NEW Product

EXB50 Dual
Application Note

ARTESYN® TECHNOLOGIES

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- **Two independently regulated positive outputs**
- **Each output offers ultra-wide output voltage trim range (1.5V....5.25V)**
- **High efficiency topology, 89% typical**
- **Approved to IEC60950, UL/cUL60950**
- **Operating ambient temperature of -40°C to +70°C (natural convection)**
- **No minimum load on either output**
- **Complies with ETS 300 019-1-3/2-3**
- **Complies with ETS 300 386-1**

1. Introduction

The EXB50 Dual series is a family of open-frame DC/DC converters providing two positive outputs. High-efficiency operation is achieved through the use of synchronous rectification and planar magnetics. Both outputs are independently regulated, and provide an ultra-wide trim range. The EXB50 Dual series offers a wide output current SOA (Safe Operating Area) and load mix flexibility. Through a control input the unit can be remotely controlled, and sent into a low-dissipation sleep mode. An independent latching over-voltage protection (OVP) feature for both outputs is provided. The OVP trip-point is also trimmable, i.e. tracks the output voltage setpoint. Over-temperature protection (OTP) protects the unit from thermal stress. Automated manufacturing methods together with an extensive qualification program have produced a highly reliable range of converters.

2. Models

Due to its ultra-wide trim range, any two output voltages between 1.5V and 5.25V can be covered with one model. This allows the EXB50 Dual to deliver any arbitrary dual positive output voltage combination.

Model	Input Voltage	Output Voltage	
		#1	#2
EXB50-48D05-3V3	36V-75V	1.5V-5.25V Default (untrimmed): 5.0V	1.5V-5.25V Default (untrimmed): 3.3V

Table 1 - Output Voltages

Features

- Industry standard half-brick pin-out and footprint: 61.0 x 57.9 x 10.0 mm (2.4 x 2.3 x 0.4 inches)
- Wide operating ambient temperature range (typically –40°C to +70°C natural convection)
- Two independently regulated positive outputs
- Ultra-wide output voltage adjustability
- Load mix flexibility
- No minimum load on either output
- Primary side control input for remote on/off control
- Constant switching frequency
- Continuous short circuit protection
- Latching output overvoltage protection
- Input undervoltage protection

3. General Description

3.1 Electrical Diagram

A block diagram of the EXB50 Dual converter is shown in Figure 1. High efficiency power conversion is achieved through the use of synchronous rectification for both outputs, as well as planar magnetic components.

The power stage topology is buck-derived. Power is magnetically transferred across the isolation barrier through an isolating transformer. The secondary side voltage is rectified by synchronous rectifiers providing an internal DC voltage bus. Two equivalent synchronous buck converters derive the two independently regulated output voltages Vo1 and Vo2 from the internal DC voltage bus.

Two tightly regulated positive outputs are provided. The grounds of the outputs are connected internally (i.e. Vo1- is connected to Vo2-). Both outputs are independently trimmable over an ultra-wide range of 1.5V to 5.25V each.

Both outputs can be shut down via a primary side control input. The control input is compatible with popular logic devices. By default the control input is "active high", i.e. the converter is enabled if the control input is high (or floating) and disabled if the control input is low.

Both outputs are independently monitored for over-voltages. If an over-voltage due to an internal fault is detected on any of the two outputs, the converter will latch off, disabling both outputs.

The converter is also equipped with over-temperature sensors. If the converter is over-loaded, or the ambient temperature gets too high, the converter will shut down until the temperature falls below a certain threshold. After cooling down the converter will operate again.

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.

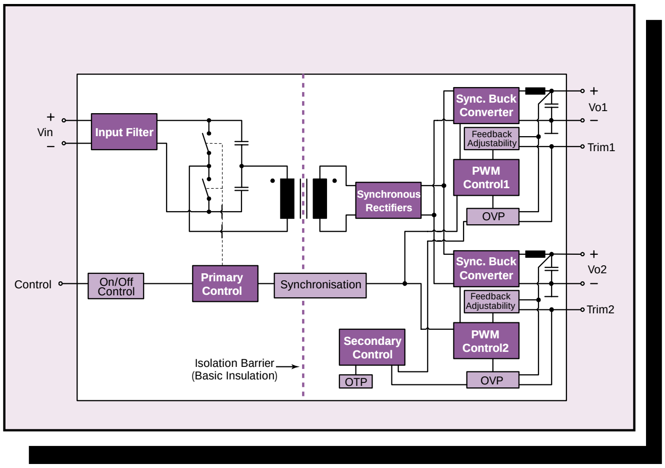


Figure 1 - Electrical Block Diagram

3.2 Physical Construction

The EXB50 Dual series is constructed using a single multi-layer FR4 PCB. SMT components are placed on both sides of the PCB and in general, the heavier power components are mounted on the top side in order to optimise heat dissipation.

The converter is sold as an open-frame product and no case is 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 low to medium DC/DC converters' Design Note 102 is available from Artesyn Technologies. The effective elimination of potting and a case has been made possible by the use of modern automated manufacturing techniques and in particular the 100% use of SMT components, the use of planar magnetics and the exceptionally high efficiencies.

4. Features and Functions

4.1 Wide Operating Temperature Range

The wide ambient operating temperature range of the EXB50 Dual module is a result of the extremely high power conversion efficiency and resultant low power dissipation. The maximum ambient temperature at which the module can be operated depends on a number of parameters, such as:

- the target application input voltage range
- the output voltage set-points, which can be varied over an ultra-wide range of 1.5V to 5.25V
- the output load currents
- if present, air velocity in a forced air convection environment
- mounting orientation of target application pcb, i.e. vertical or horizontal mount (especially important in natural convection conditions)
- target application pcb design, especially ground planes which can be effective heatsinks for the power converter

In a typical application the EXB50 Dual can deliver up to 5A at each output in a natural convection, -40°C to +70°C environment.

A number of design graphs are included in the long-form datasheet. They simplify the design task and allow the power system designer to determine the maximum local ambient temperature at which the EXB50 Dual module may be operated, for a given set of application conditions. A chapter of this application note is dedicated to two design examples demonstrating the use of these design graphs.

4.2 Over-Temperature Protection

The EXB50 Dual 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 125°C (typical) the converter will shut down disabling both outputs. When the substrate temperature has decreased by 10°C (typical), the converter will automatically restart.

The EXB50 Dual converter might experience over-temperature conditions in case of a persistent over-load on one or both outputs. 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 Over-voltage Protection

Both outputs are monitored for over-voltages to protect the load circuitry from damage should the converter fail.

OVP trip points are set at 125% of the output voltage set-point for each output. Note that the OVP threshold tracks the output voltage set-point when trimmed over the full 1.5V to 5.25V range.

