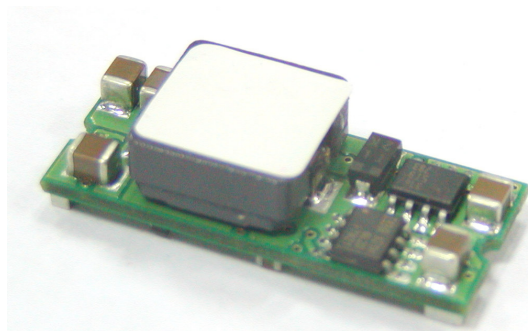


NON-ISOLATED DC-DC Converter

8.3-14Vin, 0.75- 5.0Vout, 10A

INSTALLATION / APPLICATION NOTE



PL10SMS-12C

Content

1. INTRODUCTION	3
2. MODELS	3
3. CONVERTER FEATURES	3
4. GENERAL DESCRIPTION	3
4.1 Electrical Description	3
4.2 Thermal Packaging and Physical Design	4
5. MAIN FEATURES AND FUNCTIONS	4
5.1 Operating Temperature Range	4
5.2 Over-Temperature Protection (OTP)	4
5.3 Output Voltage Adjustment	4
5.4 Safe Operating Area (SOA)	4
5.5 Over Current Protection	4
5.6 Remote ON/OFF	4
5.7 UVLO (Under-Voltage Lockout)	5
6. SAFETY	5
6.1 Input Fusing and Safety	5
7. APPLICATIONS	5
7.1 Layout Design	5
7.2 Convection Cooling	6
7.3 Thermal Considerations	6
7.4 Power De-Rating Curves	7
7.5 Efficiency vs Load Curves	9
7.6 Input Capacitance	11
7.7 Test Set-Up	11
7.8 Remote Sense Compensation	11
7.9 Output Voltage Adjustment	12
7.10 Output Ripple and Noise Measurement	12
7.11 Output Capacitance	12
7.12 SMS Reflow Profile	12
8. MECHANICAL	13
8.1 Outline Diagrams	13
8.2 SMS Tape and Reel Dimensions	13

1. Introduction

This application note describes the features and functions of Lambda's PL10SMS-12C series of Non Isolated DC-DC Converters. These "Point of Load" modules serve the needs specifically of the fixed and mobile telecommunications and computing markets. Capable of operating over a wide input voltage range of 8.3 –14VDC, this series provides a precise regulated output voltage within the range of 0.75V to 5.0Vdc. The operating ambient temperature range is –40°C to +85°C. Ultra-high efficiency operation is achieved through the use of synchronous rectification.

The modules are fully protected against short circuit and over-temperature conditions.

2. Models

Model	Input Voltage	Output Voltage	Output Current
PL10SMS-12C	8.3 – 14VDC	0.75 – 5.0VDC	10A

Table 1 – Models

Output Voltage	Output Current	Input Current (mA)		Efficiency typ.
		No Load	Full Load	
0.75V	10A	40	781mA	80%
1.2V	10A	50	1163mA	86%
1.5V	10A	50	1402mA	89%
1.8V	10A	60	1666mA	90%
2.0V	10A	60	1832mA	91%
2.5V	10A	60	2264mA	92%
3.3V	10A	70	2956mA	93%
5.0V	10A	70	4385mA	95%

Table 2 –Efficiency and Input Current

3. Converter Features

- High efficiency topology, typically 95% at 5.0Vdc
- Industry standard footprint
- Wide ambient temperature range, -40°C to +85°C
- Cost efficient open frame design
- Programmable output voltage via external resistor from 0.75 to 5.0Vdc
- No minimum load requirement (stable at all loads)
- Remote ON/OFF
- Remote sense compensation
- Fixed switching frequency
- Continuous short-circuit protection and over current protection
- Over-temperature protection (OTP)
- Monotonic Startup with pre-bias at the output.
- UL/IEC/EN60950 Certified.

4. General Description

4.1 Electrical Description

A block diagram of the converter is shown in Figure 1. The topology is based on a non-isolated synchronous buck converter. The control loop is optimized for unconditional stability, fast transient response and very tight line and load regulation. In a typical pre-bias application the converter does not draw any reverse current at start-up. The output voltage can be adjusted from 0.75 to 5.0vdc, using the TRIM pin with an external resistor. The converter can be shut down via a remote On/Off input that is referenced to ground. This input is compatible with readily available logic devices. A 'positive' logic input is supplied as standard. Positive logic implies that the converter is enabled if the remote On/Off input is high (or floating), and disabled if it is low.

The converter is protected against over-temperature conditions. If the converter is overloaded or the ambient temperature exceeds its specified operating range, the converter will shut down and re-start once the fault condition is removed.

