NEW Product

EXB250 Single

Application Note 119

ARTESYN® TECHNOLOGIES

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- **High efficiency topology, typically 90% at 3.3V**
- **Industry standard footprint**
- **Wide baseplate temperature range, -40˚C to +100˚C (natural convection)**
- **90% to 110% output trim**
- **No minimum load**
- **Over-voltage protection**
- **Remote ON/OFF**

Features
- Industry standard half-brick pin-out and footprint: 2.4 x 2.28 x 0.5 inches
- Wide operating temperature range (-40°C to +100°C baseplate temperature)
- ±10% output voltage adjustability
- No minimum load requirement
- Remote ON/OFF control (primary-side referenced)
- Remote sense compensation
- Constant switching frequency
- Brickwall over-current protection
- Continuous short-circuit protection
- Non-latching output over-voltage protection (OVP)
- Over-temperature protection (OTP)
- Input under/over-voltage lockout protection (U/OVLO)

1. Introduction

This application note describes the features and functions of Artesyn Technologies' EXB250 series of high power density, half-brick DC/DC converters. These open-frame, single-output modules are targeted specifically at the fixed and mobile telecommunications, industrial electronics and distributed power markets.

All EXB250 series converters offer a wide input voltage range of 33-75VDC and feature a wide baseplate operating temperature range of -40°C to +100°C. Ultra-high efficiency operation is achieved through the use of proprietary synchronous rectification and control techniques. The modules are fully protected against over-current, over-voltage and over-temperature conditions. Standard features include Remote ON/OFF and remote sense.

The EXB250 series is 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, and a high level of reliability has been designed into all models through extensive use of conservative de-rating criteria. Automated manufacturing methods, together with an extensive qualification program, ensure that all EXB250 series converters are produced to the same rigorous quality levels.

2. Models

The EXB250 series comprises seven models, as listed in Table 1.

Model	Input Voltage	Output Voltage	Output Current
EXB250-48S1V2	33-75VDC	1.2V	60A
EXB250-48S1V5	33-75VDC	1.5V	60A
EXB250-48S1V8	33-75VDC	1.8V	60A
EXB250-48S2V5	33-75VDC	2.5V	60A
EXB250-48S3V3	33-75VDC	3.3V	50A
EXB250-48S05	33-75VDC	5.0V	33A
EXB250-48S12	33-75VDC	12.0V	13.75A

Table 1 - Output Voltages

3. General Description

3.1 Electrical Description

A block diagram of the EXB250 converter is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of synchronous rectification techniques [patents pending].

The EXB250 is implemented using a current-mode controlled interleaved flyback topology. Power is transferred magnetically across the isolation barrier, via an isolating power transformer. 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 90% to 110% of the nominal output voltage, using the TRIM pin.

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 over-voltage conditions. The converter will clamp at the over-voltage set-point if an over-voltage condition caused by an internal fault is detected at the output.

The converter is also protected against over-temperature conditions. If the converter is overloaded or the baseplate 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 to 5ºC, 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 for further details on filter implementation and emissions.

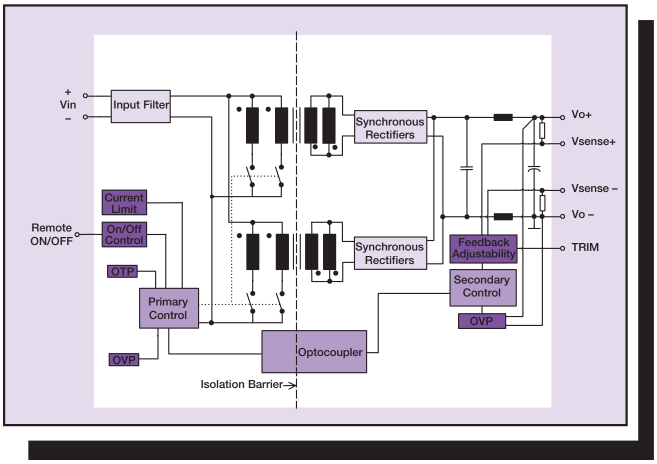


Figure 1 - Electrical Block Diagram

3.2 Physical Construction

The EXB250 is constructed using a multi-layer FR4 PCB and an integrated metal substrate (IMS). SMT power components are placed on one side of the IMS while low power control components are placed on the PCB. This approach optimizes heat dissipation of the power components on the baseplate, and also thermally isolates the control components.

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 such as opto-couplers
- **Environmental:** some encapsulants are not kind to the environment and create problems in incinerators. Furthermore, open-frame converters are more easily re-cycled
- **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 EXB250's ability to accommodate a wide range of ambient temperatures is a result of its extremely high power conversion efficiency and resultant low power dissipation, combined with the excellent thermal performance of its IMS. 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 -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 EXB250 module may be operated for a given baseplate temperature and airflow.

4.2 Over-Temperature Protection

All EXB250 converters feature non-latching over-temperature protection. The temperature of the main substrate is monitored by a sensor. If the temperature exceeds a threshold of 115°C (typical) the converter will shut down, disabling the output. When the substrate temperature has decreased by between 3˚C and 5°C, the converter will automatically restart.

The converter might experience over-temperature 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 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 8.4.

4.4 Output Over-Voltage Protection

The clamped over-voltage protection (OVP) feature is used to protect the module and the user's circuitry in the unlikely event of a fault occurring in the main control loop. Faults of this type include optocoupler failure, an open-circuit sense resistor or error amplifier failure. The unit is also protected in the event of the output being trimmed above the recommended maximum specification.

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 voltage at the output power terminals of the module. The sensed 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 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 EXB250 converter is shown in Figure 2. Assuming the converter is operated within its thermal 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 de-rated by 10%. The module can still deliver $I_{o,max}$ when trimmed down.