Response time to an OVP event is typically around 2ms. If an OVP event is detected the converter will latch off disabling both outputs. The converter will remain shut down until the input voltage is cycled. Alternatively, the converter can be re-enabled by toggling the control input.

Note that the converter does not provide clamp devices (e.g. TVS) across the outputs. This means that the converter will detect over-voltages present at the outputs, but it cannot clamp them. Users may want to clamp over-voltages by external means (e.g. TVS, crowbars).

4.4 Safe Operating Area

The Safe Operating Area (SOA) of the EXB50 Dual converter is shown in Figure 2. It can be seen that each output Io_1 and Io_2 can deliver an output current in the range of 0A to 7.5A. Zero load operation and load mix flexibility are valuable features of the EXB50 Dual converter. Assuming the converter is operated within its thermal hotspot constraints, it can deliver a total output current Io(total) ($=Io_1+Io_2$) of 15A. The SOA remains valid across the full trim range of the converter.

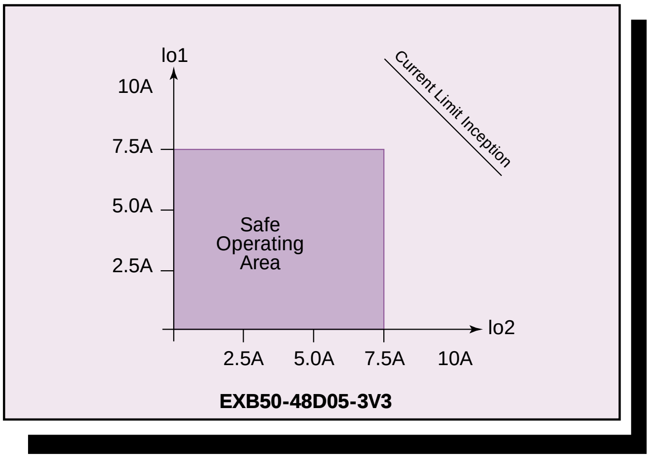


Figure 2 - Maximum Output Current Safe Operating Area

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 Optimum Thermal Performance for further discussions.

4.5 Current Limit and Short Circuit Protection

The EXB50 Dual converter has a built in current limit function and continuous short circuit protection. Both the specified maximum output current and the current limit inception point refer to the sum of the output currents Io(total) (i.e. Io_1+Io_2).

If the output currents Io_1 and Io_2 are outside the SOA the converter is being operated in overload mode. None of the datasheet specifications are guaranteed when in overload mode. While transient overload conditions are acceptable (e.g. start-up into capacitive loads), permanent overload operation is not. Permanent overload conditions can reduce the lifetime of the converter, and the unit may suffer permanent damage.

If Io(total) exceeds the current limit threshold for a time period of >20ms, the converter will shut down for 200ms. After 200ms the converter will start up again. For a persistent overload condition the converter will work in a low-frequency hiccup mode with an ON time of 20ms and an OFF time of 200ms. In hiccup mode the hiccup frequency is 1/220ms=4.5Hz with a hiccup duty cycle of 20ms/220ms=9%. Hiccup mode operation greatly reduces the thermal stress of the converter, protects wiring and load, and increases system reliability.

In short circuit operation the converter also enters a low-frequency hiccup mode. The RMS value of the pulsating output current in short circuit operation is limited to 15A maximum, simplifying the design of external crowbar circuits. While the unit is specified to operate into a continuous short circuit, frequent short circuits will reduce the lifetime of the converter.

4.6 Remote ON/OFF

The control input allows external circuitry to put the EXB50 Dual converter into a low dissipation sleep mode. The control input is sometimes also referred to as a remote ON/OFF input. Preferred, and by default, EXB50 Dual converters provide an active-high control input, but are also available with active-low logic.

Table 2 lists the converter operating condition (enabled or disabled) vs. control pin logic level for both logic options. The signal level of the control input is defined with respect to Vin-.

Logic Type	Control Input		
	Low	High	Floating
Positive (Default)	Disabled	Enabled	Enabled
Negative (-R option)	Enabled	Disabled	Disabled

Table 2 - Remote ON/OFF Configuration

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

The control input can be driven in a variety of ways as shown in Figure 3. If the control signal originates on the primary side, the control 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 control input can be isolated and driven through an optocoupler.

4.7 Output Voltage Adjustment

The ultra-wide output voltage trim range offers major advantages to users of the EXB50 Dual. It is no longer necessary to purchase a variety of modules in order to cover different output voltages. Both output voltages can be trimmed in a range of 1.5V to 5.25V. No relative restrictions apply, i.e. Vo_1 can be higher or lower than Vo_2.

When the EXB50 Dual converter leaves the factory the outputs have been adjusted to the following default voltages: Vo_1=5.0V and Vo_2=3.3V

Both output voltages can be independently adjusted using resistors. One trim pin per output is provided. Connecting a resistor between the trim pin and the positive output will trim the output voltage down. A resistor between the trim pin and the negative output will trim the output voltage up. A trim pot with its terminals connected to the positive and negative outputs, and the wiper connected to the trim pin, allows a variable trim, either up or down. This is shown in Figure 4 and Figure 5.

