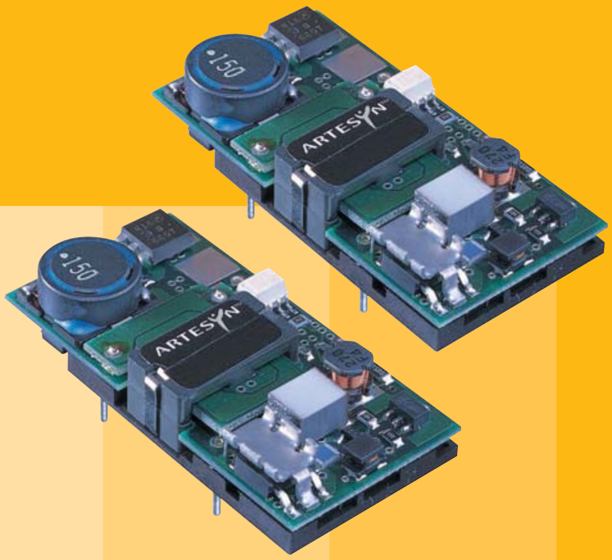
CXA10 SERIES
Application Note 100

NOTICE SOME MODELS LISTED IN THIS DOCUMENT HAVE BEEN DISCONTINUED

Please contact your local Artesyn representative or use the on line model number search tool at http://www.artesyn.com/powergroup/products.htm to find a suitable alternative.



ARTESYN® TECHNOLOGIES

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- **4:1 input voltage range**
- **Approved to EN60950, UL1950, CSA C22.2 No. 234/950**
- **Operating ambient temperature of -40°C to +70°C in still air**
- **Complies with ETS 300 019-1-3/2-3**
- **Complies with ETS 300 132-2 input voltage and current requirements**
- **Fully compliant with ETS 300 386-1**
- **Pin compatible with NFC10 and BXA10 series**
- **Basic insulation system (input to output)**

1. Introduction

The CXA10 series is a new generation of DC/DC converters which were designed in response to the growing need for low cost, high reliability DC/DC converters.

Automated manufacturing methods and use of planar magnetics combined with an extensive qualification program have produced one of the most reliable converters on the market.

2. Models and Features

The CXA10 comprises five separate models as shown in Table 1. All popular integrated circuit operating voltages are covered by the entire range.

Model	Input Voltage	Output Voltage
CXA10-48S3V3	18-75VDC	3.3V
CXA10-48S05	18-75VDC	5.0
CXA10-48S12	18-75VDC	12V
CXA10-48D05	18-75VDC	±5.0V
CXA10-48D12	18-75VDC	±12V
CXA10-48D15	18-75VDC	±15V

Table 1 - CXA10 Models

Features
- Optional primary remote On/Off
- Continuous short circuit protection
- Overcurrent limiting

3. General Description

Electrical Description
The CXA10 is a resonant reset forward converter. A simplified schematic is shown in Figure 1.

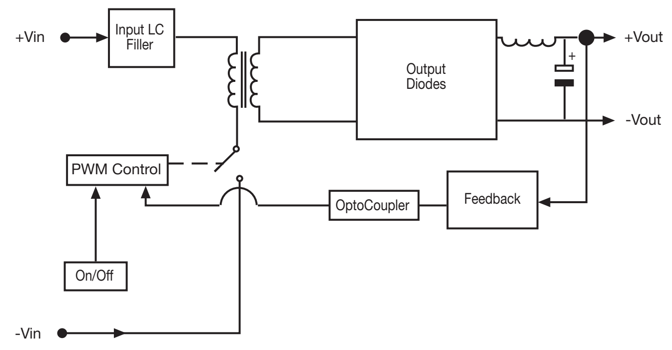

Figure 1 - CXA10 Simplified Schematic

The DC input is filtered by an LC filter before it reaches the main transformer. A PWM controller is used to regulate the output. The main power switch is a MOSFET running at a control frequency of 400KHz.

The output is sensed and compared with a secondary side reference and an error signal is fed back via an optocoupler to the PWM controller.

OVP transients are eliminated through the use of an output TVS on all models.

The optional remote On/Off allows the user to disable the switching of the converter, hence forcing the converter into a low power dissipation mode. The remote On/Off option is indicated by a '-S' suffix on the base model number.

