Intronics Power Inc.®
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S SERIES DC/DC MODULES

Applications

- Servers, Switches and Data Storage
- Wireless Communications
- Distributed Power Architecture
- Semiconductor Test Equipment
- Networking Gear
- Data Communications
- Telecommunications
- Industrial / Medical

The S Families of high efficiency non-isolated DC/DC converters offer power levels of up to 80 Watt, which exceeds that of other Industry-standard SMT and Through-Hole SIPs with the same package, while also providing ultra-wide input voltage range for 3.3Vin and 5Vin. These converters provide versatility without sacrificing the board space. All models feature an input filter and regulated outputs. The open-frame construction facilitates maximum power delivered with the highest efficiency of up to 95%. All converters combine creative design practices with highly derated power devices to achieve very high reliability, high performance and low cost solution to systems designers.

Specifications & Features Summary

- Industry Standard SIP or SMT Pinout
- High Efficiency to 95%
- Ultra-Wide Input Voltage Range
- User-Adjustable Outputs (S10-12S5, S15 & S16 Models)
- Over Temperature Protection
- Continuous Short Circuit Protection
- Remote ON/OFF
- Pending UL Approval
- **PLEASE ADD SUFFIX "T" FOR THROUGH-HOLE PACKAGE**
- **PLEASE ADD SUFFIX "N" FOR NEGATIVE LOGIC CONTROL[5]**

MODEL NUMBER	INPUT VOLTAGE	OUTPUT VOLTAGE	OUTPUT CURRENT	INPUT CURRENT NO LOAD	INPUT CURRENT FULL LOAD	% EFF	PACKAGE
S10-5S1.0	3.0 –5.5VDC	1.0 Vdc	10 A	50 mA	2353mA	85	SIP / SMT
S10-5S1.2	3.0 –5.5VDC	1.2 Vdc	10 A	50 mA	2791mA	86	SIP / SMT
S10-5S1.5	3.0 –5.5VDC	1.5 Vdc	10 A	50 mA	3409mA	88	SIP / SMT
S10-5S1.8	3.0 –5.5VDC	1.8 Vdc	10 A	50 mA	4000mA	90	SIP / SMT
S10-5S2.0	3.0 –5.5VDC	2.0 Vdc	10 A	60 mA	4396mA	91	SIP / SMT
S10-5S2.5	3.0 –5.5VDC	2.5 Vdc	10 A	60 mA	5376mA	93	SIP / SMT
S10-5S3.3	4.5 –5.5VDC	3.3 Vdc	10 A	60 mA	6947mA	95	SIP / SMT
S10-12S5	8.3 –14.0VDC	0.75-5Vdc	10 A	Various	Various	93 max.	SIP / SMT
S15-5S3.3	3.0 –5.5VDC	0.9-3.63 Vdc	15 A	Various	Various	94 max.	SIP / SMT
S16-12S5	9.0 –14.0VDC	0.75-5Vdc	16A	Various	Various	94 max.	SIP / SMT

Typical at Ta= +25 °C under nominal input voltages of 5V and 12VDC, unless noted. The information and specifications contained in this brief are believed to be accurate and reliable at the time of publication. Specifications are subject to change without notice. Refer to product specification sheet for performance characteristics and application guidelines.

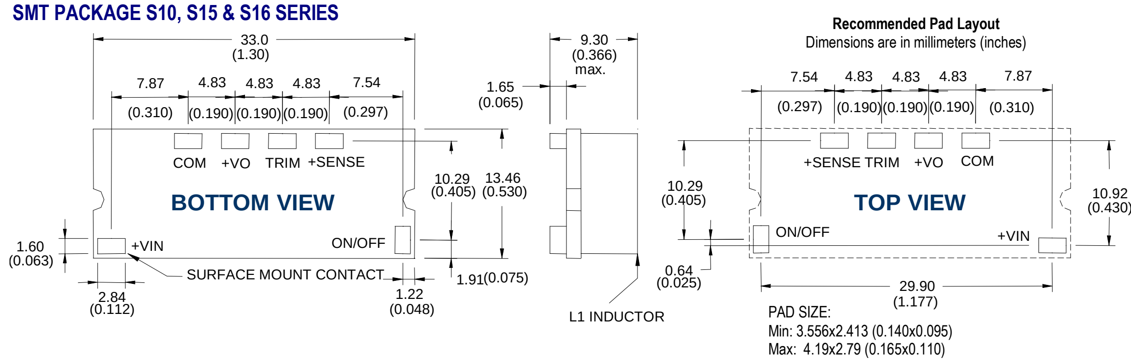
Consult factory for hundreds of other available input/output voltage

INPUT SPECIFICATIONS	
Under Voltage Lockout Power-Up/Power-Down (S10 & S15)	2.8V typ. / 2.7V typ.
S10-12S5	8.0V typ. / 7.7V typ.
S16-12S5	8.5V typ. / 8.0V typ.
Input Filter Type	Capacitive
Positive Remote on/off Control: Module ON	Open Circuit or Vin High
Module OFF	<0.4Vdc

OUTPUT SPECIFICATIONS	
Voltage Accuracy	±1.5% max.
Transient Response: 25% Step Load Change	<200u sec.
Ripple and Noise, 20MHz BW, **Note 3**	
S10 / S15 - 20mV rms max. (50mV pk-pk max).	**S16 -** 30mV rms max.(75mV pk-pk max)
Temperature Coefficient	±0.03%/C max.
Short Circuit Protection	Continuous
Line Regulation, **Note1**	±0.2% max., (SMT S15 is ±0.4% max)
Load Regulation, **Note2**	±0.5% max.
External Trim Adj. Range (S10 Family)	±10%
Efficiency	See Table
Isolation Voltage	Not Isolated
Switching Frequency	300KHz typ.
Over Temperature Protection	120°C typ., 130°C for S16
Operating Ambient Temperature Range	-40°C to +85°C
Derating Temperature	See Application Notes
Storage Temperature Range	-55°C to +125°C
Dimensions: (Through-Hole Package) S10/S15	2"x0.5"x0.33" (50.8x12.7x8.3 mm)
(Through-Hole Package) S10-12S5 & S16	2"x0.512"x0.327" (50.8x13.0x8.3 mm)
(SMT Package)	1.3"x0.53"x0.366" (33.00x13.46x9.3 mm)
Structure	Non-potted With Open Frame Type

NOTES	
1. Measured from High Line to Low Line	S15(S16) Family Vo, set =1.8(3.3)Vdc
2. Measured from Full Load to Zero Load	S15/16 Family Vo, set =3.3Vdc
3. Measured with 10uf tantalum cap & 1uf ceramic cap across output.	
4. 100uf, ESR <20mΩ (S10/S15) or <100mΩ (S10-12S5/S16)Cap across Vin recommended	
5. Suffix "N" to the Model Number with Negative	Module ON – Open Circuit or <0.4Vdc

SMT PACKAGE S10, S15 & S16 SERIES



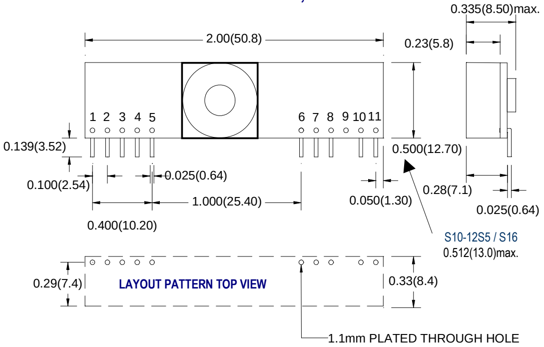
S10-12S5 & S16-12S5 External Resistor Values for programming output voltage

Vo,set (V)	Rtrim (KΩ)
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
5.00	1.47

S15-5S3.3 External Resistor Values for programming output voltage

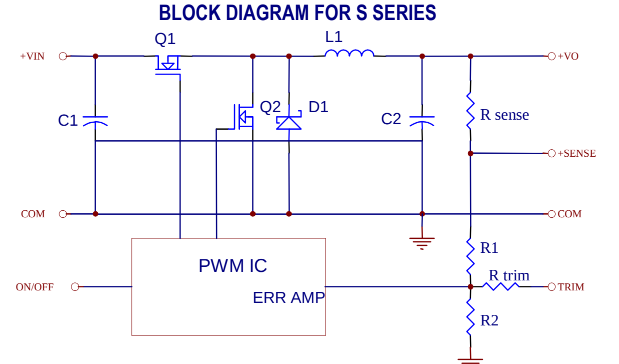
Vo,set (V)	Rtrim (KΩ)
0.90	135.36
1.00	79.17
1.20	41.71
1.50	22.98
1.80	14.96
2.00	11.75
2.50	6.93
3.30	3.15

TRHOUGH – HOLE PACKAGE S10"T", S15 & S16"T" SERIES



PIN CONNECTION	
Pin	FUNCTION
1	+Output
2	+Output
3	+Sense
4	+Output
5	Common
6	Common
7	+V Input
8	+V Input
9	No Pin
10	Trim
11	On/Off Control

BLOCK DIAGRAM FOR S SERIES



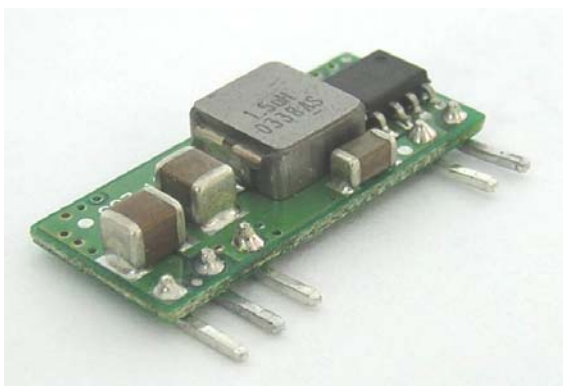
Dimensions are in inches (millimeters)

Tolerances: X.X ±0.5mm(0.02"), X.XX ±0.25mm(0.010"), unless otherwise noted.

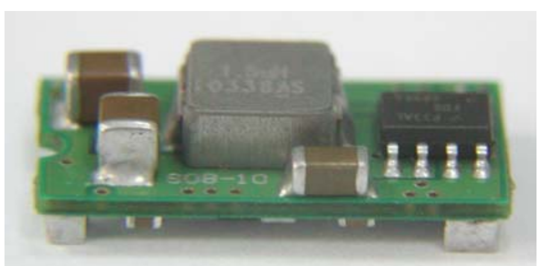
NON-ISOLATED DC-DC Converter

S5-5S3.3T, S5-5S3.3
3.0-5.5Vin, 0.75- 3.63Vout, 5A

APPLICATION NOTE
Ver10



S5-5S3.3T (Suffix "T" Indicates Through-Hole Version)



S5-5S3.3

Content

1. Introduction

This application note describes the features and functions of Intronics' S5 series of Non Isolated DC-DC Converters. These are highly efficient, reliable and compact, high power density, single output DC/DC converters. These "Point of Load" modules serve the needs specifically of the fixed and mobile telecommunications and computing market, employing economical distributed Power Architectures. The S5 series provide precisely regulated output voltage range from 0.75V to 3.63Vdc over a wide range of input voltage (Vi=3.0 – 5.5Vdc) and can operate over an ambient temperature range of –40℃ to +85℃. Ultra-high efficiency operation is achieved through the use of synchronous rectification and drive control techniques.
The modules are fully protected against short circuit and over-temperature conditions. Intronics' world class automated manufacturing methods, together with an extensive testing and qualification program, ensure that all S5 series converters are extremely reliable.

2. Models

The adjustable S5 series models are shown in table1.

Model	Input Voltage	Output Voltage	Output Current
S5-5S3.3T	3.0 – 5.5VDC	0.75 – 3.63VDC	5A
S5-5S3.3	3.0 – 5.5VDC	0.75 – 3.63VDC	5A

Table 1 – S5 Series Models

The S5 SERIES efficiency and input current at 5.0Vin are shown in table2.

Output Voltage	Output Current	Input Current (mA)		Efficiency typ.
		No Load	Full Load	
0.75V	5A	25	0.949	79%
1.2V	5A	30	1.412	85%
1.5V	5A	30	1.724	87%
1.8V	5A	35	2.022	89%
2.0V	5A	35	2.222	90%
2.5V	5A	35	2.217	92%
3.3V	5A	35	3.511	94%

Table 2 – S5 Series Efficiency and Input Current

3. 5A SIP/SMT Converter Features

- High efficiency topology, typically 94% at 3.3Vdc
- Industry standard footprint
- Wide ambient temperature range, -40C to +85C
- Cost efficient open frame design
- Programmable output voltage via external resistor from 0.75 to 3.63Vdc
- 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 S5 Series converter is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of synchronous rectification and drive techniques. Essentially, the powerful S5 series topology is based on a non-isolated synchronous buck converter. The control loop is optimized for unconditional stability, fast transient response and a very tight line and load regulation. In a typical pre-bias application the S5 series converters do not draw any reverse current at start-up. The output voltage can be adjusted from 0.75 to 3.63vdc, using the TRIM pin with a external resistor. The converter can be shut down via a remote ON/OFF input that is referenced to ground. This input is compatible with popular 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 also protected against over-temperature conditions. If the converter is overloaded or the ambient temperature gets too high, the converter will shut down to protect the unit.

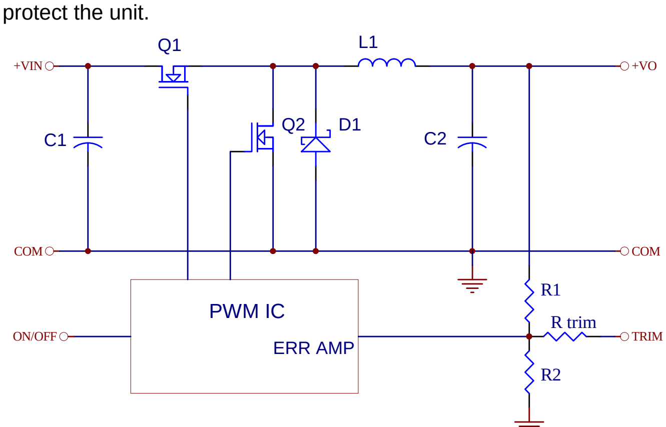


Figure 1. Electrical Block Diagram

4.2 Thermal Packaging and Physical Design.

The S5 series uses a multi-layer FR4 PCB construction. All surface mount power components are placed on one side of the PCB, and all low-power control components are placed on the other 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 more sensitive, small signal control components.
- **Environmental:** Lead free open-frame converters are more easily re-cycled.
- **Cost Efficient:** No encapsulation**.** Cost efficient open-frame construction.
- **Reliable:** Efficient cooling provided by open frame construction offers high reliability and easy diagnostics.

5. Main Features and Functions

5.1 Operating Temperature Range

Intronics' S5 series converters highly efficient converter design has resulted in its ability to operate over a wide ambient temperature environment (-40℃ to 85℃). Due consideration must be given to the de-rating curves when ascertaining 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 S5 Series converters are equipped with non-latching over-temperature protection. A temperature sensor monitors the temperature of the hot spot (typically, top switch). If the temperature exceeds a threshold of 120°C (typical) the converter will shut down, disabling the output. When the temperature has decreased the converter will automatically restart.
The over-temperature condition can be induced by a variety of reasons such as external overload condition or a system fan failure.

5.3 Output Voltage Adjustment

Section 7.8 describes in detail as to how to trim the output voltage with respect to its set point. The output voltage on all models is trimmable in the range 0.75 – 3.63Vdc.

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.

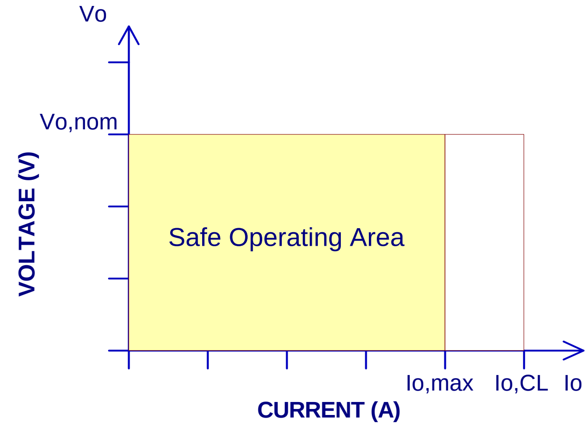


Figure 2. Maximum Output Current Safe Operating Area

5.5 Over Current Protection

All different voltage models have a full continuous short-circuit protection. The unit will auto recover once the short circuit is removed. To provide protection in a fault condition, the unit is equipped with internal over-current protection. The unit operates normally once the fault condition is removed. The power module will supply up to 150% of rated current. In the event of an over current converter will go into a hiccup mode protection.

5.6 Remote ON/OFF

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 S5 series converters are turned on if the remote ON/OFF pin is high, or left open or floating. Setting the pin low will turn the converter 'Off'. The signal level of the remote on/off input is defined with respect to ground. If not using the remote on/off pin, leave the pin open (module will be on). The part number suffix "N" is Negative remote ON/OFF version. The unit is guaranteed OFF over the full temperature range if this voltage level exceeds 2.8Vdc. The converters are turned on If the on/off pin input is low or left open. The recommended SIP/SMT remote on/off drive circuit as shown as figure 3, 4.

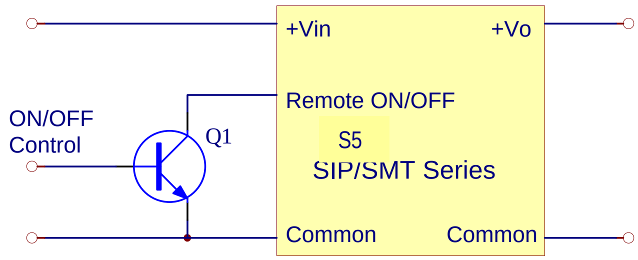


Figure 3. Positive Remote ON/OFF Input Drive Circuit

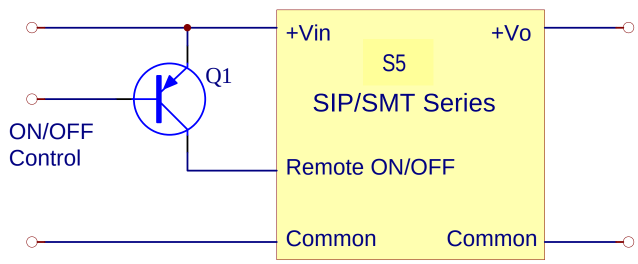


Figure 4. Negative Remote ON/OFF Input Drive Circuit

5.7 UVLO (Under-Voltage Lockout)

The voltage on the Vcc pin determines the start of the operation of the Converter. When the input Vcc rises and exceeds about 2.0V the converter initiates a soft start. The UVLO function in the converter has a hysteresis (about 100mV) built in to provide noise immunity at start-up.

6. Safety

6.1 Input Fusing and Safety Considerations.

Agency Approvals: The power Supply shall be submitted to and receive formal approval from the following test agencies.

1.The power supply shall be approved by a nationally recognized testing laboratory to UL/CSA 60950 3rd Edition (North America) and EN60950 (International)

2. CB Certificate from an internationally recognized test house in accordance with EN 60950.

The S5 series converters do not have an internal fuse. However, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a time-delay fuse with a maximum rating of 10A.

7. Applications

7.1 Layout Design Challenges.

In optimizing thermal design the PCB is utilized as a heat sink. Also some heat is transferred from the SIP/SMT 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 S5 series 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. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended SIP/SMT footprint as shown as figure 5, 6.

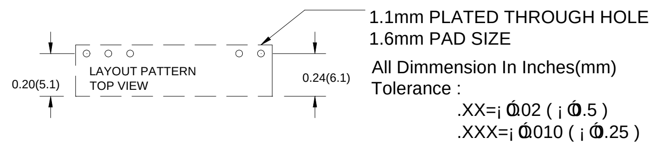


Figure 5. Recommended SIP Footprint

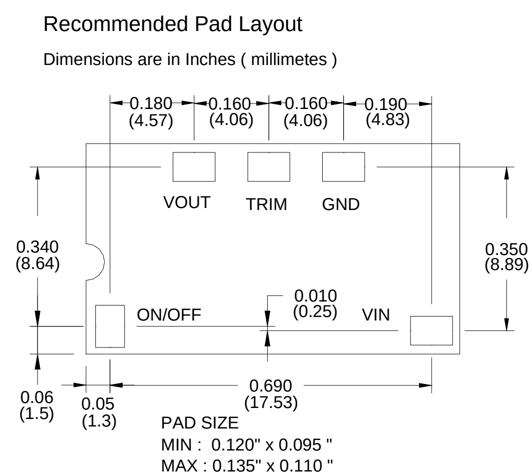
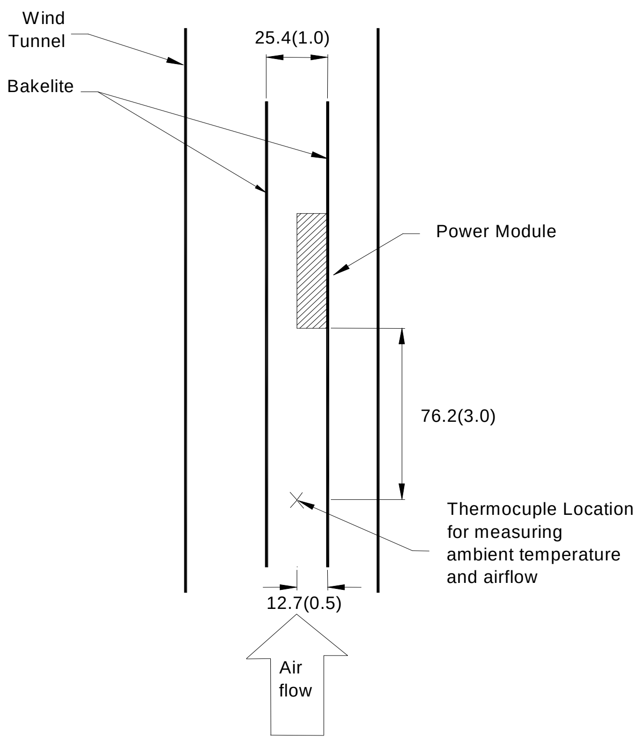


Figure 6. Recommended SMT Footprint (Top View)

7.2 Convection Requirements for Cooling

To predict the approximate cooling needed for the module, refer to the Power De-rating curves in Figures 10 to 13 . These de-rating curves are approximations of the ambient temperatures and airflows required to keep 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 7 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 8,9.



Note : Dimensions are in millimeters and (inches)

Figure 7. Thermal Test Setup

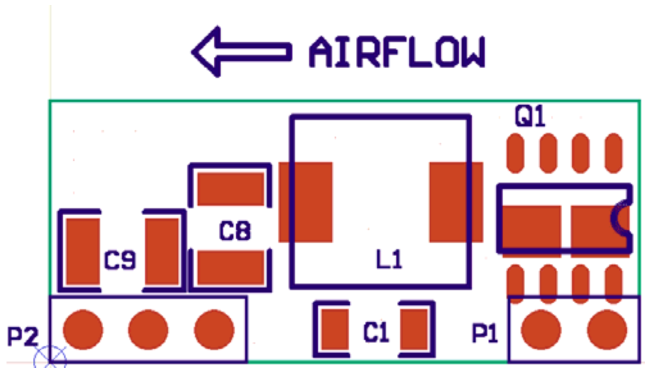


Figure 8. Temperature Measurement Location for SIP

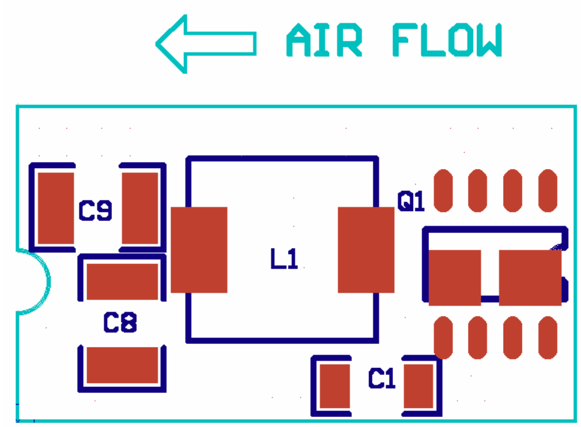


Figure 9. Temperature Measurement Location for SMT

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 by conduction, convection, and radiation to the surrounding environment. The thermal data presented is based on measurements taken in a set-up as shown in Figure7. Figures 10 to 13 represent the test data. Note that the airflow is parallel to the long axis of the module as shown in Figure7 for the SIP/SMT. The temperature at either location 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). The SMT Version of S5 Family thermal data presented is based on measurements taken in a wind tunnel. The test setup shown in Figure 7 and EUT need to solder on 33mm x 40.38mm(1.300" x 1.59") test pcb. Note that airflow is parallel to the long axis of the module as shown in Fig7.