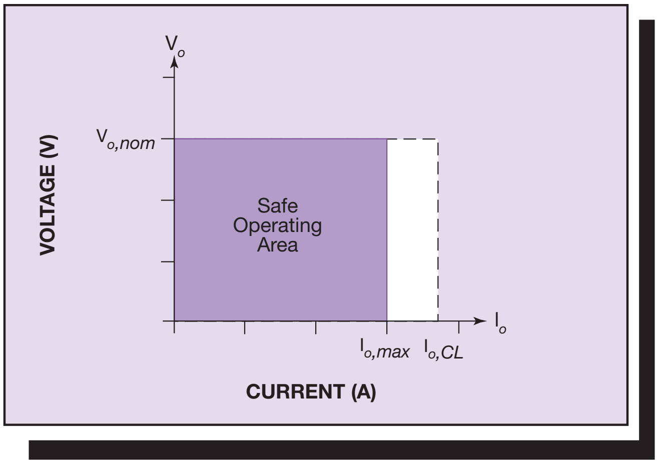


Figure 2 - Maximum Output Current Safe Operating Area

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 details.

4.6 Brickwall Current Limit and Short-Circuit Protection

All EXB250 models have 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, $I_{o,CL}$. The current limit inception point is dependent upon baseplate temperature and line voltage, and also has a parametric spread. For all models, the inception point is typically 115% of rated full load. The brickwall current limit scheme has many advantages, including increased capacitive load start-up capability (see Section 8.6).

Note that although none of the module specifications is guaranteed when the unit is operated in an over-current condition, the unit will not be damaged, because it will be protected by the OTP function.

4.7 Remote ON/OFF

The Remote ON/OFF input allows external circuitry to put the EXB250 converter into a low dissipation sleep mode. Active-high Remote ON/OFF is available as standard and active-low logic can be specified as an an option by adding the suffix '-R' to the part number.

Active-high units of the EXB250 series are turned on if the Remote ON/OFF pin is high (or 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-}.

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 EXB250 long-form 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.

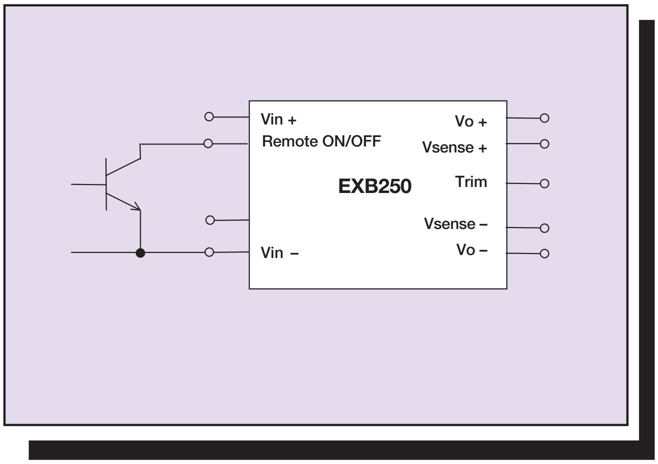


Figure 3 - Remote ON/OFF Input Drive Circuits for Non-Isolated Bipolar

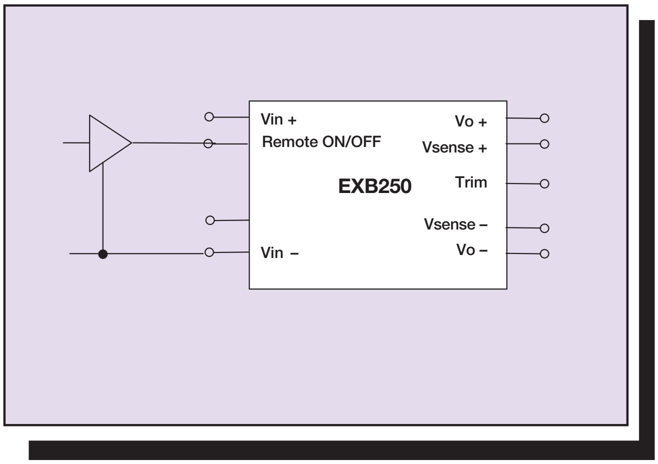


Figure 4 - Remote ON/OFF Input Drive Circuits for Logic Driver

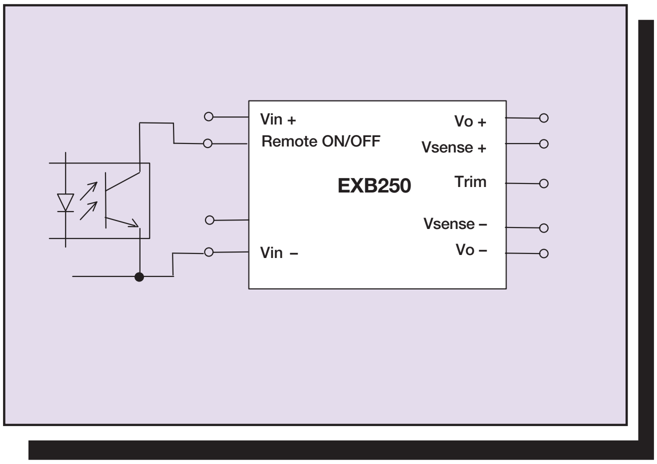


Figure 5 - Remote ON/OFF Input Drive Circuits for Isolated through Optocoupler

5. Safety

5.1 Electrical Isolation
The EXB250 has been submitted to independent safety agencies and has EN60950 and UL1950 safety approvals. Operational insulation is provided in accordance with EN60950.