Physical Construction
The CXA10 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 the unit has no case or cover. 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.** The majority of 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 modules in-depth 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, in particular, the 100% use of SMT components and the use of planar magnetics. Traditional reasons for potting no longer hold true for the CXA10 design.

4. Features and Functions

Overvoltage Protection
A TVS is used across the output on all models to clamp all transients of short duration that may occur.

Output Voltage	TVS Value
5V	6.8V
3.3V	3.6V
12V	13V
15V	18V

Table 2 - Output TVS Clamping Voltages

The maximum duration of these pulses and their peak power is dependent on a number of factors. Appendix 2 contains details of the output TVS ratings. For a single pulse the maximum peak power at 1ms is 600W at 25°C as can be seen in Appendix 1, Figure A1. As the ambient temperature increases so the peak pulse power derates as also shown in Appendix 1, Figure A2.

Repetitive pulses are not as straightforward and an extra derating chart is supplied in Appendix 1, Figure A3. `The derating is expressed here as a function of the pulse duty cycle and pulse width. Note that these derating factors are quoted at 25°C and must be further derated for temperature by referring to Figure A2.

Current Limit and Short Circuit
All models of the CXA10 have a built in current limit function and full continuous short circuit protection.

The current limit inception point is dependent on the input voltage, ambient temperature and has a parametric spread also. For all models the inception point is typically 140% of full load. It may go as high as 200% or as low as 100% over all operating conditions and the lifetime of the product.

None of the specifications are guaranteed when the unit is operated in an overcurrent condition.

In short circuit the unit enters a 'hiccup' foldback current mode and may be operated continuously in this condition. The duty cycle of this hiccup is dependent on input voltage, temperature etc. The RMS value of the short circuit current is guaranteed to be a maximum of 1A RMS over all operating conditions and the lifetime of the product. While the unit is specified to operate into a continuous short circuit, extended or frequent short circuits will reduce the lifetime of the converter.

A short circuit is defined as a resistance of 20mΩ or less.

The dual output models are specified for continuous operation in all three modes of short circuit. The three modes are a single short between either the positive or negative output and output common and a short from the positive output to the negative output.

Remote On/Off
The optional remote On/Off function allows the unit to be controlled by an external signal which puts the module into a low power dissipating sleep mode. Methods of applying this are given in the applications section.

5. Safety

Isolation
The CXA10 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 3.

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 3 - Insulation categories for Basic

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

The CXA10 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 CXA10 the minimum creepage requirement between primary and secondary is 1.4mm or 55 thou. Clearance is the distance through air and the minimum requirement is 0.7mm or 27 thou. See the recommended layout in the Applications section of this note for further information.

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 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 then the fuse may be in either input line. A 1.5A Anti-Surge or Slow Blow fuse should be used. High Rupture Capacity fuses are recommended.

6. EMC

The CXA10 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.

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 switchmode 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 CXA10 is primarily intended for PCB mounting in Telecommunication Rack systems.

For the purpose of the radiated test the unit was mounted on a 6U high PCB with a 10W load on board and connections to the remote On/Off. All radiated and conducted tests were performed using the recommended layouts.

A 4.7µF capacitor was connected across the input and the ground plane was connected to the output 0V. It was found through measurement that connecting the ground plane to the input ground made no difference to the results. The test results for the CXA10-48S05 are shown in the tables below. The testing was carried out by an independent Test House and a copy of the report is available on request. The results summarised in Table 4 show CXA10-48S05 meeting the class A radiated limit of 40dBµV/m.

Frequency (MHz)	Response (dBµV/m)
36.27	35.5
87.51	37.2
116.47	23.5
176.28	29.43

Table 4 - Radiated Emissions on CXA10-48S05 (class A limit = 40dBµV/m). No ground plane

A 4.7µF capacitor was placed across the voltage input pins, right next to the converter. The results in Table 5 show the CXA10-48S05 passing the class B radiated limit of 40dBµV/m with 0.4dBµV/m of margin in this configuration.

