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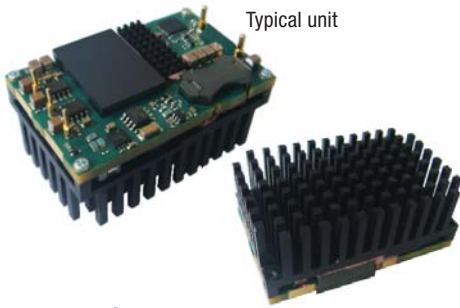
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### FEATURES

- Fixed DC outputs, 11.5V @43.5A
- Advanced Bus Converter industry standard quarter-brick with digital PMBus™ interface
- Optional five pin version (DOSA compatible pinouts)
- 38 to 75 Volt DC input range (48 VDC nominal)
- Remote ON/Off enable control
- High efficiency (95.5%)
- Stable no-load operation
- Monotonic startup into pre-bias output condition
- Certified to UL 60950-1, CSA-C22.2 No. 60950-1, 2nd edition safety approvals
- Extensive self-protection, OVP, input undervoltage, current limiting and thermal shutdown

### PRODUCT OVERVIEW

The DRQ 500W series provides a fully regulated, digitally controlled DC output in a ¼-brick format that will support the evolving Advanced Bus Converter (ABC) industry standard footprint for isolated board mounted power modules. The DRQ series supports advances in power conversion technology including a digital interface supporting the PMBus protocol for communications to power modules.

The DRQ series offers high output current (up to 43.5 Amps) in an industry standard “quarter brick” package. The DRQ series is an isolated, regulated, 500W-11.5Vout quarter brick that supports the TNV input voltage range of 38V-75V with a typical efficiency of 95.5%.

Advanced automated surface mount assembly and planar magnetics deliver galvanic isolation

rated at 2250 Vdc for functional insulation. Target markets include networking equipment, Power over Ethernet applications, wireless networking equipment, telecommunications equipment, wireless pre-amplifiers, industrial and test equipment, and applications requiring a regulated 11.5V output.

A wealth of self-protection features include input undervoltage lockout and overtemperature shut-down; over current protection using the “hiccup” autorestart technique provides indefinite short-circuit protection, along with output OVP. The DRQ series is certified to safety standards UL/IEC/CSA 60950-1, 2nd edition. It meets RFI/EMI conducted emission compliance to EN55022, CISPR22 with an external filter.

### APPLICATIONS

- Embedded systems, datacom and telecom installations, wireless base stations
- Instrumentation systems, R&D platforms, automated test fixtures
- Disk farms, data centers and cellular repeater sites
- Data concentrators, voice forwarding and speech processing systems
- Remote sensor systems, dedicated controllers

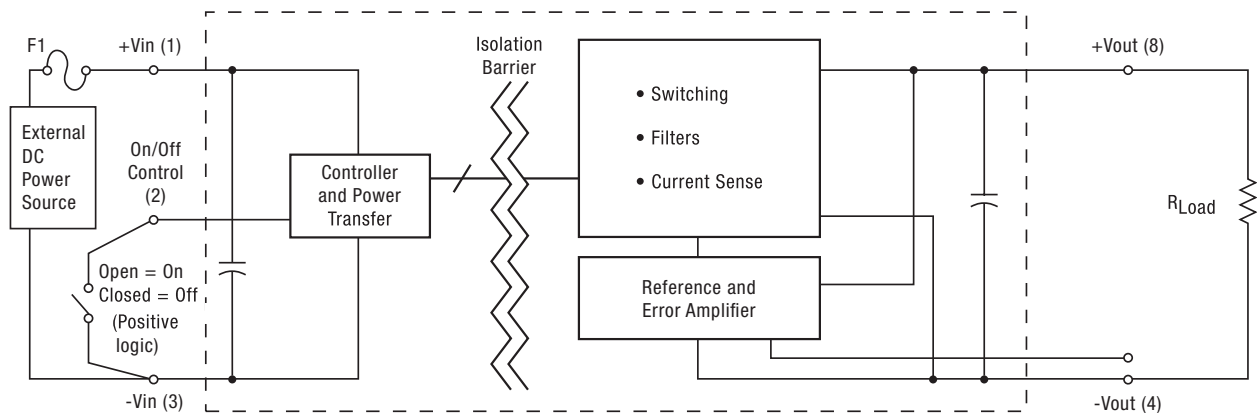


Figure 1. Connection Diagram (without digital interface)

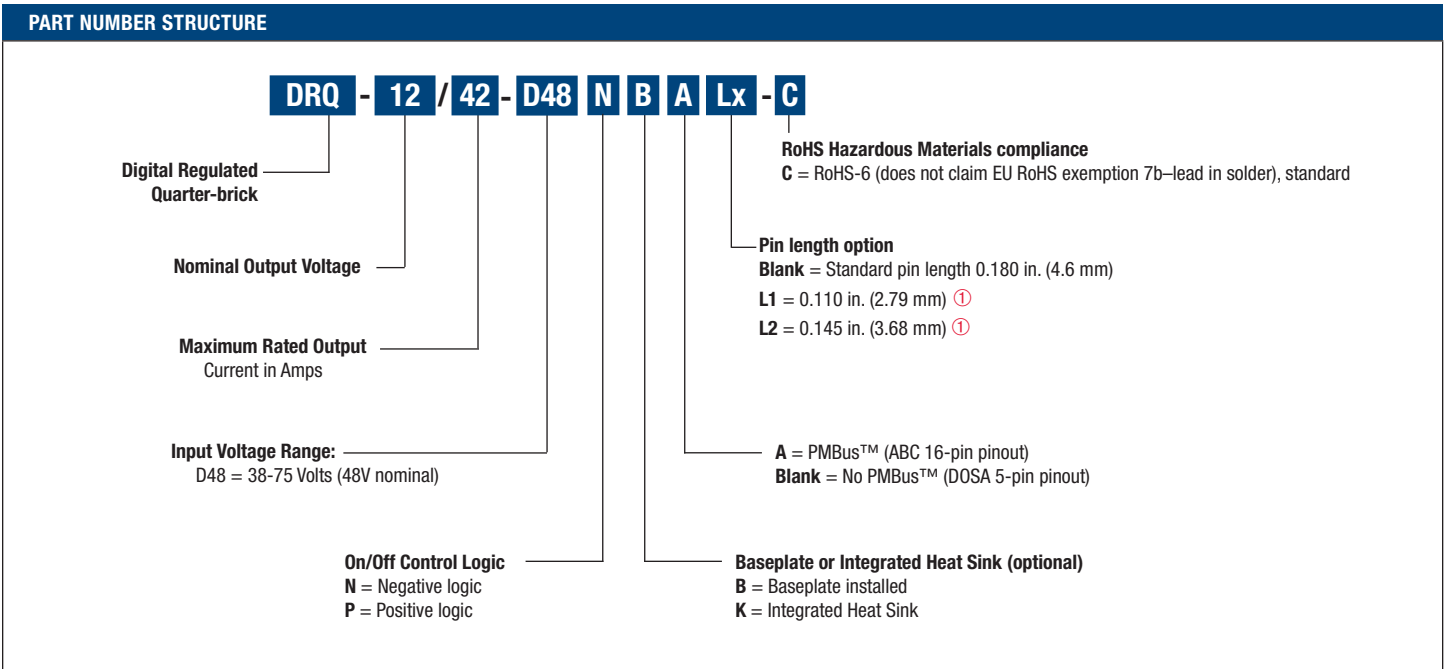
Typical topology is shown. Murata Power Solutions recommends an external fuse.



| PERFORMANCE SPECIFICATIONS SUMMARY AND ORDERING GUIDE ① ② |                                |                               |                     |                |      |                       |       |                              |               |                              |            |                                  |                   |                     |
|---|--------------------------------|-------------------------------|---------------------|----------------|------|-----------------------|-------|------------------------------|---------------|------------------------------|------------|----------------------------------|-------------------|---------------------|
| Root Model ①  | Output                         |                               |                     |                |      |                       | Input |                              |               |                              | Efficiency | Dimensions with baseplate        |                   |                     |
|   | V <sub>OUT</sub> (Volts, max.) | I <sub>OUT</sub> (Amps, max.) | Power (Watts, max.) | R/N (mV pk-pk) |      | Regulation (mV, max.) |       | V <sub>IN</sub> Nom. (Volts) | Range (Volts) | I <sub>IN</sub> no load (mA) |            | I <sub>IN</sub> full load (Amps) | Typ.              | (inches)            |
|   |                                |                               |                     | Typ.           | Max. | Line                  | Load  |                              |               |                              |            |                                  |                   |                     |
| DRQ-12/42-D48   | 11.85                          | 43.5                          | 515.5               | 80             | 120  | 100                   | 100   | 48                           | 38-75         | 130                          | 11.39      | 95.5%                            | 2.3 x 1.45 x 0.52 | 58.4 x 36.8 x 13.21 |

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. These caps are necessary for our test equipment and may not be needed for your application.



① Special quantity order is required; samples available with standard pin length only.  
 ② Some model number combinations may not be available. See website or contact your local Murata sales representative.

**Complete Model Number Example:** **DRQ-12/42-D48NKL1-C**  
 Negative On/Off logic, Integrated Heat Sink installed, 0.110" pin length, RoHS-6 compliance

### FUNCTIONAL SPECIFICATIONS

| ABSOLUTE MAXIMUM RATINGS  | Conditions ①   | 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  |         |                 | 2250    | Vdc                     |
| On/Off Remote Control   | Power on, referred to -Vin   | 0       |                 | 13.5    | Vdc                     |
| Output Power  |  | 0       |                 | 515.5   | W                       |
| Output Current  | Current-limited, no damage, short-circuit protected                      | 0       |                 | 43.5    | 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   |  | 38      | 48              | 75      | Vdc                     |
| Recommended External Fuse   | Fast blow  |         | 25              |         | A                       |
| Start-up threshold: (measured @ no load)  | Rising input voltage   | 37      | 37.5            | 38      | Vdc                     |
| Undervoltage shutdown: (measured @ no load)   | Falling input voltage  | 35      | 35.5            | 36      | Vdc                     |
| Internal Filter Type  |  |         | Pi              |         |                         |
| Input current   |  |         |                 |         |                         |
| Full Load Conditions  | Vin = nominal  |         | 11.39           | 11.68   | A                       |
| Low Line  | Vin = minimum  |         | 14.55           | 14.63   | A                       |
| Inrush Transient  |  |         | 0.15            | 0.30    | A <sup>2</sup> -Sec.    |
| Short Circuit Input Current   |  |         | 0.05            | 0.1     | A                       |
| No Load Input Current   | Iout = minimum, unit = ON  |         | 130             | 200     | mA                      |
| Shut-Down Input Current (Off, UV, OT)   |  |         | 10              | 20      | mA                      |
| Reflected (back) ripple current ②   | Measured at input with specified filter                                  |         | 40              | 70      | mA, p-p                 |
| Pre-biased startup  | External output voltage < Vset   |         | Monotonic       |         |                         |
| GENERAL and SAFETY  |  |         |                 |         |                         |
| Efficiency  | Vin = 48V, full load   |         | 95.5            |         | %                       |
|   | Vin = min., full load  |         | 95.5            |         | %                       |
| Isolation   |  |         |                 |         |                         |
| Isolation Voltage   | Input to output  |         |                 | 2250    | Vdc                     |
| Isolation Voltage   | Input to baseplate   |         |                 | 1500    | Vdc                     |
| Isolation Voltage   | Output to baseplate  |         |                 | 1500    | Vdc                     |
| Insulation Safety Rating  |  |         | Functional      |         |                         |
| Isolation Resistance  |  |         | 10              |         | MΩ                      |
| Isolation Capacitance   |  |         | 1500            |         | pF                      |
| Safety  | Certified to UL-60950-1, CSA-C22.2 No. 60950-1, IEC/60950-1, 2nd edition |         | Yes             |         |                         |
| Calculated MTBF   | Per Telcordia SR332, issue 1, class 3, ground fixed, Tambient = +25°C    |         | 1.3             |         | Hours x 10 <sup>6</sup> |
| DYNAMIC CHARACTERISTICS   |  |         |                 |         |                         |
| Switching Frequency   | Variable frequency control (default)                                     |         | 175-250         |         | KHz                     |
| Vin Start up delay time   |  |         | 25              | 30      | mS                      |
| Enable Start up delay time  |  |         | 3               | 5       | mS                      |
| Rise time   |  |         | 15              | 20      | mS                      |
| Vout Fall Time of Regulated Off: (from 100% to 0%)  |  | 18      | 20              | 22      | mS                      |
| Dynamic Load Response   | 50-75-50% load step, settling time to within 1% of Vout (Cout=1000μF)    |         | 200             | 300     | μSec                    |
| Dynamic Load Peak Deviation   | same as above  |         | ±400            | ±600    | mV                      |
| FEATURES and OPTIONS  |  |         |                 |         |                         |
| Remote On/Off Control ④   |  |         |                 |         |                         |
| "N" suffix:   |  |         |                 |         |                         |
| Negative Logic, ON state  | ON = Ground pin or external voltage                                      | -0.1    |                 | 0.8     | V                       |
| Negative Logic, OFF state   | OFF = Pin open or external voltage                                       | 3.5     |                 | 13.5    | V                       |
| Control Current   | Open collector/drain   |         |                 | 5       | mA                      |
| "P" suffix:   |  |         |                 |         |                         |
| Positive Logic, ON state  | ON = Pin open or external voltage  | 3.5     |                 | 13.5    | V                       |
| Positive Logic, OFF state   | OFF = Ground pin or external voltage                                     | 0       |                 | 0.8     | V                       |
| Control Current   | Open collector/drain   |         |                 | 1       | mA                      |

