

# 45 Watt XT Single Series DC/DC Converters



## Features

- Fully Shielded/Filtered Design
- Lowest Noise Outputs, 50 mV P-P
- Very Low and Specified Reflected Ripple Current
- Low I/O Capacitance, 500 pF Typical
- Water Washable Shielded Copper Case
- Five Year Warranty

## Description

These single output converters are designed for ultra wide input range low noise telecommunications, industrial, and instrument applications. The very wide input range (4:1) is ideal for battery or unregulated input applications while the low noise complements even the most sensitive analog circuitry.

These converters are state of the art 220 kHz MOSFET based designs that provide outstanding line and load regulation and efficiencies exceeding 80%.

Remote output voltage sense, output voltage trim and ON/OFF functions are also included.

The converters are protected from output shorts to common by a high speed pulse by pulse digital current limit circuit and a self resetting thermal overload protection circuit.

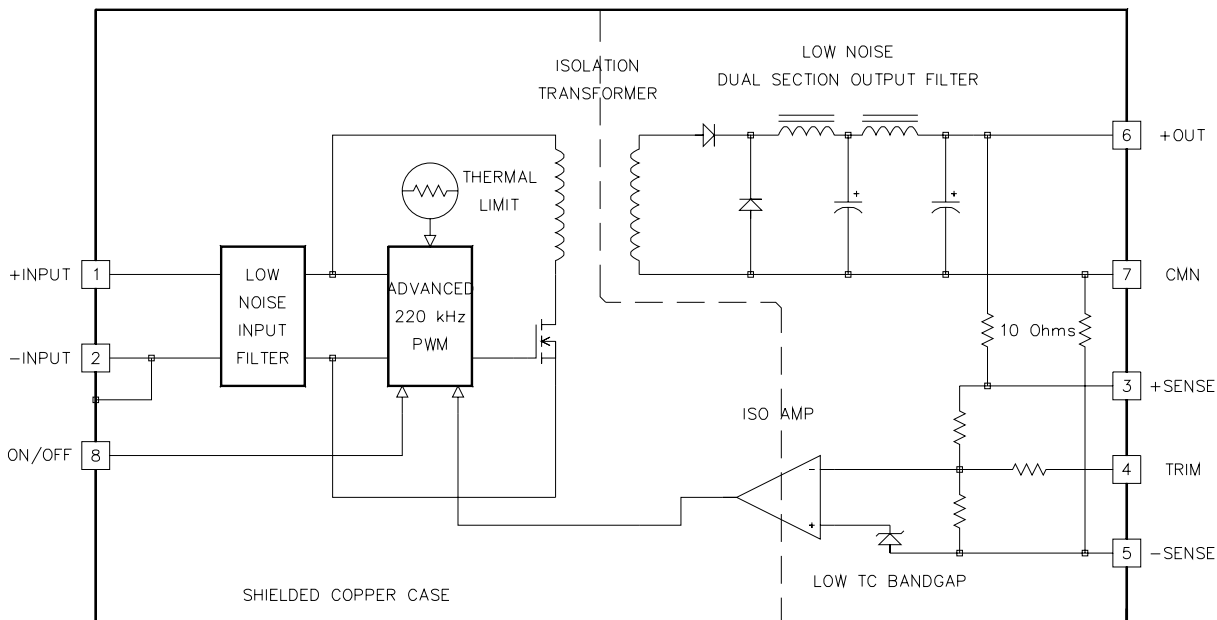
As with all CALEX converters the 45 watt XT Single series is covered by our 5 Year Warranty.

Selection Chart				
Model	Input Range VDC		Output VDC	Output AMPS
	Min	Max		
24S3.6XT	9	36	3.33	6.0
24S5.7XT	9	36	5.0	7.0
24S12.4XT	9	36	12.0	3.75
24S15.3XT	9	36	15.0	3.0
48S3.7XT	20	72	3.33	7.0
*48S5.8XT	20	72	5.0	8.0
48S12.4XT	20	72	12.0	3.75
48S15.3XT	20	72	15.0	3.0

Note: See Input Derating Curves for 24S Models.