The TNV or Telecommunication Voltage definitions are given in Table V.1 of IEC950, from which EN60950 and UL1950 are derived. The EXB250 series of power modules have an approved insulation system that satisfies the requirements of the safety standards. In order for the user to maintain the insulation requirements of these safety standards, it is necessary for the required creepage and clearance distances to be maintained between input and output. Creepage is the distance along a surface such as a PCB, and for the EXB250 the creepage requirement between primary and secondary is 1.0mm or 40 thou. Clearance is the distance through air and the requirement is 0.7mm or 27 thou (PCB layout information incorporating the appropriate creepage distances is given in section 8.1).

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. 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 (level 3). If connected to a >60VDC power system, reinforced insulation must be provided in the power supply that isolates the input from the mains. Single fault testing in the power supply must be performed in combination with the DC/DC power module to demonstrate that the output meets the requirement for SELV. One pole of the input and one pole of the output is to be grounded or both are to be kept floating. 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
The EXB250 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 required fuse rating for the EXB250 converter is 10A, HRC, anti-surge, rated for 200V. A fuse should be used at the input of each EXB250 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 in order that the remainder of the system can continue operating.

- 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 the model. Refer to the fuse manufacturer's data for further information.

6. EMC

The EXB250 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 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's fundamental switching frequency and its harmonics. Common-mode noise, generated in switching converters, is measured between the input lines and system ground, and can be broadband in nature. The EXB250 series of converters bypasses common-mode noise internally by using a 2.2nF, 2kV capacitor between V_{in-} and V_{o-}. Common-mode noise currents flowing in the application circuitry will therefore be minimized. Furthermore, the EXB250 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 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}, L_{x2}, 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}, C_{y2}, C_{y5}, C_{y6} 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}, L_{x2} The ground plane can be connected to the case when case tie-downs are employed. Resistors R_{y1} and R_{y2} help damp the common-mode filter inductance and Y-capacitance.

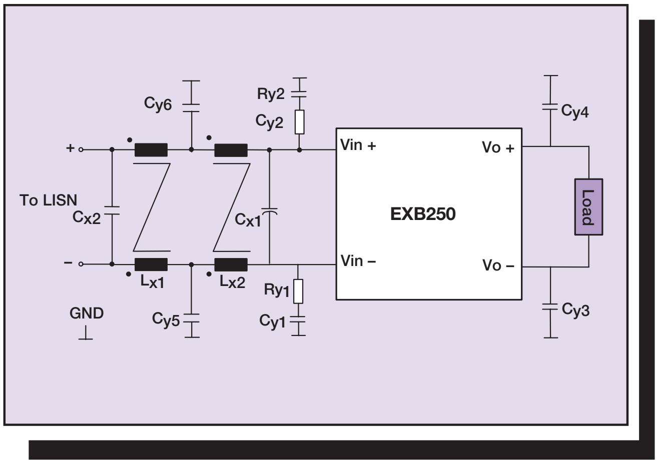


Figure 6 - Recommended Filter for Class A and B Compliance

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

C_{x2}, ITW Paktron 4µF 100V SMT film capacitor, 405K100CS4
C_{x1}, UCC 33µF 100V electrolytic capacitor, KMF100VB33RM10X12
C_{y1}, C_{y2}, C_{y5}, C_{y6}, AVX 5.6nF, 1.5kV, 1812SC562KA1
C_{y3}, C_{y4}, AVX 0.1µF 100V, 12061C104KAT
R_{y1}, R_{y1}, 5.6Ω 1206 resistor
L_{x1},L_{x2} Pulse Eng PO353

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 6.

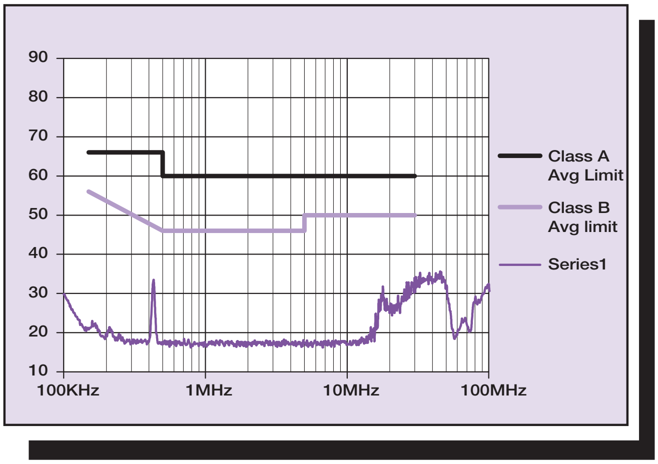


Figure 7 -Typical Spectrum of the EXB250-48S3V3 (Vin = 48V, Vo = 3.3V, Io = 50A), 5µH LISN, Class A and B Average Limit Lines are shown

6.2 Common-Mode Noise

Common-mode noise is generated in switching converters and can contribute to both radiated emissions and input conducted emissions. The EXB250 series of converters bypasses common-mode noise internally by using a 2.2nF 2kV capacitor between input ground and output ground. The EXB250 series will therefore minimize common-mode noise currents flowing in the application circuitry. Furthermore, the three-wire EMI filters outlined in Figure 6 will provide significant common-mode noise attenuation.

7. Use in a Manufacturing Environment

7.1 Resistance to Soldering Heat

All EXB250 series converters are 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°C±10°C 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

7.2 Water Washing

The EXB250 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

EXB250 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.

7.4 Mounting Brick Type Converters to System PCB

The EXB250 should be mounted to the end-use printed circuit board in accordance with Application Note 103. The threaded inserts on each converter are insert molded, which gives added strength during mounting. Please contact Artesyn Technologies if further assistance is needed with regard to PCB mounting.

7.5 Heat Sink Mounting

Depending on the thermal requirements of the application, and the available space, heatsinks can provide increased thermal performance. The converter can be screw-mounted on the end-use PCB, and can also have a heatsink attached to its top. The industry standard footprint allows the use of many types of off-the-shelf heatsinks. If multiple converters are to be mounted to a single heatsink or cold plate, care must be taken during assembly. Please contact Artesyn Technologies for further information.