### FUNCTIONAL SPECIFICATIONS, (CONT.)

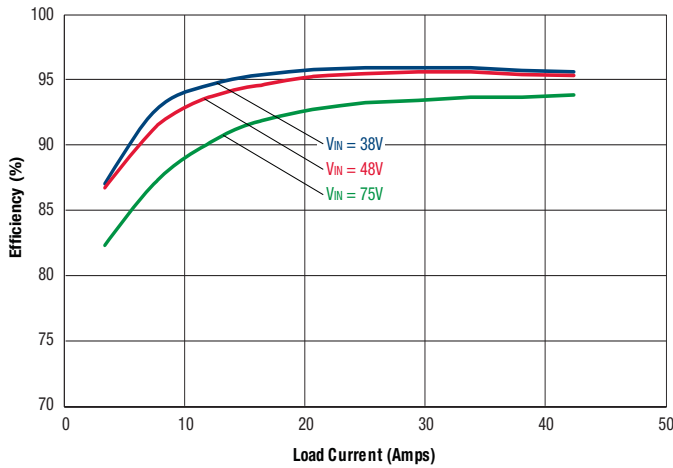
| OUTPUT  | Conditions ①   | Minimum | Typical/Nominal      | Maximum | Units         |
|---|--|---------|----------------------|---------|---------------|
| <b>Total Output Power</b>                                 |  | 0       | 500.25               | 515.5   | W             |
| <b>Voltage</b>  |  |         |                      |         |               |
| <b>Nominal Output Voltage</b>                             | No trim (@ all conditions)                           | 11.16   | 11.5                 | 11.85   | Vdc           |
| <b>Output Voltage</b>                                     | @ Vin=48V, Iout=0, temp=+25°C                        | 11.45   |                      | 11.55   | Vdc           |
| <b>Setting Accuracy</b>                                   | At 50% load, no trim                                 | -2      |                      | 2       | % of Vnom     |
| <b>Overvoltage Protection</b>                             | Via magnetic feedback                                | 13.8    | 14.4                 | 15.6    | Vdc           |
| <b>Current</b>  |  |         |                      |         |               |
| <b>Output Current Range</b>                               |  | 0       |                      | 43.5    | A             |
| <b>Cold condition</b>                                     | Default, Configurable via PMBUS                      | 52      | 54                   | 56      |               |
| <b>After warm up</b>                                      | Default, Configurable via PMBUS                      | 51      | 53                   | 55      | A             |
| <b>Short Circuit</b>                                      |  |         |                      |         |               |
| <b>Short Circuit Current</b>                              | Hiccup technique, autorecovery within ±1.25% of Vout |         | 0.4                  | 1       | 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>Line Regulation</b>                                    | Vin = 38 to 75V, Vout = nom., Iout = nom.            |         | 30                   | 100     | mV            |
| <b>Load Regulation</b>                                    | Iout = min. to max., Vin = 48V                       |         | 50                   | 100     | mV            |
| <b>Ripple and Noise ⑥</b>                                 | 5 Hz - 20 MHz BW                                     |         | 80                   | 120     | mV pk-pk      |
| <b>Temperature Coefficient</b>                            | At all outputs                                       |         | 0.01                 | 0.02    | % of Vout./°C |
| <b>Maximum Capacitive Loading</b>                         | Low ESR  |         |                      | 10000   | µF            |
| <b>MECHANICAL (Through Hole Models)</b>                   |  |         |                      |         |               |
| <b>Outline Dimensions (with heat sink)</b>                |  |         | 2.3 x 1.45 x 1.1     |         | Inches        |
| (Please refer to outline drawing)                         | LxWxH  |         | 58.4 x 36.83 x 27.94 |         | mm            |
| <b>Outline Dimensions (with baseplate)</b>                |  |         | 2.3 x 1.45 x 0.52    |         |               |
|   |  |         | 58.4 x 36.8 x 13.21  |         |               |
| <b>Through Hole Pin Diameter</b>                          |  |         | 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                                      |         | 98.4-299             |         | µ-inches      |
|   | Gold overplate                                       |         | 4.7-19.6             |         | µ-inches      |
| <b>ENVIRONMENTAL</b>                                      |  |         |                      |         |               |
| <b>Operating Ambient Temperature Range</b>                | See Derating   | -40     |                      | 85      | °C            |
| <b>Operating Case Temperature</b>                         | No derating  | -40     |                      | 110     | °C            |
| <b>Storage Temperature</b>                                | Vin = Zero (no power)                                | -55     |                      | 125     | °C            |
| <b>Thermal Protection/Shutdown</b>                        | Measured in center                                   |         | 132                  |         | °C            |
| <b>Electromagnetic Interference</b>                       | External filter is required                          |         |                      |         |               |
| <b>Conducted, EN55022/CISPR22</b>                         |  |         | B                    |         | Class         |
| <b>RoHS rating</b>  |  |         | RoHS-6               |         |               |

### Notes

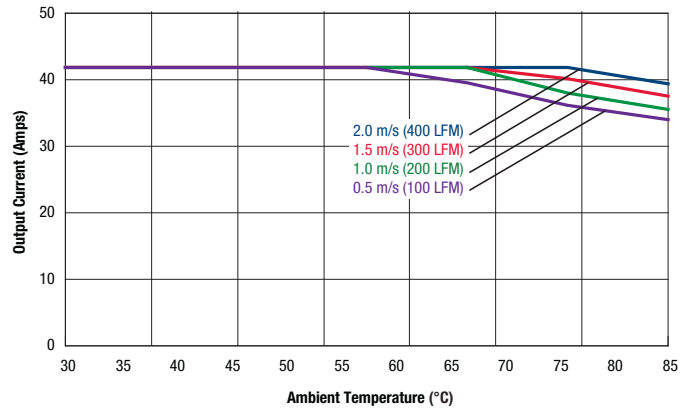
- ① Unless otherwise noted, all specifications apply at Vin = nominal, nominal output voltage and full output load. General conditions are near sea level altitude, no base plate installed and natural convection airflow unless otherwise specified. All models are tested and specified with external parallel 1 µF and 10 µF output capacitors (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.
- ⑥ Output Ripple and Noise is measured with Cout = 1 µF || 10 µF, 20 MHz oscilloscope bandwidth and full resistive load.

## PERFORMANCE DATA

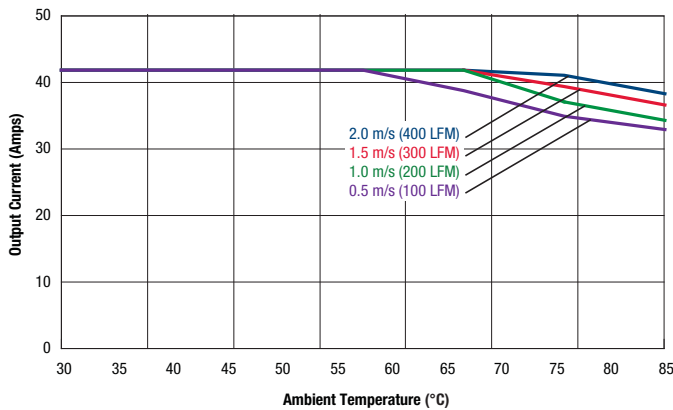
Efficiency vs. Line Voltage and Load Current @ +25°C



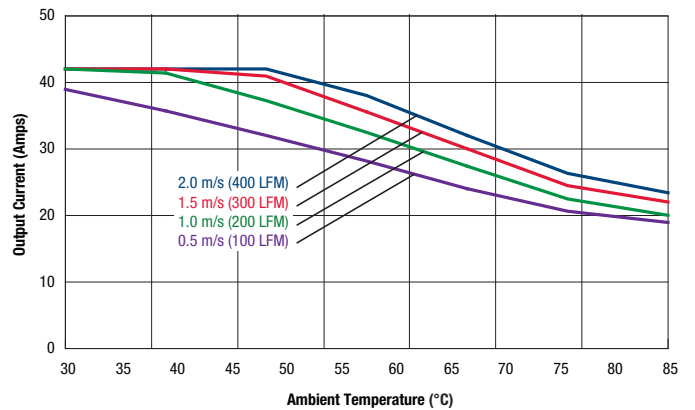
Maximum Current Temperature Derating at sea level (Vin = 40V, airflow from -Vin to +Vin, with heat sink)



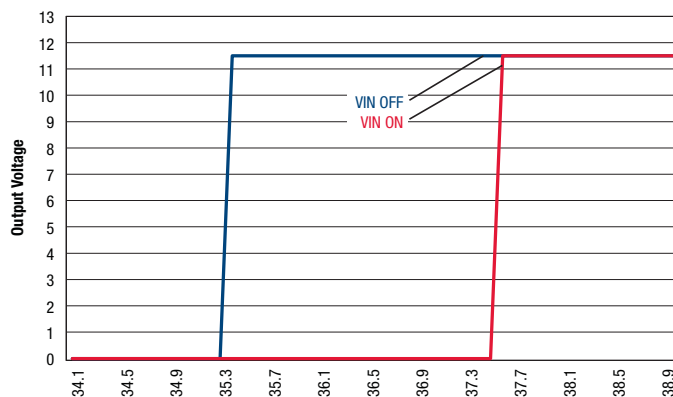
Maximum Current Temperature Derating at sea level (Vin = 48V, airflow from -Vin to +Vin, with heat sink)



Maximum Current Temperature Derating at sea level (Vin = 75V, airflow from -Vin to +Vin, with heat sink)



Output vs. Input Voltage @ No Load



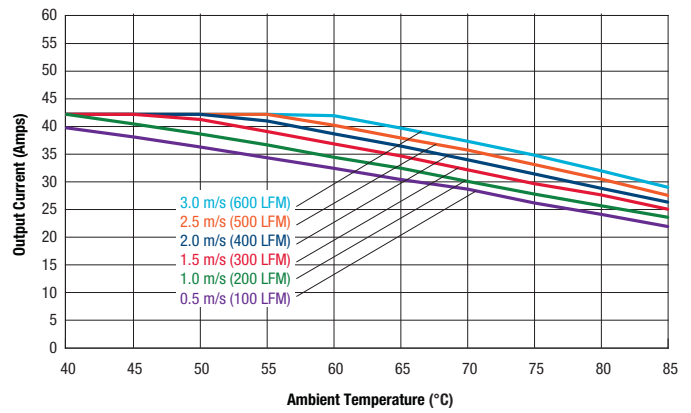
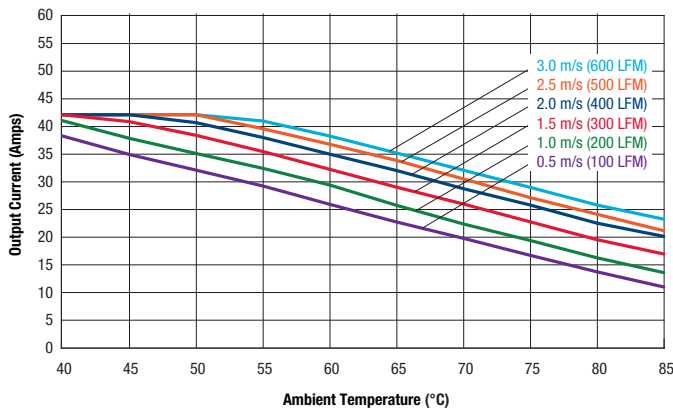
**PERFORMANCE DATA**

**Longitudinal**

**Transverse**

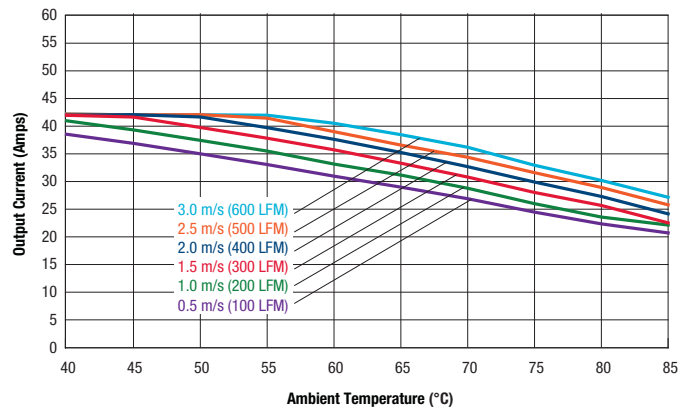
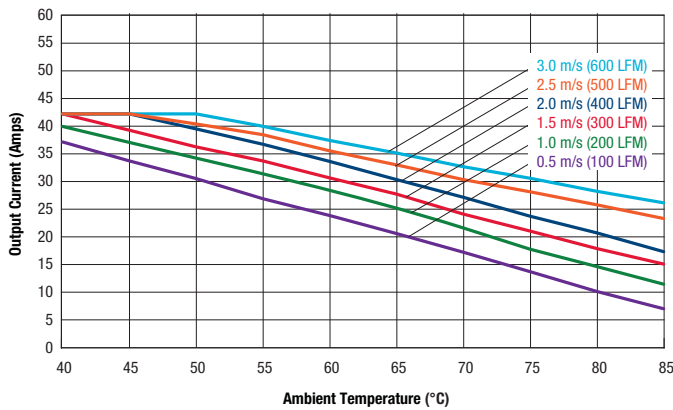
Maximum Current Temperature Derating at sea level  
(Vin = 38V, airflow from Vin to Vout, with baseplate)

Maximum Current Temperature Derating at sea level  
(Vin = 38V, airflow from -Vin to +Vin, with baseplate)