\*Agency Approvals: CSA/UL 60950

45 Watt XT Single Series Block Diagram



# 45 Watt XT Single Series DC/DC Converters

Input Parameters*						
Model		24S3.6XT	24S5.7XT	24S12.4XT	24S15.3XT	Units
Voltage Range (8)	MIN	9				VDC
	MAX	36				
Input Current Full Load	TYP	1120	1900	2400	2400	mA
	TYP	10	10	10	10	
Efficiency	TYP	74	76	79	79	%
	TYP	60				
Reflected Ripple (1)	TYP	8				mA RMS
	TYP	60				
Switching Frequency	TYP	220				kHz
Maximum Input Overvoltage, 100ms	MAX	45				VDC
Turn-on Time, 1% Output Error	TYP	25				ms
Recommended Fuse		(2)				AMPS
Model		48S3.7XT	48S5.8XT	48S12.4XT	48S15.3XT	Units
Voltage Range	MIN	20				VDC
	MAX	72				
Input Current Full Load	TYP	640	1050	1150	1150	mA
	TYP	10	10	10	10	
Efficiency	TYP	76	79	81	81	%
	TYP	45				
Reflected Ripple (1)	TYP	5				mA RMS
	TYP	45				
Switching Frequency	TYP	220				kHz
Maximum Input Overvoltage, 100ms	MAX	80				VDC
Turn-on Time, 1% Output Error	TYP	25				ms
Recommended Fuse		(2)				AMPS

Output Parameters*										
Model		24S3.6XT	48S3.7XT	24S5.7XT	48S5.8XT	24S12.4XT	48S12.4XT	24S15.3XT	48S15.3XT	UNITS
Output Voltage		3.33		5		12		15		VDC
Output Voltage Accuracy	MIN	3.30		4.95		11.90		14.90		VDC
	TYP	3.33		5.00		12.00		15.00		
	MAX	3.36		5.05		12.10		15.10		
Rated Load Range (9)	MIN	1.5	1.5	1.7	0.3	0.3		0.3		A
	MAX	6	7	7	8	3.75		3		
Load Regulation: 25%-100% Full Load	TYP	0.01								%
	MAX	0.1								
Line Regulation Vin = Min-Max VDC	TYP	0.5				0.1				%
	MAX	2.0				0.2				
Transient Response (3)	TYP	500		100		100		100		µs
Dynamic Response (4)	TYP	200		250		120		120		mV peak
Input Ripple Rejection (5)	TYP	> 25								dB
Noise, 0-20MHz bw (1)	TYP	25	25	25	50	25	50	25	50	mV p-p
RMS Noise, 0.1 - 1MHz bw (1)	TYP	6	10	6	10	6	10	6	10	mV RMS
Temperature Coefficient	TYP	50								ppm/°C
	MAX	150								
Short Circuit Protection		Output to Common and Thermal Protection								

## NOTES

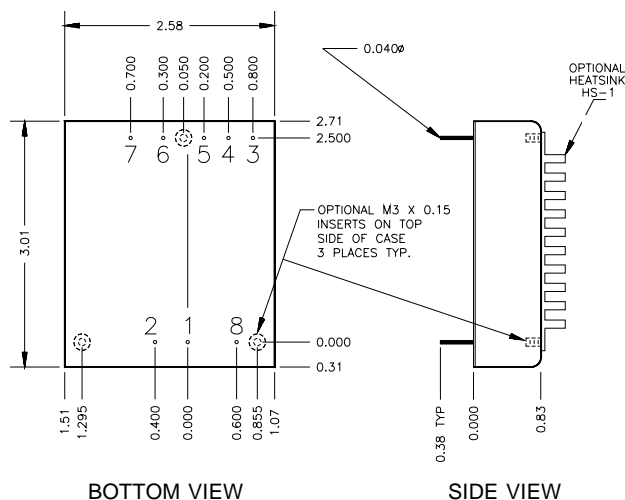
\* All parameters measured at Tc = 25°C, nominal input voltage and full rated load unless otherwise noted. Refer to the CALEX Application Notes for the definition of terms, measurement circuits and other information.

- Noise is measured per CALEX application notes. Measurement bandwidth is 0-20 MHz. RMS noise is measured over a 0.01-1 MHz bandwidth. To simulate standard PCB decoupling practices, output noise is measured with a 10µF tantalum and 0.01µF ceramic capacitor located 1 inch away from the converter. Input ripple is measured into a 10µH source impedance.
- See our application note for picking the correct fuse size.
- Transient response is specified for a 50 to 75% step load change. Rise time of step is 2 microseconds.
- Dynamic response is the peak overshoot for a transient as described in note 3.

