PowerWatt

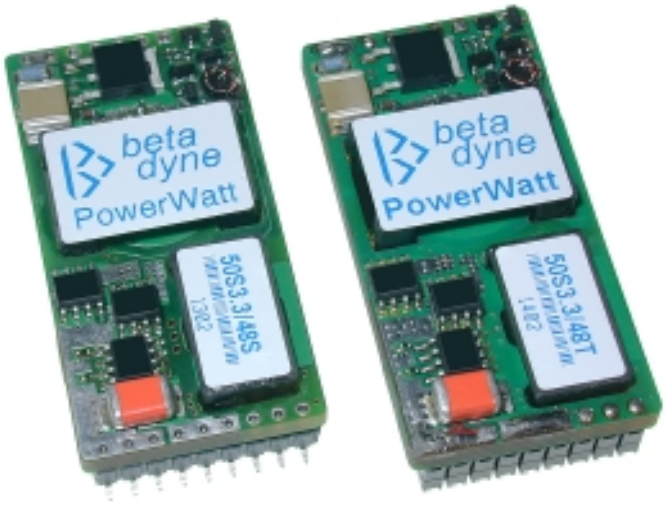
50W Single DC/DC Converter

Industry's First 1"×2"×0.380"

Patented Technology

Key Features

- Efficiency up to 92%
- Power density of 66W/in^3
- 50µS transient response time
- 150µA off-state current
- Output synchronous rectification
- 2:1 input voltage range
- Input to output isolation
- Soft start
- Short circuit protection
- Thermal protection
- Undervoltage protection



Applications

Electronic Data Processing (EDP)

Instrumentation/Industrial/Medical

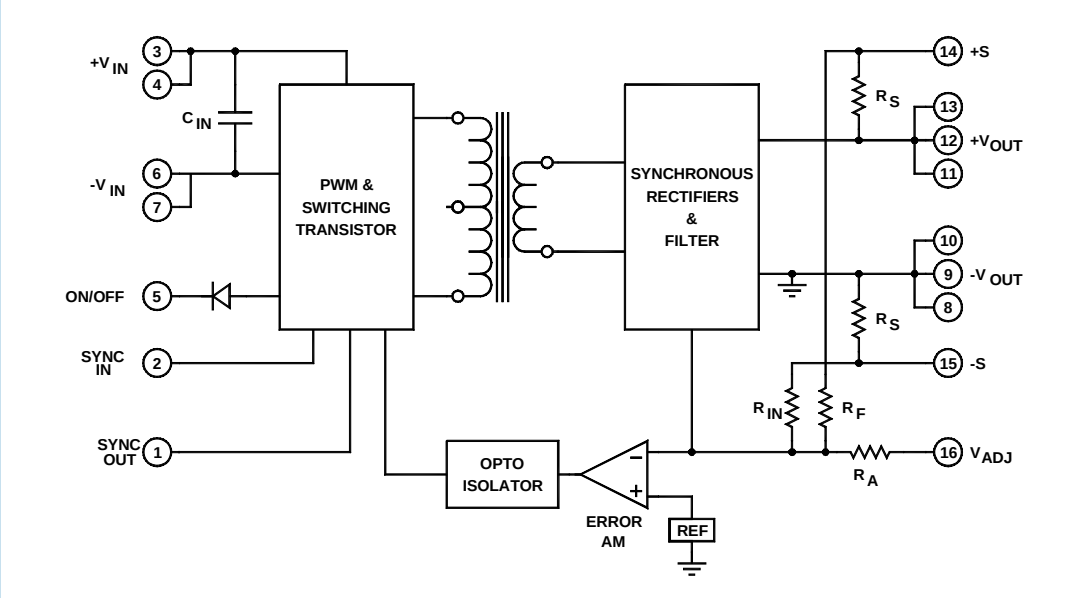
Communications

Computers

Fiber optics

Functional Description

The 50W series is a family of single output DC/DC converters available in two pin arrangements: an SMD *S* version (1"×2"×0.380") and a through-hole *T* version (1"×2"×0.430"). Their high efficiency and density is a result of innovative, patented designs utilizing improved synchronous rectification techniques and planar magnetics. The high efficiency, coupled with a multilayer PCB and thermal management, minimizes power dissipation and allows the converter to operate without an external heatsink. The through-hole and surface-mount pins allow for low-cost installation and act as an integrated heatsink for the converter.



Typical Block Diagram

Electrical Specifications

Unless otherwise specified, all parameters are given under typical ambient temperature of +25°C with an airflow rate = 400LFM. With the given power derating, the operating range is -40°C to +125°C. Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS

PARAMETER / VALUE / UNIT
Input Voltage
Non-operating..... 100V continuous
Operating..... 75V contnuous
Input/Output Isolation..... 1500Vdc
Operating Temperature..... -40 to +125°C
Storage Temperature..... -55 to +125°C
Voltage at On/Off Input Pin..... +40/-1Vdc
Semiconductor Junction Temperature..... 150°C
PCB Operating Temperature..... 150°C
Connector Pins Current Rating..... 10A@25°C
Output Capacitance..... 20,000µF

INPUT SPECIFICATIONS

PARAMETER	CONDITION / NOTE	MIN	TYP	MAX	UNIT
Input Voltage Range	See Model Selection Guide				
Input Startup Voltage, 48V_{IN}				35	Vdc
Input Startup Voltage, 24V_{IN}				17	Vdc
Undervoltage Shutdown, 48V_{IN}		32			Vdc
Undervoltage Shutdown, 24V_{IN}		16			Vdc
Input Filter	Capacitor				
Reflected Ripple	See Figure 1		40		mA_{PP}
No Load Input Current	See Model Selection Guide				
Input Surge Current (20µS Spike)				10	A
Short Circuit Current Limit			125	150	% I_{IN} Max
Off State Current			150		µA
Remote ON/OFF Control					
Supply ON	Pin 5 Open (Open circuit voltage: 12V Max.)				
Supply OFF		0		0.8	Vdc
Logic Input Reference	-Input pins 6 & 7 for ON/OFF, SYNC IN and SYNC OUT				
Logic Compatibility	TTL Open Collector or CMOS Open Drain				