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. The two planes act as EMC shields (note that the recommended layout shown in Figure 25 does not guarantee system EMC compliance since this depends on the end application).

These recommended layouts will maintain the creepage and clearance requirements discussed in the safety section of this application note. However, the end-user must ensure that other components and metal in the vicinity of the EXB250 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 electrical operating conditions of the EXB250, namely:

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

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
- Parts mounted on system PCB that may block airflow
- Real airflow characteristics at the converter location

these factors determine the particular baseplate temperature of the converter. The maximum acceptable baseplate temperature measured at the thermal reference point shown in Figure 9 is 100°C.

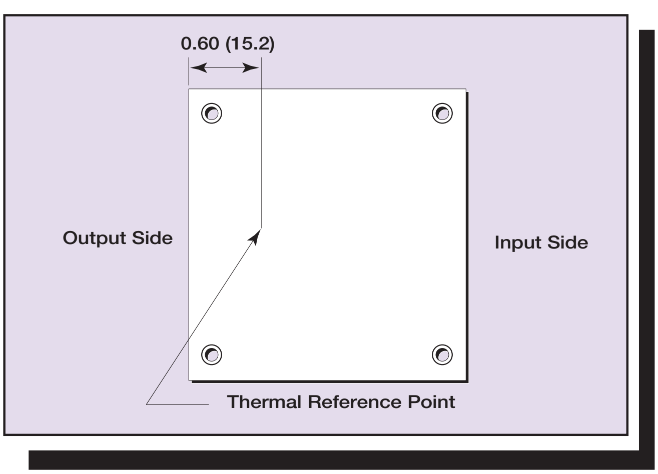


Figure 9 - Baseplate Temperature Check Point

To simplify the thermal design task, a number of graphs are given in the data sheet and are repeated here in Figures 10, 11, 12, 13, 14, 15 and 16. The set of de-rating graphs show the load current of EXB250 converters versus ambient air temperature and forced air velocity. However, since thermal performance is heavily dependent upon the final system application, the user needs to ensure that 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 Artesyn's stringent de-rating criteria, the baseplate temperature should never exceed +100°C. Alternatively, please contact Artesyn Technologies for further support**.**

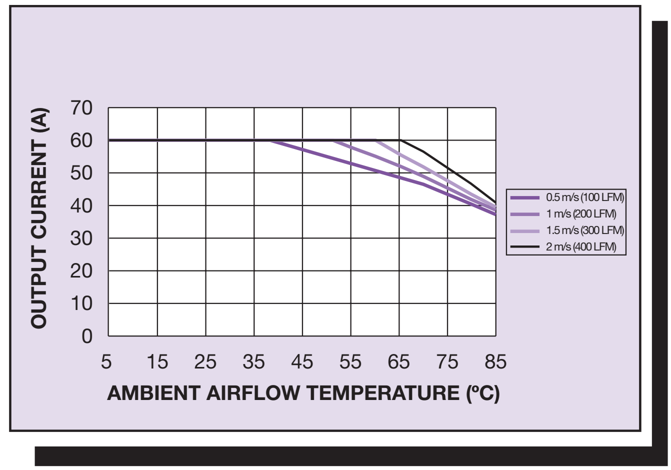


Figure 10 - Maximum Output Current vs. Ambient Temperature and Airflow for EXB250-48S1V2 Model

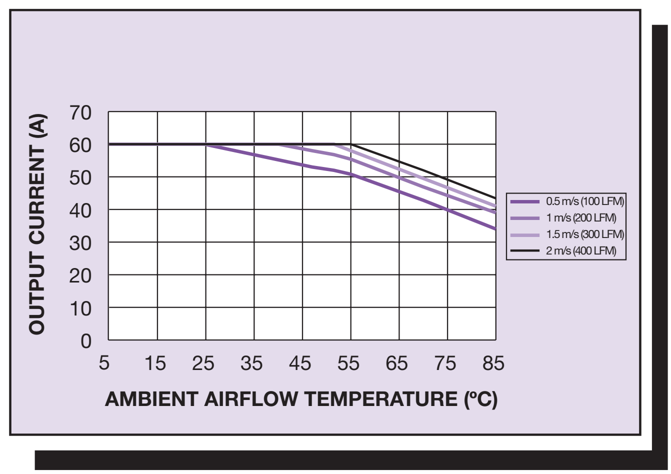


Figure 11 - Maximum Output Current vs. Ambient Temperature and Airflow for EXB250-48S1V5 Model

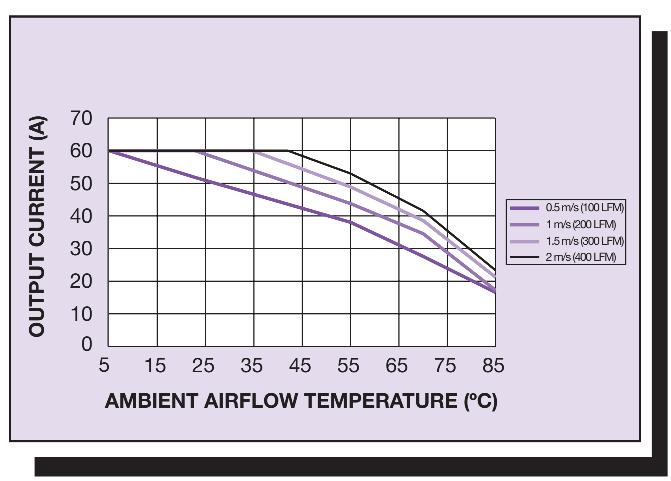


Figure 12 - Maximum Output Current vs. Ambient Temperature and Airflow for EXB250-48S1V8 Model

