typhoon

QUARTER-BRICK DUAL SERIES

Application Note 137

ARTESYN® TECHNOLOGIES

137 Rev. 07 / 18 July 2005

File Name: an_quarter_brick_dual.pdf

1. Introduction

This application note describes the features and functions of the Artesyn Technologies series of high power density, open frame, dual output, quarter brick modules targeted specifically at the telecommunications, industrial electronics, mobile telecommunications and distributed power markets.

The Quarter-Brick Dual series offers a wide input voltage range of 36-75VDC and the recommended hotspot operating temperature is –40°C to +120°C. Ultra-high efficiency operation is achieved through the use of proprietary synchronous rectification and control techniques. A wide output voltage trim range is provided and the module is fully protected against over-current, over-voltage and over-temperature. A positive logic remote ON/OFF input is included as standard to send the unit into a sleep mode. Negative logic remote ON/OFF is available as an option. A non-latching over-voltage protection (OVP) feature is provided while over-temperature protection (OPT) protects the unit from excessive thermal stress.

The series has been designed primarily for telecommunication applications and complies with the appropriate immunity and emission standards for high priority of service class. In addition, the series complies with all of the appropriate environmental standards (all classes) including shock, vibration, humidity and thermal performance. EN60950 and UL/cUL60950 safety approvals have been obtained. Finally, a high level of reliability has been designed into all models through the extensive use of conservative derating criteria. Automated manufacturing methods, together with an extensive qualification program, have produced a highly reliable range of converters.

2. Models

The Quarter-Brick Dual series comprises nine models, as listed in Table 1.

Model	Input Voltage	Output Voltage	Output Current
Performance Models			
LQD40A48-3V3-1V2	36-75VDC	3.3V and 1.2V	20A/20A
LQD40A48-3V3-1V5	36-75VDC	3.3V and 1.5V	20A/20A
LQD40A48-3V3-1V8	36-75VDC	3.3V and 1.8V	20A/20A
LQD40A48-3V3-2V5	36-75VDC	3.3V and 2.5V	20A/20A
Value Models			
LQD30A48-3V3-1V2	36-75VDC	3.3V and 1.2V	15A/15A
LQD30A48-3V3-1V5	36-75VDC	3.3V and 1.5V	15A/15A
LQD30A48-3V3-1V8	36-75VDC	3.3V and 1.8V	15A/15A
LQD30A48-3V3-2V5	36-75VDC	3.3V and 2.5V	15A/15A
LQD25A48-5V0-3V3	36-75VDC	5.0V and 3.3V	10A/15A

Table 1 - Quarter-Brick Models

Features

- Industry standard dual-output quarter-brick pinout and footprint: 2.300 x 1.450 x 0.300 inches (58.42 x 36.83 x 7.62mm)
- Wide operating temperature range (-40°C to +120°C hotspot temperature)
- ±10% output voltage adjustability
- No minimum load requirement
- Primary side referenced positive logic remote ON/OFF control
- Constant switching frequency
- Brickwall over-current protection
- Continuous short-circuit protection (see over-current description below
- Non-latching output over-voltage protection (OVP)
- Over-temperature protection (OPT)
- Back-bias/over-voltage lockout protection (U/OVLO)
- Basic insulation system
- 100 Volt, 100ms, transient rated

3. General Description

3.1 Electrical Description

As shown in Figure 1, this series is implemented using a unique, voltage-mode controlled, interleaved, half-bridge topology. Power is magnetically transferred across the isolation barrier via isolating power transformers. In all models, the secondary side rectification stage consists of synchronous rectifiers controlled by drive circuitry that optimises the timing between the primary and secondary sides which is critical for high efficiency power conversion. Each output has its own power train and regulation network providing two outputs that have extremely minimal cross regulation.

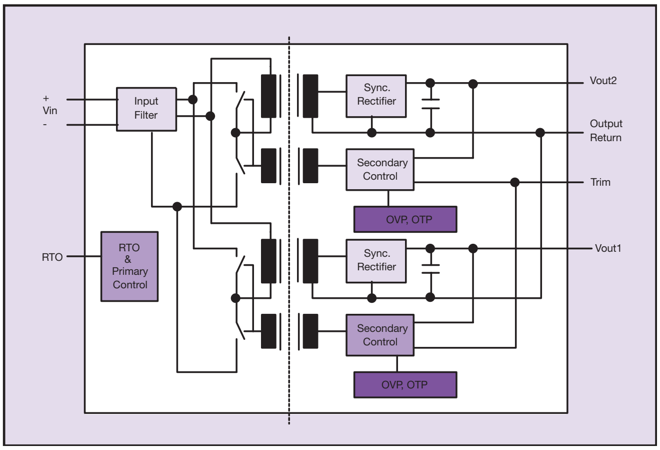


Figure 1 - Electrical Block Diagram

The outputs are adjustable over a range of 90% to 110% of the nominal output voltage using the TRIM pin which is referenced to Vout–.

The converter can be shut down via a primary side referenced remote ON/OFF input. This input is compatible with popular logic devices. Both ‘positive’ and ‘negative’ logic control are available. Positive logic indicates that the converter is enabled if the remote ON/OFF input is high (or floating) and disabled if the remote ON/OFF input is low. Conversely, negative logic implies the converter is enabled if the remote ON/OFF input is low and disabled if the remote ON/OFF input is high (or floating).

The converter is also equipped with an over-temperature sensor. Temperature correlation between the sensor and the converter's hotspot has been established, such that, if the hot spot exceeds 120ºC, the converter will shut down for approximately 200 milliseconds and then attempt to restart. If the unit's sensor has fallen approximately 4ºC during this time, the converter will turn on and provide output power until the hotspot temperature has increased to 120ºC (assuming no other fault condition has occurred.)

An internal second order input filter (LC) smoothes the input current and reduces conducted and radiated EMI. Further improvement can be achieved through the use of an optional external input filter. See section 6.1 for further details.

3.2 Physical Construction

This series is constructed using a multi-layer FR4 printed circuit board with in-the-board planar magnetics. In general, SMT power components are placed on one side of the card, while low power control components are placed on both sides of the FR4.

The converter is sold as an open-frame and no case or case pins are required. The open frame design has several advantages over encapsulated closed devices. Among these advantages are:

- **Cost:** no potting compound, case or associated process costs involved.
- **Thermals:** Air can flow more easily over all of the components, reducing thermal stress, minimizing thermal gradients between components, and more closely aligning the temperature sensor with the hotspot temperature.
- **Environmental:** Some encapsulants are not kind to the environment and create problems in incinerators. In addition open frame converters are more easily recycled.
- **Reliability:** Open frame modules are more reliable for a number of reasons.