Frequency (MHz)	Response (dBµV/m)
31.04	27.5
36.12	29.6
75.31	26.25
87.72	19.20

Table 5 - Radiated Emissions on CXA10-48S05 with 4.7µF across input (class B limit = 30dBµV/m). No ground plane

A ground plane was added to the PCB on which the CXA10 under test was mounted. The 4.7µF capacitor from the previous configuration was maintained. The results in Table 6 show the CXA10-48S05 passing the class B radiated limit of 30dBµV/m with 4.6dBµV/m of margin in this configuration.

Frequency (MHz)	Response (dBµV/m)
32.47	22.00
37.41	22.70
77.35	25.40
119.92	20.30

Table 6 - Radiated emissions on a CXA10-48S05 with ground plane and 4.7µF capacitor across input pins

The configuration used for the previous test was maintained. The effect of using a metal can shield placed cover the CXA10 was investigated. As can be seen from the results in Table 7, the shield changes the shape of the profile of the radiated emission spectra, however it does not provide a significant benefit in EMC performance.

Frequency (MHz)	Response (dBµV/m)
32.47	19.00
77.35	25.40
110.80	19.00
130.13	21.50
143.33	24.55

Table 7 - Radiated emission on a CXA10-48S05 with ground plane, 4.7µF capacitor and metal 'can' shield

Conducted Emissions

The required standard for conducted is EN55022 Class A (FCC Part 15). The CXA10 has quite a substantial LC filter on board to enable it to meet this standard with just the addition of one external component. Putting this extra component on board the CXA10 would have added to the cost and footprint of the module.

This would also have removed the flexibility that end users have to add a single filter to the inputs of all converters on a card thereby reducing cost and space.

The conducted noise graphs for the CXA10-48S05 are shown in Figures 2, 3, 6 and 7. The filter circuits used to achieve these results are shown in Figures 4 and 5. All other models have similar curves and are available on request.

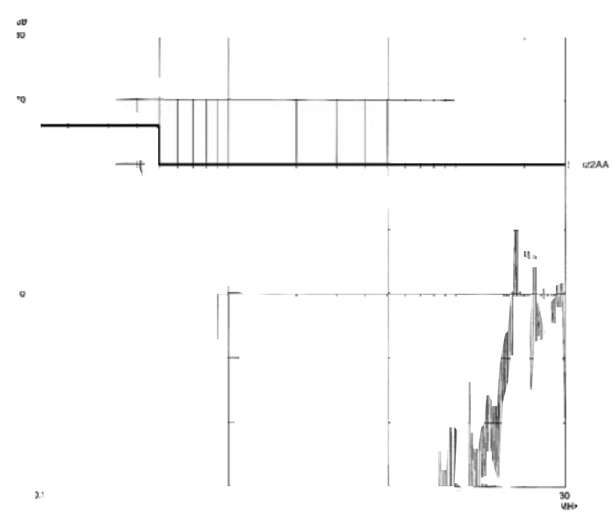

Figure 2 - Conducted Noise measurements on a CXA10-48S05 (meets class A average)

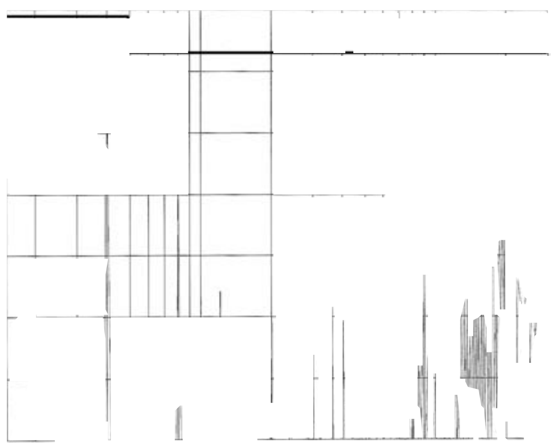

Figure 3 - Conducted Noise measurements on a CXA10-48S05 (Meets class A Quasi-peak)

The required Filter to meet Class A for all models is shown in Figure 4.

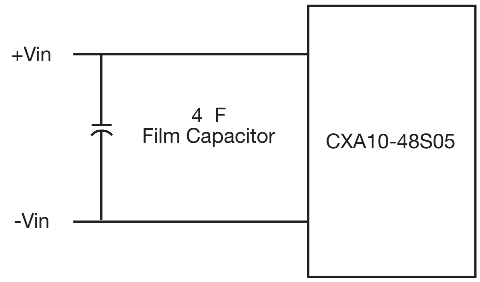

Figure 4 - Required Filter for Class A

To meet class B for all the models, the filter shown in Figure 5 should be used.

