

COOL POWER TECHNOLOGIES

Eighth-Brick Isolated DC/DC Converter

Features

- Wide input voltage range: 18 – 36 Vin
- Output: 12V at 14A, 168W max.
- High efficiency – 94% typical @ 14A load
- RoHS 3 Directive 2015/863/EU
- No minimum load required
- Low height - 0.465" (11.8mm) max.
- Baseplate option - 0.500" (12.7mm) tall
- 2250V Isolation
- Withstands 50 V input transients
- Fixed-frequency operation
- Industry standard 1/8th brick footprint
- Remote sense
- Full protection (OTP, OCP, OVP, UVLO – auto-restart)
- Remote ON/OFF - positive or negative enable logic options
- Output voltage trim range: +10%/-20% (industry-standard trim equations)
- Weight: 0.79 oz [22.4 g]; 39.1 g (1.38 oz.) baseplate model
- On-board input differential LC-filter
- Meets UL94, V-0 flammability rating
- Compliant to REACH (EC) No 1907/2006, 205 SVHC update
- Complies with UL/CSA60950-1, TUV per IEC/EN60950-1, 2nd edition
- Designed to meet Class B conducted emissions per FCC and EN55032 when used with external filter (see EMC Compliance section below.)



Description

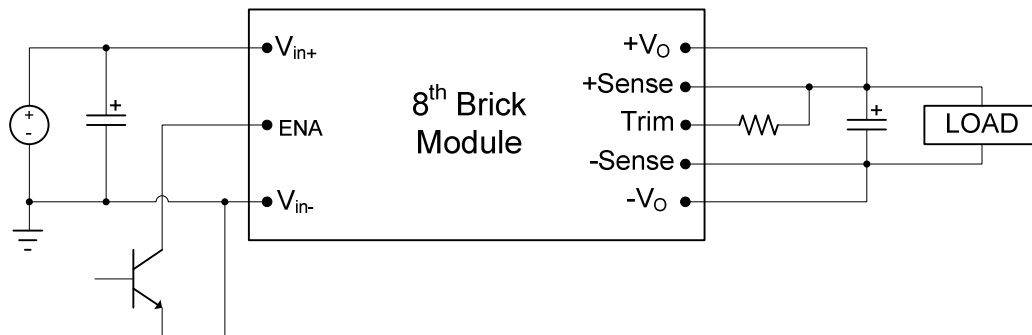
The CPE14B24 “Cool Power Technologies” DC-DC converter is an open frame eighth-brick DC-DC converter that conforms to industry standard specifications. The converter operates over an input voltage range of 18 to 36 VDC, and provides a tightly regulated output voltage with an output current rating of 14 A. The output is fully isolated from the input and the converter meets Basic Insulation requirements. The standard feature set includes remote On/Off (positive or negative enable), input undervoltage lockout, output overvoltage protection, overcurrent and short circuit protections, output voltage trim, remote sense and overtemperature shutdown with hysteresis. The high efficiency of the CPE14B24 allows operation over a wide ambient temperature range with minimal derating (see Characteristic Curves section below.)



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APPLICATION DIAGRAM



ELECTRICAL SPECIFICATIONS

18–36Vin, 12V/14Aout

Conditions: $T_A = 25\text{ }^\circ\text{C}$, Airflow = 300 LFM, $V_{in} = 24\text{ VDC}$, $C_{in} = 100\text{ }\mu\text{F}$, unless otherwise specified.

| Input Characteristics | | | | | |
|---|---|--------------|--------------|---------------------|---------------------|
| Parameter | Conditions | Min | Typ | Max | Unit |
| Operating Input Voltage Range | | 18 | 24 | 36 | VDC |
| Input Under-Voltage Lock-out Turn-on Threshold Turn-off Threshold | | 17.2 15.8 | 17.6 16.2 | 18 16.6 | VDC |
| Input Voltage Transient | 100ms | | | 50 | VDC |
| Maximum Input Current | $V_{IN} = 18\text{VDC}; I_{out} = 14\text{A}$ | | | 10.5 | A |
| Input Standby Current | Converter Disabled | | 2 | 5 | mA |
| Input No-Load Current | Converter Enabled | | 165 | 250 | mA |
| Short Circuit Input Current | | | 30 | | mA _{RMS} |
| Input Reflected Ripple Current | 5Hz to 50MHz | | 25 | 40 | mA _{PK-PK} |
| Input Voltage Ripple Rejection | 120Hz | | 50 | | dB |
| Inrush Current | All | - | - | 0.1 | A ² /s |
| Output Characteristics | | | | | |
| Parameter | Conditions | Min | Typ | Max | Unit |
| Output Voltage Set point | Sense pins connected to output pins | 11.82 | 12.00 | 12.18 | VDC |
| Output Current | | 0 | | 14 | A |
| Output Current Limit Inception | | 14.5 | 15.5 | 18 | A |
| Peak Short-Circuit Current | 10mΩ Short | | | 24 | A |
| RMS Short-Circuit Current | 10mΩ Short | | 2.25 | 3.0 | A _{RMS} |
| External Load Capacitance | | | | 4700 | μF |
| Output Ripple and Noise | 20 MHz bandwidth | | 65 | 120 | mV _{PK-PK} |
| Output Regulation Line: Load: Overall Output Regulation: | Over line, load & temp. | 11.76 | ±5 ±5 | ±12 ±12 12.24 | mV mV V |



