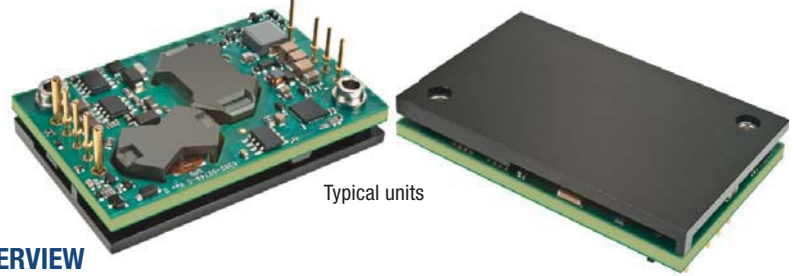


Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range



## KEY PRODUCT FEATURES

- 2:1 Input Voltage Range (36V – 75V)
- Trimmable 23.84 (-20%) to 32.78 (10%) Volts output (29.8V, nom)
- Up to 150W output power @ 36 - 75Vin
- Efficiency = 92.5% (typ)
- Industry standard 1/4 brick package
- Optional Baseplate for conduction cooling applications
- Optional Baseplate to ground connection pin
- Positive & negative logic on/off control option
- Monotonic startup into pre-bias/pre load output conditions
- Over-current (power limiting); Over-temperature protection; Over-Voltage Protection
- Low output ripple and noise
- Strong thermal derating performance
- Operational temperature range -40°C to +100°C (baseplate temperature)
- 2250V I/O isolation, Basic insulation
- Certified to UL/EN 60950-1, CSA-C22.2 No. 60950-1, 2nd edition safety approvals

## PRODUCT OVERVIEW

Murata Power Solutions' fully isolated Power Amplifiers Quarter-Brick series of DC-DC converters is used in power radio-applications and is optimized for the new generation of micro cell transmitter applications requiring up to 150W. With an input voltage range of 36 to 75 Volts, the PAQ Series delivers up to 5 Amps of output current from a fully regulated 29.8V output.

The PAQ offers a wide output voltage range with the flexibility to adjust its output voltage with the range of 23.84 to 32.78V (29.8V nom) that accommodates multiple power-amplifiers designs, industry leading efficiency (92.5% @29.8Vout full load), and optimized design to reduce component count for increased reliability. Design features include an optional baseplate that is optimized for RFPA applications being deployed in sealed box applications with its heat sink fixed directly to the host equipment chassis.

The PAQ is designed as an open-frame ¼ brick, through-hole mounting, with options for positive or negative logic and optional baseplate. Intended markets include Micro Base Stations (Micro Cell Transmitters, RFPA (radio frequency power amplifiers), Microwave Radio communications, and Telecom and Data Equipment applications where a 2:1 input voltage, 23 to 33Vout and isolated power is needed.

The PAQ offers Output over voltage, over current protection, thermal shutdown, Input under-voltage lockout, and short circuit protection. The option for adding a baseplate for cold plate applications is also available with an optional baseplate to ground connect pin. The modules are designed to meet Conducted EMI requirement for class B with an optional external filter. The PAQ provides voltage isolation (basic) from input to output of 2250V. The PAQ series is certified to safety standards UL/EN/IEC/CSA 60950-1, 2nd edition.

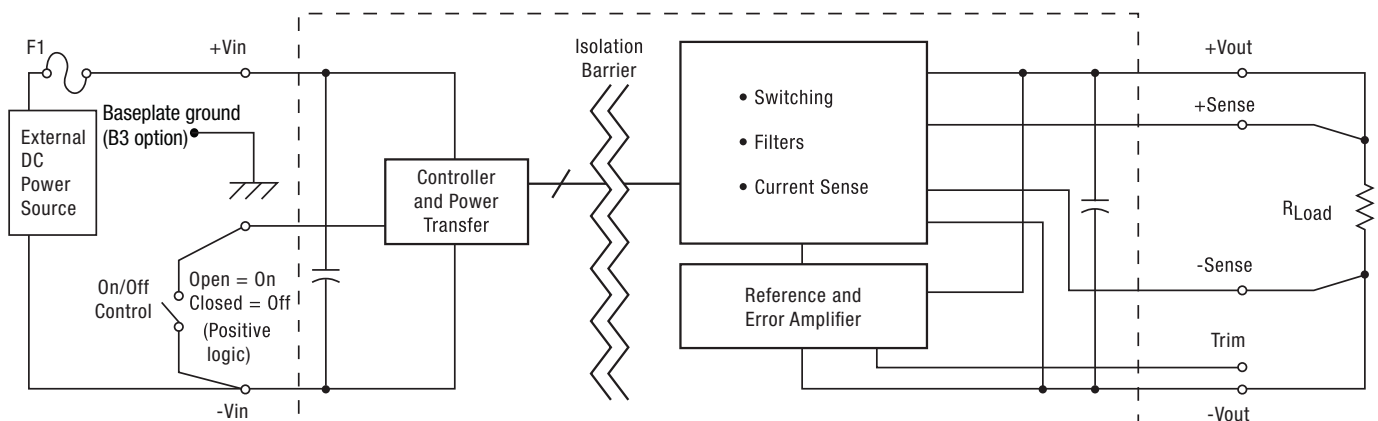


Figure 1. Connection Diagram

Typical topology is shown. Murata Power Solutions recommends an external fuse.



Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

ORDERING GUIDE ①															
Root Model ①	Output						Input				Efficiency		Dimensions (open frame)		
	V <sub>OUT</sub> (Volts)	I <sub>OUT</sub> (Amps, max.)	Power (Watts)	R/N (mV pk-pk)		Regulation (Max.) ②		V <sub>IN</sub> Nom. (Volts)	Range (Volts)	I <sub>IN</sub> no load (mA)	I <sub>IN</sub> full load (Amps)	Min.	Typ.	(inches)	(mm)
				Typ.	Max.	Line	Load								
PAQ-29/5-D48-C	29.8	5	150	40	90	±0.1%	±0.1%	48	36-75	85	3.36	91%	92.5%	2.3x1.45x0.46	58.4x36.8x11.7

① Please refer to the part number structure for additional ordering information and options.  
 ② All specifications are typical at nominal line voltage and full load, +25°C unless otherwise noted. See

detailed specifications. Output capacitors are 1 µF || 10 µF with a 22µF input capacitor. These caps are necessary for our test equipment and may not be needed for your application.

**To Be Discontinued \***

**NOTE: The following models are To Be Discontinued.**  
 PAQ-29/5-D48PB3-C, PAQ-29/5-D48PB-C and PAQ-29/5-D48P-C.

**PART NUMBER STRUCTURE**

**PAQ - 29 / 5 - D48 N B 3 Lx - C**

- PAQ** - Power Amplifier Quarter-Brick
- 29 / 5** - Nominal Output Voltage (29.8V) / Maximum Rated Output Current in Amps
- D48** - Input Voltage Range (D48 = 36-75 Volts (48V nominal))
- N** - On/Off Control Logic (N = Negative logic, P = Positive logic)
- B** - Baseplate Option (Blank = No baseplate, standard; B = Baseplate installed, optional)
- 3** - Baseplate Pin 3, see Mechanical Drawings (special order)\* (Blank = No pin 3, standard; 3 = Pin 3 installed, optional)
- Lx** - Pin length option (Blank = standard pin length 0.190 in. (4.8 mm); L1 = 0.110 in. (2.79 mm)\*; L2 = 0.145 in. (3.68 mm)\*)
- C** - RoHS Hazardous Materials compliance (C = RoHS-6 (does not claim EU RoHS exemption 7b-lead in solder), standard)

**To Be Discontinued \***

\*Minimum order quantity is required. Samples available with standard pin length only.

Note: Some model number combinations may not be available. See website or contact your local Murata sales representative.

**PAQ Pin 3 Baseplate Connection**

The PAQ module has an additional pin 3 on special order that connects to the baseplate but is electrically isolated from the rest of the converter. Please refer to the mechanical drawings. Pin 3 offers a positive method of controlling the electrical potential of the baseplate, independent of the converter.

The baseplate may be ordered by adding a "B" to the model number tree and pin 3 will be pre-installed by adding a "3." The two options are separate. Please refer to the Ordering Guide. Do not order pin 3 without the baseplate. Note that "pin 3" converters may be on limited forecast, requiring minimum order quantities and scheduled deliveries.