OUTPUT SPECIFICATIONS

PARAMETER	CONDITION / NOTE	MIN	TYP	MAX	UNIT
Voltage and Current Ratings	See Model Selection Guide				
Output Voltage Accuracy			±1		%
Output Voltage Adjustment	See also footnote 3 in Model Selection Guide		±5		%
Ripple & Noise	Without external capacitor		1	2	%V_{PP} of V_{OUT}
Line Regulation	Minimum V_{IN} to maximum V_{IN}		±0.5	1	%
Load Regulation	NL to FL		±1		%
Temperature Coefficient @ FL			0.02		%/°C
Transient Response Time	50% FL to FL to 50% FL, See Figure 3		50		µS
Short Circuit Protection	By input current limiting				
Turn-on Delay with Soft Start	See Figure 4		3	4	mS
Output Overvoltage Protection	None, *(See App. Note SR-001)*				

GENERAL SPECIFICATIONS

PARAMETER	CONDITION / NOTE	MIN	TYP	MAX	UNIT
Efficiency (at full power)	See Model Selection Guide and Figures 2 & 5				
Isolation Voltage (1 min.), Input to Output	All models		1500		Vdc
Isolation Resistance			10^9		Ω
Isolation Capacitance			300		pF
Switching Frequency			400		kHz

ENVIRONMENTAL SPECIFICATIONS

PARAMETER	CONDITION / NOTE	MIN	TYP	MAX	UNIT
Operating Temperature Range (Ambient)[2]	Industrial, See Figure 6	-40		+71	°C
Storage Temperature Range		-55		+150	°C
Maximum Operating PCB Temperature				125	°C
Derating	See Figure 6				
Cooling	See Figure 6				
MTBF	per MIL-HNBK-217F (Ground benign, +25°C)		1.1×10^6		hours

PHYSICAL CHARACTERISTICS

PARAMETER	CONDITION / NOTE	MIN	TYP	MAX	UNIT
Case Size - T version (Through-hole)	1×2×0.430in. (25.4×50.8×19.92mm)				
Case Size - S version (SMD)	1×2×0.380in. (25.4×50.8×9.65mm)				
Weight	1oz. (28.3g)				

Model Selection Guide

MODEL NUMBER	INPUT					OUTPUT		
	Voltage (Vdc)		**Current** (mA)		**Reflected Ripple**[2] (mA_{PP})	**Voltage** (Vdc)	**Current** (A)	**Efficiency Full Load** (%)
	Nominal	**Range**	**No Load**	**Full Load**[1]				
50S1.8/24[3]	24	18-36	81	1765	40	1.8	20	85
50S2.5/24	24	18-36	81	2395	40	2.5	20	87
50S3.3/24	24	18-36	81	2341	40	3.3	15	89
50S5/24	24	18-36	160	2400	40	5.0	10	87
50S1.8/48[3]	48	36-72	40	872	20	1.8	20	86
50S2.5/48	48	36-72	40	1184	20	2.5	20	88
50S3.3/48	48	36-72	40	1132	20	3.3	15	92
50S5/48	48	36-72	40	1145	20	5.0	10	91

[1] The maximum input current at any given input range measured at minimum input voltage is given as $1.6*I_{NOMINAL}$. Nominal input current is the typical value measured at the input of the converter under full-load room temperature and nominal input voltage (24Vdc and 48Vdc).
[2] Measured with 22µF capacitor for $48V_{IN}$ and 100µF capacitor for $24V_{IN}$ at the input power pins in series with 10µH inductor (see Figure 1A).
[3] The $1.8V_{OUT}$ models have ±20% output voltage adjustment range from $1.5V_{OUT}$ to $2V_{OUT}$.

ORDERING GUIDE

50 S __/__ _

- Power
- Number of Outputs (**S** = Single)
- Output Voltage
- Input Voltage
- Connector Option (**T** = Through-hole, **S** = SMD)

EXTERNAL SYNCHRONIZATION

Our 50W DC/DC converters can be synchronized to an external TTL or CMOS clock signal. Insert a 470pF to 1000pF ceramic capacitor between the driving clock signal and the SYNC pin (Pin 2) of the convertor. The frequency of the signal must be between 380kHz and 420kHz, with a duty cycle of 50% and an amplitude between 3Vdc minimum and 5Vdc typical.

See Application Note DC-005: Synchronization.

EXTERNAL TRIMMING OF OUTPUT VOLTAGES

To trim the output voltage DOWN, connect a 5% ¼W resistor between the + (plus) output and trim pin of the converter. To trim the output voltage UP, connect a 5% ¼W resistor between the – (minus) output and trim pins of the converter. For UP/DOWN trimming capability, connect a 10kW potentiometer between the + and – output pins, with the wiper arm connected to the trim pin. The trim resistors/potentiometer can be connected at the converter output pins or the load. However, if connected at the load, the resistance of the runs becomes part of the feedback network which improves load regulation. If the load is some distance from the converter, connect the trim resistors/potentiometer at the same point where the sense pins are connected and bypass the V_{ADJ} and sense pins with a 0.01µF to 0.10µF capacitor at the converter pins.

