700W-SH Power Supply
Hardware v1.0

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1 Scope

This specification defines the requirement for a 700W standalone, single-voltage power supply, powered from AC and DC lines, and used for IT systems for both online and backup power functions. This device works in conjunction with the Open Compute Project battery backup cabinet (see the *Open Compute Project Battery Cabinet Hardware v1.0* specification) and custom power strips.

2 Contents

3 Overview

When data center design and hardware design move in concert, they can improve efficiency and reduce power consumption. To this end, the Open Compute Project is a set of technologies that reduces energy consumption and cost, increases reliability and choice in the marketplace, and simplifies operations and maintenance. One key objective is openness—the project is starting with the opening of the specifications and mechanical designs for the major components of a data center, and the efficiency results achieved at facilities using Open Compute technologies.

One component of this project is a custom server power supply. This document describes in detail the technical specifications of the 700W-SH AC/DC power converter, a single voltage 12.5Vdc, closed frame, self-cooled power supply used in high efficiency IT applications. The supply is configurable to a 450W-SH power rating (like the Open Compute Project 450W power supply), as both models use the same PCBs, with just pin-to-pin component replacements.

The requirements listed in this specification are valid for both versions unless otherwise stated. Two more versions with reversed airflow are also available: a 700W-SH/R model and 450W-SH/R model (four individual part numbers).

The power converter includes independent AC input and DC output connectors, and a DC input connector for backup voltage. The power converter can provide temporary backup in case of AC outage; backup voltage needs to be applied to the DC input to enable this function. Both AC and DC inputs are hot swappable, and their respective connector counterparts are installed on cable assemblies (power cords).

Current sharing and parallel operations capabilities are designed to support up to 8 modules in parallel, using droop-share topology.

Throughout the specification, the power converter is referred to as a power supply.

3.1 Accessibility

The power supply must be physically installed in a restricted (controlled) area with service accessibility exclusively permitted to authorized personnel only; certified and trained personnel only can have access to the actual power supply and its interconnections.

3.2 License

infringement, fitness for a particular purpose, or title, related to the Specification. The entire risk as to implementing or otherwise using the Specification is assumed by the Specification implementer and user. IN NO EVENT WILL ANY PARTY BE LIABLE TO ANY OTHER PARTY FOR LOST PROFITS OR ANY FORM OF INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY CHARACTER FROM ANY CAUSES OF ACTION OF ANY KIND WITH RESPECT TO THIS SPECIFICATION OR ITS GOVERNING AGREEMENT, WHETHER BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE), OR OTHERWISE, AND WHETHER OR NOT THE OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

4 Compliance Requirements

The power supply complies with the following standards as standalone unit, and is certified and labeled accordingly.

4.1 Safety Certifications, Applicable Documents

- UL60950-1 (Standard for Safety of IT Equipment)
- CAN/CSA-C22.2 No. 60950-1-03 (Standard for Safety of IT Equipment)
- EN60950-1:2006 / IEC60950-1 (Standard for Safety of IT Equipment)
- cCSAus Certification is allowed in place of the equivalent UL certification
- CE Mark, CB Report & Certificate
- EU Low Voltage Directive, EMC Directive
- UL94V-0 material flammability rating, with an oxygen index of at least 28%

4.2 Immunity Standards, EMC

- EN61000/IEC61000 applicable standards for Emissions and Immunity Requirements
- EN61000-3-2 (AC Mains Harmonic Current Emissions)
- EN61000-3-3 (Voltage Flicker)
- EN61000-4-2, Level 4 (ESD)
- EN61000-4-3 (Radiated Immunity, 3V/m)
- EN61000-4-4, Level 4 (EFT/Burst)
- EN61000-4-5 (AC Mains Surge Immunity, see levels at section 5.9)
- EN61000-4-6 (Conducted Radio Frequency Immunity, 3V/m)
- EN61000-4-8 (Power Frequency Magnetic Fields)
- EN61000-4-9 (Pulse Magnetic Field)
- EN61000-4-11 (AC Mains Voltage Dips & Sags, Fluctuations)
- Power supply always resumes operations after any fatal PLD
- Output voltage never dips if backup voltage is applied to the power supply
- Backup functionality is not affected by substantial repetitive dips and sags
- GR-1089-CORE, Issue 4 (Power Line Disturbances)
- BS EN 55024:1998, CISPR 24:1997 - Information Technology Equipment

Note: Once the power supply is installed, the EUT powered by the power supply continues to operate without interruptions and/or reset occurrences during above tests under EN61000-4-(*).

4.3 Further Applicable Immunity Standards

The power supply meets the EN61000 standards for industrial immunity:

- EN61000-6-1 (Immunity / Light Industry)
- EN61000-6-2 (Immunity / Industry)

This section of BS EN 61000 applies to electrical and electronic apparatus intended for use in industrial environments. This standard applies to an apparatus intended to be connected to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding industrial plants, and intended to operate in (or in proximity to) industrial locations. This standard applies also to apparatus that is battery operated and intended to be used in industrial locations. The environments encompassed by this standard are industrial, both indoor and outdoor, and where heavy inductive or capacitive loads are frequently switched, and/or with presence of high currents and associated magnetic fields.

4.4 EMI Compliance and Limits

- The AC mains tests are conducted as a standalone unit, at both 200Vac and 277Vac, full load
- FCC Part 15, EN55022, CISPR 22: Conducted Emission, Class B (peak-reading)
- FCC Part 15, EN55022, CISPR 22: Radiated Emission, Class B
- The DC backup converter meets Class A with 3 dB margin, at 48Vdc input and full load
- At system level, the power supply complies with Class A limits for both conducted and radiated emissions, with at least 3 dB margin, and for both AC and DC inputs/converters

4.5 Environmental Engineering Standards

- ETS 300 019-2-3, Class 3.2 (Operation)
- ETS 300 019-2-2, Class 2.3 (Transportation)
- ETS 300 019-2-1, Class 1.2 (Storage)

4.6 AC Mains Leakage Current

Leakage current complies with applicable EN/IEC standards, and does not exceed 2mA RMS at 60Hz and 277Vac.

4.7 RoHS compliance

The power supply is RoHS-6 compliant (BOM and Manufacturing Process).

5 AC Input Requirements (Main AC to DC Converter)

5.1 AC Input Voltage, AC LOSS Detection Time

The AC input voltage range is 180Vac to 305Vac RMS (auto ranging).

The nominal AC input voltage is 277Vac RMS (200 – 277 VAC).

The power supply complies with the specification up to 290Vac RMS, which corresponds to 277Vac (+5%).

All the components used in the AC input section shall have a voltage rating compatible with 300Vac operations, up to 305Vac which is 277Vac (+10%). The power supply can withstand continuous exposure to 305Vac RMS input with no damage, while at this voltage level is not expected to meet the Power Factor and iTHD requirements. Input voltages higher than 310Vac RMS may damage the power supply.

The front-end circuitry can detect any AC loss within 5ms after the actual occurrence, at any AC input level, and at any PHASE of the input AC sinusoidal waveform (from 1 degree to 360 degrees, wherever the AC loss event occurs).

5.2 Input AC Connector and Fuse, EMI filter

The AC input power inlet is a 3 position Tyco Mate-N-Lok p/n 643228-1 socket connector. Refer to figures in section 13 and Figure 14 for the drawing, the exact location, and pin layout.

The connector counterpart used in the AC power cord is a 3 position Tyco Mate-N-Lok "Plug" contacts, wire-terminated free-hanging type. A Tyco Mate-N-Lok "Strain Relief" is installed on the sheathed cable for a safe and reliable power cord assembly.

The AC input fuse is a non-replaceable leaded component soldered directly to the board, used for safety and for extreme protection in case of catastrophic failures. The AC input connector is polarized and so, the fuse, in the power supply layout, is connected in series to the hot conductor (Line). The fuse is rated 6.3A "slow blow" type for the 700W-SH model and 5A slow blow type for the 450W-SH model. The fuse never trips during inrush or any AC input current transients the power supply is designed to stand under normal conditions. The fuse is a safety-approved component with a rating of at least 305Vac RMS, and 5 x 20mm minimum size (may be bigger due to the high AC voltage involved). At system level, the power supply is powered by a custom AC power strip embedding its own protection fuse rated 20A; a proper I^2T coordination is verified when the power supply is powered by the strip (for example, the AC input stage of the power supply fails in short → the power supply input AC fuse blows and the AC power strip fuse does not blow).

The EMI filter uses two cells, with low series DC resistance. The design uses bulky choke components in order to reduce copper losses and to maximize efficiency. As already mentioned, all the components used in the AC input power section must be rated at least 305Vac RMS (AC input connector, protection fuse, X2 EMI caps, surge protection devices, bleeder resistors, and so forth). A rating of 300VAC may be used instead; this would be the maximum AC voltage allowed for the power supply.

5.3 Primary MOS and BULK caps (Ratings)

The bulk capacitors are rated 500V 105C, and are long life components. For each bulk cap, a single component rated 500V is required (compared to the potential alternative of having two caps rated 250V each and connected in series). Voltage stress, especially when positive peak of the low frequency ripple voltage at worst conditions is included, is not negligible, while at the same time a reliable design, fully working up to 290Vac RMS input, must be guaranteed (305Vac RMS peak). See section 5.5 for more information.

The 500V rating gives enough margin for a nominal bulk voltage that likely is in the range of 430Vdc ~ 440Vdc.

All of the high-voltage power MOS used in the primary side must be rated 600V (min), 650V preferred.

5.4 AC Inrush Current, Preferred Topology

The inrush current never exceeds 8A peak at cold start, Vin = 290Vac RMS, Tamb = +35°C.

5.5 AC Hold-up Time

The minimum hold-up time is 20ms.

Hold-up time is measured at full load, with no extra capacitance added to the output, at T=25°C, sinusoidal 200Vac RMS, 50Hz, from when AC is lost at the sinusoidal 0V crossing, to when the output voltage falls below 12V, full load 700W (or 450W).

5.6 AC Input Under Voltage Protection

The power supply shuts down for input AC under-voltage and automatically restarts when a minimum voltage level is reached: input AC voltage threshold is set to 180Vac (+0V, -5V) with 10Vac (+2.5V, -0V) of hysteresis. No hiccups or ON/OFF oscillations are allowed under any conditions.

The power supply withstands multiple input dropouts under all conditions without damage, and:

- It resumes normal operations when no backup voltage is connected to the power supply.
- It resumes normal operations after multiple successful backup sequences, when backup voltage is connected to the power supply, without any output voltage dips.
- Input over voltage protection is not required.

5.7 Internal Bias Supply

The internal DC bias supply (auxiliary supply) is intended for housekeeping functions only (no standby voltage externally available is required). The implementation of an independent bias supply is preferred solution and it should work from a minimum of 100Vac RMS (corresponding to 140Vdc on the bulk capacitors). Bias supply should be implemented with a high efficiency scheme.