To meet class B a pi filter is required, composed of two 4µF film capacitors and a 57µH inductor as shown in Figure 5 for the CXA10-48S05.

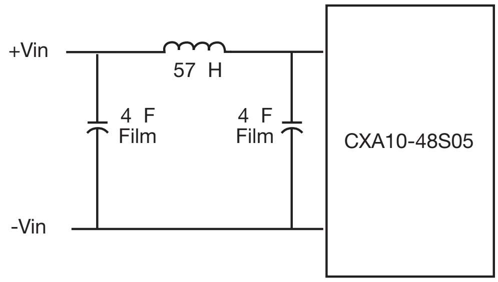

Figure 5 - Required Filter for Class B

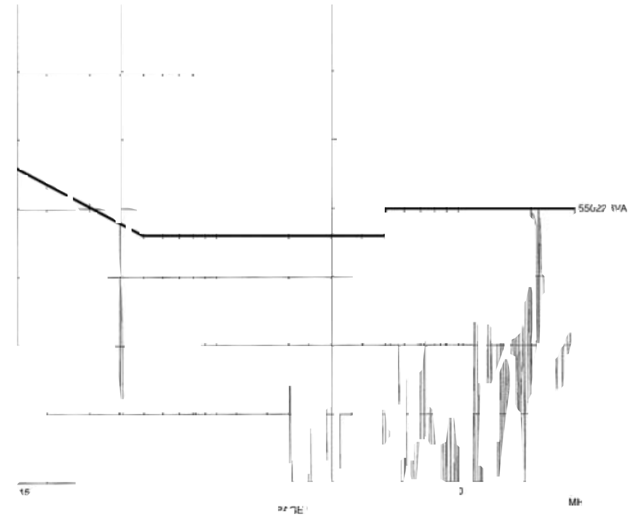

Figure 6 - CXA10-48S05 meeting Class B average with the Filter of Figure 4

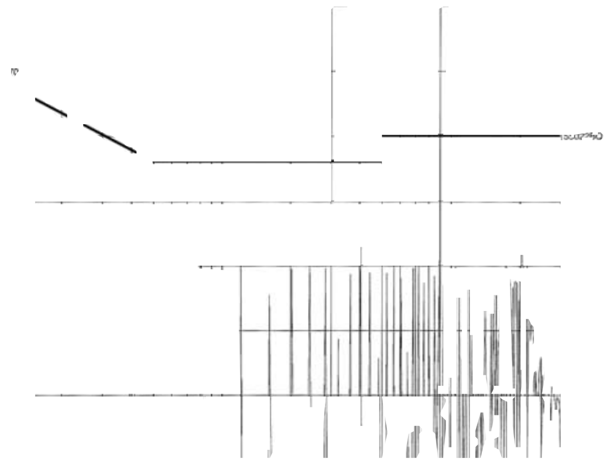

Figure 7 - CXA10-48S05 meeting Class B Quasi-peak with the filter of Figure 4

7. Use in a Manufacturing Environment

Resistance to Soldering Heat

The CXA10 is intended for PCB mounting. Artesyn has determined how well it can resist the temperatures associated with the soldering of PTH components without its performance or reliability being affected. 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 6.

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

Table 6 - Wave Solder Test Conditions

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

Water washing
The CXA10 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

ESD control
The CXA10's are manufactured in an ESD controlled environment and supplied in conductive packaging to prevent ESD damage from 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

Optimum PCB layout
The recommended PCB layout for single output models on a double-sided PCB is given in Figure 8 and for a single-sided PCB in Figure 10.

