NEW Product

EXQ60 Dual
Application Note

ARTESYN® TECHNOLOGIES

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- **Two positive outputs**
- **Output voltage tracking**
- **High efficiency**
- **Approved to EN60950 (TÜV Rheinland), UL/cUL1950**
- **Operating baseplate temperature of -40°C to +100°C**
- **Up to 100% load imbalance**
- **Trim function**
- **No minimum load**
- **Complies with ETS 300 019-1-3/2-3**
- **Fully compliant with ETS 300 386-1**

Features

- Industry standard dual output quarter brick pinout and footprint: 58.4 x 38.1 x 12.7mm (2.3 x 1.5 x 0.5 inches)
- Wide operating temperature range (–40°C to +100°C baseplate temperature)
- ±10% output voltage adjustability
- No minimum load requirement
- Primary side referenced positive logic remote ON/OFF control
- Constant switching frequency
- Brickwall overcurrent protection
- Continuous short circuit protection
- Non-latching output over-voltage protection (OVP)
- Overtemperature (OTP) protection
- Input under/over-voltage lockout protection (U/OVLO)

1. Introduction

This application note describes the features and functions of the Artesyn Technologies EXQ60 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 series offers a wide input voltage range of 33-75VDC and the recommended baseplate operating temperature is –40°C to +100°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 overcurrent, overvoltage and overtemperature. 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. An independent clamped mode and non-latching over-voltage protection (OVP) feature is provided while over-temperature protection (OTP) protects the unit from excessive thermal stress.

The series has been designed primarily for telecommunication applications and complies with ETS 300 386-1 immunity and emission standards for high priority of service class. In addition, the series complies with ETS 300 019-1-3/-2-3 environmental standards (all classes) including shock, vibration, humidity and thermal performance. EN60950 and UL/cUL1950 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 EXQ60 series consists of two models listed in Table 1.

Model	Input Voltage	Output Voltage	Output Current
EXQ60-48D05-3V3	33-75VDC	5.0V/3.3V	12A/15A
EXQ60-48D3V3-2V5	33-75VDC	3.3V/2.5V	12A/16A

Table 1 - EXQ60 Models

3. General Description

3.1 Electrical Description

A block diagram of the EXQ60 converter is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of synchronous rectification techniques (patents pending).

The EXQ60 is implemented using a current-mode controlled interleaved flyback 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 proprietary circuitry to optimise the timing, which is critical for high efficiency power conversion. Two tightly coupled cross-regulated output voltages are provided
The output is adjustable over a range of 90% to 110% of the nominal output voltage using the TRIM pin which is referenced to V_{out-}.

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 cross-coupled outputs are monitored for over-voltages. If an over-voltage due to an internal fault is detected on the output, the converter will clamp at the over-voltage set point.

The converter is also equipped with over-temperature sensors. If the converter is over-loaded or the baseplate temperature gets too high, the converter will shut down until the temperature falls below a minimum threshold. There is typically 3-5ºC of thermal hysteresis included 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.

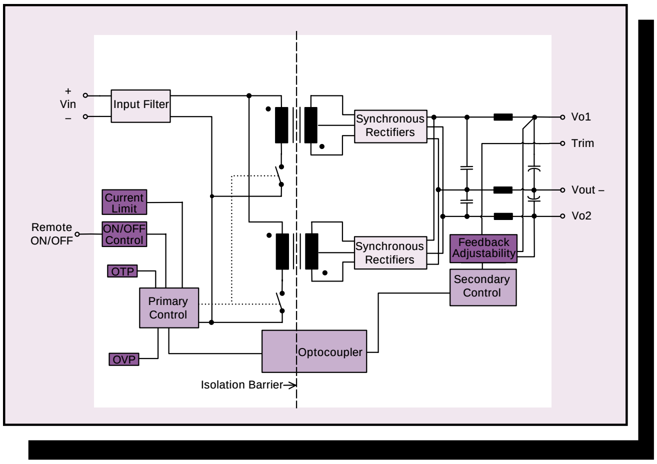


Figure 1 - Electrical Block Diagram

3.2 Physical Construction

The EXQ60 is constructed using a multi-layer FR4 PCB and an insulated metal substrate (IMS). SMT power components are placed on one side of the IMS while low power control components are placed on both sides of the FR4. Heat dissipation of the power components mounted on the baseplate is optimised while at the same time critical control components are thermally isolated.

The converter is sold as an open-frame and no case or case pin 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:** The heat is removed from the heat generating components without heating more sensitive, less tolerant components such as opto-couplers
- **Environmental:** Some encapsulants are not kind to the environment and create problems in incinerators. In addition open frame converters are more easily re-cycled
- **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 from the Artesyn Technologies website.

4. Features and Functions

4.1 Wide Operating Temperature Range

The wide ambient operating temperature range of the EXQ60 module is a result of the extremely high power conversion efficiency and resultant low power dissipation combined with the excellent thermal performance of the PCB substrate. 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
- If present, air velocity 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 ground planes which can be effective heatsinks for the power converter

The converter can be operated from –40ºC to a maximum baseplate temperature of +100ºC. 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 EXB60 module may be operated for a given baseplate temperature and airflow.

4.2 Over-Temperature Protection

The EXQ60 converters are equipped with a non-latching over-temperature protection. A temperature sensor monitors the temperature of the main substrate. If the temperature exceeds a threshold of 113°C (typical) the converter will shut down disabling the output. When the substrate temperature has decreased by 3-5°C, the converter will automatically restart.

The EXQ60 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. OTP 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 voltage on all models is trimmable by –10% to +10% of the nominal output voltage. Details on how to trim all models are provided in section 8.5.

4.4 Output Over-Voltage Protection

The clamped overvoltage protection (OVP) feature is used to protect the module and the user's circuitry when a fault occurs in the main control loop. Faults of this type include optocoupler failure, blown sense resistor or error amplifier failure.

The OVP circuit consists of an auxiliary control loop running in parallel to the main control loop. However, unlike the main loop, the OVP loop senses the cross-coupled output voltages on the primary side of the converter. This voltage is compared to a separate OVP reference and a compensated error signal is generated such that the output voltage is regulated to the OVP clamp level. Note that even an optocoupler is not required during operation of the OVP clamp circuit. OVP clamp levels are typically set at 120-125% of the nominal output voltage setpoint for all models.

