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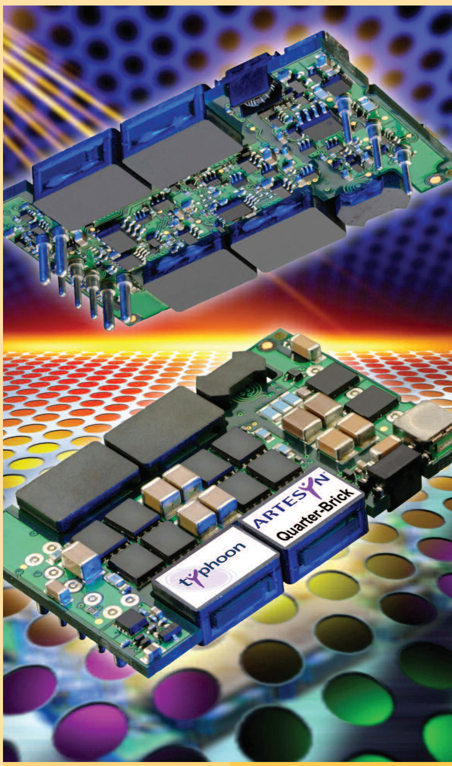
QUARTER-BRICK SINGLE

Application Note 141



RoHS 2002/95/EC

ARTESYN® TECHNOLOGIES

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1. Introduction

This application note describes the features and functions of Artesyn Technologies' series of high power density, Quarter-Brick single dc-dc converters. These open-frame, single-output modules are targeted specifically at the fixed and mobile telecommunications, industrial electronics and distributed power markets.

This converter offers a wide input voltage range of 18 Vdc to 36 Vdc or 36 Vdc to 75 Vdc and features a wide ambient operating temperature range of -40 °C to +85 °C. Ultra high efficiency operation is achieved through the use of a proprietary topology, synchronous rectification and microprocessor control techniques. The modules are fully protected against overcurrent, overvoltage and overtemperature conditions. Standard features include remote ON/OFF and remote sense.

These converters are designed to qualify to standards applicable to the target markets. EN60950-1 and UL/cUL60950 safety approvals have been obtained, and a high level of reliability has been designed into all models through conservative derating criteria. Automated manufacturing methods, together with an extensive qualification program, ensure that all the Quarter-Brick single converters are produced to rigorous quality levels.

RoHS Compliance Ordering Information

The 'J' at the end of the part number indicates that the part is Pb-free (RoHS 6/6 compliant). TSE RoHS 5/6 (non Pb-free) compliant versions may be available on special request, please contact your local sales representative for details.

Features

- Industry standard Quarter-Brick single pinout and footprint: 2.300 x 1.450 x 0.300 in (58.42 x 36.83 x 7.62 mm)
- Wide operating temperature range (-40 °C to +85 °C ambient temperature)
- -20% to +10% output voltage adjustability
- No minimum load requirement
- Remote ON/OFF control (primary-side referenced)
- Remote sense compensation
- Constant switching frequency
- Brickwall overcurrent protection
- Continuous short-circuit protection
- Non-latching output overvoltage protection (OVP)
- overtemperature protection (OTP)
- Input under/overvoltage lockout protection (U/OVLO)
- Available RoHS compliance

2. Models

The Quarter-Brick single series comprises fifteen models, as listed in Table 1.

Model	Input Voltage	Output Voltage	Output Current
48 V Value Models			
LQS50A48-1V2J	36-75 Vdc	1.2 V	50 A
LQS50A48-1V5J	36-75 Vdc	1.5 V	50 A
LQS50A48-1V8J	36-75 Vdc	1.8 V	50 A
48 V Performance Models			
LQS100A48-1V2J	36-75 Vdc	1.2 V	100 A
LQS80A48-1V5J	36-75 Vdc	1.5 V	80 A
LQS80A48-1V8J	36-75 Vdc	1.8 V	80 A
LQS50A48-2V5J	36-75 Vdc	2.5 V	50 A
LQS50A48-3V3J	36-75 Vdc	3.3 V	50 A
48 V Ultra Models			
LQS100A48-1V5J	36-75 Vdc	1.5 V	100 A
LQS100A48-1V8J	36-75 Vdc	1.8 V	100 A
LQS80A48-2V5J	36-75 Vdc	2.5 V	80 A
LQS60A48-3V3J	36-75 Vdc	3.3 V	60 A
LQS40A48-5V0J	36-75 Vdc	5.0 V	40 A
24 V Models			
LQS30A24-1V8J	36-75 Vdc	1.8 V	30 A
LQS30A24-3V3J	36-75 Vdc	3.3 V	30 A

Table 1 - Quarter-Brick Single Models

3. General Description

3.1 Electrical Description

A block diagram is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of a unique, fixed frequency, voltage mode controlled, interleaved, half-bridge topology. Power is transferred magnetically across the isolation barrier via isolating power transformers. In all models, the secondary-side rectification stage consists of synchronous rectifiers controlled by proprietary circuitry to optimize the timing which is critical for high efficiency power conversion. The regulated voltage on the output pins is governed by the voltage sensed at the module's sense pins, V_{sense+} and V_{sense-}.

The output is adjustable over a range of 80% to 110% of the nominal output voltage, using the TRIM pin which is referenced to V_{sense-}.

The converter can be shut down via a remote ON/OFF input that is referenced to the primary side. The input is compatible with popular logic devices; a 'positive' logic input is supplied as standard, with 'negative' logic available as an option. Positive logic implies that the converter is enabled if the remote ON/OFF input is high (or floating) and disabled if it is low. Conversely, negative logic implies that the converter is enabled if the remote ON/OFF input is low, and disabled if it is high (or floating).

