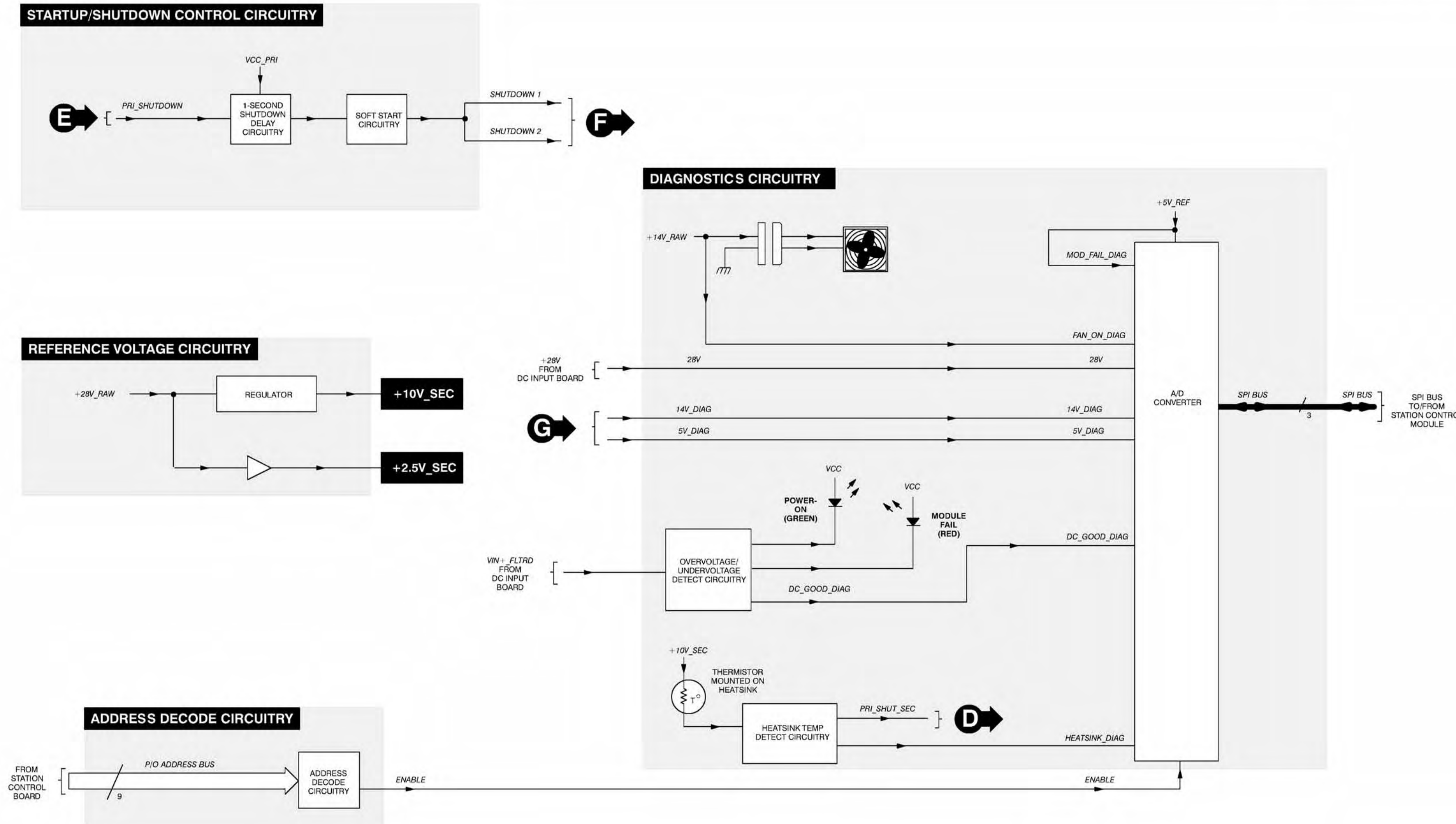


Figure 3. CPN6068A DC Output Board Functional Block Diagram (2 of 2)

END OF PART 10