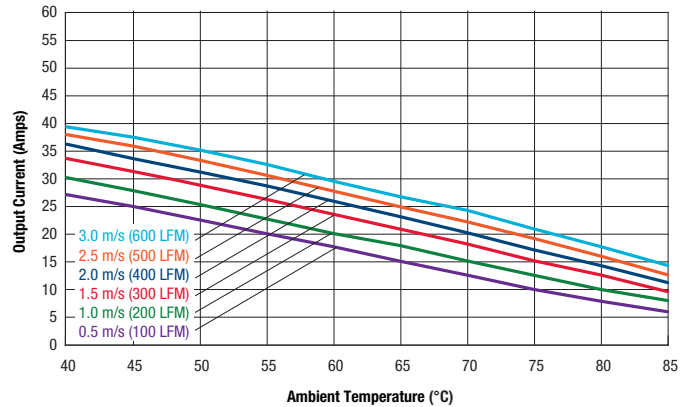
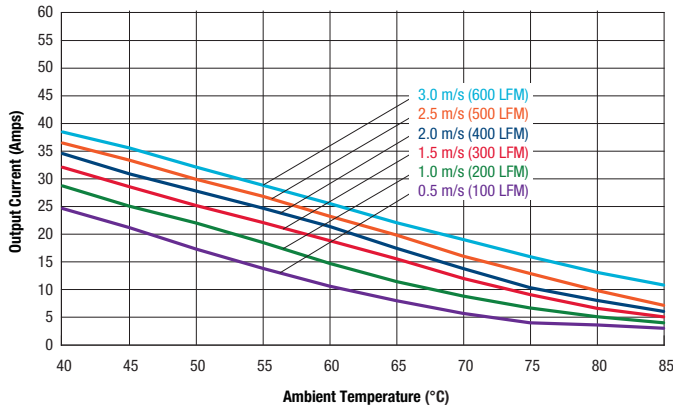
Maximum Current Temperature Derating at sea level  
(Vin = 48V, airflow from Vin to Vout, with baseplate)

Maximum Current Temperature Derating at sea level  
(Vin = 48V, airflow from -Vin to +Vin, with baseplate)



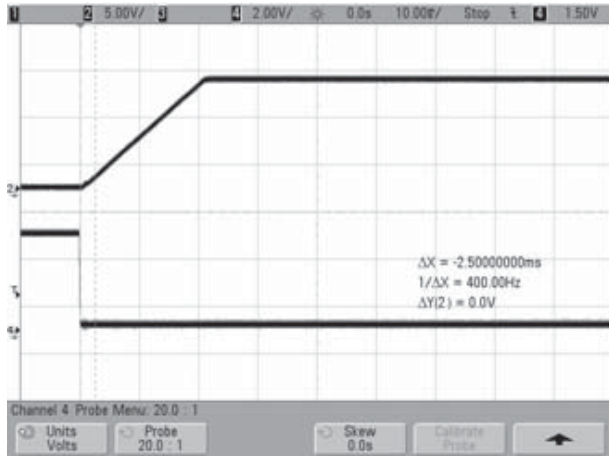
Maximum Current Temperature Derating at sea level  
(Vin = 75V, airflow from Vin to Vout, with baseplate)

Maximum Current Temperature Derating at sea level  
(Vin = 75V, airflow from -Vin to +Vin, with baseplate)

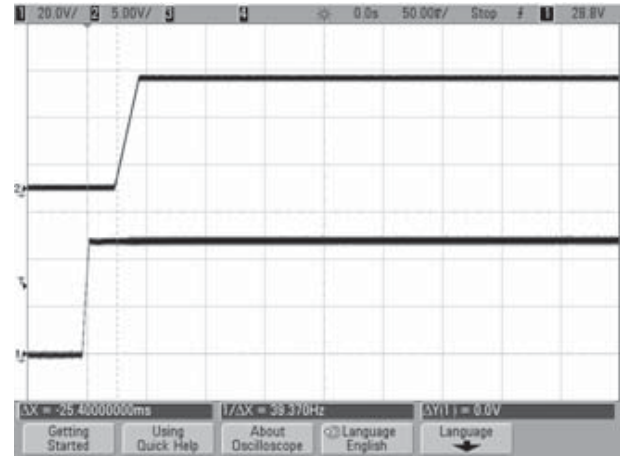


## PERFORMANCE DATA

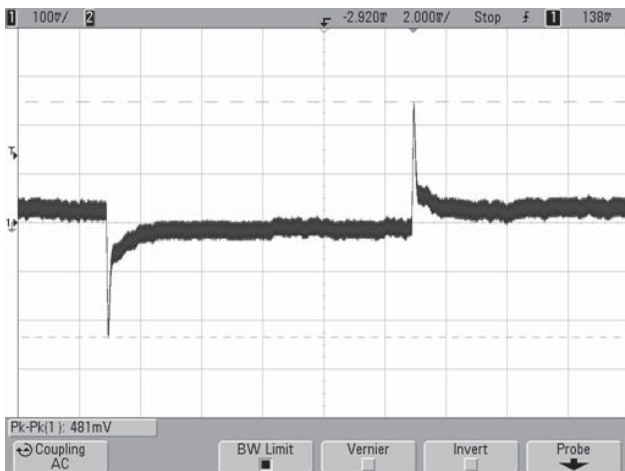
Enable Startup Delay (Vin = 48V, Iout = full load, Cout = 10000µF, Ta = +25°C)  
Ch2 = Vout, Ch4 = Enable.



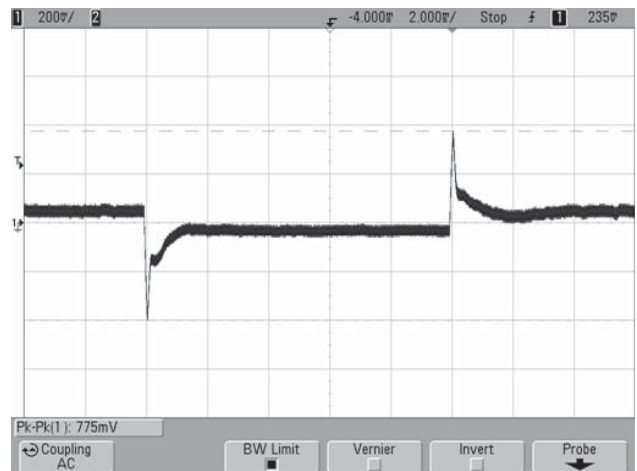
Startup Delay (Vin = 48V, Iout = full load, Cout = 10000µF, Ta = +25°C) Ch1 = Vin, Ch2 = Vout.



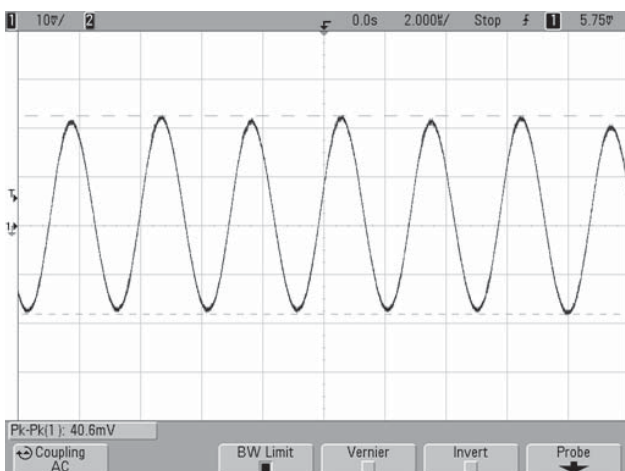
Stepload Transient Response (Vin = 48V, Iout = 50-75-50% of Iout, Cloud = 1000µF)



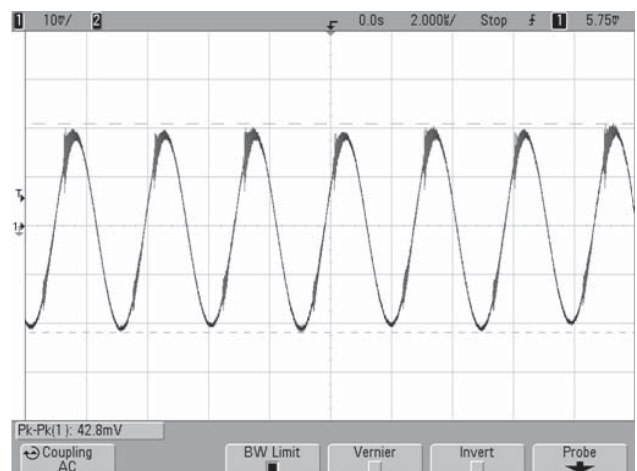
Stepload Transient Response (Vin = 48V, Iout = 25-75-25% of Iout, Cloud = 1000µF)



Output Ripple & Noise (Vin = 48V, Iout = 0A, Cout = 1µF || 10µF, Ta = +25°C)



Output Ripple & Noise (Vin = 48V, Iout = full load, Cout = 1µF || 10µF, Ta = +25°C)





**TECHNICAL NOTES**

### Power Management Overview

The module includes a wide range of readable and configurable power management features that are easy to implement with a minimum of external components. Furthermore, the module includes protection features that continuously protect the load from damage due to unexpected system faults. The SMBALERT pin alerts the host if there is a fault in the module. The following product parameters can continuously be monitored by a host: Vout, Iout, Vin, Temperature, and Power Good. The module is distributed with a default configuration suitable for a wide range operation in terms of Vin, Vout, and load. All power management functions can be reconfigured using the PMBus interface. The product provides a PMBus digital interface that enables the user to configure many aspects of the device operation as well as monitor the input and output parameters. Please contact our FAE for special configurations.

### Soft-start Power Up

The default rise time of the ramp up is 20 ms. When starting by applying input voltage the control circuit boot-up time adds an additional 10 ms delay. The soft-start power up of the module can be reconfigured using the PMBus interface.

### Over Voltage Protection (OVP)

The module includes over voltage limiting circuitry for protection of the load. The default OVP limit is 20% above the nominal output voltage. If the output voltage surpasses the OVP limit, the module can respond in different ways. The default response from an over voltage fault is to immediately shut down. The device will continuously check for the presence of the fault condition, and when the fault condition no longer exists the device will be re-enabled. The OVP fault level and fault response can be reconfigured using the PMBus interface.

### Over Current Protection (OCP, Current limit)

The module includes current limiting circuitry for protection at continuous over load. The default setting for the product is hicup mode. The current limit could be configured by simply setting the IOOUT\_OC\_FAULT\_LIMIT to be greater than the IOOUT\_OC\_WARN\_LIMIT. The maximum value that the current limit could be set is 50A.

### Power Good

The module provides Power Good (PG) flag in the Status Word register that indicates the output voltage is within a specified tolerance of its target level and no fault condition exists. The Power Good pin default logic is negative and it can be configured by MFR\_PGOOD\_POLARITY.

### Switching Frequency Adjust Using PMBus

By default the switching frequency is set to 175-250 KHz variable frequency control. The product is optimized at this frequency but it can be changed to 175 KHz fixed frequency control. The thermal performance can be affected if the switching frequency is changed when Vin is above 50 Vdc. The following graph shows Frequency vs. Vin.

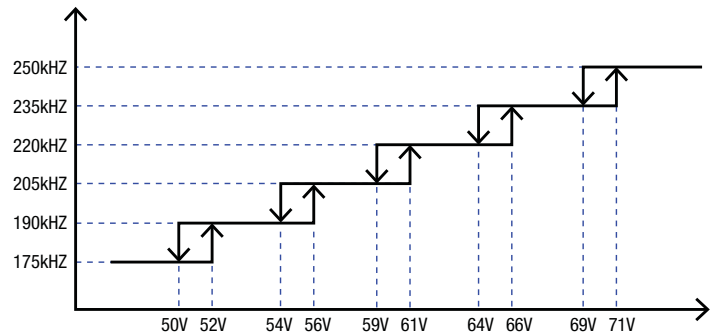


Figure 1. Frequency graph

### PMBus Interface

This module offers a PMBus digital interface that enables the user to configure many characteristics of the device operation as well as to monitor the input and output voltages, output current and device temperature. The module can be used with any standard two-wire I2C or SMBus host device. In addition, the module is compatible with PMBus version 1.2 and includes an SMBALERT line to help alleviate bandwidth limitations related to continuous fault monitoring. The module supports 100 kHz and 400 kHz bus clock frequency only.

| PMBUS Logic Level | MIN. | NOM. | MAX. | UNITS |
|-------------------|------|------|------|-------|
| Logic high input  | 2    |      | 3.3  | V     |
| Logic low input   | 0    |      | 0.8  | V     |
| Logic high output | 2.4  |      | 3.6  | V     |
| Logic low output  | -0.1 |      | 0.4  | V     |

### Monitoring via PMBus

A system controller (host device) can monitor a wide variety of parameters through the PMBus interface. The controller can monitor fault conditions by monitoring the SMBALERT pin, which will be asserted when any number of pre-configured fault or warning conditions occur. The system controller can also continuously monitor any number of power conversion parameters including but not limited to the following:

- Input voltage
- Output voltage
- Output current
- Module temperature

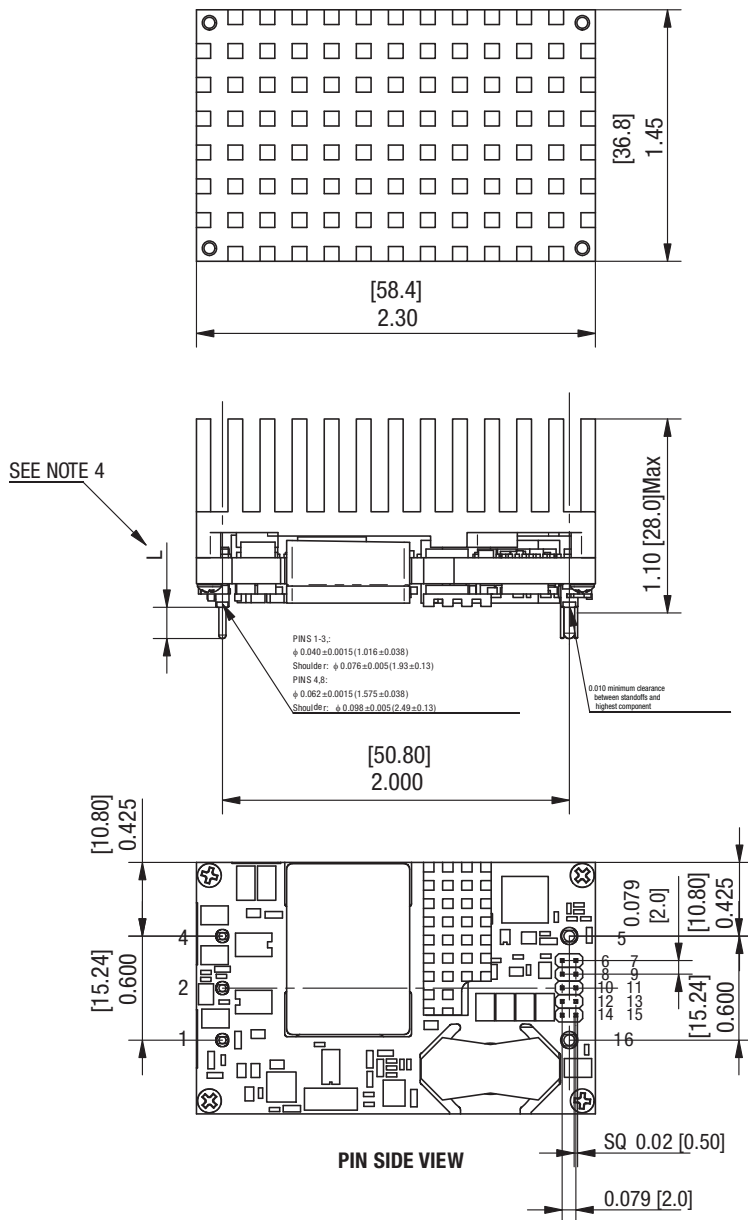
### Software Tools for Design and Production

For these modules, Murata-PS provides software for configuring and monitoring via the PMBus interface. For more information please contact your local Murata-PS representative.