5.8 Power Factor and iTHD

The power supply complies with EN61000-3-2 (see section 4.2) up to 290Vac RMS input. See further requirements at section 6.9.3, Power Quality.

5.9 Input AC Surge

See section 4.2 (EN61000-4-5) with the following limits:

- 1KV DM (Differential Mode is Line to Neutral)
- 2KV CM (Common Mode is Line/Neutral to Ground)

The power supply is protected against surge events and it will not get damaged in such occurrences. The power supply can continue to operate without functional failures or hiccups during surge tests per the above limits, and the output voltage is not affected by the surge pulses under any conditions. Surge events cannot reset the system. At system level (in the server rack), the power supply is powered by a custom AC power strip embedding its own surge protection circuitry. Under these conditions, the power supply passes 2KV DM and 4KV CM, both standalone (with a passive load) and at system level (with actual server load).

5.9.1. Isolation Requirements

The power supply supports safety-reinforced insulation between the high-voltage AC primary section and any secondary sections (3000Vac RMS of isolation).

Isolation between the high-voltage AC primary section and chassis GND is 1500Vac RMS.

Both positive and negative 12.5Vdc output terminals are floating with respect to the chassis GND, with a galvanic isolation of 100Vdc.

The input of the DC backup converter is a safe voltage, and so its DC primary section needs to support reinforced insulation with the AC primary section.

The DC backup converter is isolated with at least 500Vdc of insulation between its primary section and the secondary of the power supply (12.5Vdc output). The isolation capability may be higher than 500Vdc depending on the actual topology implemented for the backup function.

6 DC Output Requirements (Main Converter)

6.1 Output Voltage and Power

The power supply is a single-voltage power converter.

The nominal output voltage (Droop-Share function inactive) is set to 12.5Vdc (±1% set point at 75% load, 25°C ambient). The IC reference voltage for the DC main converter is the same as the one used for the DC backup converter. The SMT dividing resistors for output voltage reading are rated 0.1%.

The output voltage regulation is ±1% under any conditions of input voltage, load, temperature, aging, and so forth.

The power supply can withstand a no-load condition for indefinite time, without damage and with (or without) the max allowed capacitive load connected to the output terminations.

The nominal continuous output power is 700W (450W for the 450W-SH version).

Output OR-ing MOS is installed outside at system level for parallel operations, using a hot-swap IC powered by the common 12.5V bus voltage. Current share, parallel operations, and hot swap are required when the power supply works in SHARE mode.

6.2 Output Over Current Protection

Over current threshold is set to 65A (+5%, -2%) for the 700W-SH version, and 45A (+5%, -2%) for the 450W-SH version. The protection mode, during short or overload, is "constant current" mode. Output voltage recovers automatically when the over current condition (or short) is removed. The power supply is sized (thermally and electrically) to indefinitely stand a short circuit, without damage, and under any conditions.

An over current condition lasting more than 2 sec (±0.1 sec) latches off the power supply, and AC recycle (≥100ms) is needed to resume operations. The 2 sec timer resets every time the power supply exits the over current condition even for a very short time (>20ms typical).

The power supply can start under overload or short circuit condition.

6.3 Output Over Voltage Protection

The over voltage threshold is set to 15Vdc.

Protection mode is a latchoff type, so AC input recycle (≥100ms) is needed to attempt to resume operations after an over voltage event.

The over voltage circuitry is independent, includes a separate voltage reference device, and does not make use of the microprocessor to implement the function. The microprocessor is notified in case of an over voltage event.

6.4 Over Temperature Protection (OT)

The power supply is protected against overheating to prevent damage or degradation. The power supply may overheat for many reasons, including (but not only) internal failing conditions, environmental factors, or because of improper use such as air obstruction or similar. The power supply shuts down for OT protection and can automatically resume operations once the temperature falls back within the expected range (with some hysteresis). No components can be over stressed at the temperature shutdown threshold level.

All the thermal sensors should be routed to the microprocessor (primary sensors are opto-isolated).

Inlet and outlet air temperature sensor is needed for the implementation of the fan automatic speed control (both normal and reversed airflow).

Note: The microprocessor oversees all power supply functionality.

6.5 Capacitive Load

The maximum capacitive load at system level is 12,000μF (700W version) and 8,000μF (450W version). The power supply can start properly and, more importantly, is unconditionally stable when such a capacitance (or lesser value) is connected to the output (in parallel to any resistive loads, or just the capacitance).

6.6 Transient Response

The amplitude of the positive and negative output voltage peaks during transient-loads test shall be within ±2.5% of the nominal output voltage (±300mV), with a response time < 5ms, under the following test conditions (droop share not enabled):

- Electronic load set in constant current mode.
- Current steps cycling from 50% to 100% of the power supply maximum load, 50Hz dynamic load frequency, 50% duty cycle, 1A/μS slew rate (minimum).
- Transient requirements shall be met with (or without) the maximum allowed capacitive load connected to the output terminations.

6.7 Output Voltage Ripple and Noise

The maximum ripple and noise never exceeds 200mV peak-peak at 20Mhz bandwidth for both versions.

Measurement is performed at the connector at PCB level, with the board installed in the chassis, safety ground connected through AC power cord, 180Vac input, and full load. A digital oscilloscope is used for this measurement, with acquisition set to Peak Detect mode. The probe is utilized without a cap to minimize the length of the return connection, in order to achieve a reliable R&N reading (negative return is directly the metal body of the probe). A small 1μF X7R 0805 SMT ceramic capacitor may be connected locally to the probe tip during this measurement. The 12.5V output stage may include a small CM choke added very near to the output connector for common mode noise suppression.

6.8 Output Turn-ON/Turn-OFF

Under any conditions of dissipative load, capacitive load, temperature, and with or without backup voltage connected to the power supply:

- The power supply turns on when a valid AC input is provided. A standby switch and/or on/off signal are not required. The design of the PFC and DC-DC circuitry, soft starts, and so forth, is such that the total time from when a valid AC input is applied and the DC output voltage reaches regulation, is a maximum of 2 seconds under any conditions and Vin > 200Vac RMS.
- The power supply starts properly under no load conditions or overload conditions.
- For any loads (from "no-load" to "max-load"), the output voltage will rise monotonically from 0V to 12.5Vdc, without overshoot or ringing, at any turn-ON following application of AC input voltage, and anytime when the power supply resumes functioning after an automatic protection condition. The output voltage will fall monotonically from 12.5Vdc to 0V, without undershoot or ringing, at any AC loss, and at any turn-OFF caused by an automatic protection condition.
  Note: The backup voltage is not applied.
- Output voltage never reverses polarity at turn off (all conditions, backup converter included.
- The power supply includes a soft-start (PFC, DC-DC) that promptly resets at any input AC loss > 20ms, or after any automatic protection conditions.
- See section 9.4 for power supply behavior on AC loss, when a valid backup voltage is connected to the power supply.

Output Voltage Rise Time (all conditions, for both main and backup converters):

- After the bulk voltage is in regulation, the rise time of the individual DC main converter is always < 10ms, and is always < 1ms when the output capacitance is already pre-charged to 12.5V.
- After the DC input (range between 42Vdc to 58Vdc) is applied, the rise time of the individual DC backup converter is always < 10ms, and is always < 1ms when the output capacitance is already pre-charged to 12.5V. A rapid startup is needed for optimum backup performance, and to meet DEAD-BUS requirements.

6.8.1. Power Supply Turn-ON Sequence

Under normal conditions, after a valid AC input is applied, the internal bias supply turns on, the whole circuitry gets powered, the power supply turns on, and the output voltage reaches regulation.

There must always be a turn-ON sequence when AC is restored during a backup phase, and there can also be a turn-ON sequence when AC is first applied to the power supply depending on the configuration of one logic signal. Note that the PFC always starts promptly when a valid AC input is applied.

1. The first time AC is applied to the power supply, including after the 90 sec backup timeout, the power supply turns on with a random delay between 0 sec and 2 sec. **Sequence**: After AC voltage is applied, the internal AUX supply starts, the μP boots and keeps the DC main converter OFF, with a green LED blinking at 5Hz with a 50% duty-cycle. Then the μP generates a random number N (between 0 and 2000), turning on the DC main converter with an N millisecond delay (LED becomes solid green, or solid yellow if DC backup voltage is not applied).

2. When AC is restored after an AC outage of less than 8 seconds, the power supply turns on with a random delay between 0 and 2 sec. **Sequence**: After AC voltage is restored, the μP keeps the DC main converter off, then it generates a random number N (between 0 and 2000) turning on the DC main converter with an N millisecond delay (LED becomes solid green after blinking yellow).

3. When AC is restored after an AC outage of more than 8 seconds, the power supply turns on with a random delay between 0 and 8 sec. **Sequence**: After AC voltage is restored, the μP keeps the DC main converter off, then it generates a random number N (between 0 and 2000) turning on the DC main converter with a 4N millisecond delay (LED becomes solid green after blinking yellow).

The three random numbers above are dynamically generated right after each AC recycle, and not generated once and then stored in the EEPROM for future use.

The above random functionality may be wholly or partially disabled depending on the configuration of the two signals B1 and B2 (see Figure 5).

The PFC promptly starts once AC voltage is available. Then the DC main converter powered by the bulk voltage is turned on randomly (when applicable). The startup current peak of the PFC is always lower than the AC inrush current peak.

Note: During a random restart of a large number of systems after AC power is restored, the DC input voltage (battery voltage) increases rapidly because the battery pack's load powering the systems will quickly decrease in the subsequent 8 sec (or 2 sec) random window of AC main converter restart, when AC power takes over for DC backup power.

6.8.2. DEAD-BUS Event

As described above, when AC power gets restored during a backup phase, the power supply will randomly restart in an 8 sec (or 2 sec) window. If the DC input (battery voltage) fails during that 8 sec (2 sec) window when the AC mains are actually available, or within the 1 sec filter window always present before any DC main converter startup (see Backup Sequence, interval "D" — see Figure 3), then the power supply turns on instantly, with the output voltage not dipping below 11.3Vdc at full load. See the complete backup sequence in Figure 3 and Figure 4. Thus, the power supply must be able to start fast enough to meet the DEAD-BUS requirement when battery voltage Vin(DC) ≥ 42.5Vdc and full load (there is no requirement below 42.5V).

The battery pack includes an LVD device that isolates the batteries when the voltage level locally falls below 42Vdc, which protects the batteries from excessive discharge. If the backup converter in the power supply is still running when the battery voltage approaches the 42V LVD level, this means that a whole system shutdown event is imminent (the standby emergency power generator did **not** turn on, and AC is not available). This is not the DC input failure mode discussed above.