A separate paper discussing the benefits of open-frame DC/DC converters (Design Note 102) is available at www.artesyn.com.

4. Features and Functions

4.1 Wide Operating Temperature Range

The wide ambient operating temperature range of the Quarter-Brick Dual series module is a result of the extremely high power conversion efficiency and resultant low power dissipation. The maximum output power that the module can deliver depends on a number of parameters, primarily

- The target application input voltage range
- The output load current
- Air velocity in a forced convection environment
- Mounting orientation of target application PCB, i.e. vertical/horizontal mount

The converter can be operated from –40ºC to a maximum hotspot temperature of +120ºC. A number of design graphs are included in the long-form datasheet that simplify the design task and allow the power system designer to determine the maximum output current at which the module may be operated for a given hot spot temperature and airflow.

4.2 Over-Temperature Protection

The Quarter-Brick Dual series converters are equipped with a non-latching over-temperature protection. Temperature correlation between the sensor and the converter's hotspot has been established, such that, if the hot spot exceeds 120ºC, the converter will shut down for approximately 200 milliseconds. If the unit's sensor has fallen approximately 4ºC during this time, the converter will restart and provide output power until the hotspot temperature has increased to 120ºC (assuming no other fault condition has occurred.)

The converter might experience over-temperature conditions in case of a persistent over-load on the output. Over-load conditions can be caused by external faults. OPT might also be entered due to a loss of control of the environmental conditions (e.g. increase in converter temperature due to a failing fan).

4.3 Output Voltage Adjustment

The output voltages on all models can be trimmed by –10% to +10% of the nominal output voltage and each output will be trimmed by the same percentage. Details on how to trim all models are provided in section 8.5.

4.4 Output Over-Voltage Protection

The over-voltage protection (OVP) feature is used to protect the module and the user's circuitry when a fault occurs at either output. The unit will shut off when any output voltage reaches between 112-125% of its nominal voltage setpoint. After shut off, the converter will check approximately every 200 milliseconds to see if the over-voltage condition still exists and will resume normal operation when the over-voltage problem is resolved.

4.5 Brickwall Current Limit and Short-Circuit Protection

All models have a built in brickwall current limit function. Thus, the V–I characteristic in current limit, will be almost vertical at the current limit inception point, Io,CL. This means that the output current will be almost constant irrespective of the output voltage during overload until the voltage reaches approximately one-half of its nominal voltage setpoint. Once the output voltage has been pulled to this point, the unit will enter a hiccup mode where the unit is off for approximately 200 milliseconds and then on for approximately 20 milliseconds. During the on time, the unit's output will behave as a brickwall current limit, and be at zero volts if the output is shorted. This will continue indefinitely until the fault is removed.

The current limit inception point is nearly independent of temperature, line voltage, and load split. For all models the inception is typically between 115% and 120% of rated full current. The brickwall current limit scheme has many advantages including increased capacitive load start-up capability (see section 8.7).

Note, however, that none of the module specifications are guaranteed when the unit is operated in an over current condition. The unit will not be damaged in an over current condition as it will protect itself through the use of the OPT function before any damage occurs.

4.6 Remote ON/OFF

The control input allows external circuitry to put this converter into a sleep mode. The control input is sometimes also referred to as a remote ON/OFF input. These converters are available with either an active-high control input, or with active-low logic.

Active-high units of the series are turned on if the remote ON/OFF pin is high (or floating). Pulling the pin low will turn off the unit. Active-low units of the series are turned on if the remote ON/OFF pin is low. Pulling the pin high (or floating) will turn off the unit. The signal level of the remote ON/OFF input is defined with respect to Vin–.

To simplify the design of the external control circuit, logic signal thresholds are specified over the full temperature range. The maximum remote ON/OFF input open circuit voltage, as well as the acceptable leakage currents are specified.

The remote ON/OFF input can be driven in a variety of ways as shown in Figures 2, 3 and 4. If the remote ON/OFF signal originates on the primary side, the remote ON/OFF input can be driven through a discrete device (e.g. a bipolar signal transistor), or directly from a logic gate output. The output of the logic gate may be an open-collector (or open-drain) device. If the drive signal originates on the secondary side, the remote ON/OFF input can be isolated and driven through an optocoupler. In any case, insure that the drive device's low voltage output meets the requirements specified in the data sheet. Also care should be taken regarding the leakage currents of the optocouplers chosen. Excessive leakage current could cause unreliable operation of the remote ON/OFF function.