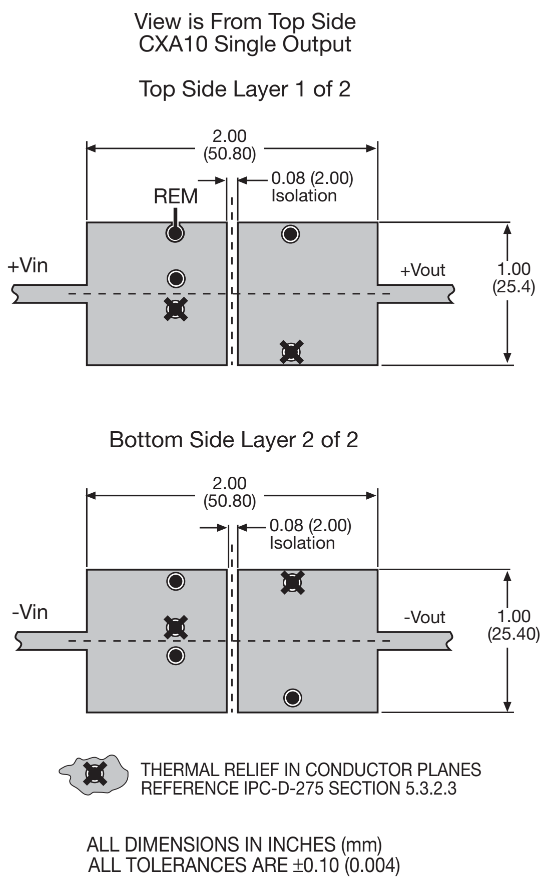

Figure 8 - Optimum PCB layout for Single Output CXA10's on a double sided PCB

At a minimum 2Oz/ft² or 70μm copper should be used. The PCB acts as a heatsink and draws heat from the unit via conduction through the pins and radiation. The two layers also act as EMC shields. If the recommended layout or 2Oz/ft² copper isn't used then the user needs to ensure that the hot-spots highlighted in the thermal section are kept within their limits.

These recommended PCB 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 located in the vicinity of the CXA10 meet the spacing requirements that the system is approved to.

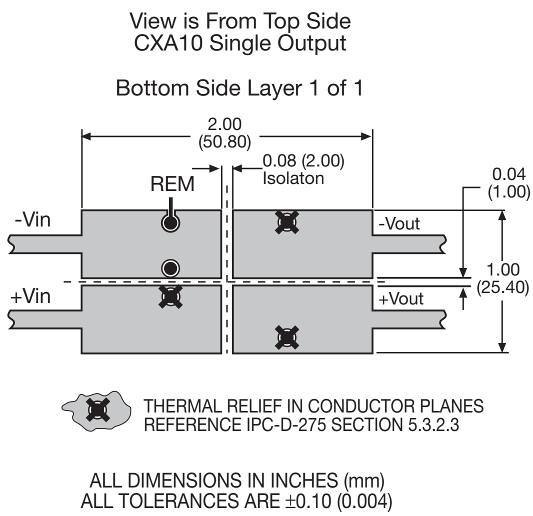

Figure 9 - Optimum PCB layout for Single Output CXA10's on a single-sided PCB

The recommended PCB layout for dual output models on a double-sided PCB is given in Figure 10 and for a single-sided PCB in Figure 11.

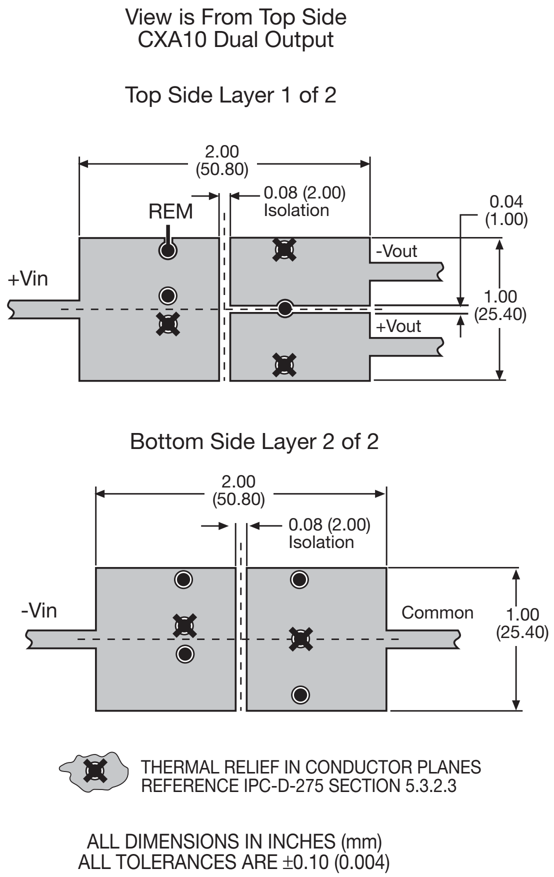

Figure 10 - Optimum PCB layout for dual output CXA10's on a double-sided PCB.