4.5 Safe Operating Area

The Safe Operating Area (SOA) of the EXQ60 converter is shown in Figure 2. Assuming the converter is operated within its thermal hotspot constraints, it can deliver an output current $I_{o,max}$ governed by 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 will still deliver $I_{o,max}$ when trimmed down.

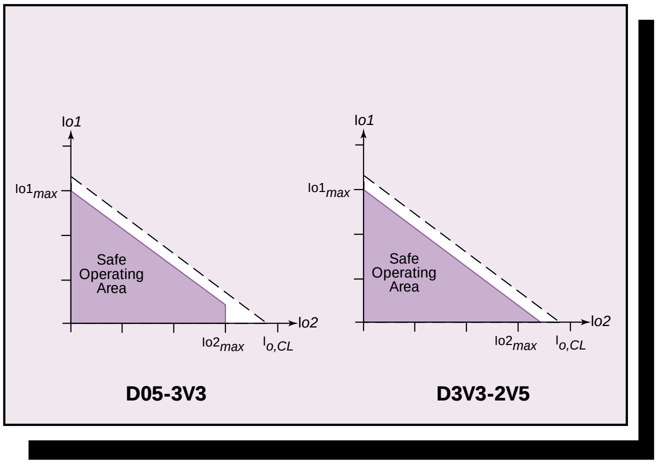


Figure 2 - Maximum Output Current Safe Operating Area

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 discussion.

4.6 Brickwall Current Limit and Short Circuit Protection

All EXQ60 models have a built in brickwall current limit function and full continuous short circuit protection. Thus the V–I characteristic in current limit, 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. The current limit inception point is dependent upon baseplate temperature, line voltage and, for a given output, the load split. For all models the inception is typically 115% of rated full power. The brickwall current limit scheme has many advantages including increased capacitive load start-up capability. See section 8.8 for further discussion.

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 OTP function before any damage occurs.

4.7 Remote ON/OFF

The control input allows external circuitry to put the EXQ60 converter into a sleep mode. The control input is sometimes also referred to as a remote ON/OFF input. The EXQ60 converters are available with either an active-high control input, or with active-low logic.

Active-high units of the EXQ60 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 EXQ60 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 V_{in-}.

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 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 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.

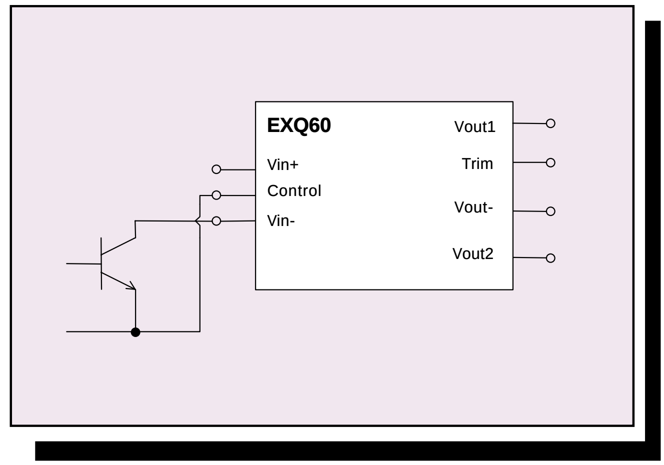


Figure 3 - Remote ON/OFF Input Drive Circuits for Non-Isolated Bipolar

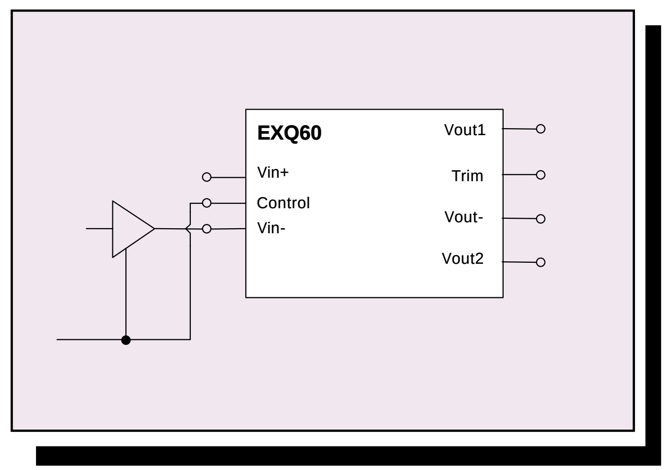


Figure 4 - Remote ON/OFF Input Drive Circuits for Logic Driver

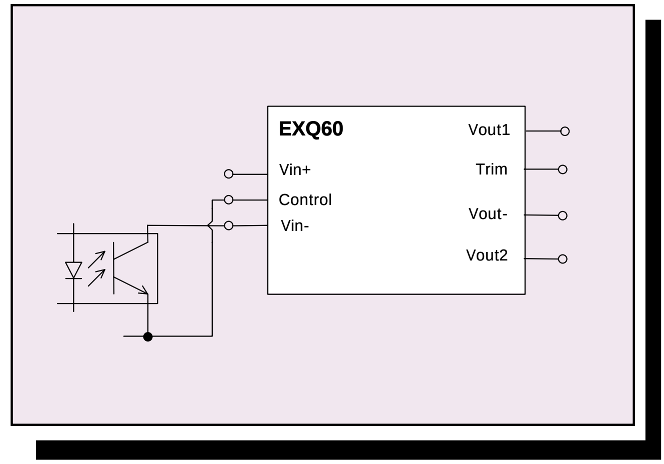


Figure 5 - Remote ON/OFF Input Drive Circuits for Isolated through Optocoupler

5. Safety

5.1 Electrical Isolation

The EXQ60 series of power modules have been submitted to independent safety agencies and has EN60950 and UL1950 safety approvals. Operational insulation is provided between the input and output of the power supply in accordance with EN60950. 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, CAN/CSA-C22.2, No. 850-95 UL1950, third edition, including revisions through revision date March 1, 1998 which are based on the fourth amendment to IEC950, second edition, sub-clause 2.9.

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 60V DC power system, reinforced insulation 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; the test voltage between input and output is 1.5kVDC. Also, note that flammability ratings of the terminal support header blocks and internal plastic constructions meet UL94V-0.

5.2 Input Fusing

This EXQ60 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 EXQ60 converter is 5A, HRC (high rupture capacity), anti-surge, rated for 200V. A fuse should be used at the input of each EXQ60 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 source 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

TThe EXQ60 has been 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 centres, high priority of service. 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 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 EXQ60 series of converters bypasses common mode noise internally by using two paralleled 1nF, 2kV capacitors between V_{in} and V_o. Common mode noise currents flowing in the application circuitry will therefore be greatly minimised. Furthermore, the EXQ60 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 Figure 6.