**Complete Model Number Example: PAQ-29/5-D48NBL1-C**

Negative On/Off logic, baseplate installed, 0.110" pin length, RoHS-6 compliance

### FUNCTIONAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS	Conditions ① /Comments	Minimum	Typical/Nominal	Maximum	Units
Input Voltage, Continuous		0		80	Vdc
Input Voltage, Transient	100 mS max. duration			100	Vdc
Isolation Voltage	Input to output, continuous			2250	Vdc
On/Off Remote Control	Power on, referred to -Vin	0		13.5	Vdc
Output Power		0		150.49	W
Output Current	Current-limited, no damage, short-circuit protected	0		5	A
Storage Temperature Range	Vin = Zero (no power)	-55		125	°C
Absolute maximums are stress ratings. Exposure of devices to greater than any of these conditions may adversely affect long-term reliability. Proper operation under conditions other than those listed in the Performance/Functional Specifications Table is not implied or recommended.					
INPUT	Conditions ① ③				
Operating voltage range		36	48	75	Vdc
Recommended External Fuse	Fast blow			8	A
Start-up threshold	Rising input voltage	32.75	33.5	35	Vdc
Undervoltage shutdown	Falling input voltage	31	32	34	Vdc
Internal Filter Type			L-C		
Input current					
Full Load Conditions	Vin = nominal		3.36	3.45	A
Low Line	Vin = minimum		4.45	4.54	A
Inrush Transient			0.125	0.15	A <sup>2</sup> -Sec.
Output in Short Circuit			0.2	0.3	A
No Load	Iout = 0, unit = ON		85	115	mA
Shut-Down Input Current (Off, UV, OT)			2	5	mA
Reflected (back) ripple current ②	Measured at input with specified filter		25	30	mA, p-p
Pre-biased startup	External output voltage < Vset. Monotonic				
GENERAL and SAFETY					
Efficiency	Vin = 48V, full load	91	92.5		%
	Vin = min.	92	93		%
Isolation					
Isolation Voltage	Input to output, continuous	2250			Vdc
	Input to baseplate	1500			Vdc
	Output to baseplate.	1500			Vdc
Insulation Safety Rating	Basic				
Isolation Resistance			100		MΩ
Isolation Capacitance			1500		pF
Safety (certified to the following requirements)	UL-60950-1, CSA-C22.2 No.60950-1, IEC/EN60950-1, 2nd edition		Yes		
Calculated MTBF	Per Telcordia SR-332, issue 1, class 3, ground fixed, Tambient = +25°C		TBD		Hours x 10 <sup>3</sup>
DYNAMIC CHARACTERISTICS					
Fixed Switching Frequency		180	190	200	KHz
Startup Time	Power on to Vout regulated		70	80	mS
Startup Time	Remote ON to Vout regulated		70	80	mS
Dynamic Load Response	50-75-50% load step, settling time to within 3% of Vout		60	120	μSec
Dynamic Load Peak Deviation	same as above		±300	±400	mV
FEATURES and OPTIONS					
Remote On/Off Control ④					
"N" suffix:					
Negative Logic, ON state	ON = Pin connected to -Vin or to external source	0		1	Vdc
Negative Logic, OFF state	OFF = Pin open or connected to external voltage source	3.5		13.5	Vdc
Control Current	Open collector/drain		1		mA
"P" suffix:					
Positive Logic, ON state	ON = Pin open or connected to external voltage source	3.5		13.5	Vdc
Positive Logic, OFF state	OFF = Pin connected to -Vin or to external voltage	0		1	Vdc
Control Current	Open collector/drain		1		mA
Base Plate	"B" suffix				
Case to Ground pin option	("3" Suffix)				

### FUNCTIONAL SPECIFICATIONS, (CONT.)

OUTPUT	Conditions ① /Comments	Minimum	Typical/Nominal	Maximum	Units
<b>Total Output Power</b>		0	149	150.49	W
<b>Voltage</b>					
<b>Nominal Output Voltage</b>	No trim	29.502	29.8	30.098	Vdc
<b>Setting Accuracy</b>	At 50% load, no trim	-1		1	% of Vnom
<b>Output Voltage Range</b>	User-adjustable	-20		10	% of Vnom.
<b>Overvoltage Protection</b>	Via magnetic feedback		38	40	Vdc
<b>Current</b>					
<b>Output Current Range</b>		0	5	5	A
<b>Current Limit Inception</b>	98% of Vnom., after warmup	5.5	6.8	8.2	A
<b>Short Circuit</b>					
<b>Short Circuit Current</b>	Hiccup technique, autorecovery within 1.25% of Vout		1.5	2	A
<b>Short Circuit Duration (remove short for recovery)</b>	Output shorted to ground, no damage; continuous				
<b>Short circuit protection method</b>	Current limiting				
<b>Regulation ⑤</b>					
<b>Total Accuracy:</b>	Over line, load (0-5A), and temp.	28.906		30.69	Vdc
<b>Line Regulation</b>	Vin = min. to max., Vout = nom., Iout = nom.			±0.1	% of Vout
<b>Load Regulation</b>	Iout = min. to max., Vin = 48V			±0.1	% of Vout
<b>Ripple and Noise</b>	5 Hz - 20 MHz BW		40	90	mV pk-pk
<b>Remote Sense</b>			10		%
<b>Temperature Coefficient</b>	At all outputs		±0.02		% of Vout./°C
<b>Maximum Capacitive Loading</b>	Low ESR, resistive load only		1	2200	µF
<b>MECHANICAL</b>					
<b>Outline Dimensions (open frame)</b>			2.3 x 1.45 x 0.46		Inches
<b>(Please refer to outline drawing)</b>			58.4 x 36.8 x 11.7		mm
<b>Outline Dimensions (with baseplate)</b>			2.3 x 1.45 x 0.5		Inches
			58.4 x 36.8 x 12.7		mm
<b>Weight</b>	Open frame		1.56		Ounces
			43.8		Grams
	With baseplate		2.13		Ounces
			60.5		Grams
<b>Through Hole Pin Diameter</b>	pins (1-4,6-8) & (5,9)		0.04 & 0.062		Inches
			1.016 & 1.575		mm
<b>Through Hole Pin Material</b>			Copper alloy		
<b>TH Pin Plating Metal and Thickness</b>	Nickel subplate		50		µ-inches
	Gold overplate		5		µ-inches
<b>ENVIRONMENTAL</b>					
<b>Operating Ambient Temperature Range</b>	With Derating	-40		85	°C
<b>Operating Baseplate Temperature</b>	No derating,	-40		100	°C
<b>Storage Temperature</b>	Vin = Zero (no power)	-55		125	°C
<b>Thermal Protection/Shutdown</b>		115	125	130	°C
<b>Electromagnetic Interference Conducted, EN55022/CISPR22</b>	External filter is required Class B				
<b>RoHS rating</b>	RoHS-6				

### Notes

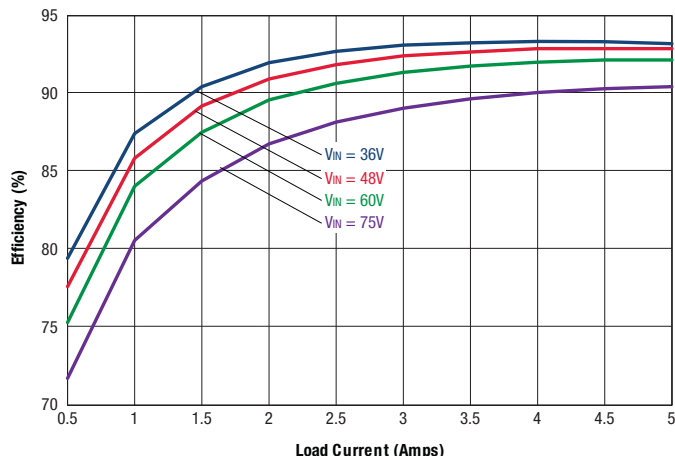
- ① Unless otherwise noted, all specifications apply at Vin = nominal, nominal output voltage and full output load. General conditions are near sea level altitude, no base plate installed and natural convection airflow unless otherwise specified. All models are tested and specified with external parallel 1 µF and 10 µF output capacitors and a 22µF external input capacitor (see Technical Notes). All capacitors are low-ESR types wired close to the converter. These capacitors are necessary for our test equipment and may not be needed in the user's application.
- ② Input (back) ripple current is tested and specified over 5 Hz to 20 MHz bandwidth. Input filtering is Cin = 33 µF/100V, Cbus = 220µF/100V and Lbus = 12 µH.

- ③ All models are stable and regulate to specification under no load.
- ④ The Remote On/Off Control is referred to -Vin.
- ⑤ Regulation specifications describe the output voltage changes as the line voltage or load current is varied from its nominal or midpoint value to either extreme. The load step is ±25% of full load current.

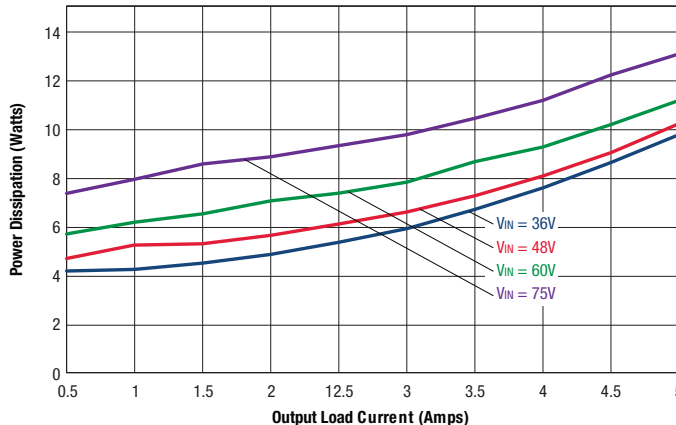
Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

**PERFORMANCE DATA**

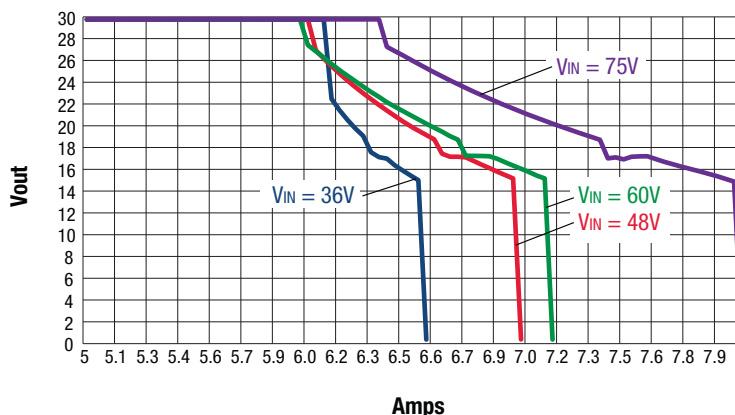
Efficiency vs. Line Voltage and Load Current @ +25°C