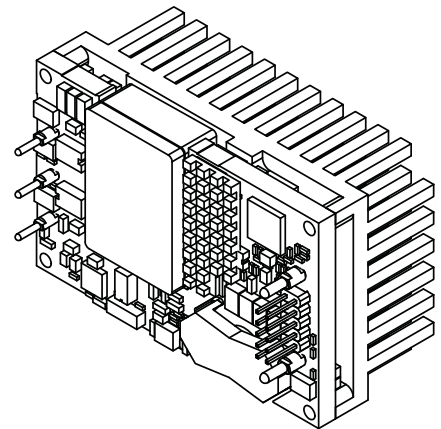
See <http://power.murata.com/datasheet/?data/apnotes/dcan-63.pdf> for Application Note AN-63, Digital DC-DC Evaluation Board User Guide.

See <http://power.murata.com/datasheet/?data/apnotes/dcan-64.pdf> for Application Note AN-64, Murata Power Brick GUI User Guide.

**ABC (PMBUS) MECHANICAL SPECIFICATIONS WITH HEAT SINK**



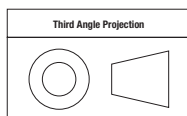
- NOTES:  
 UNLESS OTHERWISE SPECIFIED:  
 1: ALL DIMENSIONS ARE IN INCHES [MILLIMETERS];  
 2: ALL TOLERANCES:  $x.xx \times in, \pm 0.02in (x.xxmm, \pm 0.5mm)$   
 $x.xxx \times in, \pm 0.01in (x.xxxmm, \pm 0.25mm)$   
 3: COMPONENTS WILL VARY BETWEEN MODELS  
 4: STANDARD PIN LENGTH: 0.180 Inch  
 FOR PIN LENGTH OPTIONS, SEE PART NUMBER STRUCTURE.



ISOMETRIC VIEW

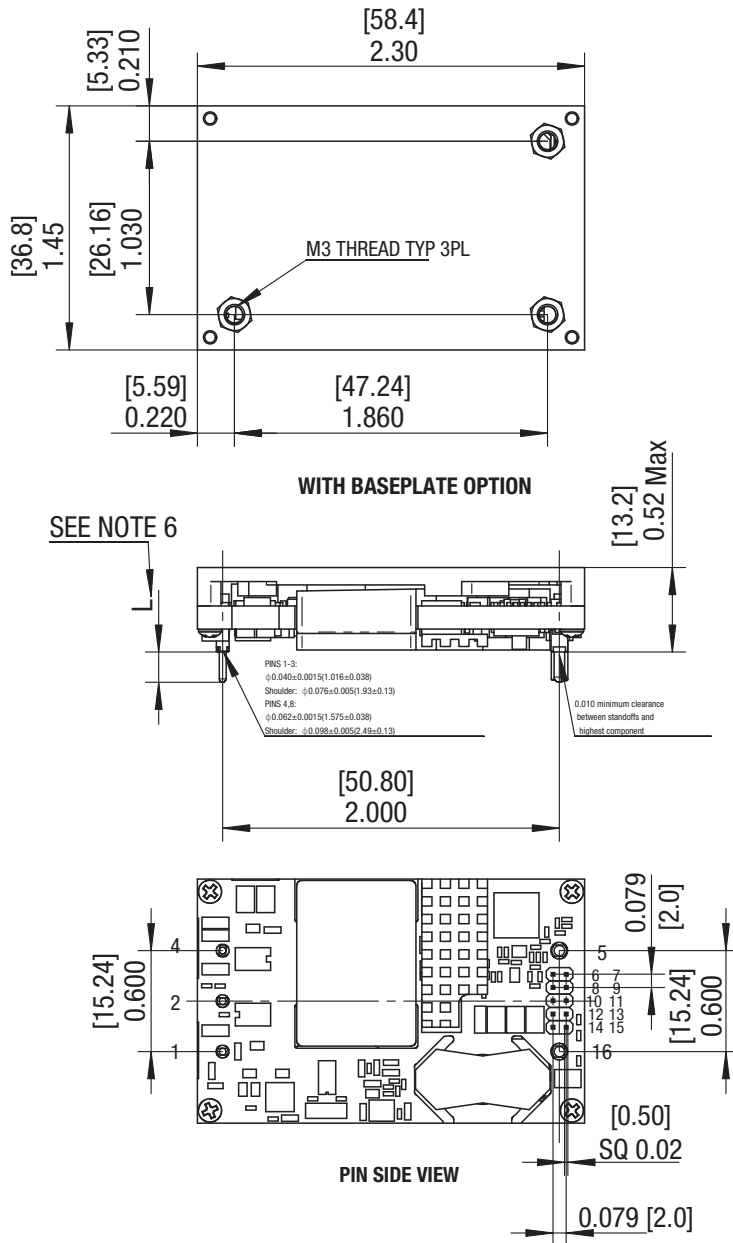
| INPUT/OUTPUT CONNECTIONS |                  |                          |
|--------------------------|------------------|--------------------------|
| Pin                      | Designation      | Function                 |
| 1                        | +VIN             | Positive Input           |
| 2                        | On/Off 1 Control | Primary On/Off Control   |
| 3                        | No Pin           | No Pin                   |
| 4                        | -VIN             | Negative Input           |
| 5                        | -VOUT            | Negative Output          |
| 6                        | +S               | Positive Remote Sense    |
| 7                        | -S               | Negative Remote Sense    |
| 8                        | SA0              | Address Pin 0            |
| 9                        | SA1              | Address Pin 1            |
| 10                       | SCL              | PMBus Clock              |
| 11                       | SDA              | PMBus Data               |
| 12                       | PG               | Power Good Output        |
| 13                       | DGND             | PMBus Ground             |
| 14                       | SMBALERT         | PMBus Alert Signal       |
| 15                       | On/Off 2 Control | Secondary On/Off Control |
| 16                       | +VOUT            | Positive Output          |

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  $\pm 2^\circ$

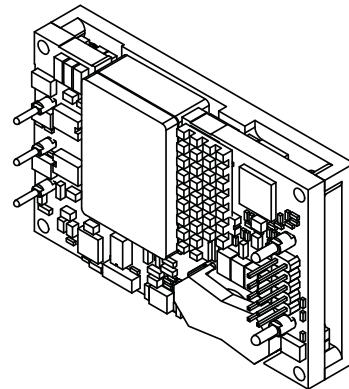
**ABC (PMBUS) MECHANICAL SPECIFICATIONS WITH BASEPLATE**



**NOTES:**

UNLESS OTHERWISE SPECIFIED:

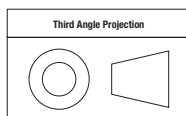
- 1: M3 SCREW USED TO BOLT UNIT'S BASEPLATE TO OTHER SURFACES (SUCH AS HEATSINK) MUST NOT EXCEED 0.11"(2.8mm) DEPTH BELOW THE SURFACE OF BASEPLATE
- 2: APPLIED TORQUE PER SCREW SHOULD NOT EXCEED 5.3In-lb (0.6Nm);
- 3: ALL DIMENSIONS ARE IN INCHES [MILLIMETERS];
- 4: ALL TOLERANCES: x.x×in, ±0.02in (x.x×mm, ±0.5mm)  
x.x××in, ±0.01in (x.x××mm, ±0.25mm)
- 5: COMPONENTS WILL VARY BETWEEN MODELS
- 6: STANDARD PIN LENGTH: 0.180 Inch  
FOR PIN LENGTH OPTIONS, SEE PART NUMBER STRUCTURE.



**INPUT/OUTPUT CONNECTIONS**

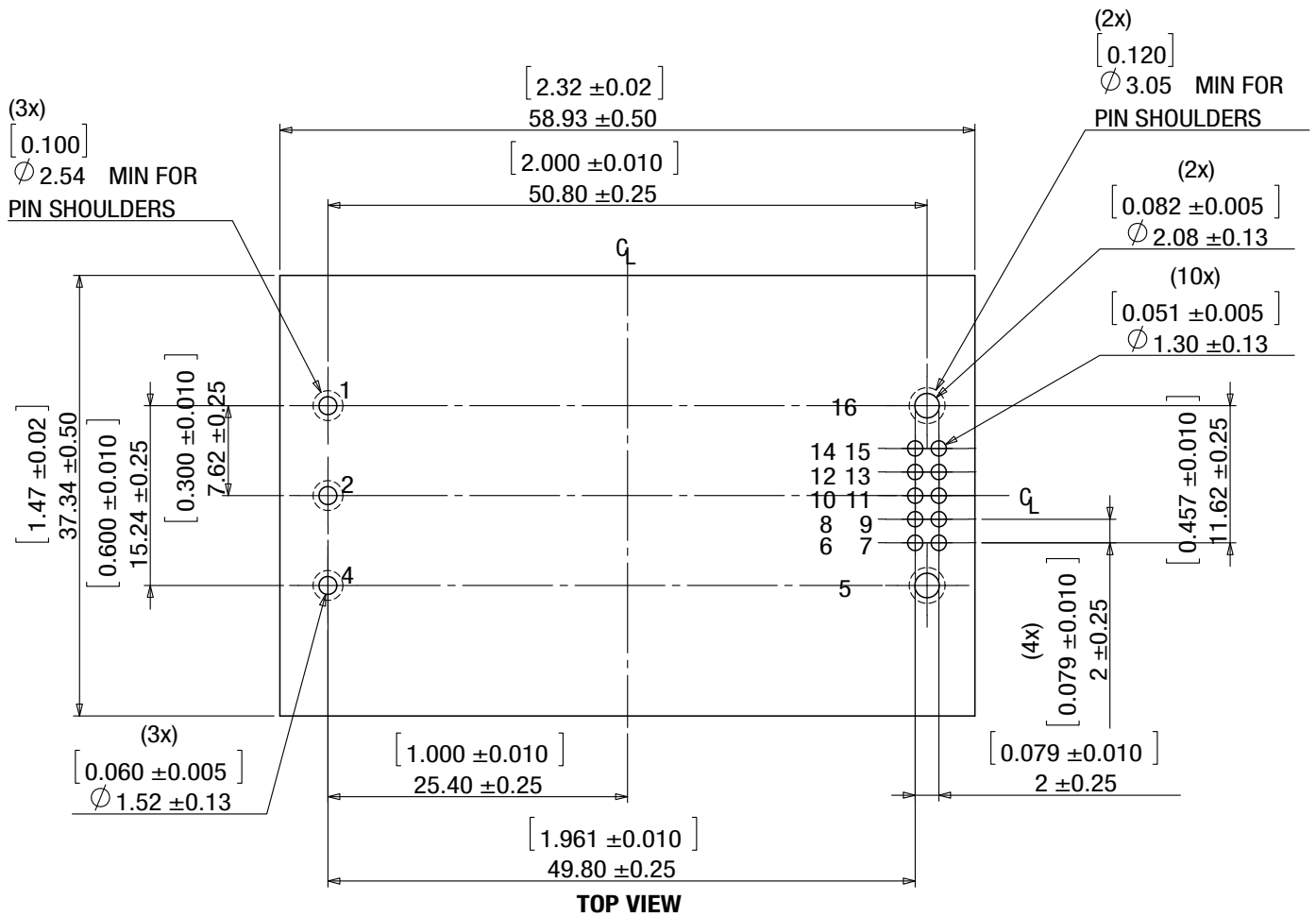
| Pin | Designation      | Function                 |
|-----|------------------|--------------------------|
| 1   | +VIN             | Positive Input           |
| 2   | On/Off 1 Control | Primary On/Off Control   |
| 3   | No Pin           | No Pin                   |
| 4   | -VIN             | Negative Input           |
| 5   | -VOUT            | Negative Output          |
| 6   | +S               | Positive Remote Sense    |
| 7   | -S               | Negative Remote Sense    |
| 8   | SA0              | Address Pin 0            |
| 9   | SA1              | Address Pin 1            |
| 10  | SCL              | PMBus Clock              |
| 11  | SDA              | PMBus Data               |
| 12  | PG               | Power Good Output        |
| 13  | DGND             | PMBus Ground             |
| 14  | SMBALERT         | PMBus Alert Signal       |
| 15  | On/Off 2 Control | Secondary On/Off Control |
| 16  | +VOUT            | Positive Output          |

