

# 12 Watt LV Single Series DC/DC Converters



## Description

The universal input of the LV single series spans 3.5 to 16 volts. This makes these converters ideal for 4.8 to 12 volt battery and the more traditional 5 volt logic powered systems.

Coupled with this is the very low output noise of typically 40 mV peak to peak. The noise is also fully specified for RMS value and if even these impressive noise figures aren't enough, our applications section shows a simple add on circuit that can reduce the output noise to less than 5 mV P-P.

Full isolation is provided to help cut ground loops in logic powered systems that could create havoc with sensitive, high precision analog circuitry.

No heatsinking is required for most applications saving you design time and valuable PCB space.

What all this means to you is a tighter, more compact overall system that has the capability of being universally

## Features

- Universal 3.5 to 16 Volt Input Range
- Up to 12 Watts of PCB Mounted Power
- Low and Specified Input/Output Capacitance
- Fully Isolated, Filtered Design
- Low Noise Outputs, Typically 40 mV P-P
- Very Low I/O Capacitance, 375 pF Typical
- Water Washable Shielded Copper Case
- 5 Year Warranty

Selection Chart				
Model	Input Range VDC		Output VDC	Output mA
	Min	Max		
5S3.2000LV	3.5	16	3.33	2000
5S5.2000LV	3.5	16	5	2000
5S12.1000LV	3.5	16	12	1000
5S15.800LV	3.5	16	15	800

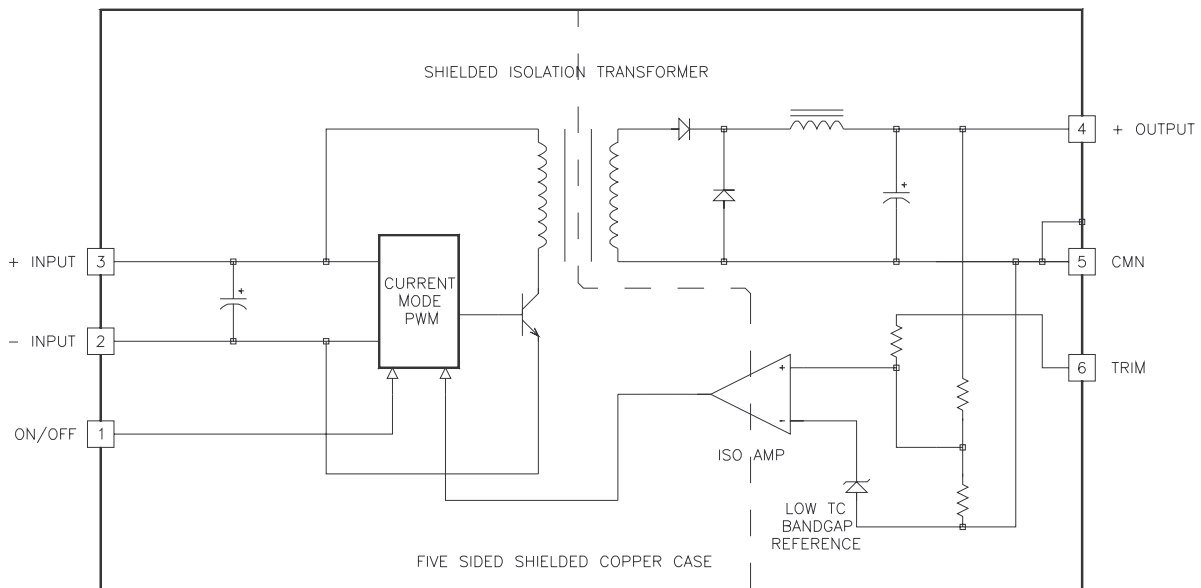
powered. Full application information is provided to make integrating this supply in your system a snap.

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

Other input and output voltage combinations may be factory ordered, contact CALEX applications engineering at 1-800-542-3355 for more information.

