Cool Power Technologies

Eighth-Brick Isolated DC/DC Converter

Features

- Ultra-wide input voltage range: 9 – 36Vin
- Output: 24V at 3A, 72W max.
- High Efficiency – 91.6% typical @ FL
- No minimum load/capacitance required
- RoHS 3 Directive 2015/863/EU
- Low height - 0.465" (11.8mm) max.
- Baseplate option - 0.500" (12.7mm) tall
- Withstands 50 V input transients
- Fixed-frequency operation
- Industry standard 1/8th brick footprint
- Full protection (OTP, OCP, OVP, UVLO – auto-restart)
- Remote ON/OFF - positive or negative enable logic options
- Remote sense
- Output voltage trim range: ±10% (industry-standard trim equations)
- Weight: 0.79 oz (22.4 g) open frame, 1.38 oz (39.1 g) baseplate model
- On-board input differential LC-filter
- Meets UL94, V-0 flammability rating
- Compliant to REACH (EC) No 1907/2006, 197 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.)

RoHS COMPLIANT

Description

The CPE3D18 "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 9 to 36 VDC, and provides a tightly regulated output voltage with an output current rating of 3 Amps. 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 CPE3D18 allows operation over a wide ambient temperature range with minimal derating (see Characteristic Curves section below.)

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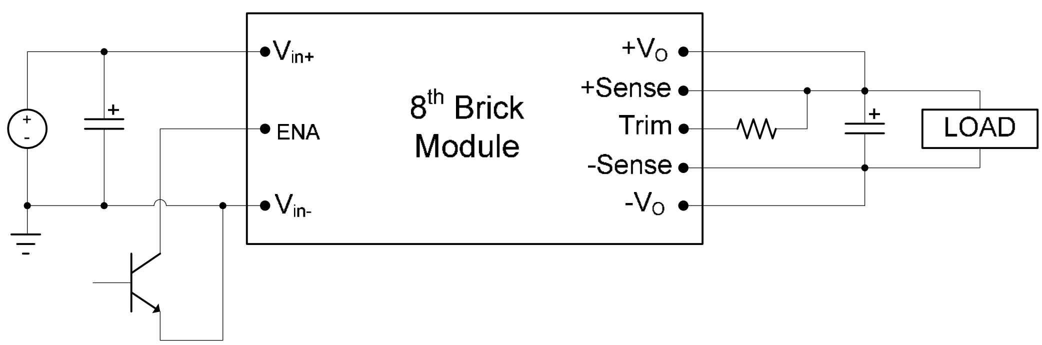
APPLICATION DIAGRAM



ELECTRICAL SPECIFICATIONS 9–36Vin, 24V/3Aout

Conditions: T_A = 25 °C, Airflow = 300 LFM, Vin = 24 VDC, Cin = 220 μF, unless otherwise specified.

Input Characteristics					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Operating Input Voltage Range		9[1]	24	36	VDC
Input Under-Voltage Lock-out Turn-on Threshold Turn-off Threshold		 10.6 8.7	 10.8 9.0	 11.0 9.3	VDC
Input Voltage Transient	100ms			50	VDC
Maximum Input Current	V_{IN} = 10VDC; I_{out} = 3A			8.2	A
Input Standby Current	Converter Disabled		2	5	mA
Input No-Load Current	Converter Enabled		150	200	mA
Short Circuit Input Current	RMS		30		mA
Input Reflected Ripple Current	5Hz to 50MHz See Fig 13 for setup		30	50	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	23.64	24	24.36	VDC
Output Current		0		3	A
Output Current Limit Inception		3.4	4	7	A
Peak Short-Circuit Current	10mΩ Short			9	A
RMS Short-Circuit Current	10mΩ Short			0.6	A_{RMS}
External Load Capacitance[3]	+ Full Resistive Load	0		1000	uF
Output Ripple and Noise	20MHz Bandwidth 1 uF Ceramic + 10uF Tantalum See Fig 14 for setup		60	120	mV_{PK-PK}
Output Regulation Line: Load: Overall Output Regulation:	 Over line, load & temp.	 23.4	 ±10 ±10	 ±20 ±20 24.6	 mV mV V

ELECTRICAL SPECIFICATIONS (continued) 9–36Vin, 24V/3Aout

Conditions: T_A = 25 °C, Airflow = 300 LFM, Vin = 24 VDC, Cin = 220 µF, unless otherwise specified.