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

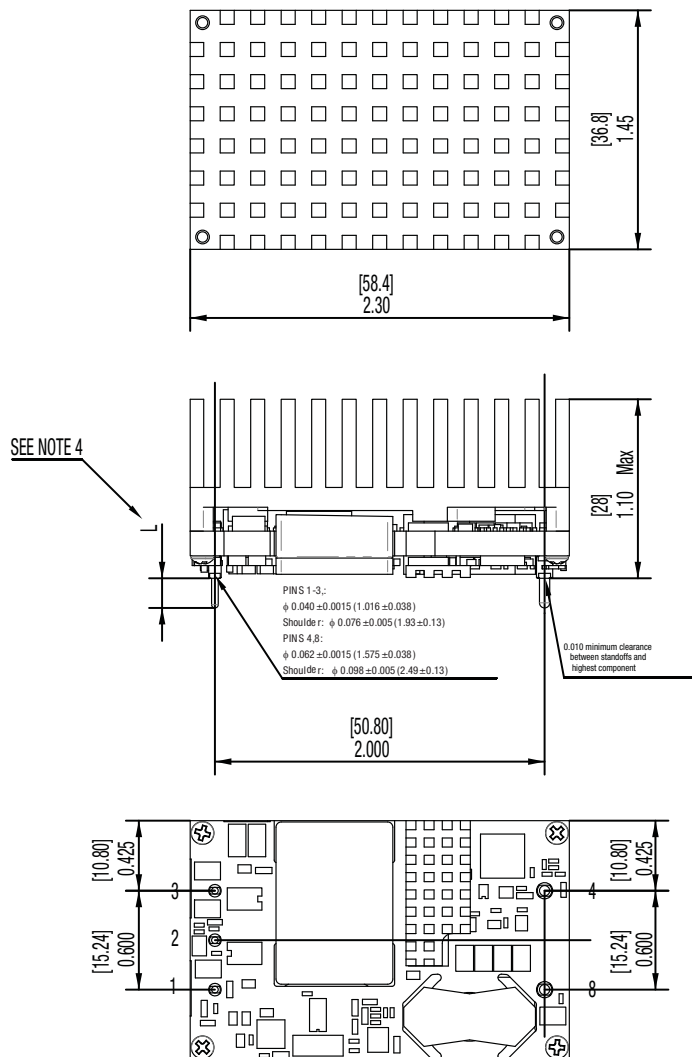


Tolerances (unless otherwise specified):  
 .XX ± 0.02 (0.5)  
 .XXX ± 0.010 (0.25)  
 Angles ± 2°

ABC (PMBUS) RECOMMENDED FOOTPRINT



**MECHANICAL SPECIFICATIONS (NO PMBUS) WITH HEAT SINK**

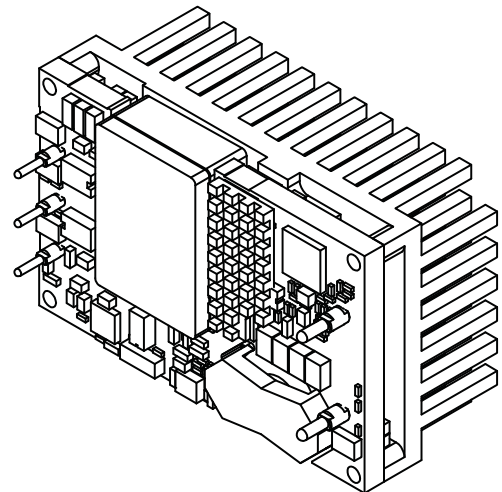


**PIN SIDE VIEW**

**NOTES:**

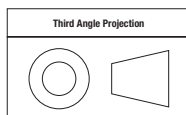
UNLESS OTHERWISE SPECIFIED:

- 1: ALL DIMENSIONS ARE IN INCHES [MILLIMETERS];
- 2: ALL TOLERANCES:  $x.x \times \text{in}$ ,  $\pm 0.02 \text{in}$  ( $x.x \text{mm}$ ,  $\pm 0.5 \text{mm}$ )  
 $x.x \times \text{in}$ ,  $\pm 0.01 \text{in}$  ( $x.x \text{mm}$ ,  $\pm 0.25 \text{mm}$ )
- 3: COMPONENTS WILL VARY BETWEEN MODELS
- 4: STANDARD PIN LENGTH: 0.180 Inch  
FOR PIN LENGTH OPTIONS, SEE PART NUMBER STRUCTURE.
- 5: DOSA 5 PIN COMPATIBLE



**ISOMETRIC VIEW**

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

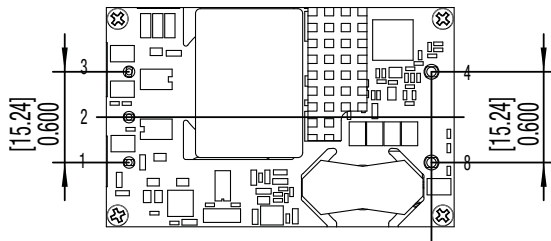
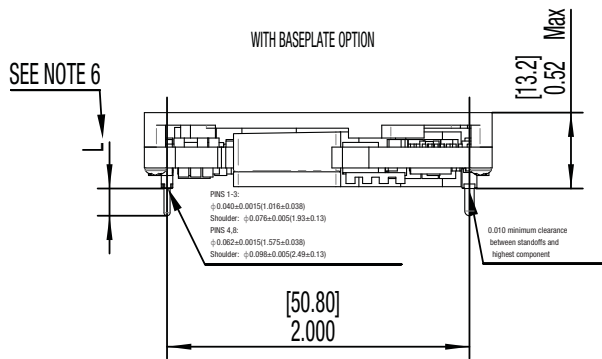
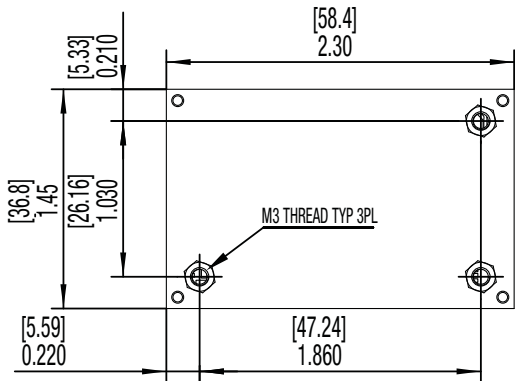


Tolerances (unless otherwise specified):  
 .XX ± 0.02 (0.5)  
 .XXX ± 0.010 (0.25)  
 Angles ± 2°

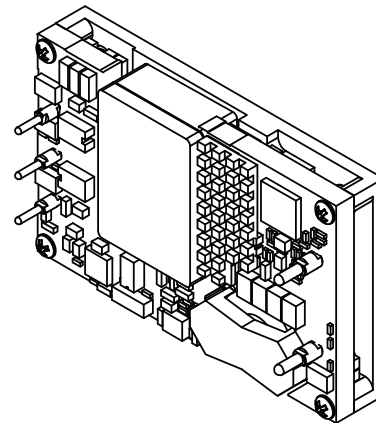
**I/O Connections**

| Pin | Function              |
|-----|-----------------------|
| 1   | +Vin                  |
| 2   | Remote On/Off Control |
| 3   | -Vin                  |
| 4   | -Vout                 |
| 8   | +Vout                 |

**MECHANICAL SPECIFICATIONS (NO PMBUS) WITH BASEPLATE**



**PIN SIDE VIEW**



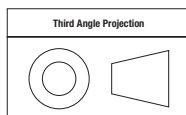
**ISOMETRIC VIEW**

**NOTES:**

UNLESS OTHERWISE SPECIFIED:

- 1: M3 SCREW USED TO BOLT UNIT'S BASEPLATE TO OTHER SURFACES (SUCH AS HEATSINK) MUST NOT EXCEED 0.11"(2.8mm) DEPTH BELOW THE SURFACE OF BASEPLATE
- 2: APPLIED TORQUE PER SCREW SHOULD NOT EXCEED 5.3In-lb (0.6Nm);
- 3: ALL DIMENSIONS ARE IN INCHES [MILIMETERS];
- 4: ALL TOLERANCES:  $x.x \times \text{in}$ ,  $\pm 0.02 \text{in}$  ( $x.x \text{mm}$ ,  $\pm 0.5 \text{mm}$ )  
 $x.x \times \text{in}$ ,  $\pm 0.01 \text{in}$  ( $x.x \text{mm}$ ,  $\pm 0.25 \text{mm}$ )
- 5: COMPONENTS WILL VARY BETWEEN MODELS
- 6: STANDARD PIN LENGTH: 0.180 Inch  
FOR PIN LENGTH OPTIONS, SEE PART NUMBER STRUCTURE.
- 7: DOSA 5 PIN COMPATIBLE

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

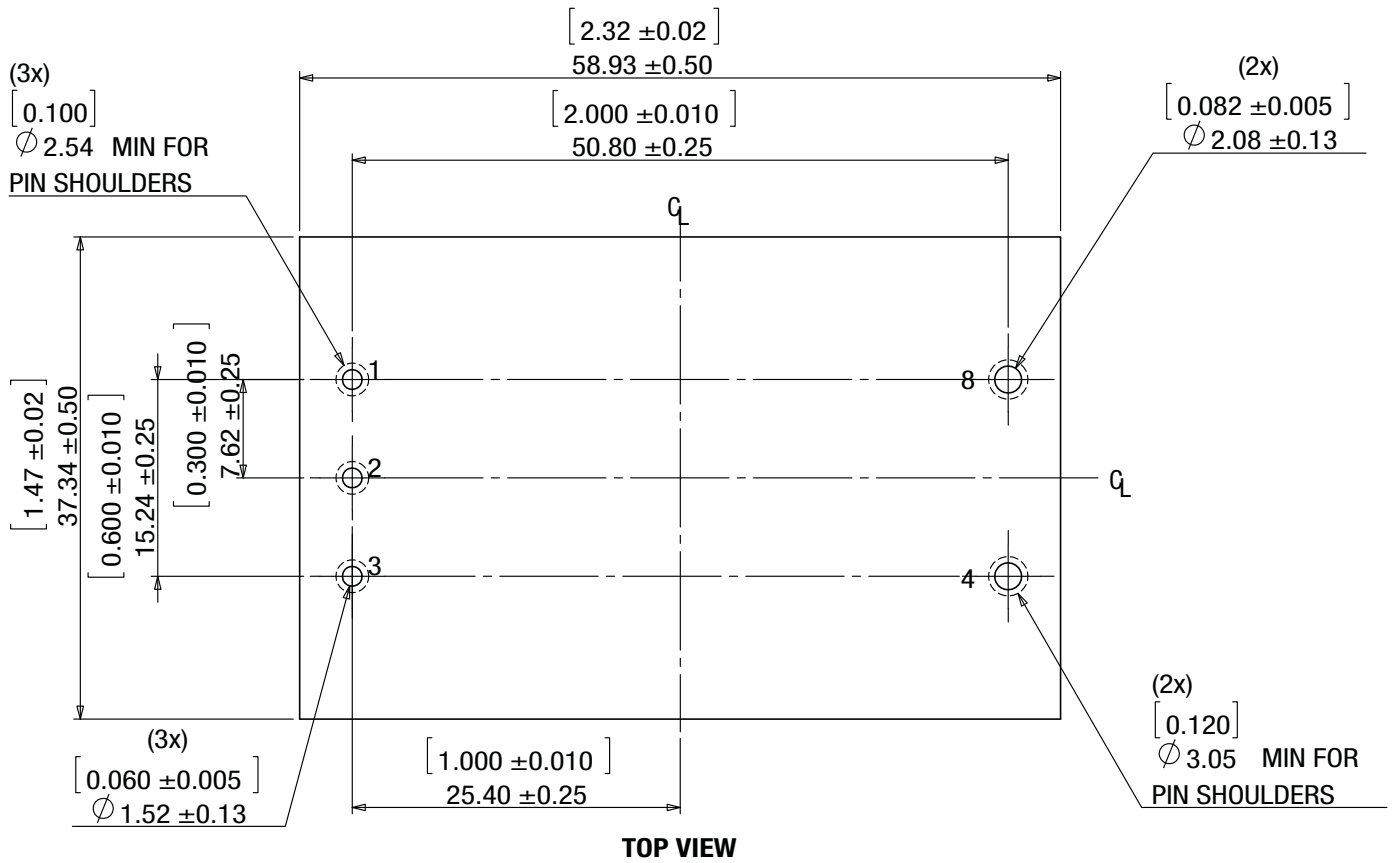


Tolerances (unless otherwise specified):  
 .XX  $\pm 0.02$  (0.5)  
 .XXX  $\pm 0.010$  (0.25)  
 Angles  $\pm 2^\circ$

**I/O Connections**

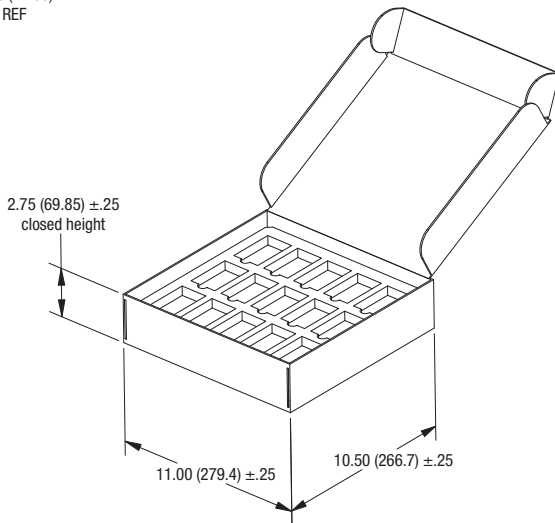
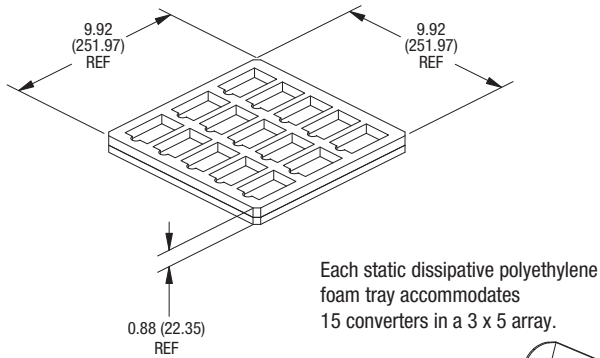
| Pin | Function              |
|-----|-----------------------|
| 1   | +Vin                  |
| 2   | Remote On/Off Control |
| 3   | -Vin                  |
| 4   | -Vout                 |
| 8   | +Vout                 |

**RECOMMENDED FOOTPRINT (NO PMBUS)**



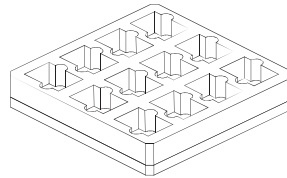
**STANDARD PACKAGING**

**BASEPLATE VERSION**

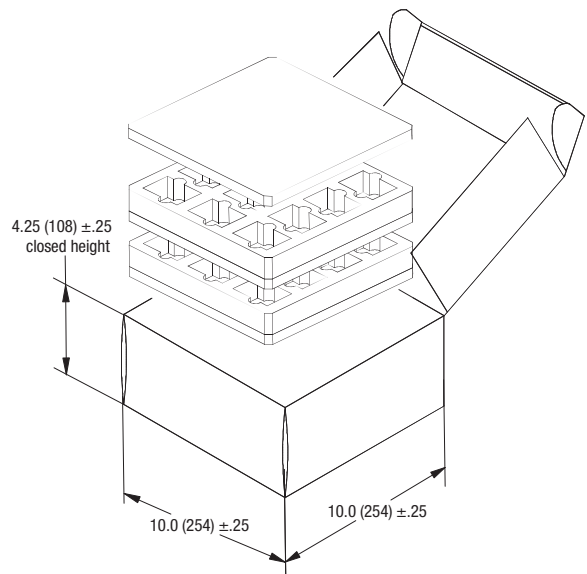


Carton accommodates two (2) trays yielding 30 converters per carton

**HEATSINK VERSION**

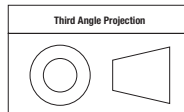


Each static dissipative polyethylene foam tray accommodates 12 converters in a 3 x 4 array.