- Input ripple rejection is specified for a DC to 120 Hz ripple with a modulation amplitude of 1% of Vin or less.
- The functional temperature range is intended to give an additional data point for use in evaluating this power supply. At the low functional temperature the power supply will function with no side effects, however sustained operation at the high functional temperature may reduce the expected operational life. The data sheet specifications are not guaranteed over the functional temperature range.
- The case thermal impedance is specified as the case temperature rise over ambient per package watt dissipated.
- See power/voltage derating curves.
- No harm when operated at less than maximum load. See section on Operation with Light Loads.
- Specifications subject to change without notice.

# 45 Watt XT Single Series DC/DC Converters

General Specifications*			
All Models			Units
<b>ON/OFF Function</b>			
ON Logic Level or Leave Pin Open	MIN	4	VDC
OFF Logic Level or Tie Pin to -Input	MAX	1.5	VDC
Open Circuit Voltage	TYP	5	VDC
Input Resistance	TYP	6	kohms
Converter Idle Current ON/OFF Pin Low	TYP	7	mA
<b>Isolation</b>			
Isolation Voltage Input to Output, 24S	MIN	700	VDC
Input to Output, 48V 10µA Leakage	MIN	1544	VDC
Input to Output Capacitance	TYP	500	pF
<b>Output Trim Function</b>			
Trim Range	MIN	±10	%
Input Resistance	MIN	10	kohms
Open Circuit Voltage	TYP	2.5	VDC
<b>Environmental</b>			
Case Operating Range	MIN MAX	-40 85	°C
Case Functional Range (6)	MIN MAX	-55 90	°C
Storage Range	MIN MAX	-55 100	°C
Thermal Shutdown Case Temperature	TYP	100	°C
Thermal Impedance (7)	TYP	4.4	°C/Watt
Unit Weight	TYP	7	oz
<b>Mounting Options</b>			
MS9	Chassis Mounting Kit		
-I Suffix on Part Number	Inserts In Case		
-HS Suffix on Part Number	Heat Sink Option		



Mechanical tolerances unless otherwise noted:

X.XX dimensions: ±0.020 inches

X.XXX dimensions: ±0.005 inches

Pin	Function
1	+INPUT
2	-INPUT
3	+SENSE
4	TRIM
5	-SENSE
6	+OUTPUT
7	CMN
8	ON/OFF

## Application Information

You truly get what you pay for in a CALEX converter, a complete system oriented and specified DC/DC converter - no surprises, no external noise filtering circuits needed, no heatsinking problems, just "plug and play".

The 45 watt XT Single series like all CALEX converters carries the full 5 year CALEX no hassle warranty. We can offer a five year warranty where others can't because with CALEX it's rarely needed.

Keep reading, you'll find out why.

## General Information

The XT Single series is mindful of battery operation for industrial, medical control and remote data collection applications. The remote ON/OFF pin places the converter in a very low power mode that draws typically less than 10 mA from the input source.

Noise has also achieved new lows in this single design, while the industry standard is to specify output noise as 1 to 5% peak to peak typical with no mention of measurement bandwidth. The XT converters achieve 50 mV peak to peak typical and are fully specified and tested to a wide bandwidth of 0-20 MHz.

Input filtering reduces reflected ripple noise and is similarly low and also fully specified for typical values (exact value depends on input voltage range). Typical RMS noise over a 10 kHz to 1 MHz bandwidth is specified for both the input and output.

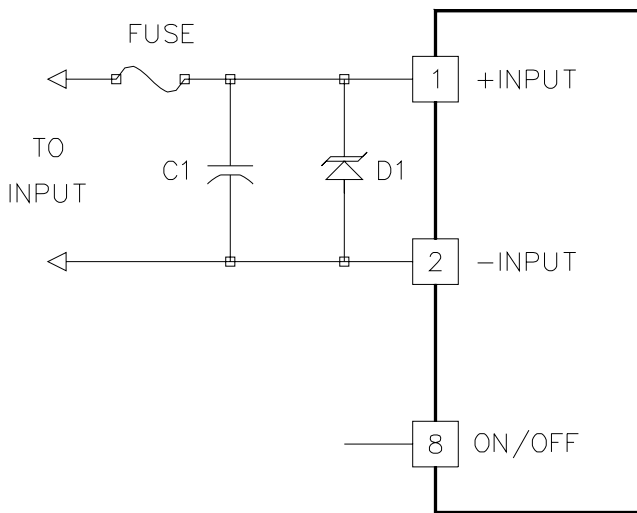
Full overload protection is provided by independent pulse-by-pulse current limiting and an over-temperature shutdown circuit. These protection features assure you that our XT single will provide you with zero failure rate operation.