DEAD-BUS performance gets worse at low temperature.

6.9 Microprocessor Control

All the logic and housekeeping functions (excluding over voltage) are implemented and driven by a low power consumption microprocessor and low power consumption circuitry. The microprocessor oversees all power supply functionality. If a DSP is used to drive the PWM(s), then it may (or may not) include the microprocessor functions.

The firmware of the microprocessor and/or DSP must be upgradable anytime during the life of the power supply. The power supply chassis cover has a small opening to reach a connector placed at the top of the logic board for downloading a firmware upgrade easily, without needing to uninstall the power supply cover. A small indentation on the metal chassis or a mark provides a reference for pin 1 of the programming connector. A small plastic (or metal) panel is added for protection, easy to open without tools, and retained to the power supply cover. The location of the opening on top cover is toward the center.

6.9.1. Internal Cooling Fan, External Fan Guard (SH/R Models)

The power supply is self-cooled using an internal power-efficient fan pulling fresh air inside the power supply (airflow is front to back), or pushing air outside the power supply in SH/R reversed airflow models (adopting an external chrome-plated fan guard and a full-fan, grid-style opening hard-tooled in the chassis fan plate.

The power supply front (faceplate) is where the input connectors and LEDs are installed (air intake for normal power supply models, and air exit for SH/R models). The fan mechanical mounting method is such that it limits propagation of vibrations to the power supply chassis caused by fan rotation; damping soft rubber sheet material, or something similar, may be used for this purpose between the fan housing and sheet metal. The fan is installed using four flathead screws, properly located in order to avoid any potential air short-circuits. The screws attaches to both the fan and the fan guard in the SH/R models.

The fan is a 12V component, size 60 x 60 x 25mm, 30 CFM (minimum), and is a 4-wire, double ball bearing type.

Fan speed is driven by the microprocessor, with automatic speed control based on the intake air temperature. The fan cools the power supply and provides some extra airflow. The minimum duty cycle of the PWM signal applied to the fan is at least 40% for the 700W-SH model and 30% for the 450W-SH model, regardless of the power supply cooling conditions. A base speed is needed because the power supply must provide some minimum degree of CFM air to the system and to avoid hot spots inside the power supply itself. See Figure 1.

An air temperature sensor for automatic speed control is located near the air inlet panel, in either the power supply's front panel or rear panel, depending on the model (normal or reversed airflow).

The fan speed does not directly change with the output current level. When the power supply turns on, the fan starts at full speed and then settles down to the self-regulated speed value.

Because the fan is a 12V component, it can be powered directly by the output voltage. A C-L-C filter is used to power the fan in order to reduce injection of spikes to the main 12.5Vdc supply output. Note that brushless fans generate a lot of ripple and noise to their DC supply. The electrolytic capacitor connected directly in parallel to the fan can endure the low frequency ripple current with extra margin (low ESR and long life component).

Layout rule: At board level, the fan positive and negative terminals are connected directly to the main output capacitors before the further output filters normally used to clean noise on the 12.5V output, using independent dedicated copper traces routed away from any noise sensitive circuitry (like the main feedback loop circuitry).

The microprocessor monitors the fan speed using the tachometer signal, and will not shut down the power supply in case of fan failure, blocked fan, or inconsistent fan speed readings. Under any fan failure condition, the FAIL red LED will blink while power supply is running (see also section 15).

The fan always runs at full speed during the backup phase.

The fan's L10 lifespan is at least 50,000 hours at 45°C inlet air temperature and full speed.

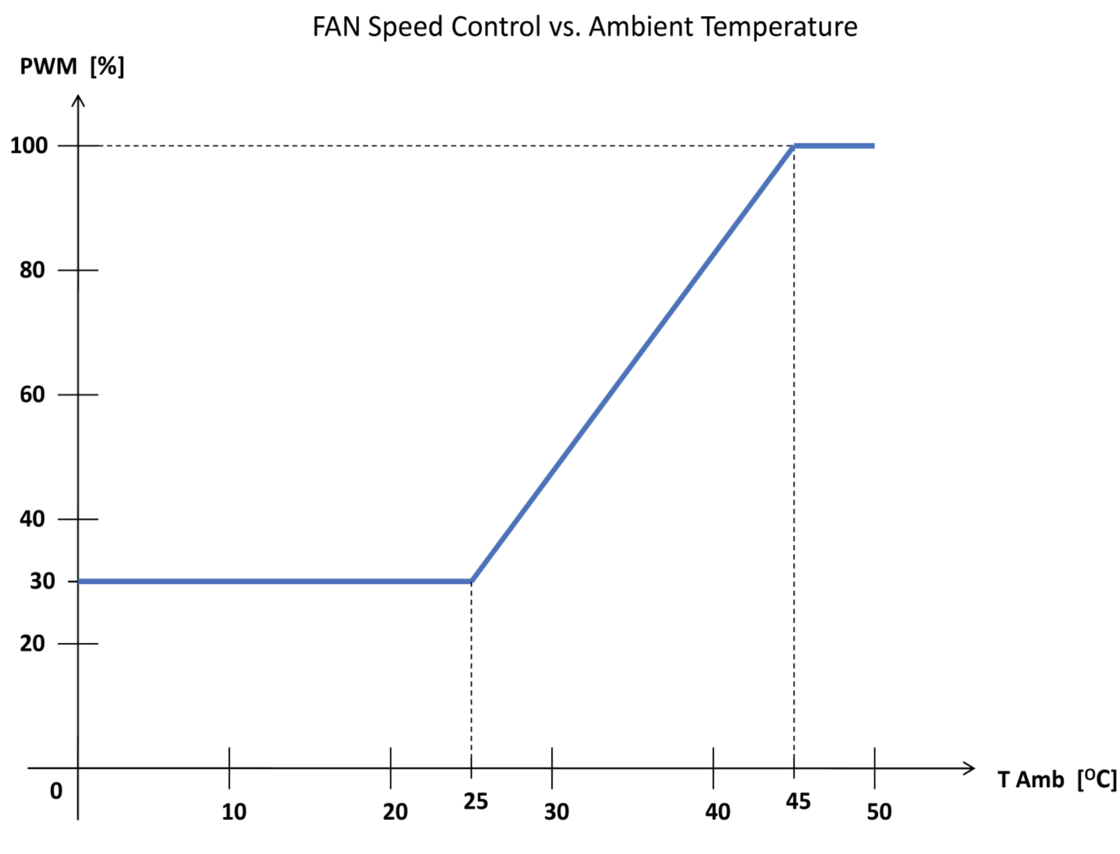


Figure 1 Fan Speed Control vs Ambient Temperature (450W-SH Model Shown)

6.9.2. Power Supply Efficiency (AC Main Converter)

Efficiency exceeds the Climate Savers Computing Initiative PLATINUM (as of September 2009). Those limits are:

- Efficiency > 90% at 20% load
- Efficiency > 94% at 50% load
- Efficiency > 91% at full load

Methodology for the measurement follows the CSCI directive, but at 200Vac RMS input.

Further target efficiency requirements include:

- Efficiency > 95% (between 50% and 90% of maximum load).
- Wider than above load range is desired, but not a target at this time.

Measurements are performed as follows:

- Input AC voltage is 277Vac RMS (50Hz or 60Hz).
- AC and DC voltage are measured directly at the respective PCB pads.
- The power supply board is correctly installed in the chassis, with the cover, and with safety chassis GND connected through AC power cord.
- The cooling fan is powered using an external generator but with the speed controlled by the power supply logic, as happens during normal operations.
- Ambient temperature of +25C.
- Measurements are taken after 30 minutes under initial 75% load, over five samples (they all need to pass). Efficiency measurements shall be provided in a table, in 5% load steps, with added power factor (PF) and total input AC current harmonic distortion (iTHD) values for each step.
- Droop share is not active

6.9.3. Power Quality

Efficiency is the first priority. Power Factor and iTHD (Total Harmonic Distortion) of AC input current, with order of the harmonics up to and including 39:

- PF > 0.95 (>20% of maximum load)
- iTHD < 10% (>20% of maximum load)

Measurements are performed as following:

- Input AC voltage of 277Vac RMS (50Hz or 60Hz).
- A power analyzer with reading accuracy better than 0.1% will be used for the measurements.
- A precise low distortion AC source supplies the voltage during the measurements.
- The power supply board is correctly installed in the chassis, with the cover, and with the safety chassis GND connected through the AC power cord.
- Ambient temperature of +25°C.
- Measurements are taken after 30 minutes under initial 75% load, over five samples (they all need to pass).

6.9.4. Stability

The power supply is unconditionally stable, under any conditions and combinations of resistive and capacitive loading, constant power loading, temperature, aging, and so forth.

A Bode graph shows a phase margin better the 45 degrees at worst conditions (or 60 degrees at nominal conditions). The dynamic step-load plots (see section 6.6) show no ringing.

Stability criteria is met with and without the maximum allowed capacitive load.

6.9.5. Output Connector

The DC output connector is power blade FCI part number 51770-043, five position, right-angle solder, receptacle female contacts, for board-to-board interconnection. The configuration of the contacts is: 2Power -- 8signals -- 2Power. The two negative power blades and the negative return signal pin are pre-mating. Refer to Figure 10 and Figure 14 for the exact location and pin layout. The power supply mates directly with the system without cabling.

7 Battery Backup Section (Backup Converter)

The power supply can provide short-term backup power in case of AC outage. To enable this function, an independent isolated DC-DC converter capable of at least 700W (450W) of output power (called the DC backup converter or backup converter) is included within the power supply, with dedicated logic driving all functionality for the backup sequence. It provides seamless backup power, enabling smooth operations under any conditions during transitions of AC input, and is equivalent at system level to an online UPS. This functionality is enabled only when a valid DC voltage (called *backup voltage*) is applied to the input DC connector located on power supply faceplate.

7.1 Summary of Whole Backup Section Requirements

For the backup converter, all the input and output requirements, performance, compliance requirements, and so forth, are *equivalent* to what is specified for the DC main converter (or main converter) powered by the high-voltage bulk. Depending on the topology used, the output of the backup converter may (or may not) supply power directly to the power supply output. The output requirements in section 9 are intended when the power supply output voltage is supported by the backup converter. All the exceptions to the requirements are listed in section 8 where they supersede (or re-phrase) certain specific requirements and/or parameters.

8 DC Input Requirements (Backup Converter)

8.1 DC Input Voltage, Max Start-Up Current at AC Outage

The nominal DC input voltage is 48Vdc.

The DC input voltage range is 39Vdc to 59Vdc. The backup converter works over this whole range without any deratings. The converter can work down to 38V for short periods of time (peak capability only), specified as 5 seconds every 1 minute for the related thermal design.