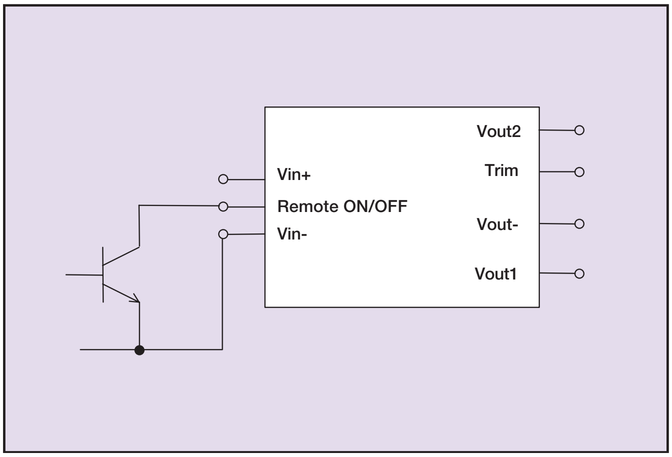


Figure 2 - Remote ON/OFF Input Drive Circuits for Non-Isolated Bipolar

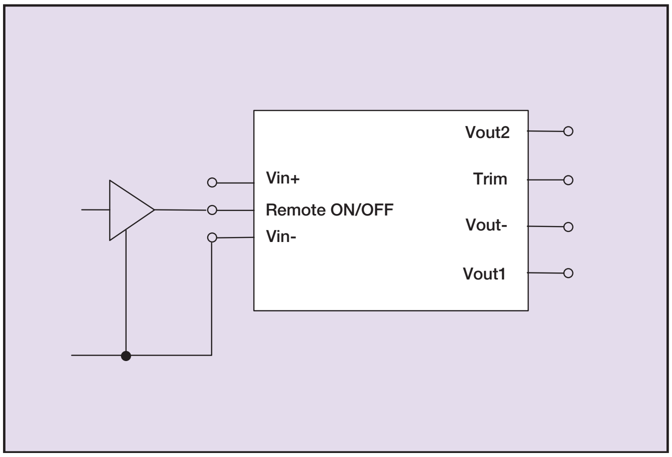


Figure 3 - Remote ON/OFF Input Drive Circuits for Logic Driver

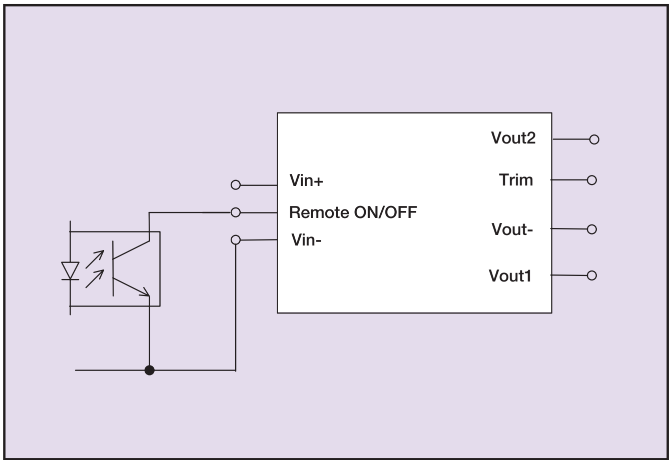


Figure 4 - Remote ON/OFF Input Drive Circuits for Isolation through Optocoupler

5. Safety

5.1 Electrical Isolation

The Quarter-Brick Dual series of power modules have been submitted to independent safety agencies and has EN60950 and UL60950 safety approvals. Basic isolation is provided between the input and output of the power supply in accordance with EN60950 and UL60950. The DC-DC power module should be installed in end-use equipment in compliance with the requirements of the application and is intended to be supplied by an isolated secondary circuit. It has been judged on the basis of the required spacings in the Standard of Safety and Information Technology Equipment, including electrical business equipment, EN60950 and UL60950.

When the supply to the DC/DC power module meets all the requirements for SELV (<60VDC), the output is considered to remain within SELV limits and not at hazardous energy level. If connected to a 60VDC power system, reinforced isolation must be provided in the power supply that isolates the input from the mains.

The galvanic isolation is verified in an electric strength test in production with the test voltage between input and output being 2,250VDC in accordance with IEEE 802.3af. Also, note that flammability ratings of the internal plastic constructions meet UL 94V-0.

5.2 Input Fusing

This series power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of a sophisticated distributed power architecture. To preserve maximum flexibility, internal fusing is not included. However, in order to comply with safety requirements the user must provide a fuse in the unearthed input line if an earthed input is used. The reasons for putting the fuse in the unearthed line is to avoid earth being disconnected in the event of a failure. If an earthed input is not being used the fuse may be in either input line. The recommended fuse rating for the converter is 10A, HRC (high rupture capacity), anti-surge, rated for 200V. A fuse should be used at the input of each module. If a fault occurs in the module such that the input source is shorted, the fuse will provide the following two functions:

- Isolate the failed module from the input supply bus so that the remainder of the system may continue operation.
- Protect the distribution wiring from overheating.

Based on the information provided in the long form data sheet on inrush energy and maximum DC input current, the same type of fuse with a lower rating can be used, depending on model. Refer to the fuse manufacturer's data for further information.

6. EMC

These converters have been designed to comply with the most stringent EMC requirements of public telecommunications equipment. The following sections detail the list of standards which apply and with which the product complies.

6.1 Conducted Emissions

The applicable standard for conducted emissions is EN55022 (FCC Part 15). Conducted noise can appear as both differential mode and common mode noise currents. Differential mode noise is measured between the two input lines with the major components occurring at the converter fundamental switching frequency and harmonics thereof. Common mode noise, generated in switching converters and which can contribute to both radiated emissions and input conducted emissions, is measured between the input lines and system ground and can be broadband in nature. The converters bypass common mode noise internally by using a 1.5nF, 2kV capacitor between Vin and Vo. Common mode noise currents flowing in the application circuitry will therefore be greatly minimised. Furthermore, the Quarter-Brick Dual series has a substantial second order differential mode filter on board to enable it to meet the above standard using a simple externally connected differential and common mode filter. The circuit diagram of the filter required for Class B compliance is presented in Figure 5.

Differential mode noise is attenuated by a (π) filter comprised of the series inductance presented by the leakage inductance of the common mode choke, L_x1, and the X-capacitors, C_x1 and C_x2. The converter side capacitor is typically an electrolytic with a relatively significant ESR component that helps maintain input system stability. The common-mode noise filter comprises the Y-capacitors, C_y1 and C_y2, from each input line to a chassis ground plane, capacitors C_y3 and C_y4 from each output line to the ground plane and the common-mode choke, L_x1. The ground plane can be connected to the case when case tie-downs are employed. Resistors R_y1 and R_y2 help damp any high frequency oscillation occurring around the common mode loop.

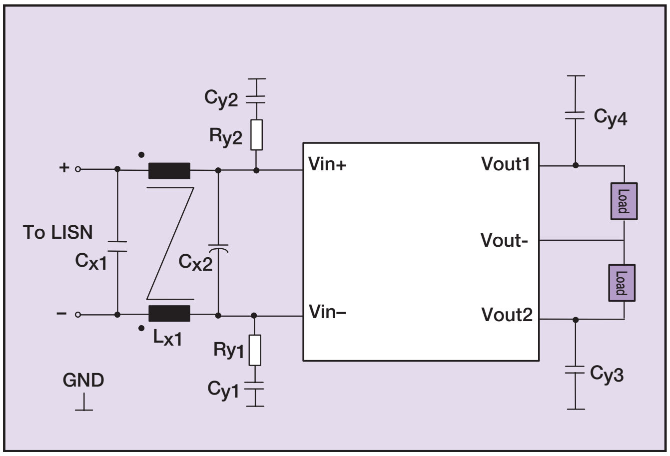


Figure 5 - Recommended Class B Filter

The components used in the filter shown in Figure 6, together with the manufacturers' part numbers for these components, are as follows:

C_x1, 2 each connected in parallel, ITW Paktron 4μF, 100V, SMT film capacitor, 405K100CS4
C_x2, UCC 33μF, 100V, electrolytic capacitor, KMF100VB33RM10X1, and an AVX 0.1μF, 100V, 12061C104KAT connected in parallel
C_y1, C_y2, AVX 5.6nF, 1.5kV, 1812SC562KA1
C_y3, C_y4, AVX 0.1μF, 100V, 12061C104KAT
R_y1, R_y1, 5.6 resistor
L_x1, Pulse Eng PO351

General recommended layout guidelines of the specified filter are shown in Figure 6. Section 8.1 discusses this subject in more detail, particularly with reference to safety related creepage and clearance requirements.