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.

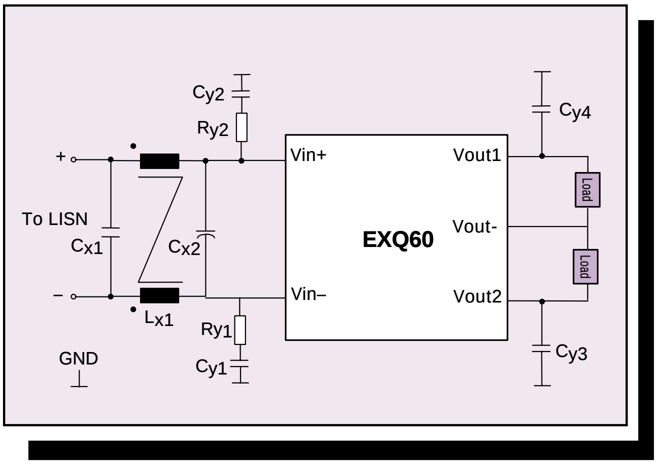


Figure 6 - Recommended Class B Filter

The components and manufacturers' part numbers used in the above filter are as follows:

C_{x1}, ITW Paktron 4µF, 100V, SMT film capacitor, 405K100CS4
C_{x2}, UCC 33µF, 100V, electrolytic capacitor, KMF100VB33RM10X12
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 7. Section 8.1 discusses this subject in more detail, particularly with reference to recommended creepage and clearance requirements.

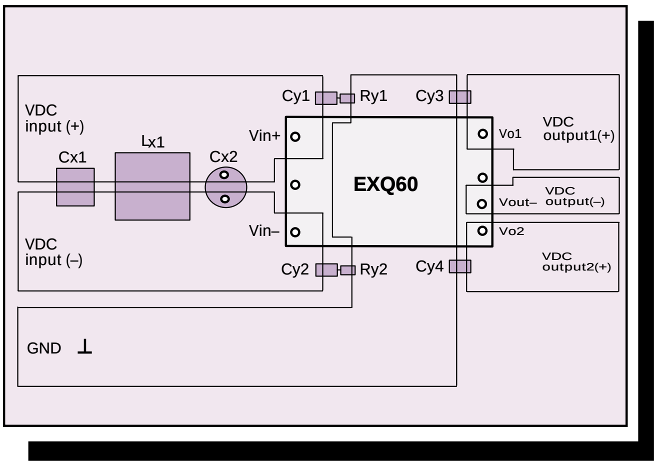


Figure 7 - Conducted EMI Filter Recommended Layout Guidelines

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.

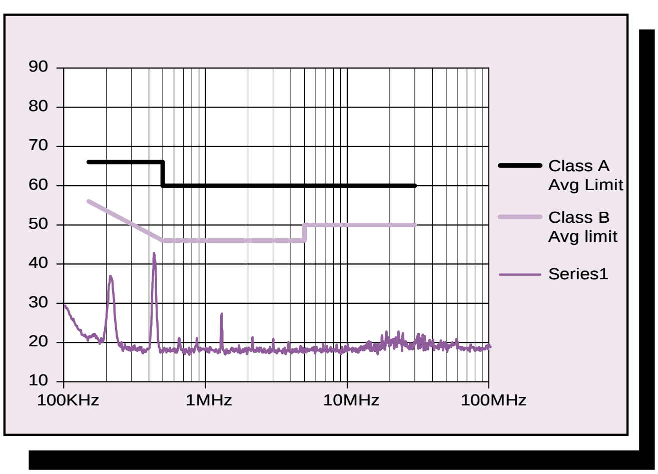


Figure 8 - Typical Spectrum of the EXQ60-48D05-3V3 (Vin=48V, Io1=6A, Io2=9A), 50µH LISN, Class A and B Average Limit Lines are Shown

6.2 Radiated Emissions

The applicable standard is EN55022 Class B (FCC Part 15). Testing DC/DC converters as a stand-alone component to the exact requirements of EN55022 is very difficult to do as the standard calls for 1m leads to be attached to the input and output ports and aligned such as to maximize the disturbance. In such a set-up it is possible to form a perfect dipole antenna that very few DC/DC converters could pass.

However the standard also states that ‘An attempt should be made to maximize the disturbance consistent with the typical application by varying the configuration of the test sample’s. In addition, ETS 300 386-1 states that the testing should be carried out on the enclosure. The EXQ60 is primarily intended for PCB mounting in telecommunication rack systems. Signal input lines to the converter are considered to be less than 3 metres in length to meet the standards.

This testing is pending. Refer to next revision for results. For the purpose of the radiated test, an EXQ60-48D05-3V3 will be mounted on a 227.3mm x 127mm (8.95” x 5.0”) test-board using the recommended PCB layout (see Appendix 1). The operating conditions were:

- Input voltage, V_{in} = 48V
- Output1 current I_o1 = 6.0A
- Output current, I_o2 = 9.0A
- Baseplate temperature, $T_{baseplate}$ = 25°C

No enclosure was used. Typical radiated emission results will be presented in Figure 9.

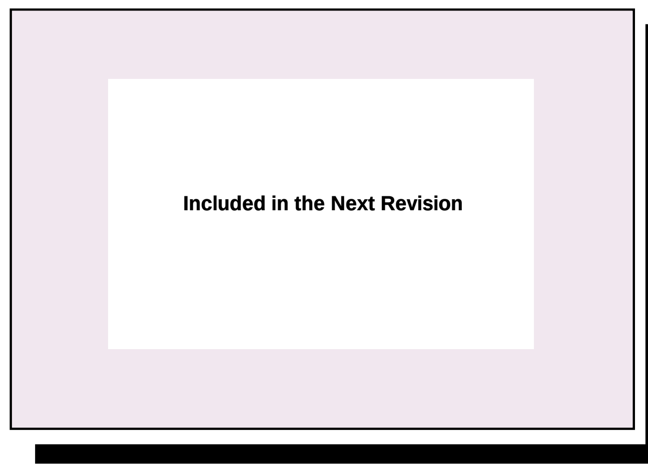


Figure 9 - Typical Radiated Emission EXQ60-48D05-3V3 (Vin=48V, Io=25A)

7. Use in a Manufacturing Environment

7.1 Resistance to Soldering Heat

The EXQ60 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/secrate

Table 2 -Wave Solder Test Conditions

7.2 Water Washing

The EXQ60 is suitable for water washing as it does not have any pockets where water may congregate long term. The user should ensure that a sufficient drying process and period are available to remove the water from the unit after washing.