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

12 Watt LV Single Series Block Diagram



# 12 Watt LV Single Series DC/DC Converters

Input Parameters*							
Model		5S3.2000LV	5S5.2000LV	5S12.1000LV	5S15.800LV	Units	
Voltage Range (1)		MIN	3.5			VDC	
		MAX	16				
Input Current Full Load		TYP	2010	2880	3500	3470	mA
No Load		TYP	10	10	16	20	
Switching Frequency		TYP	60			kHz	
Maximum Input Overvoltage, 100ms Maximum		MAX	20			VDC	
Turn-on Time, 1% Output Error		TYP	10			ms	
Recommended Fuse			(3)			AMPS	

Output Parameters*						
Model		5S3.2000LV	5S5.2000LV	5S12.1000LV	5S15.800LV	Units
Output Voltage		3.30	5	12	15	VDC
Output Voltage Accuracy	MIN	3.27	4.95	11.88	14.85	VDC
	TYP	3.30	5.00	12.00	15.00	
	MAX	3.33	5.05	12.12	15.15	
Rated Load Range (11)	MIN	0.0	0.0	0.0	0.0	A
	MAX	2.0	2.0	1.0	0.8	
Load Regulation 25% Max Load - Max Load	TYP	0.3		0.1		%
	MAX	0.7		0.5		
Line Regulation Vin = Min-Max VDC	TYP	0.1				%
	MAX	0.2				
Short Term Stability (4)	TYP	< 0.05				%/24Hrs
Long Term Stability	TYP	< 0.1				%/kHrs
Transient Response (5)	TYP	100		200	300	μs
Dynamic Response (6)	TYP	150		250	400	mV peak
Noise, Peak - Peak (2)	TYP	40		40		mV P-P
RMS Noise	TYP	10		6		mV RMS
Temperature Coefficient	TYP	50				ppm/°C
	MAX	150				
Short Circuit Protection to Common for all Outputs		Short Term Current Limit				

## 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.

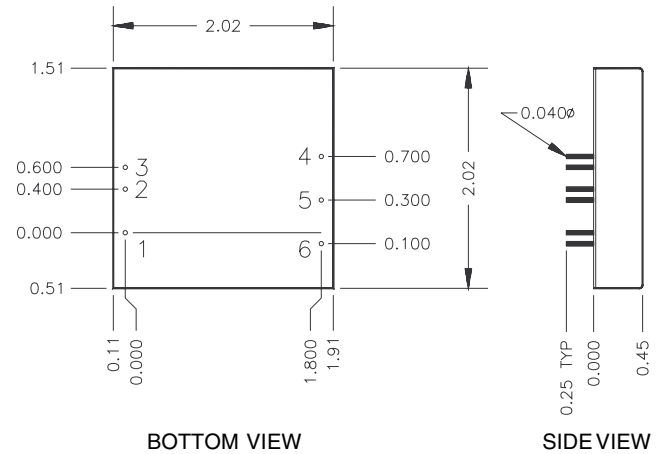
- (1) Reduced output power available at 3.5V input. Full output power is available above 4.6V input. See applications section for more information.
- (2) Noise is measured per CALEX Application Notes. Measurement bandwidth is 0-20 MHz for peak-peak measurements, 10 kHz to 1 MHz for RMS measurements. Output noise is measured with a 0.01μF ceramic in parallel with a 1μF/35V Tantalum capacitor located 1" away from the converter to simulate your PCB's standard decoupling.
- (3) To determine the correct fuse size, see CALEX Application Notes.
- (4) Short term stability is specified after a 30 minute warmup at full load, constant line and recording the drift over a 24 hour period.
- (5) The transient response is specified as the time required to settle from a 50 to 75 % step load change (rise time of step = 2 μSec) to a 1% error band.

- (6) Dynamic response is the peak overshoot voltage during the transient response time as defined in note 5 above.
- (7) See applications section for more information on applying the ON/OFF pin.
- (8) The Case is tied to the CMN output pin.
- (9) 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 will reduce expected operational life. The data sheet specifications are not guaranteed over the functional temperature range.
- (10) The case thermal impedance is specified as the case temperature rise over ambient per package watt dissipated.
- (11) No minimum load required for operation. Dynamic regulation may degrade when run with less than 5% load.
- (12) Specifications subject to change without notice.
- (13) Water Washability - Calex DC/DC converters are designed to withstand most solder/wash processes. Careful attention should be used when assessing the applicability in your specific manufacturing process. Converters are not hermetically sealed.