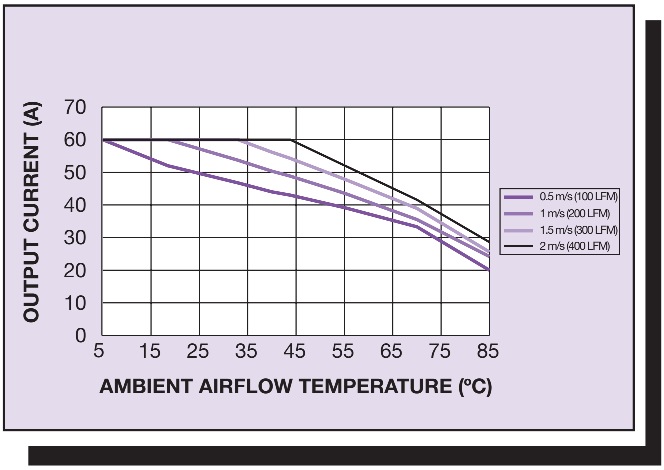


Figure 13 - Maximum Output Current vs. Ambient Temperature and Airflow for EXB250-48S2V5 Model

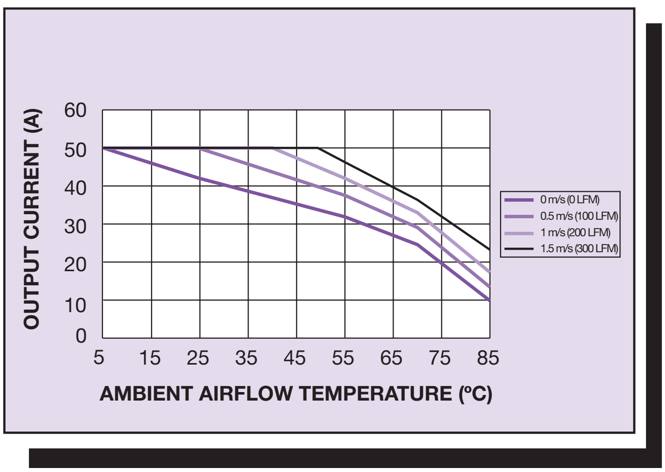


Figure 14 - Maximum Output Current vs. Ambient Temperature and Airflow for EXB250-48S3V3 Model

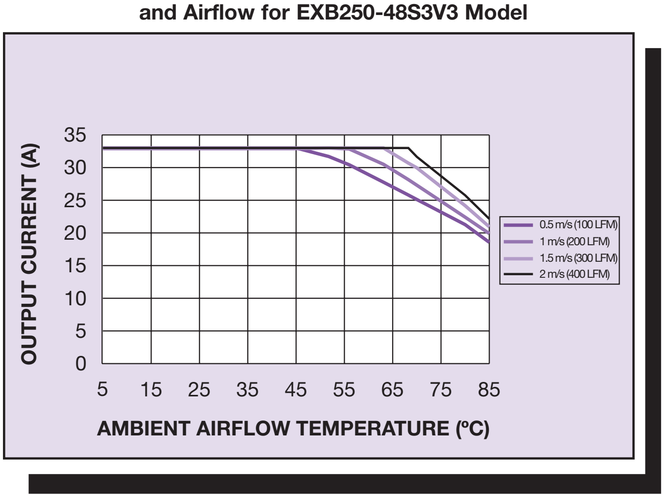


Figure 15 - Maximum Output Current vs. Ambient Temperature and Airflow for EXB250-48S05 Model

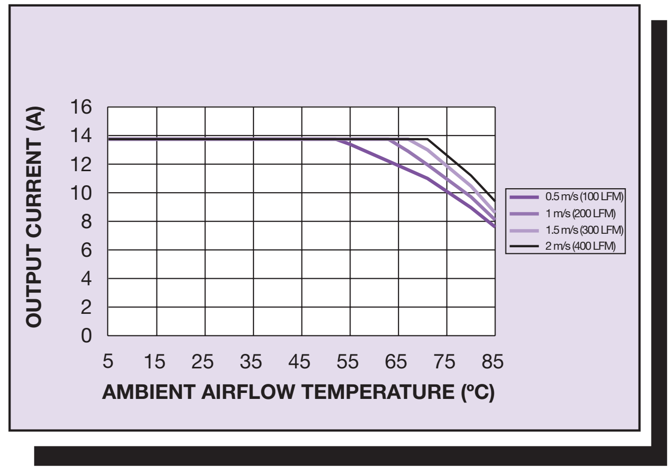


Figure 16 - Maximum Output Current vs. Ambient Temperature and Airflow for EXB250-48S12 Model

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 100nF 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 as much as +10% by connecting an external resistor between the TRIM and the V_{sense+} or V_{sense-} pin. With an external resistor between TRIM and V_{sense-}, R_{TRIM_DOWN}, the output voltage setpoint decreases. This external resistor is called $R_{TRIM\_DOWN.}$ Conversely, with an external resistor between TRIM and V_{sense+},the output voltage set point increases. In this configuration the resistor is called $R_{TRIM\_up.}$ These circuit configurations are shown in Figures 17, 18 and 19.