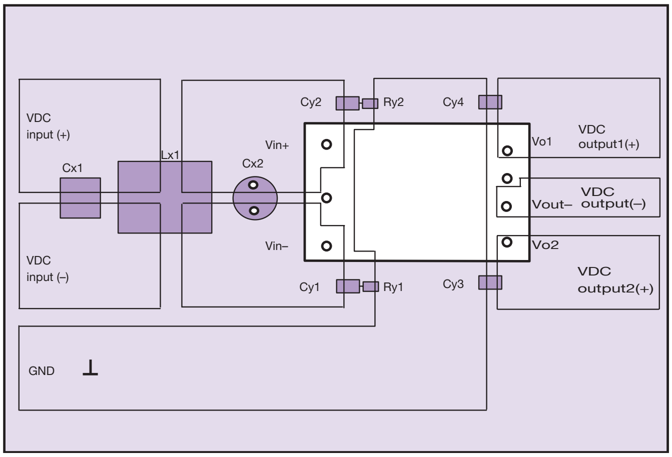


Figure 6 - Conducted EMI Filter Recommended Layout Guidelines

Typical conducted emission measurement results are shown in Figure 7. The results were obtained using the recommended external Class B input filter as outlined in Figure 5.

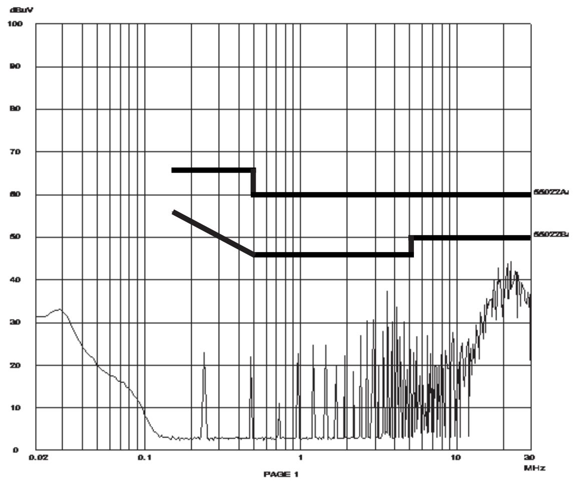


Figure 7 - Typical Spectrum of the LQD40A48-3V3-1V8 (Vin=48V, Io1=20A, Io2=20A), 50µH LISN, Class A and B Average Limit Lines are Shown

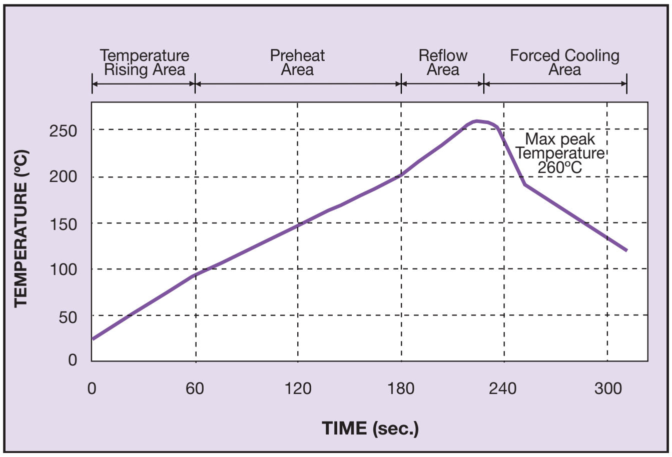


Figure 8 - Maximum Lead-Free Temperature Soldering Profile

7. Use in a Manufacturing Environment

7.1 Resistance to Soldering Heat

The Quarter-Brick Dual series are intended for PCB mounting. Artesyn Technologies has determined how well it can resist the temperatures associated with soldering of PTH components without affecting its performance or reliability. The method used to verify this is MIL-STD-202 method 210D. Within this method two test conditions were specified, Soldering Iron condition A and Wave Solder condition C.

For the soldering iron test the UUT was placed on a PCB with the recommended PCB layout pattern shown in the applications section. A soldering iron set to 350ºC 10ºC was applied to each terminal for 5 seconds. The UUT was then removed from the test PCB and was examined under a microscope for any reflow of the pin solder or physical change to the terminations. None was found.

For the wave solder test the UUT was again mounted on a test PCB. The unit was wave soldered using the conditions shown in Table 2. The UUT was inspected after soldering and no physical change was found on the pin terminations.

Temperature	Time	Temperature Ramp
260°C±5°C	10sec±1	Preheat 4°C/sec to 160°C, 25mm/sec rate

Table 2 -Wave Solder Test Conditions

7.1.1 Resistance to Lead-free, Hot Air, Forced Convection, Solder Reflow Conditions

This converter was designed to survive at least two, hot air forced convection solder reflow cycles where the peak temperature of 260°C is reached with a maximum dwell time of 10 seconds. This ability was accomplished by incorporating a high Tg FR4 board substrate, high temperature ferrite bonding adhesives, and 260°C qualified discrete components with lead-free terminations where available. To demonstrate this lead-free compatibility, HALT testing, thermal shock, solder joint cross-sectioning, and comparison of mechanical and electrical parameters before and after exposure to the lead free profile was successfully performed on a large number of units. Figure 8 shows the maximum lead-free temperature profile.

7.2 Water Washing

These converters are suitable for water washing, because it does not have any pockets where water could congregate long-term. Users should ensure that the drying process is adequate and of sufficient duration to remove all water from the converter after washing – do not power-up the unit until it is completely dry.

7.3 ESD Control

These converters are manufactured in an ESD controlled environment and supplied in conductive packaging to prevent ESD damage occurring before or during shipping. It is essential that they are unpacked and handled using approved ESD control procedures. Failure to do so could affect the lifetime of the converter.