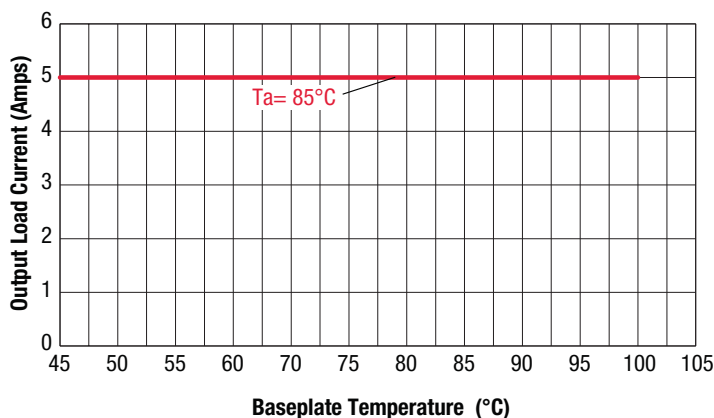
Power Dissipation vs. Load Current @ +25°C



Output Current Limit vs. Output Voltage (at various input line voltages)



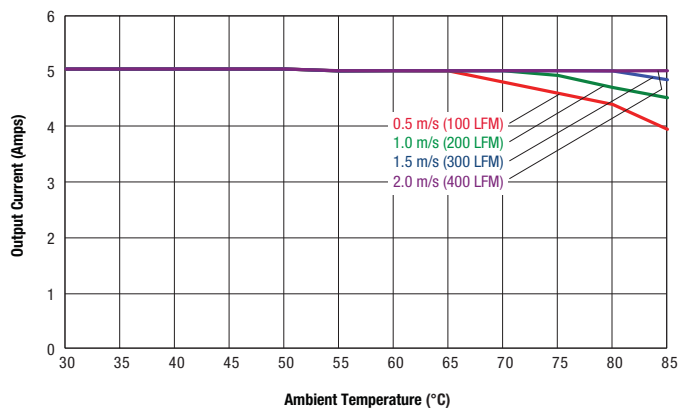
Output Power Derating in Conduction Cooling (Cold Baseplate) Applications  
(V<sub>in</sub> = 36-75V, Ambient Temperature = 85°C) See technical notes section, figure 8.



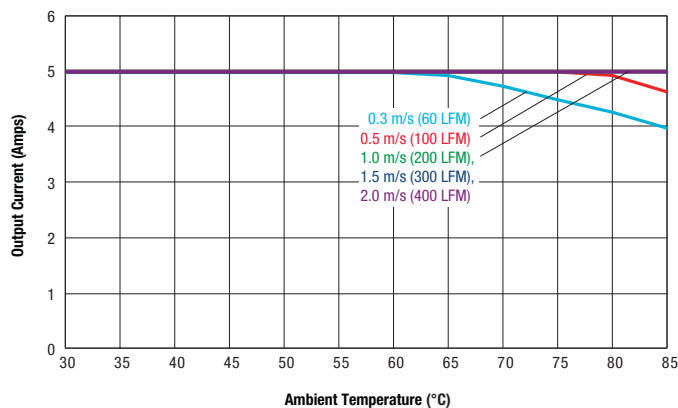
Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

**PERFORMANCE DATA**

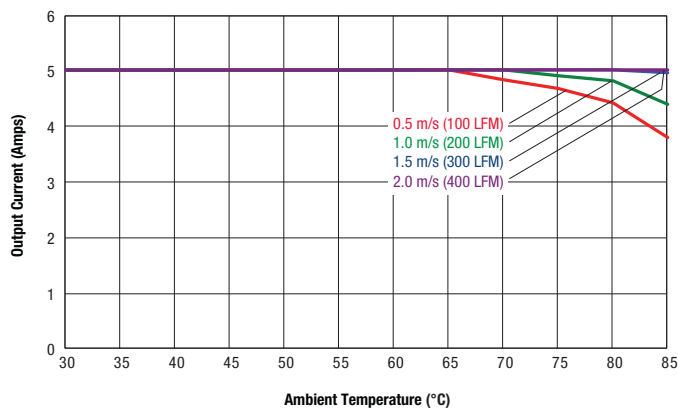
Maximum Current Temperature Derating at sea level  
(Vin = 36V, airflow from pin 1 to pin 4, without baseplate)



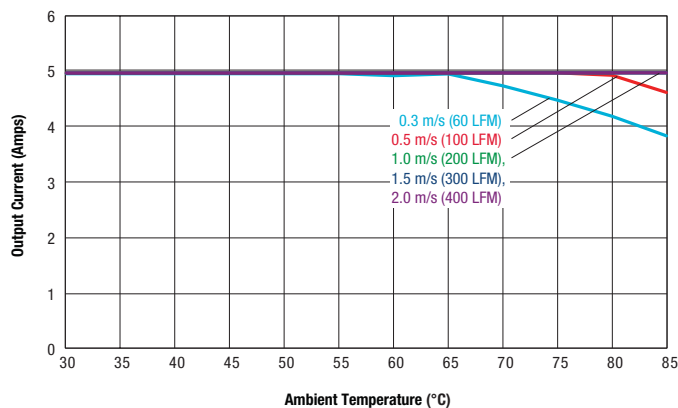
Maximum Current Temperature Derating at sea level  
(Vin = 36V, airflow from pin 1 to pin 4, with baseplate)



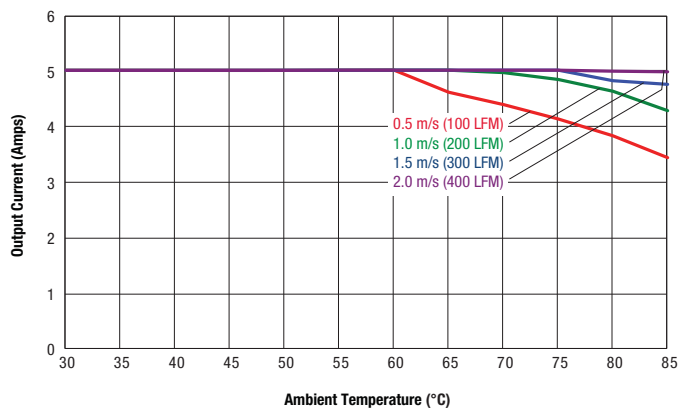
Maximum Current Temperature Derating at sea level  
(Vin = 48V, airflow from pin 1 to pin 4, without baseplate)



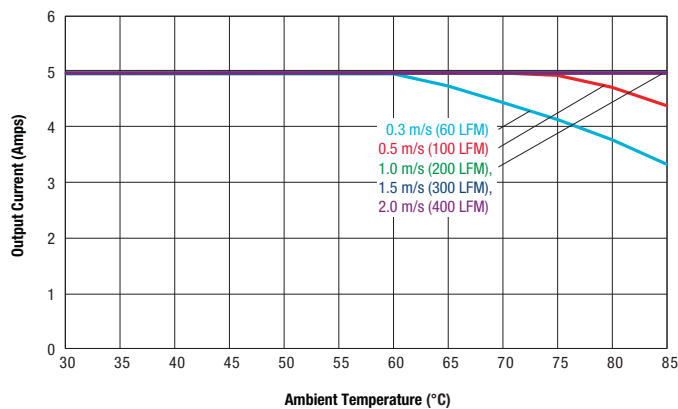
Maximum Current Temperature Derating at sea level  
(Vin = 48V, airflow from pin 1 to pin 4, with baseplate)



Maximum Current Temperature Derating at sea level  
(Vin = 60V, airflow from pin 1 to pin 4, without baseplate)



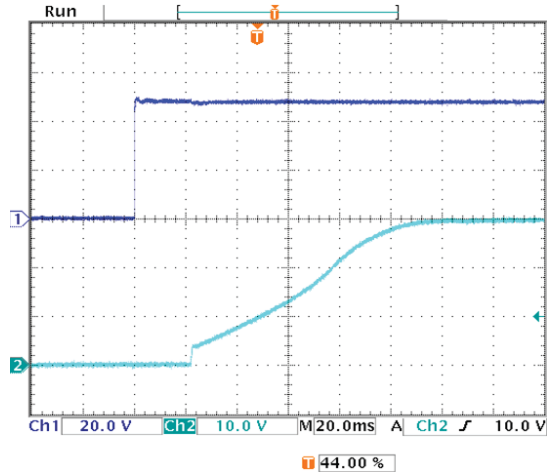
Maximum Current Temperature Derating at sea level  
(Vin = 60V, airflow from pin 1 to pin 4, with baseplate)



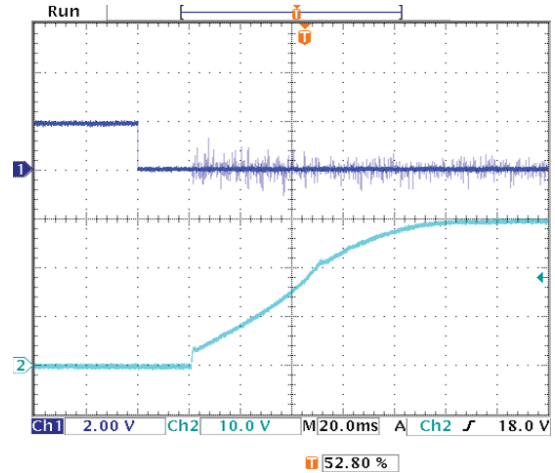
Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