7.4 Power De-Rating Curves

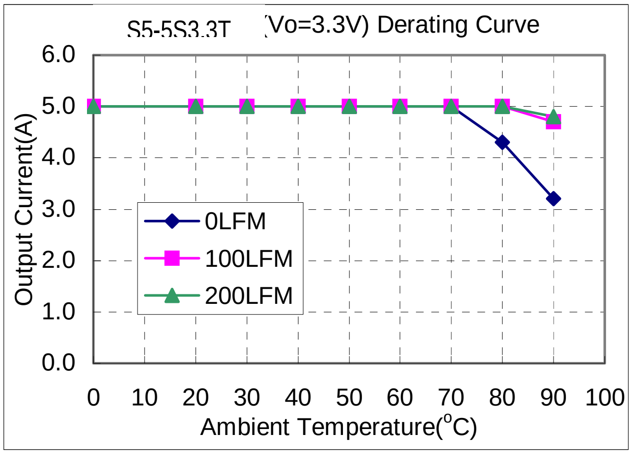


Figure10a.Typical Power De-rating for 5.0V IN 3.3Vout

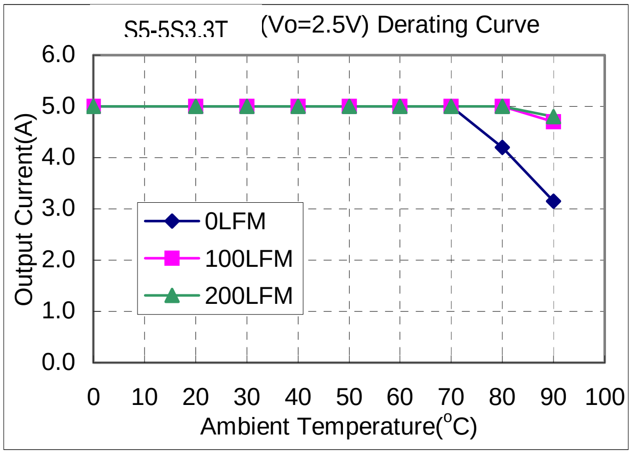


Figure 10b.Typical Power De-rating for 5.0V IN 2.5Vout

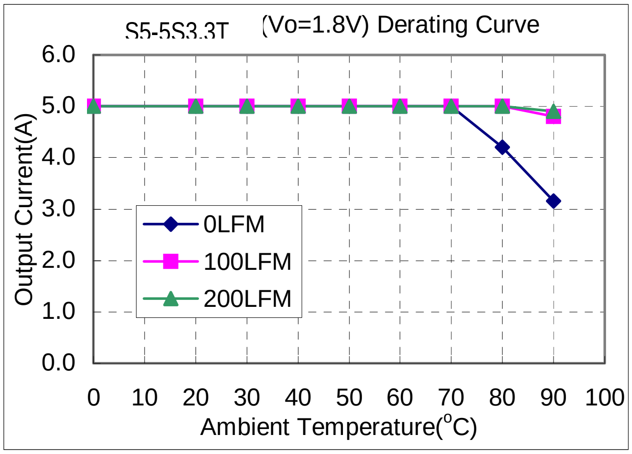


Figure10c.Typical Power De-rating for 5.0V IN 1.8Vout

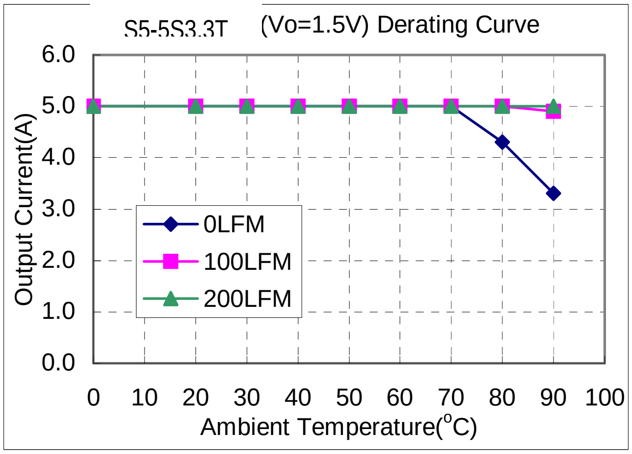


Figure 10d.Typical Power De-rating for 5.0V IN 1.5Vout

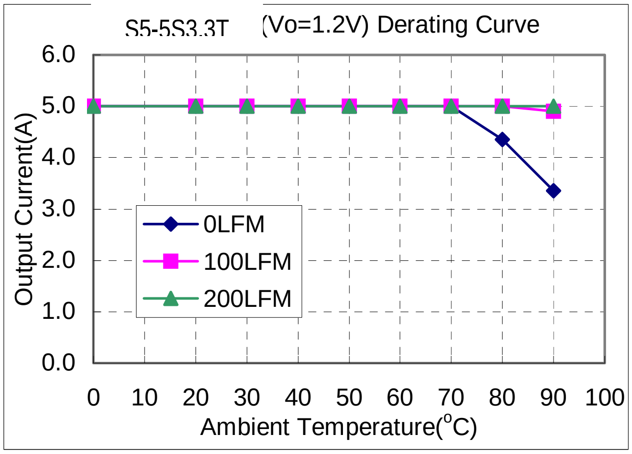


Figure10e.Typical Power De-rating for 5.0V IN 1.2Vout

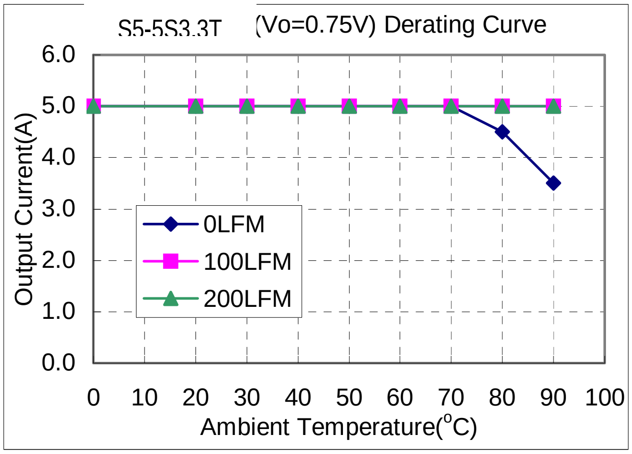


Figure 10f.Typical Power De-rating for 5.0V IN 0.75Vout

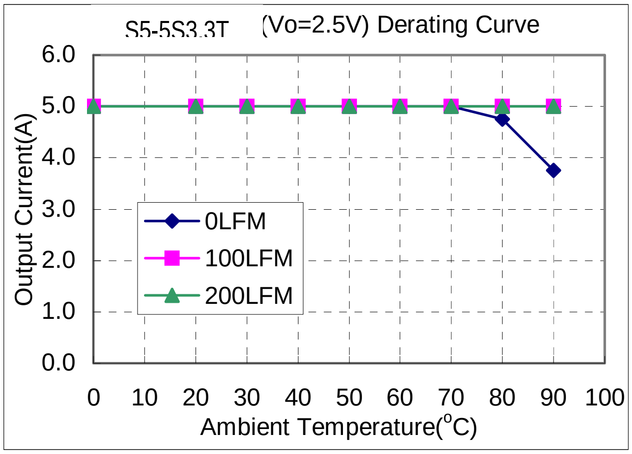


Figure11a.Typical Power De-rating for 3.3V IN 2.5Vout

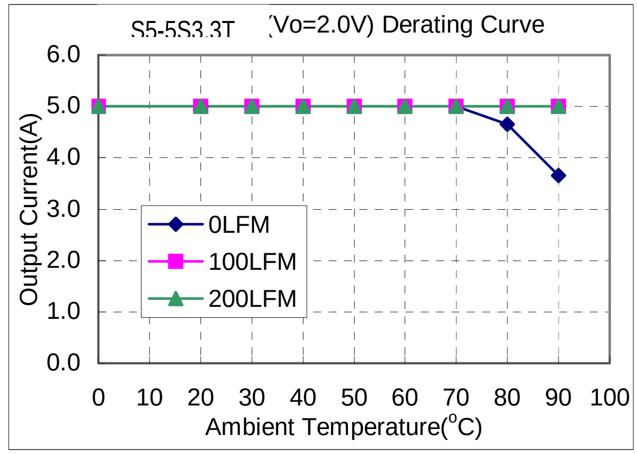


Figure 11b.Typical Power De-rating for 3.3V IN 2.0Vout

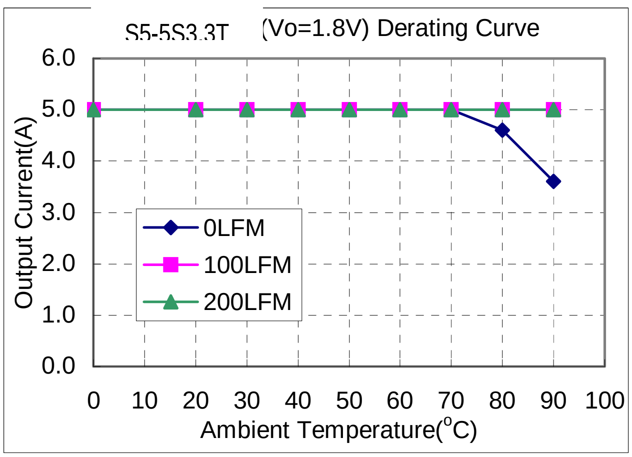


Figure11c.Typical Power De-rating for 3.3V IN 1.8Vout

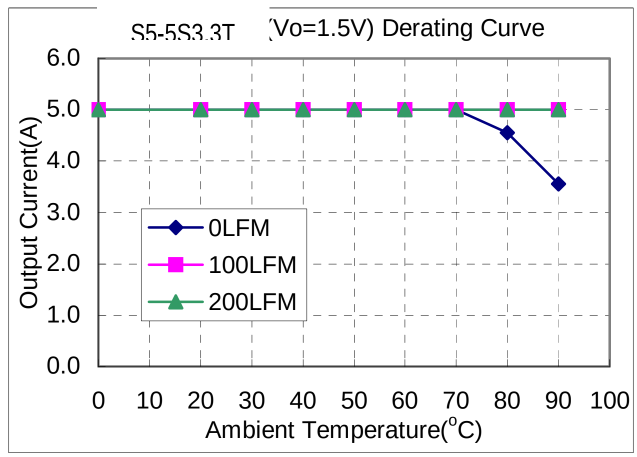


Figure 11d.Typical Power De-rating for 3.3V IN 1.5Vout

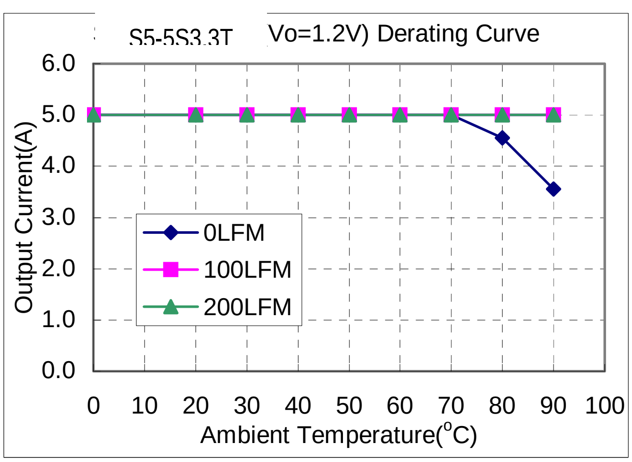


Figure11e.Typical Power De-rating for 3.3V IN 1.2Vout

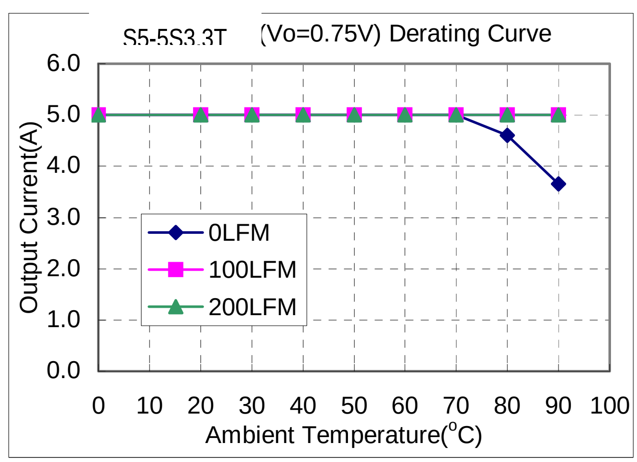


Figure 11f.Typical Power De-rating for 3.3V IN 0.75Vout

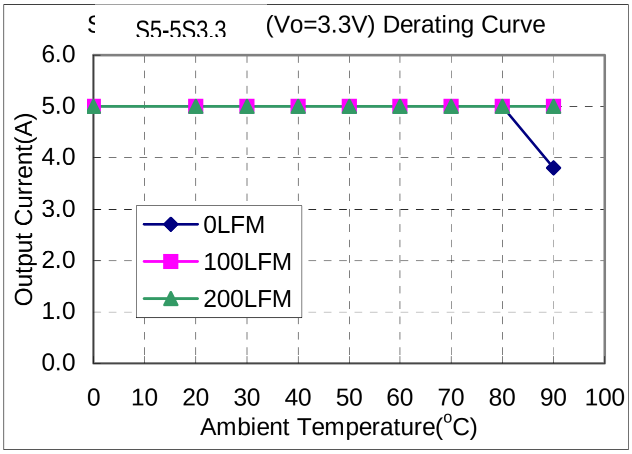


Figure12a.Typical Power De-rating for 5V IN 3.3Vout

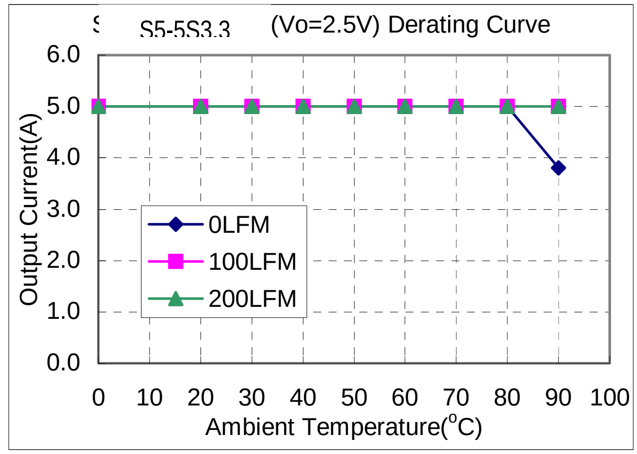


Figure12b.Typical Power De-rating for 5V IN 2.5Vout

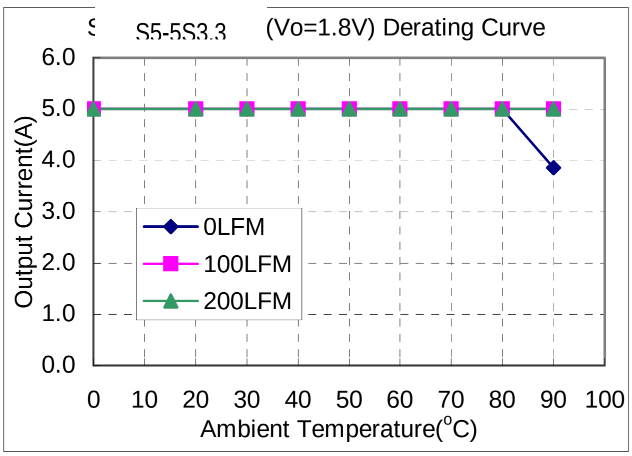


Figure12c.Typical Power De-rating for 5V IN 1.8Vout

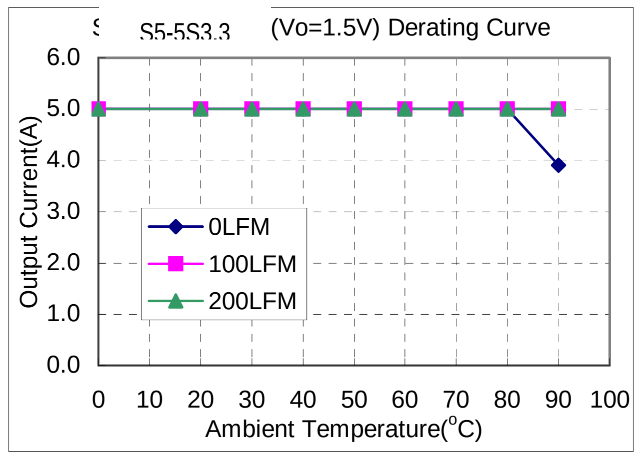


Figure 12d.Typical Power De-rating for 5V IN 1.5Vout

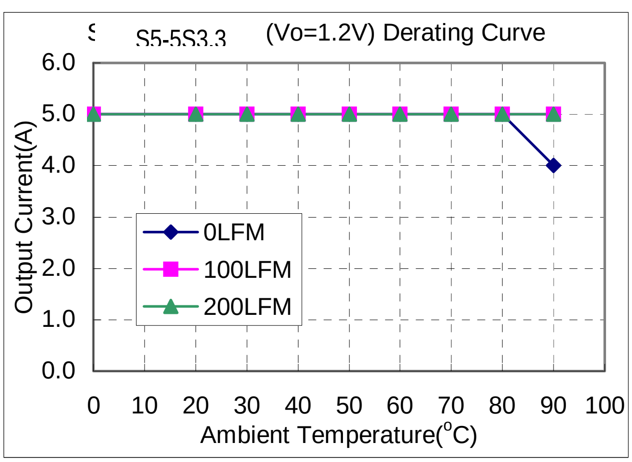


Figure12e.Typical Power De-rating for 5V IN 1.2Vout

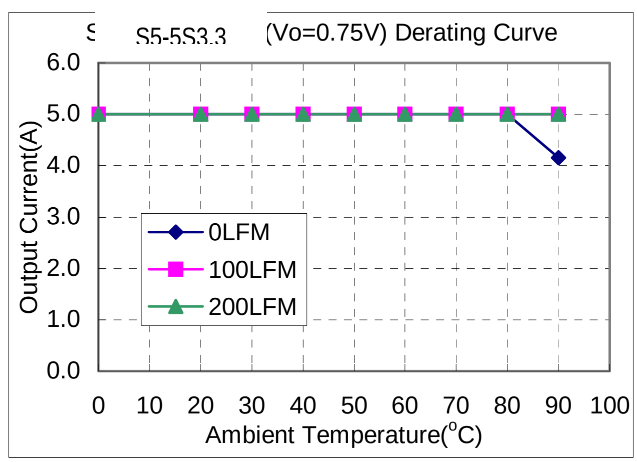


Figure 12f.Typical Power De-rating for 5V IN 0.75Vout

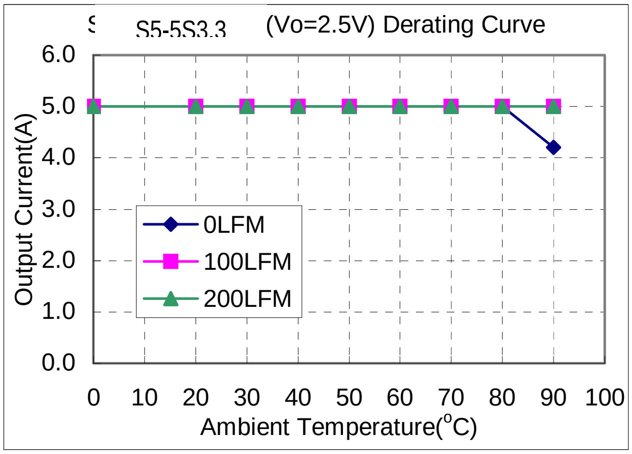


Figure13a.Typical Power De-rating for 3.3V IN 2.5Vout

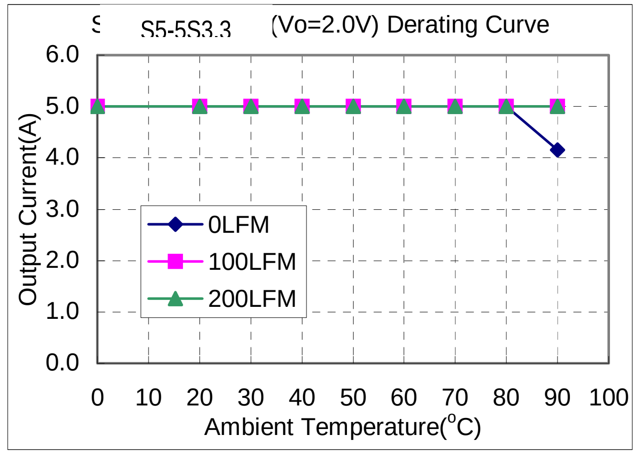


Figure 13b.Typical Power De-rating for 3.3V IN 2.0Vout

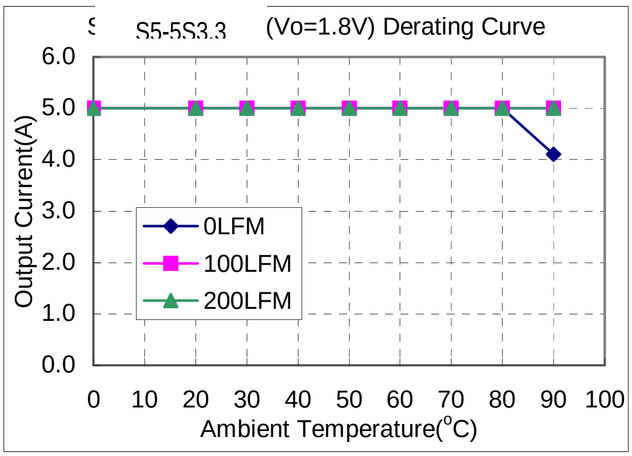


Figure13c.Typical Power De-rating for 3.3V IN 1.8Vout

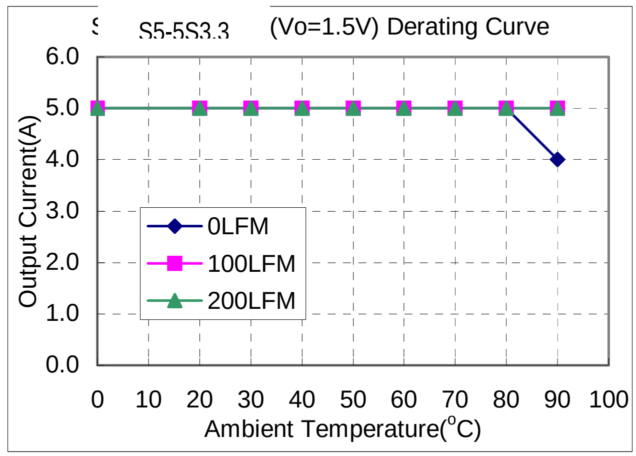


Figure 13d.Typical Power De-rating for 3.3V IN 1.5Vout

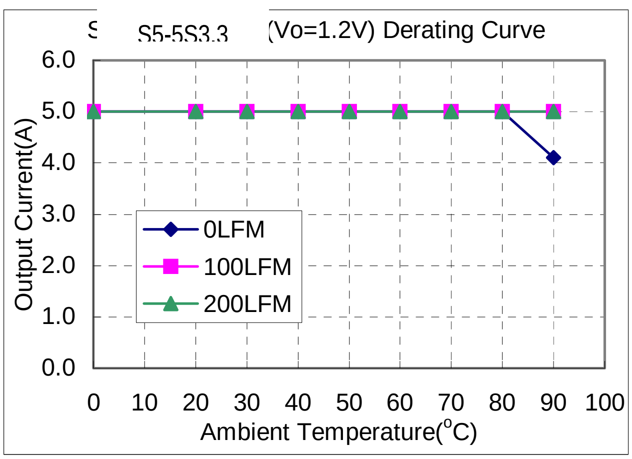


Figure13e.Typical Power De-rating for 3.3V IN 1.2Vout

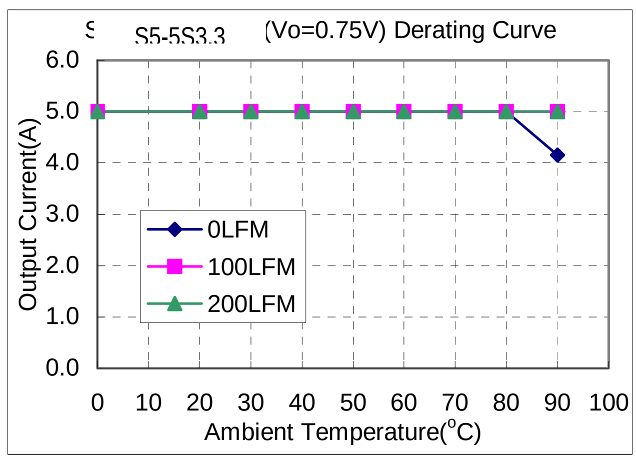
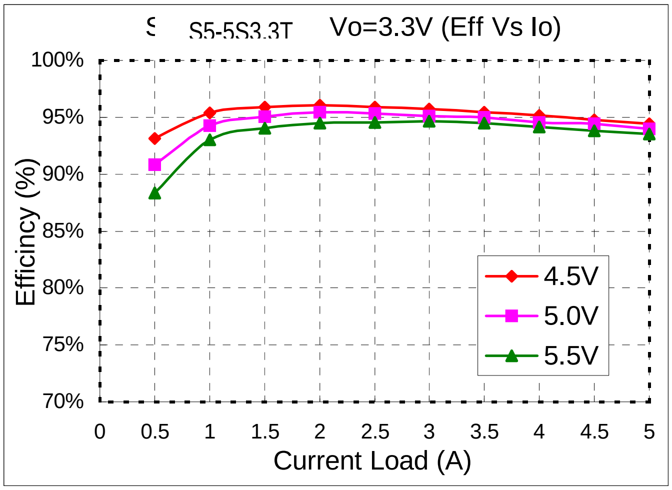
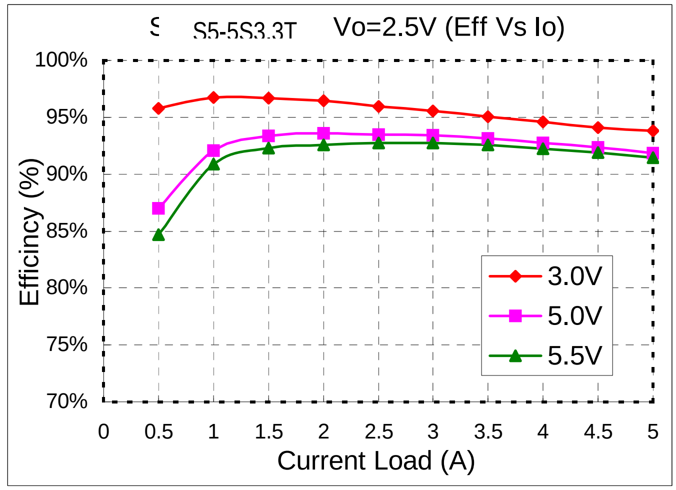
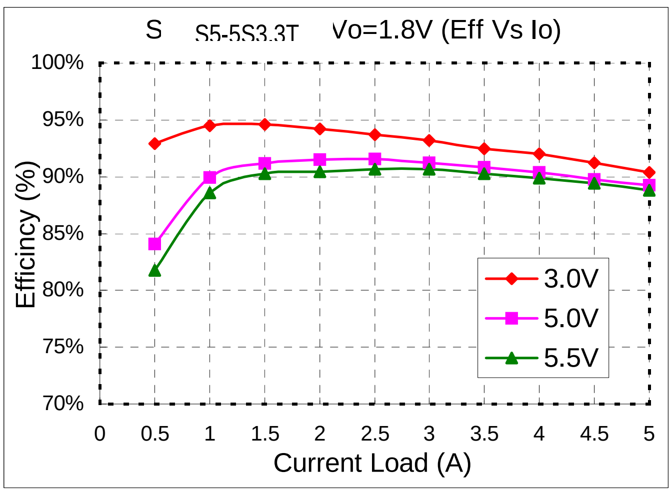