7.3 ESD Control

The EXQ60 units 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 7 does not guarantee system EMC compliance as this is dependant 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 EXQ60, namely:

- Input voltage, V_{in}
- Output voltage, V_{o1} and V_{o2}
- Output current, I_{o1} and 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 baseplate temperature of the converter will be determined. The maximum acceptable baseplate temperature measured at the thermal reference points is +100°C. The thermal reference point is shown in Figure 10.

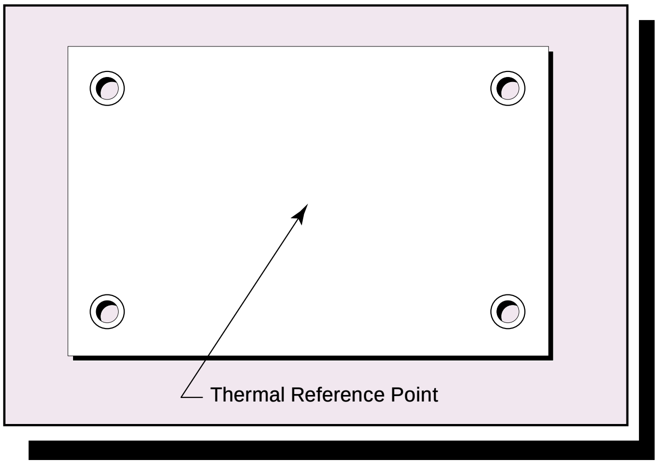


Figure 10 - EXQ60 Baseplate Temperature Check Point

To simplify the thermal design task a number of graphs are given in the long form data sheet and are repeated here in Figure 11, Figure 12, Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17. The set of derating graphs show the output power of the EXQ60-48D05-3V3 converter with the mechanical tie-downs screwed onto a ground plane and the output power of the EXQ60-48D3V3-2V5 without the use of mechanical tie-downs (no derating was required in airflow with the mechanical tie-downs screwed onto the ground plane of the test board) for various load splits 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 baseplate is kept within its recommended temperature rating. It is recommended that the temperature of the baseplate is measured using a thermocouple or an IR camera. In order to comply with the inherent stringent Artesyn derating criteria the baseplate temperature should ever exceed +100°C. Alternatively please contact Artesyn Technologies for further support.

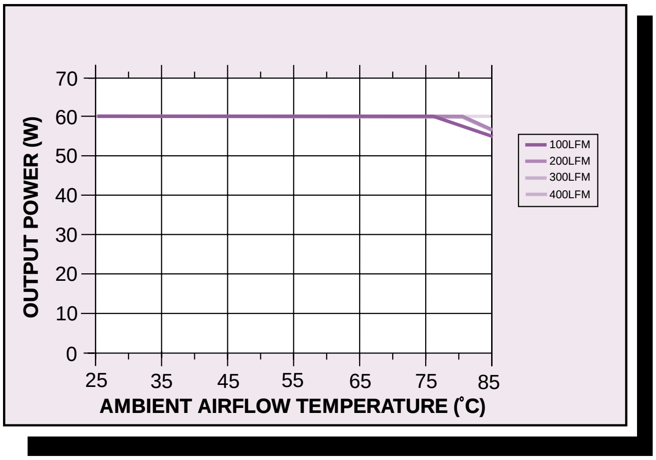


Figure 11 - Maximum Output Power vs. Ambient Temperature and Airflow for EXQ60-48D05-3V3 Model, 100% Load from Vout1

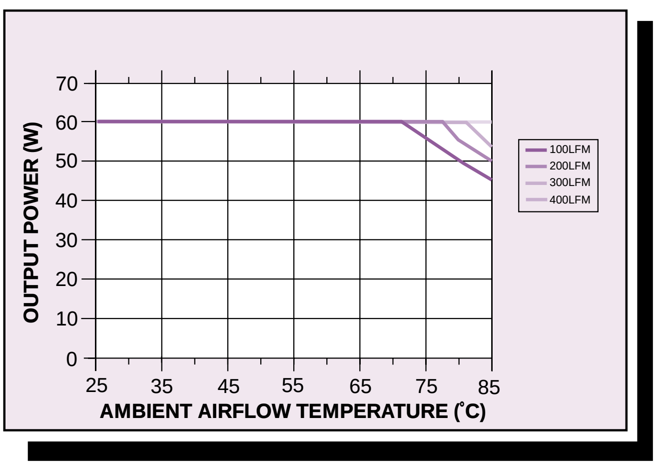


Figure 12 - Maximum Output Current vs. Ambient Temperature and Airflow for EXQ60-48D05-3V3 Model, 100% Load from Vout2

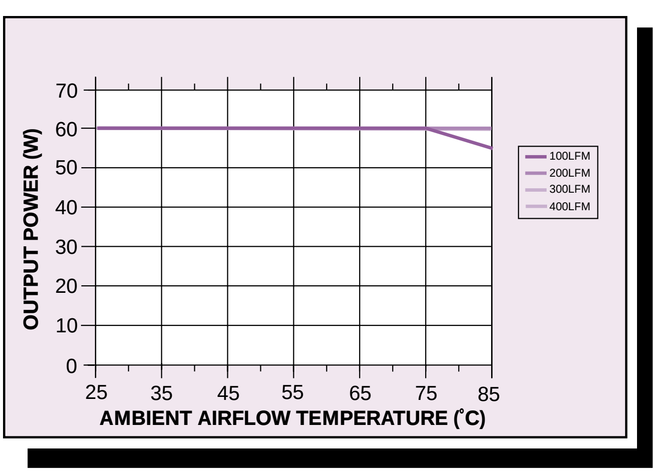


Figure 13 - Maximum Output Current vs. Ambient Temperature and Airflow for EXQ60-48D05-3V3 Model, 50% Load Split