The output is monitored for overvoltages. If an overvoltage due to an internal fault occurs, the converter will shutdown and enter a hiccup mode when the output exceeds the overvoltage set-point.

The converter is also protected against overtemperature conditions. If the converter is overloaded or the hotspot temperature gets too high, the converter will shut down until the temperature falls below a minimum threshold. There is a thermal hysteresis of typically 3 °C to 5 °C to protect the unit.

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.

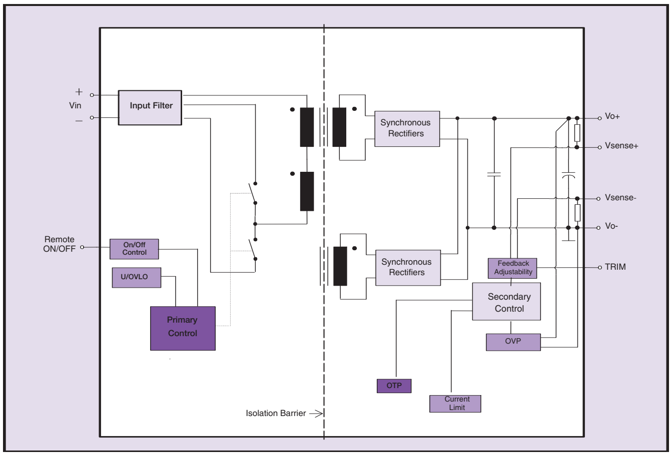


Figure 1 - Electrical Block Diagram

3.2 Physical Construction

The converter is constructed using a multi-layer FR4 PCB. SMT power and control components are placed on both sides of the PCB. Heat dissipation of the power components mounted on the top side is optimized while at the same time critical control components are thermally isolated.

The converter is an open-frame product and has no case or case pin. The open-frame design has several advantages over encapsulated closed devices, including:

- **Cost:** no potting compound, case or associated process costs involved
- **Thermals:** the heat is removed from the heat-generating components without heating more sensitive, less tolerant components
- **Environmental:** some encapsulants are not kind to the environment and create problems in incinerators. Furthermore, open-frame converters are more easily recycled
- **Reliability:** open-frame modules are more reliable for a number of reasons, including improved thermal performance and reduced thermal coefficient of expansion (TCE) stresses

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 is a result of its 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:

- Input voltage range of target application
- Output load current of target application
- Air velocity (if used in a forced convection environment)
- Mounting orientation of target application PCB, i.e. vertical/horizontal mount, or mechanically tied down (especially important in natural convection conditions)
- Target application PCB design, especially with respect to ground planes, which can provide effective heatsinks for the converter

The converter can be operated from -40 ºC to a maximum hotspot temperature of +120 ºC. A number of design graphs are included in the longform 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 hotspot temperature and airflow.

4.2 Overtemperature Protection

The converter features non-latching overtemperature protection. The temperature of the main substrate is monitored by a sensor. If the hotspot temperature exceeds a threshold of 125 °C the converter will shut down for approximately 200 milliseconds and attempt to restart. If the unit's sensor has fallen by between 3 ºC and 5 ºC, the converter will turn on and provide output power until the hotspot temperature has increased to 125 ºC assuming no other fault condition has occured.

The converter might experience overtemperature (OTP) conditions during a persistent overload on the output. Overload conditions can be caused by external faults. OTP might also be entered due to a loss of control of the environmental conditions (e.g. an increase in the converter's temperature due to a failing fan).

4.3 Output Voltage Adjustment

The output voltage is trimmable by -20% to +10% of the nominal output voltage. Details on how to trim the converters are provided in section 8.4.

4.4 Output Overvoltage Protection

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

4.5 Safe Operating Area

The Safe Operating Area (SOA) of the converter is shown in Figure 2. Assuming the converter is operated within its thermal hotspot constraints, it can deliver an output current $I_{o,max}$ as shown in Figure 2. Note, however, that the SOA does not remain valid across the full trim range of the converter. For example, if the unit is trimmed up by 10%, the output current must be correspondingly derated by 10%. The module can still deliver $I_{o,max}$ when trimmed down.

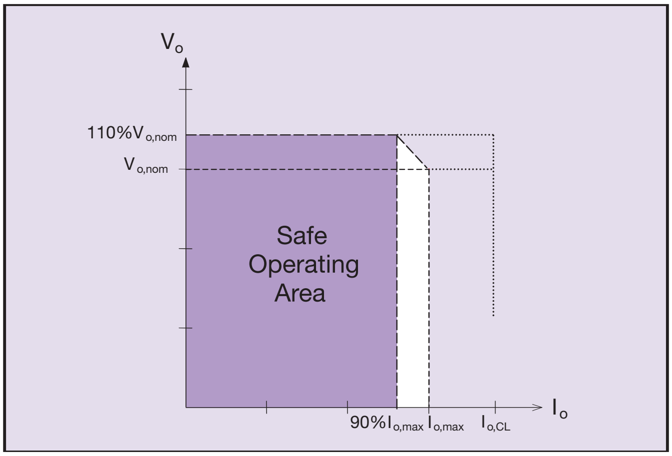


Figure 2 - Maximum Output Current Safe Operating Area

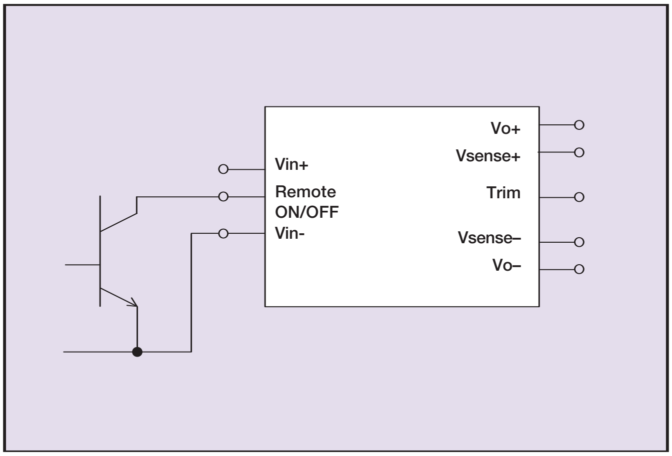


Figure 3 - Remote ON/OFF Input Drive Circuits for Non-Isolated Bipolar

It should be noted that the SOA shown in Figure 2 is valid only if the converter is operated within its thermal specification. See section 8.2 for further details.