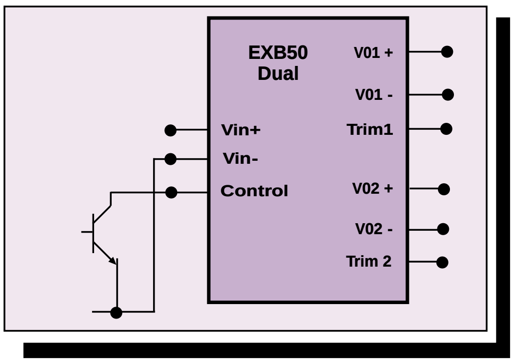


Figure 3a - Control Input Drive Circuits, Non-Isolated Bipolar

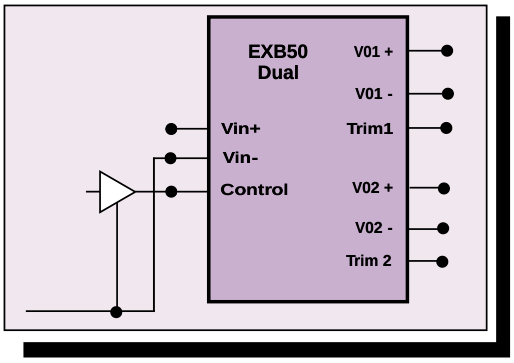


Figure 3b - Control Input Drive Circuits, Logic Driver

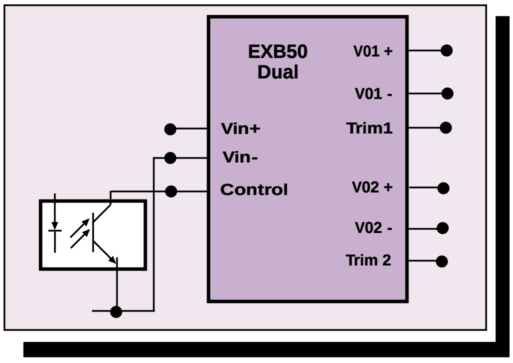


Figure 3c - Control Input Drive Circuits, Isolated through Optocoupler

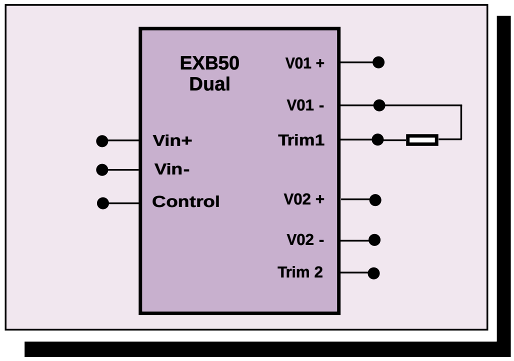


Figure 4a - Trimming Output Voltage Vo1, Trim Up

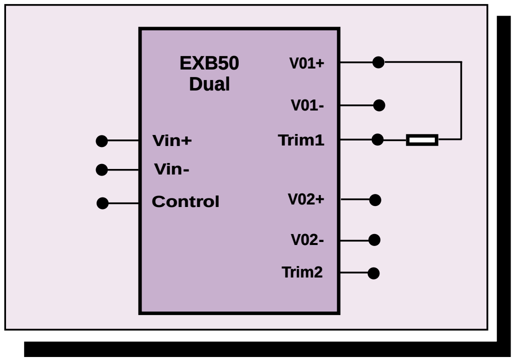


Figure 4b - Trimming Output Voltage Vo1, Trim Down

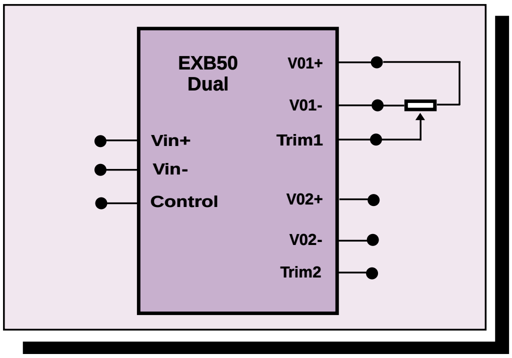


Figure 4c - Trimming Output Voltage Vo1, Variable Trim

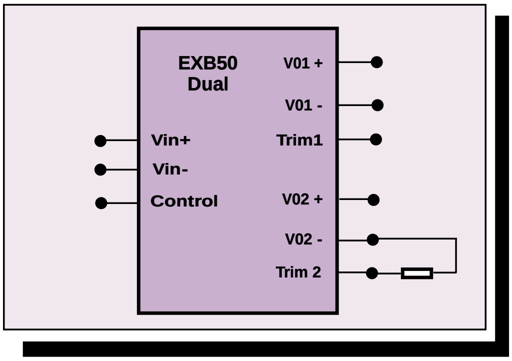


Figure 5a - Trimming Output Voltage Vo2, Trim Up

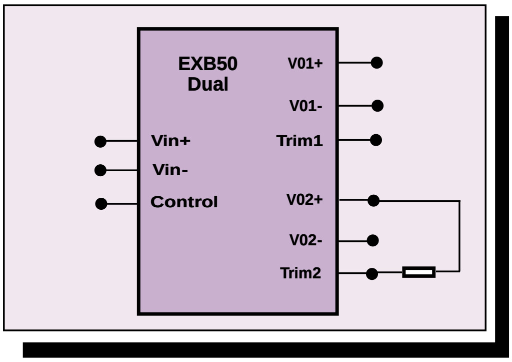


Figure5b - Trimming Output Voltage Vo2, Trim Down

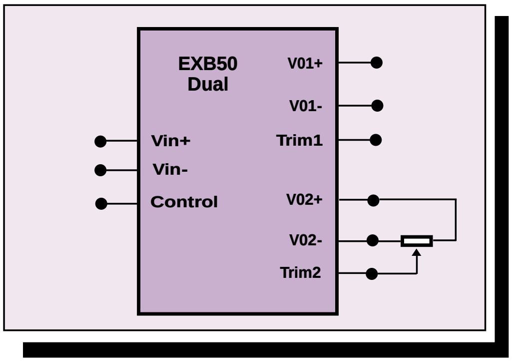


Figure5c - Trimming Output Voltage Vo2, Variable Trim

Suitable standard E96 series resistor values for all possible output voltages in 0.1V increments can be found in Table 3. Note that if the desired output voltage Vo_1=5.0V no trim resistor is required. The same applies if Vo_2=3.3V. These are the factory preset values.

Vo	Rtrim1 (Vo1)	Rtrim2 (Vo2)
1.5V	7.5Ω Trim1 to Vo1+	35.7Ω Trim2 to Vo2+
1.6V	17.4Ω Trim1 to Vo1+	78.7Ω Trim2 to Vo2+
1.7V	28Ω Trim1 to Vo1+	124Ω Trim2 to Vo2+
1.8V	39.2Ω Trim1 to Vo1+	178Ω Trim2 to Vo2+
1.9V	51.1Ω Trim1 to Vo1+	243Ω Trim2 to Vo2+
2.0V	63.4Ω Trim1 to Vo1+	309Ω Trim2 to Vo2+
2.1V	76.8Ω Trim1 to Vo1+	392Ω Trim2 to Vo2+
2.2V	90.9Ω Trim1 to Vo1+	487Ω Trim2 to Vo2+
2.3V	107Ω Trim1 to Vo1+	604Ω Trim2 to Vo2+
2.4V	124Ω Trim1 to Vo1+	750Ω Trim2 to Vo2+
2.5V	140Ω Trim1 to Vo1+	931Ω Trim2 to Vo2+
2.6V	162Ω Trim1 to Vo1+	1150Ω Trim2 to Vo2+
2.7V	182Ω Trim1 to Vo1+	1470Ω Trim2 to Vo2+
2.8V	205Ω Trim1 to Vo1+	1910Ω Trim2 to Vo2+
2.9V	232Ω Trim1 to Vo1+	2550Ω Trim2 to Vo2+
3.0V	261Ω Trim1 to Vo1+	3650Ω Trim2 to Vo2+
3.1V	287Ω Trim1 to Vo1+	5760Ω Trim2 to Vo2+
3.2V	324Ω Trim1 to Vo1+	12.1kΩ Trim2 to Vo2+
3.3V	365Ω Trim1 to Vo1+	-
3.4V	402Ω Trim1 to Vo1+	3480Ω Trim2 to Vo2-
3.5V	453Ω Trim1 to Vo1+	1650Ω Trim2 to Vo2-
3.6V	511Ω Trim1 to Vo1+	1050Ω Trim2 to Vo2-
3.7V	576Ω Trim1 to Vo1+	732Ω Trim2 to Vo2-
3.8V	649Ω Trim1 to Vo1+	549Ω Trim2 to Vo2-
3.9V	732Ω Trim1 to Vo1+	432Ω Trim2 to Vo2-
4.0V	845Ω Trim1 to Vo1+	348Ω Trim2 to Vo2-
4.1V	976Ω Trim1 to Vo1+	280Ω Trim2 to Vo2-
4.2V	1130Ω Trim1 to Vo1+	226Ω Trim2 to Vo2-
4.3V	1330Ω Trim1 to Vo1+	187Ω Trim2 to Vo2-
4.4V	1620Ω Trim1 to Vo1+	154Ω Trim2 to Vo2-
4.5V	2000Ω Trim1 to Vo1+	127Ω Trim2 to Vo2-
4.6V	2550Ω Trim1 to Vo1+	105Ω Trim2 to Vo2-
4.7V	3480Ω Trim1 to Vo1+	84.5Ω Trim2 to Vo2-
4.8V	5360Ω Trim1 to Vo1+	66.5Ω Trim2 to Vo2-
4.9V	10.7kΩ Trim1 to Vo1+	51.1Ω Trim2 to Vo2-
5.0V	-	37.4Ω Trim2 to Vo2-
5.1V	221Ω Trim1 to Vo1-	25.5Ω Trim2 to Vo2-
5.2V	61.9Ω Trim1 to Vo1-	14.7Ω Trim2 to Vo2-