ELECTRICAL SPECIFICATIONS (continued)

18–36Vin, 12V/14Aout

Conditions: $T_A = 25\text{ }^\circ\text{C}$, Airflow = 300 LFM, $V_{in} = 24\text{ VDC}$, $C_{in} = 100\text{ }\mu\text{F}$, unless otherwise specified.

| Efficiency | | | | | |
|--|---|------|-----------|-----|------------------|
| Parameter | Conditions | Min | Typ | Max | Unit |
| 100% Load | | 92.8 | 94 | | % |
| 50% Load | | 92.5 | 93.5 | | % |
| Dynamic Response | | | | | |
| Parameter | Conditions | Min | Typ | Max | Unit |
| Load Change 50%-75% or 25% to 50% of $I_{out\ Max}$, $di/dt = 0.1\text{ A}/\mu\text{s}$ | | | 120 | 200 | mV |
| Settling Time to 1% of V_{out} | $C_o = 1\text{ }\mu\text{F}$ ceramic + $10\text{ }\mu\text{F}$ tantalum | | 50 | | μs |
| Load Change 50%-75% or 25% to 50% of $I_{out\ Max}$, $di/dt = 0.2\text{ A}/\mu\text{s}$ | $C_o = 1\text{ }\mu\text{F}$ ceramic + $4700\text{ }\mu\text{F}$ electrolytic | | 50 | 100 | mV |
| Settling Time to 0.1% of V_{out} | | | 100 | | μs |
| Isolation Specifications | | | | | |
| Isolation Capacitance | | | 1000 | | pF |
| Isolation Resistance | | 10 | | | $\text{M}\Omega$ |
| Isolation Voltage | Input to Output | 2250 | | | V_{DC} |
| | Input to Baseplate | 1500 | | | V_{DC} |
| | Output to Baseplate | 1000 | | | V_{DC} |
| Reliability | | | | | |
| Per Telcordia SR-332, Issue 2: Method I, Case 3 ($I_o = 80\%$ of I_{o_max} , $T_A = 40\text{ }^\circ\text{C}$, airflow = 200 lfm, 90% confidence) | MTFB | | 2,216,014 | | Hours |
| | FITs (failures in 10^9 hours) | | 451 | | / 10^9 Hours |



ELECTRICAL SPECIFICATIONS (continued)

18–36V_{in}, 12V/14A_{out}

Conditions: Ta = 25 °C, Airflow = 300 LFM, Vin = 24 VDC, Cin=100 µF, unless otherwise specified.

| Absolute Maximum Ratings | | | | | |
|--|--|---------------|------|------|------|
| Parameter | Conditions | Min | Typ | Max | Unit |
| Input Voltage | Continuous Operation | 0 | | 36 | VDC |
| Operating Ambient Temperature | | -40 | | +85 | °C |
| Operating Temperature | Open Frame | -40 | | +123 | °C |
| | Baseplate Option | -40 | | +115 | °C |
| Storage Temperature | | -55 | | +125 | °C |
| Feature Characteristics | | | | | |
| Parameter | Conditions | Min | Typ | Max | Unit |
| Switching Frequency | | | 410 | | kHz |
| Output Voltage Trim Range ¹ | | -20 | | +10 | % |
| Remote Sense Compensation ¹ | | | | +10 | % |
| Output Over-voltage Protection | Non-latching | 115 | 120 | 130 | % |
| Over-temperature Protection | Avg. PCB temp, non-latching | | 125 | | °C |
| Peak Backdrive Output Current during startup into prebiased output | Sinking current from external voltage source equal to V _{OUT} – 0.6V and connected to the output via 1Ω resistor. C _{OUT} =220µF, Aluminum | | 400 | 500 | mA |
| Backdrive Output Current in OFF state | Converter disabled | | 0 | 5 | mA |
| Enable to Output Turn-ON Time | V _{OUT} = 0.9*V _{OUT_NOM} | | 20 | | ms |
| Output Enable ON/OFF | Negative Enable | Converter ON | -0.5 | 0.8 | VDC |
| | | Converter OFF | 2.4 | 20 | VDC |
| | Positive Enable | Converter ON | 2.4 | 20 | VDC |
| | | Converter OFF | -0.5 | 0.8 | VDC |
| Enable Pin Current Source/Sink | Converter has internal pull-up of approx. 5V | | 0.25 | 1 | mA |
| Output Voltage Overshoot @ Startup | | | 0 | 2 | %Vo |
| Auto-Restart Period | (all protection features) | | 100 | | ms |

1. Combination of remote sense + trim up not to exceed 10% of V_{onom}.



CHARACTERISTIC CURVES:

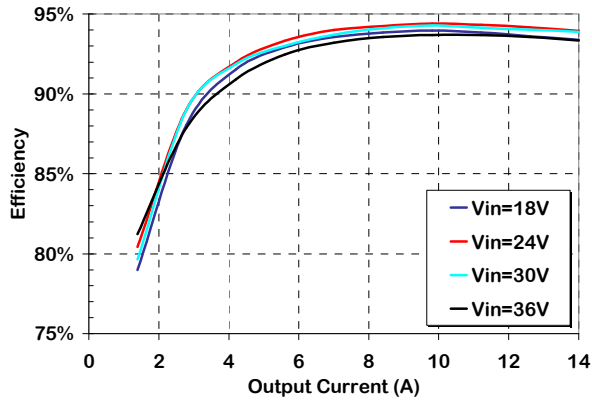


Figure 1. Efficiency vs Output Current, 300lfm airflow, 25°C ambient.