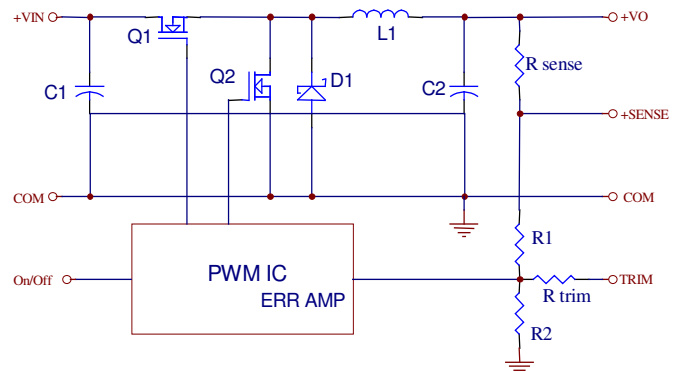


Figure 1. Electrical Block Diagram

4.2 Thermal Packaging and Physical Design

The converter uses a multi-layer FR4 PCB construction. All surface mount power components are placed on the opposite side; thus, the heat dissipation of the power components is optimized, ensuring that control components are not thermally stressed. The converter is an open-frame product and has no case or case pin. The open-frame design has several advantages over encapsulated closed devices; among these advantages are:

- **Efficient Thermal Management:** the heat is removed from the heat generating components without heating sensitive small signal control components.
- **Environmental:** Lead free open-frame converters are easily recycled.
- **Cost Efficient:** No encapsulation. Cost efficient open-frame construction.
- **Reliable:** Efficient cooling provided by open frame construction, offers high reliability.

5. Main Features and Functions

5.1 Operating Temperature Range

The converters operate over a wide ambient temperature environment (-40°C to 85°C). Due consideration must be given to the de-rating curves when determining the maximum power that can be drawn from the converter. The maximum power drawn is influenced by a number of factors, such as:

- Input voltage range.
- Output load current.
- Air velocity (forced or natural convection).
- Mounting orientation of converter PCB with respect to the airflow.
- Motherboard PCB design, especially ground and power planes; these can be effective heat sinks for the converter.

5.2 Over-Temperature Protection (OTP)

The converters are equipped with non-latching over-temperature protection. A temperature sensor is located at the hottest point within the converter, typically on top of the switching device. If the temperature exceeds a threshold of 120°C (typical) the converter will shut down, disabling the output. When the temperature has decreased to a safe operating range, the converter will automatically start.

The over-temperature condition can be induced by a variety of reasons such as an external overload condition or a system fan failure.

5.3 Output Voltage Adjustment

Section 7.9 describes in detail as to how to trim the output voltage with respect to its set point. The output voltage on all models is adjustable over the range of 0.75 – 5.0Vdc.

5.4 Safe Operating Area (SOA)

Figure 2 provides a graphical representation of the Safe Operating Area (SOA) of the converter. This representation assumes ambient operating conditions such as airflow are met as per thermal guidelines provided in Sections 7.2 and 7.3.

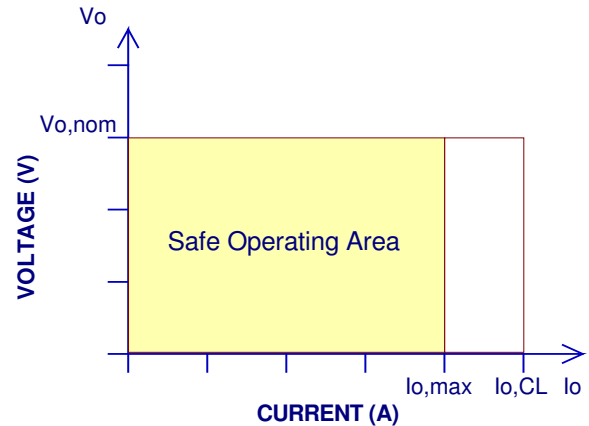


Figure 2. Maximum Output Current Safe Operating Area

5.5 Over Current Protection

All models have short-circuit and over current protection. The converter will automatically recover once either condition is removed. It will also supply up to 150% of its rated output current. In the event of an over current condition the converter will go into a hiccup mode protection.

5.6 Remote ON/OFF

Positive Logic- The remote ON/OFF input feature of the converter allows external circuitry to turn the converter ON or OFF. Active-high remote ON/OFF is available as standard. The converters are turned 'on' if the remote ON/OFF pin is high (=Vin), or left open. Setting the pin low (0.4Vdc) will turn the converter 'off'. The signal level of the remote on/off input is defined with respect to ground. If remote on/off is not needed, leave the remote on/off pin disconnected and the module will be on.

Negative Logic- Designated with a suffix "N" is the Negative remote on ON/OFF version. The unit is 'off' if this voltage level is above 2.8Vdc. The converter is 'on' if the on/off pin is low (<0.4Vdc) or left open. The recommended remote on/off drive circuits are shown in figures 3 and 4.

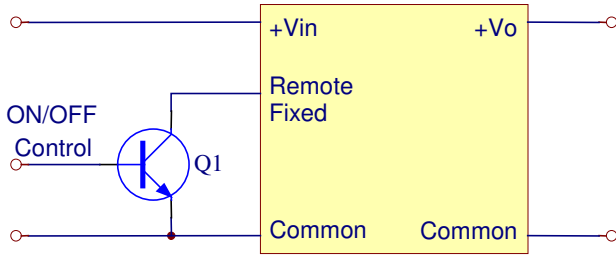


Figure 3. Positive Remote ON/OFF Input Drive Circuit

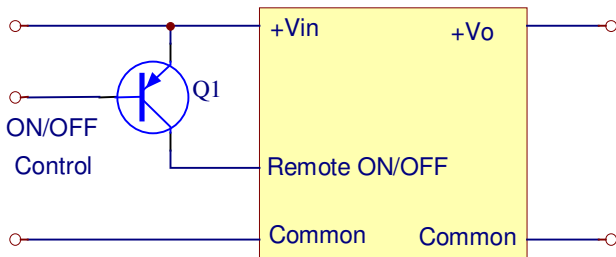


Figure 4. Negative Remote ON/OFF Input Drive Circuit

5.7 UVLO (Under-Voltage Lockout)

When the input Vcc rises above approximately 8.0V, the converter initiates a soft start. The UVLO function in the converter has a hysteresis of approximately 300mV to provide noise immunity at start-up.