**PERFORMANCE DATA**

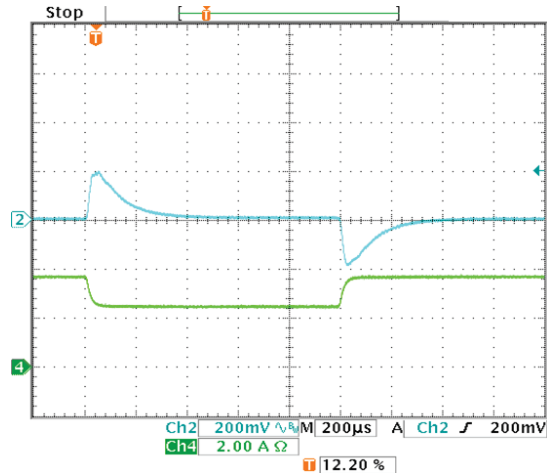
Start up Delay (Vin = 48V, Vout = nom, Iout = 5A, Co = 2200µf, Ta = +25°C)  
Ch1 = Vin, Ch2 = Vout



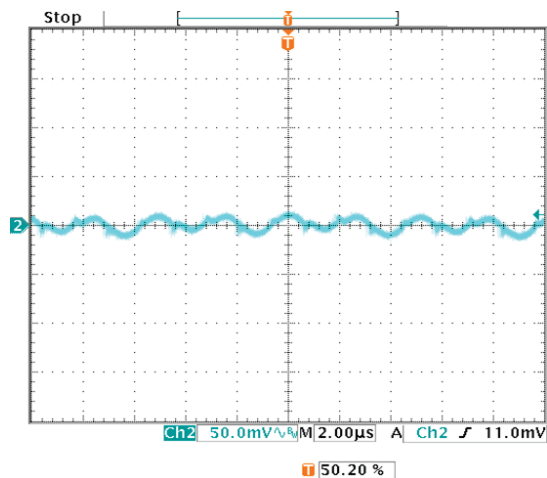
Enable Start up Delay (Vin = 48V, Vout = nom, Iout = 5A, Co = 2200µf, Ta = +25°C)  
Ch1 = Enable, Ch2 = Vout



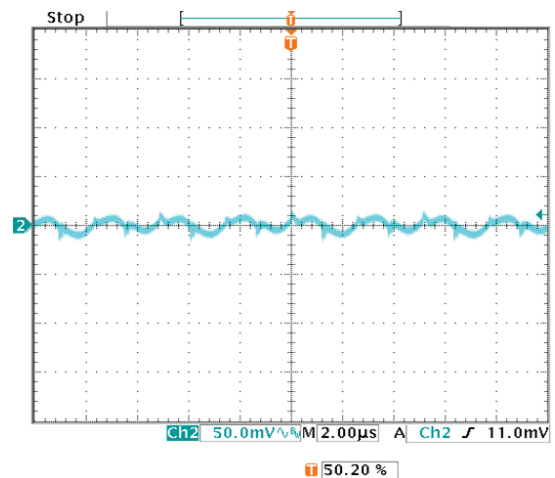
Step load Transient Response (Vin = 48V, Vout = nom, Cloud = 10µf || 1µf,  
Iout = 50-75-50% of full load (2A/div), Ta = +25°C) Ch2 = Vout, Ch4 = Iout



Output Ripple and Noise (Vin = 48V, Iout = 0A, Cloud = 1µf||10µf, Ta = +25°C)

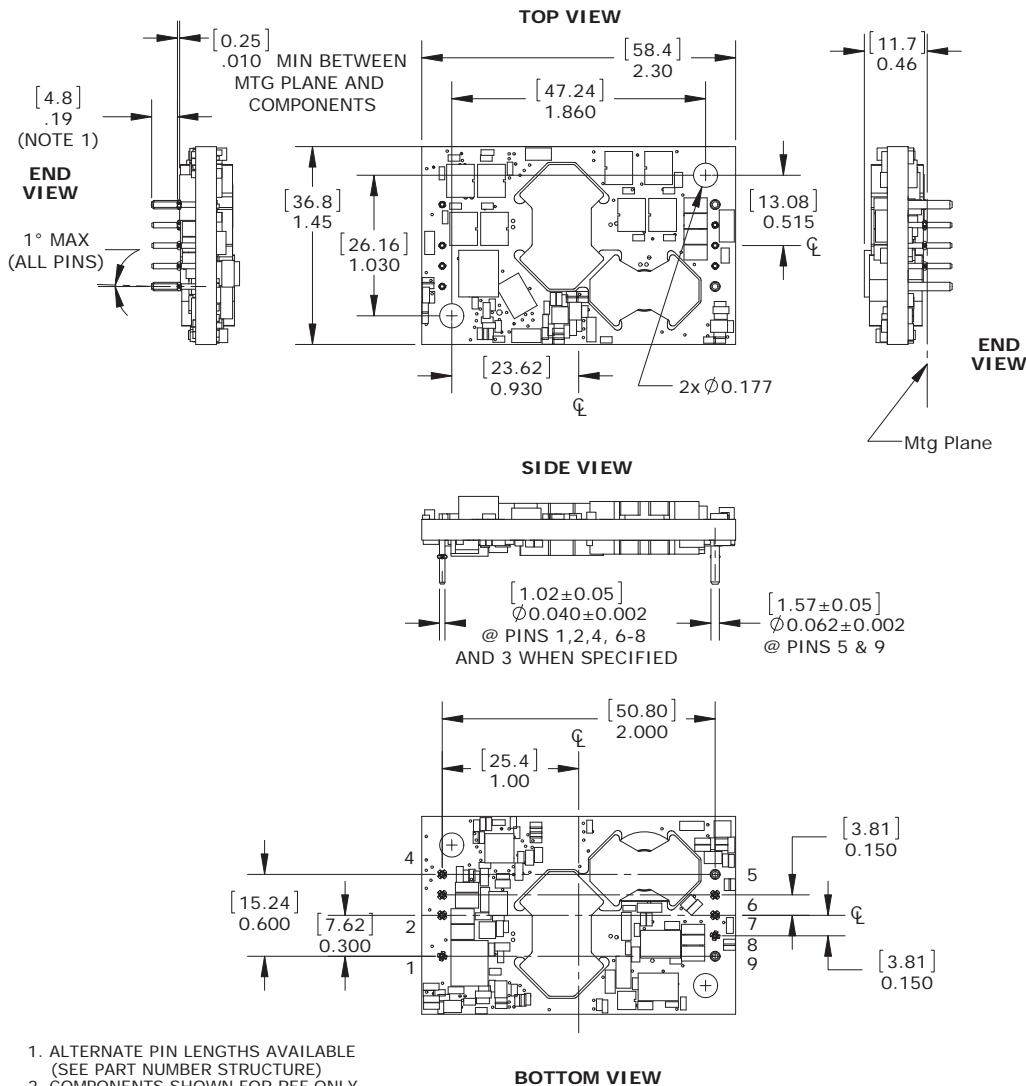


Output Ripple and Noise (Vin = 48V, Iout = 5A, Cloud = 1µf||10µf, Ta = +25°C)



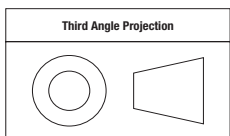
**MECHANICAL SPECIFICATIONS: OPEN FRAME**

MATERIAL:  
 Ø0.040 PINS: COPPER ALLOY  
 Ø0.060 PINS: COPPER ALLOY  
 FINISH: (ALL PINS)  
 GOLD (5u"MIN) OVER NICKEL (50u" MIN)



1. ALTERNATE PIN LENGTHS AVAILABLE (SEE PART NUMBER STRUCTURE)
2. COMPONENTS SHOWN FOR REF ONLY
3. DIMENSIONS ARE IN INCHES [mm]
4. PIN LOCATION DIMENSIONS APPLY AT CIRCUIT BOARD LEVEL

Dimensions are in inches (mm shown for ref. only).



Tolerances (unless otherwise specified):  
 .XX ± 0.02 (0.5)  
 .XXX ± 0.010 (0.25)  
 Angles ± 2°

Components are shown for reference only and may vary between units.

