CXA20 SERIES

Application Note 107

ARTESYN® TECHNOLOGIES

107 Rev. 03 / 5 April 2002

File Name: AN_CXA20.PDF

- **4:1 input voltage range**
- **Approved to EN60950, UL1950, CSA C22.2 No. 234/950**
- **Wide operating ambient temperature**
- **±10% output voltage trim**
- **Overvoltage and overtemperature protection**
- **Complies with ETS 300 019-1-3/2-3**
- **Complies with ETS 300 132-2 input voltage/ current requirements**
- **Fully compliant with ETS 300 386-1**
- **Pin compatible with NFC15 and NFC20 series**
- **Basic insulation system (input to output)**

1. Introduction

The CXA20 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 CXA20 comprises five separate models as shown in Table 1. All popular integrated circuit operating voltages are covered by the entire range. The standard models have active high control on/off. This means that the control pin (or remote on/off pin) must be high to be enabled. The pin is internally held high so the unit is enabled even if the control pin is not connected.

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 - CXA20 Models

Features
- Primary remote on/off
- Continuous short circuit protection
- Overcurrent limiting
- Output trim
- Overvoltage protection
- Overtemperature protection

3. General Description

Electrical Description
The CXA20 is a resonant reset forward converter. A simplified schematic is shown in Figure 1.

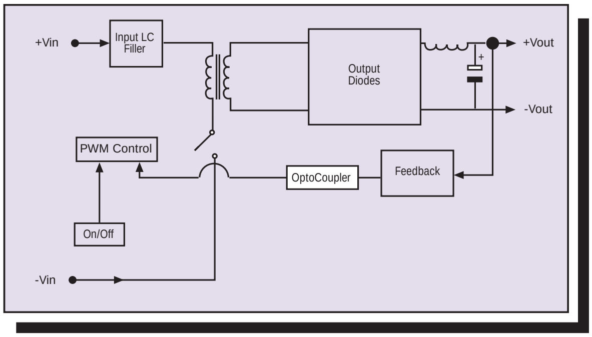


Figure 1 - CXA20 Simplified Schematic

The DC input is filtered by a damped pi 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 converter features an internal common mode bypass capacitor, value 1.5nF, between input and output to ensure low common mode EMI in the application circuitry.

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 or a zener diode on all models.

The remote On/Off pin allows the user to disable the switching of the converter, hence forcing the converter into a low power dissipation mode.

Physical Construction
The CXA20 is constructed using two multi-layered FR4 PCBs. The first PCB is populated with the power and control components. The power transformer which is a planar construction uses the second PCB for the primary and secondary windings. Electrically the transformer operates just the same as conventional transformers. The advantages of using a planar magnetic transformer are:

- Excellent thermal characteristics.
- Low leakage inductance.
- Excellent repeatability properties.

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 (Design Note 102). 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 CXA20 design.

4. Features and Functions

Primary Remote or Control On/Off
The 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 on page 8.

Overcurrent Limiting and Short Circuit Protection
All models of the CXA20 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. 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 the positive output and output common, a single short between the negative output and output common or a single short between the positive output and the negative output.

Output Trim
It is possible to trim the output voltage by ±10% minimum, details and formulae are given on pages 9 and 10. Figures 22.1 to 22.5.

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

Output Voltage	Value
5V	7V TVS
3.3V	3.9V Zener
12V	15V TVS

Table 3 - Output TVS Clamping Voltages

The maximum duration of these pulses and their peak power is dependent on a number of factors. Appendix 1 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.

For the 3V3 model refer to Appendix 1, Figure A4 for peak surge power ratings of the Zener.

Overtemperature Protection (OTP)
Overtemperature shutdown is achieved by monitoring the temperature of the PCB close to the output rectifiers using a PTC. The voltage across the PTC exceeds a reference voltage at approximately 120˚C causing the output of a comparator to transition to a logic low level which in turn disables the PWM controller. Once the temperature of the PCB drops (typically 1˚C) the output of the comparator transitions to a high voltage level which enables the PWM controller once again.

5. Safety

Isolation
The CXA20 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 Network Voltage definitions are given in Table V.1 of IEC950 from which EN60950 and UL1950 are derived. The CXA20 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 CXA20 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 2A HRC (High Rupture Capacity) is the recommended fuse rating for the CXA20 product.

6. EMC

The CXA20 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 maximize 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 maximize 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 CXA20 is primarily intended for PCB mounting in Telecommunication Rack systems.

Firstly the CXA20 was tested alone and secondly was mounted on a PCB (230mm x 170mm) with -Input connected to a copper ground plane on the PCB. A 4µF ceramic capacitor was connected across the input during both tests. In both cases the lead length from the unit to the power source was 50 cms and the resistive load lead length was approximately 10 cms.

An independent test house carried out the testing and a copy of the report is available on request. The results following the first test for the CXA20-48S05 model are given below. All the responses were broadband in nature and there were no detectable responses above 132.82MHz. (The ‘V’ or ‘H’ denotes the antenna polarization for maximum response was Vertical or Horizontal). As can be seen, Class A limit 40dBµV/m is met with margin.

Frequency (MHz)	Response (dBµV/m)
40.82	31.6V
42.43	33.5V
44.01	36.6V
64.73	29.75V
110.86	36.6H
124.14	31.9H
132.82	23.9V

Table 5 - Radiated Emissions on CXA20-48S05 with no ground plane and 4.7µF capacitor across input pins (within class A limit which is 40dBµV/m).