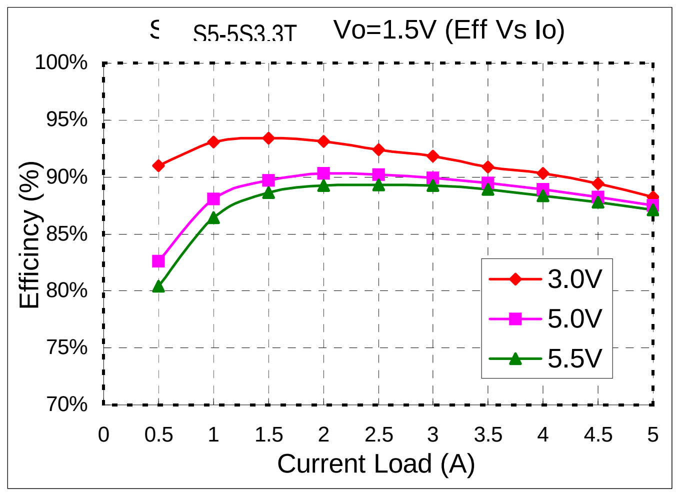
Figure 13f.Typical Power De-rating for 3.3V IN 0.75Vout

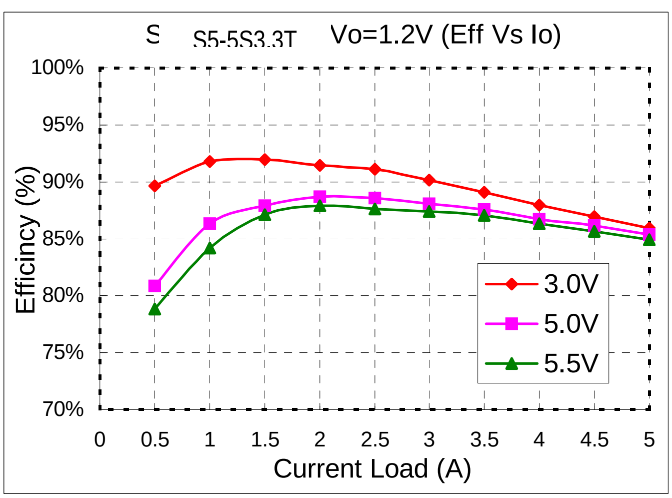
7.5 Efficiency vs Load Curves

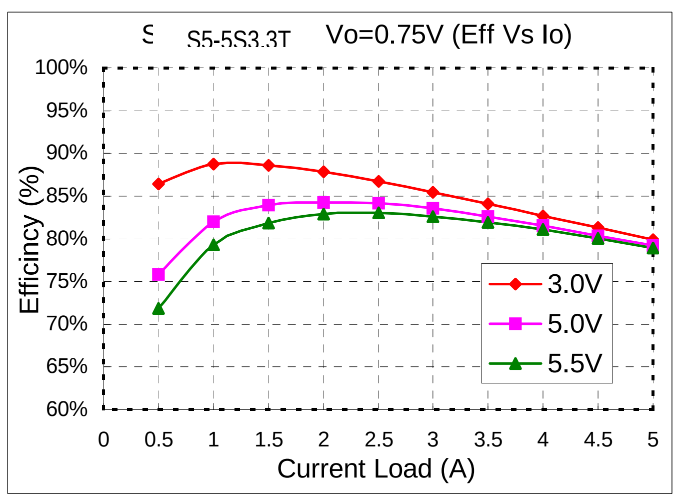












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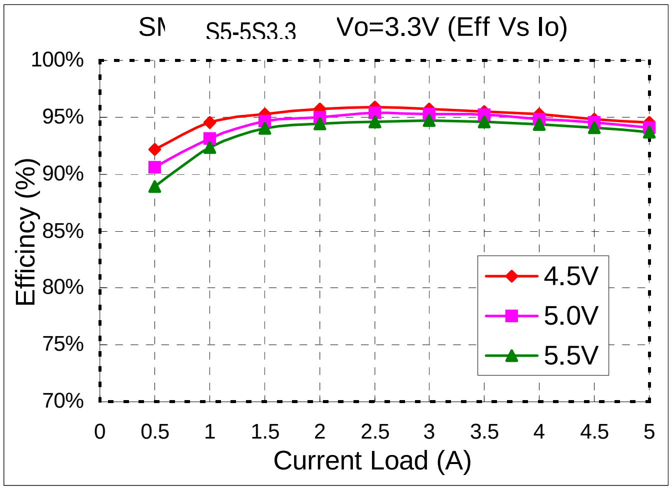
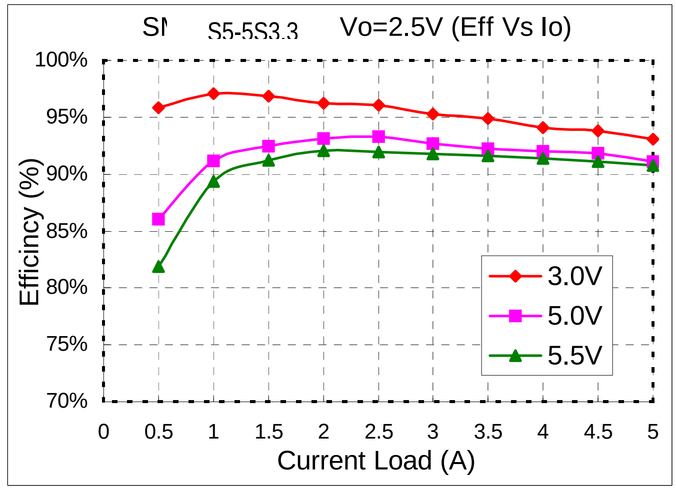
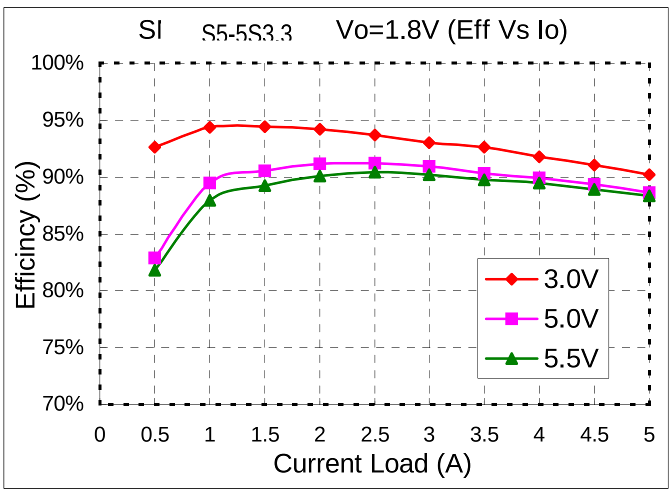
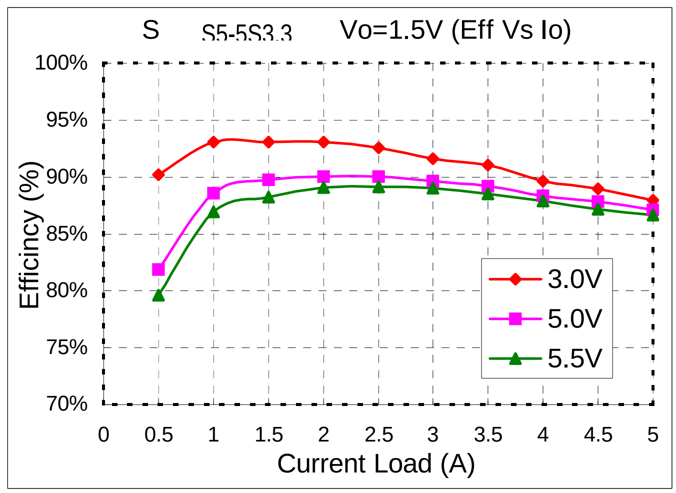
Applications

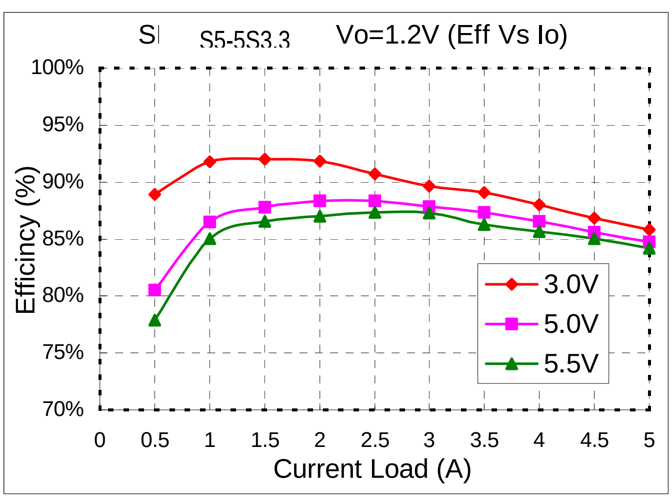
- Servers, Switches and Data Storage
- Wireless Communications
- Distributed Power Architecture
- Semiconductor Test Equipment
- Networking Gear
- Data Communications
- Telecommunications
- Industrial / Medical

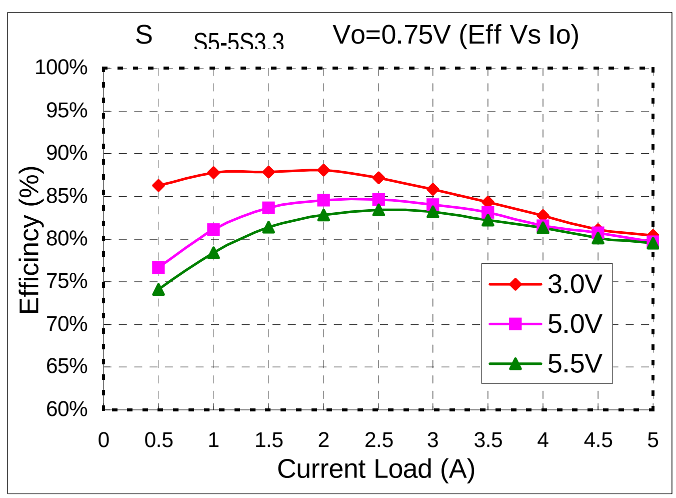












7.6 Input Capacitance at the Power Module

The SIP/SMT converters must be connected to a low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR polymers are a good choice. They have high capacitance, high ripple rating and low ESR (typical <100mohm). Electrolytic capacitors should be avoided. Circuit as shown in Figure 14 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.

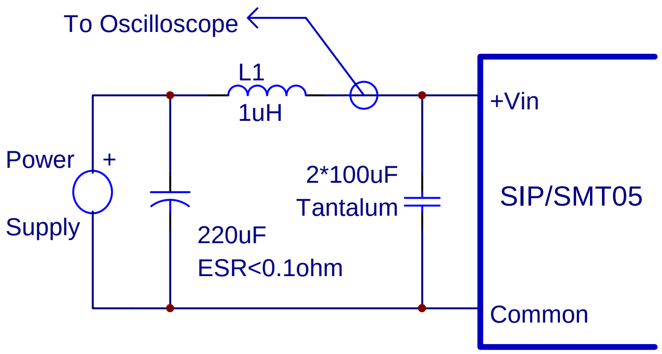


Figure 14. Input Reflected-Ripple Test Setup

7.7 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure 15. Things to note are that this converter is non-isolated, as such the input and output share a common ground. These grounds should be connected together via low impedance ground plane in the application circuit. When testing a converter on a bench set-up, ensure that $-V_{in}$ and $-V_o$ are connected together via a low impedance short to ensure proper efficiency and load regulation measurements are being made. When testing the Intronics' S5 series under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate the

- Efficiency
- Load regulation and line regulation.

The value of efficiency is defined as:

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

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.

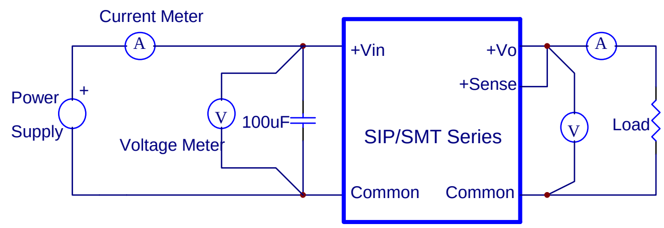


Figure 15. S5 Series Test Setup

7.8 S5 Series Output Voltage Adjustment.

The output Voltage of the S5 SERIES can be adjusted in the range 0.75V to 3.63V by connecting a single resistor on the motherboard (shown as Rtrim) in Figure 17. When Trim resistor is not connected the output voltage defaults to 0.75V

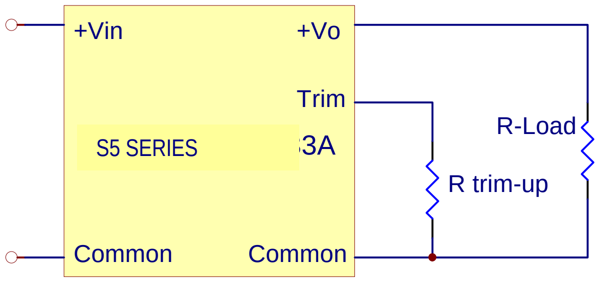


Figure 17. Trim-up Voltage Setup

The value of Rtrim-up defined as:

$$Rtrim = (\frac{21070}{Vo - 0.75} - 5110)$$

Where: Rtrim-up is the external resistor in ohm,
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:

$$Rtrim = (\frac{21070}{Vo - 0.75} - 5110)$$

Rtrim = 3153 ohm

For various output values various resistors are calculated and provided in Table 3 for convenience.

Vo,set (V)	Rtrim (Kohm)
0.75	Open
1.20	41.71
1.50	22.98
1.80	14.96
2.00	11.75
2.50	6.93
3.30	3.15
3.63	2.20

Table 3 – Trim Resistor Values

7.9 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 18. a coaxial cable with a 50ohm termination was used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies.

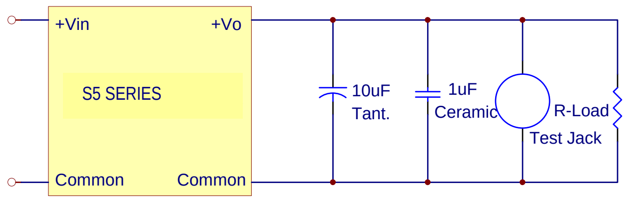


Figure 18. Output Voltage Ripple and Noise Measurement Set-Up

7.10 Output Capacitance

Intronics' S5 series converters provide unconditional stability with or without external capacitors. For good transient response low ESR output capacitors should be located close to the point of load.
For high current applications point has already been made in layout considerations for low resistance and low inductance tracks.
Output capacitors with its associated ESR values have an impact on loop stability and bandwidth. Intronics' converters are designed to work with load capacitance up-to 3,000uF. It is recommended that any additional capacitance, Maximum 3,000uF and low ESR, be connected close to the point of load and outside the remote compensation point.

7.11 SMT Reflow Profile

An example of the SMT reflow profile is given in Figure 19.
Equipment used: SMD HOT AIR REFLOW HD-350SAR
Alloy: AMQ-M293TA or NC-SMQ92 IND-82088 SN63

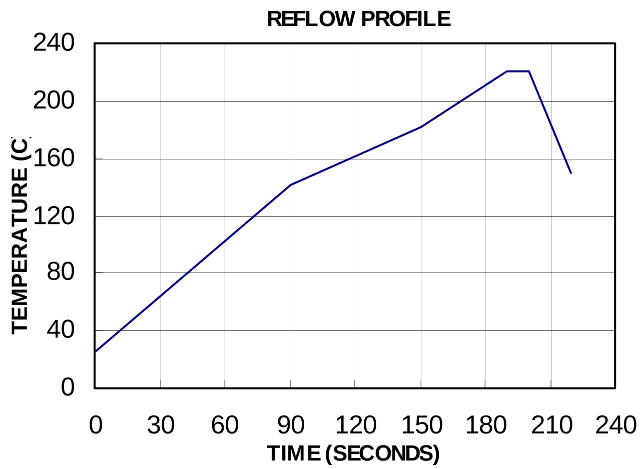


Figure 19 SMT Reflow Profile

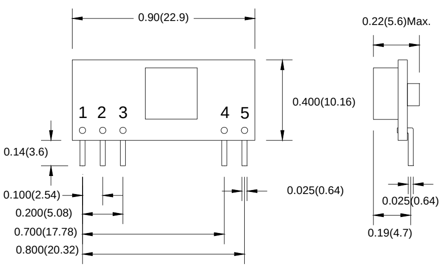
8. Mechanical Outline Diagrams

8.1 S5 SERIES Mechanical 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

SIZE SIP05



PIN CONNECTION	
Pin	FUNCTION
1	+Output
2	Trim
3	Common
4	+V Input
5	On/Off

Figure 20 S5-5S3.3T Mechanical Outline Diagram

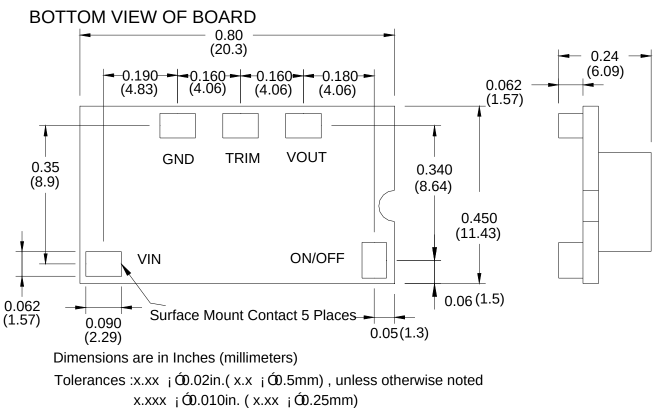
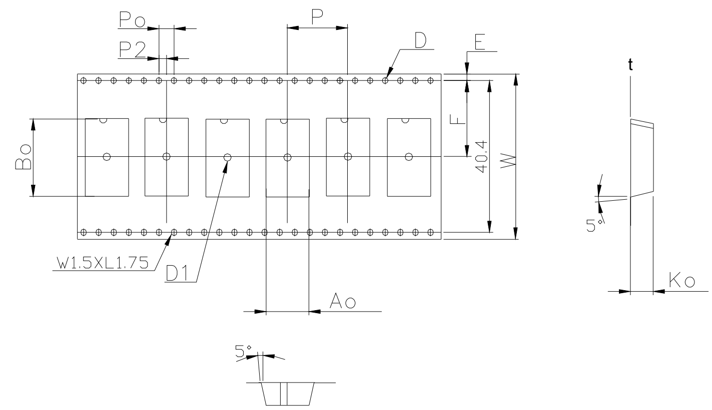


Figure 21 S5-5S3.3T Mechanical Outline Diagram

8.2 SMT Tape and Reel Dimensions

The Tape Reel dimensions for the SMT module is shown in Figure 22.



ITEM	SPEC
W	44.00 +0.30 −0.30
Ao	11.50 +0.10 −0.10
Bo	20.70 +0.10 −0.10
Ko	6.00 +0.10 −0.10
P	16.00 +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	0.35 +0.05 −0.05

Figure 22 – SMT Tape and Reel Dimensions

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S5 SERIES DC/DC MODULES

Applications

- Servers, Switches and Data Storage
- Wireless Communications
- Distributed Power Architecture
- Semiconductor Test Equipment
- Networking Gear
- Data Communications
- Telecommunications
- Industrial / Medical

The S5 Family of high efficiency non-isolated DC/DC converters offer power levels of up to 25 Watt, while also providing ultra-wide input voltage range for 3.3Vin and 5Vin, as well, as 12Vin. These converters provide versatility without sacrificing the board space. All models feature an input filter and regulated outputs. The open-frame construction facilitates maximum power delivered with the highest efficiency of up to 92%. All converters combine creative design practices with highly derated power devices to achieve very high reliability, high performance and low cost solution to systems designers.

Specifications & Features Summary

- Industry Standard SIP and SMT Pinout
- High Efficiency to 92%
- 300KHz Switching Frequency
- Stable at all Loads
- Over Temperature Protection
- Adjustable Output Range
- Continuous Short Circuit Protection
- Remote ON/OFF
- UL/C-UL 60950 Certification Pending
- Add Suffix "T" for Through-Hole Model
- Add Suffix "N" for Negative Logic Control Version

MODEL NUMBER	INPUT VOLTAGE	OUTPUT VOLTAGE	OUTPUT CURRENT	INPUT CURRENT		% EFF.	SIZE
				NO LOAD	FULL LOAD		
S5-5S3.3	3.0–5.5VDC	0.75- 3.63VDC	5 A	Various	Various	Various	SIP/SMT
S5-12S5	8.3-14VDC	0.75-5.0 VDC	5 A	Various	Various	Various	SIP/SMT

Typical at Ta= +25 ºC under nominal input voltages of 3.3V, 5V and 12VDC, unless noted. The information and specifications contained in this brief are believed to be accurate and reliable at the time of publication. Specifications are subject to change without notice. Refer to product specification sheet for performance characteristics and application guidelines.

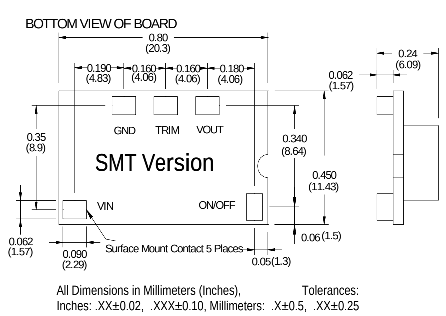
Consult factory for hundreds of other available input/output voltage configurations.