**INPUT/OUTPUT CONNECTIONS**

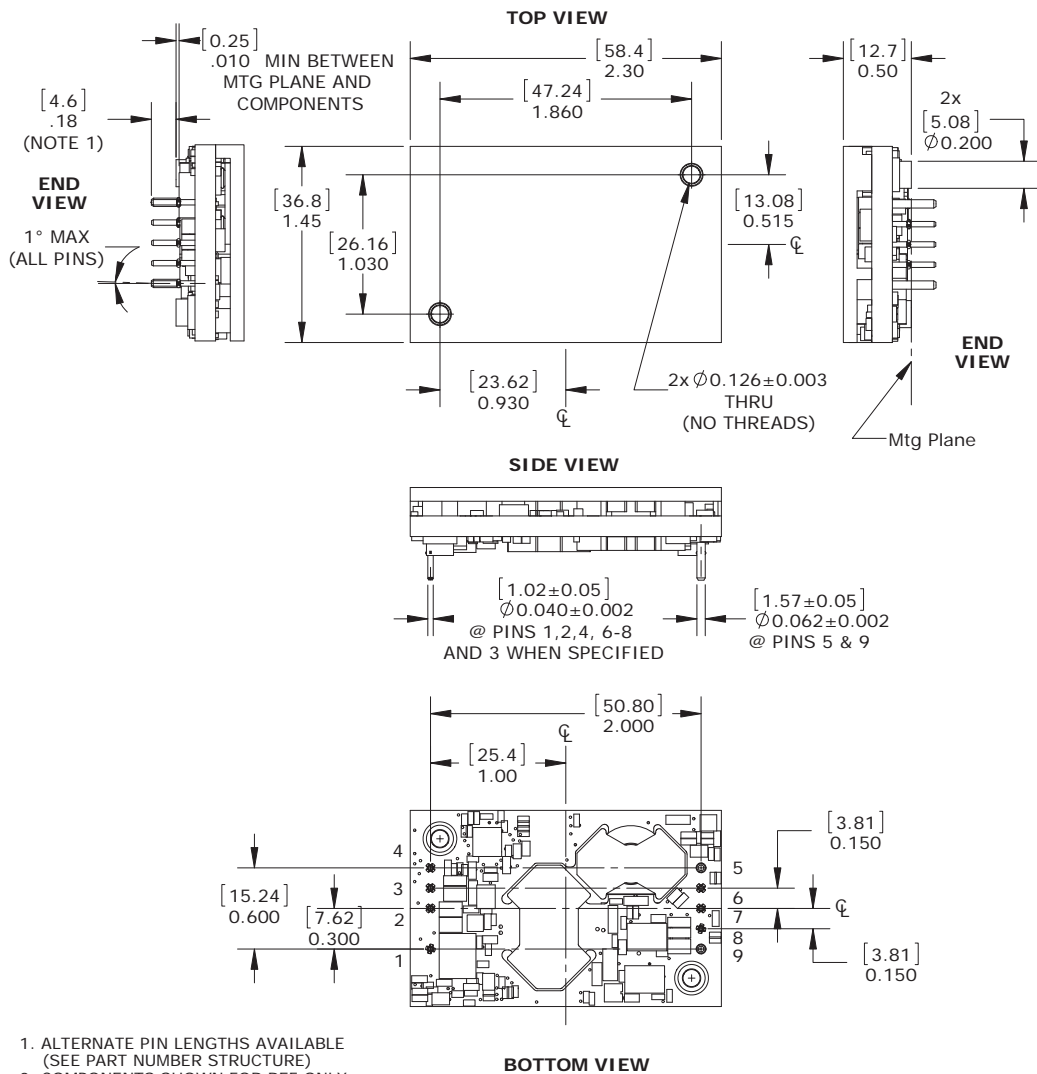
Pin	Function
1	+ Vin
2	Remote On/Off *
3	No pin
4	- Vin
5	- Vout
6	- Sense
7	Trim
8	+ Sense
9	+ Vout

\*The Remote On/Off can be provided with either positive (P suffix) or negative (N suffix) logic.



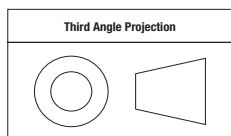
**MECHANICAL SPECIFICATIONS: WITH BASEPLATE**

MATERIAL:  
 Ø0.040 PINS: COPPER ALLOY  
 Ø0.060 PINS: COPPER ALLOY  
 FINISH: (ALL PINS)  
 GOLD (5u"MIN) OVER NICKEL (50u" MIN)



1. ALTERNATE PIN LENGTHS AVAILABLE (SEE PART NUMBER STRUCTURE)
2. COMPONENTS SHOWN FOR REF ONLY
3. DIMENSIONS ARE IN INCHES [mm]
4. PIN LOCATION DIMENSIONS APPLY AT CIRCUIT BOARD LEVEL

Dimensions are in inches (mm shown for ref. only).



Tolerances (unless otherwise specified):  
 .XX ± 0.02 (0.5)  
 .XXX ± 0.010 (0.25)  
 Angles ± 2°

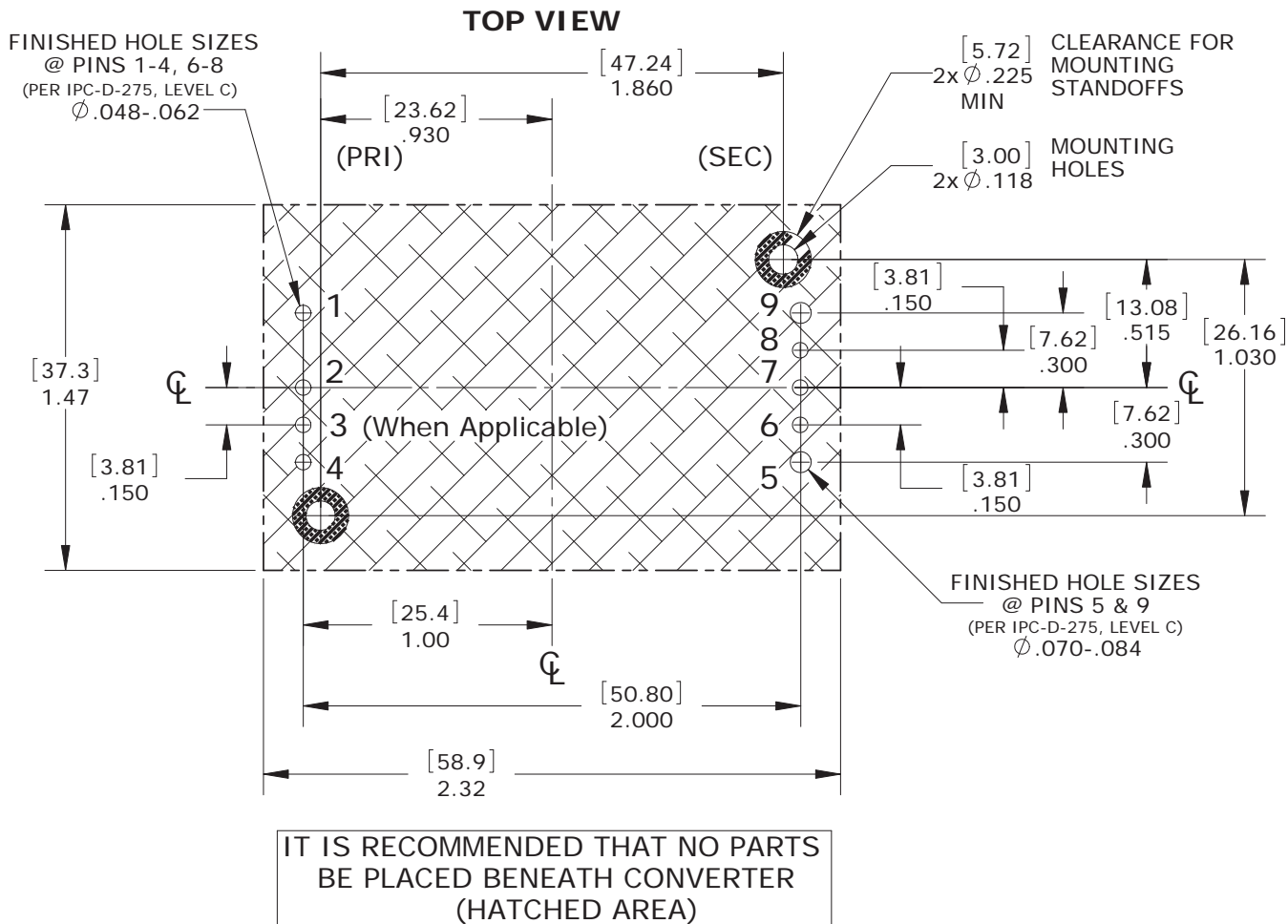
Components are shown for reference only and may vary between units.

**INPUT/OUTPUT CONNECTIONS**

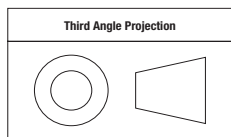
Pin	Function
1	+ Vin
2	Remote On/Off *
3	Baseplate Gnd (Optional)
4	- Vin
5	- Vout
6	- Sense
7	Trim
8	+ Sense
9	+ Vout

\*The Remote On/Off can be provided with either positive (P suffix) or negative (N suffix) logic.

**MECHANICAL SPECIFICATIONS: RECOMMENDED FOOTPRINT (VIEW THROUGH CONVERTER)**



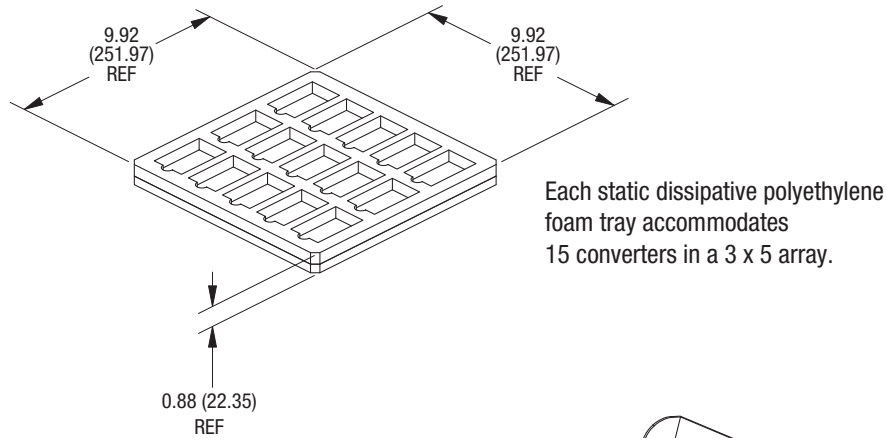
Dimensions are in inches (mm shown for ref. only).