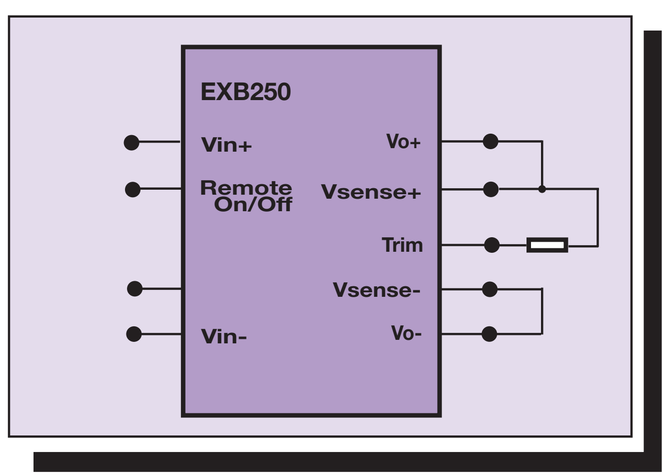


Figure 17 - Trimming Output Voltage - Trim up

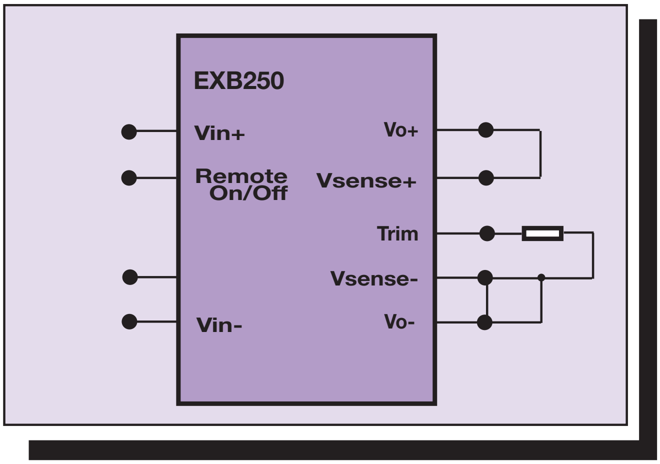


Figure 18 - Trimming Output Voltage - Trim Down

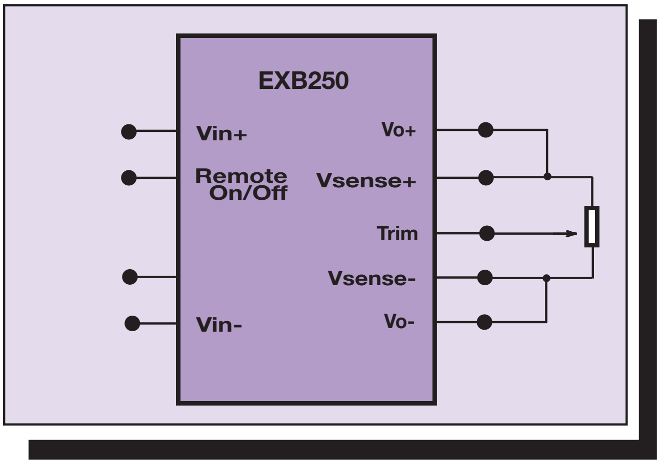


Figure 19 - Trimming Output Voltage - Variable Trim

The following equation in terms of desired output voltage (V_{des}) and output voltage before trimming V_o) can be used to calculate the value of R_{TRIM_DOWN}:

$$R_{trim\_down}\ (k\Omega) = \frac{(V_{des} \times 2 - V_o)}{V_o - V_{des}}$$

The above equation can be simplified by substituting variable Δ% which is the percent decrease in output voltage.
Where

$$\Delta\% = \frac{V_o - V_{des}}{V_o} \times 100$$

Then

$$Rtrim\_down\ (k\Omega) = \frac{100}{\Delta\%} - 2$$

In terms of Δ% the R_{TRIM_DOWN} resistance is the same for all models regardless of the output voltage. This equation is the 'industry standard' trim down equation for a 'Half Brick' converter and is plotted in Figure 20.

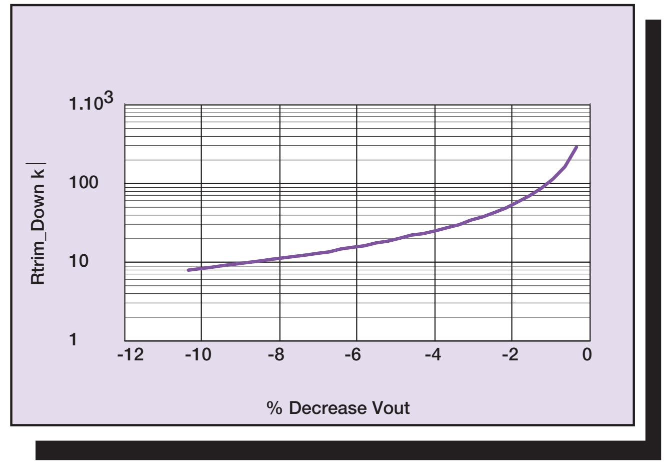


Figure 20 - Trim Down Resistor Values Vs. Output Voltage Trim Percentage

The following equation in terms of desired output voltage (V_{des}), output voltage before trimming (V_o) and internal voltage reference (V_{ref}) can be used to calculate the value of R_{Trim_up})

$$RTrim\_up\ (k\Omega) = \frac{\left[\frac{V_o}{V_{ref}} - 2\right] \times V_{des} + V_o}{V_{des} - V_o}$$

$V_{ref} = 1.225$ for $V_{out} \geq 1.5V$
$V_{ref} = 0.6125$ for $V_{out} = 1.2V$

The above equation can be simplified by substituting variable Δ% which is the percent increase in the output voltage
Where

$$\Delta\% = \frac{V_{des} - V_o}{V_o} \times 100$$

Then

$$R_{trim\_up}\ (k\Omega) = \frac{V_o \times (100 + \Delta\%)}{V_{ref} \times \Delta\%} - \frac{100 + 2\Delta\%}{\Delta\%}$$

The above equation is considered the 'industry standard' trim-up equation for a single output 'Half Brick' converter and is plotted in Figures 21, 22 and 23.