Figure 12 gives details of areas where vias should not be routed in the end application in order to avoid compromising the seating plane of the CXA10.

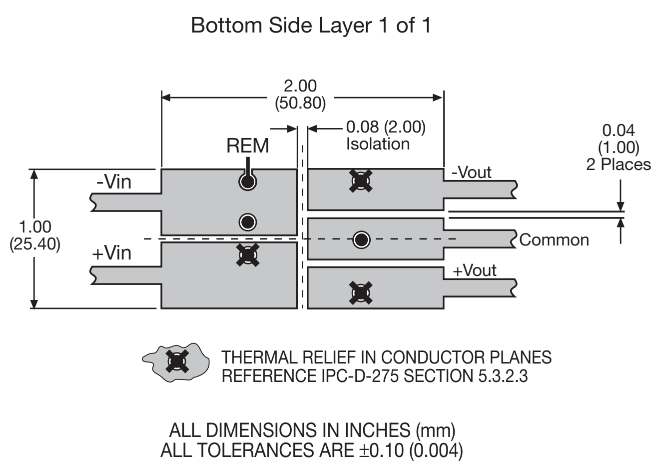

Figure 11 - Optimum PCB layout for dual output CXA10's on a single-sided PCB.

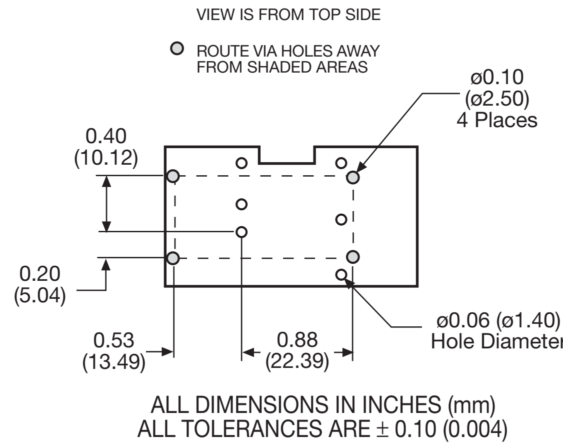

Figure 12 - Keep-Out areas for vias on both Single output and Dual output layouts

Optimum Thermal Performance

The CXA10 can operate in still air up to a maximum ambient temperature of 70°C using the recommended PCB layouts shown in the previous section. Note that the mounting orientation is not critical to optimum thermal performance. Still air, which is sometimes called natural convection is defined as 0.1m/s airflow (20LFM). Above 70°C the output power may be derated so that the maximum ambient operating temperature can be extended to 100°C as shown in Figure 13.

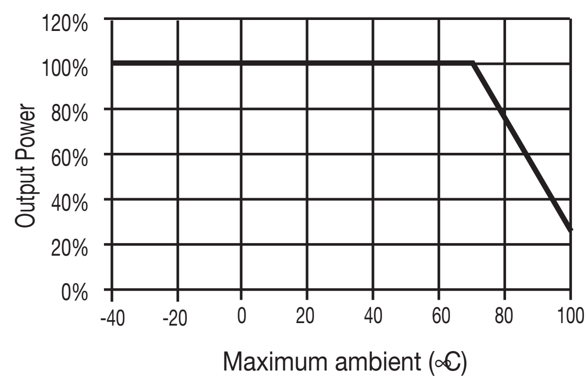

Figure 13 - Output Power versus Ambient Temperature in natural Convection.

If forced air cooling is used then the converter may be used up to 95°C at full output power dependent on the airflow. Figure 14 is a graph of the maximum allowed ambient temperature at full power versus the airflow across the converter.