The maximum peak of the startup current at AC outage, when the power supply is switching to backup mode, never exceeds +20% of the related steady-state current, for any loads. The maximum peak of the startup current never lasts more than 5ms.

An example for the 700W-SH model, with full load and 48V input voltage:

- Pout = 700W
- Pin = (700W/0.9) = 780W (minimum efficiency 90%, as specified in section 9.5)
- Iin (steady-state) = (780W/48V) = 16.2A
- Iin_{PK} (startup while switching to backup mode) = (1.2 x 16.2A) = 19.4A (for maximum 5ms)

8.2 Input DC Connector and Fuse, EMI Filter

The DC input power inlet is a 2 position Tyco Mate-N-Lok, part number 643226-1, socket connector. Refer to the figures in section 12.2 for the drawing, exact location, and pin layout.

The connector counterpart used in the DC power cord is a 2 position Tyco Mate-N-Lok "plug" contacts, wire-terminated free-hanging type. A Tyco Mate-N-Lok strain relief is installed on the sheathed cable for a safe and reliable power cord assembly.

The DC input fuse is an inexpensive, replaceable, blade-type component with a holder directly soldered on the board. It is used for safety and for extreme protection in case of catastrophic failures. The DC input connector is polarized so the fuse, in the power supply layout, is connected in series to the positive conductor. The fuse is a safety-approved component, rated 20A and 60Vdc (minimum), automotive slow blow type, and never trips during inrush or any DC input current transients the power supply is designed to withstand during normal operations. The fuse does not blow during the backup converter startup phase.

The EMI filter circuitry is simple enough to meet the EMI requirements that are less demanding in the DC backup converter (compared to the DC main converter). The requirements are set to meet Class A limits (see section 4.4).

8.3 Input DC Reverse Polarity Protection

The DC input is protected against reversal of polarity, with or without a valid AC voltage applied to the AC input. The implementation makes use of a simple scheme (see Figure 2) with a MOS in series to the negative terminal, self-biased using the DC input voltage (or equivalent), with very low-consumption circuitry. In case of reversal of the DC input polarity, the FAIL LED does not light red (see section 15). The LEDs are able to light only when a valid AC input is present and during a backup phase following an AC outage.

In case of reverse polarity, the input current is less than 10mA (see section 8.7). Reversing the input voltage polarity without waiting for the DC bulk to discharge (after the application of a direct polarity) may damage the power supply.

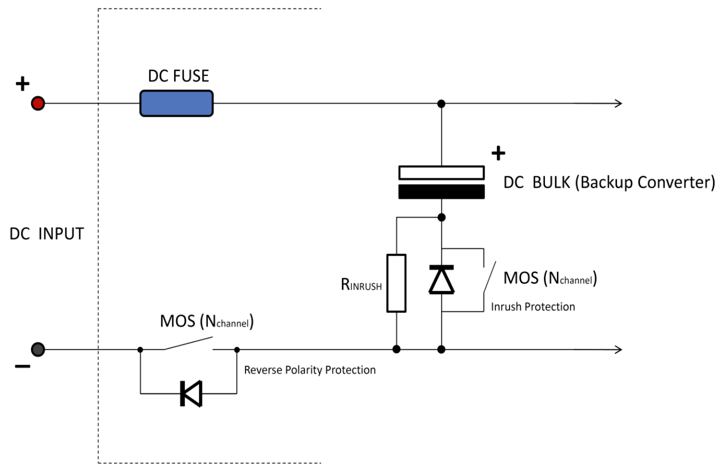


Figure 2 Input DC Reverse Polarity Protection

8.4 DC Inrush Current

The DC inrush never exceeds 5A peak under any conditions. The circuitry may use a dedicated hot swap integrated circuit for DC applications; note that there is no online auxiliary supply powered by the input DC, which needs to meet 10mA (max) of leakage DC input current. Figure 2 shows a MOS self-biased by using the input DC voltage, with very low-consumption circuitry. Limiting inrush current on input DC is always active, with or without the presence of a valid AC input. Alternate methods can be used provided they make use of MOS devices, though inrush relay for the DC input is not allowed. The inrush current spikes due to charging of any EMI ceramic caps are not allowed.

The inrush sequence repeats after any DC interruption of enough duration to cause the bulk caps to discharge below 40V, under any conditions.

8.5 Hold-up Time, Bulk Caps

There is no minimum holdup time for the DC backup converter. However, enough bulk capacitance is used to guarantee reliable backup operations, to smooth and lower the DC startup current, to provide a margin to withstand the primary ripple current of the backup converter, and for noise and EMI suppression. For these reasons, the minimum DC bulk capacitance is > 3000uF for the 700W-SH and > 2500uF for the 450W-SH. In the system, when the power supply is directed installed in a server, for example, the bulk caps are charged to 54Vdc from the OCP battery cabinet.

8.6 DC Input Under Voltage Protection, Backup Voltage

The backup converter circuitry includes an input under voltage protection set to 37V with 2V hysteresis; the converter shuts down on its own for Vin < 37Vdc (±0.5Vdc) and automatically restarts when Vin > 39Vdc (±0.5Vdc). There is a 1 sec filter delay prior to UV shutdown when the threshold is reached and maintained. When a valid AC input is present, the yellow LED turns green when an applied input DC voltage exceeds 39V, so the green activation threshold is driven by the same signal (see also section 15). No hiccups or ON/OFF oscillations occur under any conditions near the UV threshold. During a real backup phase following an AC outage, after a UV shutdown event, the backup converter does not restart even if the input DC voltage recovers regulation, because at this point the power supply is completely latched off until the AC returns. At system level, the OCP battery cabinet will isolate the battery voltage when 42V is reached during discharge (backup phase), so normally the UV protection in the power supply set to 37V would never trigger. Still, the UV protection is included in the backup converter circuitry.

Input over voltage protection is not required.

At system level, the backup voltage is provided by an external battery pack charged at 54Vdc floating voltage. During an AC main outage the batteries provide power to the DC backup converter (discharge phase). Batteries have their own independent charger, controller, and LVD (see the *Open Compute Project Battery Cabinet Hardware v1.0* specification). After the backup phase begins, the battery voltage starts to lower almost immediately, heading towards LVD disengagement (the LVD threshold is set to 42V in the battery cabinet).

8.7 Internal Bias Supply, Battery Leakage

There is no provision for an auxiliary bias supply supplied by the DC input, however if used, it draws current from the DC input only during backup phase, and shuts down latched off in case the 90 sec backup timeout is reached. If bias supply is supplied by the output, it draws current from the output only during the backup phase.

The backup converter never activates without a prior presence of a valid AC input.

The DC input leakage current is less than 10mA at 54Vdc (battery leakage at system level) under any conditions, with (or without) the presence of a valid AC input, as well as after the power supply shuts down when the 90 sec backup timeout is reached. In case of input voltage reverse polarity, the DC input leakage current is also less than 10mA.

9 DC Output Requirements (Backup Converter)

9.1 Output Voltage and Power

The nominal output voltage is set to 12.5Vdc (±1% set point at 75% load, 25°C ambient, droop share not active). The integrated circuit reference voltage for the DC backup converter is the same used for the DC main converter.

The SMT dividing resistors for the output voltage reading, for both main and backup converters, is rated 0.1% even in the case that only one output voltage divider is used to read the output voltage for both converters.

Note that the two converters share current easily during overlapping working mode (transitions from AC mode to DC backup mode, and vice versa) if the respective output voltages are identical.

The output power, like all the major requirements, is the same as what is specified for the DC main converter.

9.2 Output Over Current Protection

The output over current protection requirements are identical to the ones listed for the main converter, with the power supply latching itself off after 2 sec (±0.1 sec) of continuous output overload (or short circuit). The power supply can restart only when valid AC voltage is available again.

9.3 Over Temperature Protection (OT)

The backup converter is protected against OT using independent thermal switches (or equivalent method) that shut down the converter in case of excessive overheating.

9.4 Power Backup Sequence

1. The backup converter does not turn on when a valid DC voltage is applied to the DC input, whether or not there is valid AC input.

During the backup phase, if the DC input is removed for a long enough duration to cause the output voltage to fall below the PWR_OK min threshold (see section 15), and DC input is re-applied, then the backup converter does not resume backup mode (it does not turn on again).

2. When a valid DC voltage is applied to the DC input, the backup converter turns on when both signals below are reset (normally signals are "1" logic and change to "0" logic when reset):

- AC LOSS: AC input is lost, or drops below the minimum threshold (Vin < 170Vac RMS)
- AC_BULK OK: Bulk voltage drops below the minimum threshold

As per section 5.1 , any sinusoidal AC loss must be detected within 5ms after the actual loss. Any fast AC cycles not causing the bulk voltage to drop below its minimum threshold are covered by the AC hold-up time (20ms).

There is a 100ms timeout for backup engagement: If BULK_OK does not change 100ms after the AC LOSS signal resets and stays low, then the backup sequence starts anyway.

Bulk voltage enters regulation within 1 sec after the AC input (200Vac) is applied to the power supply.

The transition from AC mode to DC mode lasts a maximum 10ms typically, during which time the two converters will operate in parallel. During the transition from main converter (AC mode) to backup converter (DC mode), and vice-versa, output voltage must stay above 11.6V at full load, with or without current share activated. This provides a seamless change from AC input mode to DC input mode (battery backup mode) and vice versa.

The DC backup converter is switched on at the earliest ≥ 5ms after an actual AC loss event at full load. During transitions between AC input converter to DC input converter (and vice versa), both converters (AC input and DC input) operate in parallel (see Figure 3 and Figure 4), balancing the load at best.

Note: Both converters use the same reference voltage and 0.1% resistors in the voltage divider for Vout reading, so good load sharing should naturally occur. It is important to note that load sharing helps for a smooth startup of the DC backup converter at AC outage: this limits the DC input current overshoot (startup current), as specified in section 8.1 .

3. In normal conditions, when a valid AC power is present and the main converter is delivering power to the output, the backup converter is kept off to enhance the overall power supply efficiency, but ready to kick in at any AC loss. See section 6.8 for details on the power supply turn on and turn off sequences.

4. If the AC returns during a backup phase, the DC main converter turns on only after a valid bulk voltage, in conjunction with a continuously valid AC input, is continuously present for at least 1 second, and works in parallel with the DC backup converter during the following 0.25 seconds, sharing the load at best. If AC LOSS or AC_BULK OK signals toggle during the timing intervals above, the counters (1 sec or 0.25 sec) reset and start over. At the end of the 0.25 sec portion, the DC backup converter phases away in a < 20ms time window, releasing back the full load to the DC main converter (see Figure 3). This generates a backup sequence mode that guarantees the highest rejection against input AC disturbances/random dips, on top of guaranteed UPS grade performances during an AC outage.