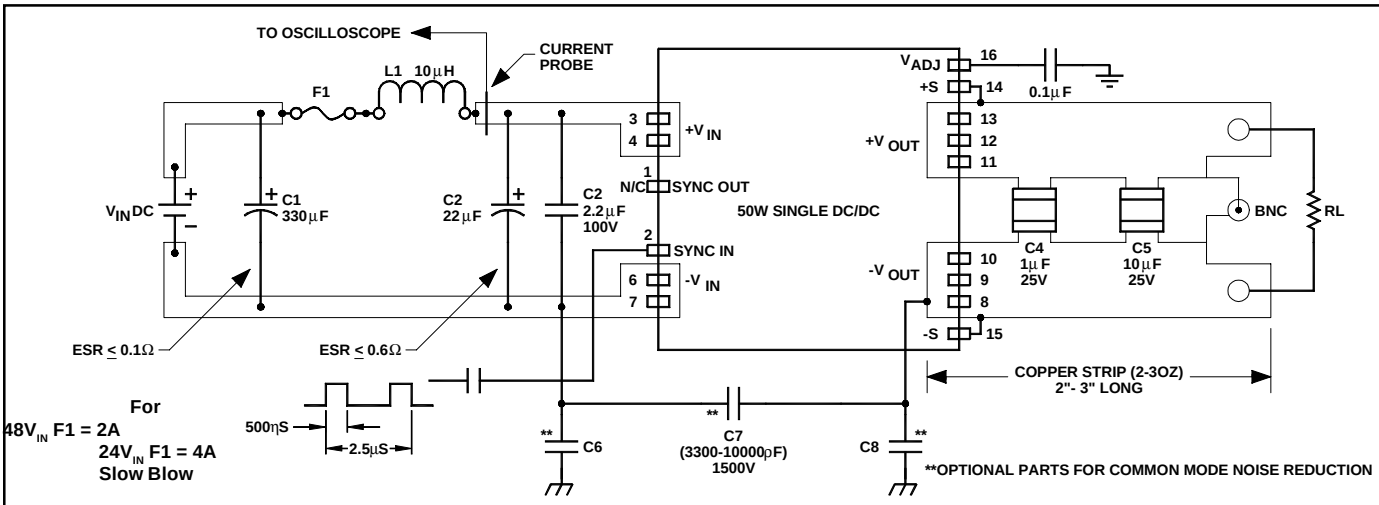


FIGURE 1A. Setup for output and reflected ripple measurement

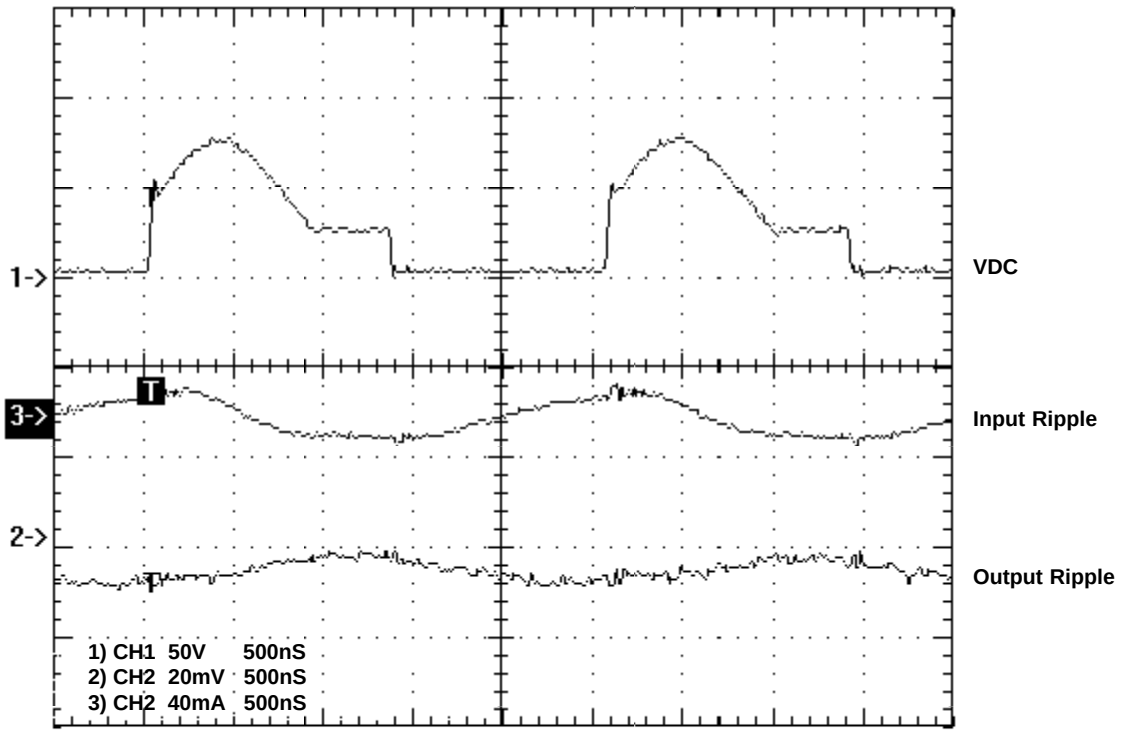


FIGURE 1B. Output ripple and reflected ripple from setup in Fig. 1A for 50S3.3/24