Table 3 - Recommended Trim Resistor Values for Various Output Voltage Setpoints

If other output voltages are required, various trim graphs are provided in Figures 6 to 8. Trim graphs are given for resistive trimming, as well as voltage trimming. The output voltages Vo_1 and Vo_2 can be trimmed by applying a voltage to the respective trim pins Trim1 and Trim2. Trim voltages are referenced to the output return pins Vo_1- and Vo_2-.

For all other trim requirements please contact Artesyn Technologies for advice.

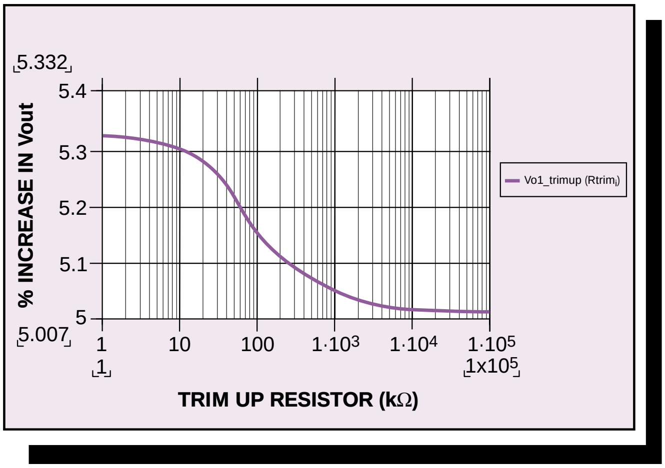


Figure 6a - Typical Trim Curve Vo1 Trim up Resistive

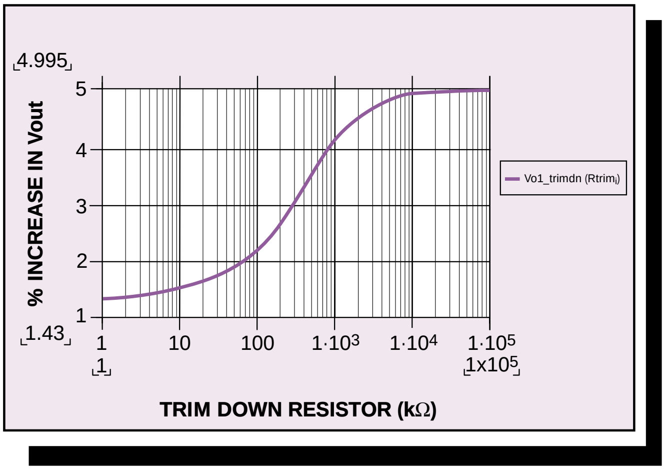


Figure 6b - Typical Trim Curve Vo1 Trim Down Resistive

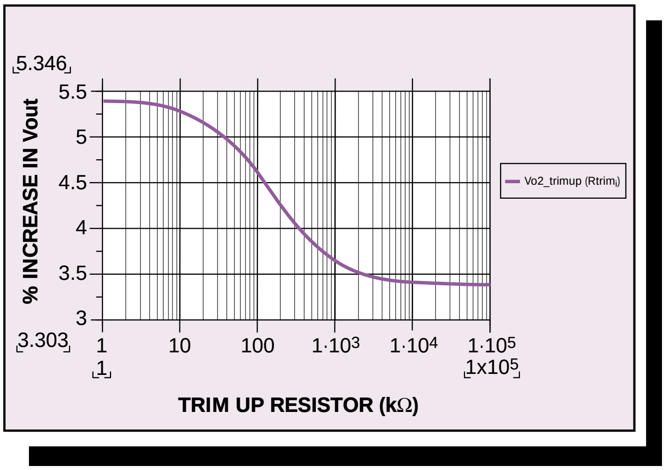


Figure 7a - Typical Trim Curve Vo2 Trim up Resistive

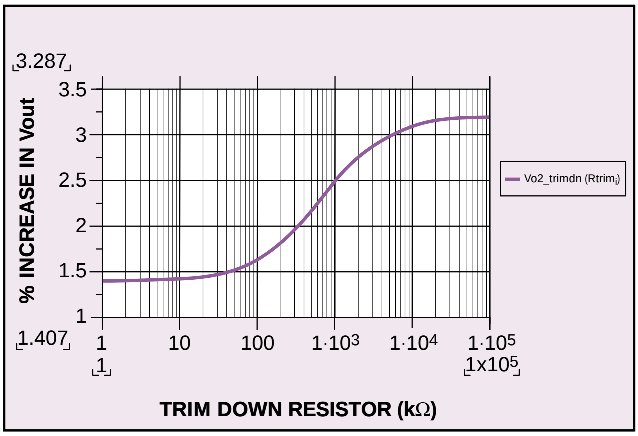


Figure 7b - Typical Trim Curve Vo2 Trim Down Resistive

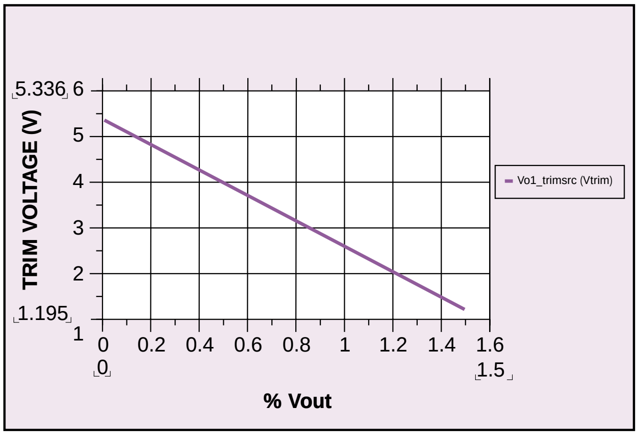


Figure 8a - Typical Trim Curve Vo1 for Trimming by Application of a Trim Voltage to the Trim Pin