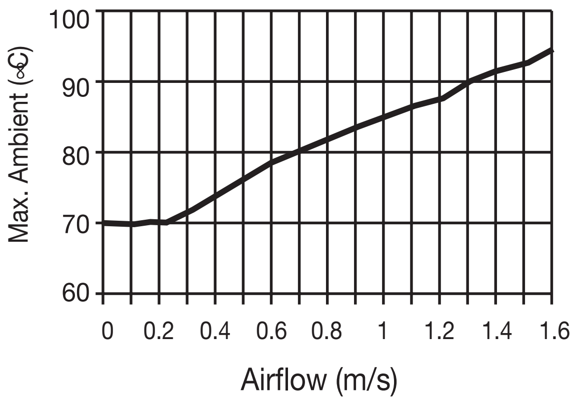

Figure 14 - Max. Ambient Temperature at full Power with Forced Airflow

If the unit is operated with enough forced airflow then it may be operated to 100°C with linear derating from the maximum ambient specified.

Figure 15 shows the derating for a converter operating with 1.5m/s forced airflow. Note that 1.5m/s = 300LFM.

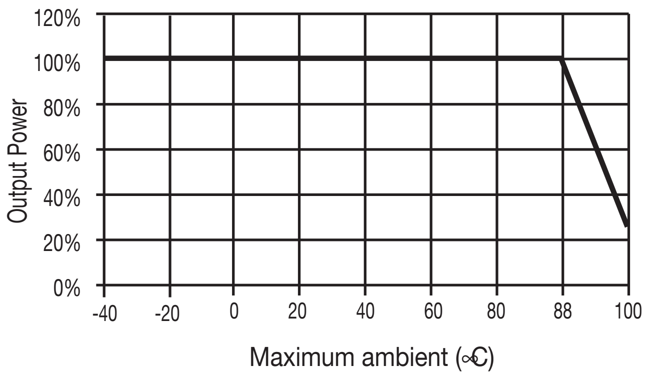

Figure 15 - Thermal Derating for 1.5m/s Forced Airflow.

The most accurate method of ensuring that the converter is operating within it's guidelines in a chosen application is to measure the temperature of a hot-spot. There are two such spots on the CXA10 and which is the hottest is dependent on the input line voltage, output load and the ambient temperature. In general they will be within 10°C of each other.

These hot spots are shown in Figure 16. They are the main primary switch and the dual schottky diode, each of which is a DPAK.

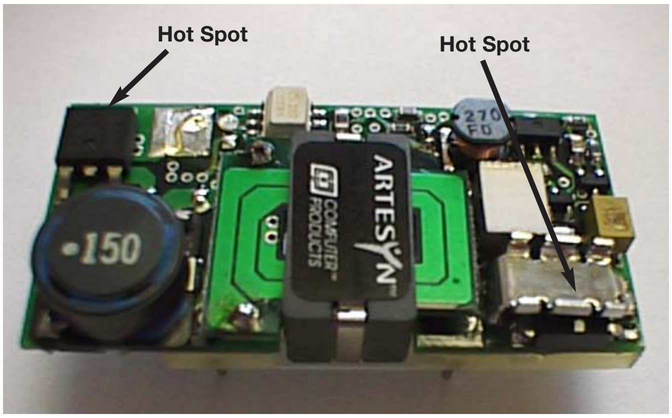

Figure 16 - Hot Spot Locations

When measuring the temperature of these points, the thermocouple should be mounted as closely as possible to the tab of the device. In order to maintain the Artesyn Derating criteria and comply with safety standards the temperatures of the devices should never exceed 120°C.

Remote On/Off Control

The optional remote On/Off control is a primary referenced function which allows the converter to be put into a low power dissipating sleep mode. The maximum current taken by the unit during this mode is 2mA over all line and temperature conditions.

The remote on/off pin can source typically 70µA of current into the collector of a transistor and can be directly connected to an optocoupler open collector output. The following three figures provide details of methods of connecting to the remote On/Off pin.