4.6 Brickwall Current Limit and Short-Circuit Protection

This converter has a built in brickwall current limit function and full continuous short-circuit protection. Thus the V–I characteristic in current limit, as indicated by the dashed line in Figure 2, will be almost vertical at the current limit inception point, $I_{o,CL}$. This means that the output current should be almost constant, irrespective of the output voltage during overload until the voltage reaches approximately one-half of the nominal voltage set-point. 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 output voltage of the unit will have a brickwall current limit characteristic, and be at zero volts if the output is shorted. This will continue indefinitely until the fault is removed. Note that although none of the module's specifications are guaranteed when the unit is operated in an overcurrent condition, the unit will not be damaged because it will be protected by the OTP function.

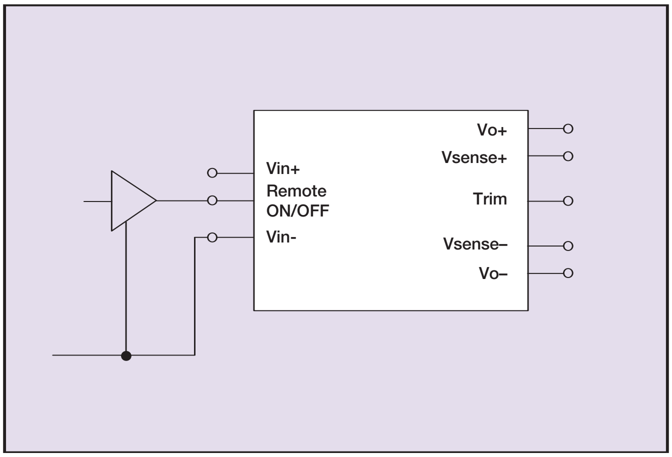


Figure 4 - Remote ON/OFF Input Drive Circuits for Logic Driver

4.7 Remote ON/OFF

The remote ON/OFF input allows external circuitry to put the converter into a low power dissipation sleep mode. Active-high remote ON/OFF is available as standard and active-low logic can be specified as an option by adding the suffix 'R' to the part number.

Active-high units of the converter are turned on if the remote ON/OFF pin is high (or left floating). Pulling the pin low will turn the unit off. Active-low units are turned on if the remote ON/OFF pin is low. Pulling the pin high (or leaving it floating) will turn the unit off. The signal level of the remote ON/OFF input is defined with respect to V_{in-}.

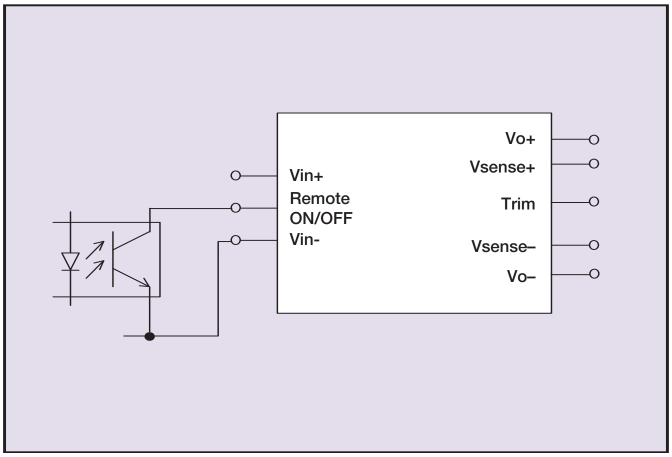


Figure 5 - Remote ON/OFF Input Drive Circuits for Isolation through Optocoupler

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 in the longform datasheet.

The remote ON/OFF input can be driven in a variety of ways as shown in Figures 3, 4 and 5. 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 can 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.

5. Safety

5.1 Electrical Isolation
The Quarter-Brick single series of power modules have been submitted to independent safety agencies and have 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-user 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 (<60 Vdc), the output is considered to remain within SELV limits and not at hazardous energy level. If connected to a 60 Vdc power system, reinforced insulation must be provided in the power supply that isolates the input from the mains.

The Basic isolation is verified in an electric strength test in production, with the test voltage between input and output being 2.25 kVdc in accordance with IEEE 802.3. Also, note that flammability ratings of the internal plastic constructions meet UL94V-0.

5.2 Input Fusing
The Quarter-Brick single 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 reason 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 can be placed in either input line. The recommended fuse rating for the converter is 10 A, HRC (high rupture capacity), anti-surge, rated for 63 V. This fuse was selected to meet safety agency approval for abnormal testing. 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, in order that the remainder of the system can continue operating
- Protect the distribution wiring from overheating

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

6. EMC

The converter is designed to comply with the EMC requirements of ETSI 300 386-1. It meets the most stringent requirements of Table 5; 'public telecommunications equipment, locations other than telecommunication centers, high priority of service'. The following section details 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's fundamental switching frequency and its harmonics. Common-mode noise, generated in switching converters, can contribute to both radiated emissions and input conducted emissions; it is measured between the input lines and system ground, and can be broadband in nature. This converter bypasses common-mode noise internally by using one 1.2 nF, 2.5 kV capacitor between V_{in} and V_o. Common-mode noise currents flowing in the application circuitry will therefore be minimized. Furthermore, the converter has a substantial second-order differential-mode filter on board, to enable it to meet the above standard using a simple externally connected differential-mode and common-mode filter. The circuit diagram of an external filter recommended for Class B compliance is presented Figure 6. A similar filter can be derived for Class A compliance using the same component set.