Absolute Maximum Ratings

Parameter	Conditions	Min	Typ	Max	Unit
Input Voltage	Continuous Operation	0		36	VDC
Operating Ambient Temperature	w/derating	-40		+85	°C
Operating Temperature T_{ref}, see Thermal Derating section	Open Frame	-40		+123	°C
	Baseplate Option	-40		+115	°C
Storage Temperature		-55		+125	°C

Feature Characteristics

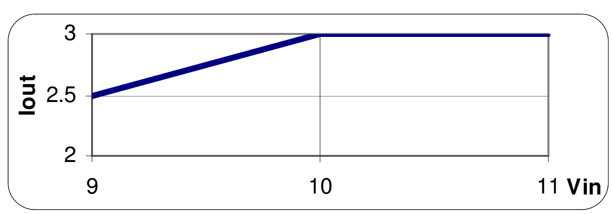
Parameter	Conditions	Min	Typ	Max	Unit
Switching Frequency			325		kHz
Output Voltage Trim Range[2]		-10		+10	%
Remote Sense Compensation[2]				+10	%
Output Over-voltage Protection	Non-latching	115	125	140	%
Over-temperature Protection	Avg. PCB temp, non-latching		150		°C
Peak Backdrive Output Current 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		900		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 Converter OFF Positive Enable Converter ON Converter OFF Enable Pin Current Source/Sink	All voltages are WRT –Vin. Converter has internal pull-up of approx. 5V	 -0.5 2.4 2.4 -0.5 	 0.25	 0.8 20 20 0.8 1	 VDC VDC VDC VDC mA
Output Voltage Overshoot @ Startup			0	2	%Vo
Auto-Restart Period	(all protection features)		100		ms

ELECTRICAL SPECIFICATIONS (continued) — 9–36Vin, 24V/3Aout

Conditions: Ta = 25 °C, Airflow = 300 LFM, Vin = 24 VDC, Cin=220 µF, unless otherwise specified.

Efficiency					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Full Load	Vin = 12Vin	90	91.8		%
	Vin = 24Vin	90	91.6		%
60% Load	Vin = 12Vin	90	91.5		%
	Vin = 24Vin	89	90.3		%
Dynamic Response					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Load Change 50%-75% or 25% to 50% of Iout Max, di/dt = 0.05 A/µs	Co = 1 µF ceramic + 10 µF tantalum		100	200	mV
Settling Time to 1% of Vout			50		µs
Load Change 50%-100% of Iout Max, di/dt = 1 A/µs	Co = 1 µF ceramic + 10 µF tantalum		500	600	mV
Settling Time to 1% of Vout			50		µs
Isolation Specifications					
Isolation Capacitance			1000		pF
Isolation Resistance		10			MΩ
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°C, airflow = 200 lfm, 90% confidence)	MTFB	4,309,253			Hours
	FITs (failures in 10^9 hours)	232			/10^9 Hours

Notes:



1. Max output current derates per following graph:
2. Combination of remote sense + trim up not to exceed 10% of V_{onom}, 10% Trim-Up for Vin > 20V
3. Higher capacitive load handling available, consult factory.

CHARACTERISTIC CURVES:

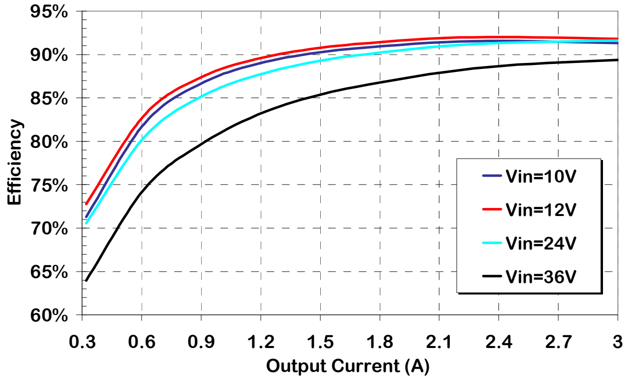


Figure 1. Efficiency vs Output Current, 300lfm airflow, 25℃ ambient.