The results when the unit is placed on a PCB with -Input connected to copper ground plane on the PCB are shown below. As can be seen with a ground plane, Class B limit 30dBµV/m is met with significant margin, even though no enclosure was used.

Frequency (MHz)	Response (dBµV/m)
51.00	21.5V
52.96	23.4V
56.64	21.7V
61.88	21.05V
110.55	26.00V

Table 6 - Radiated emissions on a CXA20-48S05 with ground plane and 4.7µF capacitor across input pins. (within class B limit which is 30dBµV/m).

Conducted Emissions
The required standard for conducted emissions is EN55022 Class A. The CXA20 has a Pi 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 CXA20 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 CXA20-48S05 are shown in Figures 2 and 3. 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.

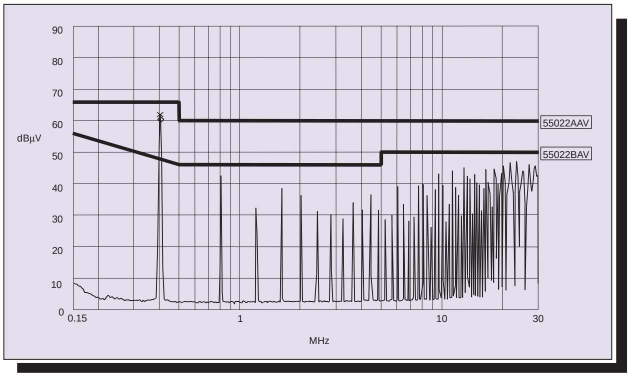


Figure 2 - Conducted Noise measurements on a CXA20-48S05 (meets class A average)

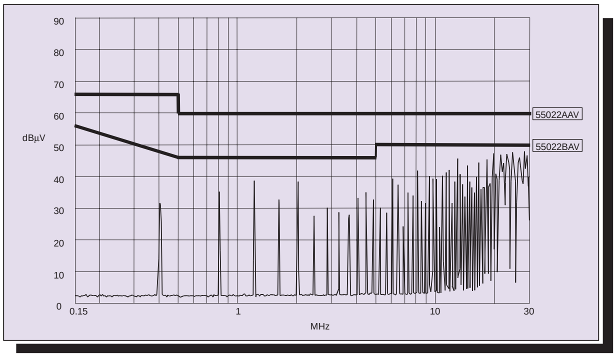


Figure 3 - Conducted Noise measurements on a CXA20-48S05 (Meets class B average)

The required Filter to meet Class A for all models is shown in Figure 4. It requires a 4µF ceramic capacitor (AVX, Part No. SM141C405PAJ120).

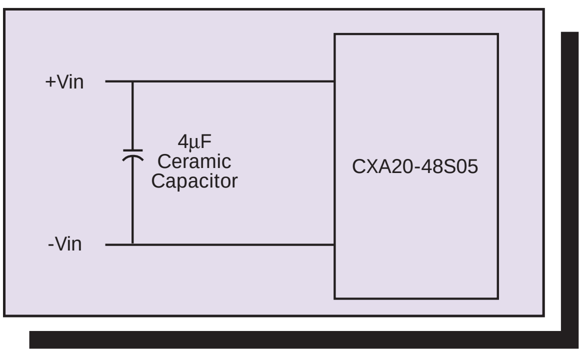


Figure 4 - Required Filter for Class A

To meet class B, additional filtering is required composed of two 4µF ceramic capacitors (AVX, Part No. SM141C405PAJ120), a differential mode choke (Philips, Part No, IIC10-14/4-3E6 2*5 turns) and two 60Ω (@ 100MHz) beads (Murata Part No. BLM41600S).

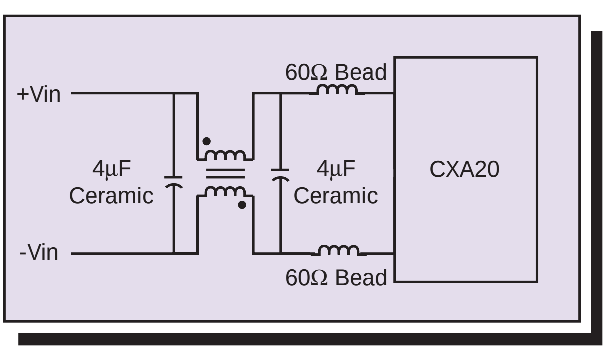


Figure 5 - Required Filter for Class B

7. Use in a Manufacturing Environment

Resistance to Soldering Heat
The CXA20 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 7.