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}. Resistors R_{y1} and R_{y2} help damp any oscillation occurring between the common-mode filter inductance and Y-capacitance.

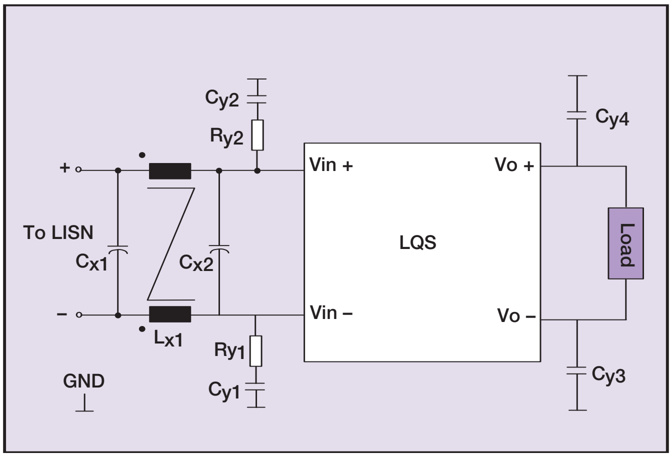


Figure 6 - Recommended Filter for Class B Compliance

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

C_{x1}: (48 Vin models) ITW Paktron 4 µF, 100 V, SMT film capacitor, 405K100CS4
C_{x1}: (24 Vin models) 2 x ITW Paktron 4 µF, 100 V, SMT film capacitor 405K100CS4
C_{x2}: (48 Vin models) UCC 33 µF, 100 V, electrolytic capacitor, KMF100VB33RM10X12
C_{x2}: (24 Vin models) Nichicon 220 µF electrolytic capacitor, OPL1H221MPH paralled with 2 x TDK 3.3 µF 50 V SMT ceramic, C4532X7R1H335K
C_{y1}, C_{y2}: 2 x AVX 5.6 nF, 1.5 kV, 1812SC562KA1
C_{y3}, C_{y4}: 2 x AVX 0.1 µF, 100 V, 12061C104KAT
R_{y1}, R_{y2}: 2 x 5.6 Ω 1206 resistor
L_{x1}: (48 Vin) Pulse Eng PO353
L_{x1}: (24 Vin) Pulse Eng PO439

General recommended layout guidelines of the specified filter are shown in Figure 7. Section 8.1 discusses this subject in more detail, particularly with reference to safety-related creepage and clearance requirements.

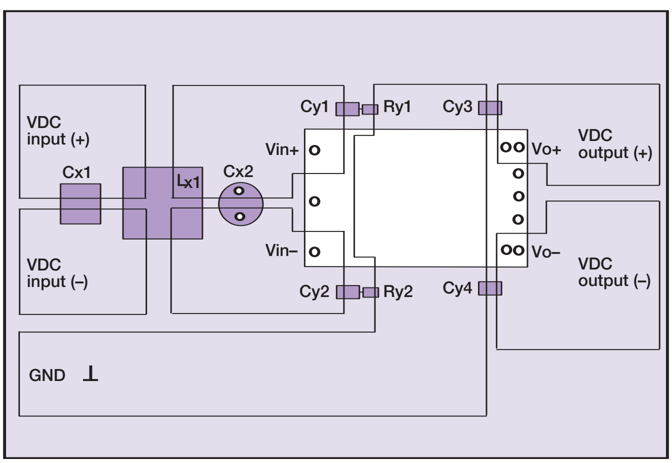


Figure 7 - Conducted EMI Filter Recommended Layout Guidelines

Typical conducted emission measurement results are shown in Figure 8. The results were obtained using the recommended external Class B input filter as outlined in Figure 6.

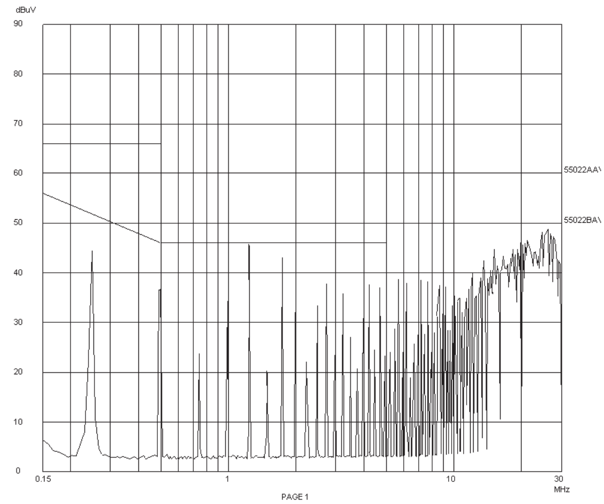


Figure 8 - Typical Spectrum of the LQS80A48-1V8J (Vin=48 V, Vo = 1.8 V, Io = 80 A), 5 µH LISN, Class A and B Average Limit Lines are Shown