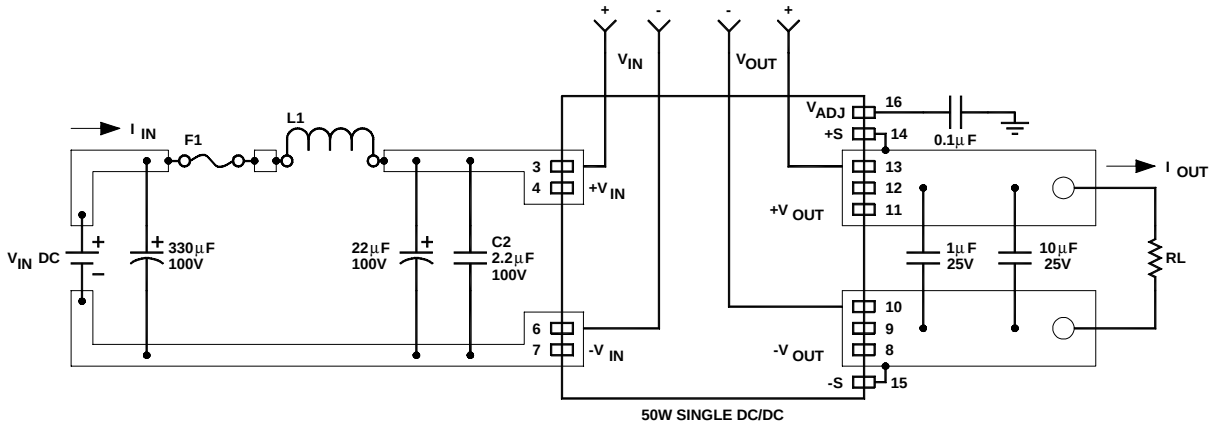


FIGURE 2. Setup for efficiency measurements

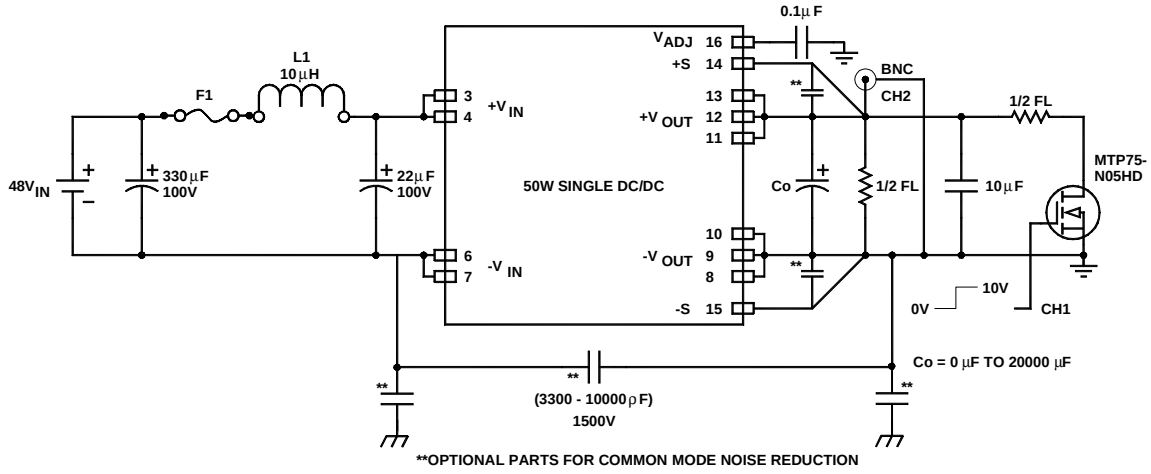


FIGURE 3A. Setup for transient response measurements

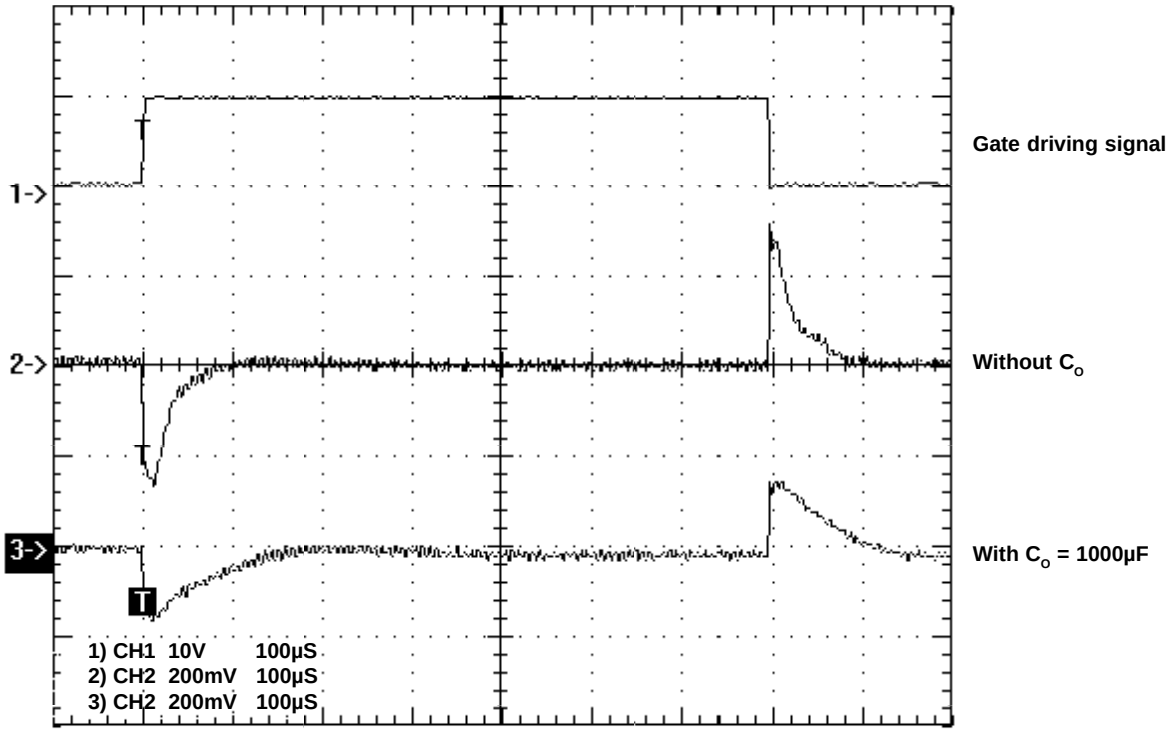


FIGURE 3B. Transient response of 50S3.3/48, 50% FL to FL load step

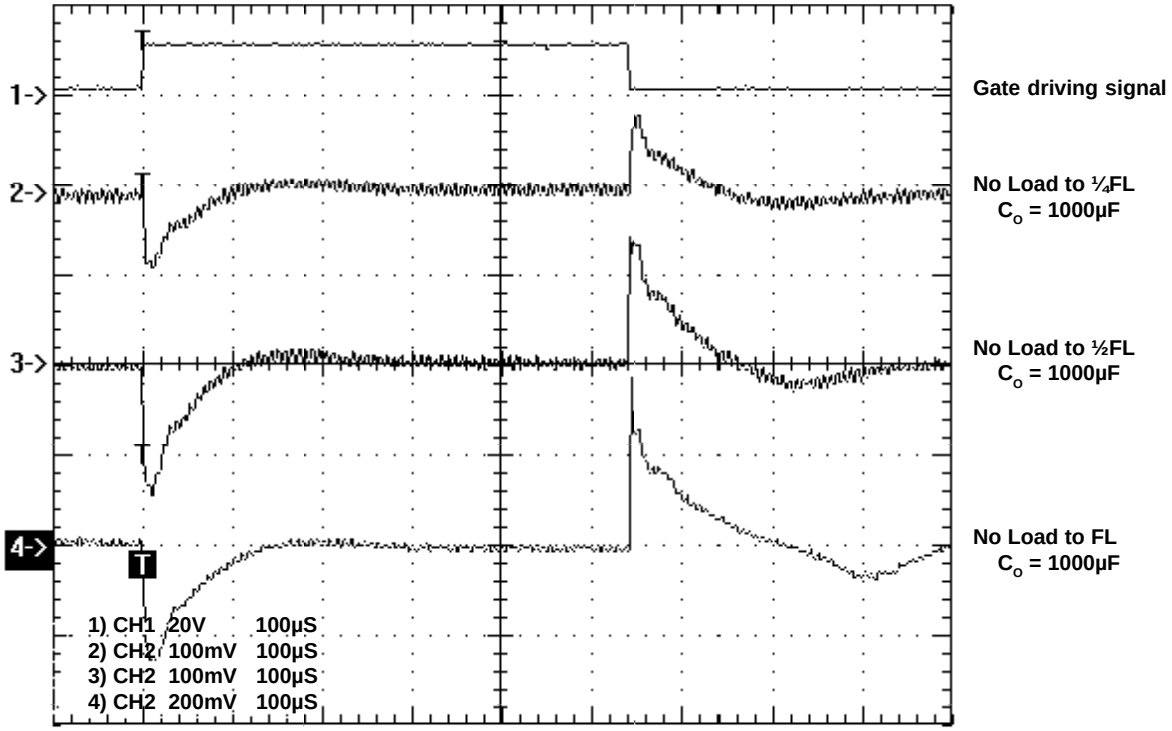


FIGURE 3C. Transient response with 1000µF capacitor with both Sense pins connected at the load (Refers to Figure 3A)