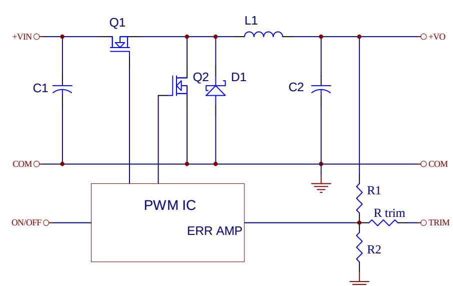
NOTE :
1. Measured From High Line to Low Line, Vo, set = 3.3Vdc
2. Measured From Full Load to Zero Load, Vo, set = 3.3Vdc
3. The output noise is measured with 10uf tantalum capacitor and 1uf ceramic capacitor across output.
4. To reduce the input ripple voltage, parallel the Input Terminals with 47uF Capacitor and 10uF Ceramic
5. Negative Logic Remote on/off:
   Module ON: Open Circuit or < 0.4VDC
   Module OFF: 2.8VDC to Vin

Vo,set (V)	Rtrim (KΩ)
0.75	Open
1.2	22.33
1.5	13.0
1.8	9.0
2.0	7.4
2.5	5.00
3.3	3.12
5.0	1.47

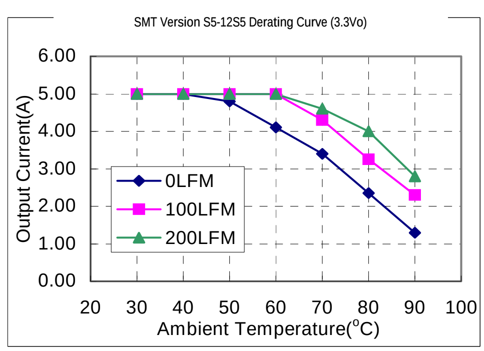
Table 1. External Resistor Values for programming output voltage

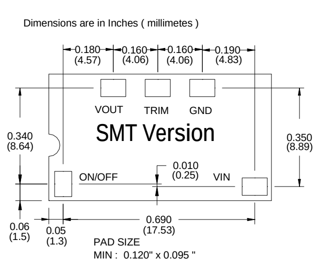
INPUT SPECIFICATIONS :	
Input Voltage Range 5V (12V)	3.0 – 5.5V (8.3 – 14.0V)
Positive Logic Remote on/off Control:	
Module ON	Open Circuit or = Vin
Module OFF	<0.4Vdc
Under Voltage Lock-out (12Vin)	
Power up	8.0V typ.
Power down	7.9V typ.
Input Filter Type	Capacitive
OUTPUT SPECIFICATIONS :	
Voltage Accuracy	±1.5% max.
Transient Response: 25% Step Load Change	<200u sec.
Ripple and Noise 20MHz BW Note3 (5Vo)	20mV rms, 50mV pk-pk max. 45mVrms, 75Vpk-pk max.
Temperature Coefficient	±0.03%/℃ max.
Short Circuit Protection	Continuous
Line Regulation, Note1	±0.2% max.
Load Regulation, Note2	±0.5% max.
Capacitive Load	Low ESR 3000uF max.
GENERAL SPECIFICATIONS :	
Efficiency	See App Notes
Isolation Voltage	Non-Isolated
Operating Ambient Temp. Range	-40℃ to +85℃
Derating	See App Notes
Storage Temperature Range	-55℃ to +125℃
Dimensions (SIP)	0.9"x0.4"x0.22" (22.9x10.16x5.6mm)
Dimensions (SMT)	0.8"x0.45"x0.24" (20.3x11.43x6.09mm)
Case Material	Non-potted Open Frame

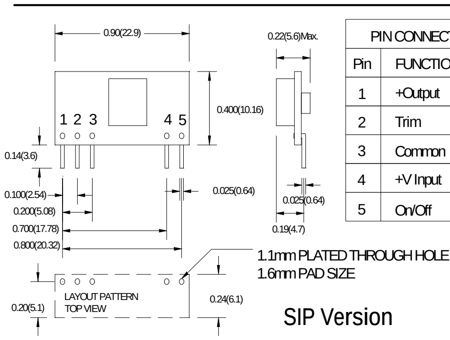




Simplified Schematic

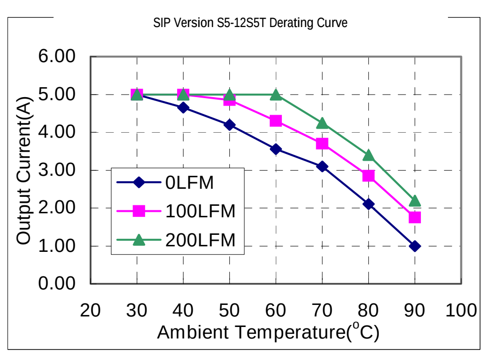






PIN CONNECTION	
Pin	FUNCTION
1	+Output
2	Trim
3	Common
4	+V Input
5	On/Off

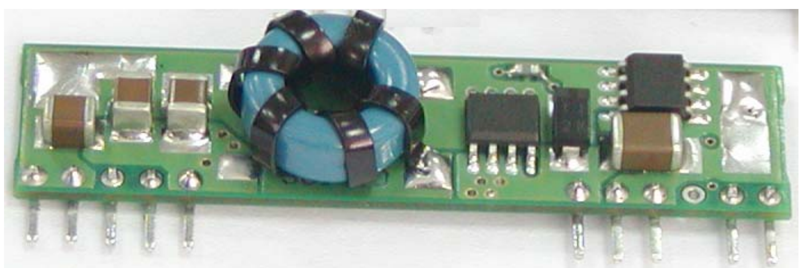
SIP Version



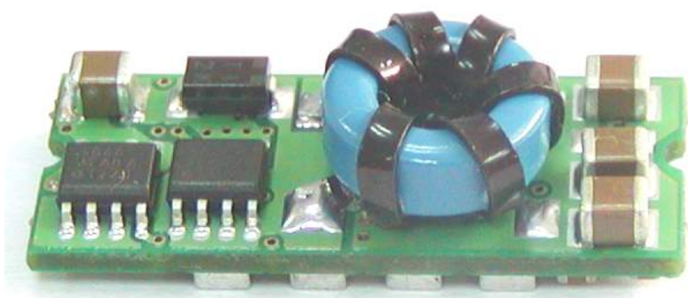
NON-ISOLATED DC-DC Converter

S10 SERIES
3.0-5.5Vin, 1-3.3Vout, 10A

APPLICATION NOTES
Ver 1.0



S10-5SX.XT (Through-Hole) Series



S10-5SX.X SMT Series

1. Introduction

This application note describes the features and functions of Intronics' S10 SMT series of Non Isolated DC-DC Converters. These are highly efficient, reliable and compact, high power density, single output DC/DC converters. These "Point of Load" modules serve the needs specifically of the fixed and mobile telecommunications and computing market, employing economical distributed Power Architectures.

The S10 SMT series provide precisely regulated output voltage range from 1.0V to 3.3Vdc over a wide range of input voltage (Vi=3.0 – 5.5Vdc) and can operate over an ambient temperature range of –40C to +85C. Ultra-high efficiency operation is achieved through the use of synchronous rectification and drive control techniques. The modules are fully protected against short circuit and over-temperature conditions.

Intronics' world class automated manufacturing methods, together with an extensive testing and qualification program, ensure that all S10-5SX.X series converters are extremely reliable.

2. Models

The adjustable S10 series currently comprises of 7 models.

Model	Input Voltage	Output Voltage	Output Current
S10-5S1.0T	3.0 – 5.5VDC	1.0V	10A
S10-5S1.2T	3.0 – 5.5VDC	1.2V	10A
S10-5S1.5T	3.0 – 5.5VDC	1.5V	10A
S10-5S1.8T	3.0 – 5.5VDC	1.8V	10A
S10-5S2.5T	3.0 – 5.5VDC	2.0V	10A
S10-5S3.3T	3.0 – 5.5VDC	2.5V	10A
S10-5S5.0T	4.5 – 5.5VDC	3.3V	10A

Table 1A – S10-5SX.XT Through-Hole Series Models

The adjustable SMT10-05 series comprises of 7 models.

Model	Input Voltage	Output Voltage	Output Current
S10-5S1.0	3.0 – 5.5VDC	1.0V	10A
S10-5S1.2	3.0 – 5.5VDC	1.2V	10A
S10-5S1.5	3.0 – 5.5VDC	1.5V	10A
S10-5S1.8	3.0 – 5.5VDC	1.8V	10A
S10-5S2.5	3.0 – 5.5VDC	2.0V	10A
S10-5S3.3	3.0 – 5.5VDC	2.5V	10A
S10-5S5.0	4.5 – 5.5VDC	3.3V	10A

Table 1B – S10-5SX.X SMT Series Models

3. 10A SIP/SMT Converter Features

- High efficiency topology, typically 95% at 3.3Vdc
- Industry standard footprint
- Wide ambient temperature range, -40C to +85C
- Cost efficient open frame design
- ±10% output voltage trimmable.
- 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 S10-5SX.X Series converter is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of synchronous rectification and drive techniques.

Essentially, the powerful S10-5SX.X series topology is based on a non-isolated synchronous buck converter. The control loop is optimized for unconditional stability, fast transient response and a very tight line and load regulation. In a typical pre-bias application the S10-5SX.X series converters do not draw any reverse current at start-up.

The output is adjustable over a range of -10% to +10% of the nominal output voltage, using the TRIM pin.

The converter can be shut down via a remote ON/OFF input that is referenced to ground. This input is compatible with popular logic devices; a 'negative' logic input is supplied as standard. Negative logic implies that the converter is enabled if the remote ON/OFF input is low (or floating), and disabled if it is high.

The converter is also protected against over-temperature conditions. If the converter is overloaded or the ambient temperature gets too high, the converter will shut down to protect the unit.

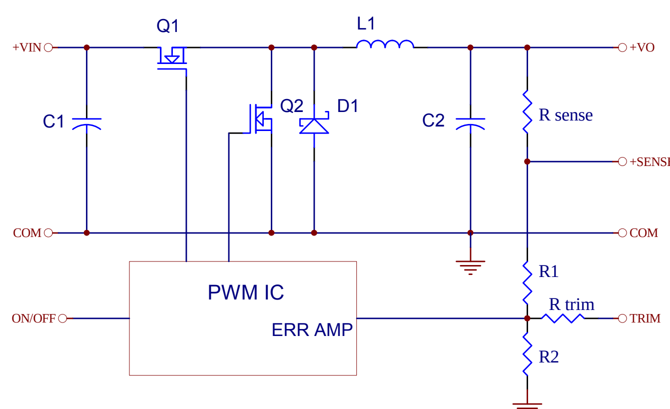


Figure 1. Electrical Block Diagram

4.2 Thermal Packaging and Physical Design.

The S10-5SX.X series uses a multi-layer FR4 PCB construction. All surface mount power components are placed on one side of the PCB, and all low-power control components are placed on the other 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 more sensitive, small signal control components.
- **Environmental:** Lead free open-frame converters are more easily re-cycled.
- **Cost Efficient:** No encapsulation**.** Cost efficient open-frame construction.
- **Reliable:** Efficient cooling provided by open frame construction offers high reliability and easy diagnostics.

5. Main Features and Functions

5.1 Operating Temperature Range

Intronics' S10-5SX.X series converters highly efficient converter design has resulted in its ability to operate over a wide ambient temperature environment (-40C to 85C). Due consideration must be given to the de-rating curves when ascertaining 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 heatsinks for the converter.

5.2 Over-Temperature Protection (OTP)

The S10-5SX.X Series converters are equipped with non-latching over-temperature protection. A temperature sensor monitors the temperature of the hot spot (typically, top switch). If the temperature exceeds a threshold of 120°C (typical) the converter will shut down, disabling the output. When the temperature has decreased the converter will automatically restart.
The over-temperature condition can be induced by a variety of reasons such as external overload condition or a system fan failure.

5.3 Output Voltage Adjustment

Section 7.8 describes in detail as to how to trim the output voltage with respect to its set point. The output voltage on all models is trimmable in the range -10% to +10%.

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.

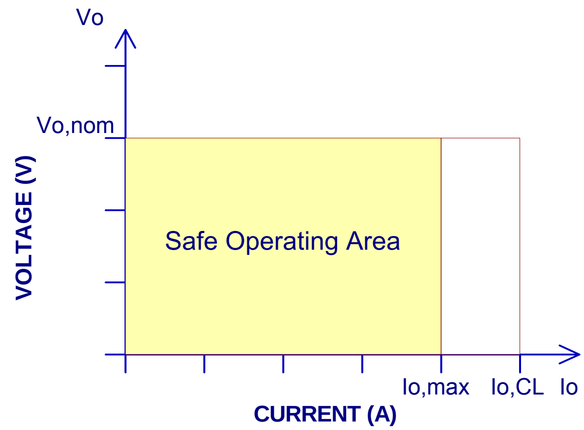


Figure 2. Maximum Output Current Safe Operating Area

5.5 Over Current Protection

All different voltage models have a full continuous short-circuit protection. The unit will auto recover once the short circuit is removed. To provide protection in a fault condition, the unit is equipped with internal over-current protection. The unit operates normally once the fault condition is removed. The power module will supply up to 170% of rated current. In the event of an over current converter will go into a hiccup mode protection.

5.6 Remote ON/OFF

The remote ON/OFF input feature of the converter allows external circuitry to turn the converter ON or OFF. Active-low remote ON/OFF is available as standard.
The S10-5SX.X series converters are turned on if the remote ON/OFF pin is low, or left open or floating. Pulling the pin high will turn the converter 'Off'. The signal level of the remote on/off input is defined with respect to ground. The unit is guaranteed OFF over the full temperature range if this voltage level exceeds 2.8Vdc.

The remote ON/OFF input can be driven as described in Figure 3.

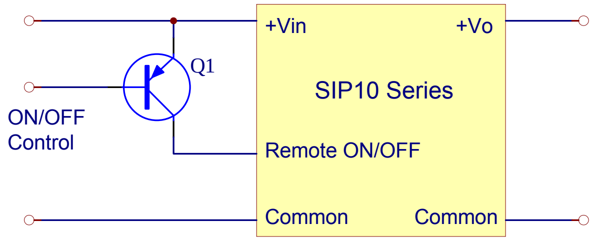


Figure 3 . Remote ON/OFF Input Drive Circuit

5.7 UVLO (Under-Voltage Lockout)

The voltage on the Vcc pin determines the start of the operation of the Converter. When the input Vcc rises and exceeds about 2.8V the converter initiates a soft start. The UVLO function in the converter has a Hysterisis (about 100mV) built in to provide noise immunity at start-up.

6. Safety

6.1 Input Fusing and Safety Considerations.

Agency Approvals: The power Supply shall be submitted to and receive formal approval from the following test agencies.

1.The power supply shall be approved by a nationally recognized testing laboratory to UL/CSA 60950 3rd Edition (North America) and EN60950 (International)

2. CB Certificate from an internationally recognized test house in accordance with EN 60950.

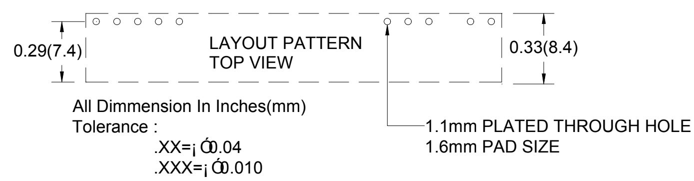
The S10-5SX.X series converters do not have an internal fuse. However, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a time-delay fuse with a maximum rating of 20A.

7. Applications

7.1 Layout Design Challenges.

In optimizing thermal design the PCB is utilized as a heatsink. Also some heat is transferred from the SIP 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 S10-5SX.X series SIP's 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. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds.



VIEW IS FROM TOP SIDE
Figure 4A. Recommended SIP Footprint

Recommended Pad Layout

Dimensions are in millimetes and(inches)

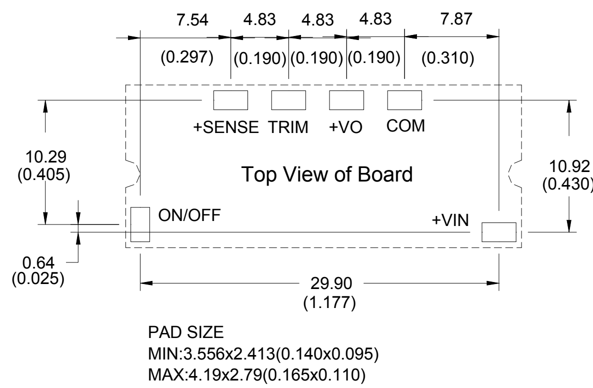


Figure 4B. Recommended SMT Footprint

7.2 Convection Requirements for Cooling

To predict the approximate cooling needed for the module, refer to the Power De-rating curves in Figures 9 and 10. These de-rating curves are approximations of the ambient temperatures and airflows required to keep 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 5 to ensure it does not exceed 110°C.

Proper cooling can be verified by measuring the power module's temperature at Q1-pin 6 and Q2-pin 6 as shown in Figure 6A,6B.

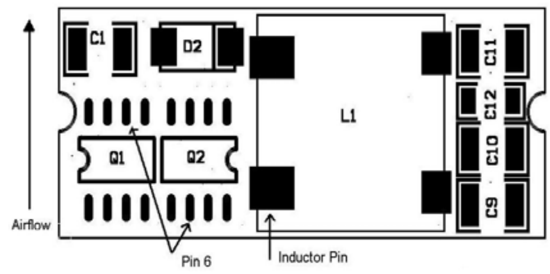
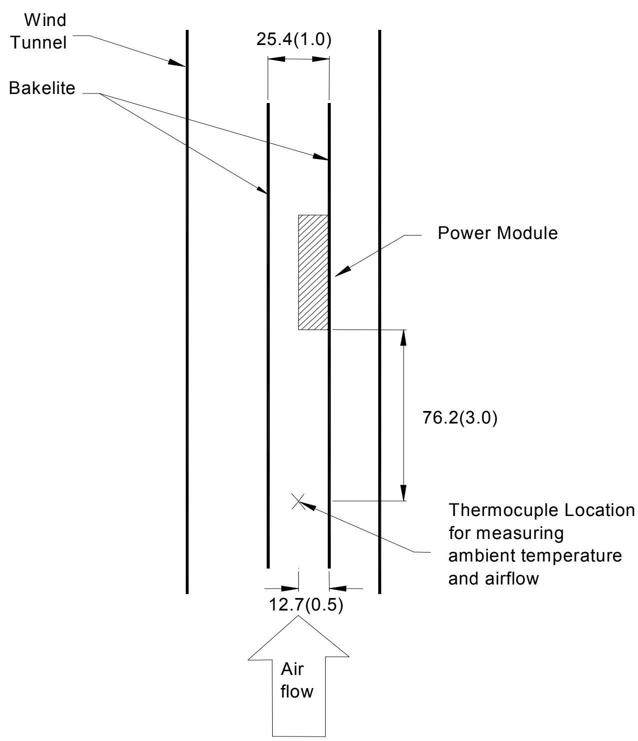


Figure 6B. Temperature Measurement Location for SMT



Note : Dimensions are in millimeters and (inches)

Figure 5. Thermal Test Setup

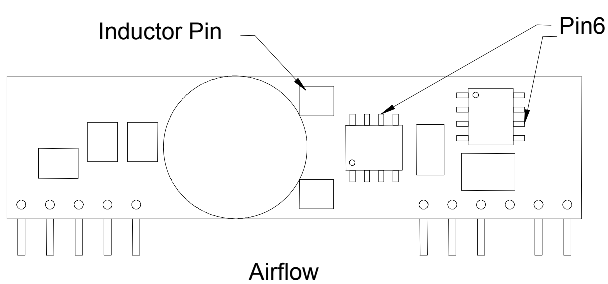


Figure 6A. Temperature Measurement Location for SIP

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 by conduction, convection, and radiation to the surrounding environment. The thermal data presented is based on measurements taken in a set-up as shown in Figure 5. Figures 7A,7B and 8A,8B represent the test data.

Note that the airflow is parallel to the long axis of the module as shown in Figure 6A for the SIP.

The temperature at either location 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).

The SMT10 thermal data presented is based on measurements taken in a wind tunnel. The test setup shown in Figure 5 and EUT need to solder on 33mm x 40.38mm(1.300" x 1.59") test pcb. Note that airflow is parallel to the long axis of the module as shown in Fig 6B

7.4 Power De-Rating Curves

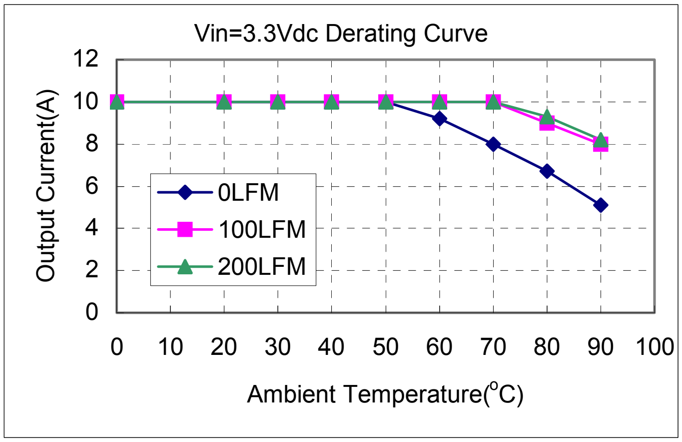


Figure7A Typical Power De-rating for 3.3V IN(SIP10)

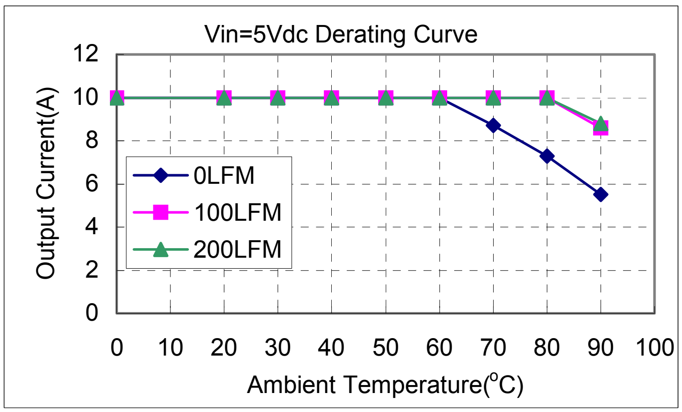


Figure7B.Typical Power De-rating for 5.0V IN(SIP10)

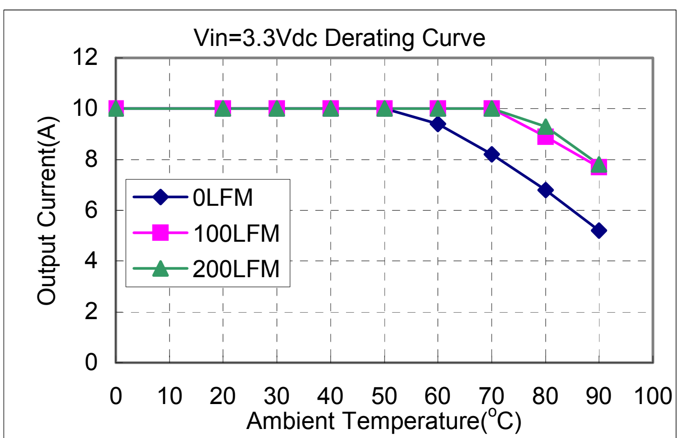


Figure8A.Typical Power De-rating for 3.3V IN (SMT10)

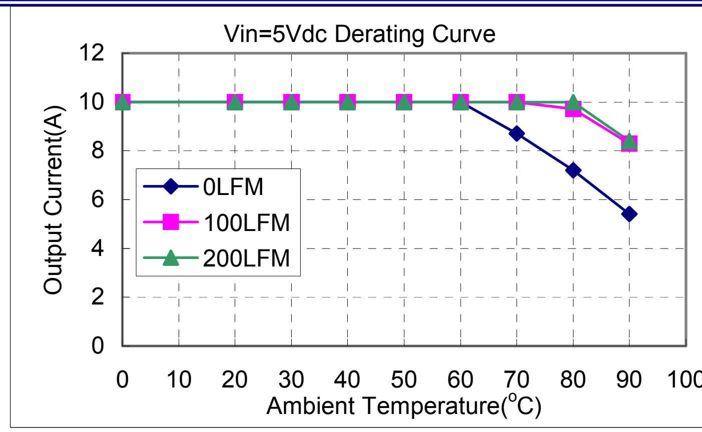


Figure8B.Typical Power De-rating for 5.0V IN(SMT10)

7.5 Input Capacitance at the Power Module

The SIP/SMT converters must be connected to a low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR polymers are a good choice. They have high capacitance, high ripple rating and low ESR (typical <20mΩ). Electrolytic capacitors should be avoided. 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.