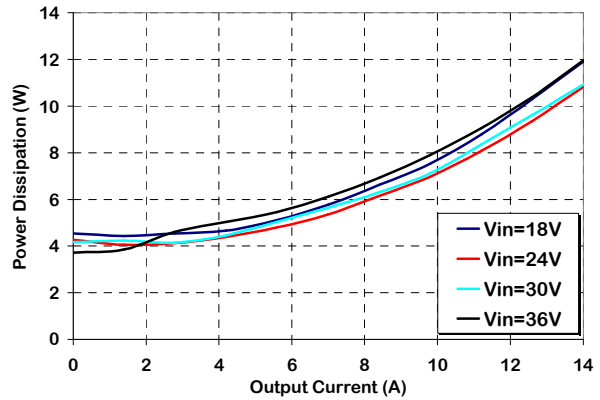


Figure 2. Power Dissipation vs. Load Current, 300lfm airflow, 25°C ambient.

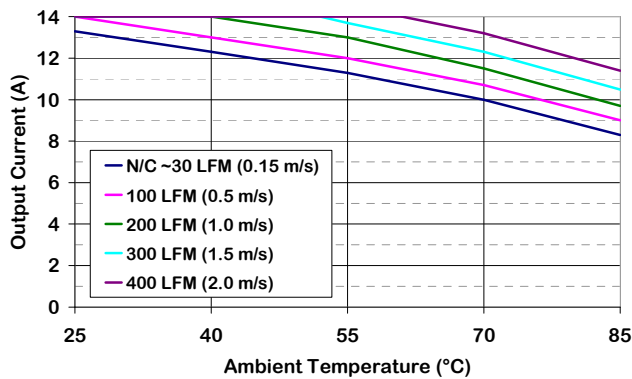


Figure 3. Output Current Derating vs Ambient Temperature & Airflow (converter mounted vertically with air flowing from pin 3 to pin 1, Vin = 24 V.)

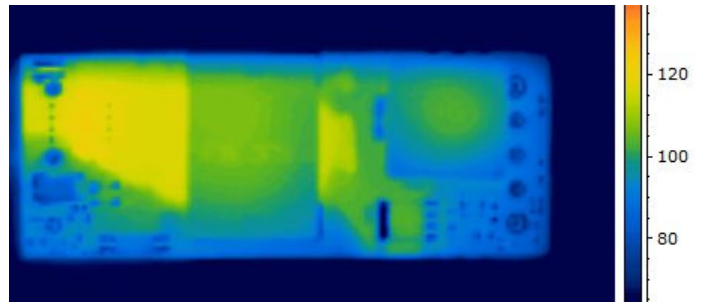


Figure 4. Thermal Image of CPE14B24 (14A output, 40C Ambient, 200lfm airflow Vin = 24V, airflow from pin 3 to pin 1, T_{max} = 123°C)

CHARACTERISTIC WAVEFORMS:

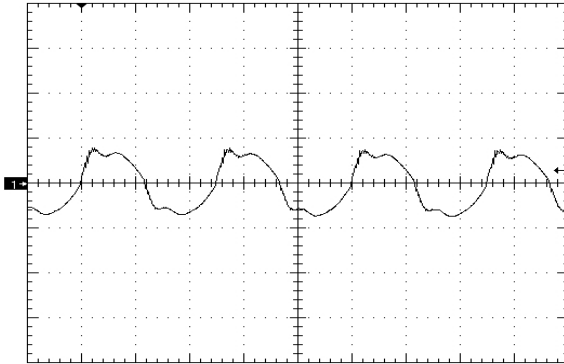


Figure 5. Output Voltage Ripple (50mV/div), time scale – 1uS/div. Vin=Vin_nom, full resistive

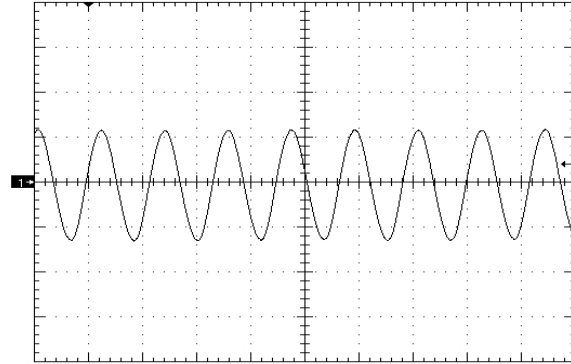


Figure 6. Input Reflected Ripple Current (10mA/div) time scale - 2uS/div. Vin=Vin_nom, full resistive