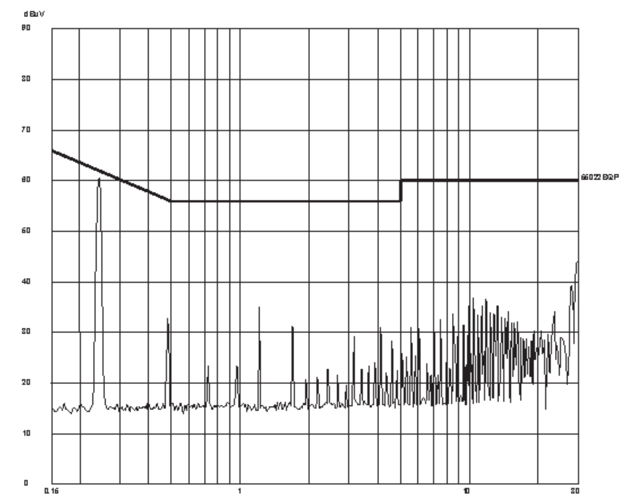


Figure 9 - Typical Spectrum of the LQS30A24-3V3J (Vin=24 V, Vo = 3.3 V, Io = 30 A), 5 µH LISN, Class A and B Average Limit Lines are Shown

7. Use in a Manufacturing Environment

7.1 Resistance to Soldering Heat
This converter is intended for PCB mounting. Artesyn Technologies has determined how well the product can resist the temperatures associated with the 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 Section 8. A soldering iron set to 350 ºC±10 ºC was applied to each terminal for 5 seconds. The UUT was then removed from the test PCB and 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	10 sec±1	Preheat 4 °C/sec to 160 °C. 25 mm/sec rate

Table 2 -Wave Solder Test Conditions

7.2 Water Washing
The converter is suitable for water washing, because it does not have any pockets where water could be trapped 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
This unit is 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 be unpacked and handled using approved ESD control procedures. Failure to do so could affect the lifetime of the converter.

7.4 Mounting Brick Type Converters to System PCB
This converter should be mounted to the end-use printed circuit board in accordance with Application Note 103. Contact Artesyn Technologies if further assistance is needed with regard to PCB mounting.

8. Applications

8.1 Optimum PCB Layout
The PCB acts as a heatsink 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 7 does not guarantee system EMC compliance, since this depends on the end application). A recommended layout for an end-user's double sided PCB, which maintains the creepage and clearance requirements discussed in the safety section of this application note, is presented in Appendix 1. However, the end-user must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces should be used where possible, particularly where high currents are flowing (such as on the output side).

8.2 Optimum Thermal Performance
The maximum acceptable hotspot temperature for this converter is +120 ºC, as measured at the thermal reference point shown in Figure 10.

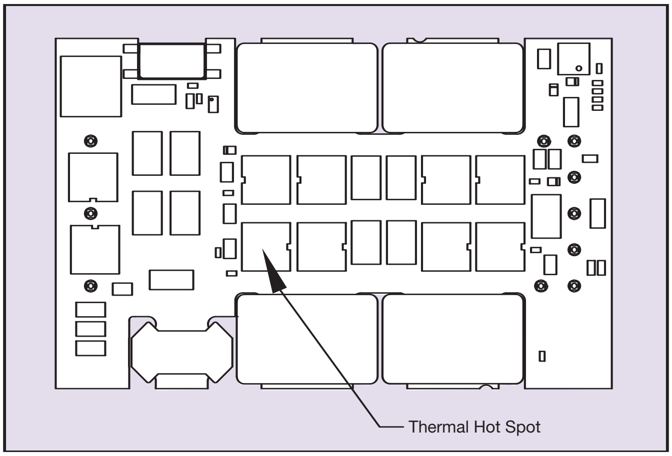


Figure 10 - Hotspot Temperature Check Point

The temperature of the hotspot is directly influenced by the amount of power being dissipated within the converter, and by the environmental conditons in which it is operating. The dissipated power is determined by the converter's electrical operating conditions, in terms of:

- Input voltage, V_{in}
- Output voltage, V_o
- Output current, I_o

And the environmental operating conditions that affect hotspot temperature are:

- Ambient temperature
- Air velocity
- Thermal efficiency of the end system application
- Parts mounted on system PCB that may block airflow
- Real airflow characteristics at the converter location

To simplify the thermal design task a number of graphs are given in the datasheet and two are repeated here in Figures 11 and 12. The set of derating graphs show the load current of the converter versus the ambient air temperature and forced air velocity. However, since the thermal performance is heavily dependent upon the final system application, the user needs to ensure that 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 never exceed +120 °C.

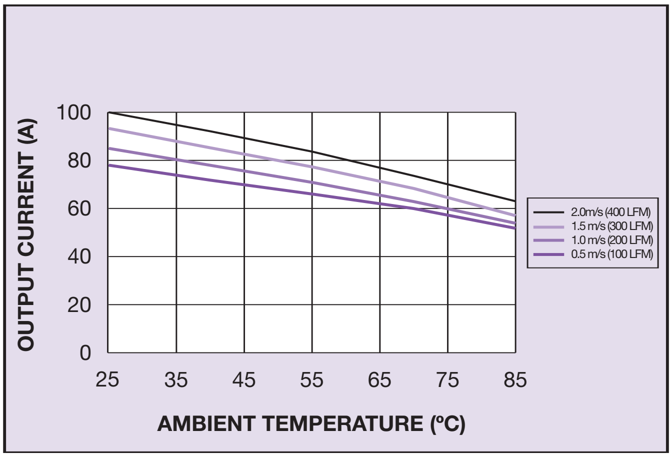


Figure 11 - Maximum Output Current vs. Ambient Temperature and Airflow for LQS100A48-1V2J Model