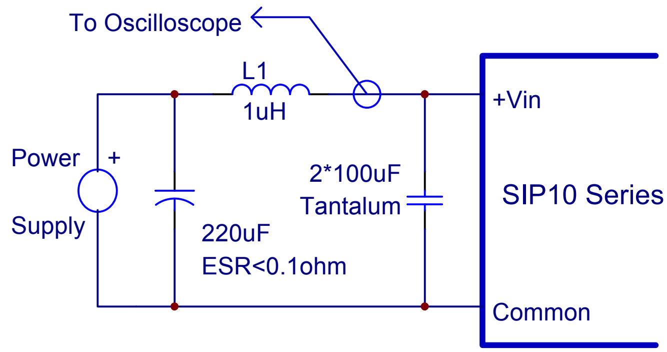


Figure 9. Input Reflected-Ripple Test Setup

7.6 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure 10. Things to note are that this converter is non-isolated, as such the input and output share a common ground. These grounds should be connected together via low impedance ground plane in the application circuit. When testing a converter on a bench set-up, ensure that $-V_{in}$ and $-V_o$ are connected together via a low impedance short to ensure proper efficiency and load regulation measurements are being made. When testing the Intronics' S10-5SX.X series under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate the

- Efficiency
- Load regulation and line regulation.

The value of efficiency is defined as :

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

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.

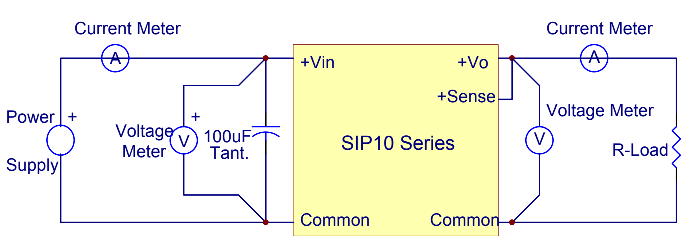


Figure 10. SIP10 Series Test Setup

7.7 Remote Sense Compensation

Remote Sense regulates the output voltage at the point of load. It minimizes the effects of distribution losses such as drops across the connecting pin and PCB tracks (see Figure 11). Please note however, the maximum drop from the output pin to the point of load should not exceed 500mV for remote 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 which, if the same output current is maintained, increases the power output by the module. 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, leave sense pin disconnected.

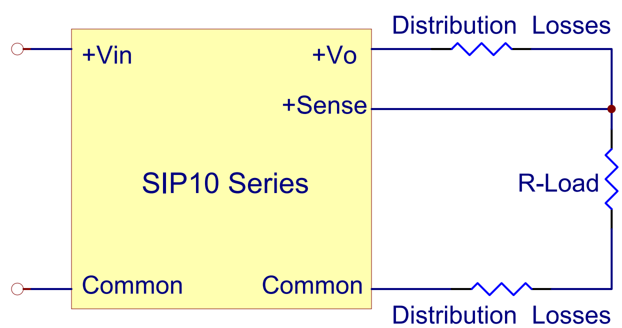


Figure 11. Circuit Configuration for Remote Sense Operation

7.8 S10-5SX.X Series Output Voltage Adustment.

In order to trim the voltage up or down one needs to connect the trim resistor either between the trim pin and ground for trim-up and between trim pin and V_{sense+} for trim-down. The output voltage trim range is ±10%. This is shown in Figures 12 and 13:

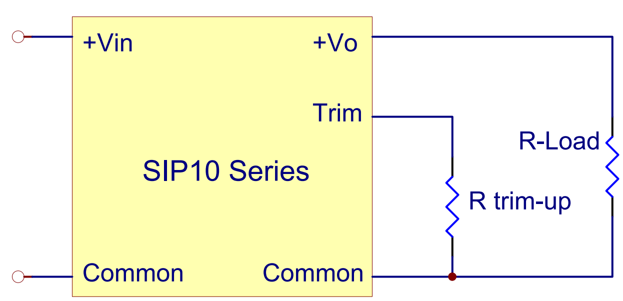


Figure 12. Trim-up Voltage Setup

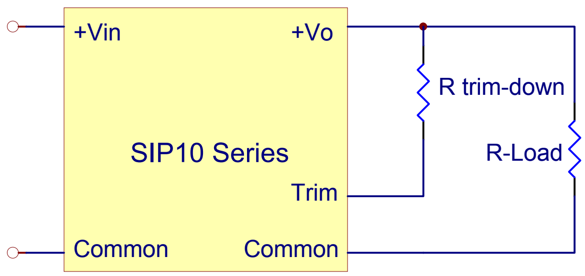


Figure 13. Trim-down Voltage Setup

The value of Rtrim-up defined as:

$$R_{trim-up} = \left(\frac{R1 \times 0.8}{Vo - V_{o,nom}}\right) - Rt \quad (K\Omega)$$

Where: Rtrim-up is the external resistor in KΩ.
Vo,nom is the nominal output voltage.
Vo is the desired output voltage.
R1 and Rt are internal to the unit and are defined in Table 2.

Output Voltage(V)	R1 (KΩ)	Rt (KΩ)
1.0	30.1	30.1
1.2	30.1	59
1.5	30.1	100
1.8	30.1	100
2.0	30.1	100
2.5	30.1	78.7
3.3	30.1	59

Table 2 – Trim Resistor Values

For example, to trim-up the output voltage of 1.5V module (SIP10-05S15E) by 8% to 1.62V , Rtrim-up is calculated as follows :

Vo – Vo,nom = 1.62 – 1.5 = 0.12V
Rt = 100 KΩ
R1= 30.1 KΩ

$$R_{trim-up} = \frac{30.1 \times 0.8}{0.12} - 100 = 100.66\ (K\Omega)$$

The value of Rtrim-down defined as:

$$R_{trim-down} = \frac{R1 \times (Vo - 0.8)}{V_{o,nom} - Vo} - Rt \quad (K\Omega)$$

Where: Rtrim-down is the external resistor in KΩ.
Vo,nom is the nominal output voltage.
Vo is the desired output voltage.
R1 and Rt are internal to the unit and are defined in Table 2.

For example,to trim-down the output voltage of 2.5V module (SIP10-05S25E) by 8% to 2.3V , Rtrim-down is calculated as follows :

Vo,nom – Vo = 2.5 – 2.3 = 0.2 V
R1 = 30.1 KΩ
Rt = 78.7 KΩ

$$R_{trim-down} = \frac{30.1 \times (2.3 - 0.8)}{0.2} - 78.7 = 147.05\ \ (K\Omega)$$

For Trim-up using an external voltage source, apply a voltage from TRIM pin to ground using the following equation:

$$V_{trim-up} = 0.8 - \left(\frac{(Vo - V_{o,nom}) \times Rt}{R1}\right)$$

For Trim-down using an external voltage source,apply a voltage from TRIM pin to ground using the following equation :

$$V_{trim-down} = 0.8 + \frac{(V_{o,nom} - Vo) \times Rt}{R1}$$

Where: Vtrim-up is the external source voltage for trim-up.
Vtrim-down is the external source voltage for trim-down.
Vo is the desired output voltage.
Vo,nom is the nominal output voltage.
Rt (internal to the module) is defined in Table 2.

If the TRIM feature is not being used, leave the TRIM pin disconnected.

7.9 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 14. a 50Ω. coaxial cable with a 50Ω termination was used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies.

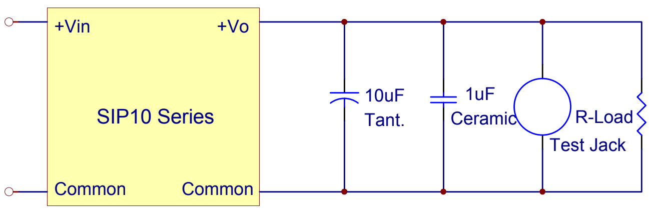


Figure 14. Output Voltage Ripple and Noise Measurement Set-Up

7.10 Output Capacitance

Intronics' S10-5SX.X series converters provide unconditional stability with or without external capacitors. For good transient response low ESR output capacitors should be located close to the point of load. For high current applications point has already been made in layout considerations for low resistance and low inductance tracks.

Output capacitors with its associated ESR values have an impact on loop stability and bandwidth.Intronics' converters are designed to work with load capacitance up-to 10,000uF. It is recommended that any additional capacitance, typically 1,000uF and low ESR (<20mΩ), be connected close to the point of load and outside the remote compensation point.

7.11 SMT Reflow Profile

An example of the SMT reflow profile is given in Figure 15.

Equipment used: SMD HOT AIR REFLOW HD-350SAR
Alloy: AMQ-M293TA or NC-SMQ92 IND-82088 SN63

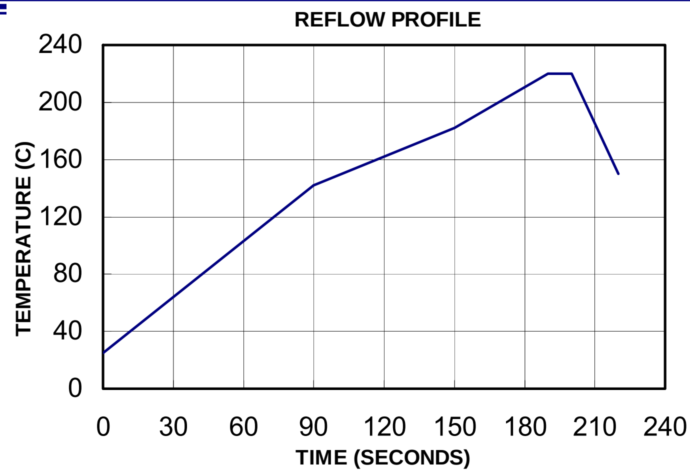
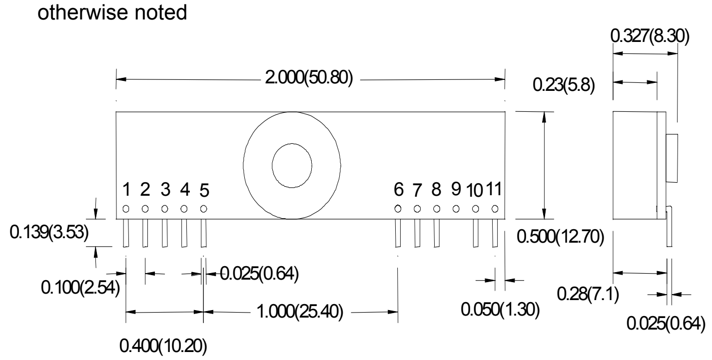


Figure 15 – SMT Reflow Profile

8. Mechanical Outline Diagrams

8.1 SIP/SMT10 Mechanical 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



PIN CONNECTION	
Pin	FUNCTION
1	+Output
2	+Output
3	+Sense
4	+Output
5	Common
6	Common
7	+V Input
8	+V Input
9	No Pin
10	Trim
11	On/Off Control

Figure 16. SIP10 Mechanical Outline Diagram

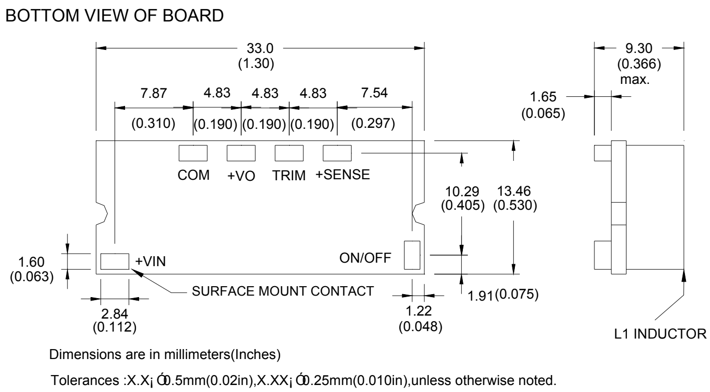
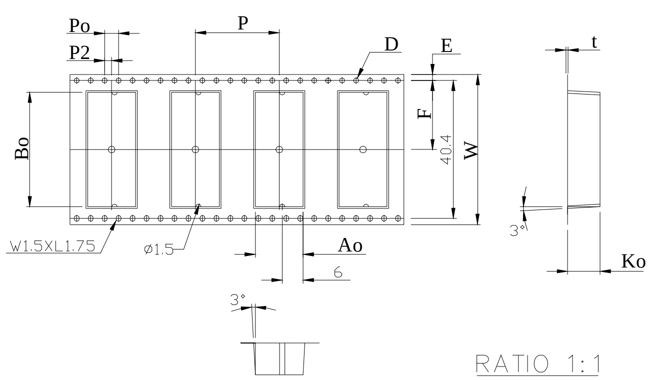


Figure 17. SMT10 Mechanical Outline Diagram

8.2 SMT Tape and Reel Dimensions

The Tape Reel dimensions for the SMT module is shown in Figure 18.



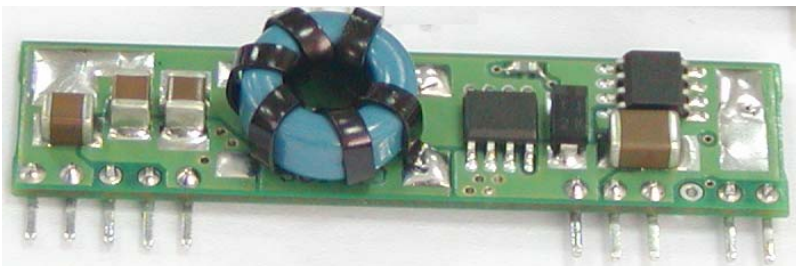
ITEM	SPEC
W	44.00 +0.30 −0.30
Ao	13.70 +0.10 −0.10
Bo	33.50 +0.10 −0.10
Ko	9.30 +0.10 −0.10
P	24.00 +0.10 −0.10
F	20.20 +0.10 −0.10
E	1.75 +0.10 −0.10
D	1.50 +0.10 −0.00
D1	2.00 +0.25 −0.00
Po	4.00 +0.10 −0.10
P2	2.00 +0.10 −0.10
t	0.40 +0.05 −0.05

Figure 18 – SMT Tape and Reel Dimensions

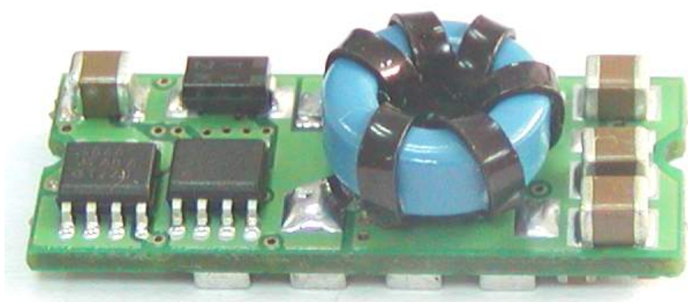
NON-ISOLATED DC-DC Converter

S15 SIP / SMT SERIES
3.0-5.5Vin, 0.9-3.63Vout, 15A

APPLICATION NOTES
Ver 1.0



S15-5S3.3T (Through-Hole) Converter



S15-5S3.3 SMT Version Converter

1. Introduction

This application note describes the features and functions of Intronics' S15-5S3.3 of Non Isolated DC-DC Converters.
These are highly efficient, reliable and compact, high power density, single output DC/DC converters. These "Point of Load" modules serve the needs specifically of the fixed and mobile telecommunications and computing market, employing economical distributed Power Architectures.
The S15-5S3.3 provide precisely regulated output voltage range from 0.9V to 3.63Vdc over a wide range of input voltage (Vi=3.0 – 5.5Vdc) and can operate over an ambient temperature range of –40C to +85C. Ultra-high efficiency operation is achieved through the use of synchronous rectification and drive control techniques. The modules are fully protected against short circuit and over-temperature conditions.
Intronics' world class automated manufacturing methods, together with an extensive testing and qualification program, ensure that all S15-5S3.3 converters are extremely reliable.

2. Models

The adjustable S15-5S3.3 series models are shown in table1 :

Model	Input Voltage	Output Voltage	Output Current
S15-5S3.3T	3.0 – 5.5VDC	0.9 – 3.63VDC	15A
S15-5S3.3	3.0 – 5.5VDC	0.9 – 3.63VDC	15A

Table 1 – 15A SIP/SMT Models

3. S15-5S3.3 Converter Features

- High efficiency topology, typically 94% at 3.3Vdc
- Industry standard footprint
- Wide ambient temperature range, -40C to +85C
- Cost efficient open frame design
- Programmable output voltage via external resistor from 0.9 to 3.63Vdc
- 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 S15-5S3.3 converter is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of synchronous rectification and drive techniques. Essentially, the powerful S15-5S3.3 topology is based on a non-isolated synchronous buck converter. The control loop is optimized for unconditional stability, fast transient response and a very tight line and load regulation. In a typical pre-bias application the S15-5S3.3 converters do not draw any reverse current at start-up.
The output voltage can be adjusted from 0.9 to 3.63vdc , using the TRIM pin with a external resistor.
The converter can be shut down via a remote ON/OFF input that is referenced to ground. This input is compatible with popular logic devices; a 'negative' logic input is supplied as standard. Negative logic implies that the converter is enabled if the remote ON/OFF input is low (or floating), and disabled if it is high.
The converter is also protected against over-temperature conditions. If the converter is overloaded or the ambient temperature gets too high, the converter will shut down to protect the unit.

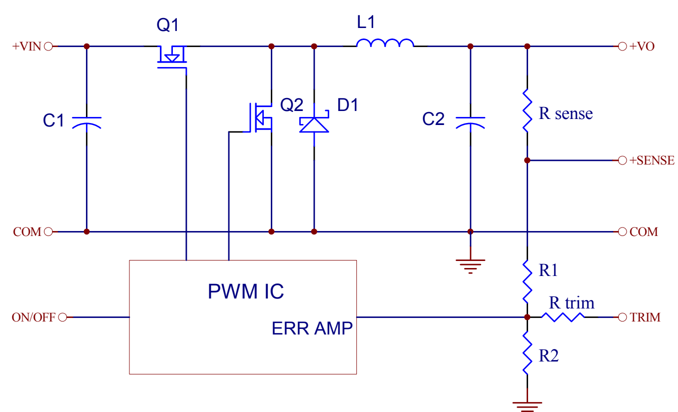


Figure 1. Electrical Block Diagram

4.2 Thermal Packaging and Physical Design.

The S15-5S3.3 uses a multi-layer FR4 PCB construction. All surface mount power components are placed on one side of the PCB, and all low-power control components are placed on the other 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 more sensitive, small signal control components.
- **Environmental:** Lead free open-frame converters are more easily re-cycled.
- **Cost Efficient:** No encapsulation**.** Cost efficient open-frame construction.
- **Reliable:** Efficient cooling provided by open frame construction offers high reliability and easy diagnostics.

5. Main Features and Functions

5.1 Operating Temperature Range

Intronics' S15-5S3.3 converters highly efficient converter design has resulted in its ability to operate over a wide ambient temperature environment (-40C to 85C). Due consideration must be given to the de-rating curves when ascertaining 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 heatsinks for the converter.

5.2 Over-Temperature Protection (OTP)

The S15-5S3.3 converters are equipped with non-latching over-temperature protection. A temperature sensor monitors the temperature of the hot spot (typically, top switch). If the temperature exceeds a threshold of 120°C (typical) the converter will shut down, disabling the output. When the temperature has decreased the converter will automatically restart.
The over-temperature condition can be induced by a variety of reasons such as external overload condition or a system fan failure.

5.3 Output Voltage Adjustment

Section 7.8 describes in detail as to how to trim the output voltage with respect to its set point. The output voltage on all models is trimmable in the range 0.9 – 3.63Vdc.

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.

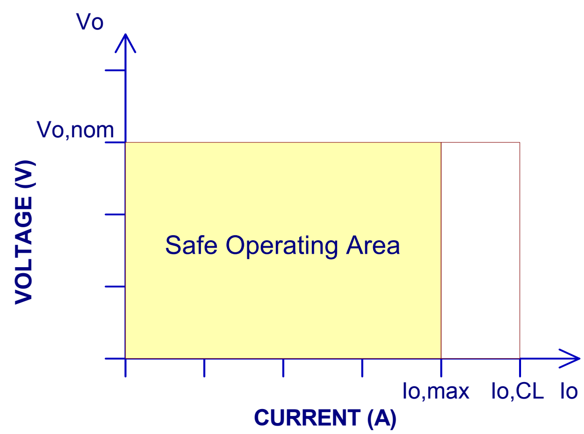


Figure 2. Maximum Output Current Safe Operating Area

5.5 Over Current Protection

All different voltage models have a full continuous short-circuit protection. The unit will auto recover once the short circuit is removed. To provide protection in a fault condition, the unit is equipped with internal over-current protection. The unit operates normally once the fault condition is removed. The power module will supply up to 140% of rated current. In the event of an over current converter will go into a hiccup mode protection.

5.6 Remote ON/OFF

The remote ON/OFF input feature of the converter allows external circuitry to turn the converter ON or OFF. Active-low remote ON/OFF is available as standard.
The S15-5S3.3 converters are turned on if the remote ON/OFF pin is low, or left open or floating. Pulling the pin high will turn the converter 'Off'. The signal level of the remote on/off input is defined with respect to ground. The unit is guaranteed OFF over the full temperature range if this voltage level exceeds 2.8Vdc.

The remote ON/OFF input can be driven as described in Figure 3.

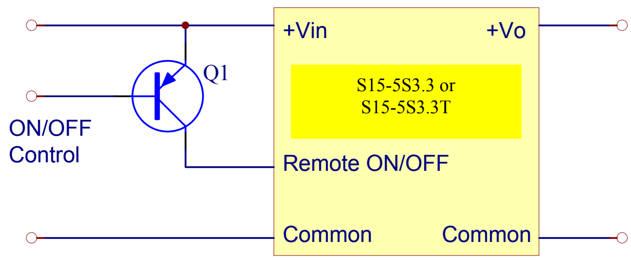


Figure 3 . Remote ON/OFF Input Drive Circuit

5.7 UVLO (Under-Voltage Lockout)

The voltage on the Vcc pin determines the start of the operation of the Converter. When the input Vcc rises and exceeds about 2.8V the converter initiates a soft start. The UVLO function in the converter has a Hysterisis (about 100mV) built in to provide noise immunity at start-up.

6. Safety

6.1 Input Fusing and Safety Considerations.

Agency Approvals: The power Supply shall be submitted to and receive formal approval from the following test agencies.

1.The power supply shall be approved by a nationally recognized testing laboratory to UL/CSA 60950 3rd Edition (North America) and EN60950 (International

2. CB Certificate from an internationally recognized test house in accordance with EN 60950.

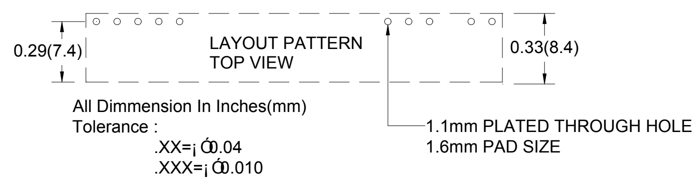
The S15-5S3.3 converters do not have an internal fuse. However, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a time-delay fuse with a maximum rating of 20A.

7. Applications

7.1 Layout Design Challenges.

In optimizing thermal design the PCB is utilized as a heatsink. Also some heat is transferred from the SIP 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 S15-5S3.3 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. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds.