8. Applications

8.1 Optimum PCB Layout

The PCB acts as a heat sink and draws heat from the unit via conduction through the pins and radiation. It is recommended that power and return planes be used. A three-wire system including a chassis or system ground is also possible and a ground plane here is also beneficial. These planes act as EMC shields (note that the recommended layout shown in Figure 5 does not guarantee system EMC compliance as this is dependent upon the end application). A recommended PCB layout is presented in Appendix 1. Low resistance and low inductance PCB layout traces should be used where possible, particularly where high currents are flowing such as the output side.

8.2 Optimum Thermal Performance

The electrical operating conditions of the series, namely

- Input voltage, V_{in}
- Output voltages, V_{o1} V_{o2}
- Output currents, I_{o1} I_{o2}

determine how much power is dissipated within the converter. Together with the environmental operating conditions, namely

- Ambient temperature
- Air velocity
- Thermal efficiency of the end system application

the particular hotspot temperature of the converter will be determined. The maximum acceptable hotspot temperature measured at the thermal reference point is 120°C. The thermal reference point is shown in Figure 9.

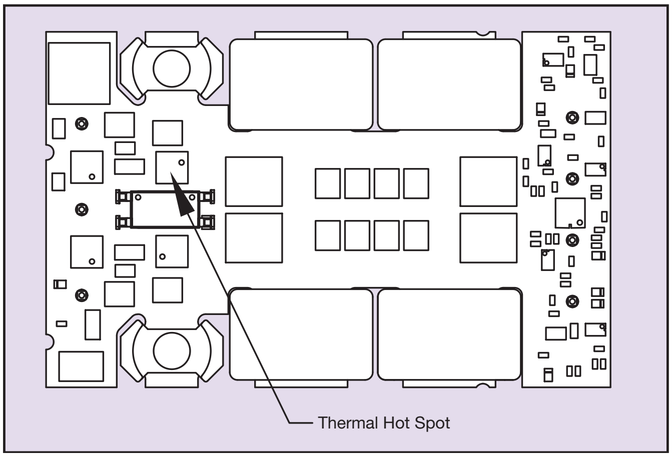


Figure 9 - Hotspot Temperature Check Point

To simplify the thermal design task, a number of graphs are given in the data sheet and some of these graphs are repeated here in Figures 10, 11, 12, 13, 14, 15, 16 and 17. The set of de-rating graphs show the output power of these converters with various load conditions versus the ambient air temperature and forced air velocity. However, since the thermal performance is heavily dependant upon the final system application the user needs to ensure the hotspot is kept within its recommended temperature rating. It is recommended that the temperature of the hotspot be measured using a thermocouple or an IR camera. In order to comply with the inherent stringent Artesyn derating criteria the hotspot temperature should ever exceed 120°C. Alternatively please contact Artesyn Technologies for further support.

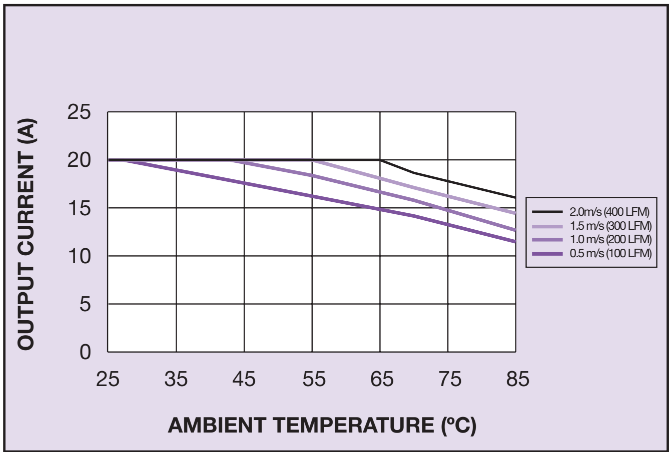


Figure 10 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-1V2. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 4

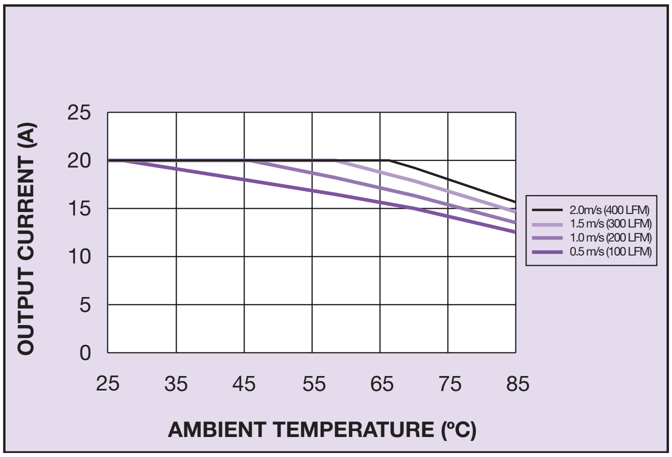


Figure 11 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-1V2. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 1

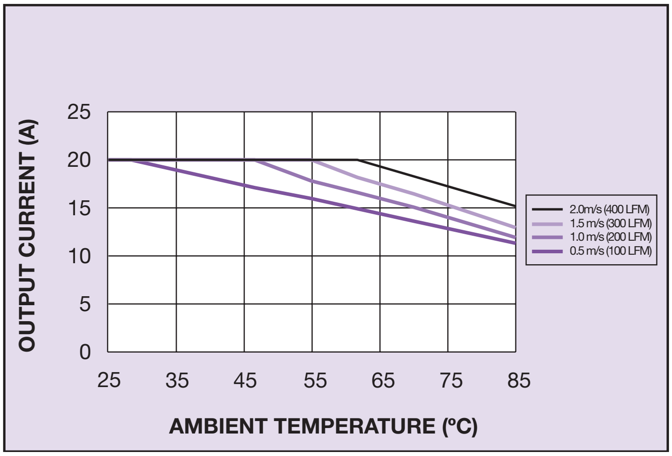


Figure 12 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-1V5. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 4

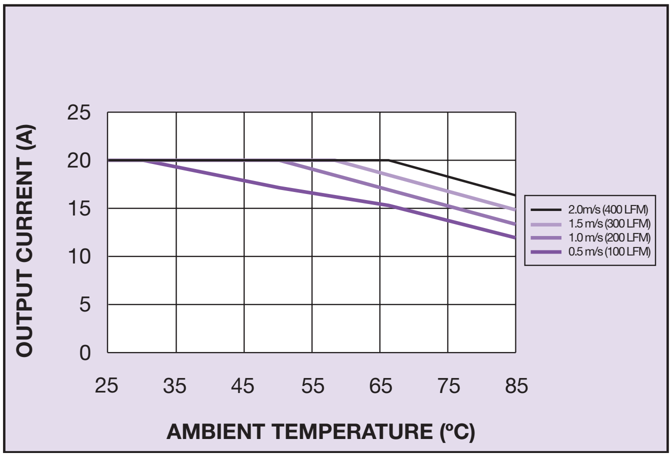


Figure 13 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-1V5. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 1