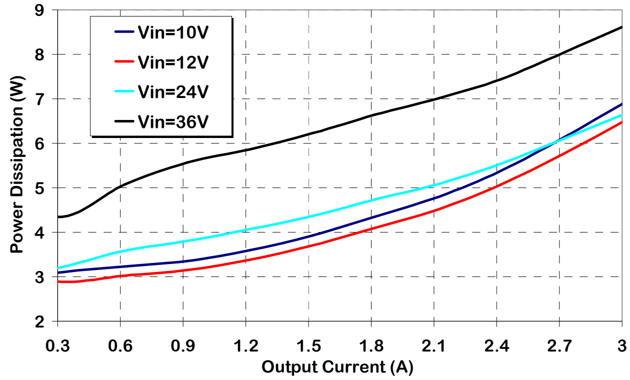


Figure 2. Power Dissipation vs. Load Current, 300lfm airflow, 25℃ ambient.

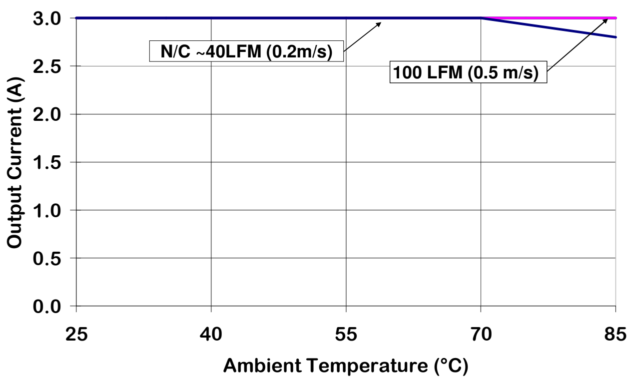


Figure 3. Output Current Derating vs Ambient Temperature & Airflow (air flowing from pin 3 to to pin 1, Vin = 24 V without baseplate)

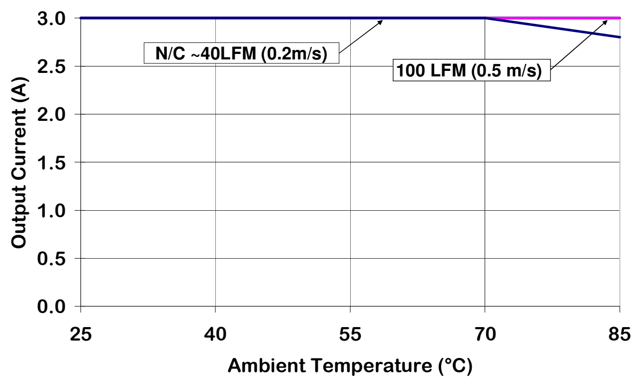


Figure 4. Output Current Derating vs Ambient Temperature & Airflow (air flowing from pin 3 to to pin 1, Vin = 24 V without baseplate)

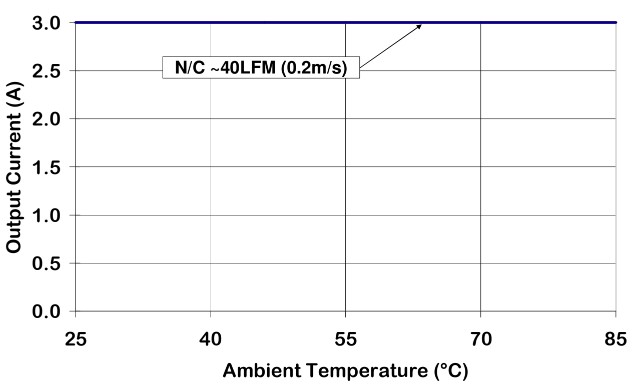


Figure 5. Output Current Derating vs Ambient Temperature & Airflow (air flowing from pin 3 to to pin 1, Vin = 12-24 V with baseplate)

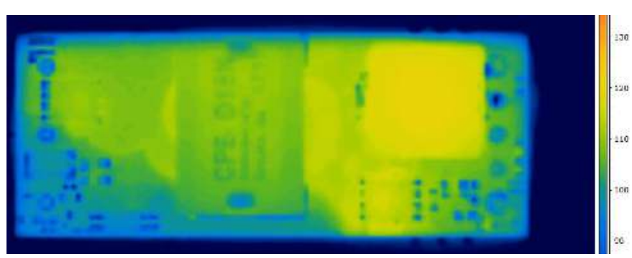


Figure 6. Thermal Image of CPE3D18 (3A output, 85C Ambient, 100lfm airflow, Vin = 24V, airflow from pin 3 to pin 1, T_{max} = 120.2℃)

CHARACTERISTIC WAVEFORMS:

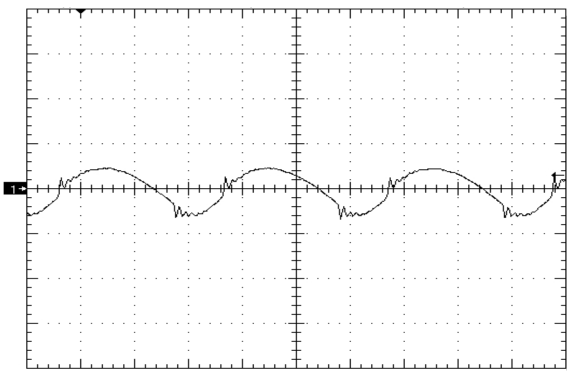


Figure 7. Output Voltage Ripple (50mV/div), time scale – 1uS/div. Vin=Vin_nom, full resistive.

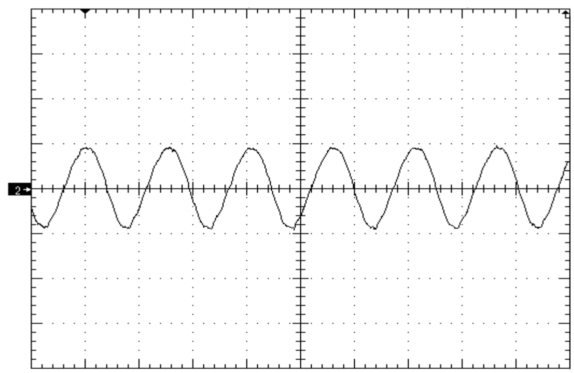


Figure 8. Input Reflected Ripple Current (20mA/div) time scale - 2uS/div. Vin=Vin_nom, full resistive.

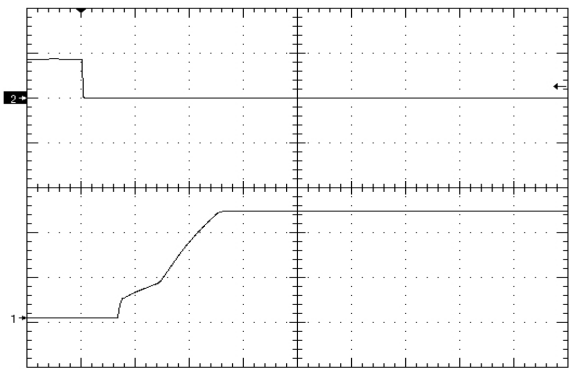


Figure 9. Startup Waveform via Enable Pin, time scale 10mS/div. Vin=Vin_nom, no load Ch1=10V/div, Ch2=5V/div

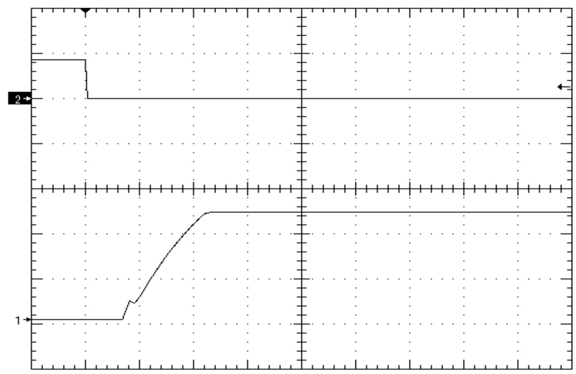


Figure 10. Startup Waveform via Enable Pin, time scale 10mS/div. Vin=Vin_nom, full resistive load + 1000uF (neg en) Ch1=10V/div,Ch2=5V/div

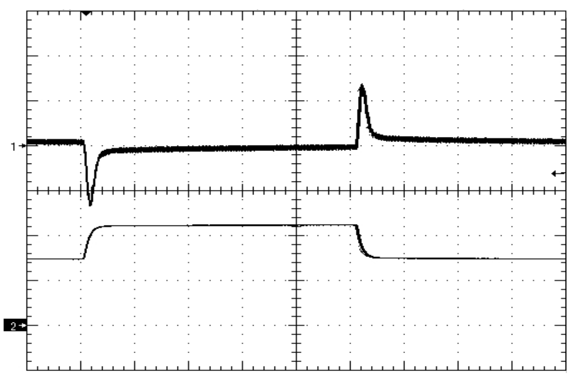


Figure 11. Load Transient Response (100mV/div), di/dt=0.1A/uS, 50% - 75% - 50% of full load, time scale: 200uS/div. Vin – 24V