Five sided shielding is standard along with specified operation over the full industrial temperature range of -40 to +85°C case temperature.

# 45 Watt XT Single Series DC/DC Converters

## Applying the Input

Figure 1 shows the recommended input connections for the XT Single DC/DC converter. A fuse is recommended to protect the input circuit and should not be omitted. The fuse serves to prevent unlimited current from flowing in the case of a catastrophic system failure.



**Figure 1.**

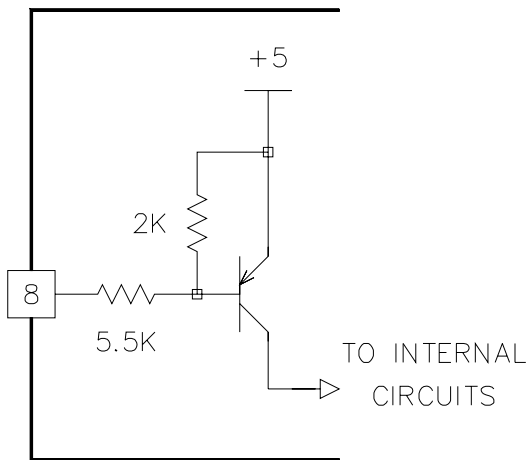
Standard connections for the XT single input. The ON/OFF pin may be left floating if it is not used. The input protection fuse should not be omitted. If desired, an external transient protection diode (D1) can be used at the input. See "Applying the input" for suggestions regarding C1.

No external capacitance on the input is required for normal operation, in fact it can degrade the converters performance. Extremely low ESR capacitors (< 0.5 ohms) should not be used at the input as this will cause peaking of the input filters transfer function and actually degrade the filters performance. Normal RF bypass capacitors in the 1000 pF to 0.01  $\mu$ F range may be used without harm.

## Remote ON/OFF Pin Operation

The remote ON/OFF pin may be left floating if this function is not used. The equivalent input circuit for the ON/OFF pin is shown in figure 2. The best way to drive this pin is with an open collector/drain or relay contact. See our application note titled "Understanding the remote ON/OFF function" for more information about using the remote ON/OFF pin.

When the ON/OFF pin is pulled low with respect to the -Input, the converter is placed in a low power drain state. The ON/OFF pin turns the converter off while keeping the input bulk capacitor fully charged, this prevents the large inrush current spike that occurs when the +input pin is opened and closed.



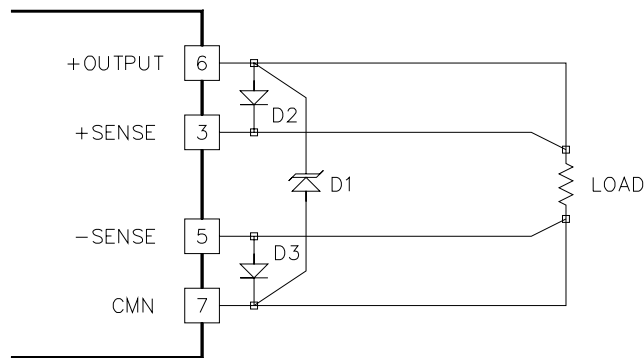
**Figure 2.**

The simplified schematic of the XT Single series ON/OFF pin. The input impedance is approximately 6k ohms. By leaving this pin floating the converter will be in the ON state. When the pin is pulled below 1.4 volts (with respect to the -Input pin) the converter is placed in the power down or OFF state. See our application note on the remote ON/OFF function for more information.

## Applying The Output

Figure 3 shows typical output connections for the XT single. In most applications no external output capacitance will be necessarily. Only your normal 1 to 10  $\mu$ F and 0.001 to 0.1  $\mu$ F bypass capacitors sprinkled around your circuit as needed locally are required. Do not add extra output capacitance and cost to your circuit "Just Because".

If you feel you must add external output capacitance, do not use the lowest ESR, biggest value capacitor that you can find! This can only lead to reduced system performance or oscillation. See our application note "Understanding Output Impedance For Optimum Decoupling" for more information.