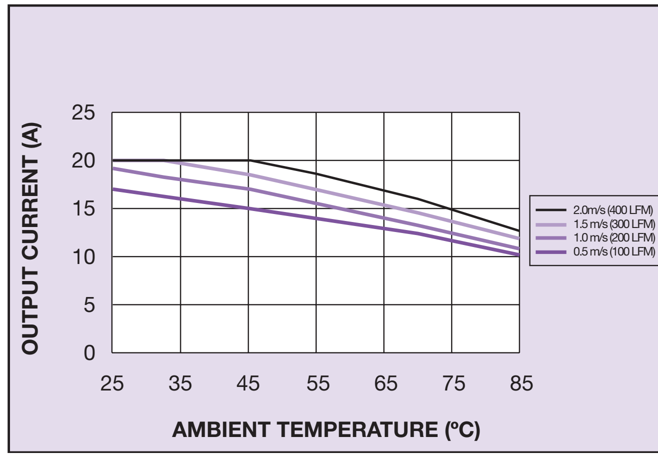


Figure 16 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-2V5. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 4

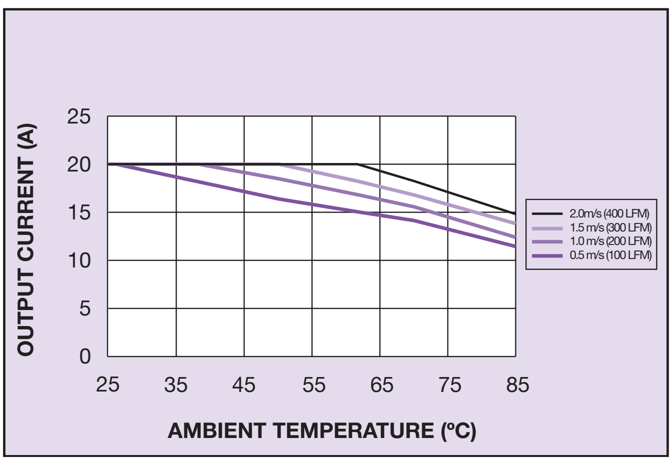


Figure 14 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-1V8. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 4

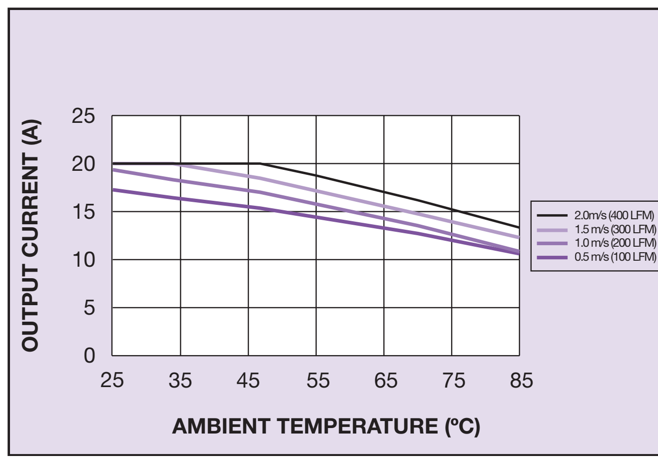


Figure 17 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-2V5. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 1

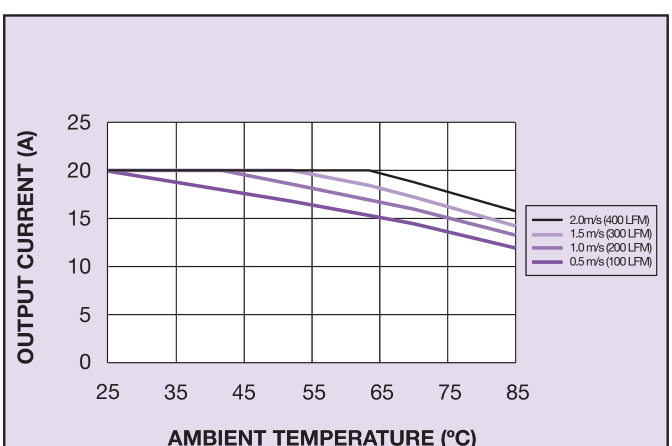


Figure 15 - Maximum Output Current vs. Ambient Temperature and Airflow for LQD40A48-3V3-1V8. Converter Mounted Horizontally with Iout1 = Iout2, Vin = 48V, Air Flowing from Pin 3 to Pin 1

8.3 Remote Sense Compensation

Due to space limitations, the converter does not feature remote sensing; however, the outputs can be trimmed up or down 10%. A discussion of the trim capability can be seen in Section 8.5.

8.4 Output Cross-Regulation

Each output has its own power train and regulation network providing two outputs that have extremely minimal cross regulation. Consequently, any load current can be employed on one output without effecting the voltage setpoint of the other output. An exception to this would be if either output's load is beyond the current limit point. In this case as the output voltage on the loaded channel falls due to the brickwall current limiting previously discussed, the other output's voltage would also fall at the same ratio.

8.5 Output Voltage Adjustment

The outputs can be externally trimmed by 10% by connecting an external resistor between the TRIM pin and either the Vout2 or Vout– pin. With an external resistor between TRIM and Vout2, RTRIM_DOWN, the output voltages' setpoint decreases. This is shown in Figure 17. Conversely, connecting an external resistor between TRIM and Vout-, RTRIM_UP, the output voltages' set point increases. This is shown in Figure 19.