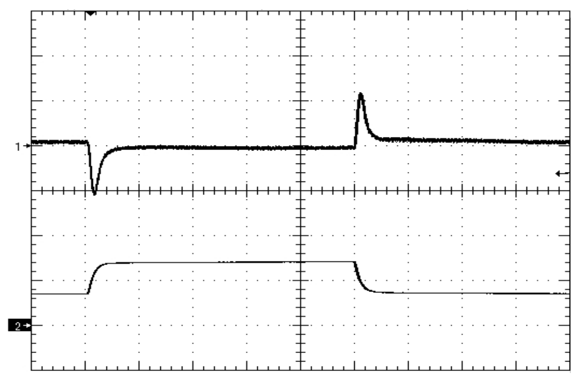
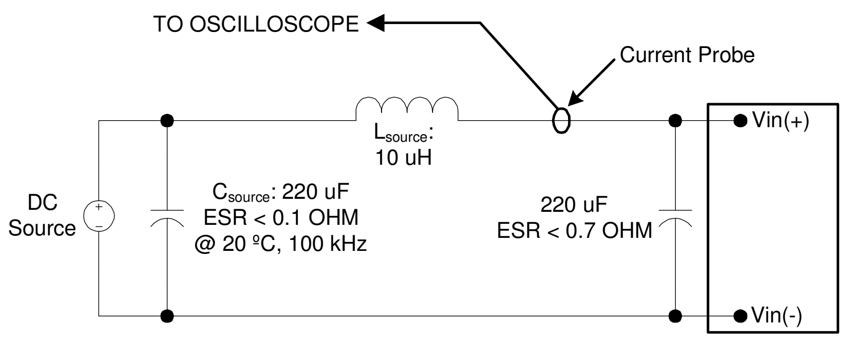


Figure 12. Load Transient Response (100mV/div), di/dt=0.1A/uS, 25% - 50% - 25% of full load, time scale: 200uS/div. Vin = 12V

Application Notes

Input Voltage Reflected Ripple Measurement

- **INPUT REFLECTED RIPPLE TEST SETUP:**

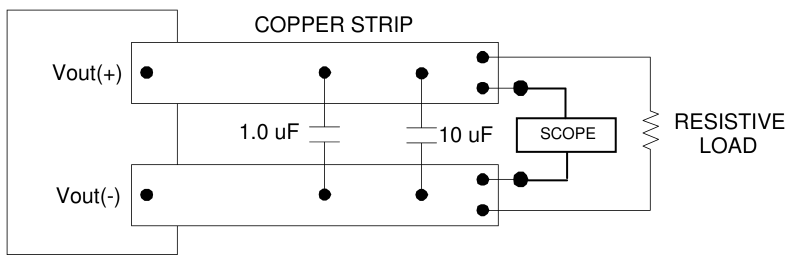


Note: Measure input reflected-ripple current with a simulated source inductance (Ltest) of 10 uH. Capacitor C_S offsets possible source impedance.

Figure 13. Input Reflected-ripple Current Test Setup.

Output Voltage Ripple Measurement

- **OUTPUT RIPPLE TEST SETUP:**



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

Figure 14. 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:**

$$R_{trim\_up} = \left[\frac{5.1 \times Vo\_nom \times (100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{510}{\Delta\%} - 10.2 \right] \times k\Omega$$

Where R_{trim_up} is the resistance value in k-ohms and Δ% is the percent change in the output voltage. E.g. to trim the output up 10%, $R_{trim\_up} = \left[\frac{5.1 \times 24 \times (100 + 10)}{1.225 \times 10} - \frac{510}{10} - 10.2 \right] \times k\Omega$ **or R_{trim_up} = 1037.9kOhm.**

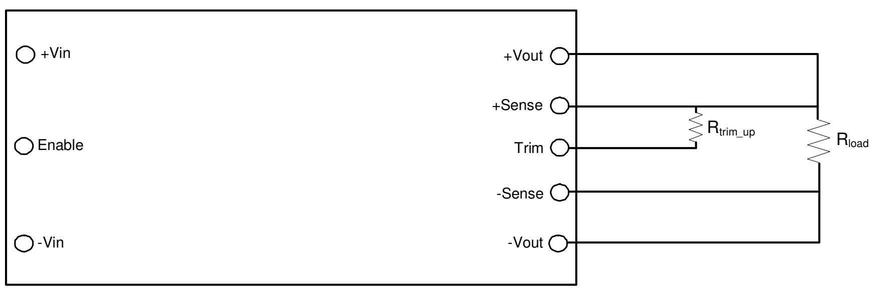


Figure 15. Trim UP circuit configuration

- **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 Δ% is the percent change in the output voltage.