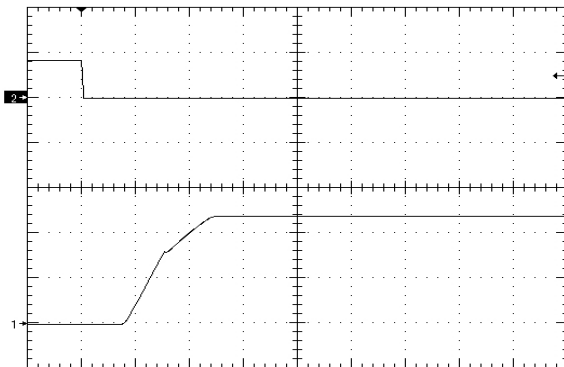


Figure 7. Startup Waveform via Enable Pin (5V/div), time scale 10mS/div. Vin=Vin_nom, full resistive load + 4700uF (negative enable.)

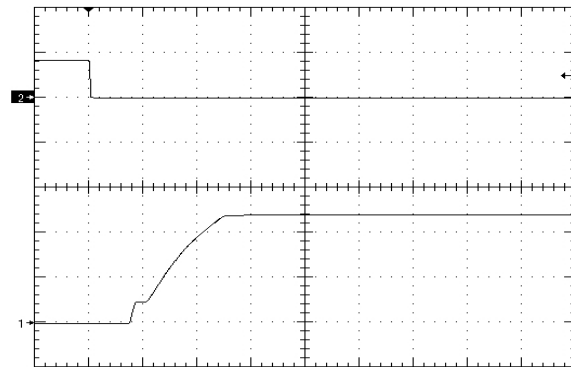


Figure 8. Startup Waveform via Enable Pin (5V/div), time scale 10mS/div. Vin=Vin_nom, No Load (negative enable.)

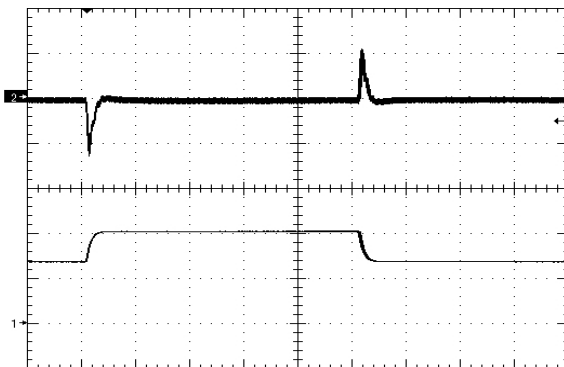


Figure 9. Load Transient Response (100mV/div), di/dt=0.1A/uS, 50% - 75% - 50% of full load, time scale: 200uS/div.

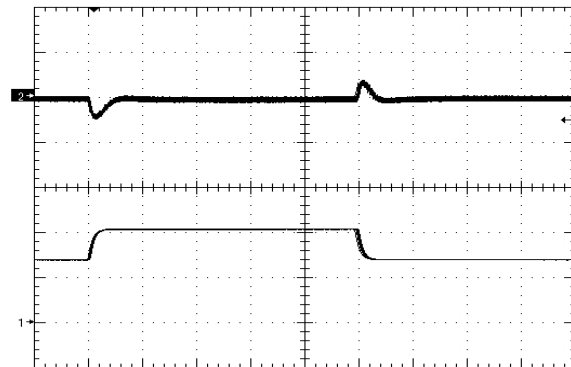
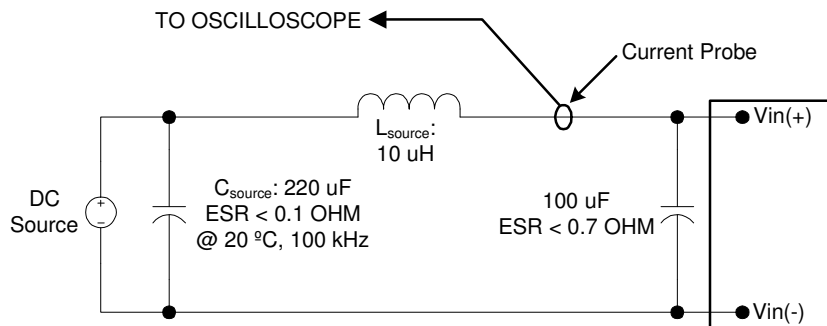


Figure 10. Load Transient Response (100mV/div), di/dt=0.15A/uS, 50% - 75% - 50% of full load, 4700uF electrolytic across output, time scale: 200uS/div.

Application Notes

Input Voltage Reflected Ripple Measurement

- INPUT REFLECTED RIPPLE TEST SETUP:

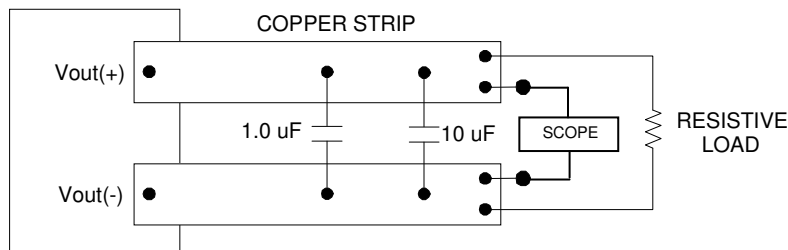


Note: Measure input reflected-ripple current with a simulated source inductance (L_{test}) of 10 μ H. Capacitor C_s offsets possible source impedance.