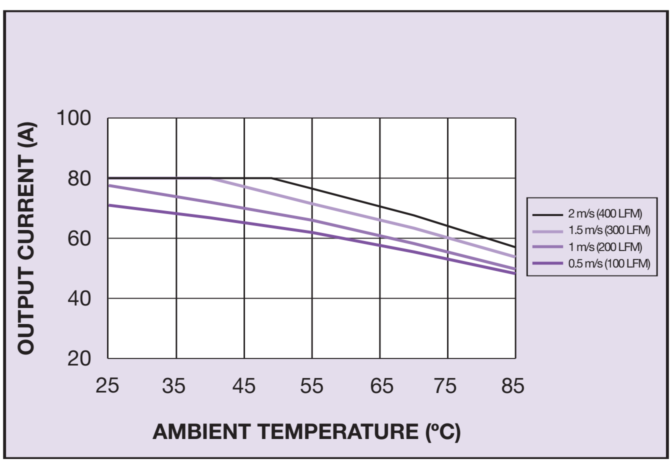


Figure 12 - Maximum Output Current vs. Ambient Temperature and Airflow for LQS80A48-1V8J Model

8.3 Remote Sense Compensation

The remote sense compensation feature minimizes the effects of resistance in the distribution system and facilitates accurate voltage regulation at the load terminals or other selected point. The remote sense lines will carry very little current and hence do not require a large cross-sectional area. However, if the sense lines are routed on a PCB, they should be located close to a ground plane in order to minimize any noise coupled onto the lines that might impair control loop stability. A small 100 nF ceramic capacitor can be connected at the point of load to decouple any noise on the sense wires. The module will compensate for a maximum drop of 10% of the nominal output voltage. However, if the unit if already trimmed up, the available remote sense compensation range will be correspondingly reduced. Remember that when using remote sense compensation, all the resistance, parasitic inductance and capacitance of the distribution system are incorporated within the feedback loop of the power module. This can have an effect on the module compensation, affecting the stability and dynamic response.

8.4 Output Voltage Adjustment

The output can be externally trimmed by -20% and +10% by connecting an external resistor between the TRIM pin and either the V_{sense+} or V_{sense-} pin. With an external resistor between TRIM and V_{sense-}, R_{TRIM_down}, the output voltage set-point decreases. Conversely, connecting an external resistor between TRIM and V_{sense+}, R_{trim_up}, will increase the output voltage set-point. A trim potentiometer with its terminals connected to the positive and negative sense pins and the wiper connected to the trim pin allows a variable trim, either up or down. This is shown in Figures 13, 14 and 15.

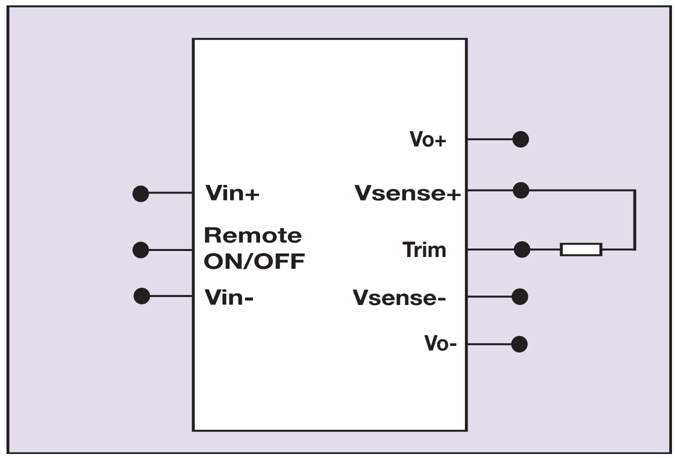


Figure 13 - Trimming Output Voltage - Trim-up

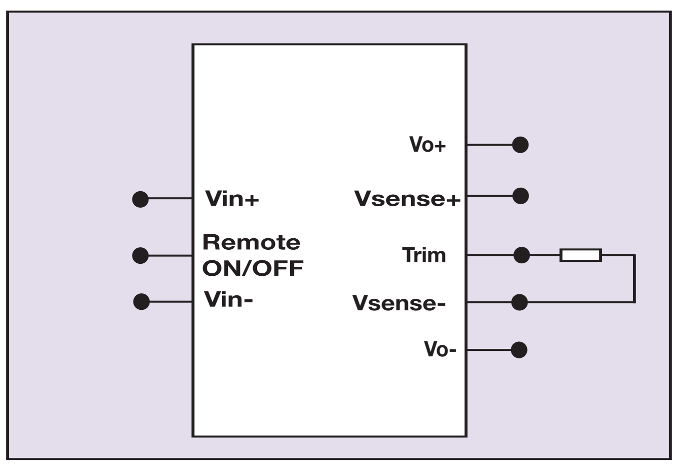


Figure 14 - Trimming Output Voltage - Trimdown

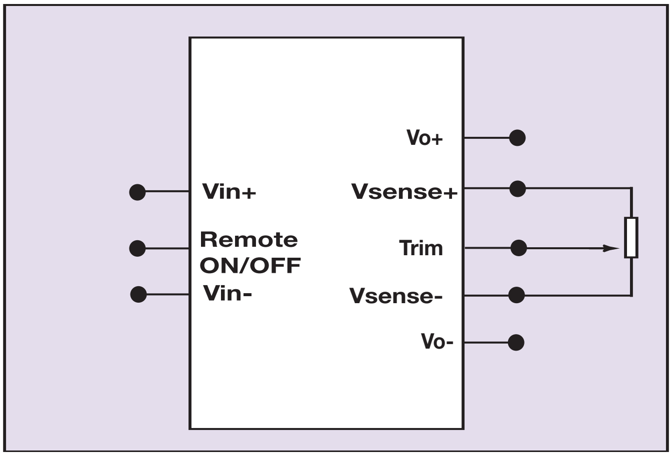


Figure 15 - Trimming Output Voltage - Variable Trim

The relevant trim equations to derive the appropriate trim resistance are as follows:

$$R_{trim\_down} = \left[\frac{511}{\Delta\%} - 10.22\right] k\Omega$$

$$R_{trim\_up} = \left(\frac{5.11 V_{out}(100 + \Delta\%)}{V_{ref}\ \Delta\%} - \frac{511}{\Delta\%} - 10.22\right) k\Omega$$