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

Table 7 - Wave Solder Test Conditions

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

Water washing
The CXA20 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

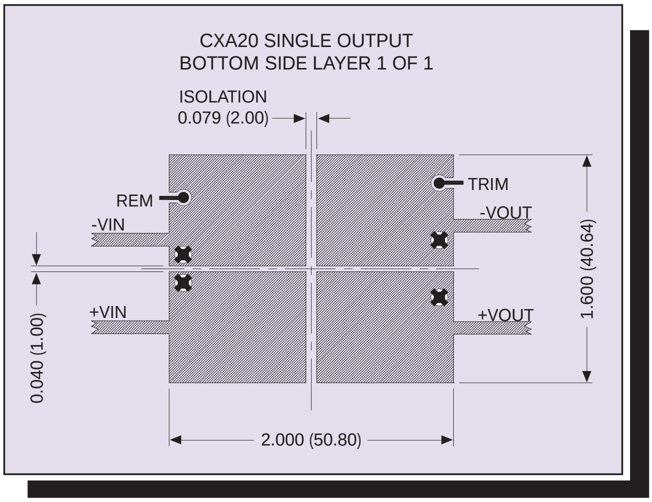
ESD control
The CXA20's are manufactured in an ESD controlled environment and supplied in conductive packaging to prevent ESD damage from occurring before or during shipping. It is essential that they are unpacked and handled using an approved ESD control procedures. Failure to do so could affect the lifetime of the converter.

8. Applications

Optimum PCB Layout
2Oz/ft² or 70µm copper should be used for connection to the pins. 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. (The recommended layouts do not guarantee system EMC compliance as this is dependent on the end application). 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 CXA20 meet the spacing requirements that the system is approved to.

VIEW IS FROM TOP SIDE

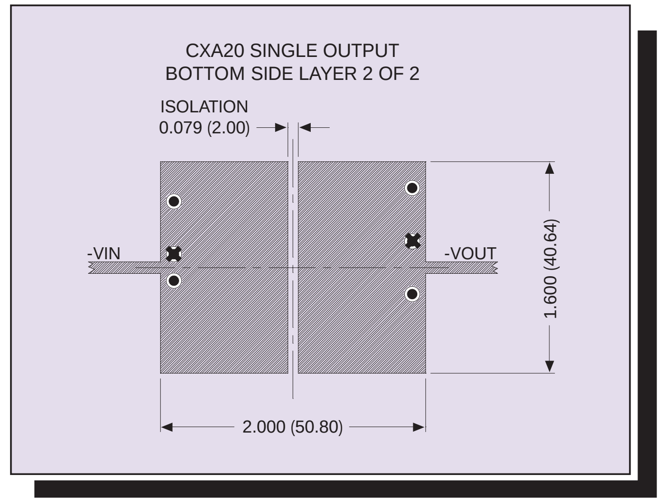


THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-D-275 SECTION 5.3.2.3

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

Figure 6 - Optimum PCB layout for EMC and Thermals for single outputs on a single-sided PCB.

VIEW IS FROM TOP SIDE

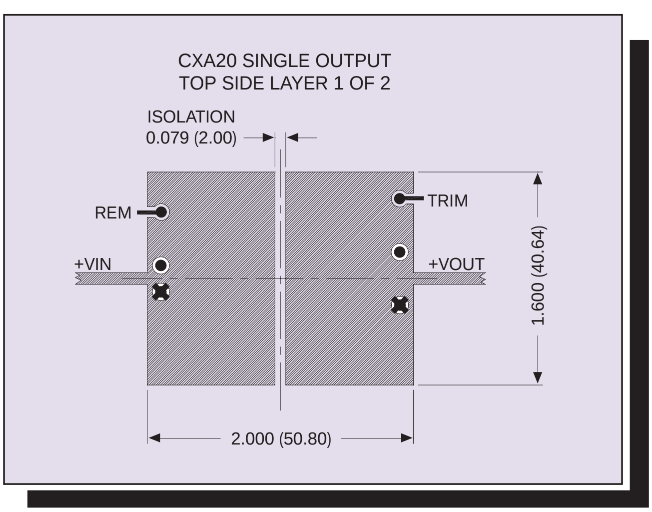


THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-D-275 SECTION 5.3.2.3

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

Figure 7.2 - Optimum PCB layout for EMC and Thermals for single outputs on a double-sided PCB (bottom).

VIEW IS FROM TOP SIDE

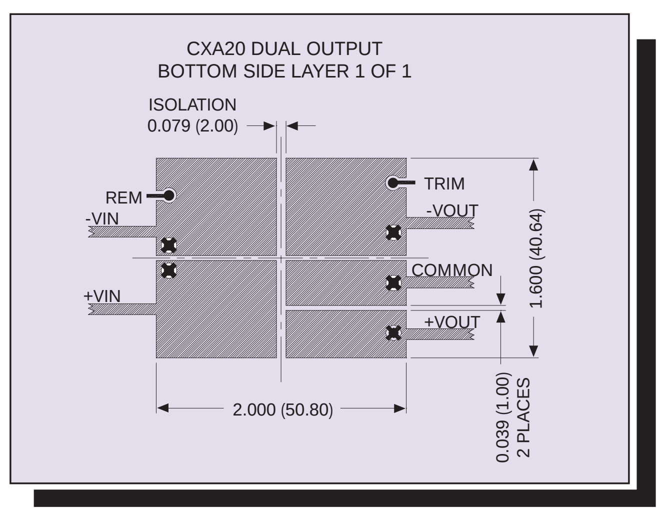


THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-D-275 SECTION 5.3.2.3

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

Figure 7.1 - Optimum PCB layout for EMC and Thermals for single outputs on a double-sided PCB (top).