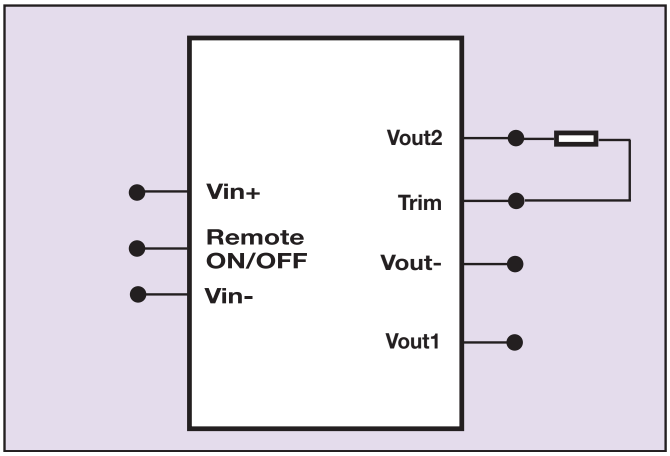


Figure 18 - Trimming Output Voltage - Trim Down

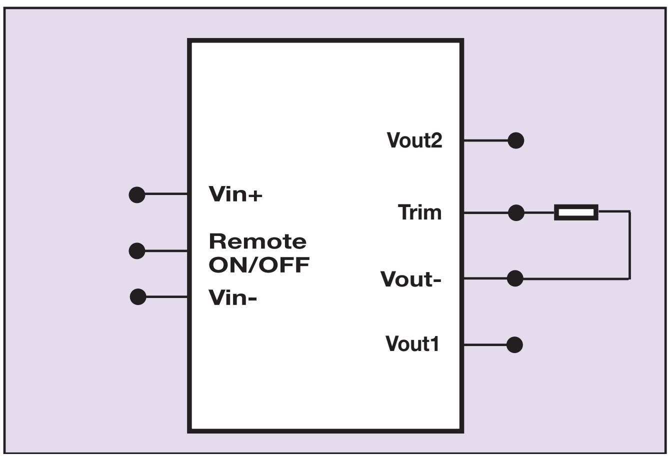


Figure 19 - Trimming Output Voltage - Trim Up

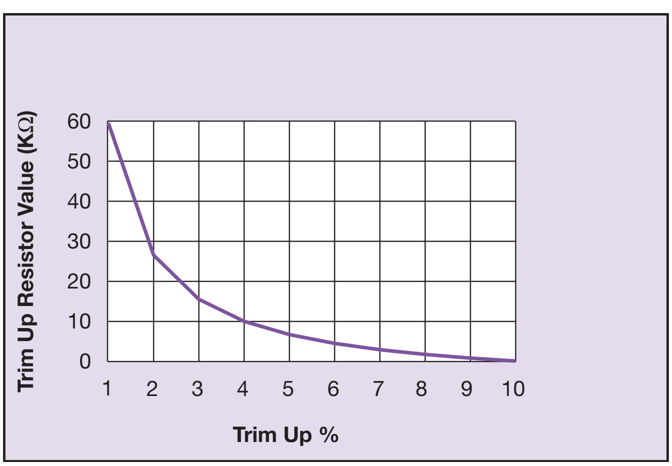


Figure 20 - Typical Trim-up Curve (resistor from TRIM to Vout-, all models)

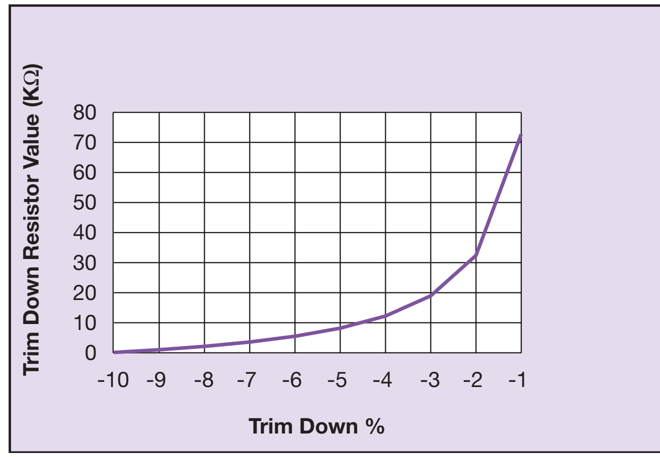


Figure 21 - Typical Trim-down Curve (resistor from TRIM to Vout2, all models)

The exact value of the trim resistor can be obtained by calculating the value as given in the following equations, which are graphed in Figures 20 and 21.

$$R_{trim\_down} = \frac{Vout2\,(1-\Delta) - Vref}{\frac{\Delta Vout2}{7500} \bullet 5.11} - 6486$$

$$R_{trim\_up} = \frac{Vref}{\frac{\Delta Vout2}{7500} \bullet 5.11} - 6486$$

Δ is the % output voltage change expressed in decimals, and

$$Vref = 1.485V$$

When the output voltages are trimmed up a certain percentage, the output currents must be derated by the same amount so that the maximum output power is not exceeded.

8.6 Parallel and Series Operation

Because of the absence of an active current sharing feature, parallel operation of multiple converters is not recommended.

The individual outputs of these converters are not isolated and as such series operation is not allowed.

8.7 Output Capacitance

This series of DC/DC converters has been designed for stable operation without the need for external capacitance at the output terminals. However, when powering loads with large dynamic current requirements, improved voltage regulation can be obtained by inserting capacitors as close as possible to the load. The most effective technique is to locate low ESR ceramic capacitors as close to the load as possible, using several capacitors to lower the effective ESR. These ceramic capacitors will handle the short duration high frequency components of the dynamic current requirement. In addition, higher values of electrolytic capacitors should be used to handle the mid-frequency components.

Note that it is equally important to use good design practices when configuring the DC distribution system. As outlined in section 8.1, low resistance and low inductance PCB layout traces should be utilized, particularly in the high current output section. Generally, as a rule of thumb, 100μF/A of output current can be used without any additional analysis.

Note that the maximum rated value of output capacitance is specified in the long form data sheet. If required, larger capacitance values are possible. Please contact the local Artesyn Technologies representative for further information.

8.8 Back-bias Start-up

The Quarter-Brick Dual series is capable of starting into a back-bias voltage on either of its outputs. Maximum back-bias on any output is limited to 90% of the nominal voltage setpoint.

8.9 Reflected Ripple Current and Output Ripple and Noise Measurement

The measurement setup outlined in Figure 22 has been used for both input reflected/capacitor ripple current and output voltage ripple and noise measurements on the converters. When measuring output ripple and noise, a 50Ω coaxial cable with a 50Ω termination should be used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies. The input ripple current measurement setup is compatible with ETS 300 386-1.