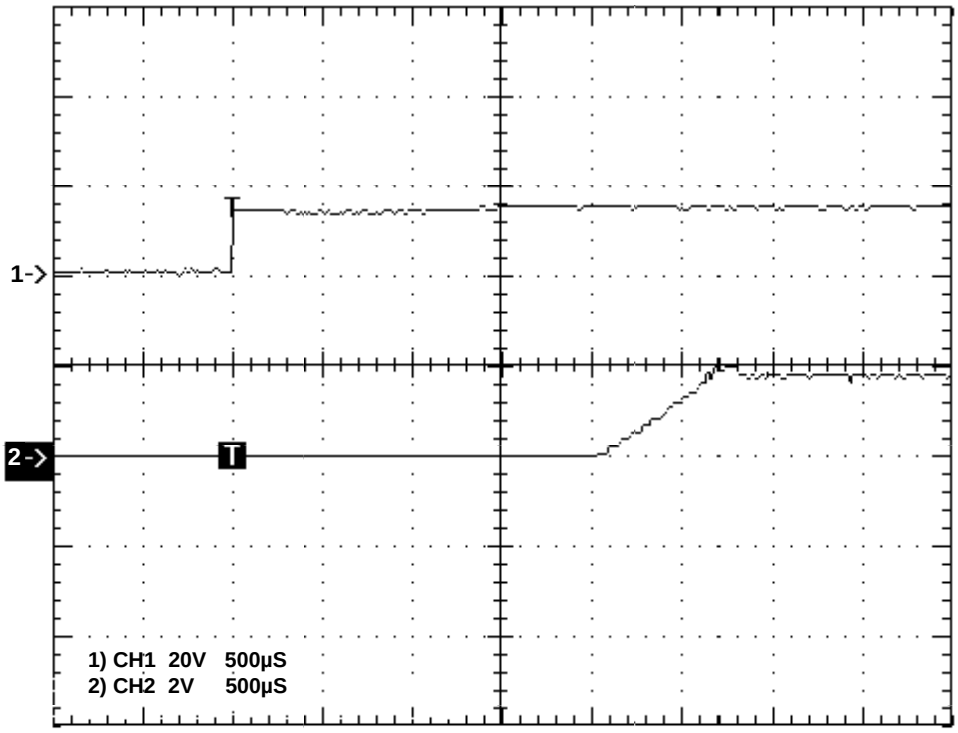


FIGURE 4. Turn-on and soft start with 4700µF capacitor connected at the output

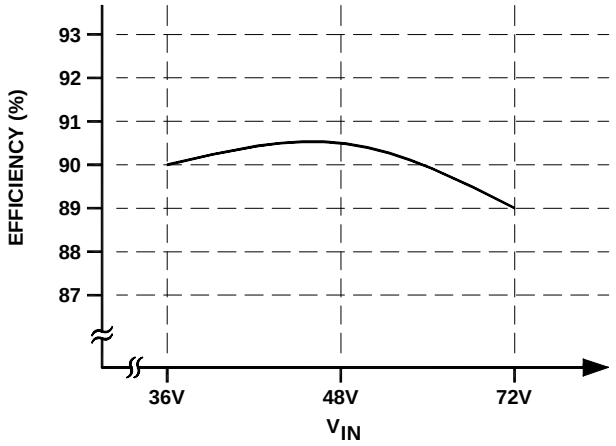


FIGURE 5A. Efficiency vs. Input Line for $3.3V_{OUT}$

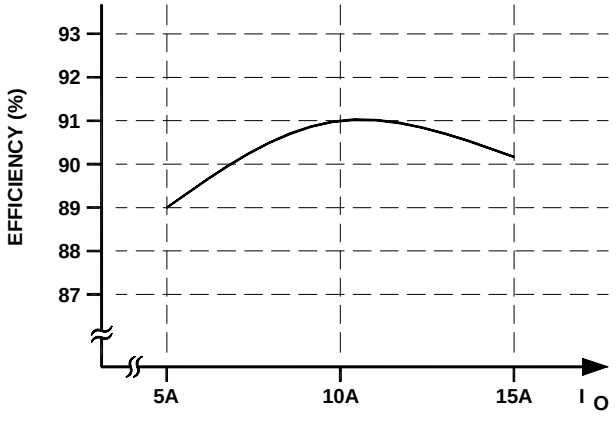


FIGURE 5B. Efficiency vs. Output Line for $3.3V_{OUT}$

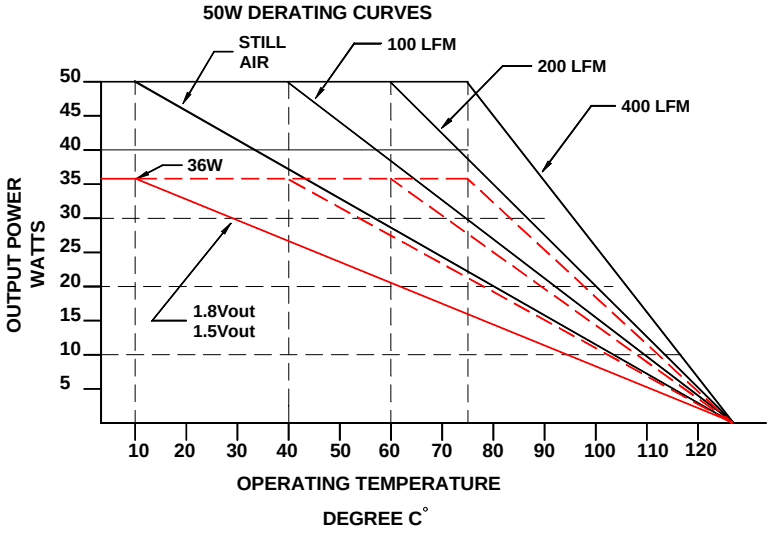
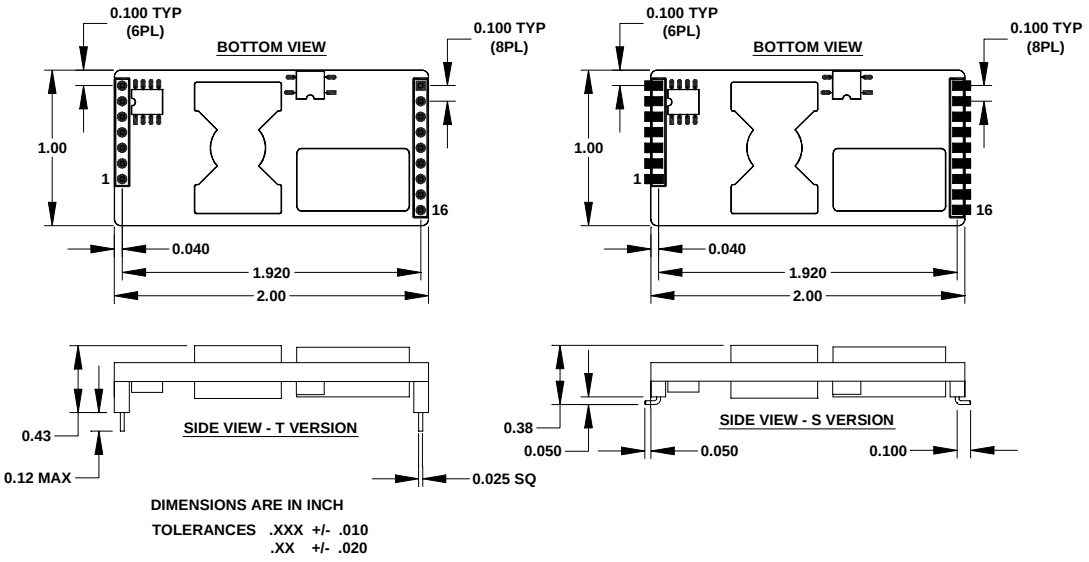


FIGURE 6. Worst case derating for 50W PowerWatt series

DIMENSIONS

in inches



INPUT PINS

Pin	Function
1	SYNC OUT
2	SYNC IN
3	$+V_{IN}$
4	$+V_{IN}$
5	ON/OFF
6	$-V_{IN}$
7	$-V_{IN}$

OUTPUT PINS

Pin	Function
8	$-V_{OUT}$
9	$-V_{OUT}$
10	$-V_{OUT}$
11	$+V_{OUT}$
12	$+V_{OUT}$
13	$+V_{OUT}$
14	+S
15	-S
16	V_{ADJ}

APPLICATION CONSIDERATIONS

Pin Functions

SYNC OUT (Pin 1): Output-driving signal of the PWM; to be used only with 50W Power Booster. Do not connect.

SYNC IN (Pin 2): Input synchronization signal to the PWM. Must be AC-coupled to an external driver synchronization signal when the switching frequency of the converter (400kHz) is required to synchronize with an external frequency source.

+V_{IN} (Pins 3 and 4): For positive input power supply connections.

ON/OFF (Pin 5): Turns converter off when pulled to ground through an open collector or open drain transistor. Maximum voltage at this pin is 10V minus a diode drop. Can be parallel connected with the ON/OFF pins of multiple converters or any Beta Dyne converter that may reside in the system. Leave this pin open for continuous operation.

-V_{IN} (Pins 6 and 7): For negative input power supply connection (or input ground).

-V_{OUT} (Pins 8, 9 and 10): Negative output (GND).

+V_{OUT} (Pins 11, 12 and 13): Positive output voltage.

+S (Pin 14): Positive output voltage sense; to be connected to the positive output voltage at the load only.

-S (Pin 15): Negative output voltage sense; to be connected to the negative output at the load only.

V_{ADJ} (Pin 16): Output voltage adjust; to be used for an output voltage adjustment. Bypass this pin with a 0.01µF to 0.10µF capacitor.