VIEW IS FROM TOP SIDE

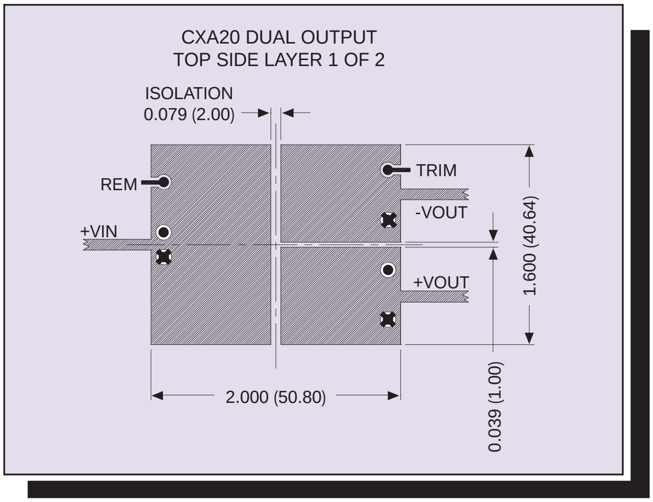


THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-D-275 SECTION 5.3.2.3

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

Figure 8 - Optimum PCB layout for EMC and Thermals for dual outputs on a single-sided PCB (bottom).

VIEW IS FROM TOP SIDE

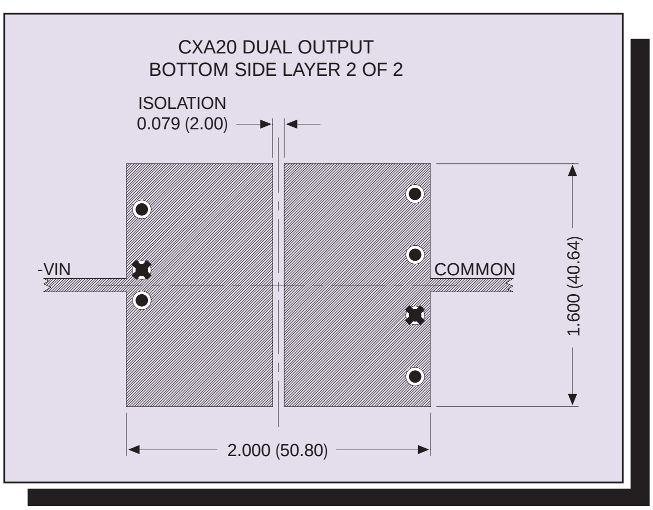


THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-D-275 SECTION 5.3.2.3

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

Figure 9.1 - Optimum PCB layout for EMC and Thermals for dual outputs on a double-sided PCB (top).

VIEW IS FROM TOP SIDE



THERMAL RELIEF IN CONDUCTOR PLANES
REFERENCE IPC-D-275 SECTION 5.3.2.3

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

Figure 9.2 - Optimum PCB layout for EMC and Thermals for dual outputs on a double-sided PCB (bottom)

Optimum Thermal Performance

The CXA20 can operate in still air up to a maximum ambient temperature of between 50°C and 60˚C depending on input voltage and model using the recommended PCB layouts shown in the previous section. Still air, which is sometimes called natural convection is defined as <0.1m/s airflow (20LFM). The output power may be derated so that the maximum ambient operating temperature can be extended to 100°C as shown in Figures 10 to 14.

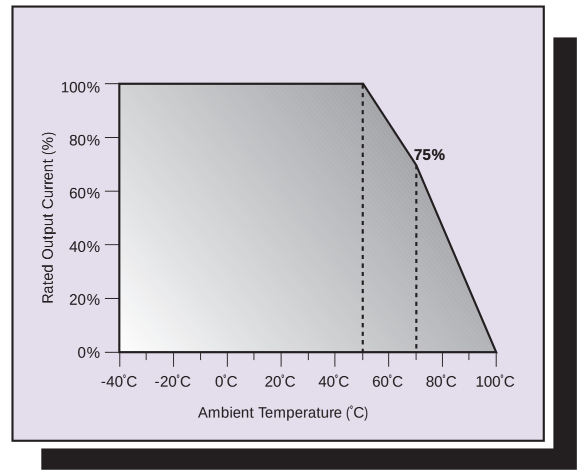


Figure 10 - Output Power versus Ambient Temperature in natural convection for 48S3V3 unit.

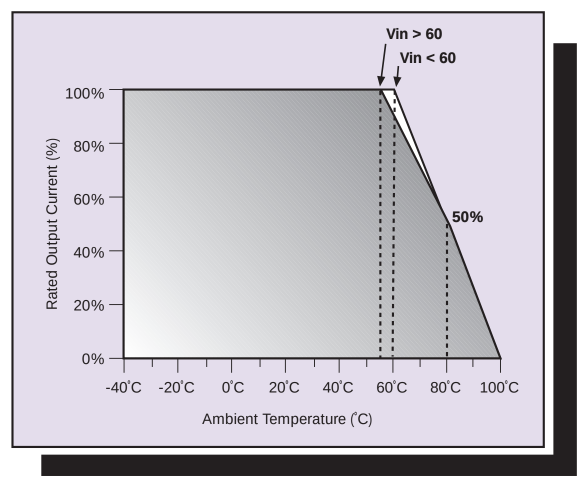


Figure 11 - Output Power versus Ambient Temperature in natural convection for 48S05 unit.