# 12 Watt LV Single Series DC/DC Converters

General Specifications*			
All Models			Units
<b>ON/OFF Function</b>			
OFF Logic Level or Tie Pin to -Input (7)	MAX	< 0.4	VDC
Open Circuit Voltage	TYP	1.4	VDC
Input Resistance	TYP	2	kohms
Converter Idle Current ON/OFF Pin Low	TYP	6	mA
<b>Isolation (8)</b>			
Isolation Voltage Input to Output 10µA Leakage	MIN	700	VDC
Input to Output Capacitance	TYP	375	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 No Derating	MIN	-40	°C
	MAX	85	
Case Functional Range (9)	MIN	-50	°C
	MAX	90	
Storage Range	MIN	-55	°C
	MAX	105	
Thermal Impedance (10)	TYP	9.5	°C/Watt
<b>General</b>			
Unit Weight	TYP	2.3	oz
Chassis Mounting Kit		MS8	



Mechanical tolerances unless otherwise noted:  
 X.XX dimensions: ±0.020 inches  
 X.XXX dimensions: ±0.005 inches

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

## General Information

The universal 3.5 to 16 volt input allows you to specify your system for operation from any 5 volt logic supply or a 4.8 to 12 volt nominal battery input.

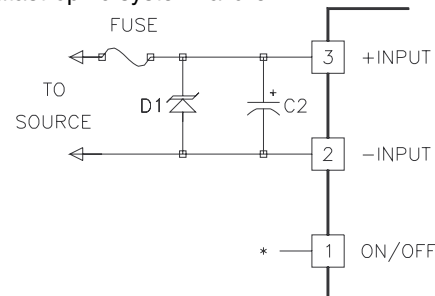
The series is also mindful of battery operation for industrial, medical control and remote data collection applications. The remote ON/OFF pin places the converter in a very low power mode that draws typically less than 6 mA from the input source.

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 LV converters achieve noise levels of 40 mV peak to peak and are fully specified and tested to a wide bandwidth of 0-20 MHz.

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

## Applying The Input

Figure 1 shows the recommended input connections for the LV 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.



\* ON/OFF MAY BE LEFT FLOATING IF NOT USED

Figure 1.

If the source impedance driving the LV Converter is more than 0.05 ohms the optional capacitor C2 may be required (See text for more information). Optional transient protector diode D1 may be used if desired for added protection. The fuse serves as a catastrophic failure protector and should not be omitted.

# 12 Watt LV Single Series DC/DC Converters

When using the LV Single be sure that the impedance at the input to the converter is less than 0.05 ohms from DC to about 100 kHz, this is usually not a problem in battery powered systems when the converter is connected directly to the battery. If the converter is located more than about 1 inch from the input source an added capacitor is required directly at the input pins for proper operation.

The maximum source impedance is a function of output power and line voltage. The impedance can be higher when operating at less than full power. The minimum impedance is required when operating with a 9 volt input. The impedance reduces as the input voltage is raised or lowered or the power is reduced. In general you should keep the peak to peak voltage measured across the input pins less than 0.15 volts peak to peak (not including the high frequency spikes) for maximum converter performance and life.

There is no lower limit on the allowed source impedance, it can be any physically realizable value, even approaching 0.

If the source impedance is too large in your system you should choose an external input capacitor as detailed below.

## Picking An External Input Capacitor

If an input capacitor is needed at the input to the converter it must be sized correctly for proper converter operation. The curve "RMS Input Current Vs Line Input" shows the RMS ripple current that the input capacitor must withstand with varying loading conditions and input voltages.

Several system tradeoffs must be made for each particular system application to correctly size the input capacitor.

The probable result of undersizing the capacitor is increased self heating, shortening it's life. Oversizing the capacitor can have a negative effect on your products cost and size, although this kind of overdesign does not result in shorter life of any components.

There is no one optimum value for the input capacitor. The size and capacity depend on the following factors:

- 1) Expected ambient temperature and your temperature derating guidelines.
- 2) Your ripple current derating guidelines.
- 3) The maximum anticipated load on the converter.
- 4) The input operating voltage, both nominal and excursions.
- 5) The statistical probability that your system will spend a significant time at any worst case extreme.

Factors 1 and 2 depend on your system design guidelines. These can range from 50 to 100% of the manufacturers listed maximum rating, although the usual derating factor applied is about 70%. 70% derating means if the manufacturer rated the capacitor at 1 A RMS you would not use it over 0.7 A RMS in your circuit.

Factors 3 and 4 realistically determine the worst case ripple current rating required for the capacitor along with the RMS ripple current curve.

Factor 5 is not easy to quantify. At CALEX we can make no assumptions about a customers system so we leave to you

the decision of how you define how big is big enough.

Suitable capacitors for use at the input of the converter are given at the end of this section.

## Startup Current Demand

Because the LV Single appears as a constant power load to your source and operation starts at about 3 volts, you should be sure that your source can supply the required current at low voltages when starting. If this presents a problem the ON/OFF pin and a simple voltage detector (comparator) may be used to prevent startup until some higher steady state voltage.