ALL D'S OPTIONAL, SEE TEXT

**Figure 3.**

The remote sense lines should be connected to their respective output pins even if they are not used in your application. If desired, an external transient protection diode can be used. D2 and D3 are optional, for more information see the "Remote sense" section.

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## Remote Sense

The XT single features provisions for remote sense connections. These allow the power supply to correct for line drops of up to 0.6 volts per side. The remote sense connections should be made with twisted pair wire or closely coupled PCB traces. If the remote sense is not to be used these pins must be connected to their respective output pins for proper output voltage accuracy and regulation. There is approximately 2 mA of current flowing in the remote sense lines.

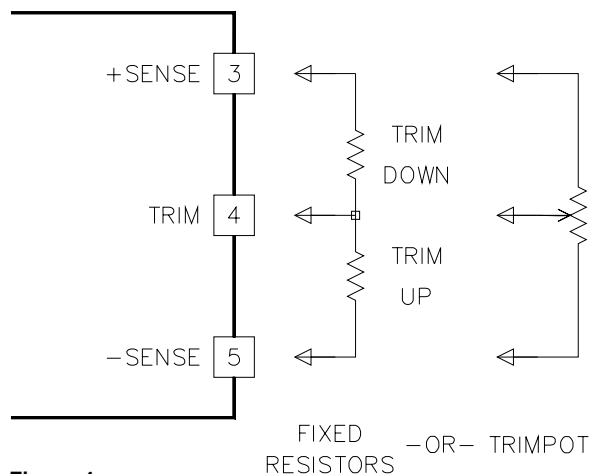
Care should be taken to not disconnect the output pins before the remote sense pins while the converter is in operation. If this happens the output load current will run down the sense leads possibly causing an output overvoltage condition. If the unit must be "Hot Plugged" in the intended application, provision should be made to disconnect the sense leads before the power leads, disconnect the input power first or use the remote ON/OFF to stop the converters operation.

Another option is to attach two 1N4001 diodes from pins 6 to 3 and pins 7 to 5 as shown in figure 3. These diodes will shunt any current through the 10 ohm internal resistors connected between the outputs and their respective outputs when the voltage drop across the resistors exceeds approximately 0.6 volts. This will limit momentary overvoltages to about 1.2 volts during a hot plug-in.

## Output Trimming

The trim pin may be used to adjust the outputs by up to  $\pm 10\%$  from the nominal factory setting. The trim may be used to adjust for system wiring voltage drops or to adjust the +5 output up to 5.2 volts for ECL applications. Figure 4 shows the proper connections to use the trim pin. If output trimming is not desired the trim pin may be safely left floating.

Trimming the output up reduces the output current proportionally to keep the maximum power constant. Output current is not increased over the listed maximum when trimming the output voltage down.



**Figure 4.**

The output can be trimmed by either a trimpot or fixed resistors. If fixed resistors are used their values may range from 0 to infinite ohms. The trimpot should be 10k ohms for 3.3 and 5 volt outputs or 20k ohms for 12 and 15 volt outputs.

## Non Standard Output Voltages

The 12 and 15 volt XT's will typically trim much lower than the -10% specified. This allows the 12 and 15 volt XT's to be trimmed lower than specified for RF or other special applications.

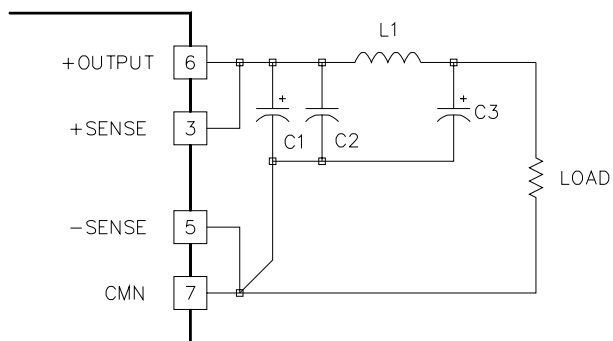
The 12 volt XT's can be typically trimmed over a range of 8.6 to 13.3 volts. The 15 volt XT's can be typically trimmed over a range of 9.8 to 16.8 volts.

Down trim actually can reduce the minimum input voltage in some circuits. Full up trim may not be achievable at minimum input voltage and full rated load.

The maximum current available does not increase from the listed maximum under low trim conditions.