5. At system level, the backup phase should not last for more than 60 sec total (genset is normally available earlier) due to rapid discharge of the batteries and so, from a thermal prospective, the backup converter is sized to guarantee 90 seconds at full load (700W or 450W), at 40Vdc input and 45°C of temperature, without degrading performance and reliability. There cannot be more than one 90 second backup event within a 10 minute period.

Backup Phase Timeout: The power supply shuts down after a continuous 90 seconds of backup operations. This functionality is built into the power supply logic.

6. The fan runs at full speed during the backup phase.

7. The DC backup converter does **not** engage (does not turn on) if the DC main converter shuts down due to any protection conditions, like output over voltage, over temperature, any failures, and so forth (backup functions do not compensate for AC-DC circuitry failures).

8. DEAD-BUS sequence: See section 6.8.2.

9.4.1. AC_BULK OK

This signal is internal to the power supply, reporting the bulk voltage status.

9.4.2. AC LOSS

This signal is internal to the power supply, reporting the AC input voltage status.

9.4.3. Front-End PFC Section

The PFC always promptly starts up after a valid AC input is available (maximum 1 second to reach bulk voltage regulation after 200Vac is applied to the power supply).

9.4.4. Backup Power Sequence Charts

Figure 3 and Figure 4 illustrate the backup power sequences.

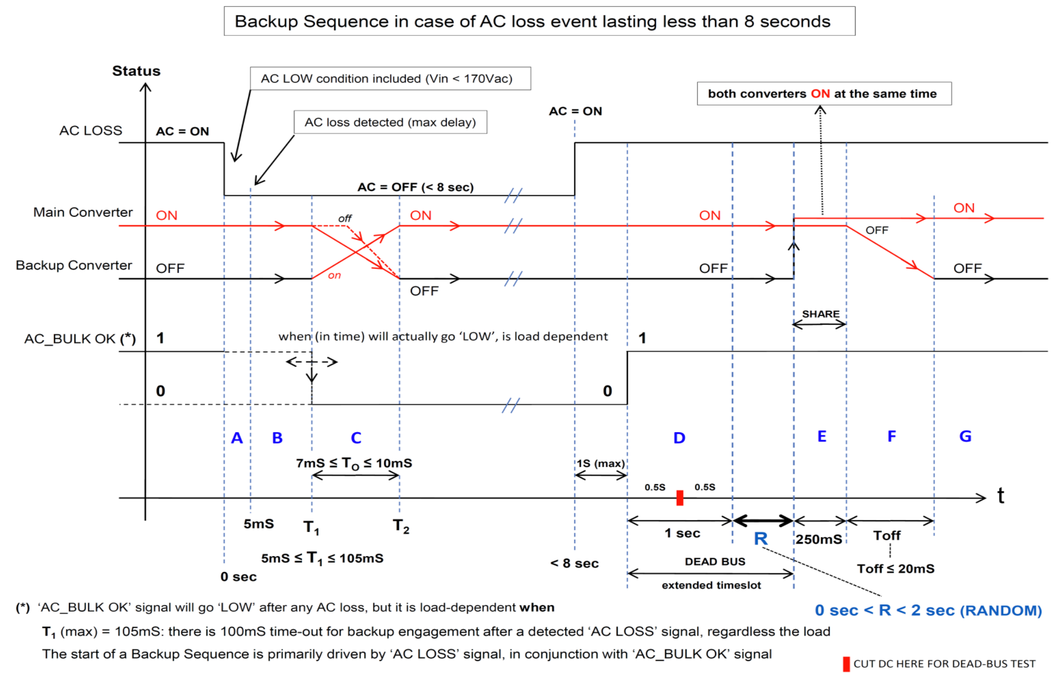


Figure 3 Backup Sequence, AC Event < 8 Seconds

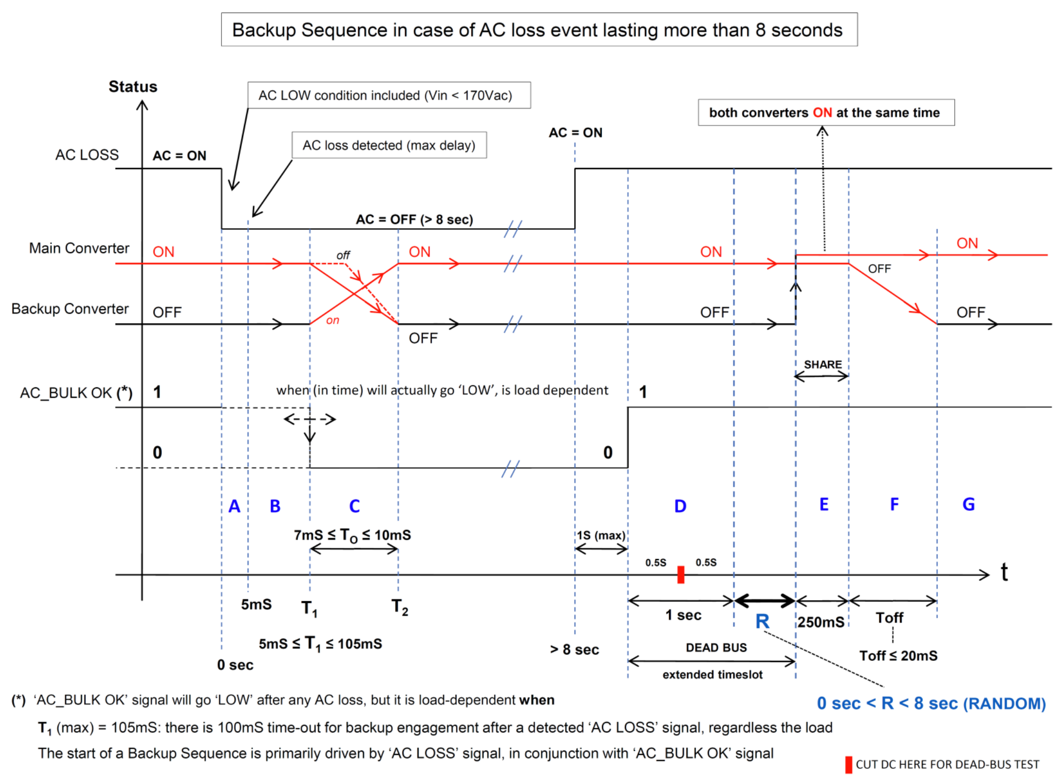


Figure 4 Backup Sequence, AC Event > 8 Seconds

Note: "SHARE" means "50% - 50% current share target" (AC main converter with DC backup converter within the same power supply).

9.5 Power Supply Efficiency (DC Backup Converter)

The efficiency of the backup converter is as follows:

- Efficiency > 90% (> 40% of maximum load)

This efficiency is intended as ratio of power supply output power and DC input power, during backup phase.

Measurements are performed as follows:

- Input DC voltage is 48Vdc
- DC voltages are measured directly at the respective mating connectors
- The power supply board is completely assembled in the chassis, with the cover
- The cooling fan runs at full speed during the backup phase (fan is not powered using an external generator, but self-powered by the power supply)
- Ambient temperature of +25°C
- Measurements are taken over five samples (they all need to pass), after 30 minutes under initial 75% load with AC present

9.6 Isolation Requirements

The backup converter supports galvanic insulation between DC input and power supply output, and supports reinforced safety insulation with the main AC input. Detailed isolation requirements are included in the section 5.9.1 and Figure 8.

10 Current Share Functionality

When activated, both the main converter and backup converter are capable of output current sharing with up to 8 power supplies connected in parallel using the "Droop Share" method. The rate of output voltage droop vs. output current is -8mV/Amp.

When enabled, current sharing is active on both main and backup converters, so the power supplies can share also during backup conditions. The current share control dynamics and bandwidth are the same in both converters, so one backup converter of one power supply is able to share the current with one main converter of another supply connected in parallel. This is required at the random restart during backup when AC returns, with units in parallel; see condition B1 = 1 & B2 = 0 in Figure 5.

The droop share function is enabled only when the signals B1 (SHARE Select [1]) and B2 (SHARE Select [2]) available at the output connector are shorted to the Secondary AUX Negative Return (-) pin , available at the output connector as "A1", as described in Figure 5. All the random startup functions are disabled in the "(N + 1) Redundant (2)" configuration, while in the "(N + 1) Redundant (1)" configuration, only the 2 sec random startup at the first application of AC is disabled (see Figure 5).

External OR-ing MOS are used in any application, with a maximum of (7+1) redundant power supplies in parallel. The power supplies installed in redundant configurations with external OR-ing MOS can start up and shut down properly, enter backup mode at AC outage, and recover when AC is restored, under any conditions, without losing regulation. Thus, following the same specifications as the power supply working alone without droop share activated, the application has the same or better backup performance as the single power supply backup performance.

The external hot-swap integrated circuit and OR-ing MOS circuitry is powered using the common 12.5V bus output voltage after the OR-ing devices, and also is optionally activated by the 5V present at pin D2 of the output connector (<1mA needed for this activation function). Hot plugging power modules does not cause any output voltage dips outside regulation. See Figure 5.

10.1 Parallel and Share Functionality during Random Restart

The main converter of one power supply connected to the 12.5V bus can share the current with the backup converter of another power supply connected to the same 12.5V bus. During a random restart when AC returns during a backup phase, the power supplies in parallel can randomly and independently restart their AC main converter without causing output voltage dips outside expected limits.

Current Share Functions: Droop-Share Table

Droop-Share is -8mV / Amp for both 450W-SH and 700W-SH models

Nominal Output Voltage is 12.5Vdc for both versions (no-SHARE, or at 12.5A with SHARE enabled)

		no-SHARE	SHARE		no-SHARE	*SHARE mode*
Model	**Pout [W] nominal**	**Vout [V]**	**Vout [V]**	**Iout [A]**	**Pout [W] nominal**	***Pout [W] actual***
450W & 700W	0	12.5	12.60	0	0	*0*
450W & 700W	156.25	12.5	12.50	12.5	156.25	*156.25*
450W & 700W	225	12.5	**12.46**	**18**	**225**	*224.21*
450W & 700W	350	12.5	**12.38**	**28**	**350**	*346.53*
450W & 700W	450	12.5	12.31	36	450	*443.23*
700W only	700	12.5	12.15	56	700	*680.51*

no-SHARE: Vout shall be set to 12.50V ± 1% at 75% load (both 450W-SH and 700W-SH)

SHARE: Vout shall be set to **12.46V** ± 0.2% at 18A load (450W-SH), and to **12.38V** ± 0.2% at 28A load (700W-SH)

The above table & parameters are valid for both Main Converter & Backup Converter

Droop Share Table

Freedom 700W-SH & 450W-SH Power Supply

FCI 51770-043		**SHARE Table**	
B1	**B2**	**SHARE Select Signal Function**	**NOTE**
0	0	Droop Current SHARE (1 + 1) Redundant	All the RANDOM start-up feautures are ENABLED
0	1	Droop Current SHARE (N + 1) Redundant (1)	Only the 2 sec first AC RANDOM start-up is DISABLED
1	0	Droop Current SHARE (N + 1) Redundant (2)	All the RANDOM start-up feautures are DISABLED
1	1	Normal (no Current SHARE)	All the RANDOM start-up feautures are ENABLED

"**0**" means: connected to Secondary AUX Negative Return (-)

"**1**" means: left open (floating)

Figure 5 Share Select Table

10.2 Current Share Accuracy

The current share accuracy is ±10% when a (1+1) redundant configuration is used, with total output power equal to the power rating of each power supply. For example:

- Two 700W-SH power supplies connected in parallel need at least ±10% share accuracy. At worst, one power supply delivers 330W and the other power supply delivers 270W.