Generally this is not a problem with battery powered circuits and only appears when the LV Single is powered by marginally sized 5 or 12 volt linear supplies that can't supply the required startup current. See the "Input Current Vs. Line Input" curve for the low voltage current requirements of the LV Single.

## Very Low Noise Input Circuit

Figure 2 shows a very low noise input circuit that may be used with the converters. This circuit will reduce the input reflected ripple current to less than 5 mA RMS ( $V_{in} = 5V$ , 10 kHz to 1 MHz bw). See the discussion above for the optimum selection of C2.

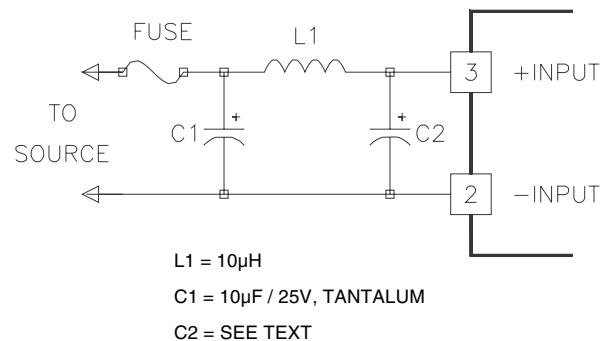


Figure 2.

This circuit will reduce the input reflected ripple current to less than 5 mA RMS. See the discussion in the text for help on the optimum selection of C2. L1 should be sized to handle the maximum input current at your lowest operating voltage and maximum expected output power.

## Suggested Capacitor Sources

These capacitors may be used to lower your sources input impedance at the input of the converter. These capacitors will work for 100% load, worst case input voltage and ambient temperature extremes. They however, may be oversized for your exact usage, see "Picking An External Input Capacitor" above for more information. You may also use several smaller capacitors in parallel to achieve the same ripple current rating. This may save space in some systems.

**United Chemi-Con** SXE, RXC, RZ and RZA series  
Suggested Part: SXE025VB820M12.5X20LL  
820µF, 25V, 105°C Rated  
ESR=0.085 ohms  
Allowable Ripple at 85 °C = 1.96 A

# 12 Watt LV Single Series DC/DC Converters

**Nichicon**  
Suggested Part: PR and PF series  
UPR1E222MRH  
2200uF, 25V, 105°C Rated  
ESR=0.053 ohms  
Allowable Ripple at 85°C = 1.98 A

**Panasonic**  
Suggested Part: HFG and HFQ Series  
ECEA1EFE332L  
300uF, 25V, 105°C Rated  
ESR=0.045 ohms  
Allowable Ripple at 85°C = 1.94 A

## Remote ON/OFF Pin Operation

The remote ON/OFF pin may be left floating if this function is not used. The best way to drive this pin is with an open collector/drain or relay contact.

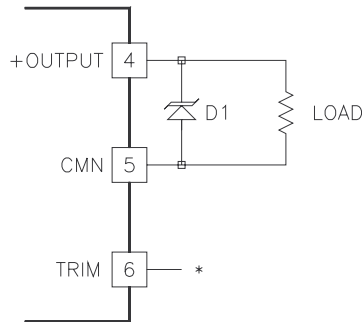
Do not drive this input from a logic gate directly. The ON/OFF pin must be left floating to turn the converter on and insure proper operation. This input is noise sensitive so it should not be routed all over your PCB.

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 capacitors fully charged, this prevents the large inrush current spike that occurs when the +input pin is opened and closed.

The ON/OFF pin should never be pulled more that 0.3 volts below the -Input or have a voltage of greater than +2 volts applied to it.

## Applying The Output

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



\* TRIM MAY BE LEFT FLOATING IF NOT USED

**Figure 3.**

The LV Single may be directly connected to your load without any external components required for most applications. Transient overvoltage diode D1 may be added for extra protection against output faults or if the input has the possibility of being shorted to the load.

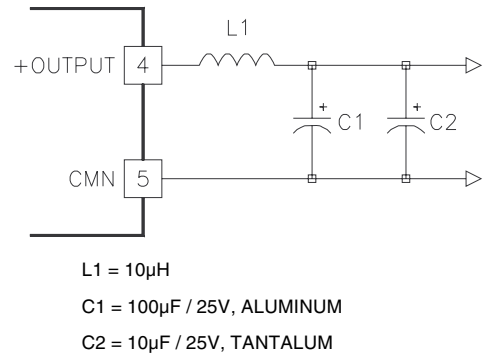
If you feel you must add external output capacitance, do not use the lowest ESR, biggest value capacitor that you can find! This can only lead to reduced system performance or oscillation. See our application note "Understanding Output Impedance For Optimum Decoupling" for more information.