Where V_{ref} = 1.225 V for all models with V_{out} >1.2 V and V_{ref} = 0.6125 V for the model with V_{out} = 1.2 V. Δ% is the percentage output voltage change. Δ% is always positive regardless of the direction of trim. For example a 5% trim-down, Δ% = 5.

The above trim equations are considered the 'industry standard' trim equations for single output 'Quarter-Brick single' dc-dc converters.

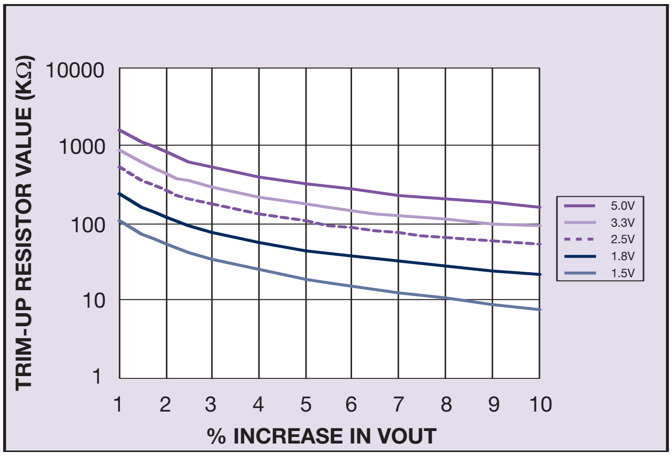


Figure 16 - Typical Trim-up Curve for Converters with >1.2 V (Resistor from TRIM to V_{sense+})

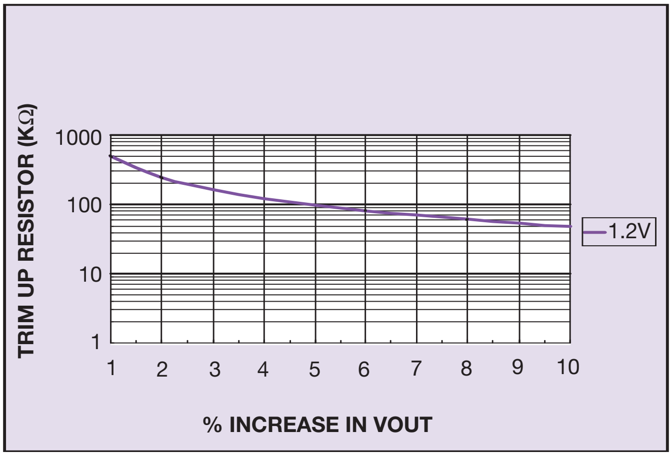


Figure 17 - Typical Trim-up Curve for 1.2 Vout Converters (Resistor from TRIM to V_{sense}+)

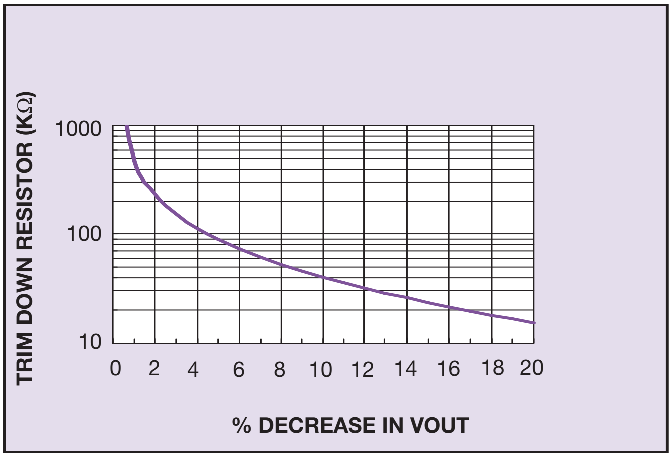


Figure 18 - Typical Trim-down Curve (Resistor from TRIM to V_{sense}- See Note 1)

[1]Trim-down curve specifying resistance or voltage required for a given decrease in nominal output voltage is the same for all models.

Alternatively, a voltage source applied between the TRIM pin and V_{sense-} can be used to trim-up or down above or below the nominal output voltage. The voltage source applied to the TRIM pin for a certain trim level is defined in Figure 19 and the following equation:

$$V_{trim} = V_{ref}\left[\frac{\%Vout}{50} - 1\right]$$

Where %Vout = a number between 80 and 110
Vref = 1.225 V for a converter with nominal output voltages >1.2 V
Vref = 0.6125 V for a converter with a nominal output voltage = 1.2 V

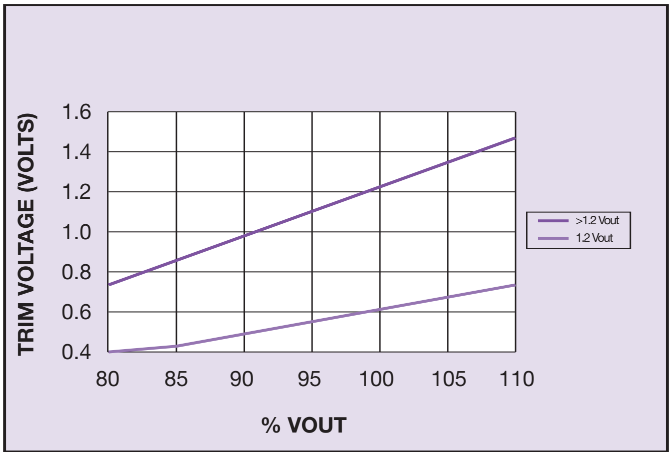


Figure 19 - Typical Trim Curve
(Voltage Source from TRIM to V_{sense}^{-})

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

8.5 Back-bias Start-up

This converter is capable of starting with a back-bias voltage applied to the output without cratering the back-bias voltage. Maximum back-bias on any output is limited to 90% of the nominal voltage set-point.