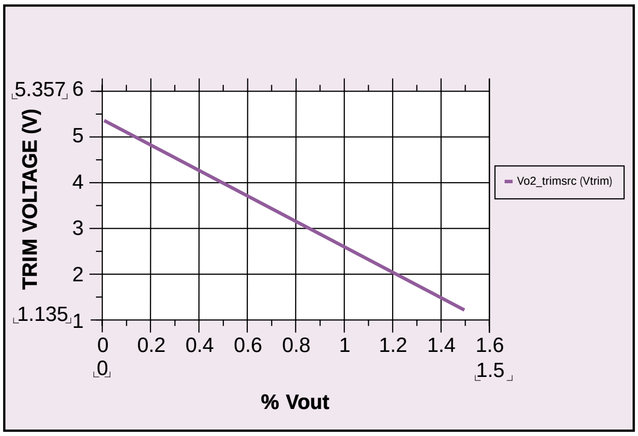


Figure 8b - Typical Trim Curve Vo2 for Trimming by Application of a Trim Voltage to the Trim Pin

5. Safety

5.1 Isolation

The EXB50 Dual series has been submitted to independent safety agencies and has EN60950 and UL1950 Safety approvals. Basic insulation is provided and the unit is approved for use between the classes of circuits listed in Table 4.

Insulation	
Between	**And**
TNV-1 Circuit	Earthed SELV Circuit Unearthed SELV Circuit
TNV-2 Circuit TNV-3 Circuit	Earthed SELV Circuit Unearthed SELV Circuit or TNV-1 Circuit
Earthed or Unearthed Hazardous Voltage Secondary Circuit	Earthed SELV Circuit ELV Circuit Unearthed Hazardous Voltage Secondary Circuit TNV-1 Circuit

Table 4 - Insulation Categories for Basic

The TNV or Telecommunication Voltage definitions are given in Table V.1 of IEC950 from which EN60950 and UL1950 are derived.

The EXB50 Dual has 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 the input and output.

Creepage is the distance along a surface such as a PCB and for the EXB50 the creepage requirement between primary and secondary is 1.4mm or 55 thou. Clearance is the distance through air and the requirement is 0.7mm or 27 thou.

5.2 Input Fusing

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 EXB50 Dual converter is 4A, HRC (High Rupture Capacity), anti-surge, rated for 200V.

6. EMC

The EXB50 Dual 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 emission is EN55022 (FCC Part 15). The EXB50 Dual has a substantial second order filter on board to enable it to meet this standard using a simple external filter.

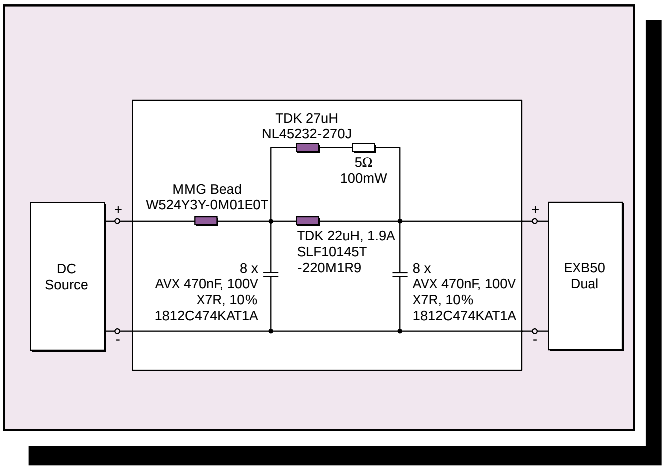


Figure 9 - Recommended External Input Filter

Conducted emission measurement results are shown in Figure 10. The results were obtained using the recommended external input filter

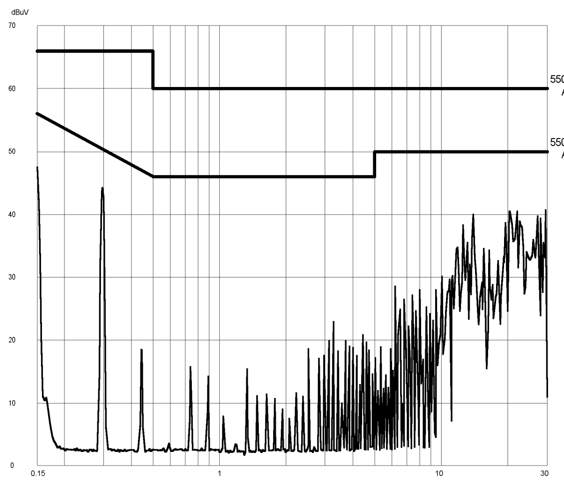


Figure 10 - Typical Spectrum EXB50-48D05-3V3 (Vin=48V, Vo1=5.0V, Io1=5A, Vo2=3.3V, Io2=5A) 50µH LISN. Class A and B Average Limit Lines Shown

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 (FCC Part 15) 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 maximise 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 maximise the disturbance consistent with the typical application by varying the configuration of the test sample'. In addition, ETS 300 386-1 states that the testing should be carried out on the enclosure. The EXB50 Dual is primarily intended for PCB mounting in telecommunication rack systems.

For the purpose of the radiated test, an EXB50-48D05-3V3 was mounted on a 6U high test-board using the recommended PCB layout (see Appendix 1). The operating conditions were:

- Input voltage Vin=48V
- Output voltage Vo1=5.0V (factory default)
- Output voltage Vo2=3.3V (factory default)
- Output current Io1=5A
- Output current Io2=5A
- Ambient temperature Tamb=25°C

No enclosure was used. Typical radiated emission results are presented in Figure 11.