## Output Power

The available output power of the LV Single is reduced when operating below 4.6 volts. See the "Low Voltage Power" curve for more information. In general, from 4.6 to 16 volts full power is available from the LV Single. Below 4.6 volts input the available output power is linearly derated from 100% at 4.6 volts to 50% at 3.5 volts. For example a 5S12.1000LV is capable of providing 6 watts of output power at 3.5 volts input.

## Ultra Low Noise Output Circuit

The circuit shown in figure 4 can be used to reduce the output noise to below 5 mV P-P over a 20 MHz bandwidth. Size inductor L1 appropriately for the maximum expected load current. All of the ground connections must be as short as possible back to the CMN pin. The filter should be placed as close to the LV Single as possible, even if your load is at some distance from the converter.



**Figure 4.**

This circuit can reduce the output noise to below 5 mV P-P over a 20 MHz bandwidth. Size inductor L1 appropriately for the maximum expected load current. All of the ground connections must be as short as possible back to the CMN pin.

## Operation With Very Light Loads

The LV Single conserves power when operating at very light loads by operating in a burst power mode. This may cause the output noise to increase with a repetition rate of 10's of milliseconds. If this causes a problem the LV Single may be operated with a pre-load of about 5% of it's full rated power. The exact value will depend on the external components in your system.

Turning the converter OFF with the remote ON/OFF pin is an attractive alternative when your load needs to be shut down.

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



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## Remote Sense

The simple circuit of figure 5 may be used to add remote sensing to the LV single series. This circuit might be useful when your actual load is at some distance from the converter and you want to automatically compensate for voltage drops. Other situations where this circuit is useful are: Compensating for the voltage drop through a connector and creating a very stiff load voltage even when the load varies greatly. The circuit shown is for a 5 volt output, change R4 for other output voltages.

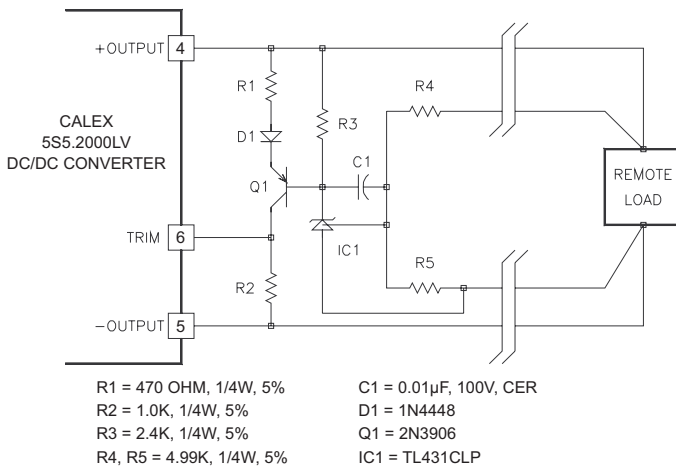


Figure 5.

This simple circuit may be added to provide for remote sensing and automatic correction of the load voltage. See our application note on this circuit for more information.

## 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 6 shows the proper connections to use the trim pin. If output trimming is not desired the trim pin may be safely left floating.

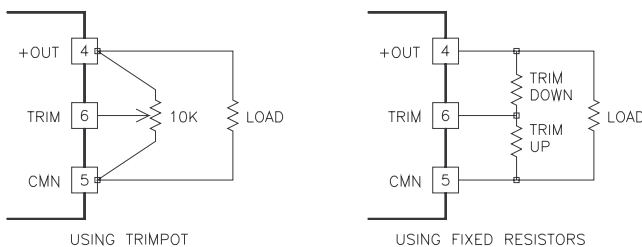


Figure 6.

Output trimming may be accomplished by using a single fixed resistor or a trimpot as shown. When using fixed resistors the values may range from 0 to infinity ohms. See the text for more information on output power when trimming. The trimpot should be 10K for 3 and 5 volt outputs and 20K for 12 and 15 volt outputs.

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.

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.

## Non Standard Output Voltages

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

The 12 volt LV's can be typically trimmed over a range of 8.7 to 13.3 volts. The 15 volt LV's can be typically trimmed over a range of 9.8 to 16.8 volts.