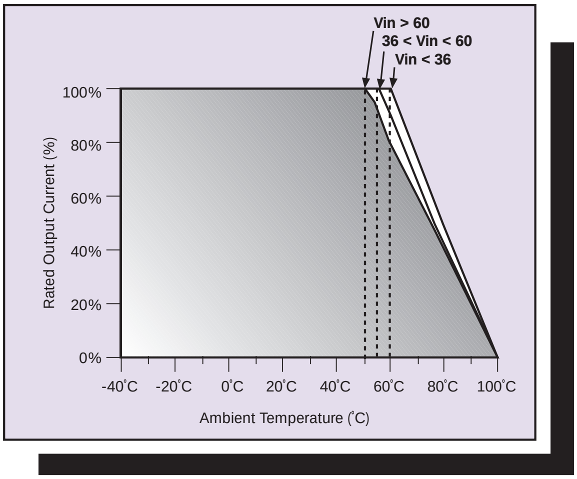


Figure 12 - Output Power versus Ambient Temperature in natural convection for 48S12 unit.

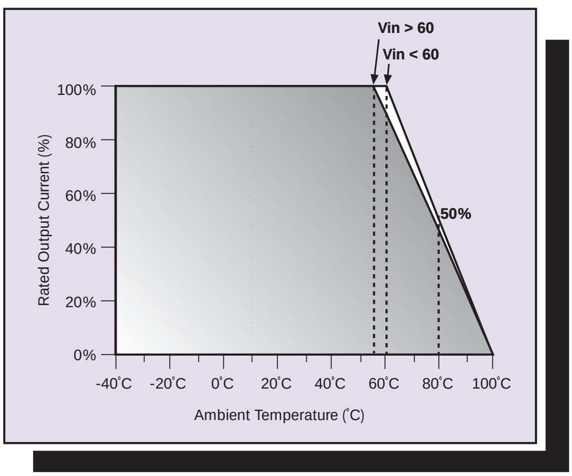


Figure 13 - Output Power versus Ambient Temperature in natural convection for 48D05 unit.

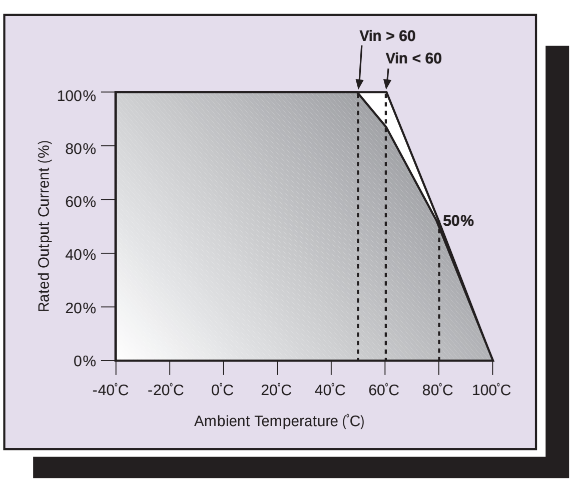


Figure 14 - Output Power versus Ambient Temperature in natural convection for 48D12 unit.

If forced air cooling is used then the converter may be used up to 85°C at full output power dependent on the airflow. Figure 15 is a graph of the increased maximum ambient temperature at full power versus the airflow across the converter.

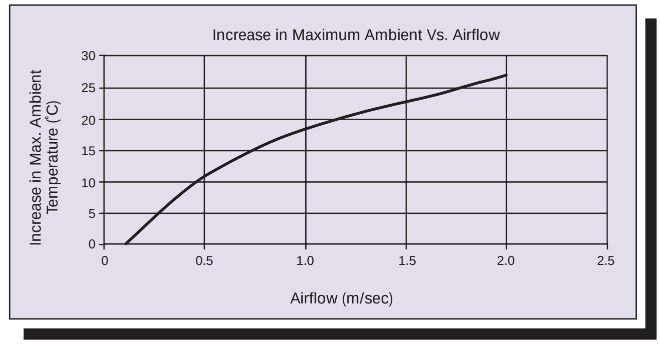


Figure 15 - Increase in Maximum Ambient Temperature at full Power with Forced Airflow

With an airflow of 1.5m/sec the increase in ambient temperature is 22.5˚C. Figure 16 shows the new derating curve for the 48S05 model operating with 1.5m/s forced airflow.

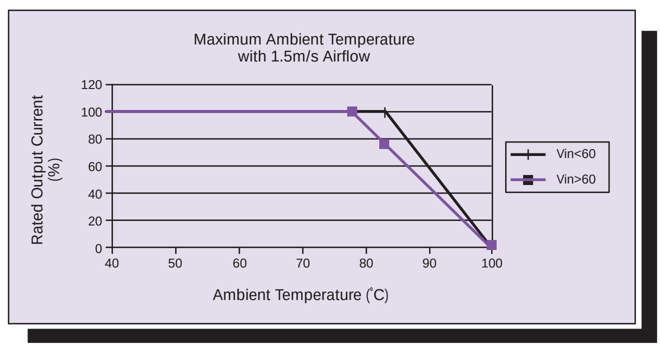


Figure 16 - Thermal Derating for 48S05 with 1.5m/s Forced Airflow

For extreme environments the most accurate method of ensuring that the converter is operating within its guidelines in a chosen application is to measure the temperature of a hot-spot. There are two such positions on the S3V3, S05 and S12 models of the CXA20. The hottest is dependent on the input line voltage, output load and even the ambient temperature. In general they will be within 10˚C of each other. These hot spots are shown in Figure 17 and are the main primary switch (the thermocouple should be mounted as closely as possible to the tab of the device) and the output inductor.