Carton accommodates two (2) trays yielding 24 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'



### PMBus Addressing

Figure 2 and the accompanying table display the recommended resistor values for hard-wiring PMBus addresses (1% tolerance resistors recommended): The address is set in the form of two octal (0 to 7) digits, with each pin setting one digit. The resistor values for each digit is shown below.

The SA0 and SA1 pins can be configured with a resistor to GND according to the following equation.

$$\text{PMBus Address} = 8 \times (\text{SA0value}) + (\text{SA1 value})$$

If the calculated PMBus address is 0d, 11d or 12d, PMBus address 119d is assigned instead. From a system point of view, the user shall also be aware of further limitations of the addresses as stated in the PMBus Specification. It is not recommended to keep the SA0 and SA1 pins left open.

### PMBus Commands

The products are designed to be PMBus compliant. The following tables list the implemented PMBus read commands. For more detailed information see “PMBus Power System Management Protocol Specification, Part I – General Requirements, Transport and Electrical Interface” and “PMBus Power System Management Protocol, Part II – Command Language.”

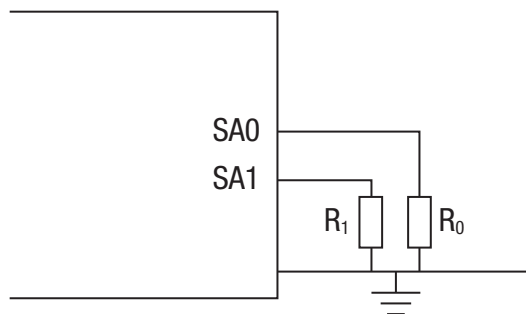


Figure 2. Schematic of Connection of Address Resistors

| Digit (SA0, SA1 index) | Resistor Value [kΩ] |
|------------------------|---------------------|
| 0                      | 10                  |
| 1                      | 22                  |
| 2                      | 33                  |
| 3                      | 47                  |
| 4                      | 68                  |
| 5                      | 100                 |
| 6                      | 150                 |
| 7                      | 220                 |

### OVERALL

| CMD | Command Name <sup>1</sup>           | SMBus Transaction Type: Writing Data | SMBus Transaction Type: Reading Data | Number Of Data Bytes | Default Value | Lower Limit | Upper Limit | Cross Check                               | Unit |
|-----|-------------------------------------|--------------------------------------|--------------------------------------|----------------------|---------------|-------------|-------------|---|------|
| 01h | OPERATION <sup>2</sup>              | Write Byte                           | Read Byte                            | 1                    | 0x80          |             |             |   |      |
| 02h | ON_OFF_CONFIG <sup>3</sup>          | Write Byte                           | Read Byte                            | 1                    | 0x1D          |             |             |   |      |
| 03h | CLEAR_FAULTS                        | Send byte                            | N/A                                  | 0                    | N/A           |             |             |   |      |
| 10h | WRITE_PROTECT                       | Write Byte                           | Read Byte                            | 1                    | 0x00          |             |             |   |      |
| 11h | STORE_DEFAULT_ALL <sup>4</sup>      | Send byte                            | N/A                                  | 0                    | N/A           |             |             |   |      |
| 12h | RESTORE_DEFAULT_ALL <sup>4</sup>    | Send byte                            | N/A                                  | 0                    | N/A           |             |             |   |      |
| 15h | STORE_USER_ALL <sup>4</sup>         | Send byte                            | N/A                                  | 0                    | N/A           |             |             |   |      |
| 16h | RESTORE_USER_ALL <sup>4</sup>       | Send byte                            | N/A                                  | 0                    | N/A           |             |             |   |      |
| 19h | CAPABILITY                          | N/A                                  | Read Byte                            | 1                    | 0xB0          |             |             |   |      |
| 20h | VOUT_MODE                           | N/A                                  | Read Byte                            | 1                    | 0x17          |             |             |   |      |
| 21h | VOUT_COMMAND                        | Write Word                           | Read Word                            | 2                    | 11.500        | 8.100       | 13.200      |   | V    |
| 22h | VOUT_TRIM                           | Write Word                           | Read Word                            | 2                    | 0             |             |             | 8.1<=Vout<=13.212                         | V    |
| 25h | VOUT_MARGIN_HIGH                    | Write Word                           | Read Word                            | 2                    | 13.199        | 8.100       | 13.199      | >VOUT_MARGIN_LOW                          | V    |
| 26h | VOUT_MARGIN_LOW                     | Write Word                           | Read Word                            | 2                    | 8.100         | 8.100       | 13.200      | <VOUT_MARGIN_HIGH                         | V    |
| 40h | VOUT_OV_FAULT_LIMIT                 | Write Word                           | Read Word                            | 2                    | 14.199        | 8.100       | 15.600      | >VOUT_OV_WARN_LIMIT                       | V    |
| 41h | VOUT_OV_FAULT_RESPONSE <sup>5</sup> | Write Byte                           | Read Byte                            | 1                    | 0xB8          |             |             |   |      |
| 42h | VOUT_OV_WARN_LIMIT                  | Write Word                           | Read Word                            | 2                    | 13.500        | 8.100       | 15.600      | <VOUT_OV_FAULT_LIMIT<br>>VOUT_COMMAND     | V    |
| 46h | IOUT_OC_FAULT_LIMIT                 | Write Word                           | Read Word                            | 2                    | 54.00         | 0.00        | 60.00       | >IOUT_OC_WARN_LIMIT                       | A    |
| 47h | IOUT_OC_FAULT_RESPONSE <sup>5</sup> | Write Byte                           | Read Byte                            | 1                    | 0xF8          |             |             |   |      |
| 4Ah | IOUT_OC_WARN_LIMIT                  | Write Word                           | Read Word                            | 2                    | 52.00         | 0.00        | 60.00       | <IOUT_OC_FAULT_LIMIT                      | A    |
| 4Fh | OT_FAULT_LIMIT                      | Write Word                           | Read Word                            | 2                    | 132           | 30          | 145         | >OT_WARN_LIMIT                            | °C   |
| 50h | OT_FAULT_RESPONSE <sup>5</sup>      | Write Byte                           | Read Byte                            | 1                    | 0xB8          |             |             |   |      |
| 51h | OT_WARN_LIMIT                       | Write Word                           | Read Word                            | 2                    | 115           | 30          | 145         | <OT_FAULT_LIMIT                           | °C   |
| 58h | VIN_UV_WARN_LIMIT                   | Write Word                           | Read Word                            | 2                    | 37.00         | 32.00       | 75.00       | <VIN_OV_WARN_LIMIT<br>>VIN_UV_FAULT_LIMIT | V    |
| 59h | VIN_UV_FAULT_LIMIT                  | Write Word                           | Read Word                            | 2                    | 35.50         | 32.00       | 75.00       | <VIN_UV_WARN_LIMIT                        | V    |
| 5Ah | VIN_UV_FAULT_RESPONSE <sup>7</sup>  | Write Byte                           | Read Byte                            | 1                    | 0xF8          |             |             |   |      |
| 5Eh | POWER_GOOD_ON                       | Write Word                           | Read Word                            | 2                    | 10.799        | 1.000       | 13.199      | >POWER_GOOD_OFF                           | V    |
| 5Fh | POWER_GOOD_OFF                      | Write Word                           | Read Word                            | 2                    | 9.600         | 1.000       | 13.199      | <POWER_GOOD_ON                            | V    |
| 60h | TON_DELAY                           | Write Word                           | Read Word                            | 2                    | 1             | 1           | 500         |   | ms   |
| 61h | TON_RISE <sup>13</sup>              | Write Word                           | Read Word                            | 2                    | 0             | 10          | 100         |   | ms   |

### OVERALL (CONT.)

| CMD | Command Name <sup>1</sup>       | SMBus<br>Transaction Type:<br>Writing Data | SMBus<br>Transaction Type:<br>Reading Data | Number<br>Of Data<br>Bytes | Default Value            | Lower<br>Limit | Upper<br>Limit | Cross Check | Unit |
|-----|---------------------------------|--|--|----------------------------|--------------------------|----------------|----------------|-------------|------|
| 64h | TOFF_DELAY                      | Write Word                                 | Read Word                                  | 2                          | 0                        | 0              | 500            |             | ms   |
| 65h | TOFF_FALL <sup>13</sup>         | Write Word                                 | Read Word                                  | 2                          | 0                        | 10             | 100            |             | ms   |
| 78h | STATUS_BYTE                     | Write Byte                                 | Read Byte                                  | 1                          | N/A                      |                |                |             |      |
| 79h | STATUS_WORD                     | Write Word                                 | Read Word                                  | 2                          | N/A                      |                |                |             |      |
| 7Ah | STATUS_VOUT                     | Write Byte                                 | Read Byte                                  | 1                          | N/A                      |                |                |             |      |
| 7Bh | STATUS_IOUT                     | Write Byte                                 | Read Byte                                  | 1                          | N/A                      |                |                |             |      |
| 7Ch | STATUS_INPUT                    | Write Byte                                 | Read Byte                                  | 1                          | N/A                      |                |                |             |      |
| 7Dh | STATUS_TEMPERATURE              | Write Byte                                 | Read Byte                                  | 1                          | N/A                      |                |                |             |      |
| 7Eh | STATUS_CML                      | Write Byte                                 | Read Byte                                  | 1                          | N/A                      |                |                |             |      |
| 88h | READ_VIN                        | N/A  | Read Word                                  | 2                          | N/A                      |                |                |             | V    |
| 88h | READ_VOUT                       | N/A  | Read Word                                  | 2                          | N/A                      |                |                |             | V    |
| 8Ch | READ_IOUT                       | N/A  | Read Word                                  | 2                          | N/A                      |                |                |             | A    |
| 8Dh | READ_TEMPERATURE_1 <sup>8</sup> | N/A  | Read Word                                  | 2                          | N/A                      |                |                |             | °C   |
| 8Eh | READ_TEMPERATURE_2 <sup>9</sup> | N/A  | Read Word*                                 | 2                          | N/A                      |                |                |             | °C   |
| 94h | READ_DUTY_CYCLE                 | N/A  | Read Word                                  | 2                          | N/A                      |                |                |             | %    |
| 95h | READ_FREQUENCY                  | N/A  | Read Word                                  | 2                          | N/A                      |                |                |             | KHZ  |
| 96h | READ_POUT                       | N/A  | Read Word                                  | 2                          | N/A                      |                |                |             | W    |
| 98h | PMBUS_REVISION                  | N/A  | Read Byte                                  | 1                          | 0x42                     |                |                |             |      |
| 99h | MFR_ID                          | N/A  | Block Read                                 | 22                         | "Murata Power Solutions" |                |                |             |      |
| 9Ah | MFR_MODEL <sup>10</sup>         | Block Write*                               | Block Read                                 | <=20                       | N/A                      |                |                |             |      |
| 9Bh | MFR_REVISION <sup>10</sup>      | Block Write*                               | Block Read                                 | <=10                       | N/A                      |                |                |             |      |
| 9Dh | MFR_DATE <sup>10</sup>          | Block Write*                               | Block Read                                 | <=10                       | N/A                      |                |                |             |      |
| 9Eh | MFR_SERIAL <sup>10</sup>        | Block Write*                               | Block Read                                 | <=10                       | N/A                      |                |                |             |      |
| A0h | MFR_VIN_MIN                     | N/A  | Read Word                                  | 2                          | 38.00                    |                |                |             | V    |
| A1h | MFR_VIN_MAX                     | N/A  | Read Word                                  | 2                          | 75.00                    |                |                |             | V    |
| A2h | MFR_IIN_MAX                     | N/A  | Read Word                                  | 2                          | 15.5                     |                |                |             | A    |
| A3h | MFR_PIN_MAX                     | N/A  | Read Word                                  | 2                          | 438                      |                |                |             | W    |
| A4h | MFR_VOUT_MIN                    | N/A  | Read Word                                  | 2                          | 8.100                    |                |                |             | V    |
| A5h | MFR_VOUT_MAX                    | N/A  | Read Word                                  | 2                          | 13.199                   |                |                |             | V    |
| A6h | MFR_IOUT_MAX                    | N/A  | Read Word                                  | 2                          | 42.00                    |                |                |             | A    |
| A7h | MFR_POUT_MAX                    | N/A  | Read Word                                  | 2                          | 500                      |                |                |             | W    |
| A8h | MFR_TAMBIENT_MAX                | N/A  | Read Word                                  | 2                          | 85                       |                |                |             | °C   |
| A9h | MFR_TAMBIENT_MIN                | N/A  | Read Word                                  | 2                          | -40                      |                |                |             | °C   |
| B0h | USER_DATA_00                    | Block Write                                | Block Read                                 | <=20                       | "..."                    |                |                |             |      |
| B1h | USER_DATA_01                    | Block Write                                | Block Read                                 | <=20                       | "..."                    |                |                |             |      |
| C0h | MFR_MAX_TEMP_1                  | N/A  | Read Word                                  | 2                          | 132                      |                |                |             | °C   |
| D0h | MFR_VARIABLE_FREQUENCY_DISABLE  | Write Byte                                 | Read Byte                                  | 1                          | 0x00                     |                |                |             |      |
| DDh | MFR_PRIMARY_ON_OFF_CONFIG       | Write Byte                                 | Read Byte                                  | 1                          | 0x04/0x06 <sup>11</sup>  |                |                |             |      |
| DEh | MFR_PGOOD_POLARITY              | Write Byte                                 | Read Byte                                  | 1                          | 0x00                     |                |                |             |      |
| E9h | MFR_VIN_UV_FAULT_HYS            | Write Word                                 | Read Word                                  | 2                          | 2.00                     | 1.00           | 20.00          |             | V    |
| EAh | MFR_OT_FAULT_HYS                | Write Word                                 | Read Word                                  | 2                          | 20                       | 5              | 50             |             | °C   |
| F6h | MFR_CALIBRATION_STATUS          | N/A  | Read Byte*                                 | 1                          | 0xC7                     |                |                |             |      |
| F9h | MFR_VIN_SENSE_CALIBRATION       | Write byte*                                | N/A  | 1                          | N/A                      |                |                |             |      |
| FAh | MFR_IOUT_SENSE_CALIBRATION      | Write Word*                                | N/A  | 2                          | N/A                      |                |                |             |      |
| FBh | MFR_VOUT_SET_POINT_CALIBRATION  | Write Word*                                | N/A  | 2                          | N/A                      |                |                |             |      |
| FC  | MFR_SUPERVISOR_PASSWORD         | Block Write                                | N/A  | N/A                        | N/A                      |                |                |             |      |