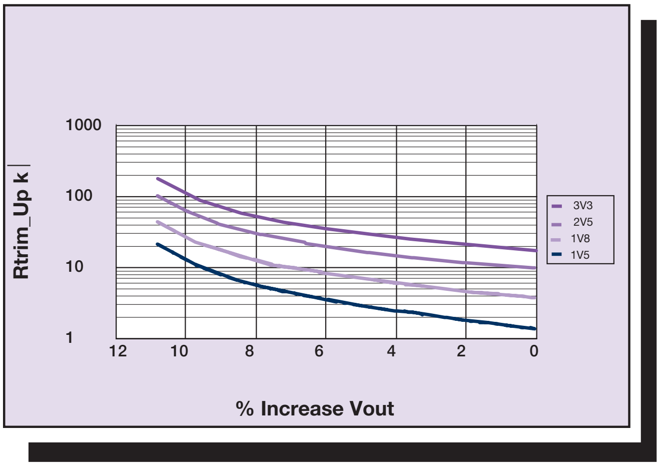


Figure 21 - Trim up (1V5, 1V8, 2V5 and 3V3 Model)

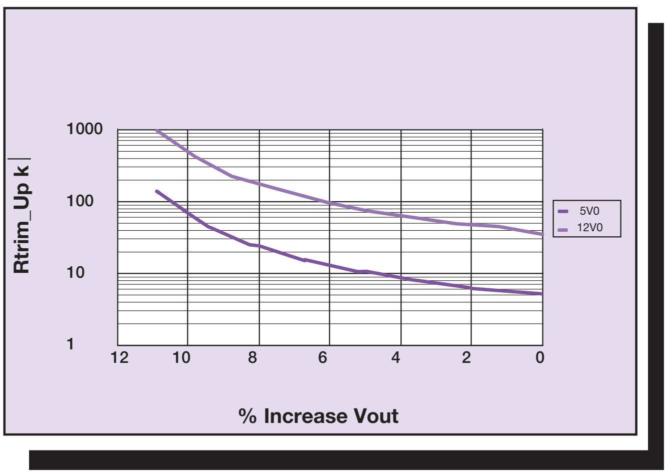


Figure 22 - Trim up (5V and 12V Models)

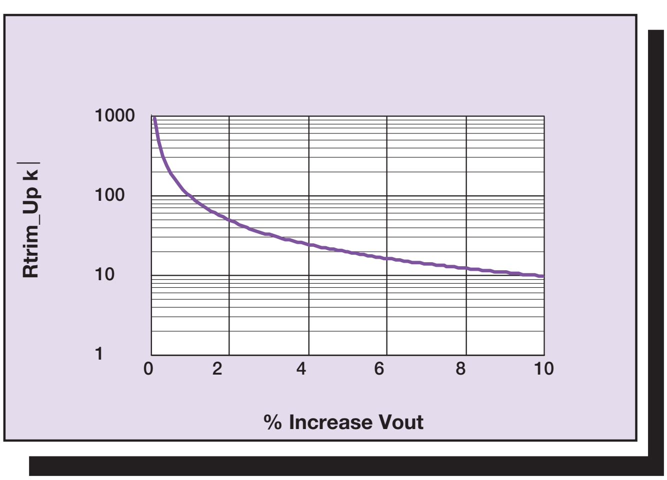


Figure 23 - Trim up (1V2 Model)

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

$$V_{trim} = V_{ref} \times \left[\frac{2\,V_{des}}{V_o} - 1 \right]$$

Or in terms of $\Delta\%$ where

$$\Delta\% = \frac{V_{des} - V_o}{V_o} \times 100$$

Then

$$V_{trim} = V_{ref} \times \left[1 + \frac{\Delta\%}{50} \right]$$

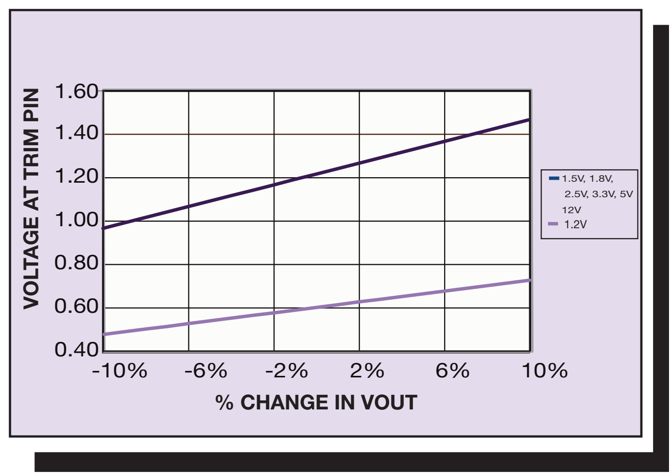


Figure 24 - Plot of V_{trim} vs $\Delta\%$

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

8.5 Parallel and Series Operation

Because of the absence of an active current sharing feature, parallel operation of multiple EXB250 converters is generally not allowed. If unavoidable, OR-ing 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.

Outputs of multiple EXB250 converters can be connected in series. However, it is possible that in certain connection configurations the common mode EMI levels may increase. It is therefore advisable to contact your local Artesyn Technologies representative for further information on this issue.

8.6 Output Capacitance

EXB250 series DC/DC converters are designed for stable operation without the need for external capacitance at their 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 closely 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 value 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. 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, 100µF/A of output current can be used without any additional analysis. For example, with a 60A power module, values of decoupling capacitance up to 6000µF can be used without regard to stability. With larger values of capacitance, the stability criteria depend on the magnitude of the ESR with respect to the capacitance. As a rule of thumb, 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 is 15000µF. If required, larger capacitance values are possible; please contact your local Artesyn Technologies representative for further information.

8.7 Reflected Ripple Current and Output Ripple and Noise Measurement

The measurement set-up outlined in Figure 25 has been used for both input reflected/terminal ripple current and output voltage ripple and noise measurements on EXB250 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.

