12 Watt LV Single Series DC/DC Converters

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

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 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

<table>
<thead>
<tr>
<th>Model</th>
<th>Input Range VDC</th>
<th>Output VDC</th>
<th>Output mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>5S3.2000LV</td>
<td>3.5</td>
<td>5.5</td>
<td>2000</td>
</tr>
<tr>
<td>5S5.2000LV</td>
<td>3.5</td>
<td>5.5</td>
<td>2000</td>
</tr>
<tr>
<td>5S12.1000LV</td>
<td>3.5</td>
<td>5.5</td>
<td>1000</td>
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<tr>
<td>5S15.800LV</td>
<td>3.5</td>
<td>5.5</td>
<td>800</td>
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</table>
# 12 Watt LV Single Series DC/DC Converters

## Input Parameters*

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Voltage Range (1)</td>
<td>MIN 3.5 MAX 16</td>
<td>MIN 3.5 MAX 16</td>
<td>MIN 3.5 MAX 16</td>
<td>MIN 3.5 MAX 16</td>
<td>VDC</td>
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<tr>
<td>Input Current Full Load</td>
<td>TYP 2010 TYP 2880</td>
<td>TYP 3500 TYP 3470</td>
<td>TYP 3500 TYP 3470</td>
<td>TYP 3500 TYP 3470</td>
<td>mA</td>
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<tr>
<td>No Load</td>
<td>TYP 10 TYP 10</td>
<td>TYP 16 TYP 20</td>
<td>TYP 16 TYP 20</td>
<td>TYP 16 TYP 20</td>
<td>mA</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td>TYP 60</td>
<td>TYP 60</td>
<td>TYP 60</td>
<td>TYP 60</td>
<td>kHz</td>
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<tr>
<td>Maximum Input Overvoltage, 100ms Maximum</td>
<td>MAX 20</td>
<td>MAX 20</td>
<td>MAX 20</td>
<td>MAX 20</td>
<td>VDC</td>
</tr>
<tr>
<td>Turn-on Time, 1% Output Error</td>
<td>TYP 10</td>
<td>TYP 10</td>
<td>TYP 10</td>
<td>TYP 10</td>
<td>ms</td>
</tr>
<tr>
<td>Recommended Fuse</td>
<td>(3)</td>
<td>(3)</td>
<td>(3)</td>
<td>(3)</td>
<td>AMPs</td>
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## Output Parameters*

<table>
<thead>
<tr>
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<tr>
<td>Output Voltage</td>
<td>3.30</td>
<td>5</td>
<td>12</td>
<td>15</td>
<td>VDC</td>
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<tr>
<td>Output Voltage Accuracy</td>
<td>MIN 3.27 TYP 3.30 MAX 3.33</td>
<td>MIN 4.95 TYP 5.00 MAX 5.05</td>
<td>MIN 11.88 TYP 12.00 MAX 12.12</td>
<td>MIN 14.85 TYP 15.00 MAX 15.15</td>
<td>VDC</td>
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<td>Rated Load Range (11)</td>
<td>MIN 0.0 TYP 2.0 MAX 2.0</td>
<td>MIN 0.0 TYP 2.0 MAX 2.0</td>
<td>MIN 0.0 TYP 2.0 MAX 2.0</td>
<td>MIN 0.0 TYP 2.0 MAX 2.0</td>
<td>A</td>
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<td>Load Regulation</td>
<td>TYP 0.3 MAX 0.7</td>
<td>TYP 0.1 MAX 0.5</td>
<td>TYP 0.1 MAX 0.5</td>
<td>TYP 0.1 MAX 0.5</td>
<td>%</td>
</tr>
<tr>
<td>25% Max Load - Max Load</td>
<td>TYP 0.1 MAX 0.5</td>
<td>TYP 0.1 MAX 0.5</td>
<td>TYP 0.1 MAX 0.5</td>
<td>TYP 0.1 MAX 0.5</td>
<td>%</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>TYP &lt; 0.05 MAX &lt; 0.05</td>
<td>TYP &lt; 0.05 MAX &lt; 0.05</td>
<td>TYP &lt; 0.05 MAX &lt; 0.05</td>
<td>TYP &lt; 0.05 MAX &lt; 0.05</td>
<td>%/24Hrs</td>
</tr>
<tr>
<td>Short Term Stability (4)</td>
<td>TYP &lt; 0.1 MAX &lt; 0.1</td>
<td>TYP &lt; 0.1 MAX &lt; 0.1</td>
<td>TYP &lt; 0.1 MAX &lt; 0.1</td>
<td>TYP &lt; 0.1 MAX &lt; 0.1</td>
<td>%/Khrs</td>
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<tr>
<td>Dynamic Response (6)</td>
<td>TYP 100 MAX 200</td>
<td>TYP 250 MAX 300</td>
<td>TYP 250 MAX 300</td>
<td>TYP 250 MAX 300</td>
<td>µs</td>
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<td>Dynamic Response</td>
<td>TYP 150 MAX 250</td>
<td>TYP 400 MAX 400</td>
<td>TYP 400 MAX 400</td>
<td>TYP 400 MAX 400</td>
<td>mV peak</td>
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<tr>
<td>Noise, Peak - Peak (2)</td>
<td>TYP 40 MAX 40</td>
<td>TYP 40 MAX 40</td>
<td>TYP 40 MAX 40</td>
<td>TYP 40 MAX 40</td>
<td>mV P-P</td>
</tr>
<tr>
<td>RMS Noise</td>
<td>TYP 10 MAX 6</td>
<td>TYP 150 MAX 6</td>
<td>TYP 150 MAX 6</td>
<td>TYP 150 MAX 6</td>
<td>mV RMS</td>
</tr>
<tr>
<td>Temperature Coefficient</td>
<td>TYP 50 MAX 150</td>
<td>TYP 50 MAX 150</td>
<td>TYP 50 MAX 150</td>
<td>TYP 50 MAX 150</td>
<td>ppm/°C</td>
</tr>
<tr>
<td>Short Circuit Protection to Common for all Outputs</td>
<td>Short Term Current Limit</td>
<td>Short Term Current Limit</td>
<td>Short Term Current Limit</td>
<td>Short Term Current Limit</td>
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</tr>
</tbody>
</table>