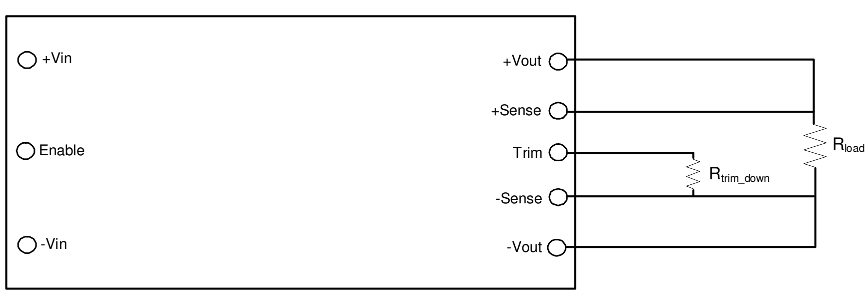
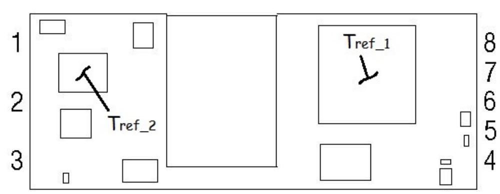


Figure 16. Trim DOWN circuit configuration

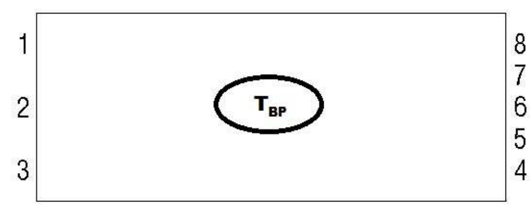
Application Notes (cont)

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_2} should be monitored for input voltages below 20 Vin, T_{ref_1} for input voltages > 20 Vin. Temperatures at the specified location(s) should be limited to 123ºC. For baseplate models, T_{BP} should not exceed 115ºC.



Open Frame Measurement Points



Baseplate Measurement Point

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 1-2 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. 135ºC, 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.

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:

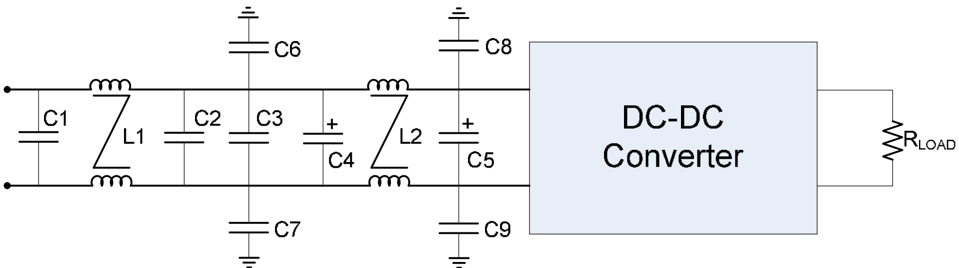


Figure 17. EMI Filter

L1, L2 =	0.63 mH Common Mode Inductor (Pulse P0469NL)
C1, C2, C3 =	2.2uF ceramic
C4 =	Not used
C5 =	220uF electrolytic
C6, C7 =	8.2nF (@2kV if output is ref. to gnd.)
C8, C9 =	8.2nF (@2kV if output is ref. to gnd.)