6. Safety

6.1 Input Fusing and Safety

These products are approved to UL 60950-1:2003, CAN/CSA C22.2 NO.60950-1:2003 and IEC/EN60950-1:2001.

These products are designed to be PCB mounted and for use within other equipment or enclosures. For safe installation and operation, carefully follow the instructions below:

Do not install, test, or operate the products near water or spill liquid on them.

Do not operate these products unless they are securely fastened.

These products must be installed in a restricted access location accessible to authorized personnel only.

These products must be professionally installed in accordance with the prevailing electrical wiring regulations and safety standards.

The output power taken from the unit must not exceed the ratings stated in the catalog datasheet.

Ensure adequate ventilation is provided to allow air to circulate.

This product has functional insulation between input and output and therefore the DC source to this product must be reinforced or double insulated to the AC input in accordance with IEC/EN 60950-1 to achieve SELV output.

Fusing – External ceramic sand-filled fuse, 250V, **F20A**, HBC.

7. Applications

7.1 Layout Design

In optimizing thermal design the PCB is utilized as a heat sink. Some heat is transferred from the module to the main board through connecting pins. The system designer or the end user must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved.

Low resistance and low inductance PCB layout traces are the norm and should be used where possible. Consideration must also be given to proper low impedance traces between the power module, input and output grounds. The recommended footprint is shown in figure 5.

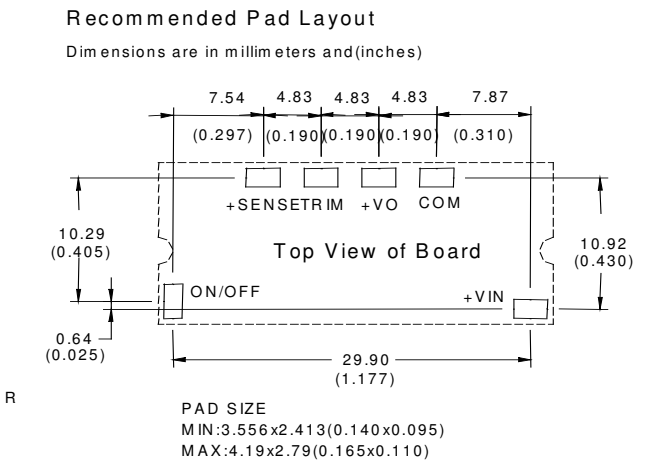


Figure 5. Recommended Footprint

7.2 Convection Cooling

To predict the approximate cooling needed for the module, refer to the Power De-rating curves in Figure 7. These de-rating curves are approximations of the ambient temperatures and airflow required to keeping the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module's temperature should be checked as shown in Figure 6 to ensure it does not exceed 110°C.

Proper cooling can be verified by measuring the power module's temperature at Q1-pin 6 as shown in Figure 7.

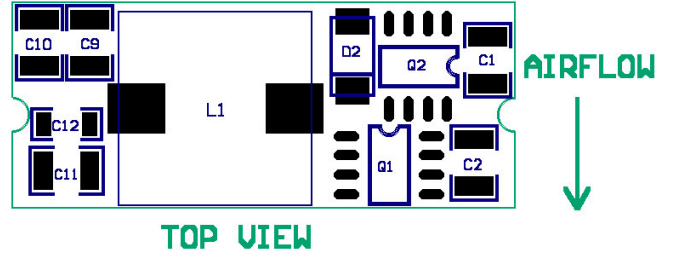
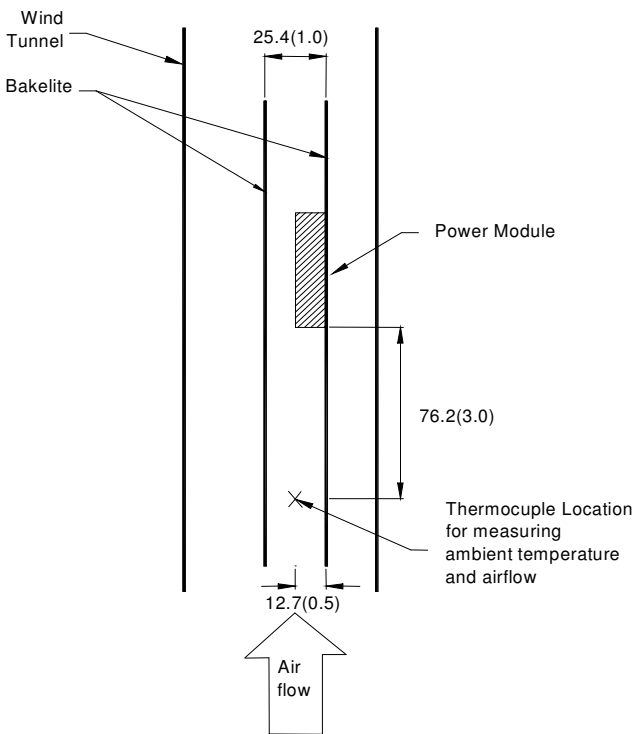


Figure 7. Temperature Measurement Location

7.3 Thermal Considerations

The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed to the surrounding environment by conduction, convection, and radiation. The thermal data presented is based on measurements taken in a set-up as shown in Figure 6. Figure 8 represents the test data. Note that the airflow is parallel to the long axis of the module as shown in Figure 6. The temperature should not exceed 110 °C. The output power of the module should not exceed the rated power for the module (VO, set x IO, max).