There is one position on the D05 and D12 models of the CXA20. The hot spot is shown in Figure 18 and is the output inductor.

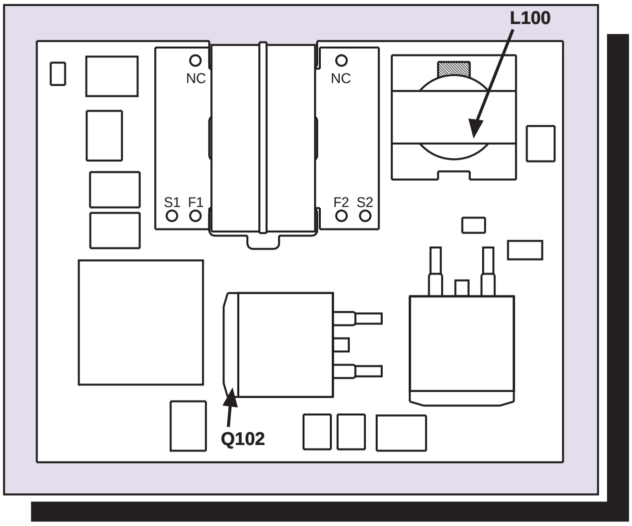


Figure 17 - Hot Spot Locations on S3V3, S05 and S12 Models

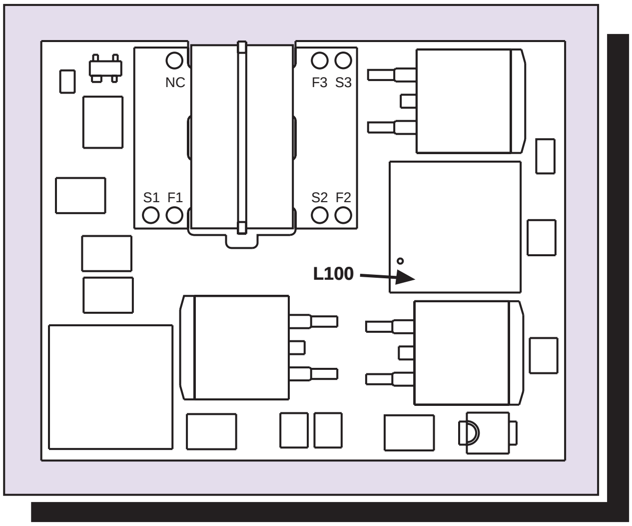


Figure 18 - Hot Spot Location on D05 and D12 Models

In order to maintain the artesyn derating criteria and comply with safety standards the temperatures of the hotspots should never rise above 105°C.

Remote On/Off Control

The remote on/off control feature allow the user to switch the converter on and off electronically when the appropriate signal is applied to the remote pin. This is a primary referenced function which allows the converter to be put in a low dissipating sleep mode.

The CXA20 models are available in a positive or negative logic remote on/off configuration. The control pin is held high through an internal resistor.

Positive Logic

This means that for the active high model, no connection is needed to the control pin for the module to be enabled. But the control pin needs to be driven low and kept low to put the module into sleep mode.

Specification for the Control On/Off

See signal electrical interface on the CXA20 data sheet.

Isolated Closure Remote On/Off

An isolated closure is a closure with both high and low impedance states that sinks current, but does not source current. For on/off control the closure is between the on/off pin and Vi(-), this can be a device such as a mechanical switch, open collector transistor or opto-isolator.

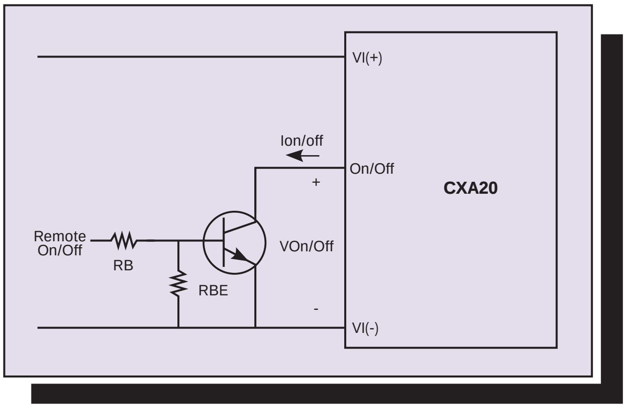


Figure 19 - Isolated Closure using a Transistor

Note in the data sheet, the 'acceptable high level leakage current'. The maximum acceptable leakage current is 50µA. The isolation device should have a leakage current less than this value or the module may go into a low power dissipation mode (remote off).

Level Controlled Remote On/Off

Units can also be controlled by applying a voltage to the remote on/off pin. The figure below shows a TTL output control.