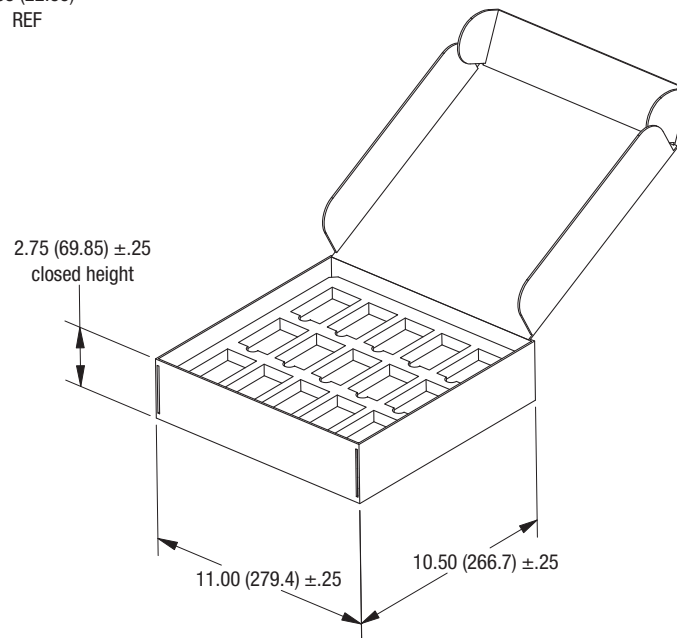
Tolerances (unless otherwise specified):  
 .XX  $\pm$  0.02 (0.5)  
 .XXX  $\pm$  0.010 (0.25)  
 Angles  $\pm$  2°

Components are shown for reference only and may vary between units.

**STANDARD PACKAGING**

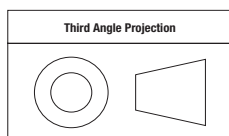


Each static dissipative polyethylene foam tray accommodates 15 converters in a 3 x 5 array.



Carton accommodates two (2) trays yielding 30 converters per carton

Dimensions are in inches (mm shown for ref. only).



Tolerances (unless otherwise specified):  
 .XX ± 0.02 (0.5)  
 .XXX ± 0.010 (0.25)  
 Angles ± 2°

Components are shown for reference only and may vary between units.

Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

**TECHNICAL NOTES**

**Input Fusing**

Certain applications and/or safety agencies may require fuses at the inputs of power conversion components. Fuses should also be used when there is the possibility of sustained input voltage reversal which is not current-limited. For greatest safety, we recommend a fast blow fuse installed in the +Vin input supply line.

The installer must observe all relevant safety standards and regulations. For safety agency approvals, install the converter in compliance with the end-user safety standard.

**Input Under-Voltage Shutdown and Start-Up Threshold**

Under normal start-up conditions, converters will not begin to regulate properly until the rising input voltage exceeds and remains at the Start-Up Threshold Voltage (see Specifications). Once operating, converters will not turn off until the input voltage drops below the Under-Voltage Shutdown Limit. Subsequent restart will not occur until the input voltage rises again above the Start-Up Threshold. This built-in hysteresis prevents any unstable on/off operation at a single input voltage.

Users should be aware however of input sources near the Under-Voltage Shutdown whose voltage decays as input current is consumed (such as capacitor inputs), the converter shuts off and then restarts as the external capacitor recharges. Such situations could oscillate. To prevent this, make sure the operating input voltage is well above the UV Shutdown voltage AT ALL TIMES.

**Start-Up Delay**

Assuming that the output current is set at the rated maximum, the Vin to Vout Start-Up Delay (see Specifications) is the time interval between the point when the rising input voltage crosses the Start-Up Threshold and the fully loaded regulated output voltage enters and remains within its specified regulation band. Actual measured times will vary with input source impedance, external input capacitance, input voltage slew rate and final value of the input voltage as it appears at the converter.

These converters include a soft start circuit to moderate the duty cycle of the PWM controller at power up, thereby limiting the input inrush current.

The On/Off Remote Control interval from inception to Vout regulated assumes that the converter already has its input voltage stabilized above the Start-Up Threshold before the On command. The interval is measured from the On command until the output enters and remains within its specified regulation band. The specification assumes that the output is fully loaded at maximum rated current.

**Input Source Impedance**

These converters will operate to specifications without external components, assuming that the source voltage has very low impedance. Since real-world voltage sources have finite impedance, performance is improved by adding external filter components. Sometimes only a small ceramic capacitor is sufficient. Since it is difficult to totally characterize all applications, some experimentation may be needed. Note that external input capacitors must accept high speed switching currents.

Because of the switching nature of DC/DC converters, the input of these converters must be driven from a source with both low AC impedance and adequate DC input regulation. Performance will degrade with increasing input

inductance. Excessive input inductance may inhibit operation. The DC input regulation specifies that the input voltage, once operating, must never degrade below the Shut-Down Threshold under all load conditions. Be sure to use adequate trace sizes and mount components close to the converter.

**I/O Filtering, Input Ripple Current and Output Noise**

All models in this converter series are tested and specified for input reflected ripple current and output noise using designated external input/output components, circuits and layout as shown in the figures below. External input capacitors (CIN in the figure) serve primarily as energy storage elements, minimizing line voltage variations caused by transient IR drops in the input conductors. Users should select input capacitors for bulk capacitance (at appropriate frequencies), low ESR and high RMS ripple current ratings. In the figure below, the Cbus and Lbus components simulate a typical DC voltage bus. Specific system configurations may require additional considerations. Please note that the values of CIN, Lbus and Cbus may vary according to the specific converter model.

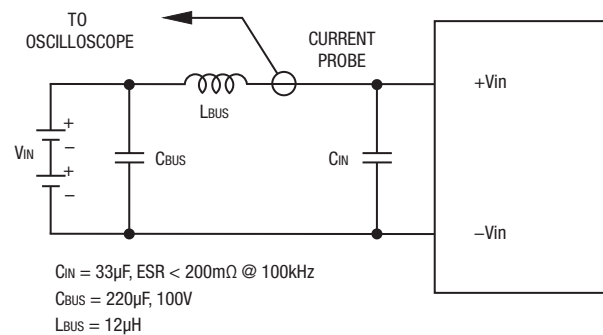


Figure 2. Measuring Input Ripple Current

In critical applications, output ripple and noise (also referred to as periodic and random deviations or PARD) may be reduced by adding filter elements such as multiple external capacitors. Be sure to calculate component temperature rise from reflected AC current dissipated inside capacitor ESR. In figure 3, the two copper strips simulate real-world printed circuit impedances between the power supply and its load. In order to minimize circuit errors and standardize tests between units, scope measurements should be made using BNC connectors or the probe ground should not exceed one half inch and soldered directly to the fixture.

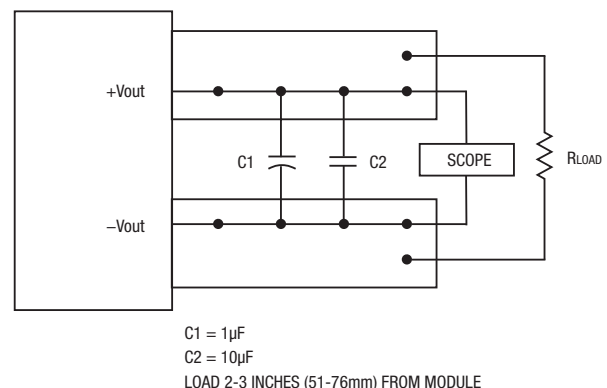


Figure 3. Measuring Output Ripple and Noise (PARD)

## Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

### Floating Outputs

Since these are isolated DC/DC converters, their outputs are “floating” with respect to their input. The essential feature of such isolation is ideal ZERO CURRENT FLOW between input and output. Real-world converters however do exhibit tiny leakage currents between input and output (see Specifications). These leakages consist of both an AC stray capacitance coupling component and a DC leakage resistance. When using the isolation feature, do not allow the isolation voltage to exceed specifications. Otherwise the converter may be damaged. Designers will normally use the negative output (-Output) as the ground return of the load circuit. You can however use the positive output (+Output) as the ground return to effectively reverse the output polarity.

### Minimum Output Loading Requirements

These converters employ a synchronous rectifier design topology. All models regulate within specification and are stable under no load to full load conditions. Operation under no load might however slightly increase output ripple and noise.

### Thermal Shutdown

To protect against thermal over-stress, these converters include thermal shutdown circuitry. If environmental conditions cause the temperature of the DC/DC's to rise above the Operating Temperature Range up to the shutdown temperature, an on-board electronic temperature sensor will power down the unit. When the temperature decreases below the turn-on threshold, the converter will automatically restart. There is a small amount of hysteresis to prevent rapid on/off cycling. CAUTION: If you operate too close to the thermal limits, the converter may shut down suddenly without warning. Be sure to thoroughly test your application to avoid unplanned thermal shutdown.