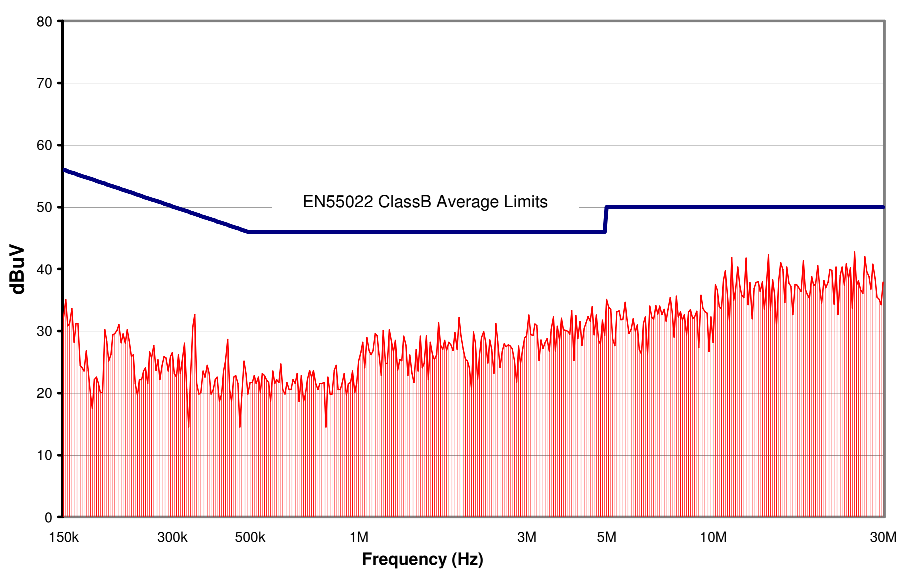
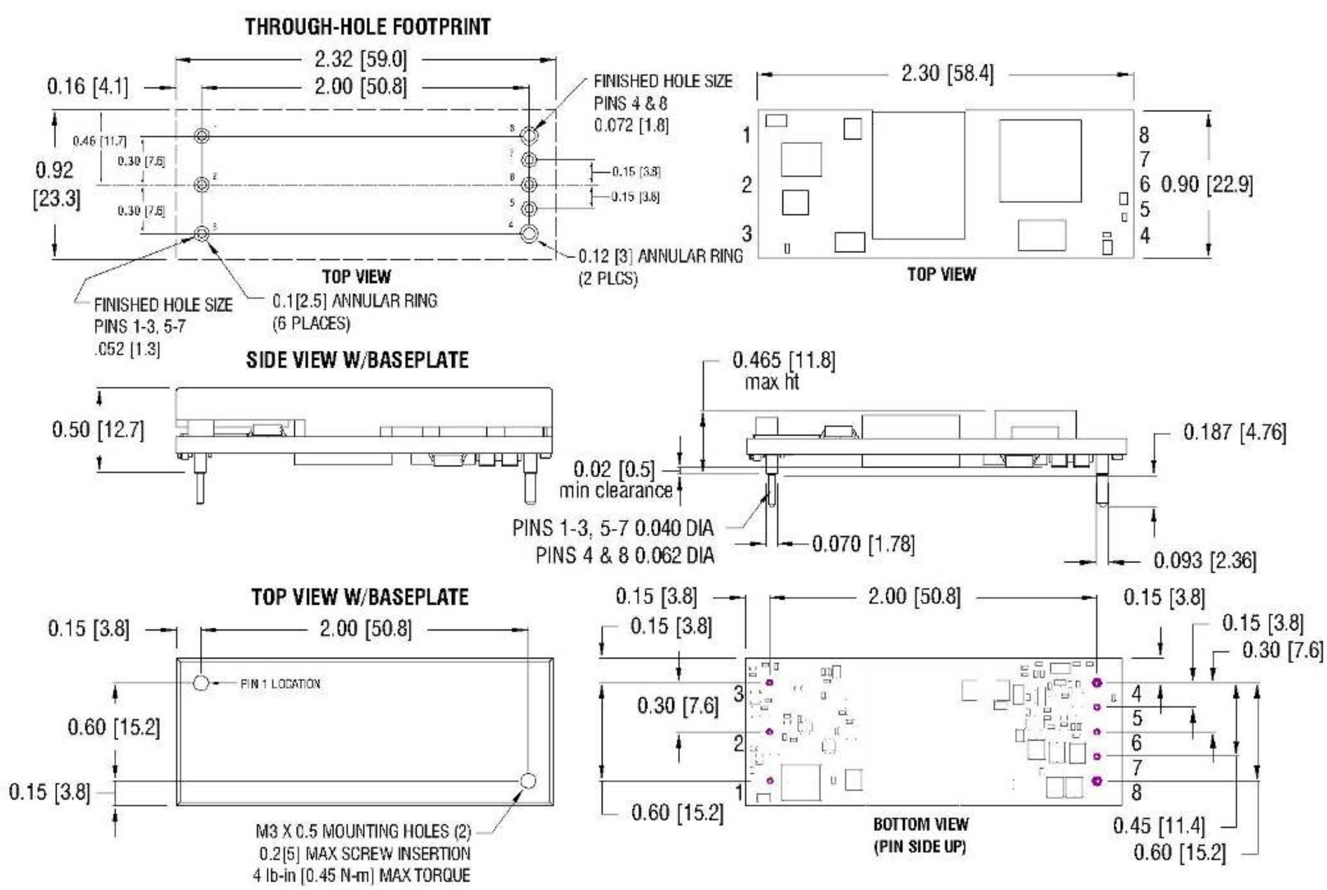