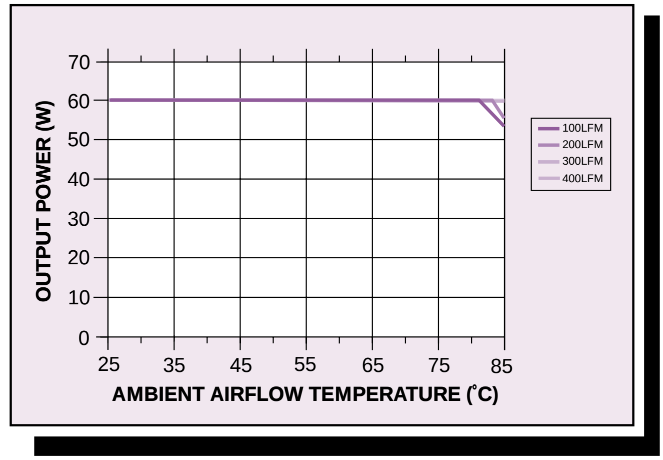


Figure 14 - Maximum Output Current vs. Ambient Temperature and Airflow for EXQ60-48D05-3V3 Model, 30% Load from Vout1, 70% Load from Vout2

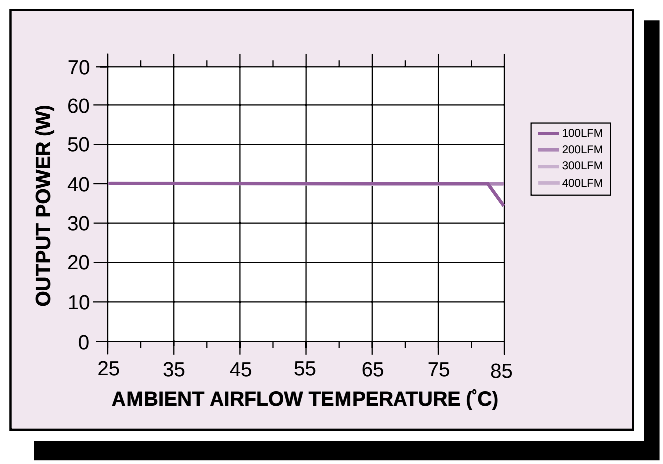


Figure 15 - Maximum Output Current vs. Ambient Temperature and Airflow for EXQ60-48D3V3-2V5 Model, 100% Load from Vout1

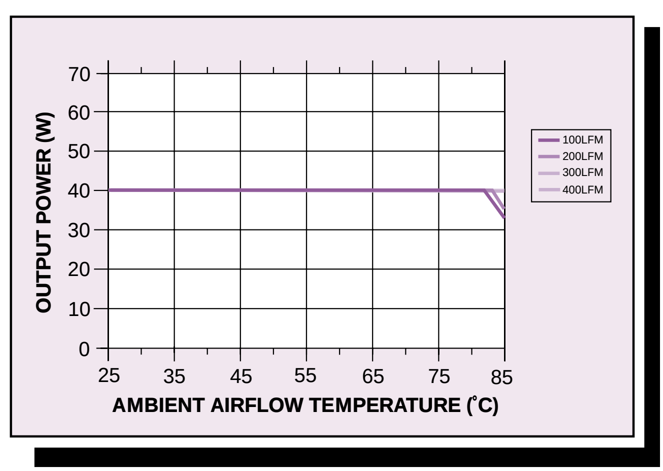


Figure 16 - Maximum Output Current vs. Ambient Temperature and Airflow for EXQ60-48D3V3-2V5 Model, 100% Load from Vout2

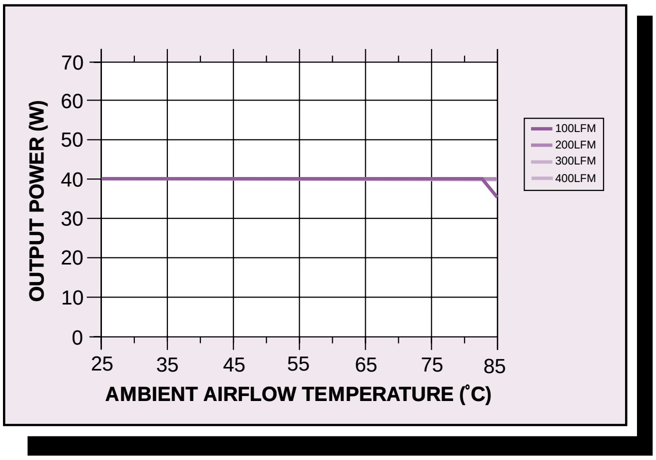


Figure 17 - Maximum Output Current vs. Ambient Temperature and Airflow for EXQ60-48D3V3-2V5 Model, 70% Load from Vout1, 30% Load from Vout2

8.3 Remote Sense Compensation

The EXQ60 features a multi-output shared regulation scheme working on tightly coupled cross-regulated outputs. Remote sense compensation is not applicable to this type of system.

8.4 Output Cross-Regulation

Typical output voltage cross-regulation against load split curves are given for 100%, 66% and 33% output loading conditions in Figures 18, Figure 19, Figure 20, Figure 21, Figure 22 and Figure 23