Note: Dimensions are in millimeters and (inches)

Figure 6. Thermal Test Setup

7.4 Power De-Rating Curves

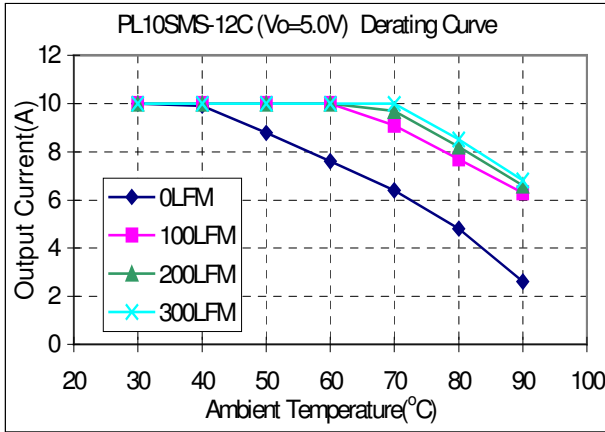


Figure 8a. Typical Power De-rating for 12V IN 5.0Vout

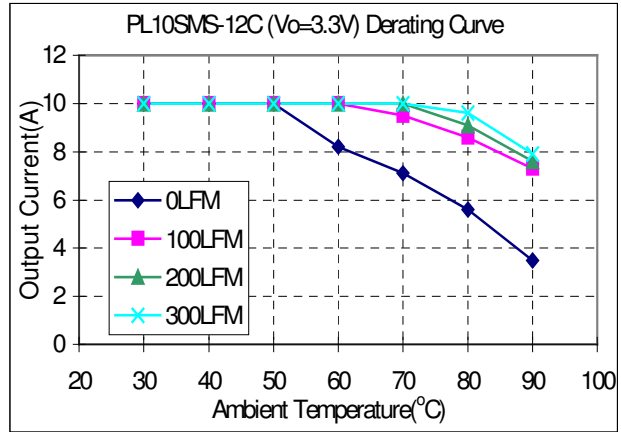


Figure 8b. Typical Power De-rating for 12V IN 3.3Vout

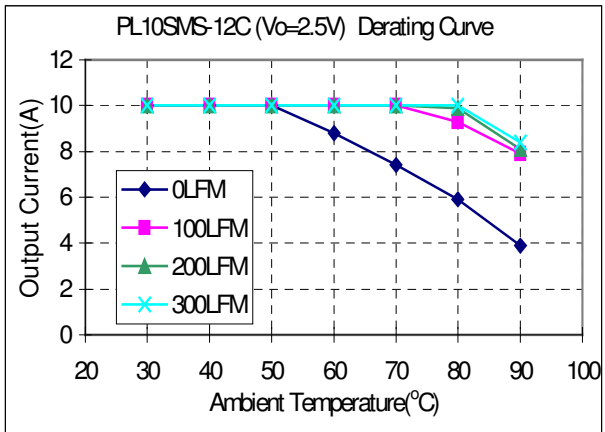


Figure 8c. Typical Power De-rating for 12V IN 2.5Vout

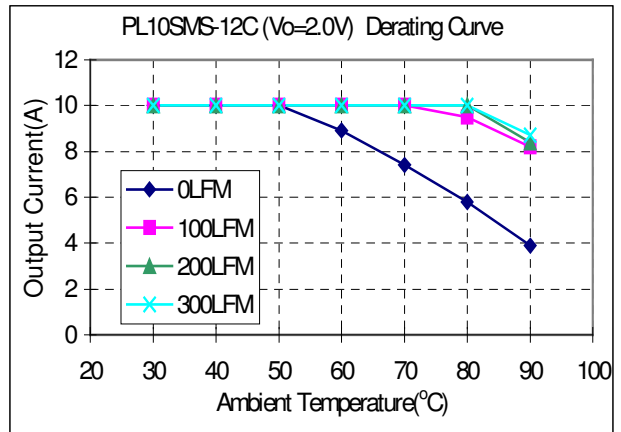


Figure 8d. Typical Power De-rating for 12V IN 2.0Vout

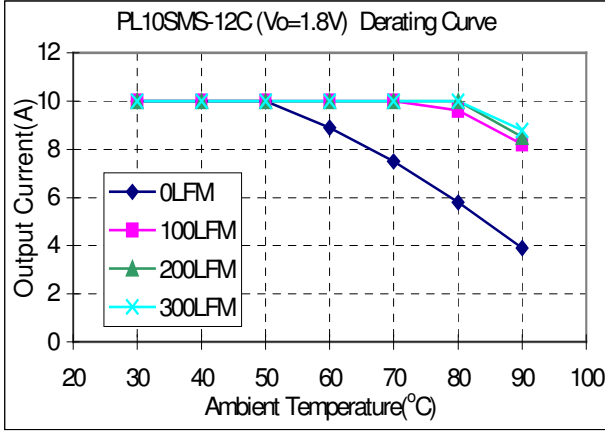


Figure 8e. Typical Power De-rating for 12V IN 1.8Vout

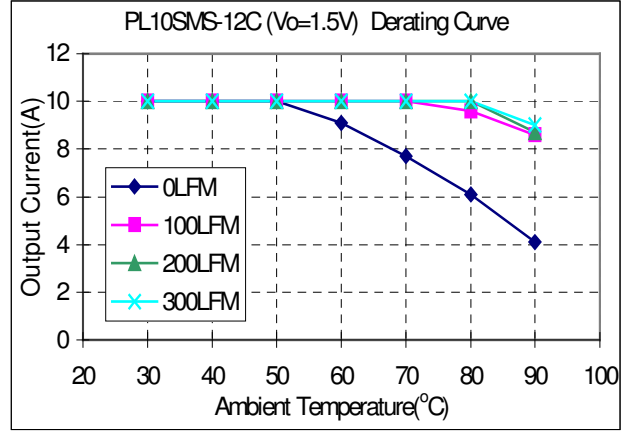