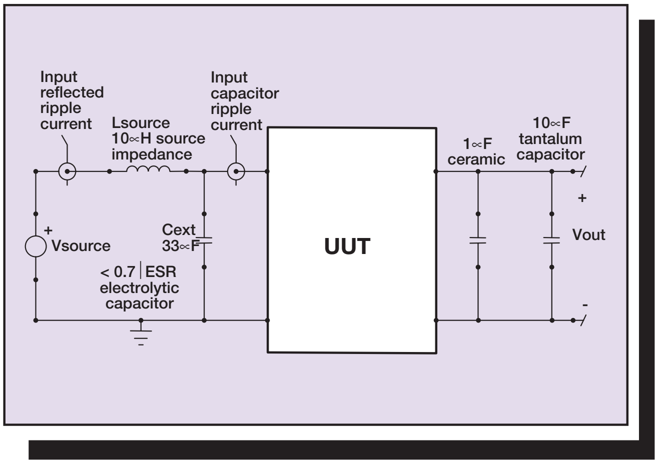


Figure 25 - Input Reflected Ripple/Capacitor Ripple Current and Output Voltage Ripple and Noise Measurement Set-Up

8.8 Compatability with ADM1070 Hot Swap Controller

Inserting circuit boards into a live -48V backplane can cause large input transient currents when large capacitances are charged. These transient currents can cause glitches on the system power supply and permanently damage components on the board. To ensure that the input voltage is stable and within tolerance before being applied to the DC-DC converter, Artesyn Technologies recommends the use of a hot-swap controller, such as the ADM1070 from Analog Devices. This device controls harmful transient currents and ensures safe insertion or removal of the application board from a live backplane.

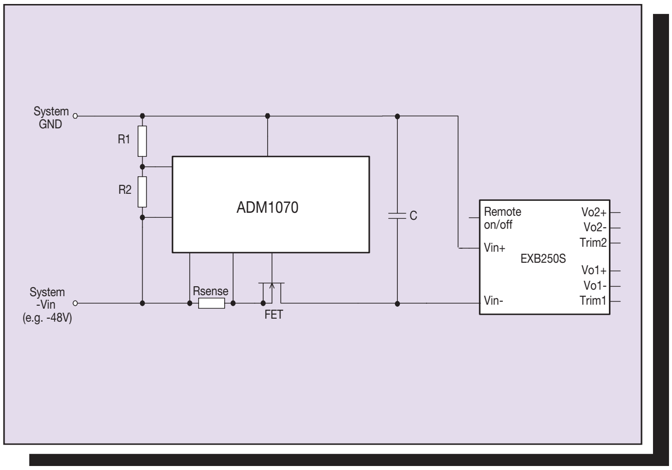


Figure 26 - Inrush Current Control using ADM1070

The ADM1070 is a 6-pin SOT-23, negative voltage hot-swap controller that allows a board to be safely inserted and removed from a live backplane. This product is compatible with the EXB250 family. The ADM1070 provides the following features:

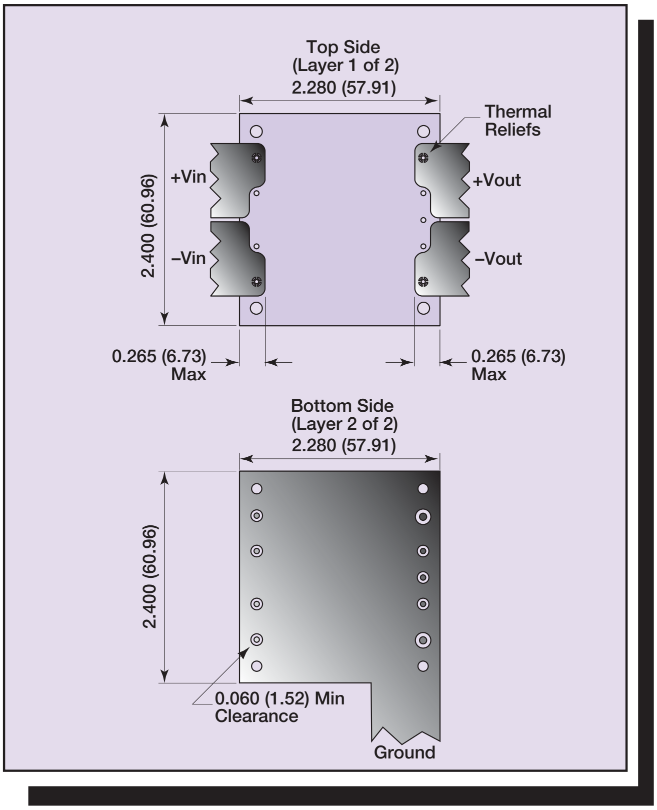
- Inrush current is limited to a programmable value by controlling the gate voltage of an external N-channel pass transistor
- The pass transistor is turned off if the input voltage is less than the programmable under-voltage threshold or greater than the over-voltage threshold. A programmable electronic circuit breaker protects the system against shorts.

The UV/OV pin can be used to detect under-voltage and over-voltage conditions at the power supply input. The EXB250 already has in-built under-voltage protection to ensure that the unit does not draw power from the source for voltages less than approximately 30V. Users should refer to the data sheet of the ADM1070 for details on setting the required UVLO and OVLO trip levels.

The ADM1070 features a current limiting function that protects against short circuits or excessive supply currents. The flow of current through the load is monitored by measuring the voltage across the sense resistor, R_{sense}. The action taken by the controller in the event of an input over-current condition will depend upon the severity of that condition. Please refer to the ADM1070 product datasheet on www.analog.com for details.

9. Appendix 1 - Recommended PCB Footprints

VIEW IS FROM TOP SIDE



THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-2221

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

Figure 27 - Recommended Footprints