- Two 450W-SH power supplies connected in parallel need at least ±10% share accuracy. At worst, one power supply delivers 247.5W and the other power supply delivers 202.5W.

FCI 51770-043 pin assignment	Function	Notes
A1	Secondary AUX Negative Return (-)	(pre-mating)
A2	Backup Signal	O.C. : LOW when PS is in backup mode
B1	SHARE Select [1]	see SHARE Table
B2	SHARE Select [2]	see SHARE Table
C1	External Green LED (*)	O.C. : replica of PS Green LED
C2	External Yellow LED (*)	O.C. : replica of PS Yellow LED
D1	External Red LED	O.C.: replica of PS Red LED
D2	+5V Secondary AUX for external LEDs	50mA (or 100mA) limited
P1	Positive Blade 12.5V (+)	Power
P2	Positive Blade 12.5V (+)	Power
P3	Negative Blade 12.5V (-)	Power (pre-mating)
P4	Negative Blade 12.5V (-)	Power (pre-mating)

(*) *Bi-Color LED (common Anode)*

Figure 6 Power Supply Signals at Output Connector

10.3 Voltage at Pin D2

Pin D2 of the output connector provides a +5V secondary voltage to power optional external LEDs through the pins C1, C2, and D1. This 5V is obtained with a small 100mA linear regulator powered by the internal secondary aux 12V bias supply, optionally backed up from the output 12.5V. This 5V is present at the pin D2 when a valid AC input is applied to the power supply or during backup, and promptly falls to 0V when AC is disconnected or when backup phase completes (including the 90 sec backup timeout). Alternately, the power supply can use the output 12.5V to back-bias the secondary auxiliary bias supply.

The 5V at pin D2 can also be used for to enable the external OR-ing MOS circuitry. See section 10 .

10.4 B1 and B2 Signals

These two signals set the share and random startup functions. See Figure 5 and Figure 6. These two signals are "1" logic if left open, or "0" logic if shorted to "-RTN signal return" (pin A1). They must be monitored in real time by the circuitry internal to the power supply logic; the microprocessor continuously monitors them and adjusts the share and random functionality for each new configuration of B1 and B2, after a 200ms time filter. After 200ms of B1 and B2 logic setting persistence, the power supply transitions to the new corresponding working mode.

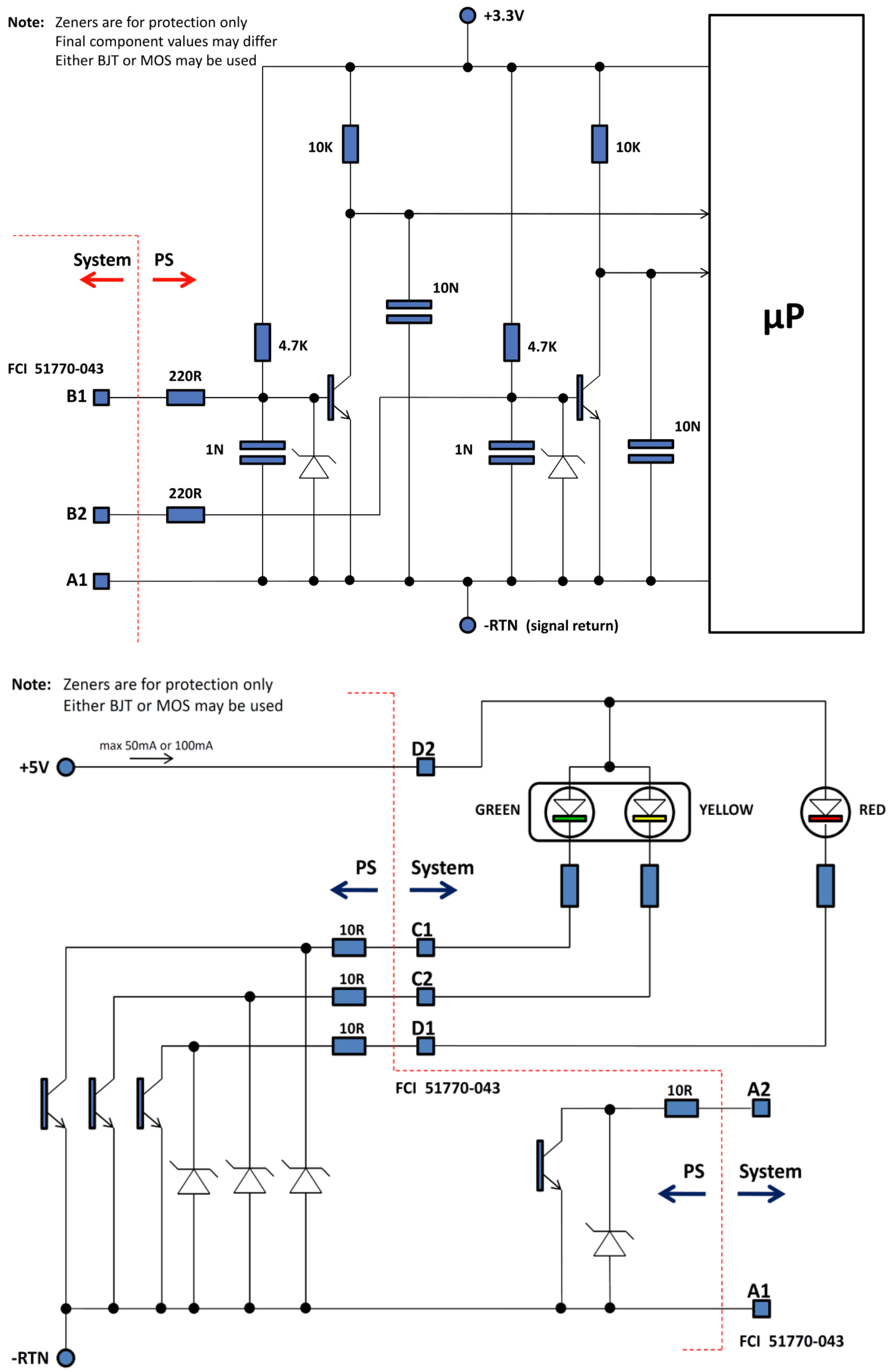


Figure 7 Internal Logic Reference Circuitry

11 Power Supply Block Diagram

This is a high-level block diagram. Isolation voltage levels are also listed.

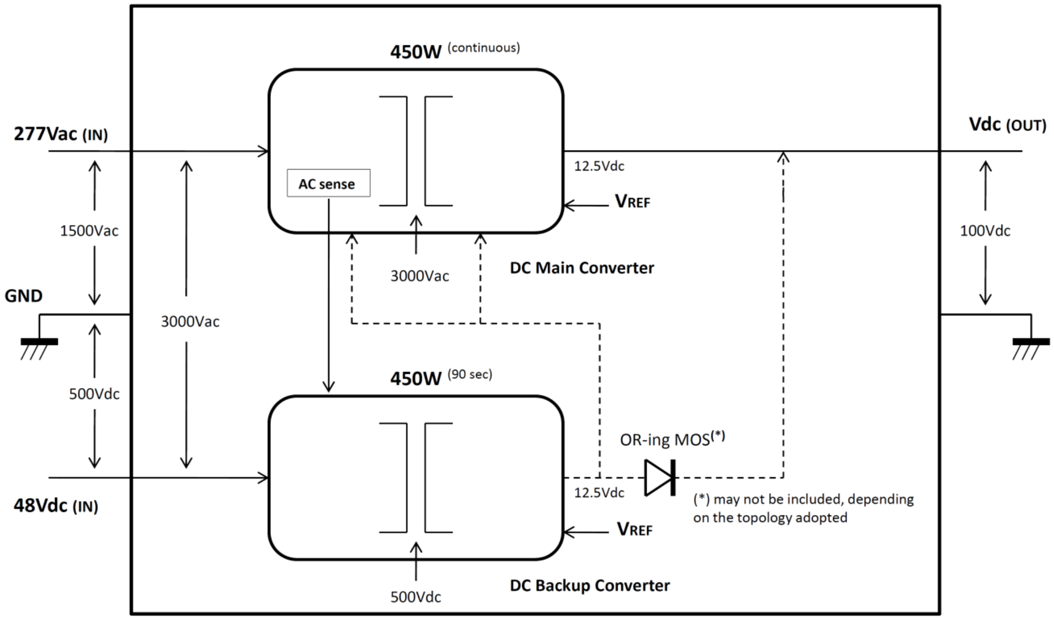


Figure 8 Power Supply Block Diagram

12 Environmental Requirements

- Gaseous contamination: Severity level G1 per ANSI/ISA 71.04-1985
- Ambient operating temperature range: -5°C to +45°C
- Power supply can start at -15°C of ambient temperature
- Operating and storage relative humidity: 10% to 90% (non-condensing)
- Storage temperature range: -40°C to +70°C
- Transportation temperature range: -55°C to +85°C (short-term storage)
- Operating altitude with no deratings: 3000m (10000 feet)
- System level ambient temperature: target is < 27°C (for information only)
- The power supply boards may be partially conformal coated (see section 12.2)

12.1 Vibration and Shock

The power supply meets shock and vibration test per IEC78-2-(*) & IEC721-3-(*) Standard & Levels, with the specifications listed below.