8.6 Parallel and Series Operation

Because of the absence of an active current sharing feature, parallel operation of multiple converters is generally not allowed. If unavoidable, ORing diodes must be used to decouple the outputs. Droop resistors will support some passive current sharing. It should be noted that both measures will adversely affect power conversion efficiency.

It is not recommended that outputs of multiple converters be connected in series because of the possibility of excess heat dissipation through the body diodes of the inactive output synchronous rectifiers if one of the converters were to shutdown due to a fault while the others remained driving the load. It may be possible, in some applications, to add protection diodes to prevent this excess heat dissipation. It is therefore advisable to contact your local Artesyn Technologies representative for further information on this issue.

8.7 Output Capacitance

The dc-dc converter is 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 through the use of such capacitance. The most effective technique is to fit low ESR ceramic capacitors as close to the load as possible, using several capacitors to lower the overall ESR. These ceramic capacitors will handle the short duration high frequency components of the dynamic current requirement. In addition, higher value electrolytic capacitors should be used to handle the mid-frequency components.

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. Remember that the capacitance of the distribution system and the associated ESR are within the feedback loop of the power module. This can have an effect on the module compensation and the resulting stability and dynamic response performance. Generally, as a rule of thumb, 100 µF/A of output current can be used without any additional analysis. With larger values of capacitance, the stability criteria depend on the magnitude of the ESR with respect to the capacitance. As much of the capacitance as possible should be outside of the remote sensing loop and close to the load.

Note that the maximum rated value of output capacitance for 48 Vin models with output voltages up to and including 1.8 V is 40,000 µF (30,000 µF for 24 Vin models). Higher voltage models will have reduced capacitive load rating. If required, larger capacitance values are possible; please contact your local Artesyn Technologies representative for further information.

8.8 Reflected Ripple Current and Output Ripple & Noise Measurement

The measurement set-up outlined in Figure 20 has been used for both input reflected/terminal ripple current and output voltage ripple and noise measurements on the Quarter-Brick single converter. When measuring output ripple and noise, a 50 Ω coaxial cable with a 50 Ω 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.

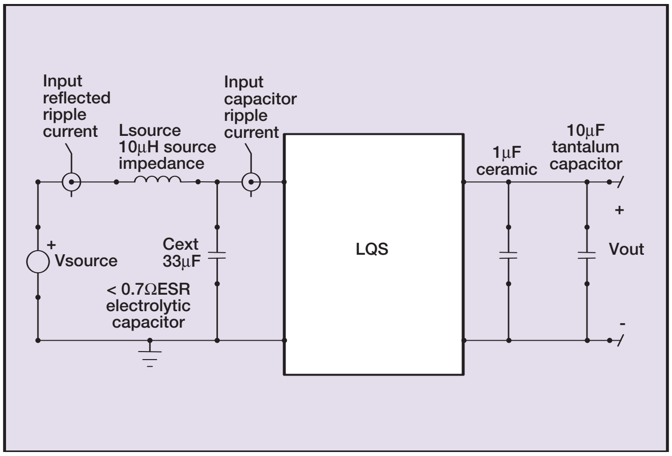
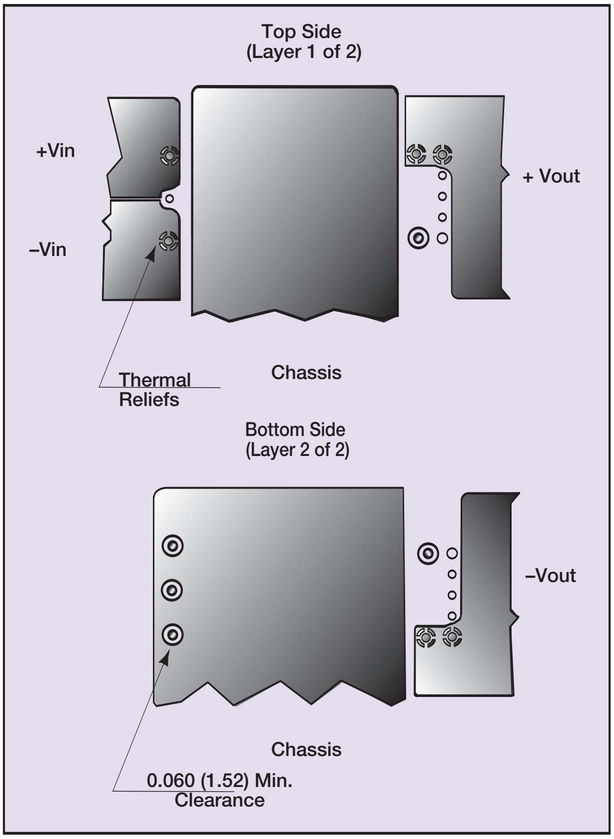


Figure 20 - Input Reflected Ripple/Capacitor Ripple Current and Output Voltage Ripple and Noise Measurement Set-Up

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 21 - Recommended Footprints