## Ultra Low Noise Output Circuit

The circuit shown in figure 5 can be used to reduce the output noise to below 10 mV P-P over a 20 MHz bandwidth. Size inductor L1 appropriately for the maximum expected load current. The remote sense lines should be looped back directly to the output pins to prevent feedback loop oscillation due to the filters extra phase shift.



C1, C3 - 220 $\mu$ F, 25V UNITED CHEM-CON LXF SERIES  
C2 - 0.01 $\mu$ F, 100V CERAMIC  
L1 - 5 $\mu$ H POWER INDUCTOR

**Figure 5.**

For very low noise applications this circuit will reduce the output noise to less than 10 mV P-P over a 0-20 MHz bandwidth. Be sure to size the inductor appropriately for the maximum expected load current.

## Operation With Light Loads

At output loads less than specified minimum, the XT single will operate in a "Burst Mode". That is the XT will cease PWM operation and instead operate in more of a burst mode. This mode significantly reduces the light load input current to the XT single. Under these conditions the output of the XT will contain a larger than normal (compared to full load) output noise, but at a lower frequency.

If this is a problem in your application the XT single may be used with a dummy load resistor to keep the static output current above the specified minimum load.

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This will help to dampen the low frequency output ripple without upsetting the dynamic operation of the XT. For more information see our application note on “Understanding DC/DC Converters Output Impedance”.

Another solution to the “No Load” condition is to use the ON/OFF pin to control no load operation and shut the converter down totally.

Dynamic response of the XT single will degrade when the unit is operated with less than 25% of full rated power.

## Grounding

The input and output sections are fully floating from each other. They may be operated fully floating or with a common ground. If the input and output sections are connected either directly at the converter or at some remote location from the converter it is suggested that a 3.3 to 10  $\mu$ F, 0.5 to 5 ohm ESR capacitor bypass be used directly at the converter output pins. This capacitor prevents any common mode switching currents from showing up at the converters output as normal mode output noise. See “Applying the Output” for more information.

Another “Trick” that can be used when operating with a common ground is to use a 10 to 100  $\mu$ H choke between the grounds. This gives you a solid low frequency ground connection, but looks like a high impedance to the switching current effects and prevents them from flowing in the connection. This will have the effect of preventing the common mode currents from showing up as normal mode components in your input or output circuits.

Be sure that the inductor has a self resonant frequency of greater than 200 kHz and that the Q of the inductor is quite low. If necessary to keep the inductor Q under control, parallel it with a 200 to 1k ohm resistor.

## Case Grounding

The copper case serves not only as a heat sink but also as a EMI shield. The .025 inch thick case provides >30 dB of absorption loss to both electric and magnetic fields at 220 kHz, while at the same time providing 20 to 40 % better heat sinking over competitive thin steel, aluminum or plastic designs.

The case shield is tied to the -Input pin. This connection is shown on the block diagram. The case is floating from the output sections. The input is coupled to the outputs only by the low 500 pF of isolation capacitance. This low I/O capacitance insures that any AC common mode noise on the inputs is not coupled to your output circuits.

Compare this isolation to the more usual 1000 - 2000 pF found on competitive designs and you will see that CALEX provides the very best DC and AC isolation available. After all, you are buying an isolated DC/DC to cut ground loops. Don't let the isolation capacitance add them back in.

## Temperature Derating

The XT Single series can operate up to 85°C case temperature without derating. Case temperature may be roughly calculated from ambient by knowing that the XT Singles case temperature rise is approximately 4.4°C per package watt dissipated.

For example: If an XT converter is outputting 35 watts, at what ambient could it expect to run with no moving air and no extra heatsinking?

Efficiency is approximately 80%, this leads to an input power of 44 watts. The case temperature rise would be 9 watts  $\times$  4.4 = 40°C. This number is subtracted from the maximum case temperature of 85°C to get: 45°C.

This example calculation is for an XT single without any extra heat sinking or appreciable air flow. Both of these factors can greatly effect the maximum ambient temperature (see below). Exact efficiency depends on input line and load conditions, check the efficiency curves for exact information.

This is a rough approximation to the maximum ambient temperature. Because of the difficulty of defining ambient temperature and the possibility that the loads dissipation may actually increase the local ambient temperature significantly, these calculations should be verified by actual measurement before committing to a production design.

## Heat Sinking

The XT Single can be ordered in a “-I” configuration which provides a case with 3 x M3 inserts located on the top surface of the case for attaching a heat sink or mounting the converter on it's back using the inserts provided. The mounting surface should be flat to within  $\pm 0.01$  inches to prevent warping the XT Single's case.