Figure 11. Input Reflected-ripple Current Test Setup.

Output Voltage Ripple Measurement

- OUTPUT RIPPLE TEST SETUP:



Note: Use a 1 μ F X7R ceramic capacitor and a 10 μ F tantalum capacitor. Scope measurement should be made using a BNC socket. Position the load 3 in. [76mm] from module.

Figure 12. Peak-to-Peak Output Noise Measurement Test Setup.

Application Notes (cont)

Output Voltage Trim

Output voltage adjustment is accomplished by connecting an external resistor between the Trim Pin and either the +Sense or -Sense pins.

- TRIM UP EQUATION:**

$$R_{trim_up} = \left[\frac{5.1 \times V_{O_nom} \times (100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{510}{\Delta\%} - 10.2 \right] \times k\Omega$$

Where R_{trim_up} is the resistance value in k-ohms and $\Delta\%$ is the percent change in the output voltage. E.g. to

trim the output up 10%, $R_{trim_up} = \left[\frac{5.1 \times 12 \times (100 + 10)}{1.225 \times 10} - \frac{510}{10} - 10.2 \right] \times k\Omega$ or $R_{trim_up} = 488 \text{ k}\Omega$.

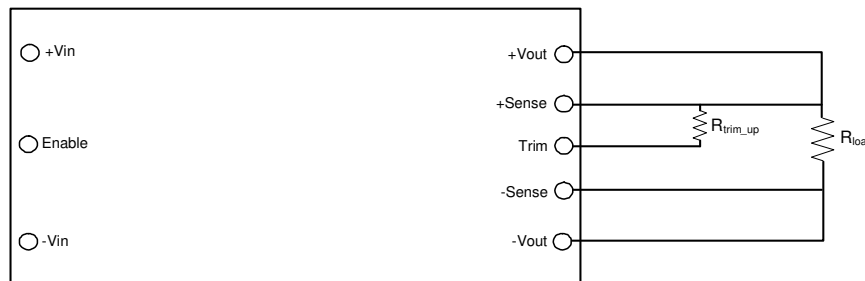


Figure 13. Trim UP circuit configuration

- TRIM-DOWN EQUATION:**

$$R_{trim_down} = \left(\frac{510}{\Delta\%} - 10.2 \right) \times k\Omega$$

Where R_{trim_down} is the resistance value in k ohms and $\Delta\%$ is the percent change in the output voltage.

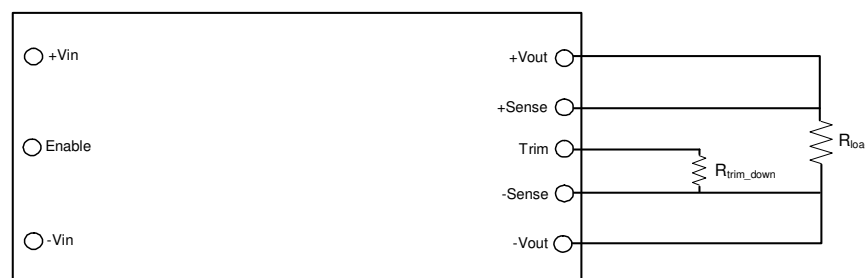


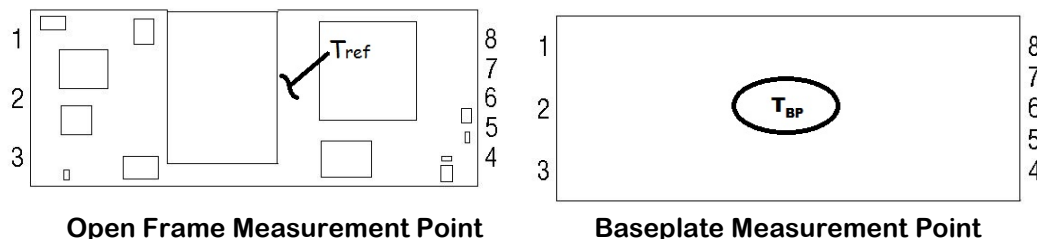
Figure 14. Trim DOWN circuit configuration



Application Notes (cont)

Thermal Derating

- It is preferable that the DC-DC module have an unobstructed flow of air across it for best thermal performance. Components taller than ~ 2mm in front of the module can deflect airflow and possibly create hotspots.
- Significant cooling is achieved through conductive flow from the modules I/O pins to the host PCB. Sufficiently large traces connecting the dc-dc converter to the source and load will help ensure thermal derating performance will meet or exceed the derating curves published in this datasheet. Solder flow-through that contacts standoff of output pins is essential for proper derating performance – especially on models with greater than 10A output current.
- If the module is expected to be operated near the load limits defined in the derating curves, in-system verification of module derating performance should be performed to ensure long-term system reliability. Peak temperatures are to be measured using infrared thermography or by gluing a fine gauge (AWG #40) thermocouple at the T_{ref} location(s) shown below. T_{ref} should be not to exceed 123°C in order to meet derating guidelines. For baseplate models, T_{BP} should not exceed 115°C.