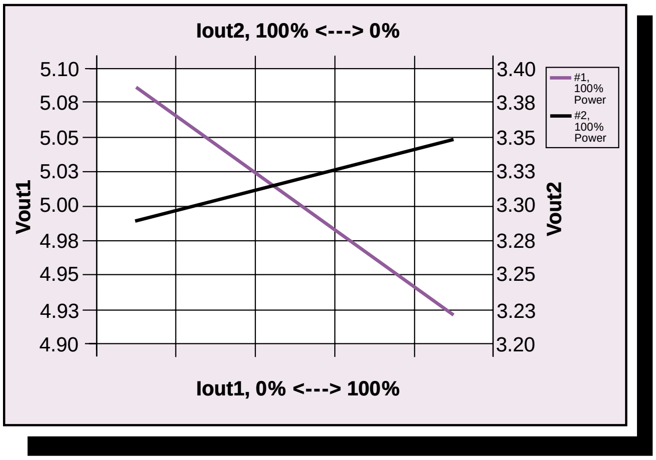


Figure 18 - EXQ60-48D05-3V3 Typical Cross Regulation at Pout=100% Poutmax

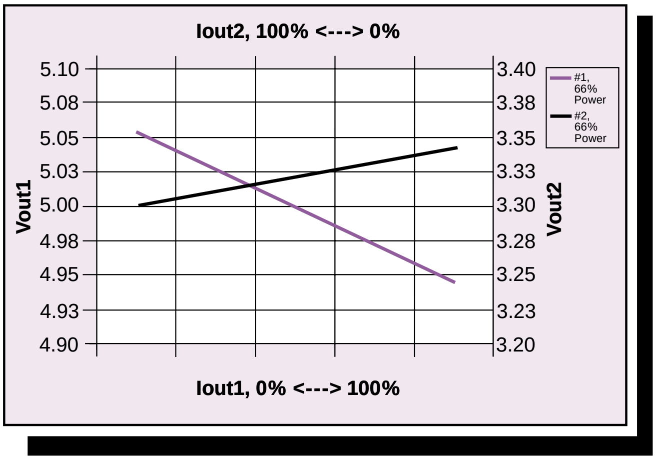


Figure 19- EXQ60-48D05-3V3 Typical Cross Regulation at Pout=66% Poutmax

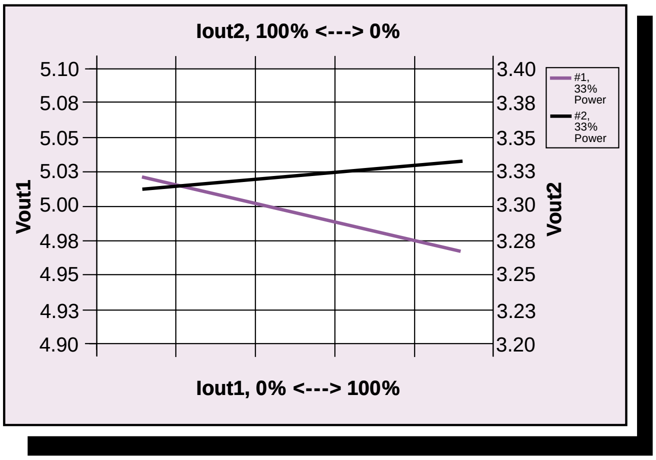


Figure 20 - EXQ60-48D05-3V3 Typical Cross Regulation at Pout=33% Poutmax

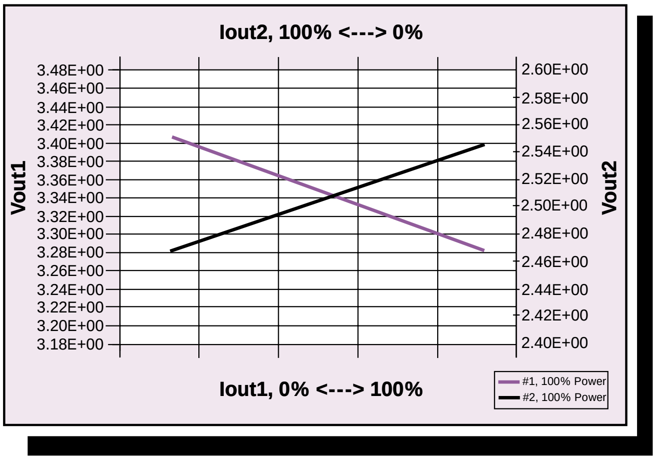


Figure 21 - EXQ60-48D3V3-2V5 Typical Cross Regulation at Pout=100% Poutmax

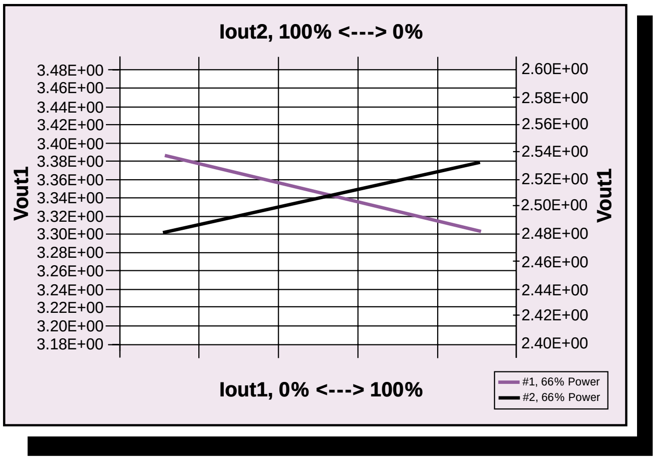


Figure 22 - EXQ60-48D3V3-2V5 Typical Cross Regulation at Pout=66% Poutmax

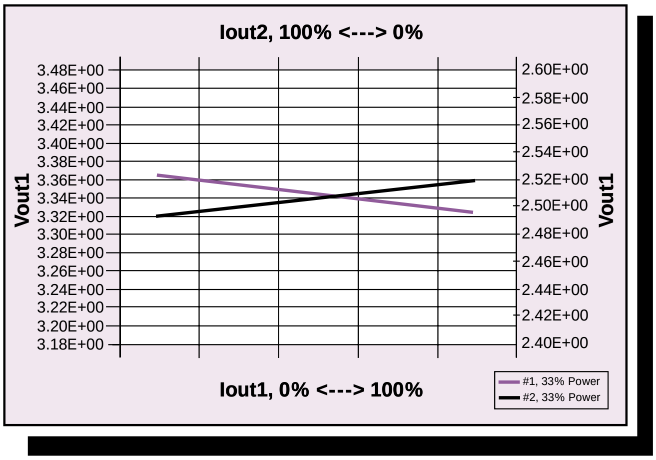


Figure 23 - EXQ60-48D3V3-2V5 Typical Cross Regulation at Pout=33% Poutmax

8.5 Output Voltage Adjustment

The output can be externally trimmed by ±10% by connecting an external resistor between the TRIM pin and either the V_{out2} or V_{out-} pin. With an external resistor between TRIM and $_{Vout2}$, R_{TRIM_DOWN}, the output voltage setpoint decreases. Conversely, connecting an external resistor between TRIM and V_{out-}, R_{TRIM_UP}, the output voltage set point increases. A trim pot with its terminals connected to the V_{out-} and V_{out2} pins and the wiper connected to the trim pin allows a variable trim, either up or down. This is shown in Figures 22, 23 and 24.