VIEW IS FROM TOP SIDE
Figure 4A. Recommended SIP Footprint

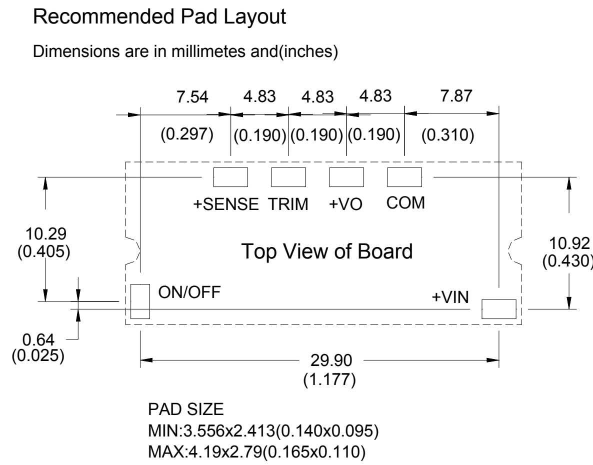
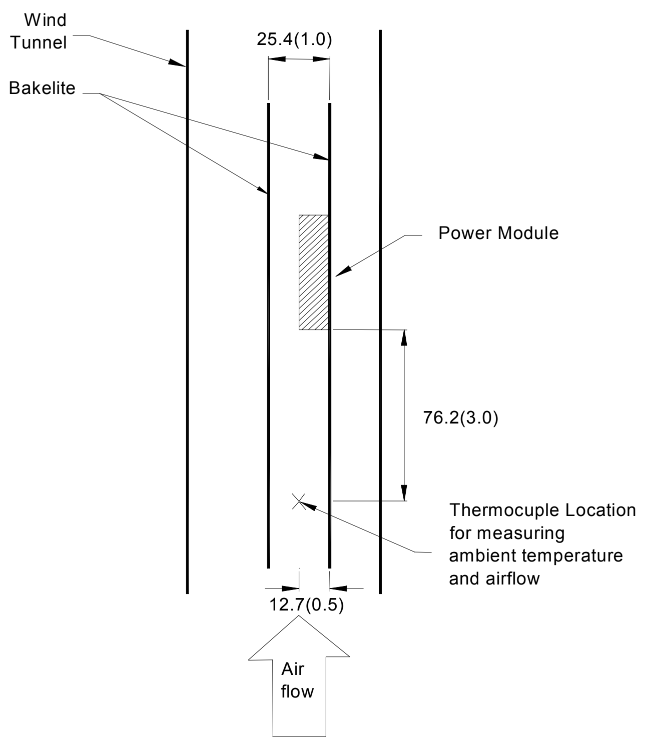


Figure 4B. Recommended SMT Footprint

7.2 Convection Requirements for Cooling

To predict the approximate cooling needed for the module, refer to the Power De-rating curves in Figures 9 and 10. These de-rating curves are approximations of the ambient temperatures and airflows required to keep 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 5 to ensure it does not exceed 110°C.

Proper cooling can be verified by measuring the power module's temperature at Q1-pin 6 and Q2-pin 6 as shown in Figure 6A,6B.



Note : Dimensions are in millimeters and (inches)

Figure 5. Thermal Test Setup

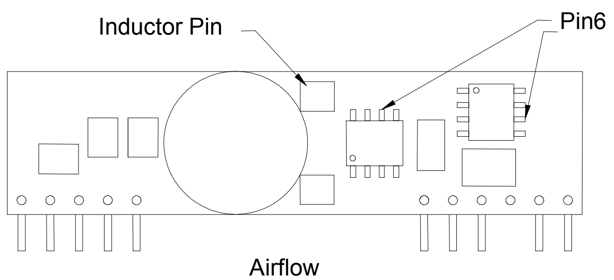


Figure 6A. Temperature Measurement Location for SIP

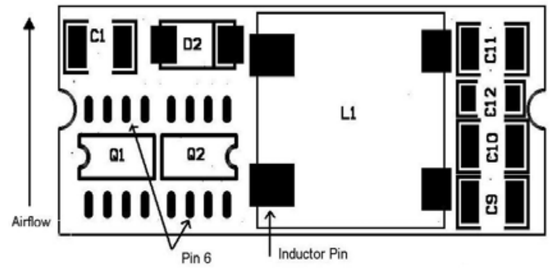


Figure 6B. Temperature Measurement Location for SMT

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 by conduction, convection, and radiation to the surrounding environment. The thermal data presented is based on measurements taken in a set-up as shown in Figure 5. Figures 7, 8 represent the test data.

Note that the airflow is parallel to the long axis of the module as shown in Figure 6A for the SIP15.

The temperature at either location 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).

The SMT15 thermal data presented is based on measurements taken in a wind tunnel. The test setup shown in Figure 5 and EUT need to solder on 33mm x 40.38mm(1.300" x 1.59") test pcb. Note that airflow is parallel to the long axis of the module as shown in Fig 6B

7.4 Power De-Rating Curves

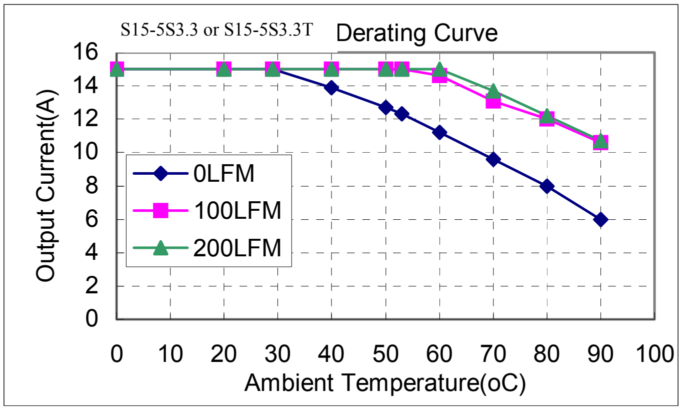


Figure 7. Typical Power De-rating for 5.0V IN(SIP15)

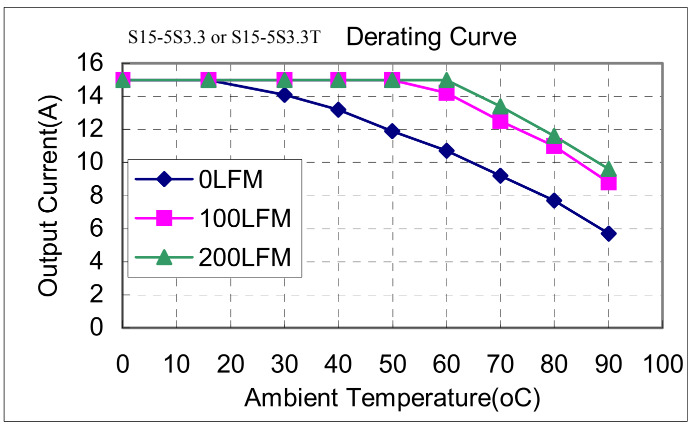


Figure 8.Typical Power De-rating for 5.0V IN (S15-5S3.3)

7.5 Input Capacitance at the Power Module

The SIP/SMT converters must be connected to a low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR polymers are a good choice. They have high capacitance, high ripple rating and low ESR (typical <20mΩ). Electrolytic capacitors should be avoided. 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.

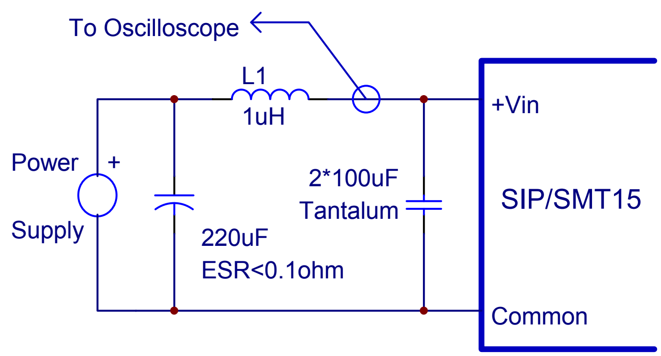


Figure 9. Input Reflected-Ripple Test Setup

7.6 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure 10. Things to note are that this converter is non-isolated, as such the input and output share a common ground. These grounds should be connected together via low impedance ground plane in the application circuit. When testing a converter on a bench set-up, ensure that $-V_{in}$ and $-V_o$ are connected together via a low impedance short to ensure proper efficiency and load regulation measurements are being made. When testing the Intronics' S15-5S3.3 under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate the

- Efficiency
- Load regulation and line regulation.

The value of efficiency is defined as :

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

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.

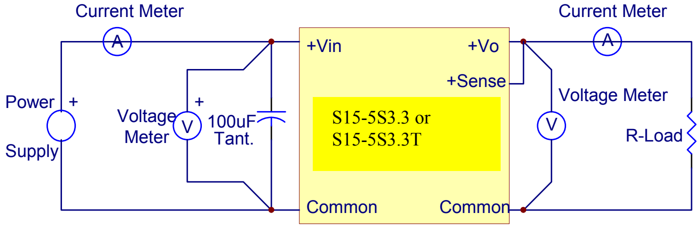


Figure 10. S15-5S3.3 Test Setup

7.7 Remote Sense Compensation

Remote Sense regulates the output voltage at the point of load. It minimizes the effects of distribution losses such as drops across the connecting pin and PCB tracks (see Figure 11). Please note however, the maximum drop from the output pin to the point of load should not exceed 500mV for remote 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 which, if the same output current is maintained, increases the power output by the module. 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, leave sense pin disconnected.

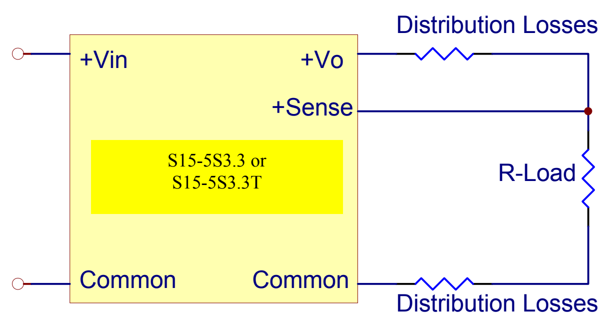


Figure 11. Circuit Configuration for Remote Sense Operation

7.8 S15-5S3.3 Output Voltage Adustment.

The output Voltage of the S15-5S3.3 can be adjusted in the range 0.9V to 3.63V by connecting a single resistor on the motherboard (shown as Rtrim) in Figure 12. When Trim resistor is not connected the output voltage defaults to 0.75V

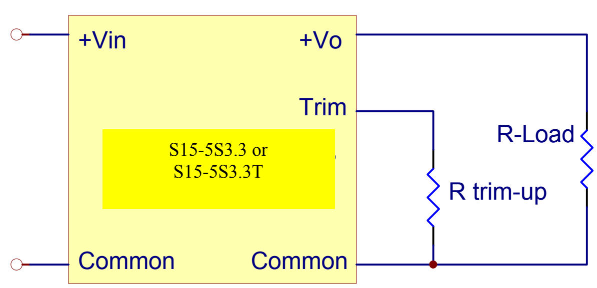


Figure 12. Trim-up Voltage Setup

The value of Rtrim-up defined as:

$$Rtrim = \left(\frac{21070}{Vo - 0.75} - 5110 \right) k\Omega$$

Where: Rtrim-up is the external resistor in KΩ,
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:

$$Rtrim = \left(\frac{21070}{3.3 - 0.75} - 5110 \right)$$

$$Rtrim = 3.15\, k\Omega$$

For various output values various resistors are calculated and provided in Table 2 for convenience.

Vo,set (V)	Rtrim (KΩ)
0.90	135.36
1.00	79.17
1.20	41.71
1.50	22.98
1.80	14.96
2.00	11.75
2.50	6.93
3.30	3.15
3.63	2.20

Table 2 – Trim Resistor Values

7.9 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 13. a 50Ω. coaxial cable with a 50Ω termination was used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies.

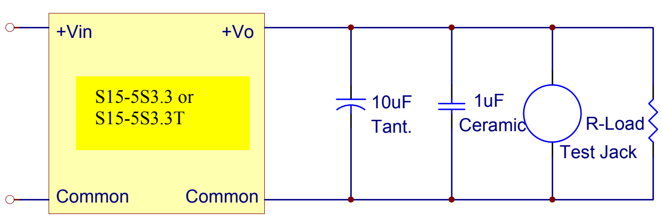


Figure 13. Output Voltage Ripple and Noise Measurement Set-Up

7.10 Output Capacitance

Intronics' S15-5S3.3 converters provide unconditional stability with or without external capacitors. For good transient response low ESR output capacitors should be located close to the point of load.
For high current applications point has already been made in layout considerations for low resistance and low inductance tracks.

Output capacitors with its associated ESR values have an impact on loop stability and bandwidth. Intronics' converters are designed to work with load capacitance up-to 10,000uF. It is recommended that any additional capacitance, typically 1,000uF and low ESR (<20m(), be connected close to the point of load and outside the remote compensation point.

7.11 SMT Reflow Profile

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

Equipment used: SMD HOT AIR REFLOW HD-350SAR
Alloy: AMQ-M293TA or NC-SMQ92 IND-82088 SN63

EMBED Excel.Chart.8 \s

Figure 14 – SMT Reflow Profile

8. Mechanical Outline Diagrams

8.1 S15-5S3.3 or S15-5S3.3T Mechanical 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

Figure 15. S15-5S3.3T Mechanical Outline Diagram

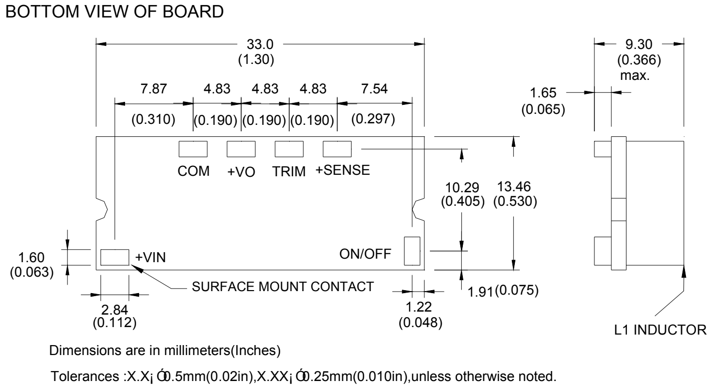
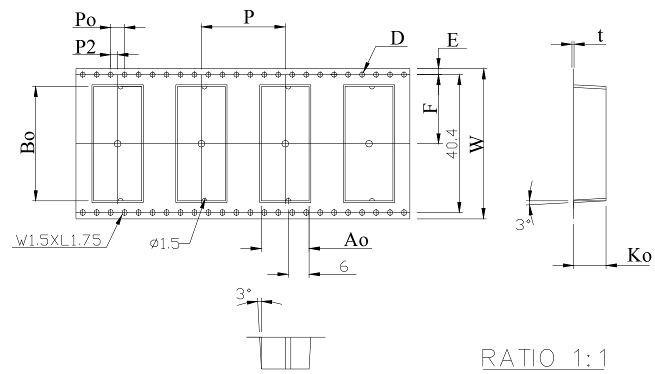


Figure 16. S15-5S3.3 Mechanical Outline Diagram

8.2 SMT Tape and Reel Dimensions

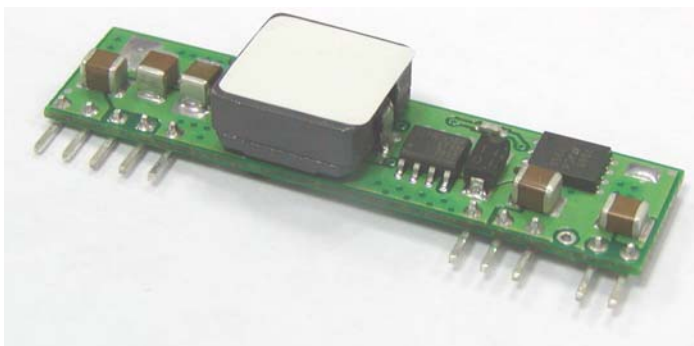
The Tape Reel dimensions for the SMT module is shown in Figure 17.



ITEM	SPEC
W	44.00 +0.30 −0.30
Ao	13.70 +0.10 −0.10
Bo	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 +0.05 −0.05

Figure 17 – SMT Tape and Reel Dimensions

NON-ISOLATED DC-DC Converter
S16-12S5T, S16-12S5
9.0-14Vin, 0.75-5.0Vout, 16A
APPLICATION NOTES
Ver. 10



S16-12S5T

S16-12S5

Content

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NORWOOD, MASSACHUSETTS 02062-5015 USA
www.intronicspower.com

S16 SERIES SIP or SMT Version Application Notes

Applications

- Servers, Switches and Data Storage
- Wireless Communications
- Distributed Power Architecture
- Semiconductor Test Equipment
- Networking Gear
- Data Communications
- Telecommunications
- Industrial / Medical

1. Introduction

This application note describes the features and functions of Intronics' S16 Series of Non Isolated DC-DC Converters. These are highly efficient, reliable and compact, high power density, single output DC/DC converters. These "Point of Load" modules serve the needs specifically of the fixed and mobile telecommunications and computing market, employing economical distributed Power Architectures. The S16 Series provide precisely regulated output voltage range from 0.75V to 5.0Vdc over a wide range of input voltage (Vi=9.0 – 14Vdc) and can operate over an ambient temperature range of –40℃ to +85℃. Ultra-high efficiency operation is achieved through the use of synchronous rectification and drive control techniques.

The modules are fully protected against short circuit and over-temperature conditions. Intronics' world class automated manufacturing methods, together with an extensive testing and qualification program ensure that all S16 Series converters are extremely reliable.

2. Models

The adjustable S16 Series models are shown in table1.

Model	Input Voltage	Output Voltage	Output Current
S16-12S5T	9.0 – 14VDC	0.75 – 5.0VDC	16A
S16-12S5	9.0 – 14VDC	0.75 – 5.0VDC	16A

Table 1 – S16 Series Models

The S16 efficiency and input current at 12Vin are shown in table2.

Output Voltage	Output Current	Input Current (mA)		Efficiency typ.
		No Load	Full Load	
0.75V	16A	40	1299mA	77%
1.2V	16A	50	1928mA	83%
1.5V	16A	50	2326mA	86%
1.8V	16A	60	2727mA	88%
2.0V	16A	60	2996mA	89%
2.5V	16A	65	3704mA	90%
3.3V	16A	75	4783mA	92%
5.0V	16A	75	7092mA	94%

Table 2 – S16 Efficiency and Input Current

3. 16A SIP/SMT Converter Features

- High efficiency topology, typically 94% at 5.0Vdc
- Industry standard footprint
- Wide ambient temperature range, -40C to +85C
- 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 S16 Series converter is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of synchronous rectification and drive techniques. Essentially, the powerful S16 Series topology is based on a non-isolated synchronous buck converter. The control loop is optimized for unconditional stability, fast transient response and a very tight line and load regulation. In a typical pre-bias application the S16 Series converters do 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 a external resistor. The converter can be shut down via a remote ON/OFF input that is referenced to ground. This input is compatible with popular 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 also protected against over-temperature conditions. If the converter is overloaded or the ambient temperature gets too high, the converter will shut down to protect the unit.

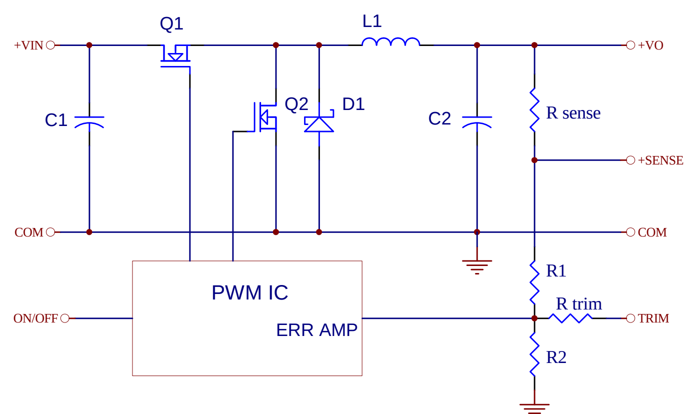


Figure 1. Electrical Block Diagram

4.2 Thermal Packaging and Physical Design.

The S16 Series uses a multi-layer FR4 PCB construction. All surface mount power components are placed on one side of the PCB, and all low-power control components are placed on the other 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 more sensitive, small signal control components.
- Environmental: Lead free open-frame converters are more easily re-cycled.
- Cost Efficient: No encapsulation. Cost efficient open-frame construction.
- Reliable: Efficient cooling provided by open frame construction offers high reliability and easy diagnostics.

5. Main Features and Functions

5.1 Operating Temperature Range

Intronics' S16 Series converters highly efficient converter design has resulted in its ability to operate over a wide ambient temperature environment (-40℃ to 85℃). Due consideration must be given to the de-rating curves when ascertaining 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 S16 Series converters are equipped with non-latching over-temperature protection. A temperature sensor monitors the temperature of the hot spot (typically, top switch). If the temperature exceeds a threshold of 130°C (typical) the converter will shut down, disabling the output. When the temperature has decreased the converter will automatically restart. The over-temperature condition can be induced by a variety of reasons such as external overload condition or a system fan failure.

5.3 Output Voltage Adjustment

Section 7.8 describes in detail as to how to trim the output voltage with respect to its set point. The output voltage on all models is trimmable in the range 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.

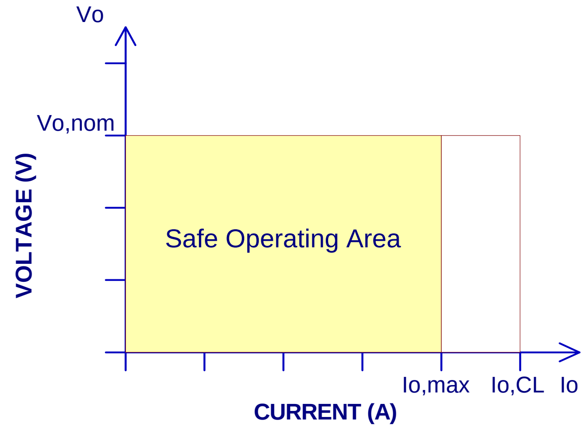


Figure 2. Maximum Output Current Safe Operating Area

5.5 Over Current Protection

All different voltage models have a full continuous short-circuit protection. The unit will auto recover once the short circuit is removed. To provide protection in a fault condition, the unit is equipped with internal over-current protection. The unit operates normally once the fault condition is removed. The power module will supply up to 150% of rated current. In the event of an over current converter will go into a hiccup mode protection.

5.6 Remote ON/OFF

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 S16 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 not using the remote on/off pin, leave the pin open (module will be on). The part number suffix "N" is Negative remote ON/OFF version. The unit is guaranteed OFF over the full temperature range if this voltage level exceeds 2.8Vdc. The converters are turned on If the on/off pin input is low (<0.4Vdc) or left open. The recommended SIP/SMT remote on/off drive circuit as shown as figure 3, 4.

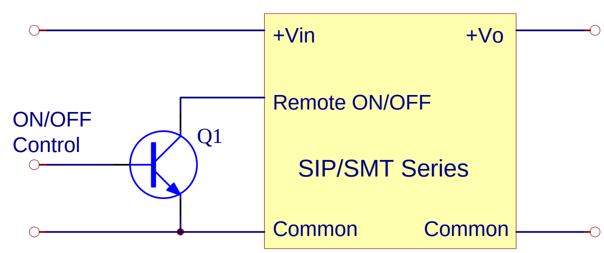


Figure 3. Positive Remote ON/OFF Input Drive Circuit

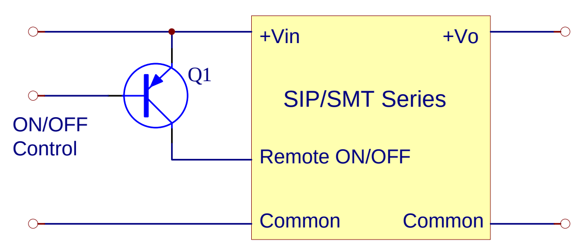


Figure 4. Negative Remote ON/OFF Input Drive Circuit

5.7 UVLO (Under-Voltage Lockout)

The voltage on the Vcc pin determines the start of the operation of the Converter. When the input Vcc rises and exceeds about 8.0V the converter initiates a soft start. The UVLO function in the converter has a hysteresis (about 300mV) built in to provide noise immunity at start-up.

6. Safety

6.1 Input Fusing and Safety Considerations.

Agency Approvals: The power Supply shall be submitted to and receive formal approval from the following test agencies.

1.The power supply shall be approved by a nationally recognized testing laboratory to UL/CSA 60950 3rd Edition (North America) and EN60950 (International)

2. CB Certificate from an internationally recognized test house in accordance with EN 60950.

The S16 Series converters do not have an internal fuse. However, to achieve maximum safety and system protection, always
use an input line fuse. The safety agencies require a time-delay fuse
with a maximum rating of 20A.

7. Applications

7.1 Layout Design Challenges.

In optimizing thermal design the PCB is utilized as a heat sink. Also some heat is transferred from the SIP/SMT 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
S16 Series 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. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended SIP/SMT footprint as shown as figure 5, 6.