Input Undervoltage Lockout

- The converter is disabled until the input voltage has exceeded the UVLO turn-on threshold. Once the input voltage exceeds this level (see Input Under-Voltage Lock-out in Electrical Specifications table) the module will commence soft-start. Hysteresis of ~2 volts minimizes the likelihood of pulling the input voltage below the turn-off threshold during startup which could create an undesirable on/off cycling condition. The converter will continue to operate until the input voltage subsequently falls below the UVLO turn-off threshold.

Enable Pin Function

- The module has a remote enable function that allows it to be turned on or off remotely. The Enable pin is referenced to the negative input pin (-Vin) of the converter. Modules can be ordered with either negative or positive enable.
- The negative enable option the module will not turn on unless the enable pin is connected to -Vin. The positive enable option allows the converter to turn on as soon as voltage sufficient to exceed the UVLO of the converter has been applied to the input terminals. In this case the module is turned off by connecting the Enable pin to -Vin. On/off thresholds are located in the Electrical Specifications table.

Application Notes (cont)

Output Overvoltage Protection

- The module has an independent feedback loop that will disable the output of the converter if a voltage greater than about 125% of the nominal set point is detected. When this threshold is reached, the converter will shut down and remain off for the amount of time specified by the Auto-Restart Period. The converter will attempt a restart once this period of time has elapsed.

Output Overtemperature Protection

- To provide protection under certain fault conditions, the unit is equipped with a thermal shutdown circuit. The unit will shutdown if the average PCB temperature exceeds approx. 135°C, but the thermal shutdown is not intended as a guarantee that the unit will survive temperatures beyond its rating. The module will automatically restart once it has cooled below the shutdown temperature minus hysteresis (typically 20 deg C.)

SMT Version Layout Considerations (if applicable)

- Copper traces with sufficient cross-section must be provided for all output & input pins. SMT pads tied to internal power/ground planes must have multiple vias around each SMT pad to couple expected current loads from module pins into internal traces/planes. One 0.024" (0.6mm) diameter via for each 4A of expected source or load current must be provided as close to the termination as possible, preferably in the direction of current flow from SMT pad to load. Vias must be at least 0.024" (0.6 mm) away from the SMT pad to prevent solder from flowing into the vias.
- SMT pads on the host card are to be 0.080" (2.03 mm) diameter. Solder paste screen opening should be 0.075" (1.9 mm) diameter and the screen should be 0.006" (0.15 mm) thick (other thicknesses are possible; 0.006" provides a good compromise between solder volume and coplanarity compensation.)

Paralleling Converters

- Modules may be paralleled but it is recommended that the total power draw not exceed the output power rating of a single module. External sharing controllers are recommended for reliability and to ensure equal distribution of the load to the converters. In lower current applications, ORing diodes can be used to prevent converter interactions and improve current sharing.



Application Notes (cont)

EMC Compliance

To meet Class B compliance for EN55032 (CISPR 32) or FCC part 15 sub part j, the following input filter is required:

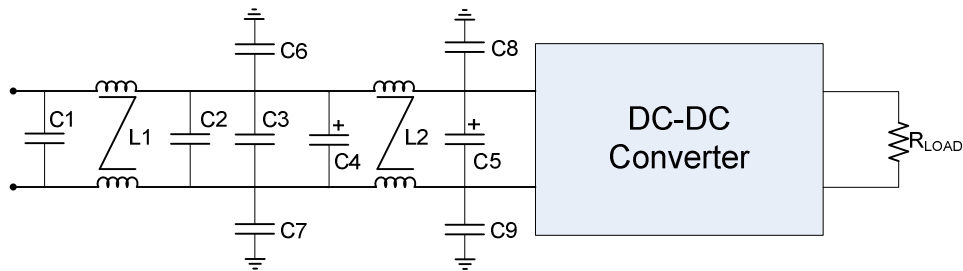


Figure 15. EMI Filter

| | |
|--------------|--|
| L1, L2 = | 0.63 mH Common Mode Inductor (Pulse P0469) |
| C1, C2, C3 = | 2.2uF ceramic |
| C4 = | Not used |
| C5 = | 100uF electrolytic |
| C6, C7 = | 8.2nF (@2kV if output is ref. to gnd.) |
| C8, C9 = | 8.2nF (@2kV if output is ref. to gnd.) |