	Operating	**Non-Operating**
Vibration	0.5g acceleration, 1.5mm amplitude, 5 to 500 Hz, 10 sweeps at 1 octave/minute for each of the three axes (one sweep is 5 to 500 to 5 Hz)	1g acceleration, 3mm amplitude, 5 to 500 Hz, 10 sweeps at 1 octave/minute for each of the three axes (one sweep is 5 to 500 to 5 Hz)
Shock	6g, half-sine 11ms, 5 shocks for each of the three axes	12g, half-sine 11ms, 10 shocks for each of the three axes

Figure 9 Vibration and Shock Requirements

12.2 Conformal Coating

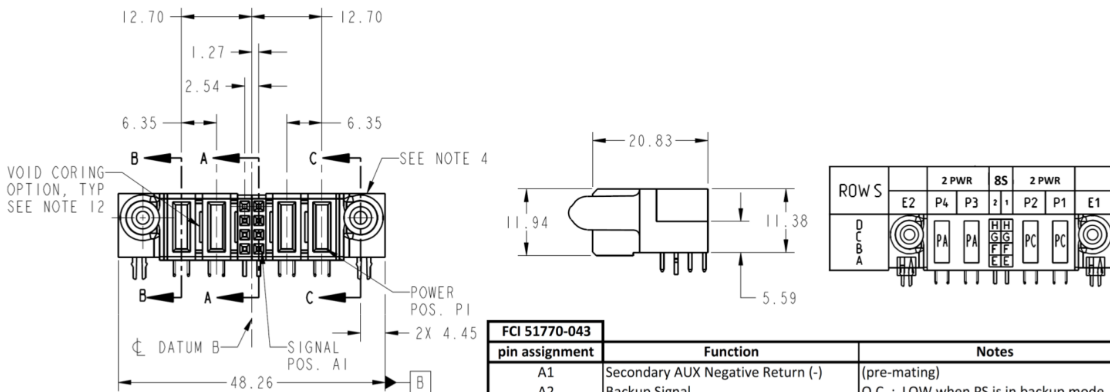
Conformal coating greatly increases the robustness of the power supply against dust pollutants in the air, the presence of zinc whiskers, and potential corner cases like condensation events.

Conformal coating can be applied to either the top or bottom of the power supply's PCB boards. These areas are the most sensitive because of their particular circuitry and because of the high voltage (> 180 Vac RMS, up to 450Vdc and 700V peaks).

13 Connectors

The input output connectors are installed directly on the PCB. No cable harnesses are used for the power supply interface to the server.

Power Supply Output Connector



FCI p/n 51770-043 (R/A Solder Receptacle)

P1 = P2 = Power Blades (+)

8 Signals

P3 = P4 = Power Blades (-)

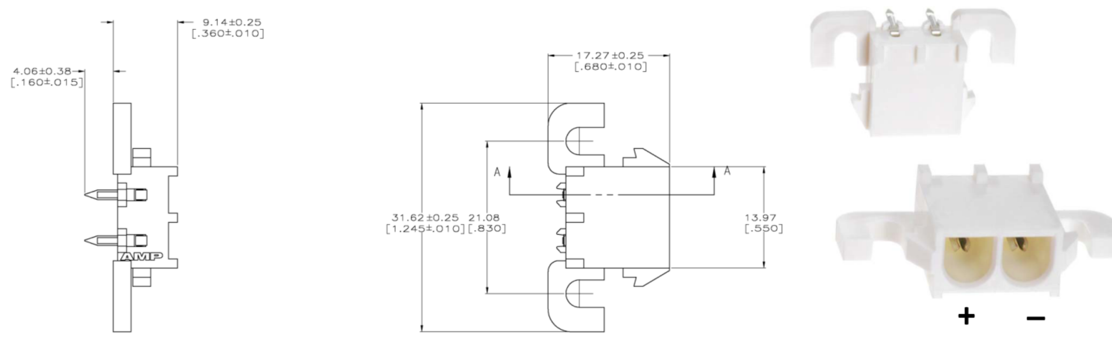
note: (P3, P4, A1) are 'pre-mating' contacts

FCI 51770-043 pin assignment	Function	Notes
A1	Secondary AUX Negative Return (-)	(pre-mating)
A2	Backup Signal	O.C. : LOW when PS is in backup mode
B1	SHARE Select [1]	see SHARE Table
B2	SHARE Select [2]	see SHARE Table
C1	External Green LED (*)	O.C. : replica of PS Green LED
C2	External Yellow LED (*)	O.C. : replica of PS Yellow LED
D1	External Red LED	O.C.: replica of PS Red LED
D2	+5V Secondary AUX for external LEDs	50mA (or 100mA) limited
P1	Positive Blade 12.5V (+)	Power
P2	Positive Blade 12.5V (+)	Power
P3	Negative Blade 12.5V (-)	Power (pre-mating)
P4	Negative Blade 12.5V (-)	Power (pre-mating)

(*) *Bi-Color LED (common Anode)*

Figure 10 Power Supply Output Connector

DC Input Connector



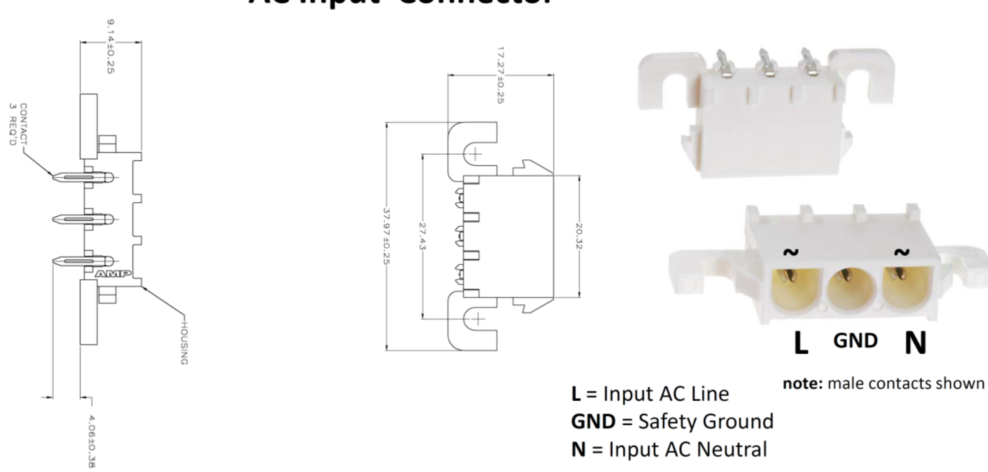
note: male contacts shown

Tyco Mate-N-Lok, p/n 643226-1

Description: 19A 600V header, female socket contacts, right-angle mount '2power', solder, retention clips

Figure 11 DC Input Connector

AC Input Connector



L = Input AC Line
GND = Safety Ground
N = Input AC Neutral

note: male contacts shown

Tyco Mate-N-Lok, p/n 643228-1

Description: 19A 600V header, female socket contacts, right-angle mount '3power', solder, retention clips

Figure 12 AC Input Connector

14 Mechanical Requirements

14.1 Physical Dimensions

The power supply dimensions are:

- Length: 220mm (8.66")
- Width: 120mm (4.72")
- Height: 64mm (2.52")

The sheet metal material is pre-plated hot-dip zinc-coated steel, 1mm thick.

The power supply mechanical chassis is composed of a base and a cover assembled using flathead screws; there are no rivets so the power supply can be opened with a screwdriver. The cover has a small opening for the microprocessor/DSP firmware upgrade (see section 6.9), with a small plate that can be easily opened to reach the connector. Mechanical parts are all hard-tooled.

The power supply is installed in a metal tray with a direct interface of the output connector to the mating connector board-mounted counterpart installed on the motherboard.

A simple mechanical interlock with mounting holes, mounting plunger pins, and a thumbscrew secures the power supply to the tray. This allows quick installation of the power supply in the tray without needing a screwdriver or any other tools.

Important: The whole power supply assembly, including the mechanical enclosure and the chassis itself, meets certain environmental contamination requirements (see section 12).