## 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 1 to 10  $\mu$ F, 0.5 to 5 ohm ESR capacitor bypass be used directly at the converters output pins. These capacitors prevent any common mode switching currents from showing up at the converters output as normal mode output noise. See "Applying the Output" for more information on selecting output capacitors.

Also see the CALEX application note "Dealing With Common Mode Noise" for more information on using common grounds.

## Case Grounding

The copper case serves not only as a heat sink but also as a EMI shield. The 0.017 inch thick case provides >25 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 CMN output pin. This connection is shown on the block diagram. The case is floating from the input sections. The input is coupled to the outputs only by the low 375 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 LV Single series can operate up to 85°C case temperature without derating. Case temperature may be roughly calculated from ambient by knowing that the case temperature rise is approximately 9.5°C per package watt dissipated.

For example: If a 12 volt output converter is delivering 9 watts with a 5 volt input, at what ambient could it expect to run with no moving air and no extra heatsinking?

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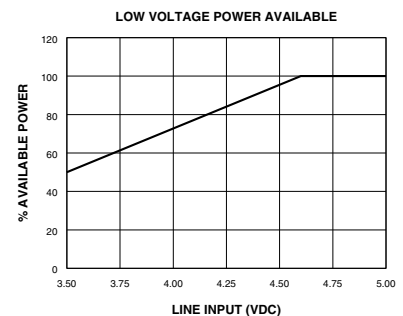
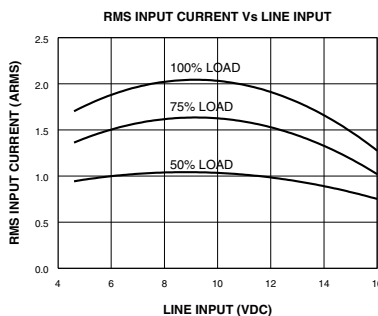
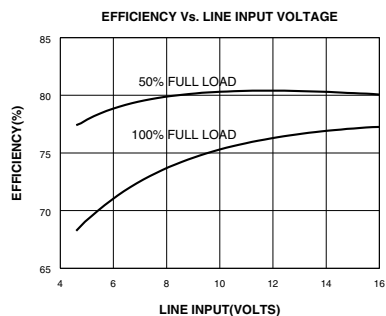
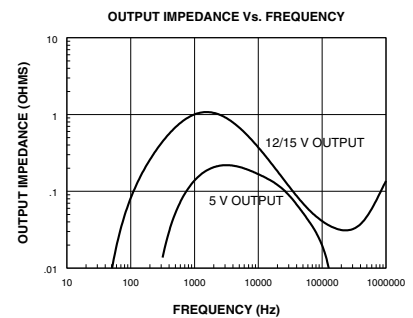
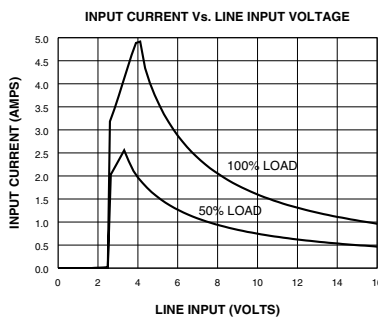
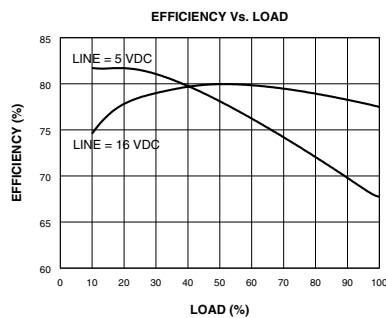
Efficiency of the converter is approximately 72% at 9 watts of output power, this leads to an input power of about 13 watts. The case temperature rise would be  $13 - 9$  watts or 4 watts  $\times$  9.5 = 38°C. This number is subtracted from the maximum case temperature of 85°C to get: 47°C.

This example calculation is for an LV 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 load's dissipation may actually increase the local ambient temperature significantly, these calculations should be verified by actual measurement before committing to a production design.

Remember, it is the system designers responsibility to be sure that the case temperature of the LV Single does not exceed 85°C for maximum reliability in operation.

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



## NOTES ON USING THE CURVES

- 1) The input currents are for 12 watts of input power. For 3.33 volt output models the input current is approximately 40% less. For 5 volt output models the current is approximately 16% less.

- 2) The efficiency curves are for 12 volt output. To use the curves for other models adjust as follows:  
3 volt models subtract approximately 4%  
5 volt models subtract approximately 2%  
15 volt models add approximately 1%

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