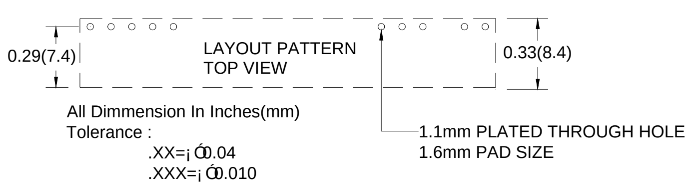


Figure 5. Recommended SIP Footprint

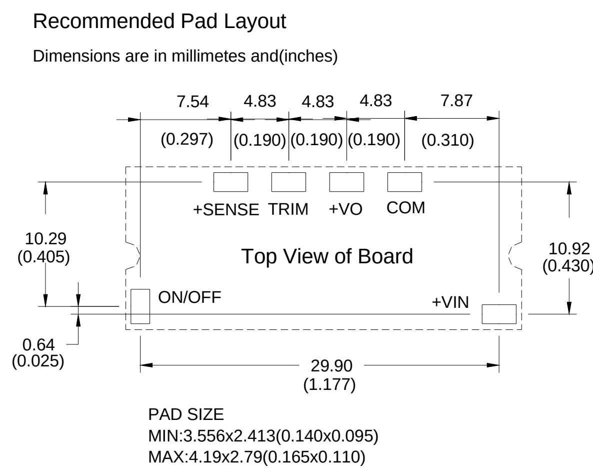
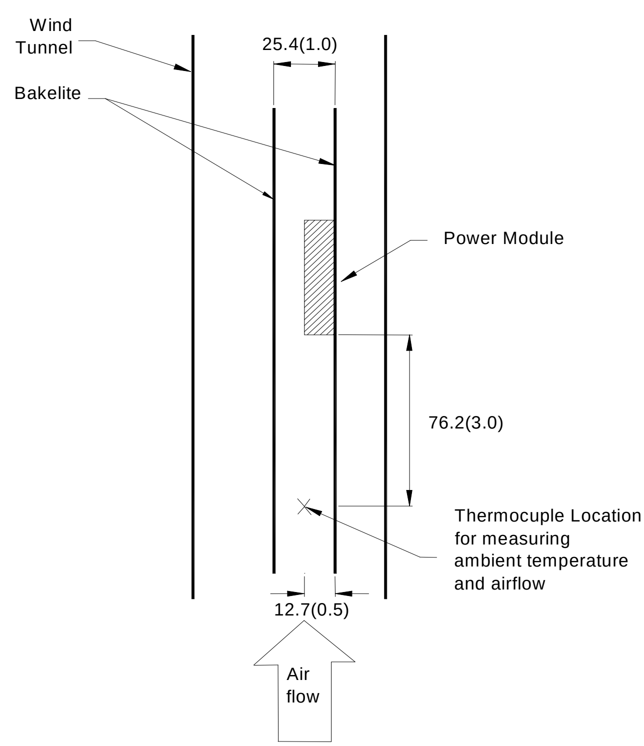


Figure 6. Recommended SMT Footprint

7.2 Convection Requirements for Cooling

To predict the approximate cooling needed for the module, refer to the Power De-rating curves in Figures 10 to 13 . These de-rating curves are approximations of the ambient temperatures and airflows required to keep 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 7 to ensure it does not exceed 120°C. Proper cooling can be verified by measuring the power module's temperature at Q1-pin 6 as shown in Figure 8,9.



Note : Dimensions are in millimeters and (inches)

Figure 7. Thermal Test Setup

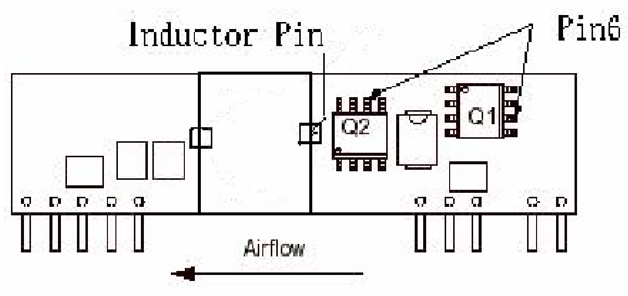


Figure 8. Temperature Measurement Location for SIP

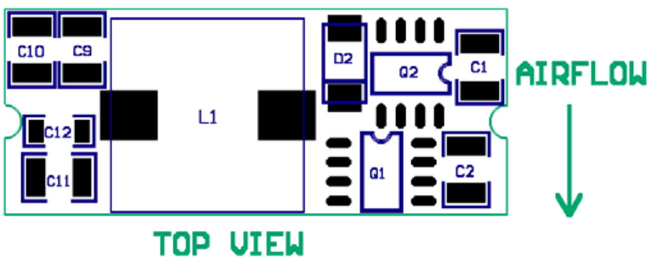


Figure 9. Temperature Measurement Location for SMT

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 by conduction, convection, and radiation to the surrounding environment. The thermal data presented is based on measurements taken in a set-up as shown in Figure7. Figures 10 to 13 represent the test data. Note that the airflow is parallel to the long axis of the module as shown in Figure7 for the SIP/SMT.

The temperature at either location should not exceed 120 °C. The output power of the module should not exceed the rated power for the module (VO, set x IO, max). The SMT05 thermal data presented is based on measurements taken in a wind tunnel. The test setup shown in Figure 7 and EUT need to solder on 33mm x 40.38mm(1.300" x 1.59") test pcb. Note that airflow is parallel to the long axis of the module as shown in Fig7.

7.4 Power De-Rating Curves

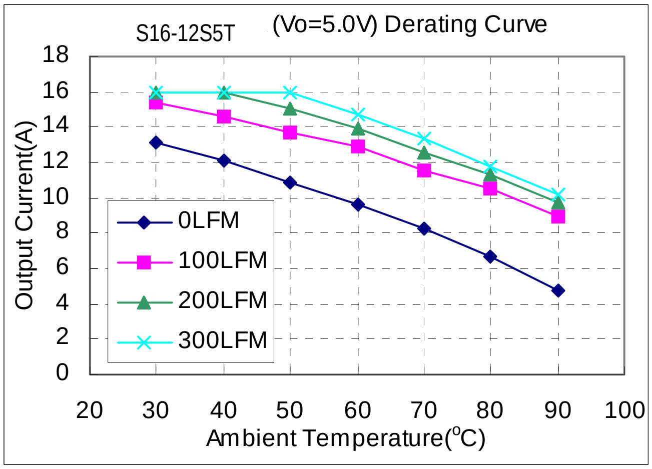


Figure10a.Typical Power De-rating for 12V IN 5.0Vout

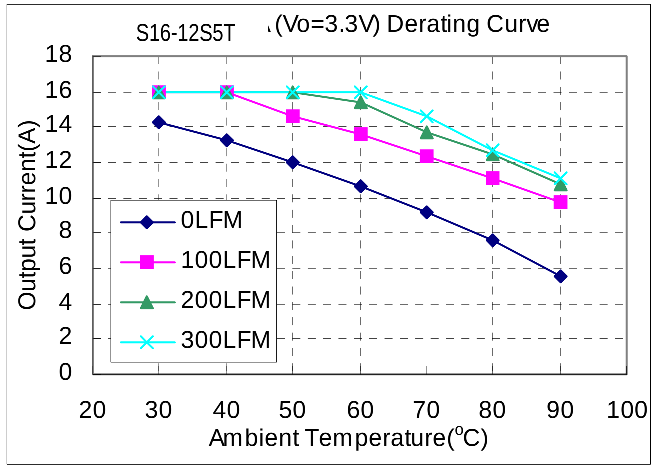


Figure 10b.Typical Power De-rating for 12V IN 3.3Vout

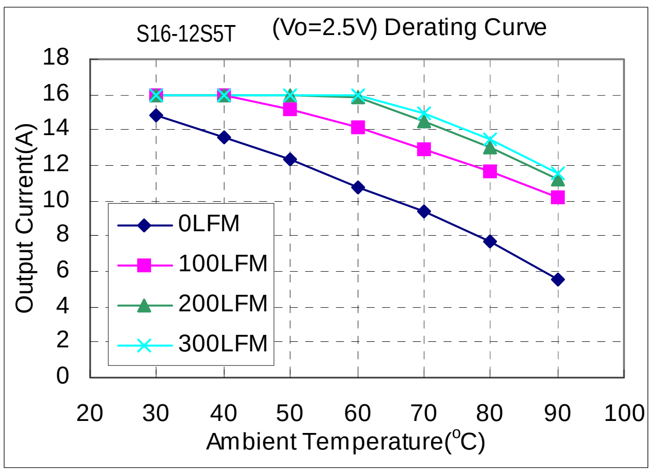


Figure10c.Typical Power De-rating for 12V IN 2.5Vout

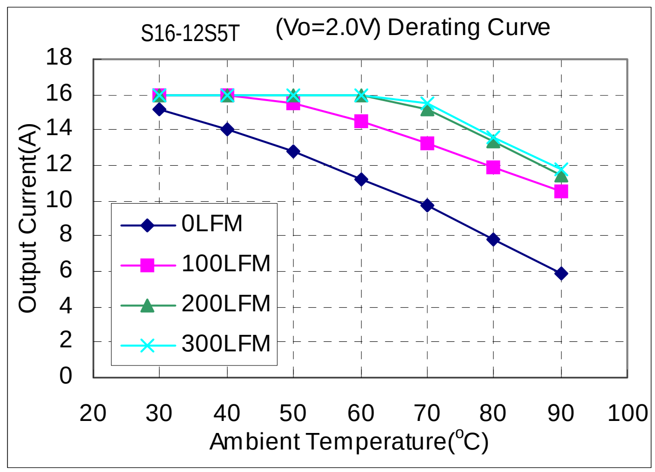


Figure 10d.Typical Power De-rating for 12V IN 2.0Vout

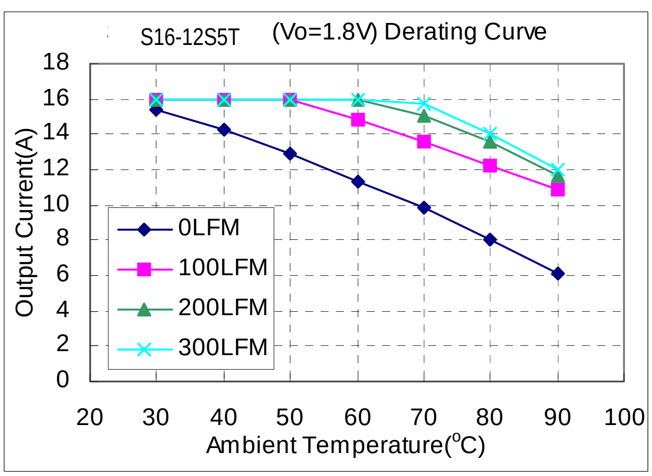


Figure10e.Typical Power De-rating for 12V IN 1.8Vout

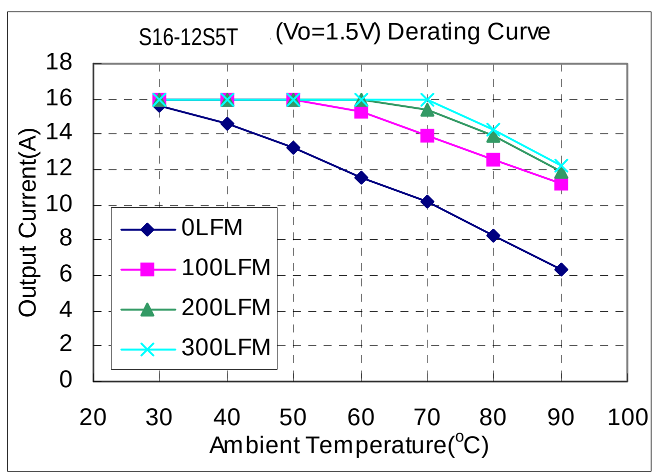


Figure 10f.Typical Power De-rating for 12V IN 1.5Vout

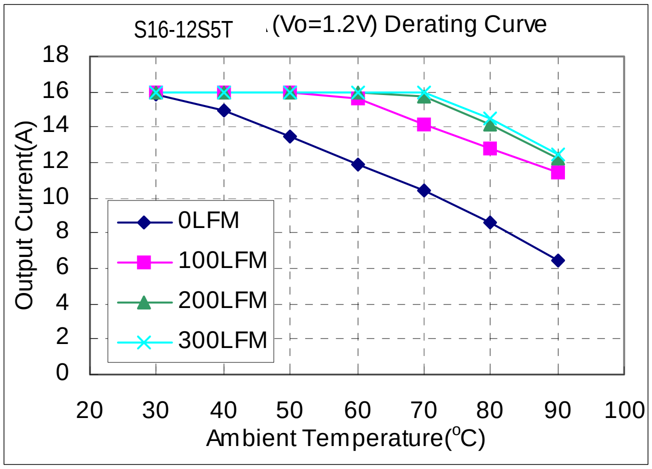


Figure10g.Typical Power De-rating for 12V IN 1.2Vout

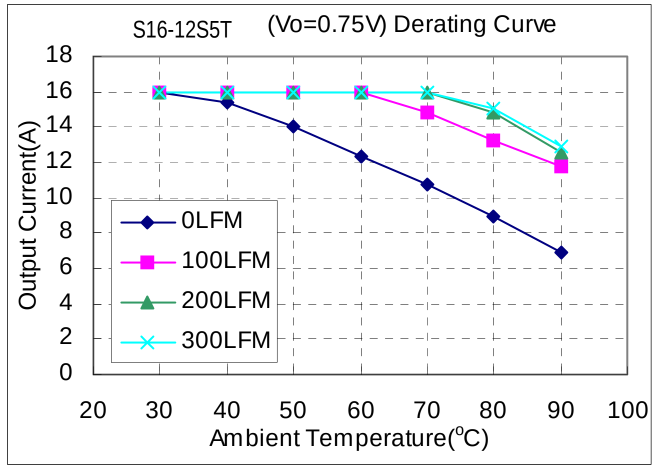


Figure 10h.Typical Power De-rating for 12V IN 0.75Vout

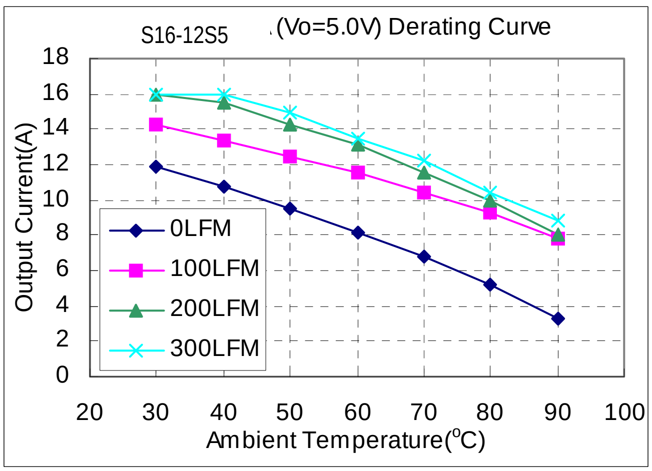


Figure11a.Typical Power De-rating for 12V IN 5.0Vout

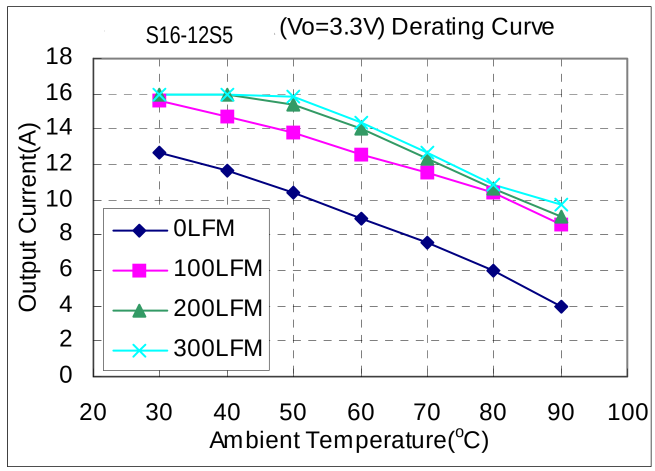


Figure 11b.Typical Power De-rating for 12V IN 3.3Vout

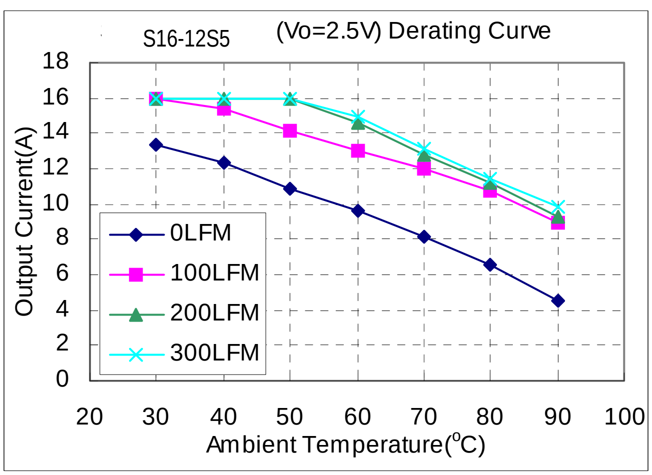


Figure11c.Typical Power De-rating for 12V IN 2.5Vout

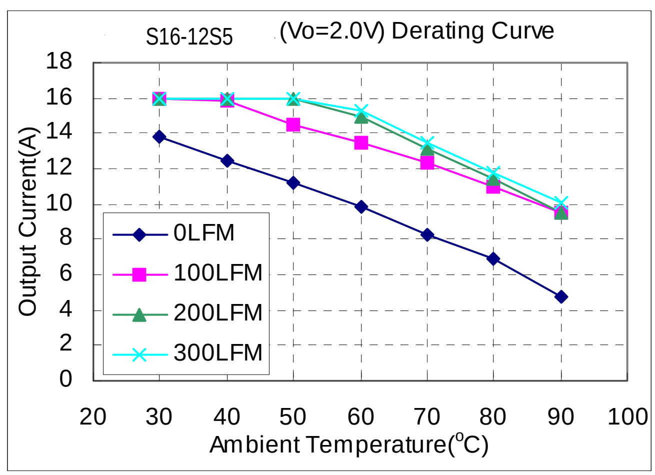


Figure 11d.Typical Power De-rating for 12V IN 2.0Vout

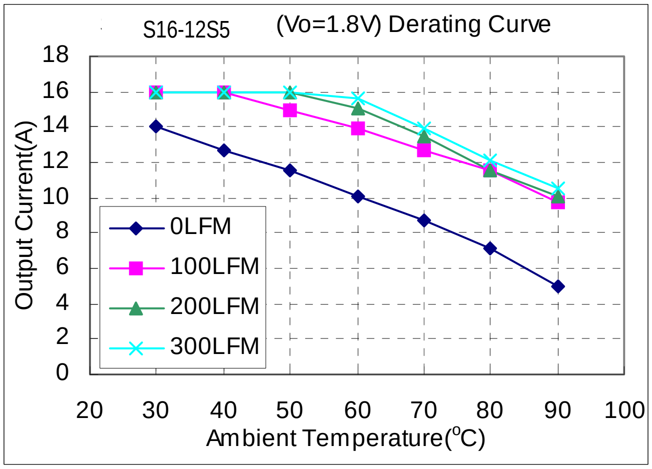


Figure11e.Typical Power De-rating for 12V IN 1.8Vout

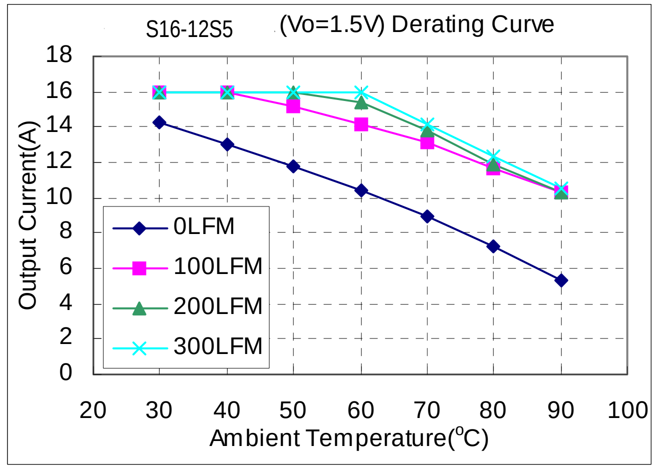


Figure11d.Typical Power De-rating for 12V IN 1.5Vout

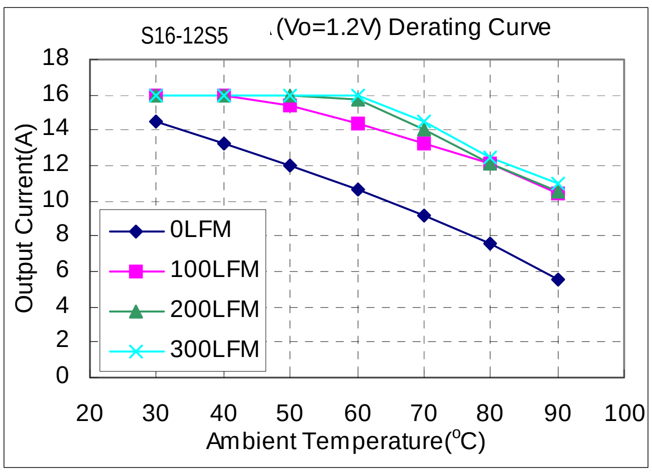


Figure11f.Typical Power De-rating for 12V IN 1.2Vout

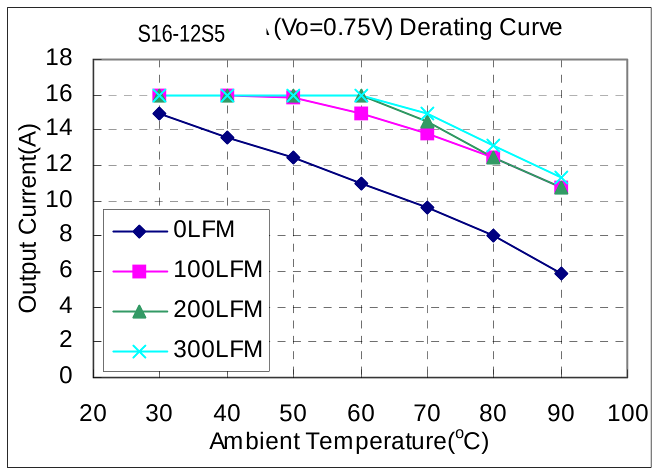
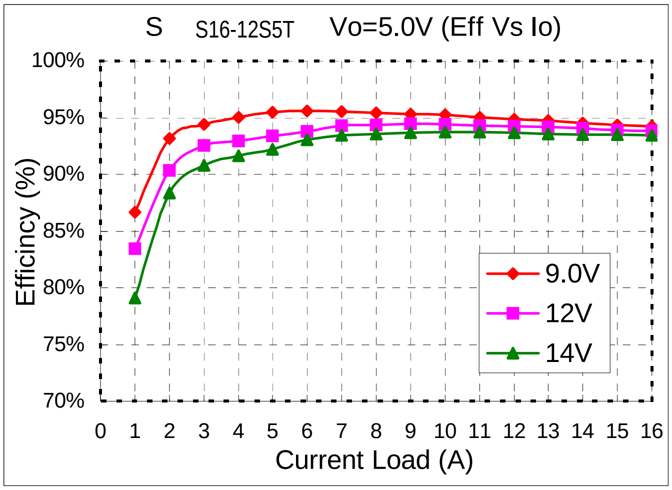
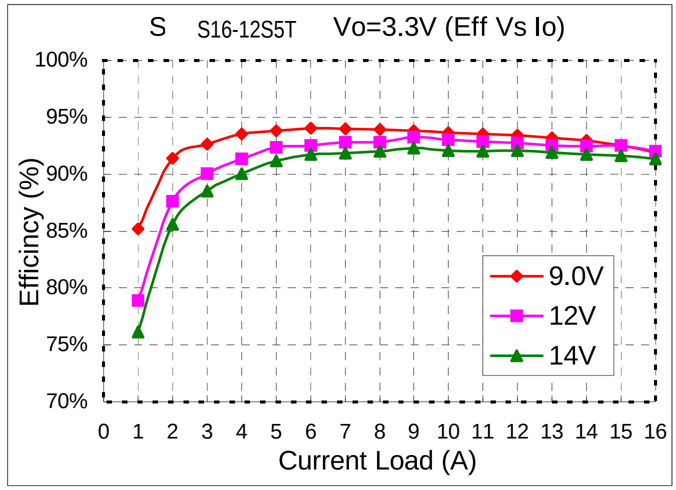
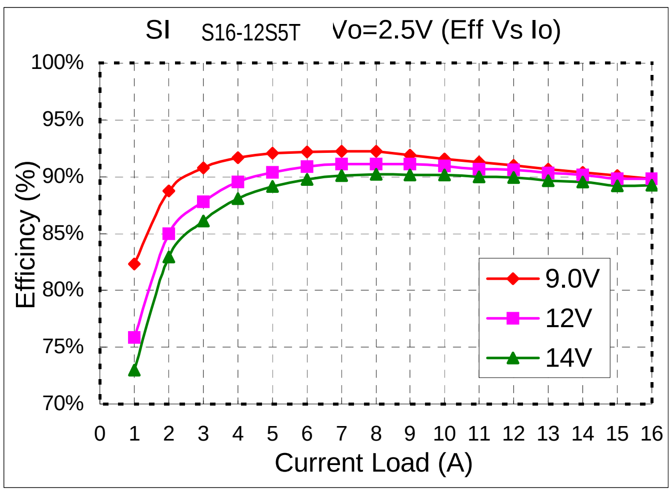