14.2 Power Supply Figures

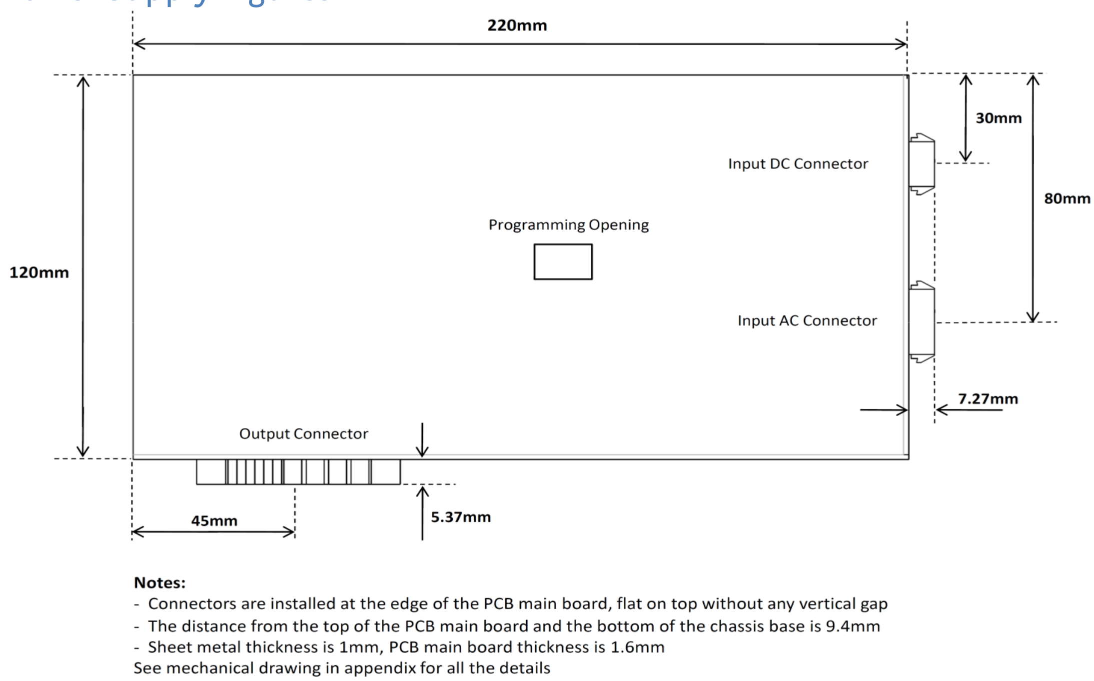


Figure 13 Power Supply Top View

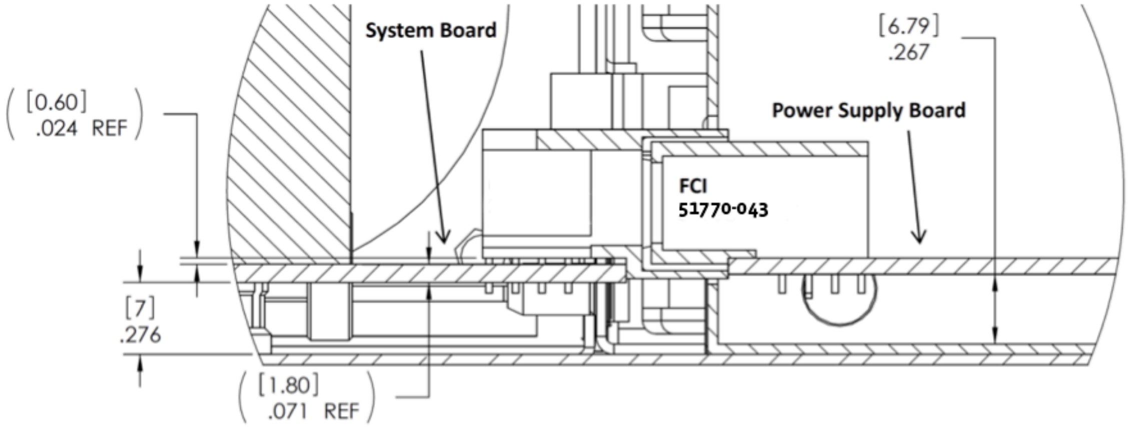
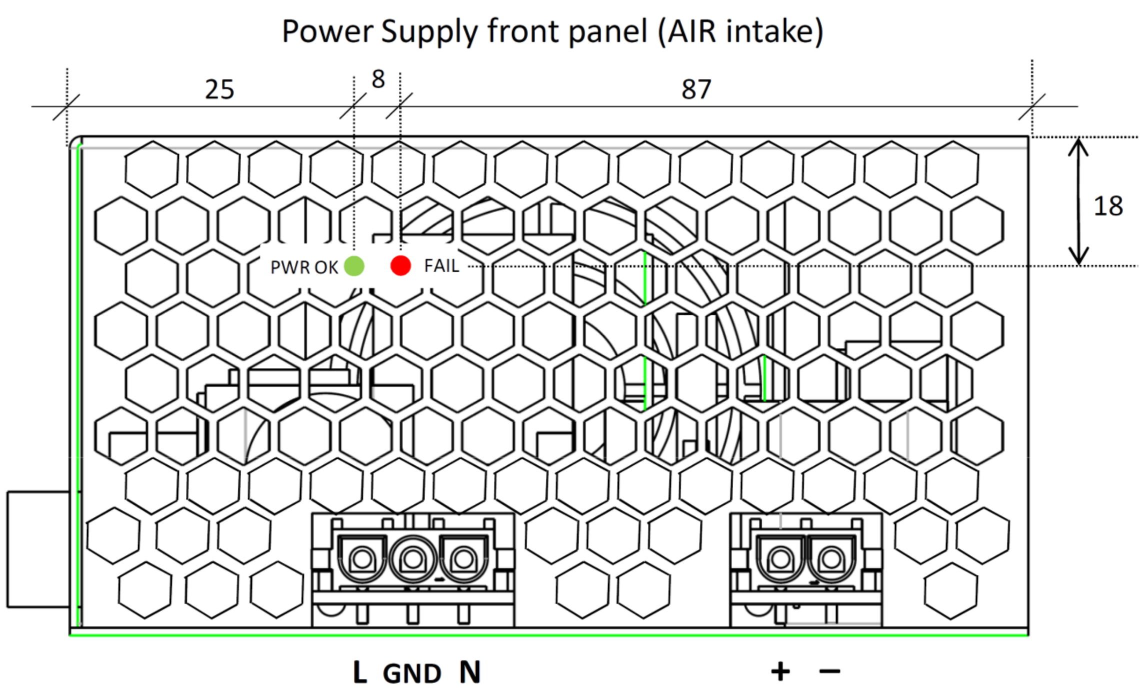


Figure 14 Connector Layout



Note: dimensions in millimeters

Figure 15 Power Supply Front View/Air Intake

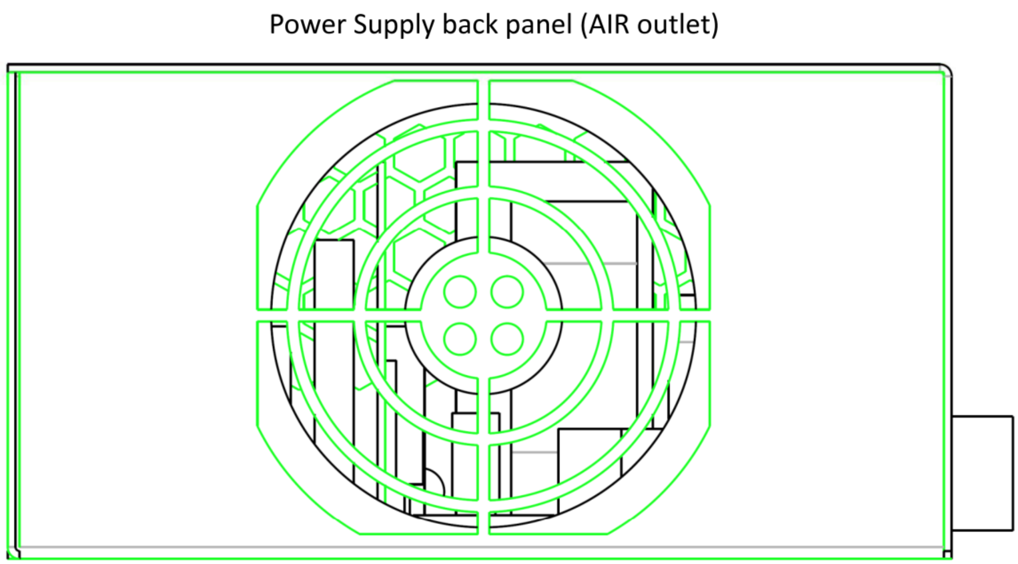


Figure 16 Power Supply Rear View/Air Outlet (Normal Airflow Model Shown)

15 LEDs, Silkscreen

Two LEDs on the front panel of the power supply indicate its status. See Figure 15.

The LEDs don't light unless a valid AC input is available, but LEDs will light during a backup phase following an AC outage.

- "Valid" AC input: Vac(in) > 180Vac RMS
- "Valid" DC input: Vin > 39Vdc (with correct polarity)
- "Valid" DC output: 11.3Vdc < Vout < 13Vdc

15.1 PWR OK LED (Bi-color Green/Yellow)

The PWR OK LED turns yellow when the output voltage is "valid" **and** the DC input is not present or "not valid," or it is applied with reversed polarity.

The PWR OK LED turns green when the output voltage is "valid" **and** the DC input is "valid." Note that at the 54Vdc input level, when the DC power cord is removed, the green LED turns turn yellow with a typical 3 to 6 second delay.

The PWR OK LED blinks green (5 Hz, 50% duty cycle) during the random first AC startup sequence.

The PWR OK LED blinks yellow (1 Hz, 50% duty cycle) during a backup phase following an AC outage (that is, every time the output power is supported by a valid DC input source).

The PWR OK LED turns off when the DC output is "not valid" under all cases (output short circuit/overload with all protections included, and failure). A simple output voltage reading is enough to determine the off status of this LED.

15.2 FAIL LED (Red)

The FAIL LED lights in case of any power supply failure except fan failure and when the power supply is under any latching off or temporary off protection conditions, like over voltage, over temperature, or over current latched off conditions (AC mode only; in DC backup mode, the LED stays off).

The FAIL LED does not light in case of output short circuit/overload condition.

The FAIL LED blinks (1 Hz, 50% duty cycle) in case of fan failure, which is defined as a tachometer fan speed reading < 750RPM. In this case, other than the actual fan failure with the corresponding blinking LED indicator, the power supply keeps working normally until a potential over temperature condition occurs.

The FAIL LED stays off otherwise.

The FAIL LED cannot be enabled during a backup phase.

Note: "**AND**" is intended as a logical operator.

The size of the LEDs is 3mm. A simple black silkscreen for the LEDs is on the power supply faceplate as shown in Figure 15.

16 Not Allowed Components

Avoiding the following components ensures a more reliable power supply.

- Trimmers and/or potentiometers
- Tantalum capacitors
- Dip switches
- High-side driver integrated circuits
- Paralleled power MOS are allowed provided that their design prevents parasitic oscillations
- Phase-shift topology is not allowed
- SMT ceramic capacitors are allowed with a case size smaller than 1206. The size 1206 can still be used when SMT capacitors are placed far from the PCB edge, and with a correct orientation that minimizes risks of cracks
- Allowed ceramics materials for SMT capacitors are: X7R or better material

The COG or NP0 types should be used in critical portions of the design, such as feedback loop, PWM clock settings, and so forth.

The use of any electro-mechanical relays should be discussed up front before any approval is given to include them in the design. No DC inrush relay is allowed.

16.1 Capacitors

All the electrolytic capacitors are rated 105°C and are made by high quality manufacturers only.

All capacitors have a predicted lifespan of at least 50,000 hours at 45°C inlet air temperature, under worst conditions.

17 Complete BOM for AC and DC Power Cords

17.1 BOM for a Complete AC Power Cord (Symmetrical Cable)

- Housing of wire-terminated male contacts (2x): TYCO part number 350766-1
- Male contacts (pin1 N, pin3 L) for AWG 14/20 (4x): TYCO part number 350218-1
  Note: The external diameter of the wires, included insulation, is between 1.52mm and 3.30mm
- Pre-mating male contact (pin2 GND) for AWG 14/20 (2x): TYCO part number 350654-1
  Note: the external diameter of the wires, included insulation, must be in between 1.52mm and 3.30mm)
- Strain relief for 3 position Mate-N-Lok (4x): TYCO p/n 641945-1
- Cable size is AWG 18, 600V, UL1015; OCP system level power cord length is 4.5 inches
- The cable is sheathed, with the sheath grabbed by the strain reliefs at both ends of the cable

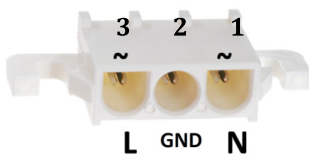


Figure 17 AC Input Connector

- Counterpart connector polarity at both AC power cord sides
- Pin definition:
  - Pin 1: NEUTRAL
  - Pin 2: GROUND
  - Pin 3: LINE

17.2 BOM for a Complete DC Power Cord (Symmetrical Cable)

- Housing of wire-terminated male contacts (2x): TYCO p/n 350777-1
- Male contacts (pin2, positive) for AWG 10/12 (2x): TYCO p/n 350922-3
- Pre-mating male contacts (pin 1, negative) for AWG 10/12 (2x): TYCO p/n 770234-3
- Strain relief for 2 position Mate-N-Lok (4x): TYCO p/n 640713-2
- Cable size is AWG 12, 300V, UL1015; OCP system power cord length is 5.5 inches
- The cable is sheathed, with the sheath grabbed by the strain reliefs at both ends of the cable

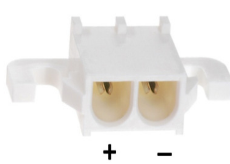


Figure 18 DC Input Connector

- Counterpart connector polarity at both DC power cord sides
- Pin definition:
  - Pin 1: NEGATIVE (0V)
  - Pin 2: POSITIVE (+48V)

18 Power Supply Mechanical Drawing