## 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.
General Specifications*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>All Models</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ON/OFF Function</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFF Logic Level or Tie Pin to -Input (7)</td>
<td>MAX</td>
<td>&lt; 0.4 VDC</td>
</tr>
<tr>
<td>Open Circuit Voltage</td>
<td>TYP</td>
<td>1.4 VDC</td>
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<tr>
<td>Input Resistance</td>
<td>TYP</td>
<td>2 kohms</td>
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<tr>
<td>Converter Idle Current ON/OFF Pin Low</td>
<td>TYP</td>
<td>6 mA</td>
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<td><strong>Isolation (8)</strong></td>
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<td>Isolation Voltage</td>
<td>MIN</td>
<td>700 VDC</td>
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<tr>
<td>Input to Output Leakage</td>
<td>MIN</td>
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<tr>
<td>Input to Output Capacitance</td>
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<td>375 pF</td>
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<td><strong>Output Trim Function</strong></td>
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<td></td>
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<tr>
<td>Trim Range</td>
<td>MIN</td>
<td>± 10 %</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>MIN</td>
<td>10 kohms</td>
</tr>
<tr>
<td>Open Circuit Voltage</td>
<td>TYP</td>
<td>2.5 VDC</td>
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<tr>
<td>Case Operating Range No Derating</td>
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<td>-40 °C</td>
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<tr>
<td>Case Functional Range (9)</td>
<td>MAX</td>
<td>85 °C</td>
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<tr>
<td>Storage Range</td>
<td>MIN</td>
<td>-55 °C</td>
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<td>Thermal Impedance (10)</td>
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<td>105 °C/Watt</td>
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<tr>
<td><strong>General</strong></td>
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<td>Unit Weight</td>
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<tr>
<td>Chassis Mounting Kit</td>
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<td>MS8</td>
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</table>

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

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.
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 (Vin = 5 V, 10 kHz to 1 MHz bw). See the discussion above for the optimum selection of C2.

![Figure 2](image)

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**

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

Panasonic HFG and HFQ Series
Suggested Part: 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 than 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 µF tantalum and 0.001 to 0.1 µF 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”.

Figure 4 shows the connection of the LV Single to your load without any external components required for most applications. 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.

L1 = 10µH
C1 = 100µF / 25V, ALUMINUM
C2 = 10µF / 25V, TANTALUM

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.
12 Watt LV Single Series DC/DC Converters

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.

![Remote Sense Circuit](image)

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 ±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.

![Output Trimming Circuit](image)

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 µF, 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 an 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?
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 (Tc=25°C, Vin=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%