DESIGN CONSIDERATIONS

Input Source Impedance

The input of the converter should be connected to a low AC-impedance source. To reduce the impedance of a potentially high-inductive DC source, use a low ESR electrolytic capacitor (ESR < 0.6W@400kHz) mounted as close to the input pins as possible to ensure stability of the converter. As suggested in Figures 1 through 3, an electrolytic capacitor (22µF for 48V_{IN} or 47µF to 100µF for 24V_{IN}) in parallel with an SMD 2.2µF ceramic capacitor will ensure stability under any line or load condition. The 330µF capacitor before the input inductor L1 will reduce both reflected ripple and any long wire impedance from the DC source.

Output Filter Impedance

The impedance of an output filter may also affect the stability of a converter when additional low-pass filters are used. If additional output ripple reduction is required, avoid installing series inductors at the output. Instead, try to maximize output capacitance. The inductor of the output copper strips and a 1000µF capacitor will be enough for most applications. Low ESR electrolytic or tantalum capacitors can be used for additional output ripple reduction in parallel with ceramic capacitors for high-frequency attenuation. We recommend Vishay Sprague 594D Solid Tantalum Chip Capacitors.

THERMAL CONSIDERATIONS

Under full load, the PowerWatt 50W converters dissipate between 5W to 9W of power (depending on the model). The generated heat is transferred to the ambient by air conduction. At room temperature without any air movement, the operating environment of the converter is higher than room temperature, 25-50°C higher, due to the fact that air around the converter heats up.

To measure the actual operating environment of the converter in a still air environment, place a thermocoupler a half-inch above the top center of the converter. Perform the same temperature measurement in a forced air convection system and use those temperature values for your thermal calculations. Do not assume the temperature is constant throughout a forced air cooling system! Surrounding components and the load can cause the converter to go to thermal shutdown.

The minimum junction temperature of all semiconductors is 150°C and the maximum operating temperature of the PCB is 150°C. When the temperature of the PCB reaches approximately 125°C, the converter will turn off. The thermal hysterisis of 20-30°C will allow the converter to cool off and resume operation once it reaches approximately 95°C. If there is not enough air circulation due to air fan failure of the system or very high environmental temperatures, the converter will stay in this so-called “hiccup” (ON/OFF) thermal mode indefinitely.

EFFICIENCY MEASUREMENTS

Using the setup given in Figure 2, measure the input and output voltage at the pins at the top of the multiplayer PCB and use these values to calculate the efficiency. The voltage drop at full load at the output (7A per output pin when measured from the top of the PCB to the other end of the pin) is 14mV_{OUT} at room temperature. Even though 14mV does not look bad, it counts for approximately 0.3W of power dissipation for both the positive and negative output pins for a total power dissipation of 0.6W. A poor layout can cause this worst-case scenario; see ***Layout Considerations*** for more details.

SHORT CIRCUIT PROTECTION

The PowerWatt series is designed to be a building block for higher power generation and to be able to charge very high output capacitance (up to 20000µF). The internal current mode PWM is designed for power limit and it will not go into hiccup mode or latch off when its output short circuits. When a short circuit is applied at the output of the converter, the PWM limits the input current to I_{IN}Max + 25% until thermal protection turns off the converter and forces it into thermal hiccup mode (see ***Thermal Considerations***).

LAYOUT CONSIDERATIONS

The maximum output current of the converter is 25A and is carried to the load through six 10A rated pins. When the converter is installed in a double-sided PCB, use both sides to connect the high current pins and use 2-3oz. copper for the plated through holes and/or power pads.

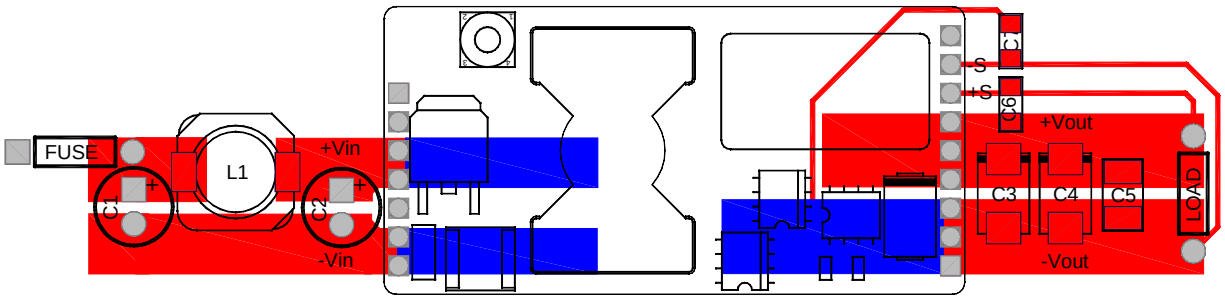
DO NOT USE sockets in production. For lab testing we recommend 3M/Texttool ZIF sockets (P/N: 210-2599-000-0602) or any other socket that offers a maximum conductive surface to the pins.

If possible, maximize the surface area on the board for the power pins and DO NOT install a solder mask (see Figure 7). A solder mask will trap the heat inside the PCB and will not allow for maximum heat transfer even in forced-air cooling systems.

To minimize any IR drop on the pins and reduce thermal resistance, the best solution is to place the multilayer PCB of the 50W on your PCB. The price you pay is a hole in your PCB. The IR drop from top to bottom at 20A is 1mV. The semiconductor junction temperature will drop by 30° to 50°C minimum in a 400LFM-cooled system (depending on the exposed area you allowed on the top and bottom surfaces of your PCB.) When the converter is placed directly on your PCB, the total height from your PCB to the top of the converter will be 0.250 inches (see Figure 8).