### Temperature Derating Curves

The graphs in this data sheet illustrate typical operation under a variety of conditions. The Derating curves show the maximum continuous ambient air temperature and decreasing maximum output current which is acceptable under increasing forced airflow measured in Linear Feet per Minute (“LFM”). Note that these are AVERAGE measurements. The converter will accept brief increases in temperature and/or current or reduced airflow as long as the average is not exceeded.

Note that the temperatures are of the ambient airflow, not the converter itself which is obviously running at higher temperature than the outside air. Also note that “natural convection” is defined as very low flow rates which are not using fan-forced airflow. Depending on the application, “natural convection” is usually about 30-65 LFM but is not equal to still air (0 LFM).

Murata Power Solutions makes Characterization measurements in a closed cycle wind tunnel with calibrated airflow. Both thermocouples and an infrared camera system are used to observe thermal performance. Sometimes it is possible to estimate the effective airflow if you thoroughly understand the enclosure geometry, entry/exit orifice areas and the fan flowrate specifications.

CAUTION: If these Derating guidelines are exceeded, the converter may have an unplanned Over Temperature shut down. Also, these graphs are all collected near Sea Level altitude. Be sure to reduce the derating for higher altitude.

### Output Overvoltage Protection (OVP)

This converter monitors its output voltage for an over-voltage condition using an on-board electronic comparator. If the output exceeds OVP limits, the sensing circuit will power down the unit, and the output voltage will decrease. After a time-out period, the PWM will automatically attempt to restart, causing the output voltage to ramp up to its rated value. It is not necessary to power down and reset the converter for this automatic OVP-recovery restart.

If the fault condition persists and the output voltage climbs to excessive levels, the OVP circuitry will initiate another shutdown cycle. This on/off cycling is referred to as “hiccup” mode.

### Current Limiting (Power limit with current mode control)

As power demand increases on the output and enters the specified “limit inception range” limiting circuitry activates in the DC-DC converter to limit/restrict the maximum current or total power available. Once the current reaches a certain range the output voltage will start to decrease while the output current continues to increase, thereby maintaining constant power, until a minimum voltage set is reached and the converter enters a “hiccup” (on off cycling) mode of operation until the load is reduced below the threshold level, whereupon it will return to a normal mode of operation. Current limit inception is defined as the point where the output voltage has decreased by a pre-specified percentage (usually a 2% decrease from nominal).

### Short Circuit Condition (Current mode control)

The short circuit condition is an extension of the “Current Limiting” condition. When the monitored peak current signal reaches a certain range, the PWM controller's outputs are shut off thereby turning the converter “off.” This is followed by an extended time out period. This period can vary depending on other conditions such as the input voltage level. Following this time out period, the PWM controller will attempt to re-start the converter by initiating a “normal start cycle” which includes softstart. If the “fault condition” persists, another “hiccup” cycle is initiated. This “cycle” can and will continue indefinitely until such time as the “fault condition” is removed, at which time the converter will resume “normal operation.” Operating in the “hiccup” mode during a fault condition is advantageous in that average input and output power levels are held low preventing excessive internal increases in temperature.

### Trimming Output Voltage

PAQ converters have a trim capability that enables users to adjust the output voltage from +10% to -20% (refer to the trim equations). Adjustments to the output voltage can be accomplished with a single fixed resistor as shown in Figures 4 and 5. A single fixed resistor can increase or decrease the output voltage depending on its connection. Resistors should be located close to the converter and have TCR's less than 100ppm/°C to minimize sensitivity to changes in temperature. If the trim function is not used, leave the trim pin open.

Standard PAQ's have a “positive trim” where a single resistor connected from the Trim pin to the +Sense will increase the output voltage. A resistor connected from the Trim Pin to the -Sense will decrease the output voltage.

Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

Trim adjustments greater than the specified +10%/–20% can have an adverse affect on the converter’s performance and are not recommended. Excessive voltage differences between V<sub>OUT</sub> and Sense, in conjunction with trim adjustment of the output voltage, can cause the overvoltage protection circuitry to activate (see Performance Specifications for overvoltage limits).

Temperature/power derating is based on maximum output current and voltage at the converter’s output pins. Use of the trim and sense functions can cause output voltages to increase, thereby increasing output power beyond the PAQ’s specified rating, or cause output voltages to climb into the output overvoltage region. Therefore:

$$(V_{out \text{ at pins}}) \times (I_{out}) \leq \text{rated output power}$$

The Trim pin (pin 6) is a relatively high impedance node that can be susceptible to noise pickup when connected to long conductors in noisy environments.

**Trim Equations**

**Trim Down**

Connect trim resistor between trim pin and –Sense

$$R_{TrimDn} \text{ (k } \Omega) = \frac{5.11}{\Delta} - 10.22$$

**Trim Up**

Connect trim resistor between trim pin and +Sense

$$R_{TrimUp} \text{ (k } \Omega) = \frac{5.11 \times V_{NOM} \times (1+\Delta)}{1.225 \times \Delta} - \frac{5.11}{\Delta} - 10.22$$

**Where,**

$$\Delta = | (V_{NOM} - V_{OUT}) / V_{NOM} |$$

V<sub>NOM</sub> is the nominal, untrimmed output voltage.

V<sub>OUT</sub> is the desired new output voltage.

Do not exceed the specified trim range or maximum power ratings when adjusting trim. Use 1% precision resistors mounted close to the converter on short leads.

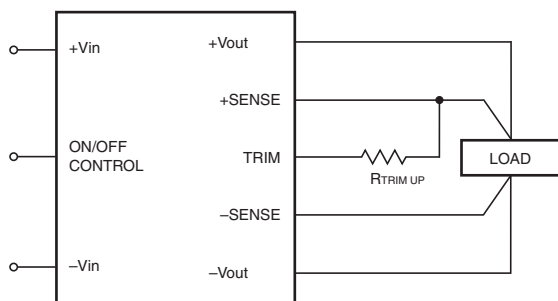


Figure 4. Trim Connections To Increase Output Voltages Using Fixed Resistors

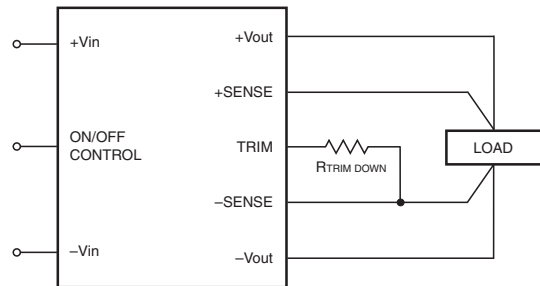


Figure 5. Trim Connections To Decrease Output Voltages Using Fixed Resistors

**Remote Sense Input**

Use the Sense inputs with caution. Sense is normally connected **at the load**. Sense inputs compensate for output voltage inaccuracy delivered at the load. This is done by correcting IR voltage drops along the output wiring and the current carrying capacity of PC board etc. This output drop (the difference between Sense and V<sub>out</sub> when measured at the converter) should not exceed 0.5V. Consider using heavier wire if this drop is excessive. Sense inputs also improve the stability of the converter and load system by optimizing the control loop phase margin.

Note: The Sense input and power V<sub>out</sub> lines are internally connected through low value resistors to their respective polarities so that the converter can operate without external connection to the Sense. Nevertheless, if the Sense function is not used for remote regulation, the user should connect +Sense to +V<sub>out</sub> and –Sense to –V<sub>out</sub> at the converter pins.

The remote Sense lines carry very little current. They are also capacitively coupled to the output lines and therefore are in the feedback control loop to regulate and stabilize the output. As such, they are not low impedance inputs and must be treated with care in PC board layouts. Sense lines on the PCB should run adjacent to DC signals, preferably Ground. In cables and discrete wiring, use twisted pair, shielded tubing or similar techniques.

Any long, distributed wiring and/or significant inductance introduced into the Sense control loop can adversely affect overall system stability. If in doubt, test

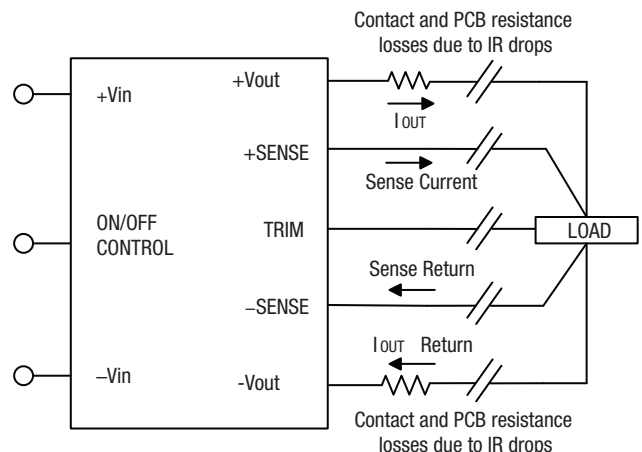


Figure 6. Remote Sense Circuit Configuration

Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

your applications by observing the converter's output transient response during step loads. There should not be any appreciable ringing or oscillation. You may also adjust the output trim slightly to compensate for voltage loss in any external filter elements. Do not exceed maximum power ratings.

Please observe Sense inputs tolerance to avoid improper operation:

$$[V_{out(+)} - V_{out(-)}] - [Sense(+)-Sense(-)] \leq 10\% \text{ of } V_{out}$$

Output overvoltage protection is monitored at the output voltage pin, not the Sense pin. Therefore excessive voltage differences between Vout and Sense together with trim adjustment of the output can cause the overvoltage protection circuit to activate and shut down the output.