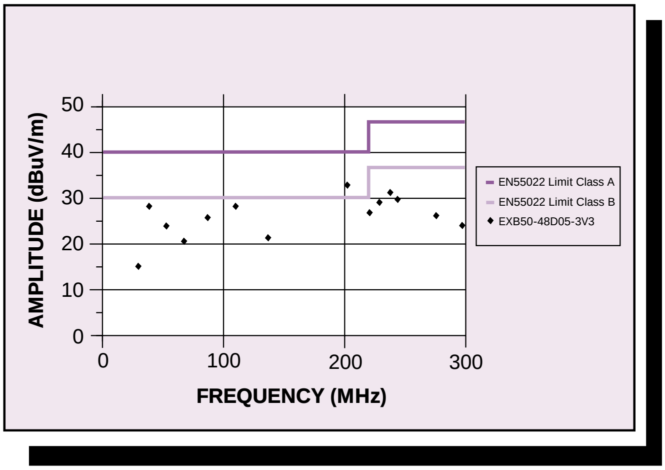


Figure 11 - Typical Radiated Emission EXB50-48D05-3V3 (Vin=48V, Io1=5A, Io2=5A)

It can be seen that the EXB50 Dual converter comfortably meets the EN55022 Limit A even without an enclosure.

6.3 Common Mode Noise

This is generated in switching converters and can contribute to both radiated emissions and input conducted emissions. The EXB50 Dual series of converters bypasses common mode noise internally by using a 2.2nF capacitor between input ground and output ground. The EXB50 Dual series will therefore greatly minimise common mode noise currents flowing in the application circuitry.

7. Use in a Manufacturing Environment

7.1 Resistance to Soldering Heat

The EXB50 Dual series are intended for PCB mounting. Artesyn has determined how well it 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 the applications section. 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 soldering test the UUT was again mounted on a test PCB. The unit was wave soldered using the conditions shown in Table 5.

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

Table 5 - Wave Solder Test Conditions

The UUT was inspected after soldering and no physical change on pin terminations was found.

7.2 Water Washing

The EXB50 Dual is suitable for water washing as it doesn't have any pockets where water may congregate long-term. The user should ensure that a sufficient drying process and period is available to remove the water from the unit after washing

7.3 ESD Control

The EXB50 Dual 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 an approved ESD control procedures. Failure to do so could affect the lifetime of the converter.

8. Applications

8.1 Optimum PCB Layout

A recommended PCB layout for a two-layer board can be found in Appendix 1. Although internally connected, it is recommended that a common secondary ground plane be used, connecting Vo_1- and Vo_2- This will result in improved efficiency, reduced output noise, and reduced radiated noise.

For compliance with safety regulations there are certain keep-out areas on the top-side (facing the EXB50 Dual converter) of the user board. Typically, for basic insulation a clearance of 0.7mm is required. The recommended footprint and layout of the user board is shown in Appendix 1. Three keep-out areas are shown and dimensioned on the top side of the layout.

8.2 Optimum Thermal Performance

The electrical operating conditions of the EXB50 Dual converters:

- input voltage Vin
- output voltage set-points Vo_1 and Vo_2 (trimmable from 1.5V to 5.25V each)
- output currents Io_1 and Io_2

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

- ambient temperature
- air velocity

they will result in a particular device temperature of the converter. The maximum acceptable device temperature measured at the thermal reference points is 110°C. The thermal reference points are shown in Figure 12.

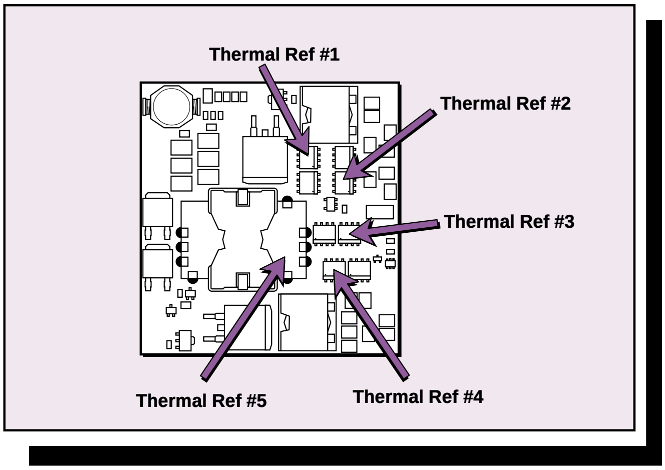


Figure 12 - Thermal Reference Points

To simplify the thermal design task a number of graphs are given in the datasheet. A set of power dissipation graphs show the power dissipation of the EXB50 Dual converter versus the input voltage. These graphs cover the most popular output voltage combinations (5.0V/3.3V, 3.3V/2.5V, 3.3V/1.8V, 2.5V/1.8V). Parameters in all of these graphs are the load combinations Io_1/Io_2 covering popular representative load combinations 5.0A/5.0A, 7.5A/2.5A, 2.5A/7.5A, 7.5A/7.5A and 2.5A/2.5A.

For all other custom output voltage set-points, and different load combinations interpolation can be used to estimate the power dissipation. Alternatively please contact Artesyn Technologies for further support.

For a given electrical operating condition the estimation of the maximum operating ambient temperature of the EXB50 Dual converter is a two-step process:

- Determine the maximum power dissipation of the converter using the appropriate power dissipation graph given in the datasheet
- Determine the maximum operating ambient temperature using the appropriate graph given in the datasheet.

The following design examples demonstrate this process.

8.3 Design Examples

Design Example 1

- Input voltage range 40V to 60V
- Output voltage Vo1=5.0V (factory default)
- Output voltage Vo2=3.3V (factory default)
- Output current Io1=7.5A
- Output current Io2=2.5A
- Natural convection

Question: What's the maximum ambient temperature at which the converter can be operated?

Step 1: Determination of the maximum power dissipation.
In the datasheet, refer to the graph "Power dissipation versus input voltage" for the output voltage combination Vo_1=5.0V and Vo_2=3.3V. This graph is reproduced in Figure 13. This graph shows the power dissipation versus input voltage for different output current combinations. It can be seen that for the electrical operating condition of design example 1 the worst case power dissipation is approximately 6.5W at an input voltage of Vin=60V.

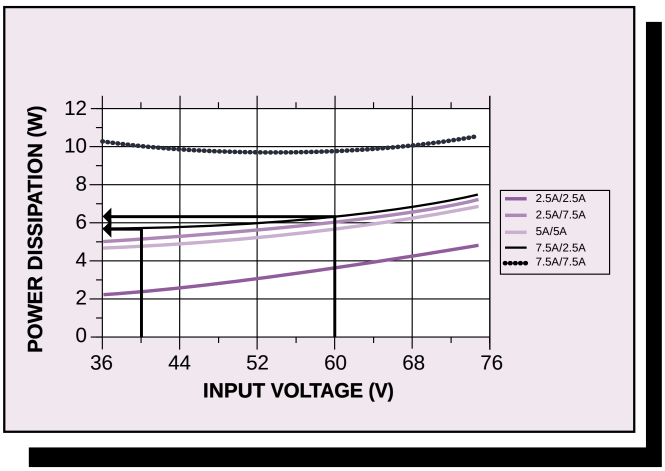


Figure 13 - Example 1 - Step 1: Determination of Power Dissipation (Vo1=5.0V, Vo2=3.3V)

Step 2: Determination of the maximum ambient operating temperature
In the datasheet, refer to the graph "Maximum ambient temperature versus power dissipation". This graph is again reproduced in Figure 14. For a power dissipation of 6.5W and an air velocity of 0.0m/s (natural convection), the maximum ambient operating temperature is 59°C.