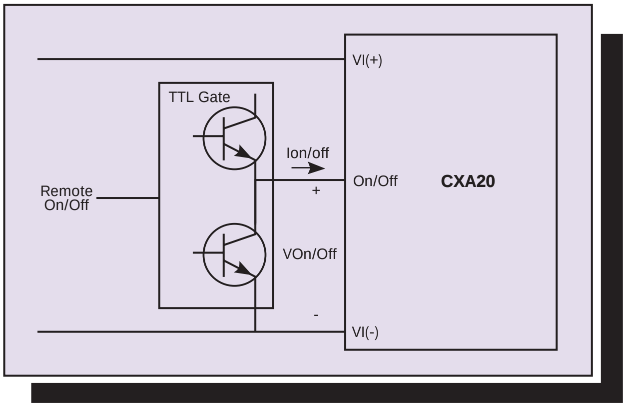


Figure 20 - Level Control Using TTL Output

As per the data sheet the TTL must be capable of sourcing the maximum low level input current of 150µA.

External Output Trimming

The output can be externally trimmed by ±10% using either method shown below. With an external resistor between Trim and +Output, the output voltage point (Vo, trim_down) is trimmed down and when the resistor is placed between -Output and Trim the output voltage (Vo, trim_up) is trimmed up.

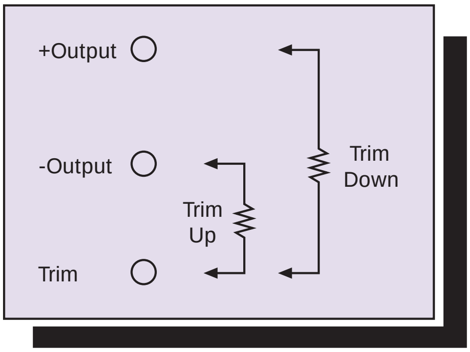


Figure 21 - 48D05 and 48D12 External output trimming

The equations used to determine the value of the external resistor (specified in kΩ) required to obtain the required output voltage (specified in Volts) are shown below. For the 48D05 and 48D12, trim up can be achieved as shown above but it may also be obtained by placing a resistor between the trim pin and the common pin. If this method is used the same formulae for the S05 and S12 should be applied.

Abbreviations:

Rtrim_up	The resistor required to achieve the desired trimmed up output voltage.
Rtrim-down	The resistor required to achieve the desired trimmed down output voltage.
Vo,t_up	The desired trimmed up output voltage.
Vo,t_down	The desired trimmed down output voltage.

$$Rtrim\_up = \left(\frac{24.86 - 6.8 * Vo,t\_up}{Vo,t\_up - 3.3} \right) k\Omega$$

$$Rtrim\_down = \left(\frac{24.8 - 8.76 * Vo,t\_down}{Vo,t\_down - 3.29} \right) k\Omega$$

Figure 22.1 - 48S3V3 Formula

$$Rtrim\_up = \left(\frac{50.48 - 9.12 * Vo,t\_up}{Vo,t\_up - 4.99} \right) k\Omega$$

$$Rtrim\_down = \left(\frac{50.5 - 11.38 * Vo,t\_down}{Vo,t\_down - 4.99} \right) k\Omega$$

Figure 22.2 - 48S05 Formula

$$Rtrim\_up = \left(\frac{27 * Vo,t\_up - 359.425}{11.975 - Vo,t\_up} \right) k\Omega$$

Note: Cannot trim CXA20-48S12 up for Vin <20V.

$$Rtrim\_down = \left(\frac{33.8 * Vo,t\_down - 359.568}{11.98 - Vo,t\_down} \right) k\Omega$$

Figure 22.3 - 48S12 Formula

$$Rtrim\_up = \left(\frac{50.55 - 6.886 * Vo,t\_up}{Vo,t\_up - 4.99} \right) k\Omega$$

$$Rtrim\_down = \left(\frac{50.5 - 11.38 * Vo,t\_down}{Vo,t\_down - 4.99} \right) k\Omega$$

Figure 22.4 - 48D05 Formula

$$Rtrim\_up = \left(\frac{359.41 - 20.2 * Vo,t\_up}{Vo,t\_up - 11.974} \right) k\Omega$$

Note: Cannot trim CXA20-48D12 up for Vin <20V.

$$Rtrim\_down = \left(\frac{33.8\ Vo,t\_down - 359.568}{11.98 - Vo,t\_down} \right) k\Omega$$

Figure 22.5 - 48D12 Formula

Trim Up Example:

Unit : CXA20-48S3V3

Output voltage required is 3.43V.
To determine the resistor required the following formula is used:

$$Rtrim\_up = \left(\frac{24.86 - 6.8 * Vo,t\_up}{Vo,t\_up - 3.3} \right) k\Omega$$

where Vo,t_up = 3.43 and

$$Rtrim\_up = \left(\frac{24.86 - 6.8 * 3.43}{3.43 - 3.3} \right) k\Omega = \left(\frac{24.86 - 23.324}{0.13} \right) k\Omega$$

$$= 11.81 k\Omega$$

The result is that a resistor of value of 11.8kΩ is required to trim a 3.3V output up to 3.43V.

Trim Down Example:

Unit : CXA20-48S05

Output voltage required is 4.75V.
To determine the resistor required the following formula is used:

$$Rtrim\_down = \left(\frac{50.5 - 11.38 * Vo,t\_down}{Vo,t\_down - 4.99} \right) k\Omega$$

where Vo,t_down = 4.75 and

$$Rtrim\_down = \left(\frac{50.5 - 11.38 * 4.75}{4.75 - 4.99} \right) k\Omega = \left(\frac{50.5 - 54.055}{-0.24} \right) k\Omega$$

$$= 14.81k\Omega$$

The result is that a resistor of value of 14.7kΩ (E96 value) is required to trim a 5V output down to 4.75V.