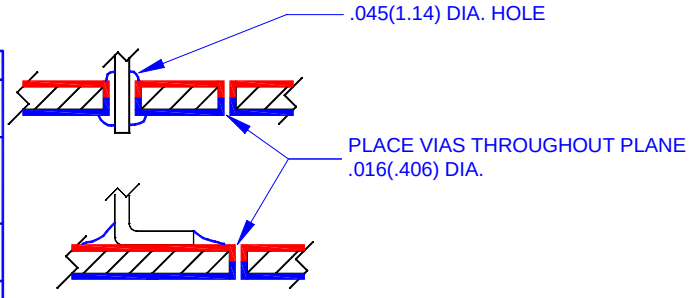
Please note that in a multilayer PCB the inner layers do not contribute much in reducing the thermal resistance of the power component, they only reduce the resistance to the load. If the top and bottom layers of your PCB can be plated up to 3-4 oz., you do not have to use a multilayer PCB for the converter.

If the sense run length exceeds 2 inches, the sense pins may have to be bypassed at a point close to the converter. Keep in mind to bypass to their respective polarity. Avoid running digital signal lines parallel to the sense pins. If more than one power device or converter is used per system board, use a star ground connection for all power devices.



SUGGESTED PARTS

	24Vin	48Vin
FUSE	PICO II 4A@125V S.B.	PICO II 4A@125V S.B.
L1	10µH SUMIDA PT#CDRH104R-100	10µH SUMIDA PT#CDRH104R-100
C1&C2	47µF-100µF UNITED CHEMI-CON	22µF-47µF@100V UNITED CHEMI-CON
C3&C4	220µF@6.3V OR 470µF@6.3V SPRAGUE	220µF@6.3V OR 470µF@6.3V SPRAGUE
C5	10µF CERAMIC UNITED CHEMI-CON	10µF CERAMIC UNITED CHEMI-CON
C6&C7	.01µF-.1µF CERAMIC	.01µF-.1µF CERAMIC



NOTES:

1. DIMENSIONS ARE IN INCH(mm).
2. TOLERANCE: .XXX ± .005

FIGURE 7. Suggested layout for converter with T version or S version pin configuration

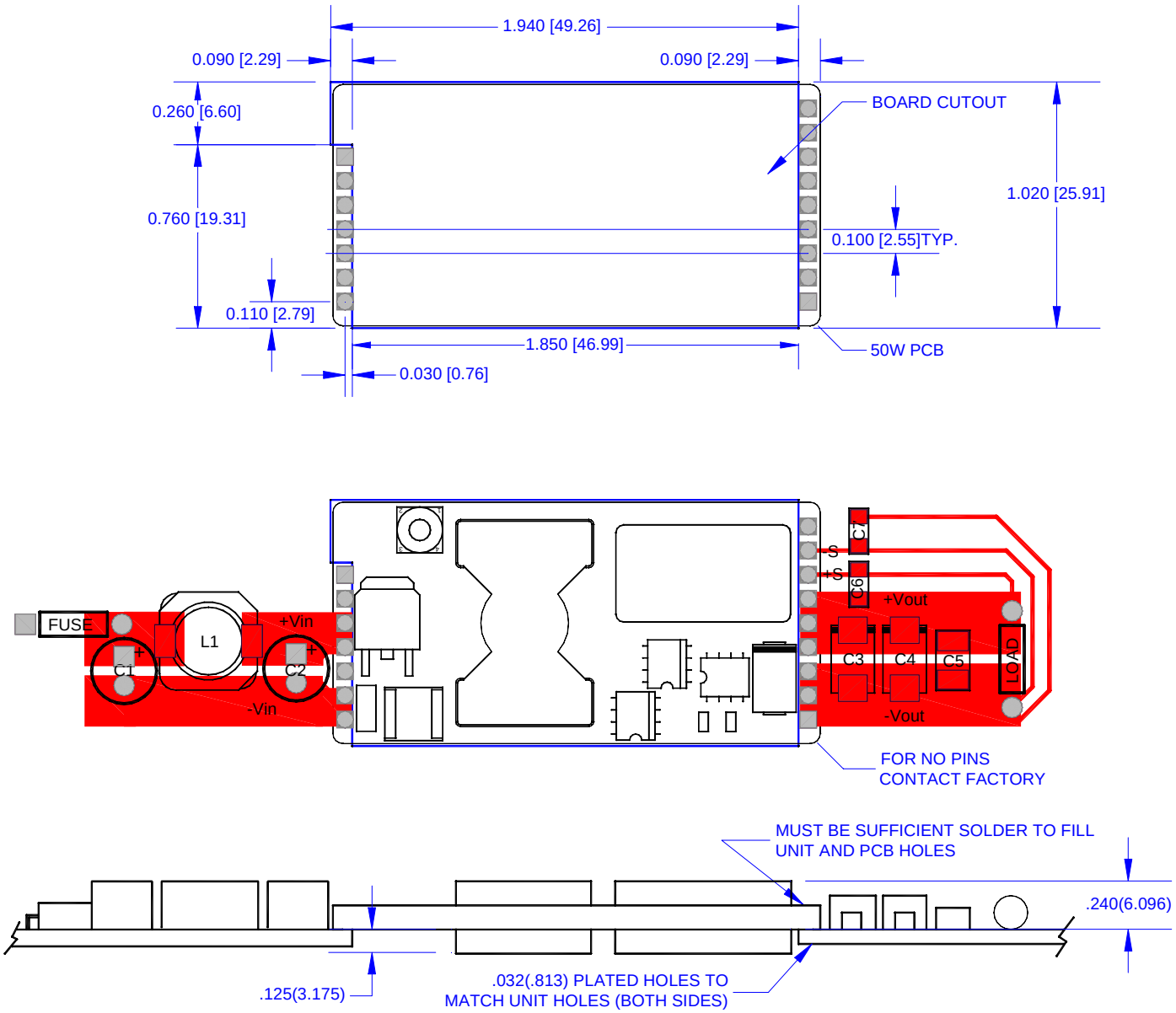


FIGURE 8. Reduced height option layout for converter with no pins

Converter is shipped to customer without pins and should be placed directly on a PCB. Connections are made through the feed-through pin holes. Follow the above PCB cutout for your board layout. To minimize any contact resistance, hand-soldering may be required.