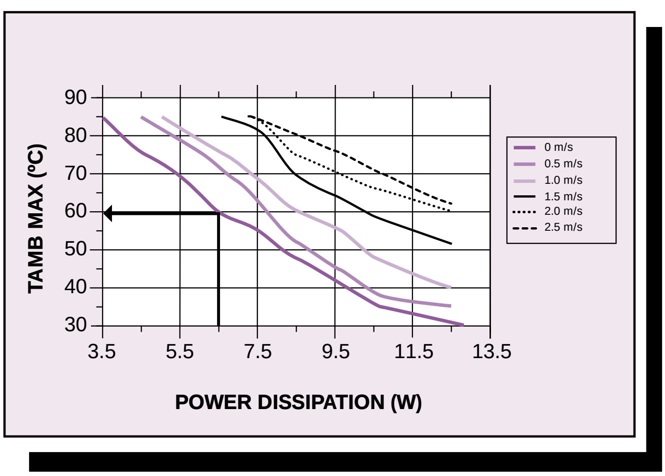


Figure 14 - Example 1. Step 2: Determination of the Maximum Ambient Operating Temperature

Answer: For an input voltage range of Vin=40V to 60V, and Vo_1=5V/Io_1=7.5A, Vo_2=3.3V/Io_2=2.5A, natural convection, the maximum ambient operating temperature is 59°C.

Design Example 2

- Input voltage range 36V to 75V
- Output voltage Vo_1=3.3V
- Output voltage Vo_2=2.5V
- Output current Io_1=7.5A
- Output current Io_2=7.5A
- Maximum ambient temperature Tamb=50°C

Question: Is forced air convection required? If so, what's the required air velocity?

Step 1: Determination of the maximum power dissipation.
The required data sheet graph of power dissipation for output voltage combination 3.3V/2.5V is reproduced in Figure 15. The worst case power dissipation of Pdiss=10.0W occurs at the maximum input voltage Vin=75V.

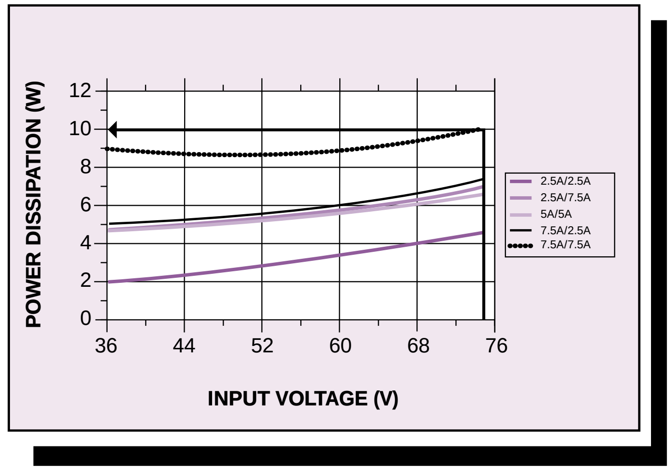


Figure 15 - Example 2 - Step 1: Determination of Power Dissipation (Vo1=3.3V, Vo2=2.5V)

Step 2: Determination of the required air velocity for forced air convection.

Refer to the graph "Maximum ambient temperature versus power dissipation". The graph is shown in Figure 16. It can be seen that for a power dissipation of 10.0W, and an ambient temperature of 50°C, forced air convection is necessary. An air velocity of 1.0m/s is adequate, and will leave a small amount of thermal headroom.

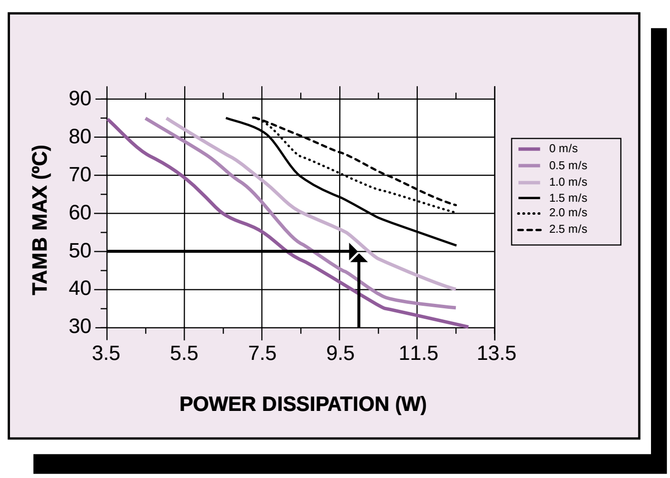


Figure 16 - Example 2 - Step 2: Determination of the Required Air Velocity

Answer: For an input voltage range of Vin=36V to 75V, Vo_1=3.3V/Io_1=7.5A, Vo_2=2.5V/Io_2=7.5A, and a maximum ambient operating temperature of 50°C, forced air convection is required. The required air velocity is vair=1.0m/s.

It should be noted that in a complex thermal setup the definition of ambient temperature can be ambiguous. The local ambient temperature seen by the converter may be considerably higher than the system ambient temperature. Also the local air velocity may deviate considerably. It is therefore absolutely essential to verify in the target system that all temperature reference points are within their specification of 110°C. Exposure of the EXB50 Dual converters to higher temperatures can cause permanent damage to the device.

As shown in Figure 12 there are five thermal reference points on the EXB50 Dual. Depending on the electrical operating conditions, any one of the thermal reference points may be the hottest. However, the temperatures of the reference points will typically be within 10°C of each other. It is recommended to measure the temperature of the reference points using thermocouples or an IR camera. In order to comply with the stringent Artesyn Derating Criteria none of the thermal reference temperatures should ever exceed 110°C.

8.4 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 17. The circuit provides a programmable inrush current limit and a programmable electronic circuit breaker. Please refer to the datasheet of the LT1640L for detailed information.

The EXB50 Dual 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 EXB50 Dual is to be increased, or additional OV protection is required. The recommended value for R7 is 200kΩ . Circuit block XF1 consists of the recommended input filter (see section Conducted Emissions), hold-up and impedance stabilising capacitors.

8.5 Parallel and Series Operation

Because of the absence of an active current sharing feature, parallel operation of multiple EXB50 Dual converters is generally not recommended. 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 the power conversion efficiency.