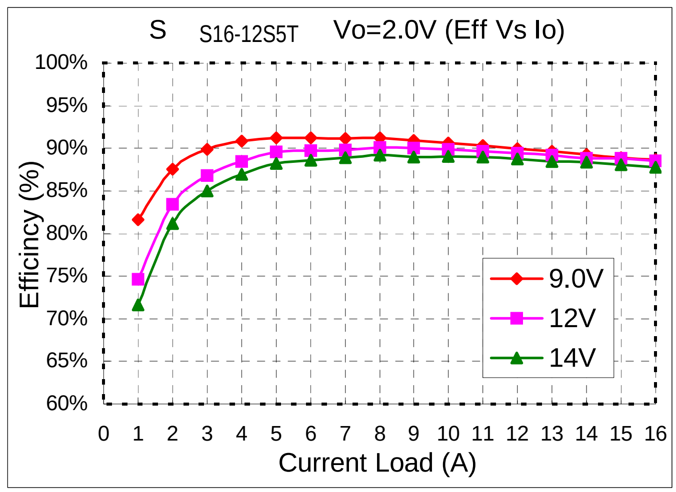
Figure 11g.Typical Power De-rating for 12V IN 0.75Vout

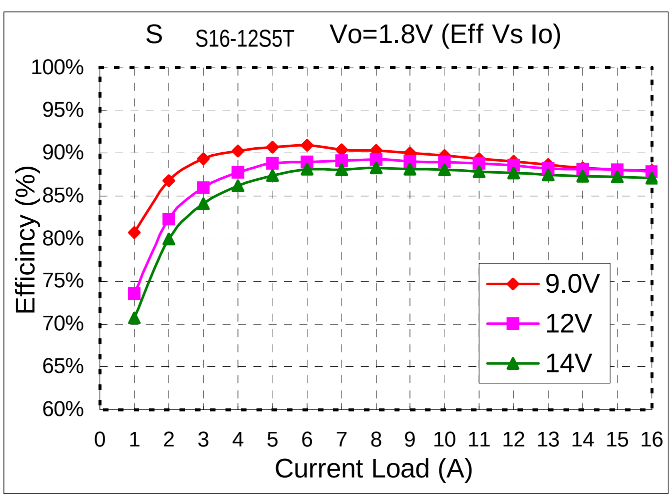
7.5 Efficiency vs Load Curves

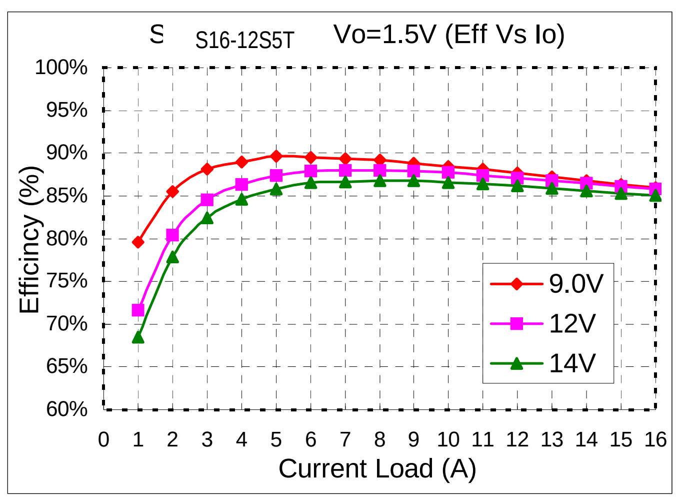


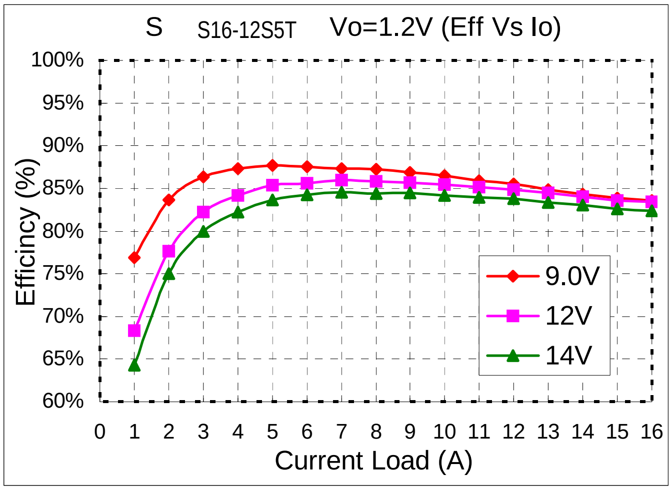


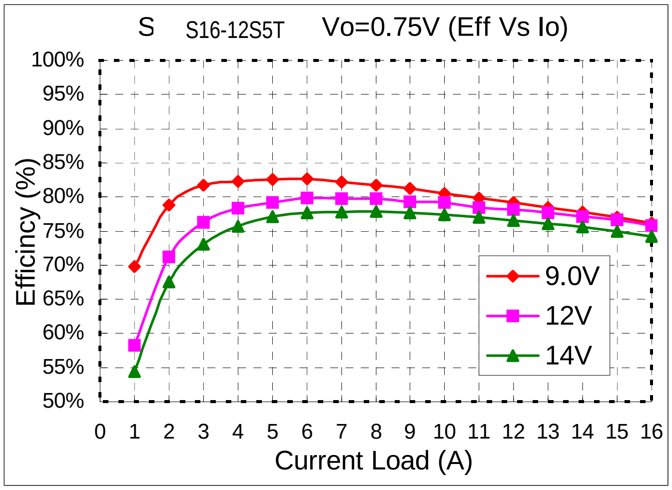


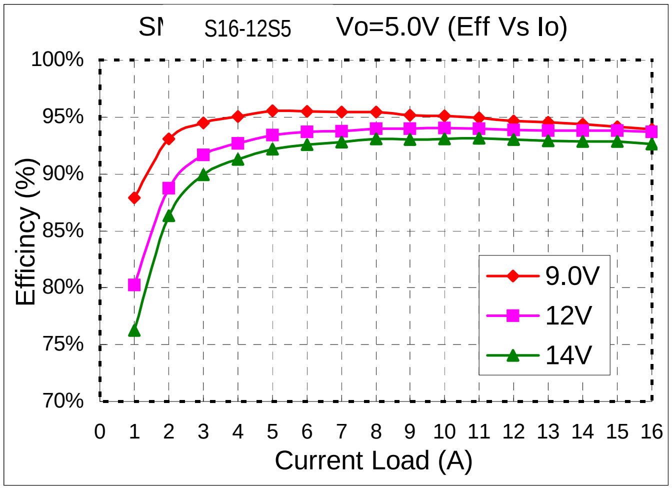


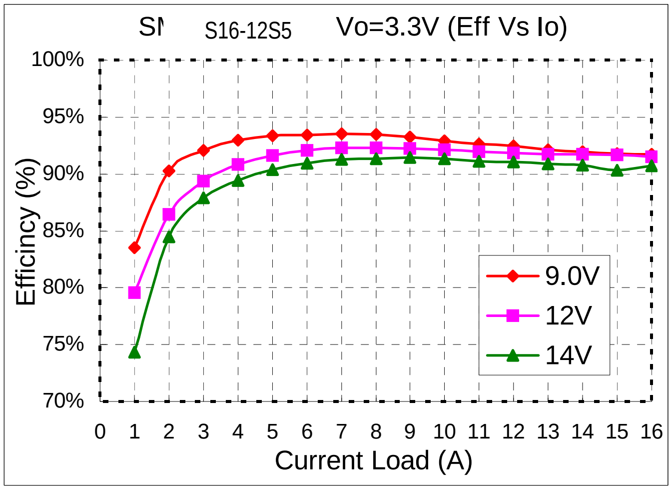


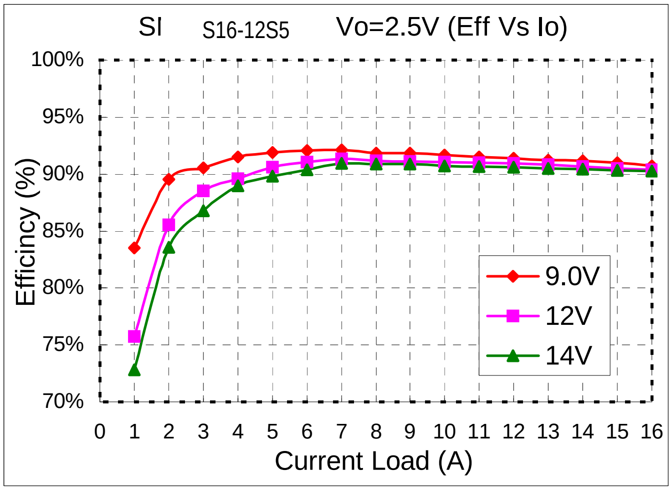


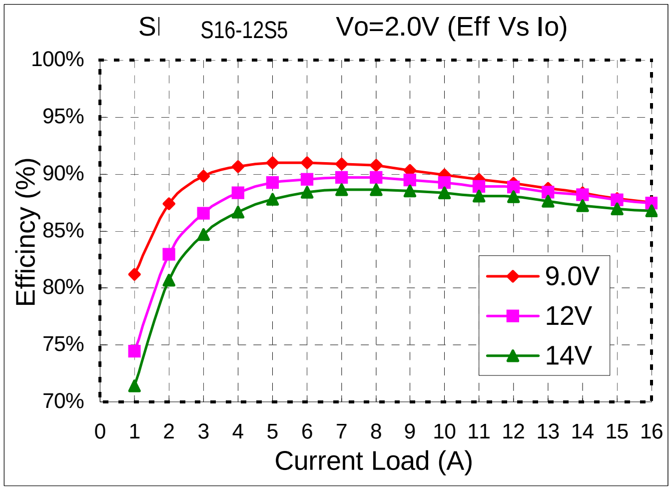

S16-12S5T Vo=1.2V (Eff Vs Io)
Efficincy (%)
Current Load (A)
9.0V
12V
14V

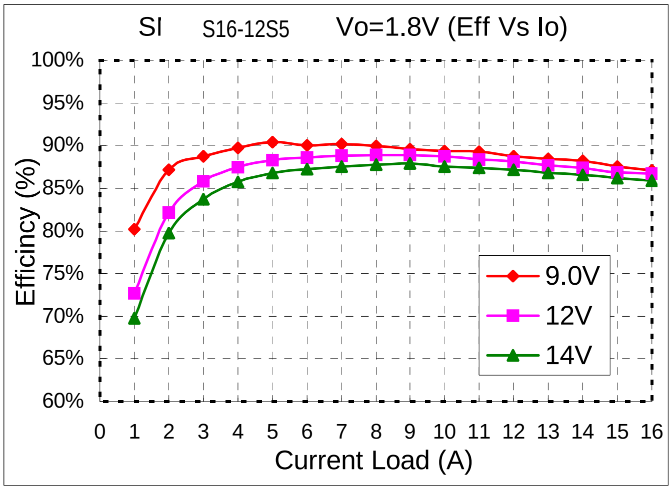

S16-12S5T Vo=0.75V (Eff Vs Io)
Efficincy (%)
Current Load (A)
9.0V
12V
14V

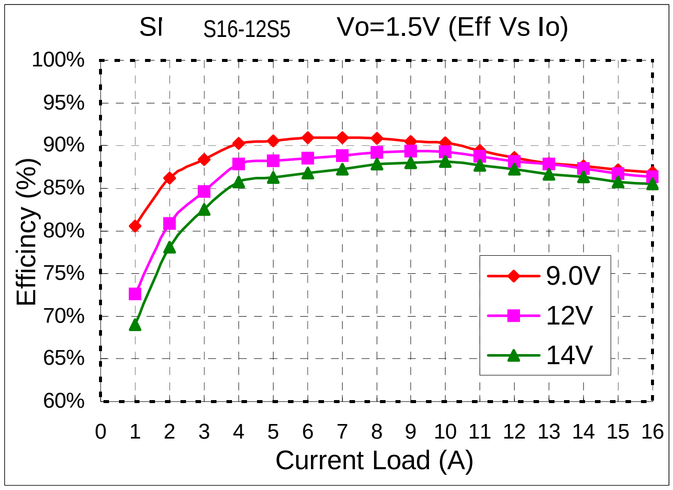

S16-12S5 Vo=5.0V (Eff Vs Io)
Efficincy (%)
Current Load (A)
9.0V
12V
14V

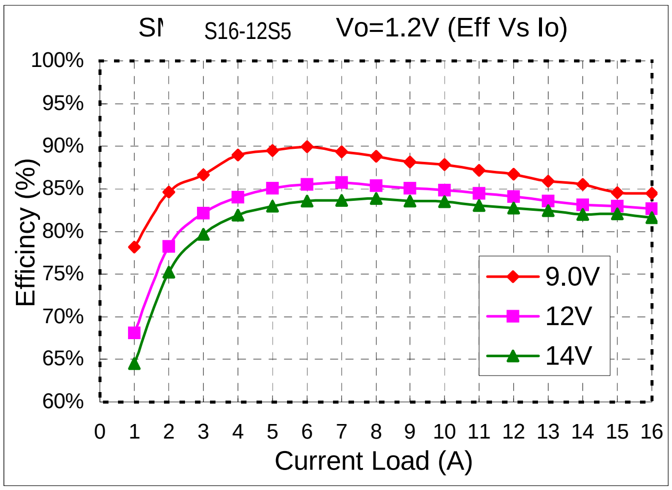

S16-12S5 Vo=3.3V (Eff Vs Io)
Efficincy (%)
Current Load (A)
9.0V
12V
14V

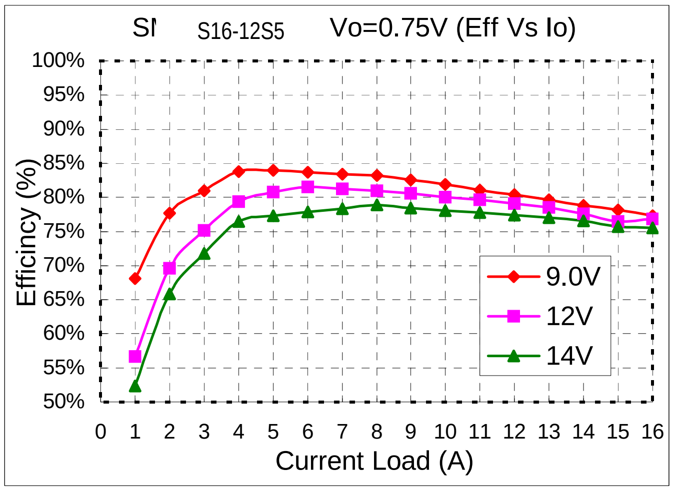

S16-12S5 Vo=2.5V (Eff Vs Io)
Efficincy (%)
Current Load (A)
9.0V
12V
14V


S16-12S5 Vo=2.0V (Eff Vs Io)
Efficincy (%)
Current Load (A)
9.0V
12V
14V


SI S16-12S5 Vo=1.8V (Eff Vs Io)
Efficincy (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Current Load (A)
9.0V
12V
14V


SI S16-12S5 Vo=1.5V (Eff Vs Io)
Efficincy (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Current Load (A)
9.0V
12V
14V


SI S16-12S5 Vo=1.2V (Eff Vs Io)
Efficincy (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Current Load (A)
9.0V
12V
14V


SI S16-12S5 Vo=0.75V (Eff Vs Io)
Efficincy (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Current Load (A)
9.0V
12V
14V

7.6 Input Capacitance at the Power Module

The SIP/SMT converters must be connected to a low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR polymers are a good choice. They have high capacitance, high ripple rating and low ESR (typical <100mohm). Electrolytic capacitors should be avoided. Circuit as shown in Figure 14 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.

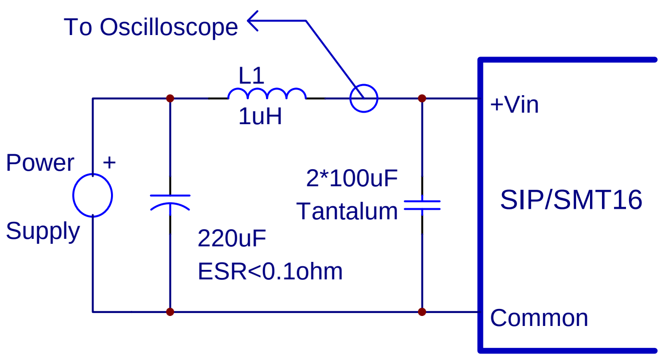


Figure 14. Input Reflected-Ripple Test Setup

7.7 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure 15. Things to note are that this converter is non-isolated, as such the input and output share a common ground. These grounds should be connected together via low impedance ground plane in the application circuit. When testing a converter on a bench set-up, ensure that -V_{in} and -V_o are connected together via a low impedance short to ensure proper efficiency and load regulation measurements are being made. When testing the Intronics' S16 Series under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate the

- Efficiency
- Load regulation and line regulation.

The value of efficiency is defined as:

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

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.

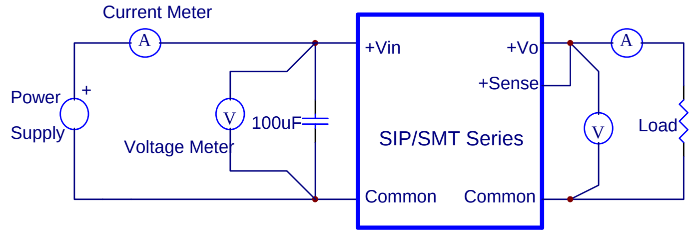


Figure 15. SIP/SMT16 Series Test Setup

7.8 S16 Series Output Voltage Adustment.

The output Voltage of the S16 can be adjusted in the range 0.75V to 5.0V by connecting a single resistor on the motherboard (shown as Rtrim) in Figure 16. When Trim resistor is not connected the output voltage defaults to 0.75V

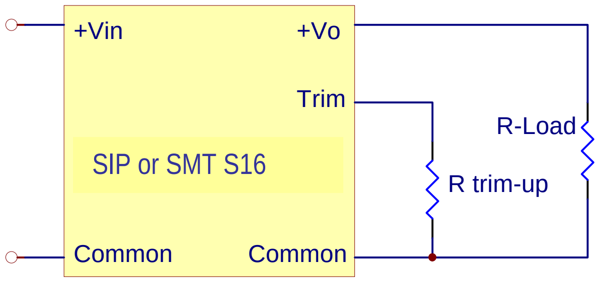


Figure 16. Trim-up Voltage Setup

The value of Rtrim-up defined as:

$$Rtrim = (\frac{10500}{Vo - 0.75} - 1000)$$

Where: Rtrim-up is the external resistor in ohm,
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:

$$Rtrim = (\frac{10500}{3.3 - 0.75} - 1000)$$

Rtrim = 3117 ohm

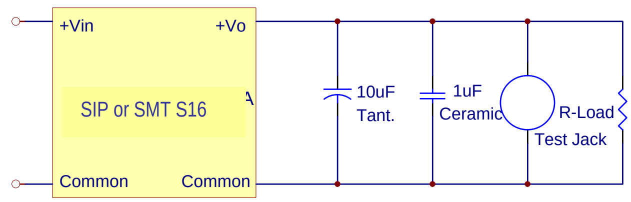
For various output values various resistors are calculated and provided in Table 3 for convenience.

Vo,set (V)	Rtrim (Kohm)
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

7.9 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 17. a coaxial cable with a 50ohm termination was used to prevent impedance mismatch reflections



disturbing the noise readings at higher frequencies.

Figure 17. Output Voltage Ripple and Noise Measurement Set-Up

7.10 Output Capacitance

Intronics' S16 Series converters provide unconditional stability with or without external capacitors. For good transient response low ESR output capacitors should be located close to the point of load.

For high current applications point has already been made in layout considerations for low resistance and low inductance tracks.

Output capacitors with its associated ESR values have an impact on loop stability and bandwidth. Intronics' converters are designed to work with load capacitance up-to 8,000uF. It is recommended that any additional capacitance, Maximum 8,000uF and low ESR, be connected close to the point of load and outside the remote compensation point.

7.11 SMT Reflow Profile

An example of the SMT reflow profile is given in Figure 18.

Equipment used: SMD HOT AIR REFLOW HD-350SAR

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

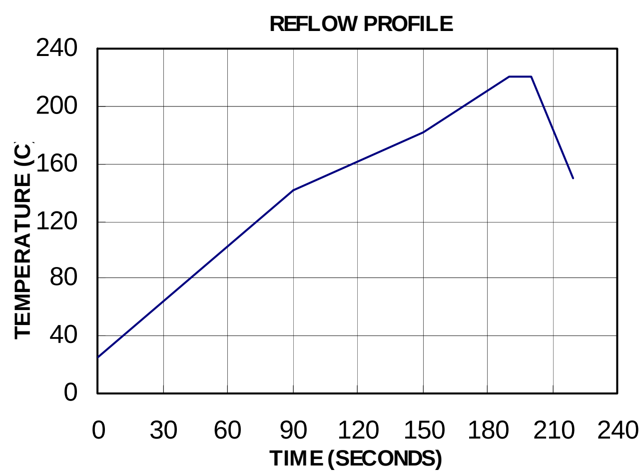


Figure 18 SMT Reflow Profile

8. Mechanical Outline Diagrams

8.1 SIP/SMT16 Mechanical 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

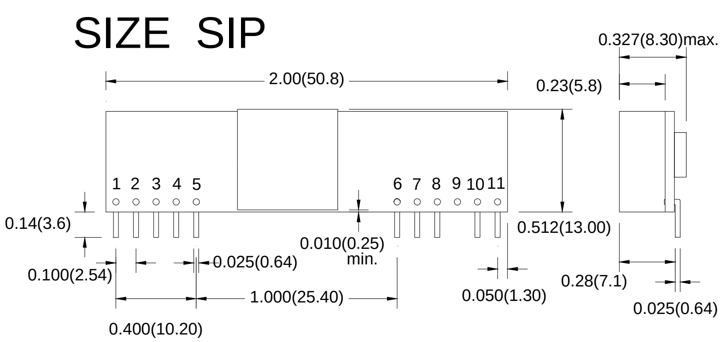


Figure 19 SIP16 Mechanical Outline Diagram

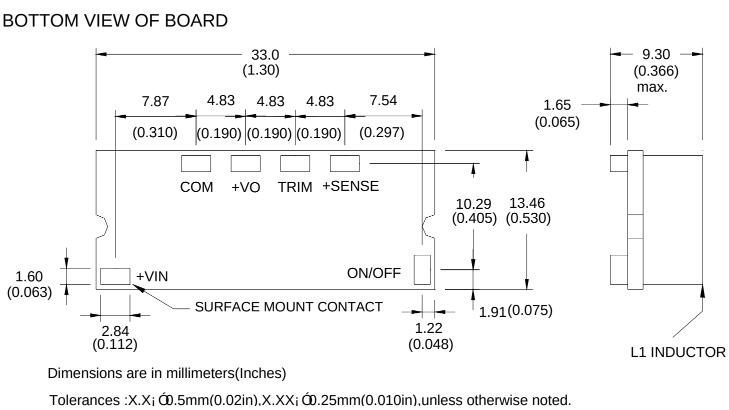
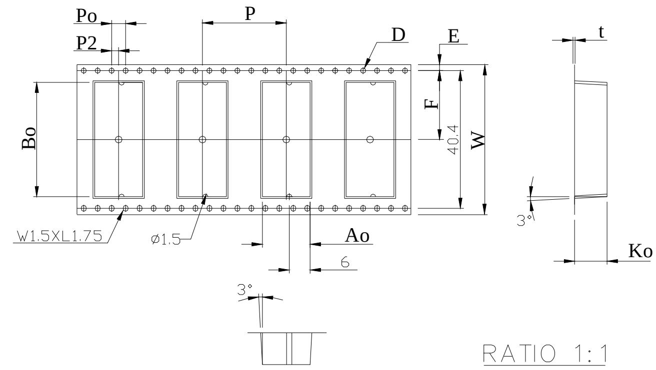


Figure 20 SMT16 Mechanical Outline Diagram

8.2 SMT Tape and Reel Dimensions

The Tape Reel dimensions for the SMT module is shown in Figure 21.



ITEM	SPEC
W	44.00 +0.30 −0.30
Ao	13.70 +0.10 −0.10
Bo	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 +0.05 −0.05

Figure 21 – SMT Tape and Reel Dimensions