The CALEX -HS heat sink was specially developed for this model and can reduce the case temperature rise to typically below 3.3°C per watt with natural convection and less with moving air. It also increases the heat removing efficiency of any cooling air flow.

When the XT single is ordered with a -I option and a -HS, CALEX will ship the converter and heatsink attached. One heat sink is needed for each converter ordered.

Customer installed heat sinks may also be used. It is recommended that either liquid heatsink compound or nothing be used on the heatsink interface. Stay away from the so called “Dry” pad heat sink materials, in our experience these materials are actually worse than no compound at all. Test them thoroughly before committing to production.

Additional heatsinking will lower internal temperatures and increase the expected operational life.

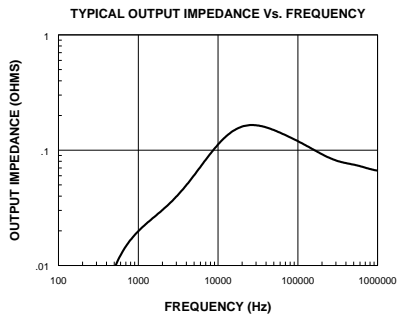
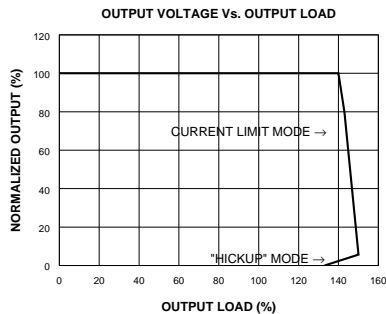
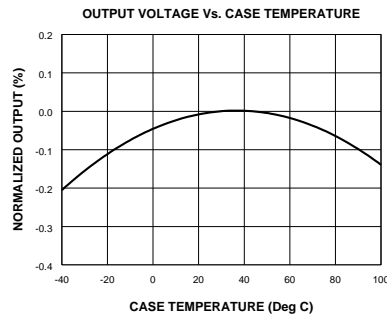
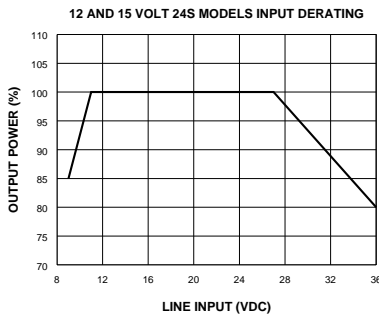
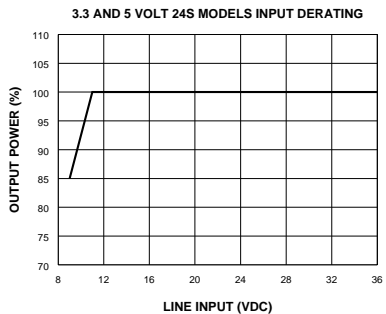
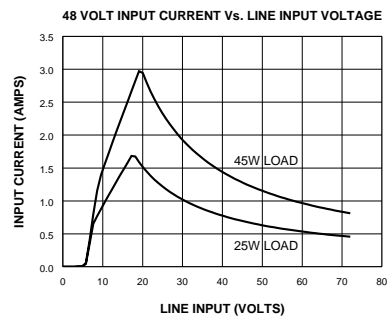
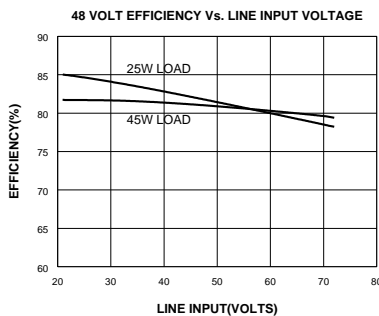
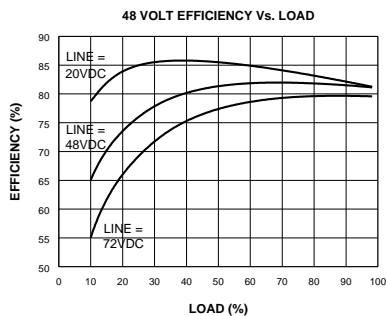
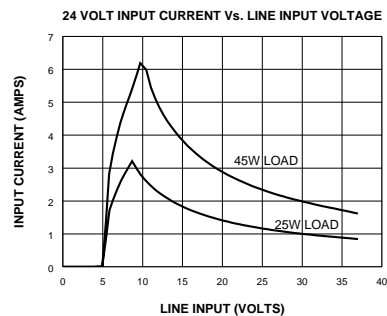
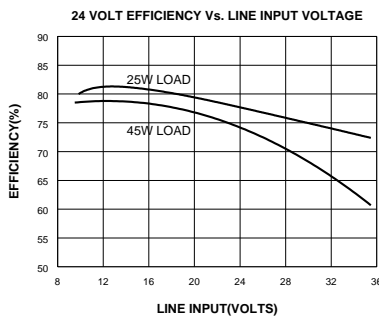
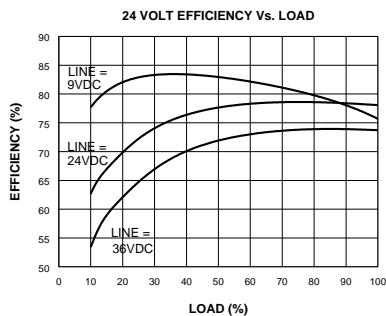
## Mounting Kit