Outputs of multiple EXB50 Dual converters can be connected in series. Note, however, that the two outputs of an individual EXB50 Dual converter are not isolated from each other, and cannot be connected in series with each other. The grounds are connected internally (i.e. Vo_1- is connected to Vo_2-).

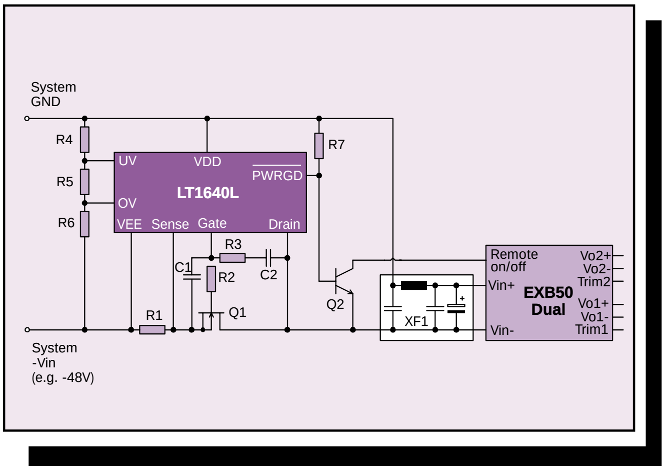


Figure 17 - Recommended Inrush Current Limiting Circuit

8.6 Output Noise and Ripple Measurement

The circuit in Figure 18 has been used for noise measurement on EXB50 Dual series converters. The large toroid will act as a common mode filter to noise which would otherwise flow through the measuring instrument or oscilloscope to disturb the measurement of the differential mode noise.

A 50Ω coax lead should be used with source and termination impedances of 50Ω. This will prevent impedance mismatch reflections which would otherwise disturb the noise reading at higher frequencies.
The 50Ω resistor which is added in series with the output of the power supply will form a voltage divider with the termination 50Ω and so ripple and noise measurement readings should be multiplied by 2.

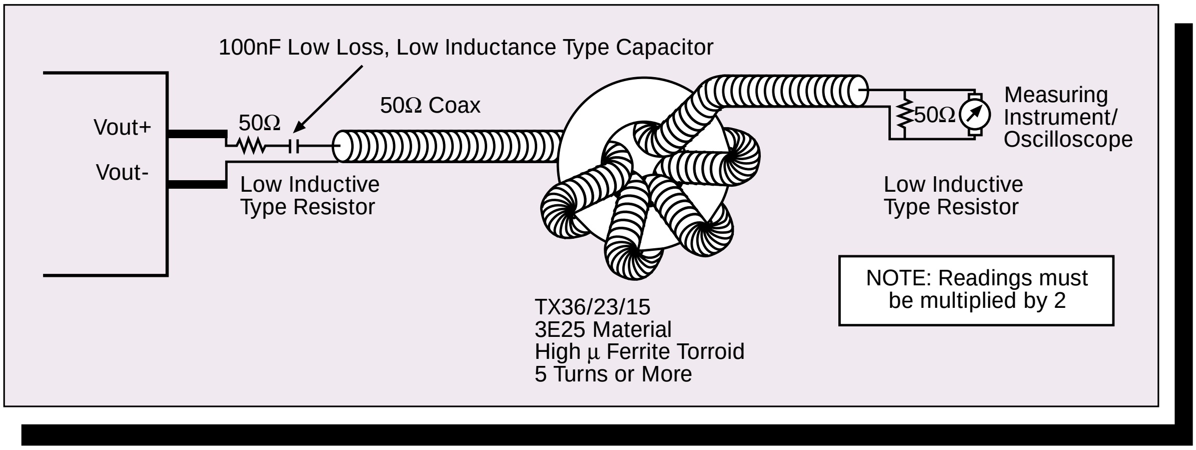


Figure 18 - Output Noise and Ripple Set-up

Appendix 1 - Recommended PCB Footbprints

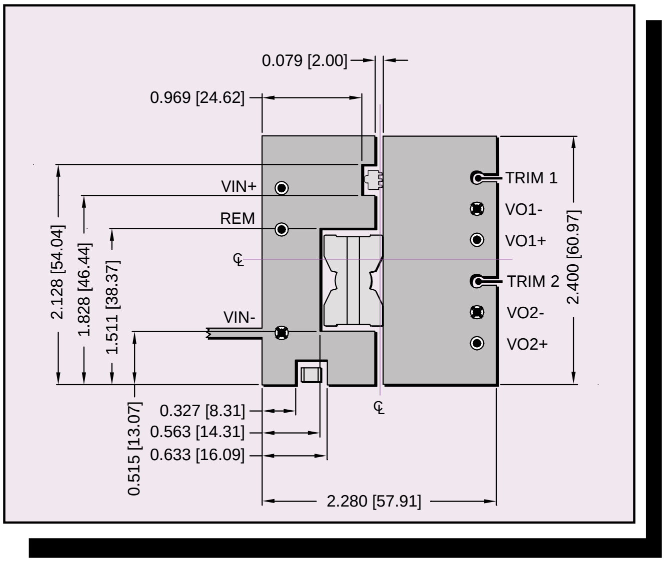
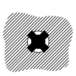


Figure 19a - Recommended Top Side Footprint (layer 1 of 2)



ALL DRAWINGS ARE VIEWED FROM THE TOP SIDE
FOR 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)

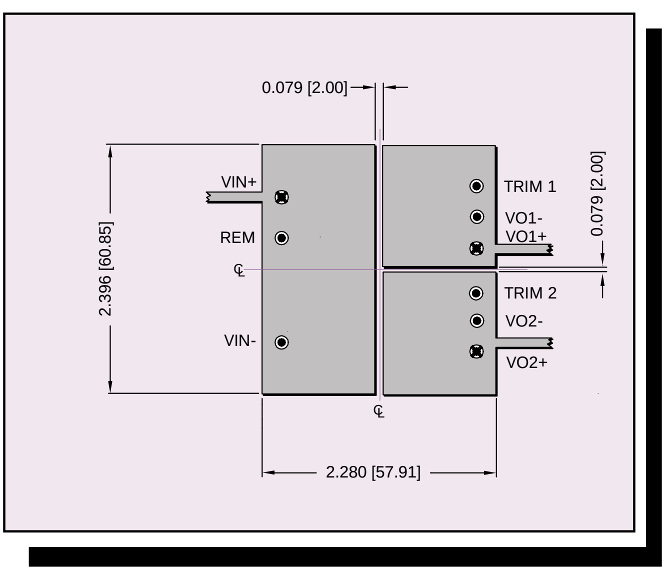


Figure 19b - Recommended Bottom Side Footprint (Layer 2 of 2)