Output noise and ripple measurement

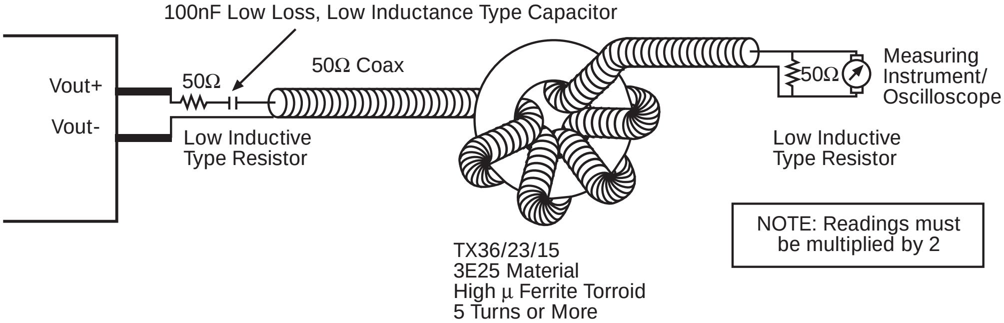


Figure 23 - Output noise and ripple measurement

The above circuit has been used for noise measurement on CXA 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.

9. Appendix 1

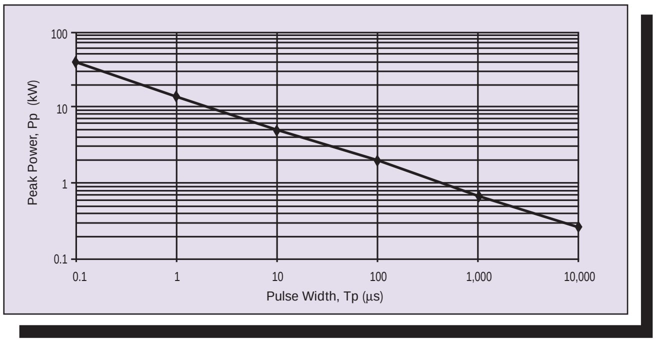


Figure A1 - Output TVS Rating vs. Pulse Width @ 25˚C Ambient

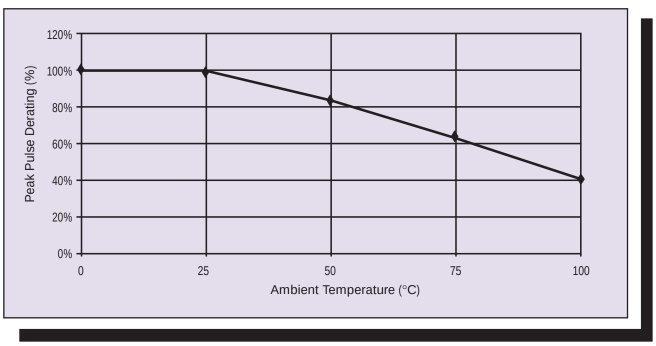


Figure A2 - Output TVS Peak Pulse Derating vs. Ambient Temperature

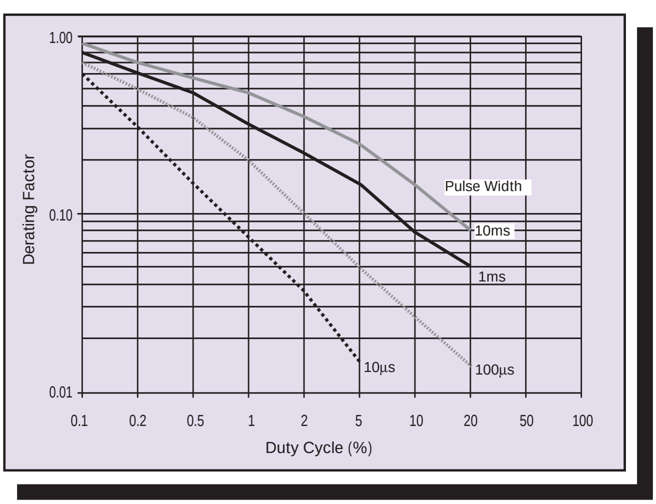


Figure A3 - Output TVS Derating Factor vs. Duty Cycle for Several Pulse Widths

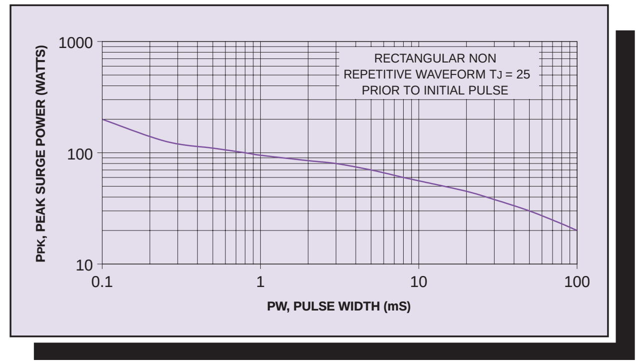


Figure A4 - Output Zener Rating vs. Pulse Width @ 25˚C Ambient