The MS9 chassis mounting kit allows for direct wire connection to the XT single series pins. The mounting kit includes two barrier strips for wire attachment. The MS9 may be conveniently attached to a chassis by use of the 4 - 0.156 inch diameter mounting holes provided at each corner.

Although the MS9 comes with solderless sockets, for improved reliability in severe environmental or vibration environments it is recommended that the XT Single be soldered to the mounting kit.

# 45 Watt XT Single Series DC/DC Converters

Typical Performance (Tc=25°C, Vin=Nom VDC, Rated Load).



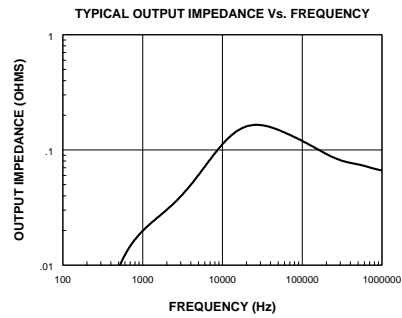
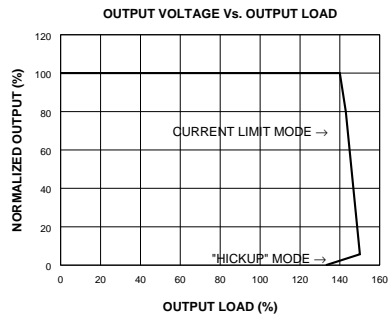
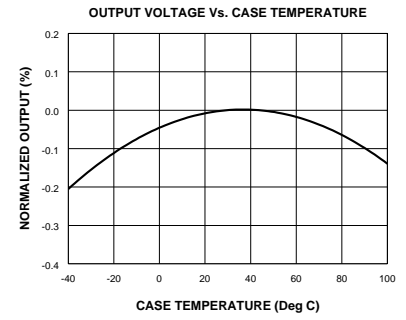
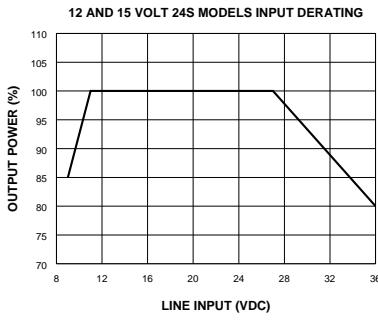
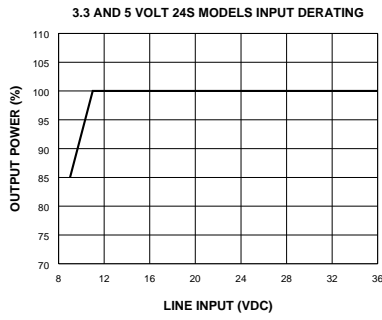
## NOTES ON USING THE CURVES

These curves were generated for 12 volt output models. To use for other models, adjust the efficiency values as shown:

- 3.3 volt models ..... subtract approximately 4%
- 5.0 volt models ..... subtract approximately 3%
- 15.0 volt models ..... add approximately 1%

# 45 Watt XT Single Series DC/DC Converters

Typical Performance ( $T_c=25^\circ\text{C}$ ,  $V_{in}=\text{Nom VDC}$ , Rated Load).



## NOTES ON USING THE CURVES

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