Figure 18. CPE3D18 Conducted Emissions using above specified input filter, Vin = 24V, Full Resistive Load

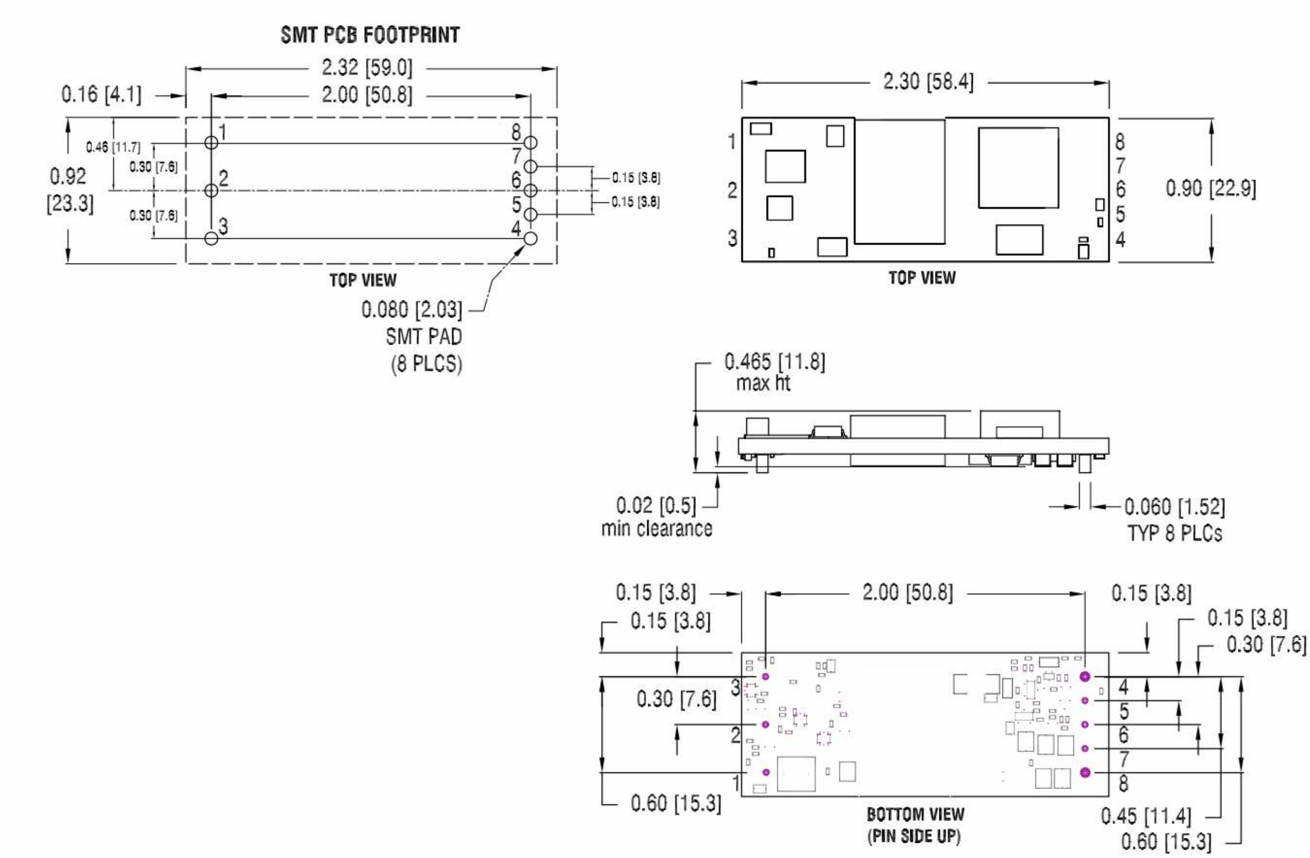
MODULE PIN ASSIGNMENT:

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 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: Meets 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 – THROUGH-HOLE:



MECHANICAL OUTLINE – SMT:



ORDERING INFORMATION:					
Product Identifier	Output Current	Output Voltage	Input Voltage	Enable logic option	Additional features
CPE	3	D	18	N or P	S or B
“Cool Power Eighth”	3A	24V	9 – 36V	N = Negative P = Positive	S = Surface Mount B = Baseplate Option