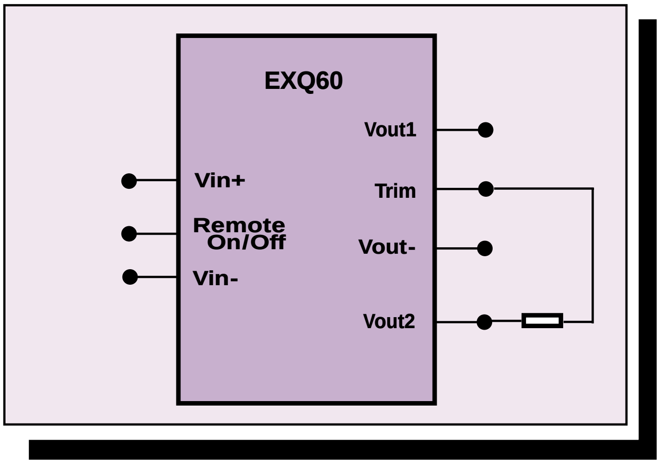


Figure 24 - Trimming Output Voltage - Trim Down

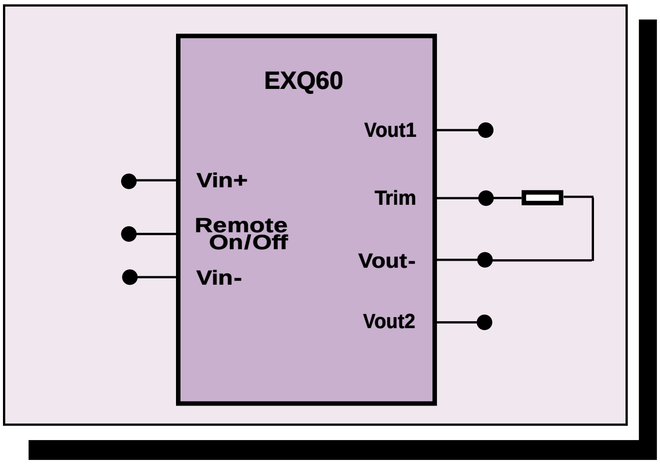


Figure 25 - Trimming Output Voltage - Trim Up

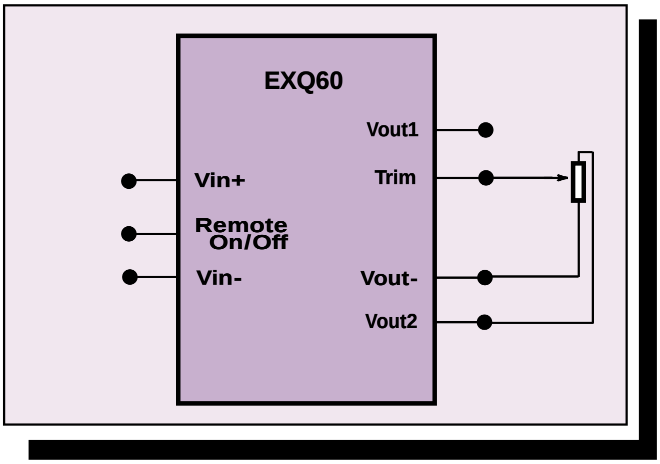


Figure 26 - Trimming Output Voltage - Variable Trim

The relevant trim curves to derive the appropriate trim resistance for the EXQ60 are shown in Figures 27, 28, 29 and 30.

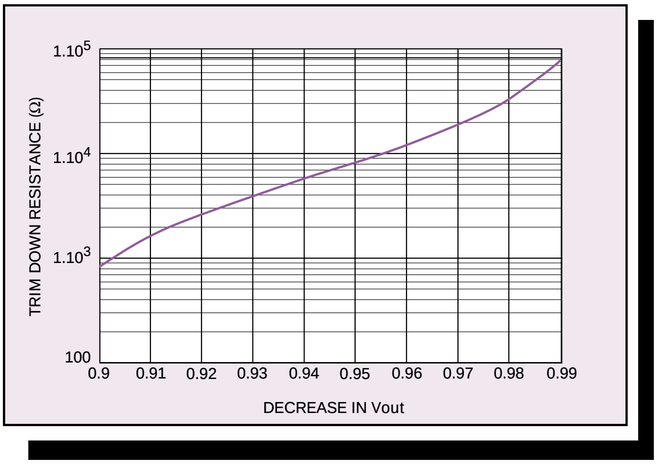


Figure 27 - EXQ60-48D05-3V3 Typical Trim Down Curve (Resistor from TRIM to V_{o2}[1])

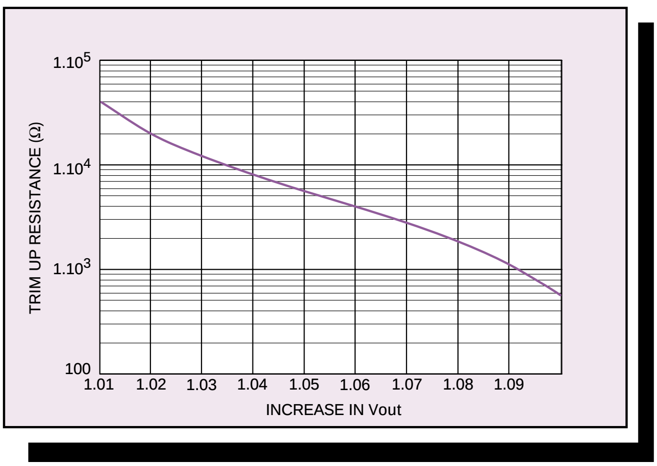


Figure 28 - EXQ60-48D05-3V3 Typical Trim Up Curve (Resistor from TRIM to V_{o-})

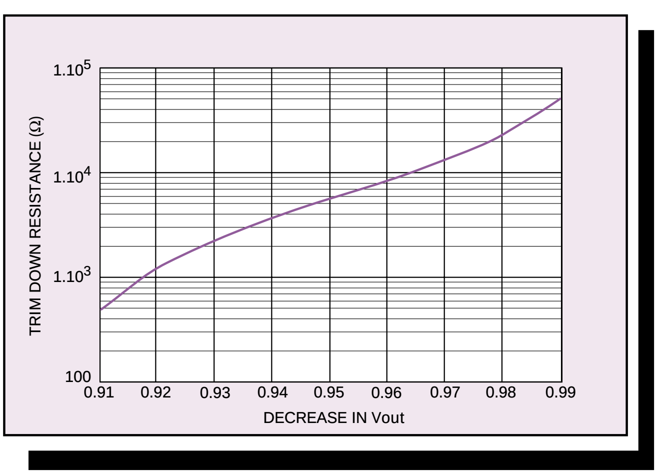


Figure 29 - EXQ60-48D3V3-2V5 Typical Trim Down Curve (Resistor from TRIM to V_{o2})

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

[2]Datasheet 'LT1640L Negative Voltage Hot Swap Controller' available from Linear Technology Corporation.