Figure 8f. Typical Power De-rating for 12V IN 1.5Vout

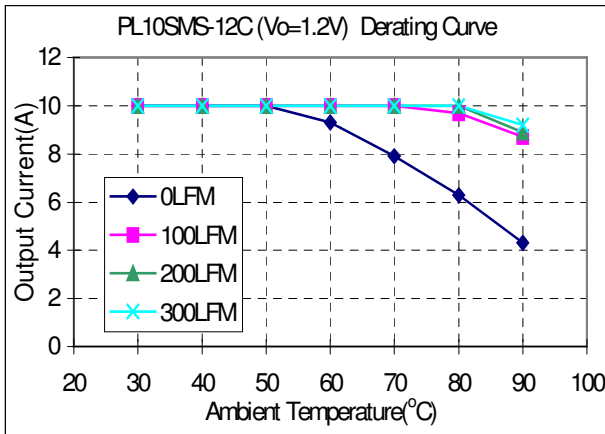


Figure 11g. Typical Power De-rating for 12V IN 1.2Vout

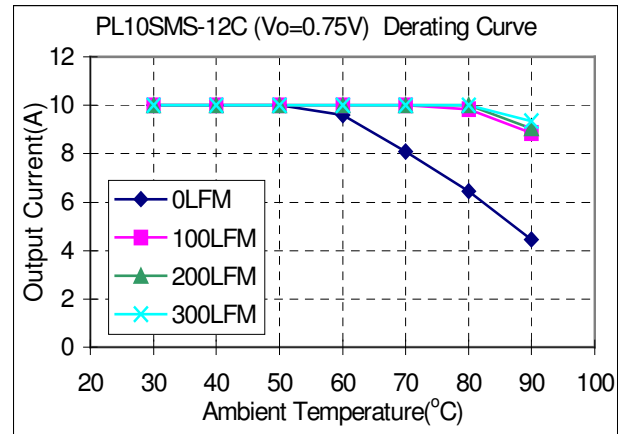
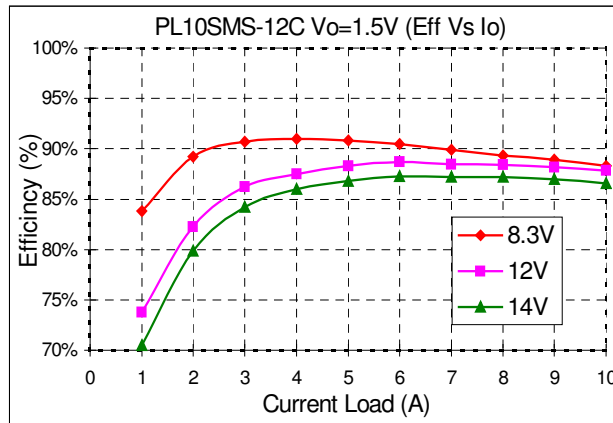
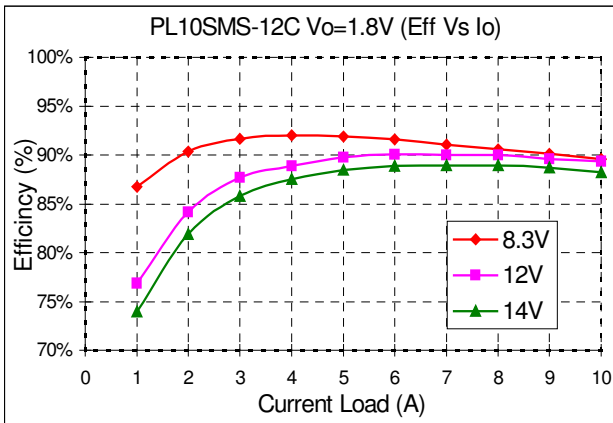
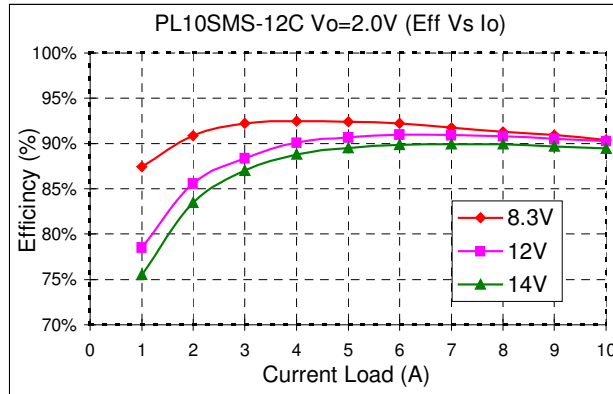
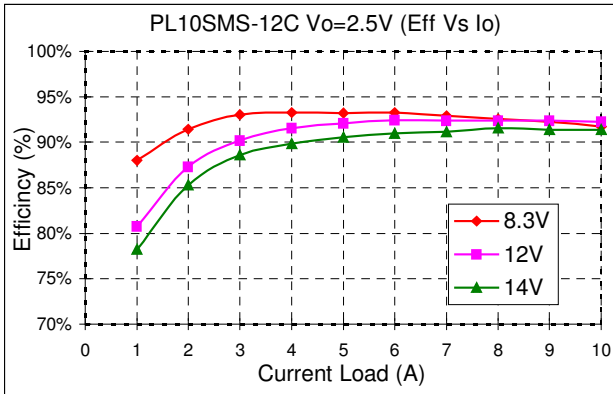
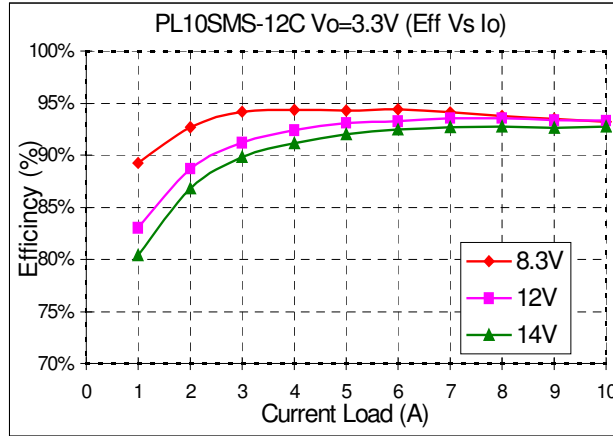
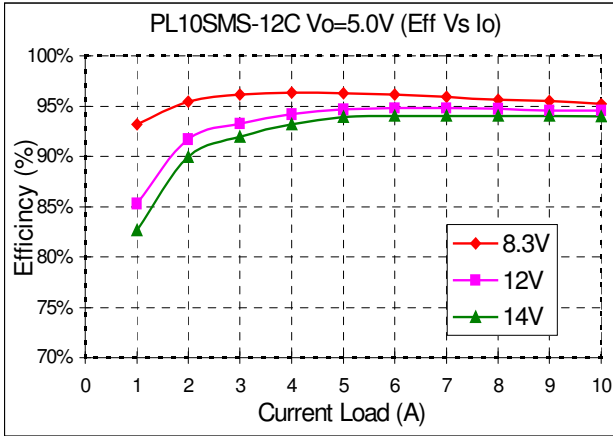
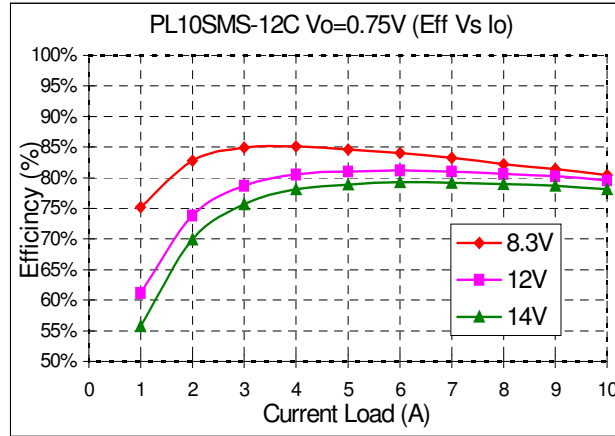
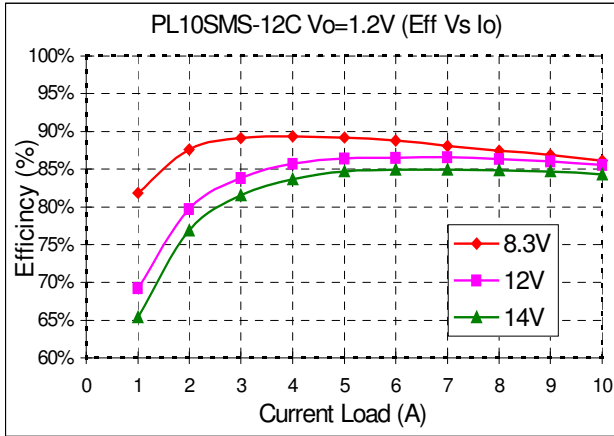


Figure 11h. Typical Power De-rating for 12V IN 0.75Vout

7.5 Efficiency vs Load Curves





7.6 Input Capacitance

The converters must be connected to a low source impedance to avoid problems with loop stability. The input capacitors should be placed close to the converter's input pins to reduce distribution inductance. Input capacitors should have a high capacitance and a low ESR (typically <100m ohms) for suitable ripple handling capability. Electrolytic capacitors should be avoided. The circuit as shown in Figure 9 represents typical measurement methods for ripple current. Input reflected-ripple current is measured with a simulated source inductance of 1uH. Current is measured at the input of the module.