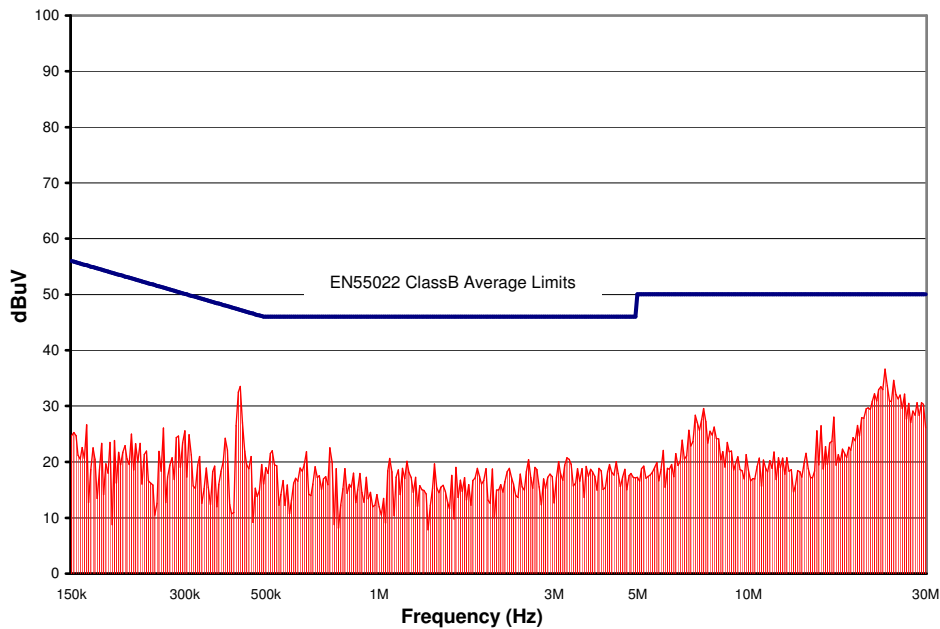
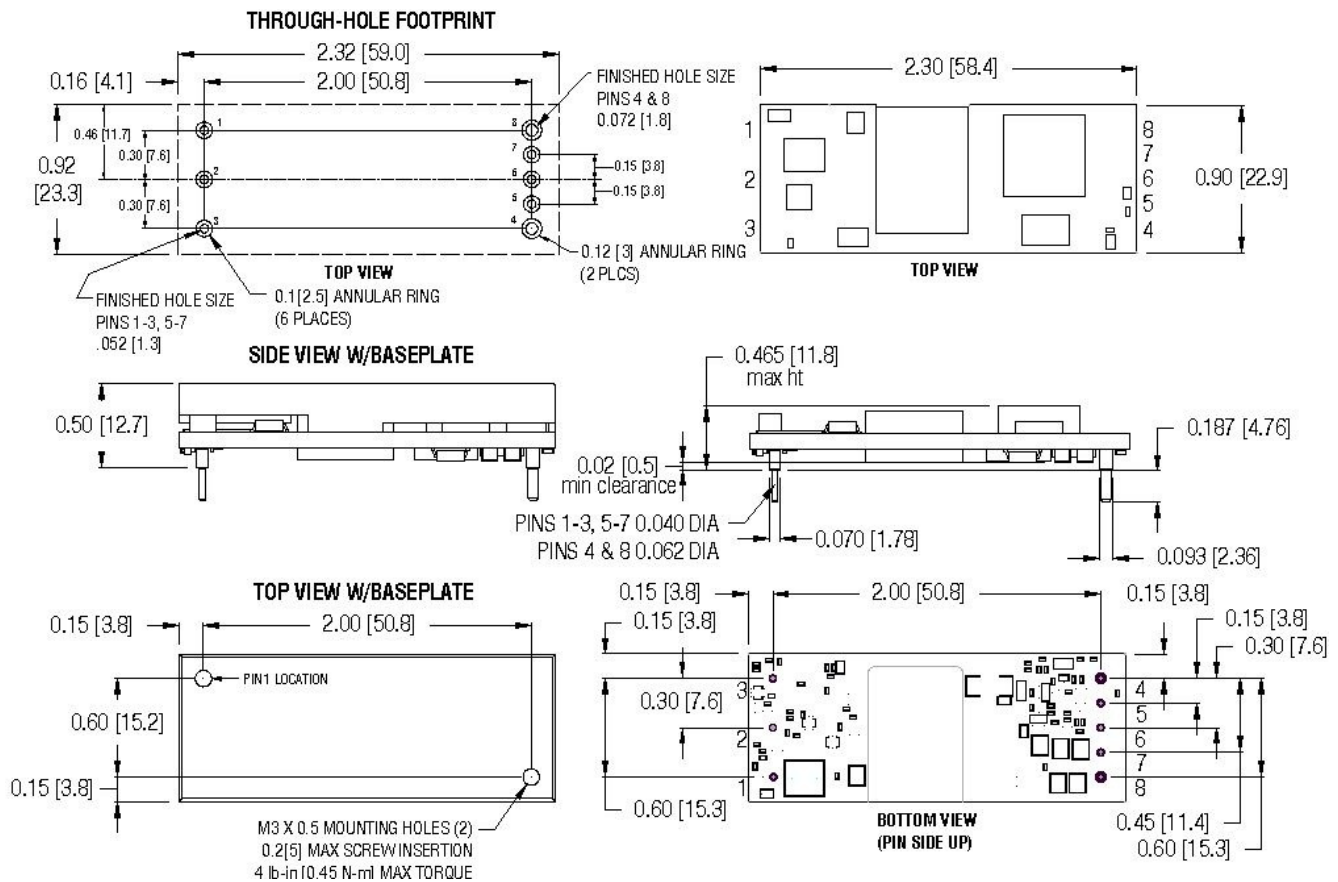


Figure 16. CPE14B24 Conducted Emissions using above specified input filter, Vin = 24V, Full Resistive Load