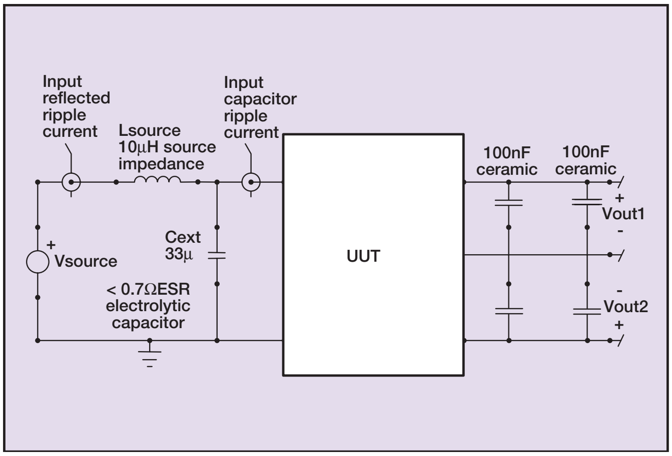


Figure 22 - Input Reflected Ripple/Capacitor Ripple Current and Output Voltage Ripple and Noise Measurement Set-Up

8.10 Inrush Current Measurement

The measurement circuit shown in Figure 23 has been used to measure inrush current. In addition a recommended External Bypass circuit is also shown. Figures 24 and 25 show the typical inrush current characteristics of the series.

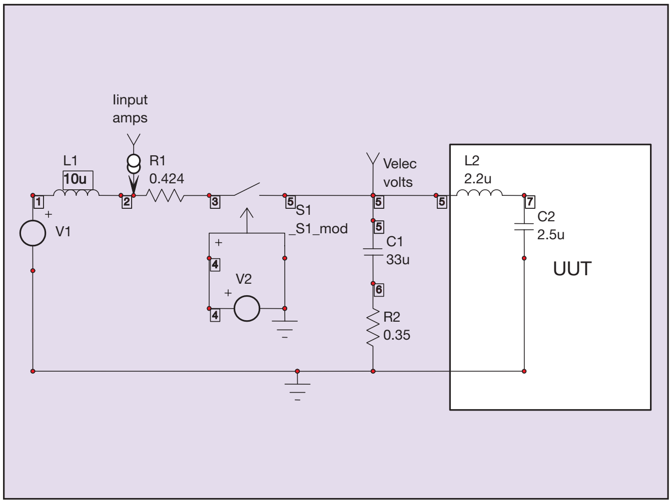


Figure 23 - Inrush Current Test with Recommended External Bypass

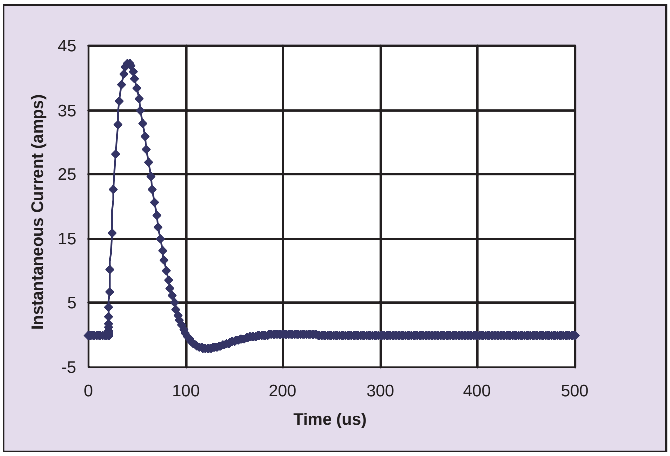


Figure 24 - Instantaneous Inrush Current (typical)

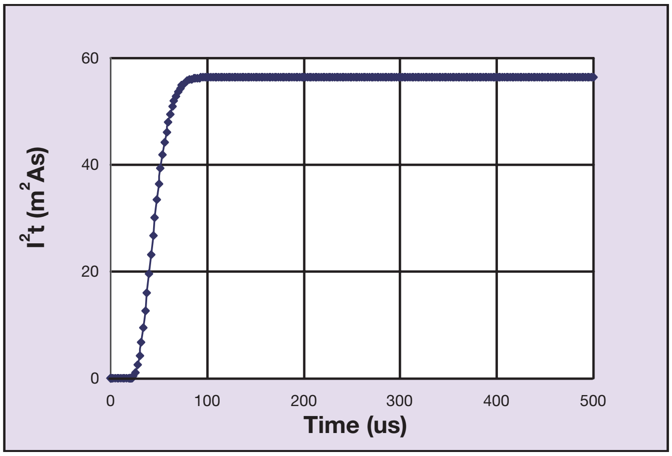
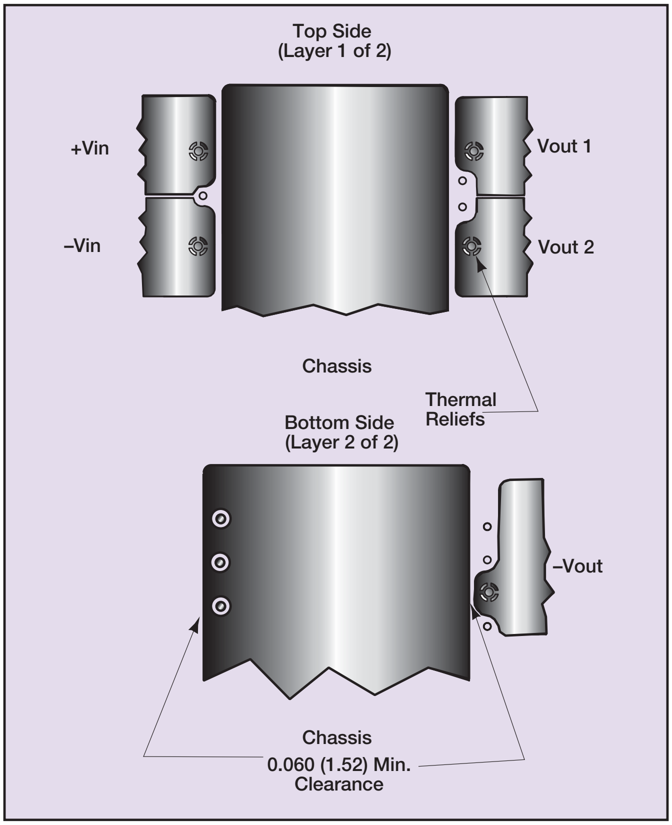


Figure 25 - Instantaneous Inrush Current (typical)

9. Appendix 1 - Recommended PCB Footprints

VIEW IS FROM TOP SIDE



THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-D-275 SECTION 5.3.2.3

ALL DIMENSIONS IN INCHES (mm)
ALL TOLERANCES ARE ±0.10 (0.004)

Figure 26 - Recommended PCB Footprints