### OVERALL (CONT.)

#### Notes:

- \* Only available in supervisor mode (default state is user mode, send password to comand 0xFC to change to supervisor mode)
- Unit restores the entire contents of the non-volatile User Store memory when power up
    - PEC is supported
    - Max bus speed: 400kHz
    - SMBALERT# is supported
    - Linear data format used
    - addressing: If the calculated PMBus address is 0d, 11d or 12d, SA0 or SA1 lefts open, default PMBus address 120d is assigned instead.
  - Not supported items:
    - 100101XXb Margin Low(Ignore Fault),
    - 101001XXb On Margin High(Ignore Fault)
  - Restart delay of turned off by OPEATION or CONTROL or primary on/off is 200ms
  - Unit will shutdown 1 second for protection, then recover automatically
  - Restart delay unit: 500ms, lower limit: 500ms.
    - Turn off delay unit: 0ms, lower limit: 0ms
    - if bits 7:6=11b, restart delay is 500ms
  - Restart delay unit and Turn off delay unit are same as note 5
    - Bits 7:6: 00b,01b,10b are not supported
  - Restart delay unit: 100ms, lower limit: 100ms.
    - Turn off delay unit:0ms, lower limit: 0ms
    - if bits 7:6=11b, restart delay is 100ms
  - Temperature of baseplate side
  - Temperature of pin side
  - Unit's actual inforamtion
  - Default value of negative logic: 0x04
    - Default value of positive logic: 0x06
  - Unit can receive any value for VOUT\_TRIM command, but Vout is limited to 8.1~13.2V, if calculated Vout exceeds limit, then equal to limit.
  - Value of 0 is acceptable, which is the same as lower limit to unit.

### MURATA-PS defined commands (01-CFh Refer to PMBus 1.2 SPEC)

| D0h: MFR_VARIABLE_FREQUENCY_DISABLE                              |   |         |   |
|--|---|---------|---|
| Bits   | Purpose   | Value   | Meaning   |
| 7:1  |   | 0000000 | Reserved  |
| 0  | Variable frequency control                        | 0       | Turn on variable frequency control                                    |
|  |   | 1       | Turn off variable frequency control                                   |
| DDh: MFR_PRIMARY_ON_OFF_CONFIG                                   |   |         |   |
| Bits   | Purpose   | Value   | Meaning   |
| 7:3  |   | 00000   | Reserved  |
| 2  | Controls how the unit responds to the CONTROL pin | 0       | Unit ignores the primary ON/OFF pin                                   |
|  |   | 1       | Unit requires the primary ON/OFF pin to be asserted to start the unit |
| 1  | Polarity of primary ON/OFF logic                  | 0       | Active low (Pull pin low to start the unit)                           |
|  |   | 1       | Active high (Pull high or open to start the unit)                     |
| 0  |   | 0       | Reserved  |
| DEh: MFR_PGOOD_POLARITY  |   |         |   |
| Bits   | Purpose   | Value   | Meaning   |
| 7:1  |   | 0000000 | Reserved  |
| 0  | Power good polarity of pin 12                     | 0       | Negative logic, output low if Vout rises to specific value            |
|  |   | 1       | Positive logic, output high if Vout rises to specific value           |
| E9h: MFR_VIN_UV_FAULT_HYS  |   |         |   |
| Hysteresis of VIN_UV_FAULT recover, Linear data format           |   |         |   |
| EAh: MFR_OT_FAULT_HYS  |   |         |   |
| Hysteresis of OT_FAULT recover, Linear data format               |   |         |   |
| F6h: MFR_CALIBRATION_STATUS                                      |   |         |   |
| Refer to calibration procedure file                              |   |         |   |
| F9h: MFR_VIN_SENSE_CALIBRATION                                   |   |         |   |
| Refer to calibration procedure file                              |   |         |   |
| FAh: MFR_IOUT_SENSE_CALIBRATION                                  |   |         |   |
| Refer to calibration procedure file                              |   |         |   |
| FBh: MFR_VOUT_SET_POINT_CALIBRATION                              |   |         |   |
| Refer to calibration procedure file                              |   |         |   |
| FCh: MFR_SUPERVISOR_PASSWORD                                     |   |         |   |
| Set unit to supervisor mode or ROM mode, Refer to password table |   |         |   |

**STATUS WORD AND BYTE (GREEN = SUPPORTED)**

| STATUS_VOUT           |
|-----------------------|
| 7 VOUT_OV_FAULT       |
| 6 VOUT_OV_WARNING     |
| 5 VOUT_UV_WARNING     |
| 4 VOUT_UV_FAULT       |
| 3 VOUT_MAX Warning    |
| 2 TON_MAX_FAULT       |
| 1 TOFF_MAX_WARNING    |
| 0 VOUT Tracking Error |

| STATUS_IOUT              |
|--------------------------|
| 7 IOUT_OC_FAULT          |
| 6 IOUT_OC_LV_FAULT       |
| 5 IOUT_OC_WARNING        |
| 4 IOUT_UC_FAULT          |
| 2 In Power Limiting Mode |
| 1 POUT_OP_FAULT          |
| 0 POUT_OP_WARNING        |

| STATUS_TEMPERATURE |
|--------------------|
| 7 OT_FAULT         |
| 6 OT_WARNING       |
| 5 UT_WARNING       |
| 4 UT_FAULT         |
| 3 Reserved         |
| 2 Reserved         |
| 1 Reserved         |
| 0 Reserved         |

| STATUS_CML                    |
|-------------------------------|
| 7 Invalid/Unsupported Command |
| 6 Invalid/Unsupported Data    |
| 5 Packet Error Check Failed   |
| 4 Memory Fault Detected       |
| 3 Processor Fault Detected    |
| 2 Reserved                    |
| 1 Other Communication Fault   |
| 0 Other Memory Or Logic Fault |

**STATUS\_WORD**

|                     |
|---------------------|
| 7 VOUT              |
| 6 IOUT/POUT         |
| 5 INPUT             |
| 4 MFR_SPECIFIC      |
| 3 POWER_GOOD#       |
| 2 FANS              |
| 1 OTHER             |
| 0 UNKNOWN           |
| 7 BUSY              |
| 6 OFF               |
| 5 VOUT_OV_FAULT     |
| 4 IOUT_OC_FAULT     |
| 3 VIN_UV_FAULT      |
| 2 TEMPERATURE       |
| 1 CML               |
| 0 NONE OF THE ABOVE |

**STATUS\_OTHER**

|                               |
|-------------------------------|
| 7 Reserved                    |
| 6 Reserved                    |
| 5 Input A Fuse/Breaker Fault  |
| 4 Input B Fuse/Breaker Fault  |
| 3 Input A OR-ing Device Fault |
| 2 Input B OR-ing Device Fault |
| 1 Output OR-ing Device Fault  |
| 0 Reserved                    |

**STATUS\_INPUT**

|                  |
|------------------|
| 7 VIN_OV_FAULT   |
| 6 VIN_OV_WARNING |
| 5 VIN_UV_WARNING |
| 4 VIN_UV_FAULT   |
| 2 IIN_OC_FAULT   |
| 1 IIN_OC_WARNING |
| 0 PIN_OP_WARNING |

**STATUS\_MFR\_SPECIFIC**

|                      |
|----------------------|
| Manufacturer Defined |
| Manufacturer Defined |
| Manufacturer Defined |
| Manufacturer Defined |
| Manufacturer Defined |
| Manufacturer Defined |
| Manufacturer Defined |
| Manufacturer Defined |

**STATUS\_FANS\_1\_2**

|                        |
|------------------------|
| 7 Fan 1 Fault          |
| 6 Fan 2 Fault          |
| 5 Fan 1 Warning        |
| 4 Fan 2 Warning        |
| 3 Fan 1 Speed Override |
| 2 Fan 2 Speed Override |
| 1 Air Flow Fault       |
| 0 Air Flow Warning     |

**STATUS\_FANS\_3\_4**

|                        |
|------------------------|
| 7 Fan 3 Fault          |
| 6 Fan 4 Fault          |
| 5 Fan 3 Warning        |
| 4 Fan 4 Warning        |
| 3 Fan 3 Speed Override |
| 2 Fan 4 Speed Override |
| 1 Reserved             |
| 0 Reserved             |

**TECHNICAL NOTES (CONT.)**

### Thermal Shutdown

Extended operation at excessive temperature will initiate overtemperature shutdown triggered by a temperature sensor outside the PWM controller. This operates similarly to overcurrent and short circuit mode. The inception point of the overtemperature condition depends on the average power delivered, the ambient temperature and the extent of forced cooling airflow. Thermal shutdown uses only the hiccup mode (autorestart) and PMBus configurable hysteresis.

### Start Up Considerations

When power is first applied to the DC-DC converter, there is some risk of start up difficulties if you do not have both low AC and DC impedance and adequate regulation of the input source. Make sure that your source supply does not allow the instantaneous input voltage to go below the minimum voltage at all times.

Use a moderate size capacitor very close to the input terminals. You may need two or more parallel capacitors. A larger electrolytic or ceramic cap supplies the surge current and a smaller parallel low-ESR ceramic cap gives low AC impedance.

Remember that the input current is carried both by the wiring and the ground plane return. Make sure the ground plane uses adequate thickness copper. Run additional bus wire if necessary.

### 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 ungrounded input supply line.

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

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. The over/under-voltage fault level and fault response and hysteresis can be configured via the PMBus interface.

### Start-Up Time

Start-Up Time (see Specifications) is the time interval between the point when the rising input voltage crosses the Start-Up Threshold and the output voltage enters and remains within its specified accuracy band.

These converters include a soft start circuit to control Vout ramp time, thereby limiting the input inrush current.

The On/Off Remote Control interval from On command to Vout (final  $\pm 5\%$ ) 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 accuracy band.

### Recommended Input Filtering

The user must assure that the input source has low AC impedance to provide dynamic stability and that the input supply has little or no inductive content,

including long distributed wiring to a remote power supply. The converter will operate with no additional external capacitance if these conditions are met.

For best performance, we recommend installing a low-ESR capacitor immediately adjacent to the converter's input terminals. The capacitor should be a ceramic type such as the Murata GRM32 series or a polymer type. More input bulk capacitance may be added in parallel (either electrolytic or tantalum) if needed.

### Recommended Output Filtering

The converter will achieve its rated output ripple and noise with no additional external capacitor. However, the user may install more external output capacitance to reduce the ripple even further or for improved dynamic response. Again, use low-ESR ceramic (Murata GRM32 series) or polymer capacitors. Mount these close to the converter. Measure the output ripple under your load conditions.

Use only as much capacitance as required to achieve your ripple and noise objectives. Excessive capacitance can make step load recovery sluggish or possibly introduce instability. Do not exceed the maximum rated output capacitance listed in the specifications.

### 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. The Cbus and Lbus components simulate a typical DC voltage bus.