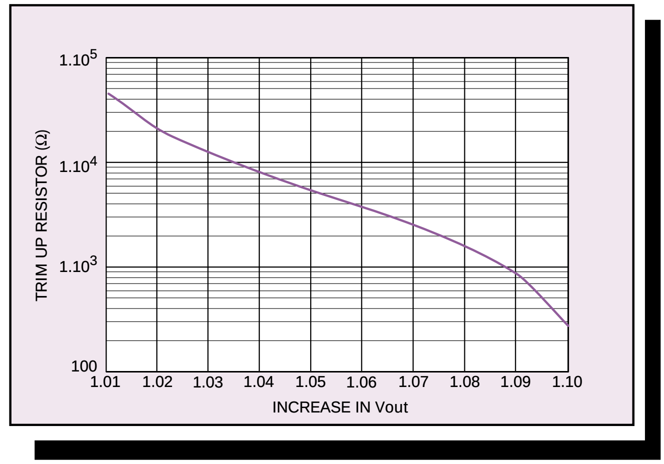


Figure 30 - EXQ60-48D3V3-2V5 Typical Trim Up Curve (Resistor from TRIM to V_{o-})

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 Active Inrush Current Limiting

To allow safe insertion and removal of a circuit card from a live backplane, the inrush current of the card has to be limited. A recommended active inrush current limiting circuit is shown in Figure 31. The circuit provides a programmable inrush current limit and a programmable electronic circuit breaker. Please refer to LT1640L Datasheet 'LT1640L[2] Negative Voltage Hot Swap Controller' available from Linear Technology Corporation for detailed information.

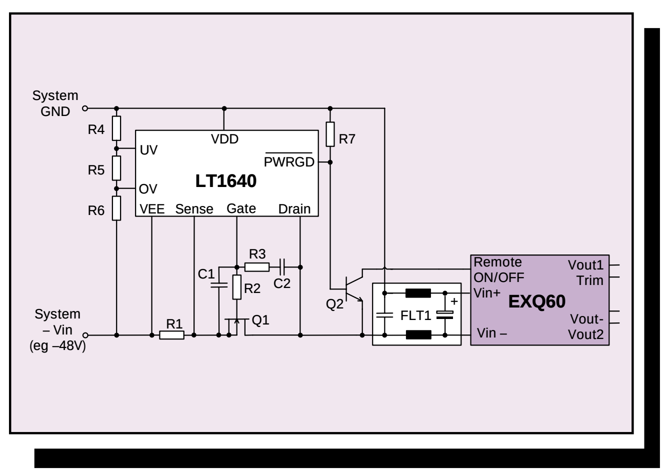


Figure 31 - Recommended Inrush Current Limiting Circuit

The EXQ60 comes with its own internal UV lockout feature. Therefore components R4, R5, R6, R7 and Q2 are required only if the UV threshold of the EXQ60 is to be increased, or additional OV protection is required. Circuit block FLT1 consists of the recommended input filter (see section 6.1). If further information is required on this issue, please contact your local Artesyn Technologies Representative.

Other inrush control chips are available with various features that may be useful for a given application. Article, EDN, August 2, 2001 Edition, Page 54, "Hot-Swapping Power" If further information is required on this issue, please contact the local Artesyn Technologies representative.

8.7 Parallel and Series Operation
Because of the absence of an active current sharing feature, parallel operation of multiple EXQ60 converters is not allowed.

The individual outputs of the EXQ60 converters are not isolated and as such series operation is not allowed.

8.8 Output Capacitance
The EXQ60 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 overall 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.

8.9 Reflected Ripple Current and Output Ripple & Noise Measurement
The measurement set-up outlined in Figure 32 has been used for both input reflected/capacitor ripple current and output voltage ripple and noise measurements on EXQ60 series 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.

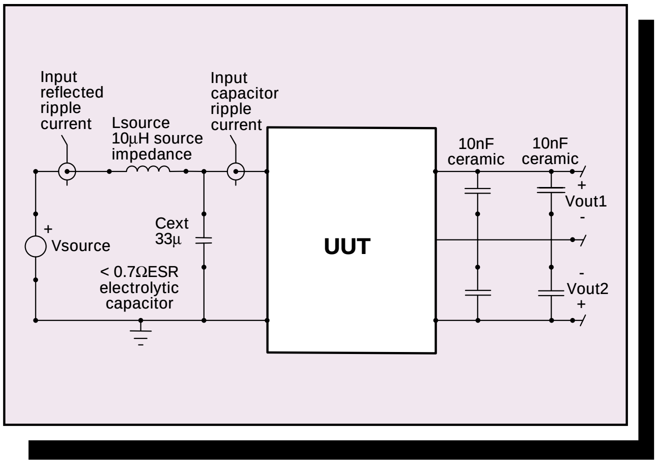
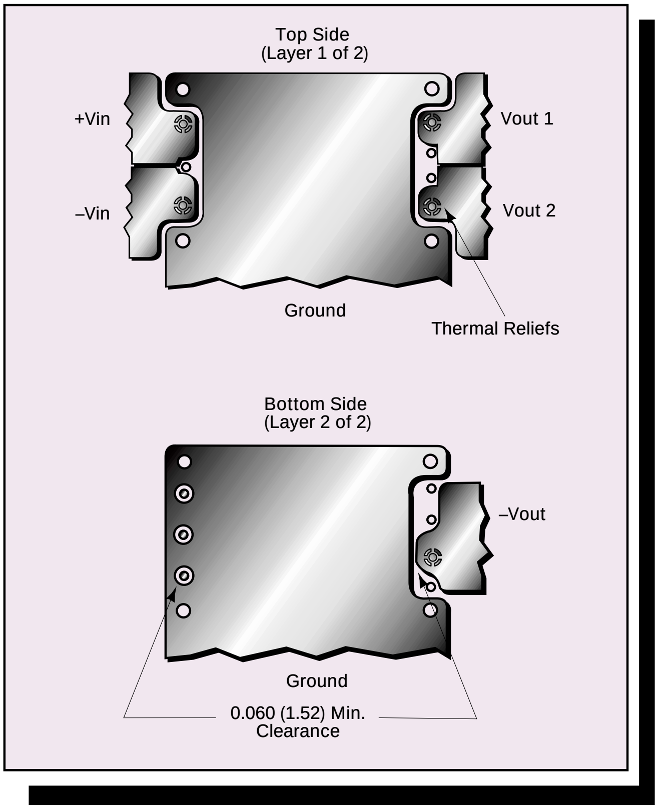
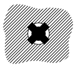


Figure 32 - Input Reflected Ripple/Capacitor Ripple Current and Output Voltage Ripple and Noise Measurement Set-Up

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 33 - Recommended Footprints