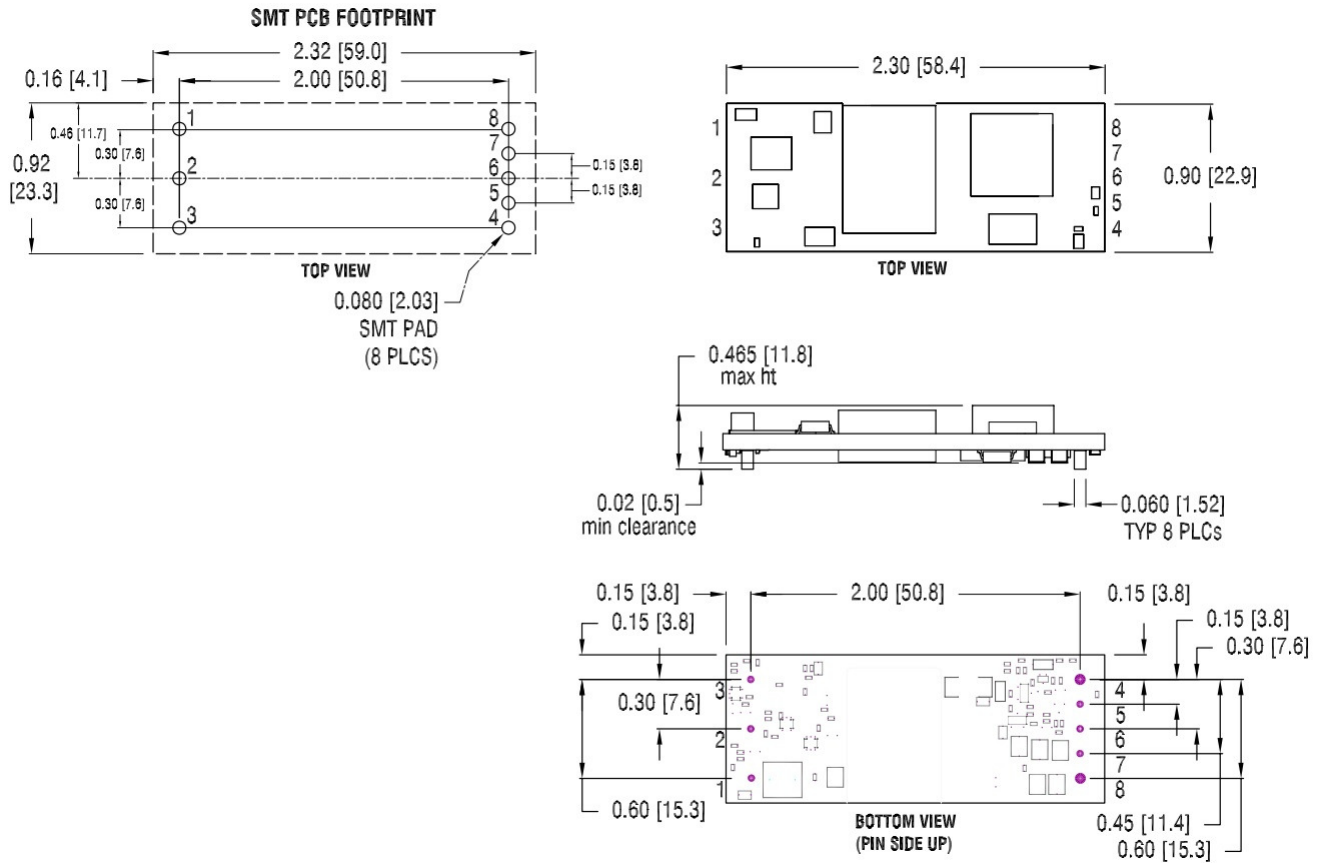
MODULE PIN ASSIGNMENT:

| PIN # | DESIGNATION | NOTES |
|-------|----------------------|--|
| 1 | V _{IN} (+) | 1) All dimensions in inches [mm] Tolerances: .xx ± 0.02 [.x ± .5] .xxx ± 0.010 [.xx ± .25] 2) Input, on/off control and sense/trim pins are Ø 0.040" [1.02] with Ø 0.070" [1.77] standoff shoulders. 3) Output pins are Ø 1.57 mm (0.062") with Ø 0.093" [2.36] shoulders (note, shoulder sits .008" above mounting surface) 4) All pins are gold plated with nickel under plating. 5) Weight: 22.4 g (0.79 oz.) open frame 39.1 g (1.38 oz.) baseplate model 6) Workmanship: Meet or exceeds IPC-A-610 Class II |
| 2 | On/Off | |
| 3 | V _{IN} (-) | |
| 4 | V _{OUT} (-) | |
| 5 | Sense (-) | |
| 6 | Trim | |
| 7 | Sense (+) | |
| 8 | V _{OUT} (+) | |

MECHANICAL OUTLINE:



MECHANICAL OUTLINE – SMT:



ORDERING INFORMATION:

| Product Identifier | Output Current | Output Voltage | Input Voltage | Enable logic option | Additional features |
|---------------------|----------------|----------------|---------------|------------------------------|---|
| CPE | 14 | B | 24 | N or P | B or S |
| “Cool Power Eighth” | 14A | 12V | 18-36V | N = Negative P = Positive | B = Baseplate Option S = Surface Mount |

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