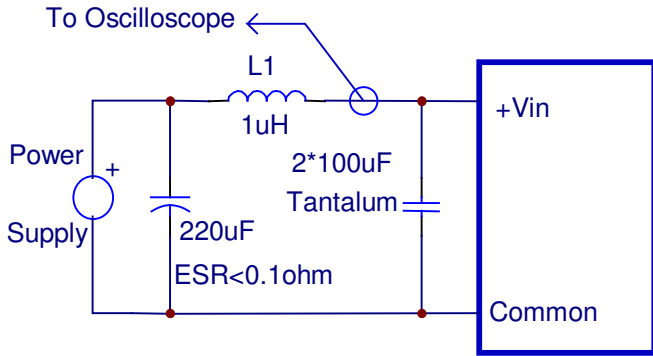


Figure 9. Input Reflected-Ripple Test Setup

7.7 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure 10. This converter is non-isolated; therefore, the input and output share a common ground. These grounds should be connected together via a low impedance ground plane in the application circuit. When bench testing a converter, ensure that -Vin and -Vo are connected together via a low impedance short to ensure proper efficiency and load regulation measurements. When testing the converter under any transient conditions, please ensure that the transient response of the source is sufficient to power the equipment under test.

The value of efficiency is defined as:

$$\eta = \frac{V_o \times I_o}{V_{in} \times I_{in}} \times 100\%$$

Where: Vo is output voltage,
Io is output current,
Vin is input voltage,
Iin is input current.

The value of load regulation is defined as:

$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

Where: V_{FL} is the output voltage at full load
V_{NL} is the output voltage at no load

The value of line regulation is defined as:

$$Line.reg = \frac{V_{HL} - V_{LL}}{V_{LL}} \times 100\%$$

Where: V_{HL} is the output voltage of maximum input voltage at full load.
V_{LL} is the output voltage of minimum input voltage at full load.

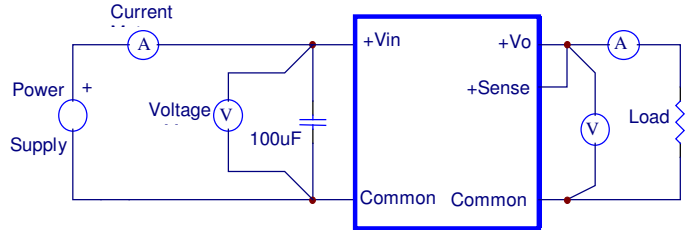


Figure 10 Test Setup

7.8 Remote Sense Compensation

The use of Remote Sense helps maintain the proper output voltage at load. It minimizes the effects of distribution losses such as drops across the connectors and PCB traces (see Figure 11). The maximum drop from the output pin to the load should not exceed 500mV for remote sense compensation to work.

The amount of power delivered by the module is defined as the output voltage multiplied by the output current (Vo x Io).

When using TRIM UP, the output voltage of the module will increase. Make sure that the maximum output power of the module remains at or below the maximum rated power.

When the Remote Sense feature is not being used, the remote sense pin should be disconnected.

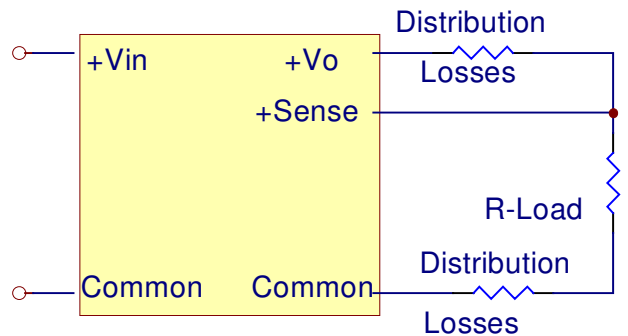


Figure 11. Circuit Configuration for Remote Sense Operation

7.9 Output Voltage Adjustment

The output Voltage of the converters can be adjusted in the range 0.75V to 5.0V by adding an external resistor (shown as Rtrim) in Figure 12. When the trim-up resistor is not connected, the output voltage defaults to 0.75V.

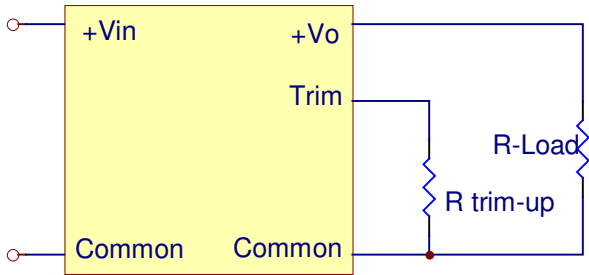


Figure 12. Trim-up Voltage Setup

The value of Rtrim-up defined as:

$$R_{trim} = \left(\frac{10500}{V_o - 0.75} - 1000 \right)$$

Where: Rtrim-up is the external resistor in ohms,
Vo is the desired output voltage

To give an example of the above calculation, to set a voltage of 3.3Vdc, Rtrim is given by:

$$R_{trim} = \left(\frac{10500}{3.3 - 0.75} - 1000 \right)$$

Rtrim-up = 3.117K ohms

For various output voltages, the resistance values provided in Table 3.