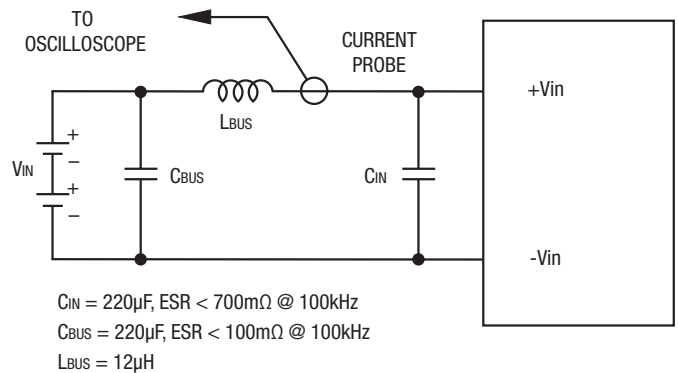
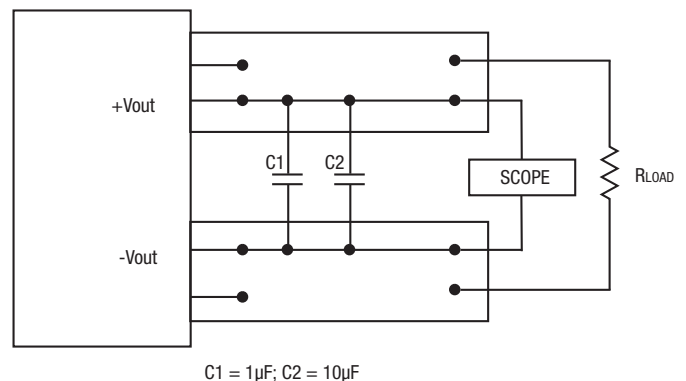


Figure 3. Measuring Input Ripple Current



C1 = 1µF; C2 = 10µF  
LOAD 2-3 INCHES (51-76mm) FROM MODULE

Figure 4. Measuring Output Ripple and Noise (PARD)

### Minimum Output Loading Requirements

All models regulate within specification and are stable under no load to full load conditions.

### Thermal Shutdown (OTP, UTP)

To prevent many over temperature problems and damage, these converters include thermal shutdown circuitry. If environmental conditions cause the temperature of the DC-DCs 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 set in the command recover temp is (OT\_FAULT\_LIMIT-MFR\_OT\_FAULT\_HYS), the hysteresis is defined in general electrical specification section. The OTP and hysteresis of the module can be reconfigured using the PMBus. The OTP and UTP fault limit and fault response can be configured via the PMBus.

**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 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. We use both thermocouples and an infrared camera system to observe thermal performance. As a practical matter, it is quite difficult to insert an anemometer to precisely measure airflow in most applications. 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 you exceed these Derating guidelines, 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 Short Circuit Condition

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.

### Remote On/Off Control

The DRQ series modules are equipped with both primary (On/Off 1, enabled, pull up internal) and secondary (On/Off 2, disabled, pull up internal) control pins for increased system flexibility. Both are configurable via PMBus. The On/Off pins are TTL open-collector and/or CMOS open-drain compatible. (See general specifications for threshold voltage levels. See also MFR\_PRIMARY\_ON\_OFF\_CONFIG section.)

**Negative-logic** models are on (enabled) when the On/Off is grounded or brought to within a low voltage (see specifications) with respect to –Vin. The device is off (disabled) when the On/Off is left open or is pulled high to +13.5Vdc with respect to –Vin. The On/Off function allows the module to be turned on/off by an external device switch.

**Positive-logic** models are enabled when the On/Off pin is left open or is pulled high to +13.5V with respect to –Vin. Positive-logic devices are disabled when the On/Off is grounded or brought to within a low voltage (see specifications) with respect to –Vin. For voltage levels for On/Off 2 signal see functional specifications.

The restart delay for this module to turn On/Off by the On/Off control pin is 100ms.

On/Off 1 can be configured by PMBus command MFR\_PRIMARY\_ON\_OFF\_CONFIG (DDh); default configuration is not ignored; required On/Off 1 control pin to be asserted to start the unit.

On/Off 2 can be configured by PMBUS command ON\_OFF\_CONFIG (02h); default configuration is ignored; treat it as always ON.

DRQ’s On/Off status is dependent on On/Off 1 control, On/Off 2 control, and OPERATION (PMBus command) status; all three must be ON to turn DRQ on; if one of them is OFF, unit will be turned off.

### On/Off 1 or 2 Control status

| On/Off 1 or 2 pin | Not ignored |         | Ignored |         |
|-------------------|-------------|---------|---------|---------|
|                   | P LOGIC     | N LOGIC | P LOGIC | N LOGIC |
| OPEN              | ON          | OFF     | ON      | ON      |
| PULL HIGH         | ON          | OFF     | ON      | ON      |
| PULL LOW          | OFF         | ON      | ON      | ON      |

### Output Capacitive Load

These converters do not require external capacitance added to achieve rated specifications. Users should only consider adding capacitance to reduce switching noise and/or to handle spike current load steps. Install only enough capacitance to achieve noise objectives. Excess external capacitance may cause degraded transient response and possible oscillation or instability.

### 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 Vout 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 Vout 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 +Vout and –Sense to –Vout 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 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:

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

### 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. Be cautious when there is high atmospheric humidity. We strongly recommend a mild pre-bake (100° C. for 30 minutes). 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:

|                             |           |
|-----------------------------|-----------|
| Maximum Preheat Temperature | 115° C.   |
| Maximum Pot Temperature     | 270° C.   |
| Maximum Solder Dwell Time   | 7 seconds |

##### For Sn/Pb based solders:

|                             |           |
|-----------------------------|-----------|
| Maximum Preheat Temperature | 105° C.   |
| Maximum Pot Temperature     | 250° C.   |
| Maximum Solder Dwell Time   | 6 seconds |

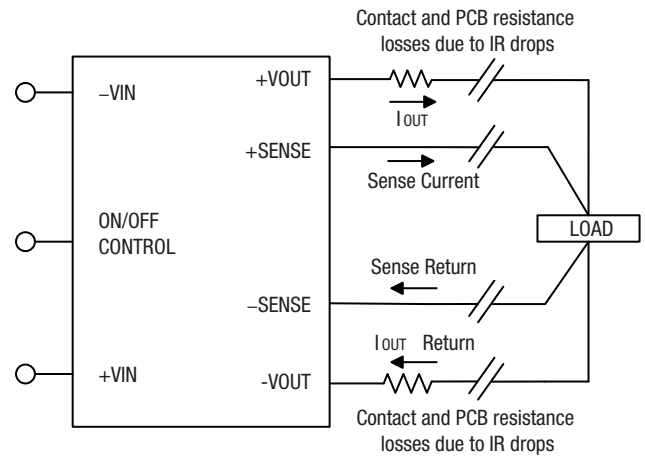


Figure 5. Remote Sense Circuit Configuration

### Emissions Performance

Murata Power Solutions measures its products for conducted emissions against the EN 55022 and CISPR 22 standards. Passive resistance loads are employed and the output is set to the maximum voltage. If you set up your own emissions testing, make sure the output load is rated at continuous power while doing the tests.

The recommended external input and output capacitors (if required) are included. Please refer to the fundamental switching frequency. All of this information is listed in the Product Specifications. An external discrete filter is installed and the circuit diagram is shown below.

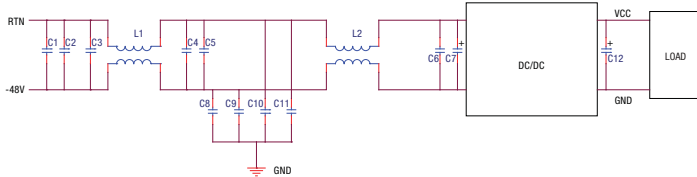


Figure 6. Conducted Emissions Test Circuit

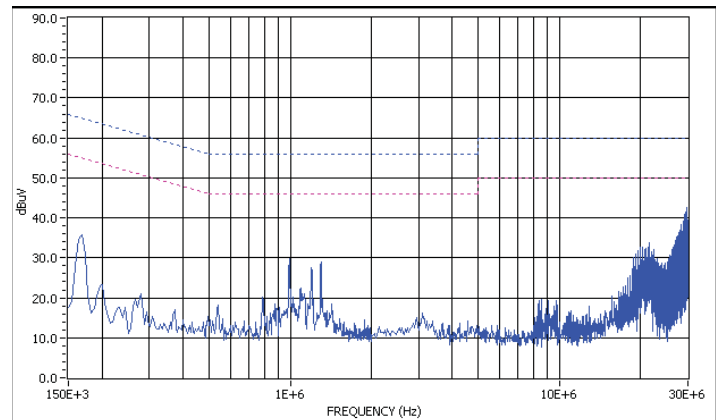
### [1] Conducted Emissions Parts List

| Reference          | Part Number        | Description                          | Vendor   |
|--------------------|--------------------|--------------------------------------|----------|
| C1, C2, C3, C4, C5 | GRM32ER72A105KA01L | SMD CERAMIC-100V-1000nF-X7R-1210     | Murata   |
| C6                 | GRM319R72A104KA01D | SMD CERAMIC100V-100nF-±10%-X7R-1206  | Murata   |
| L1, L2             | PG0060T            | COMMON MODE-473uH-±25%-14A           | Pulse    |
| C8, C9, C10, C11   | GRM55DR72J224KW01L | SMD CERAMIC630V-0.22uF-±10%-X7R-2220 | Murata   |
| C7                 | UHE2A221MHD        | Aluminum100V-220uF-±10%-long lead    | Nichicon |
| C12                | NA                 |                                      |          |

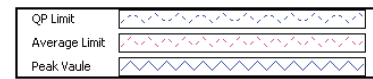
### [2] Conducted Emissions Test Equipment Used

Hewlett Packard HP8594L Spectrum Analyzer – S/N 3827A00153  
 2Line V-networks LS1-15V 50Ω/50uH Line Impedance Stabilization Network

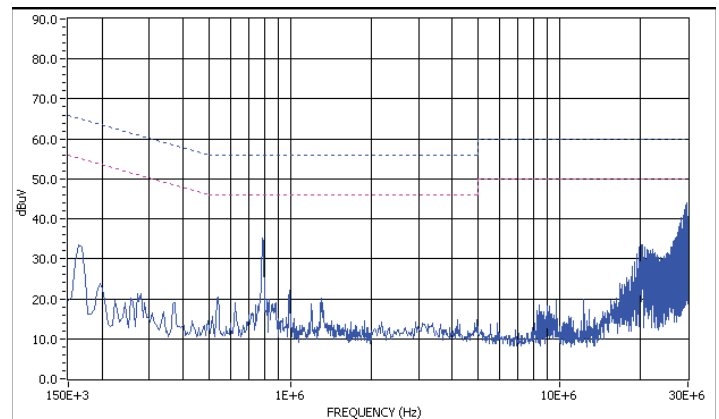
### [3] Conducted Emissions Test Results



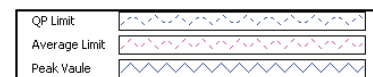
Peak Detection Value



Graph 1. Conducted emissions performance, Positive Line, CISPR 22, Class B, full load



Peak Detection Value



Graph 2. Conducted emissions performance, Negative Line, CISPR 22, Class B, full load

### [4] Layout Recommendations

Most applications can use the filtering which is already installed inside the converter or with the addition of the recommended external capacitors. For greater emissions suppression, consider additional filter components and/or shielding. Emissions performance will depend on the user's PC board layout, the chassis shielding environment and choice of external components. Please refer to Application Note GEAN-02 for further discussion.

Since many factors affect both the amplitude and spectra of emissions, we recommend using an engineer who is experienced at emissions suppression.



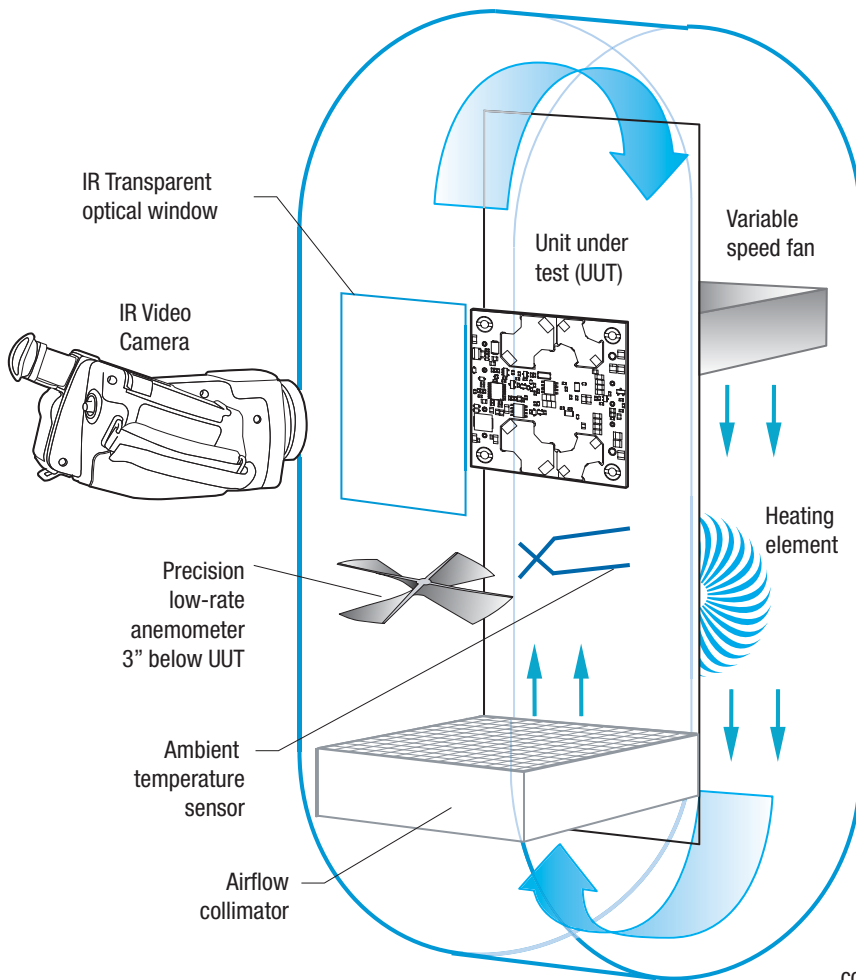


Figure 7. Vertical Wind Tunnel

### 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" x 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.