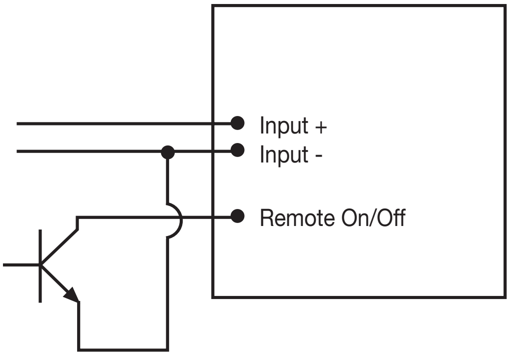

Figure 17 - Implementation of Remote On/Off with a single Transistor

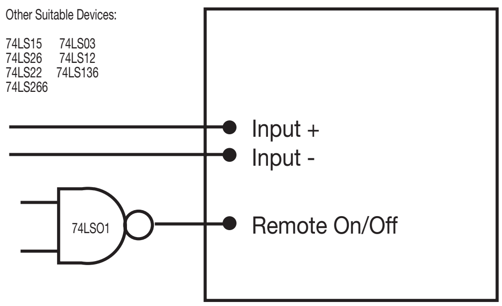

Figure 18 - Implementation of Remote On/Off with TTL Devices

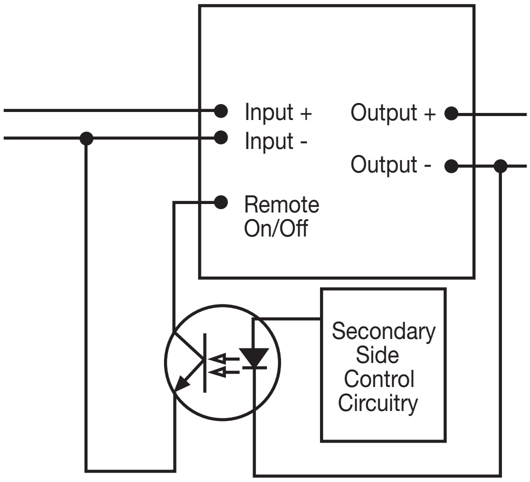

Figure 19 - Secondary Side control of Remote On/Off

9. Appendix 1

Output TVS Rating

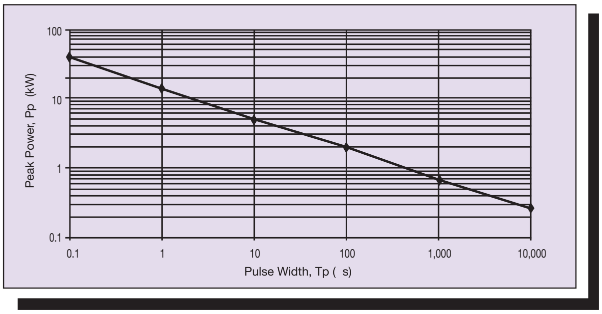

Figure A1 - TVS Output Rating vs. Pulse Width @ 25°C Ambient

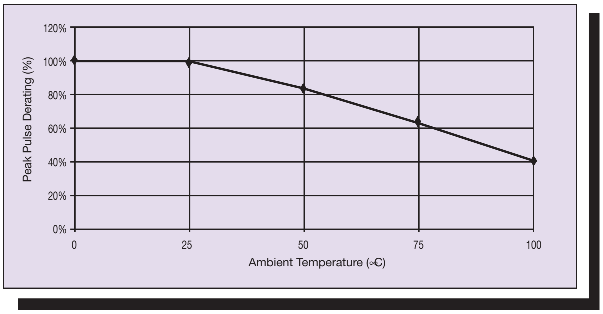

Figure A2 - Output TVS Peak Pulse Derating vs. Ambient Temperature

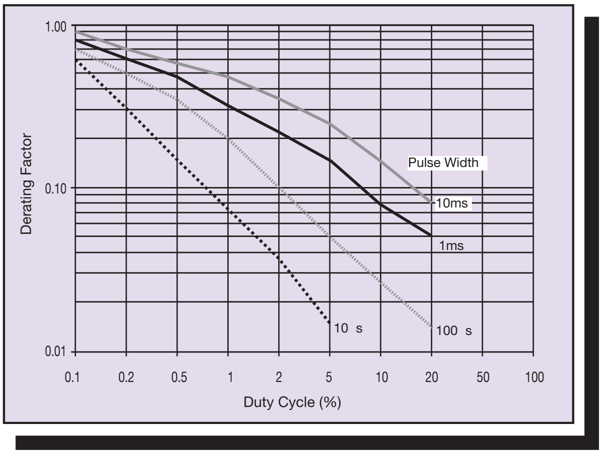

Figure A3 - Derating Factor vs. Duty Cycle for Several Pulse Widths