Power derating of the converter is based on the combination of maximum output current and the highest output voltage. Therefore the designer must ensure:

$$(V_{out \text{ at pins}}) \times (I_{out}) \leq (\text{Max. rated output power})$$

**Remote On/Off Control**

On the input side, a remote On/Off Control can be specified with either positive or negative logic as follows:

Models are on (enabled) when the On/Off is grounded or brought to within a low voltage (see Specifications) with respect to  $-V_{in}$ . The device is off (disabled) when the On/Off is left open or is pulled high to +13.5Vdc Max. with respect to  $-V_{in}$ .

Dynamic control of the On/Off function should be able to sink the specified signal current when brought low and withstand specified voltage when brought high. Be aware too that there is a finite time in milliseconds (see Specifications) between the time of On/Off Control activation and stable, regulated output. This time will vary slightly with output load type and current and input conditions.

There are two CAUTIONs for the On/Off Control:

**CAUTION:** While it is possible to control the On/Off with external logic if you carefully observe the voltage levels, the preferred circuit is either an open drain/open collector transistor or a relay (which can thereupon be controlled by logic). The On/Off prefers to be set at approx. +13.5V (open pin) for the ON state, assuming positive logic.

**CAUTION:** Do not apply voltages to the On/Off pin when there is no input power voltage. Otherwise the converter may be permanently damaged.

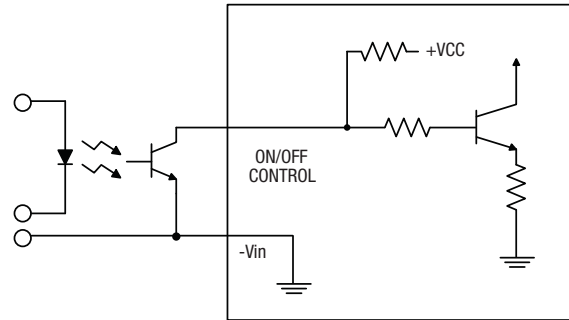


Figure 7. Driving the On/Off Control Pin (suggested circuit)

**Cold Wall Cooling Test Method (cold baseplate applications)**

Murata Power Solutions' cold wall cooling test is implemented with the baseplate of the UUT (unit under test) mounted to the large aluminum block (see figure 8). Thermocouples are attached to the known hot spots on the UUT as well as the aluminum block and still air space. The environment chamber regulates the aluminum block and baseplate temperature at a fixed value up to 100°C. The still air chamber is manually regulated to 85°C by the attached heaters. Output load is applied to the UUT and it is monitored to ensure safe operating limits at all input voltages.

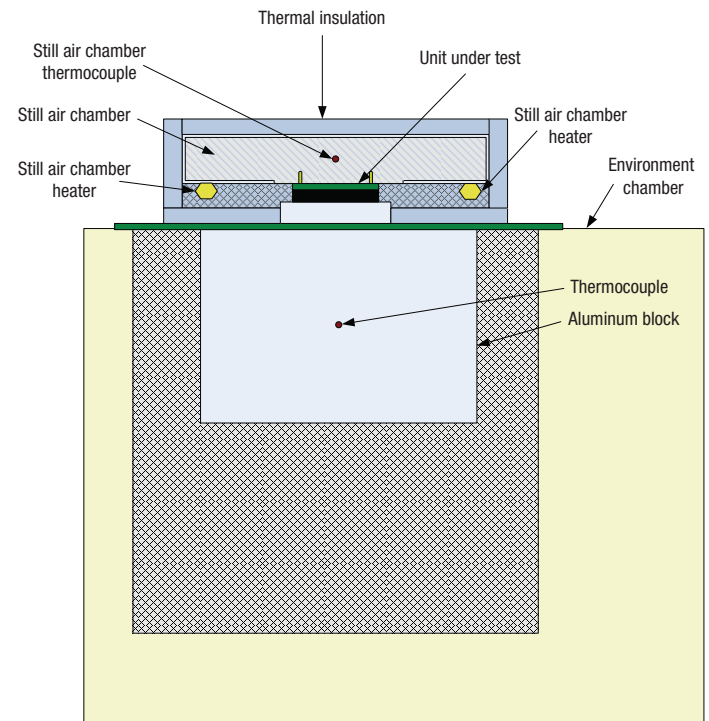


Figure 8. Cold Wall Test Fixture Equipment

Up to 150W 29.8V Nom Output Quarter-Brick Isolated DC-DC Converter with 2:1 Wide Input Range

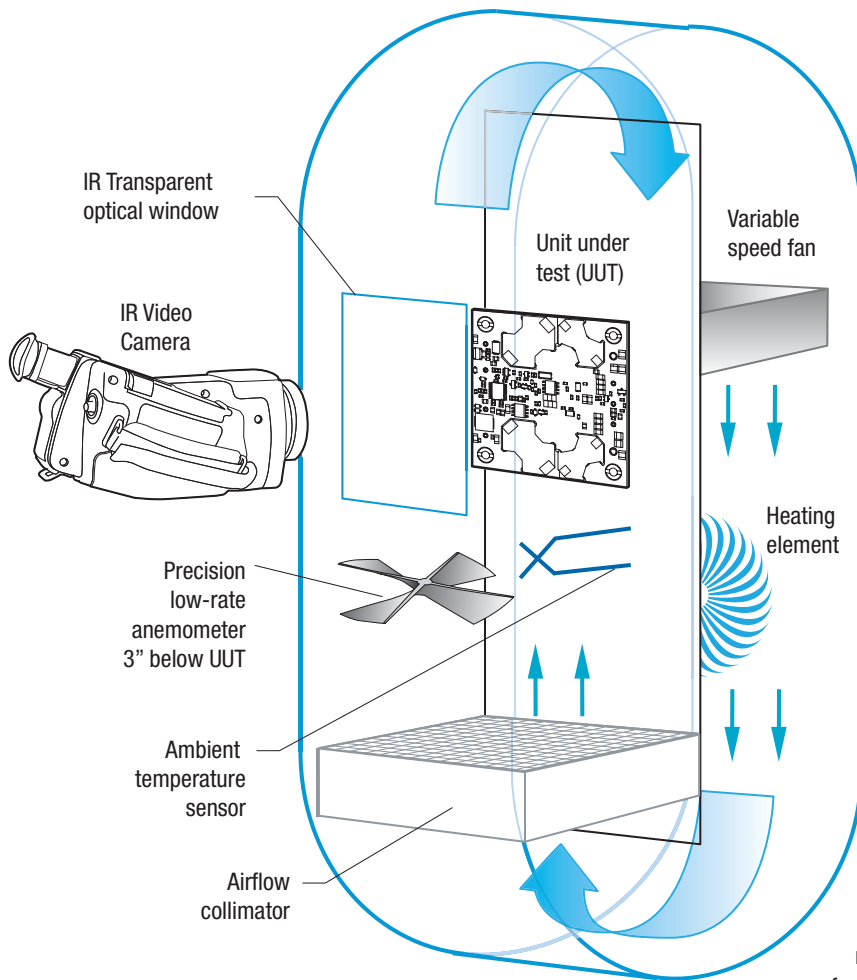


Figure 9. Vertical Wind Tunnel

**Vertical Wind Tunnel**

Murata Power Solutions employs a computer controlled custom-designed closed loop vertical wind tunnel, infrared video camera system, and test instrumentation for accurate airflow and heat dissipation analysis of power products. The system includes a precision low flow-rate anemometer, variable speed fan, power supply input and load controls, temperature gauges, and adjustable heating element.

The IR camera monitors the thermal performance of the Unit Under Test (UUT) under static steady-state conditions. A special optical port is used which is transparent to infrared wavelengths.

Both through-hole and surface mount converters are soldered down to a 10" by 10" host carrier board for realistic heat absorption and spreading. Both longitudinal and transverse airflow studies are possible by rotation of this carrier board since there are often significant differences in the heat dissipation in the two airflow directions. The combination of adjustable airflow, adjustable ambient heat, and adjustable Input/Output currents and voltages mean that a very wide range of measurement conditions can be studied.

The collimator reduces the amount of turbulence adjacent to the UUT by minimizing airflow turbulence. Such turbulence influences the effective heat transfer characteristics and gives false readings. Excess turbulence removes more heat from some surfaces and less heat from others, possibly causing uneven overheating.

Both sides of the UUT are studied since there are different thermal gradients on each side. The adjustable heating element and fan, built-in temperature gauges, and no-contact IR camera mean that power supplies are tested in real-world conditions.

**Soldering Guidelines**

Murata Power Solutions recommends the specifications below when installing these converters. These specifications vary depending on the solder type. Exceeding these specifications may cause damage to the product. Your production environment may differ; therefore please thoroughly review these guidelines with your process engineers.

Wave Solder Operations for through-hole mounted products (THMT)			
For Sn/Ag/Cu based solders:		For Sn/Pb based solders:	
Maximum Preheat Temperature	115° C.	Maximum Preheat Temperature	105° C.
Maximum Pot Temperature	270° C.	Maximum Pot Temperature	250° C.
Maximum Solder Dwell Time	7 seconds	Maximum Solder Dwell Time	6 seconds

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ISO 9001 and 14001 REGISTERED



**This product is subject to the following operating requirements and the Life and Safety Critical Application Sales Policy: Refer to: <http://www.murata-ps.com/requirements/>**

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