Vo,set (V)	Rtrim (kohms)
0.75	Open
1.20	22.33
1.50	13.0
1.80	9.0
2.00	7.4
2.50	5.0
3.30	3.12
5.0	1.47

Table 3 – Trim Resistor Values

7.10 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 13. A coaxial cable with a 50 ohm termination was used to prevent impedance mismatches.

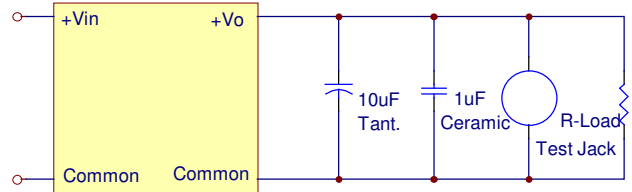


Figure 13. Output Voltage Ripple and Noise Measurement Set-Up

7.11 Output Capacitance

Lambda's converters provide a stable output with or without external capacitors. For good transient response, low ESR output capacitors should be located close to the load.

The converters are designed to work with a load capacitance of up to 8,000uF. It is recommended that any additional capacitance be a maximum of 8,000uF and have a low ESR. The capacitor should be connected close to the load.

7.12 SMS Reflow Profile

An example of the SMS reflow profile is given in Figure 14.

Equipment used: SMD HOT AIR REFLOW HD-350SAR

Alloy: AMQ-M293TA or NC-SMQ92 IND-82088 SN63

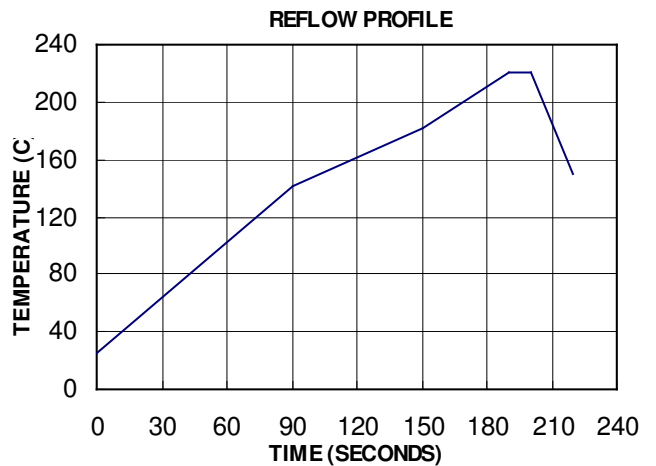


Figure 14 SMS Reflow Profile

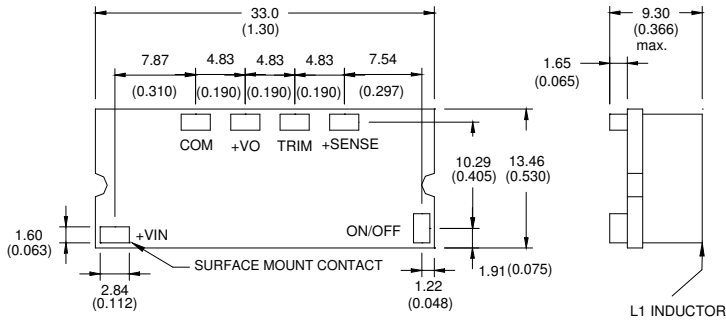
8. Mechanical

8.1 Outline Diagrams

Dimensions are in millimeters and inches

Tolerance: x.xx ±0.02 in. (0.5mm), x.xxx ±0.010 in. (0.25 mm) unless otherwise noted

BOTTOM VIEW OF BOARD



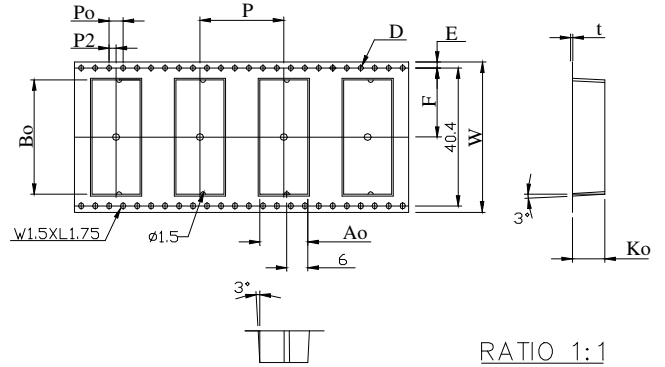
Dimensions are in millimeters(Inches)

Tolerances :X.X; Ø 0.5mm(0.02in),X.XX; Ø 0.25mm(0.010in),unless otherwise noted.

Figure 14 Mechanical Outline

8.2 SMS Tape and Reel Dimensions

The tape reel dimensions for the SMS module is shown in Figure 15.



ITEM	SPEC
W	44.00 ^{+0.30} _{-0.30}
Ao	13.70 ^{+0.10} _{-0.10}
B0	33.50 ^{+0.10} _{-0.10}
Ko	9.30 ^{+0.10} _{-0.10}
P	24.00 ^{+0.10} _{-0.10}
F	20.20 ^{+0.10} _{-0.10}
E	1.75 ^{+0.10} _{-0.10}
D	1.50 ^{+0.10} _{-0.00}
D1	2.00 ^{+0.25} _{-0.00}
Po	4.00 ^{+0.10} _{-0.10}
P2	2.00 ^{+0.10} _{-0.10}
t	0.40 ^{+0.06} _{-0.06}

Figure 15 – SMS Tape and Reel Dimensions