NEW Product

SIL30E 12Vin Single

Application Note 176

RoHS
2002/95/EC

ARTESYN® TECHNOLOGIES

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1. Introduction

This application note describes the features and functions of Artesyn Technologies' 12V, 30A series of non-isolated high power density, single DC/DC converters. These Point-of-Load modules are targeted specifically at the fixed and mobile telecommunications, industrial electronics and distributed power markets.

The SIL30E 12V is available with a 8V to 14VDC operating range and can operate over an ambient temperature range of -40°C to +85°C. Ultra-high efficiency operation is achieved through the use of synchronous rectification and control techniques. The modules are fully protected against short-circuit and over-temperature conditions. Standard features include remote ON/OFF and remote sense.

The series has been designed primarily for telecommunication applications. Automated manufacturing methods, together with an extensive qualification program, ensure that all SIL30E series converters are extremely reliable.

2. Models

The 12V series comprises of 1 model, as listed in Table 1.

Model	Input Voltage	Output Voltage	Output Current
SIL30E-12W3V3-VJ	8V - 14VDC	0.8 - 3.63V	30A

Table 1 - SIL30E Model

RoHS Compliance Ordering Information
The 'J' at the end of the part number indicates that the part is Pb-free (RoHS 6/6 compliant). TSE RoHS 5/6 (non Pb-free) compliant versions may be available on special request, please contact your local sales representative for details.

2.1 Features

- High efficiency topology, typically 93% at 3.3Vout @ full load
- Wide ambient temperature range, -40°C to +85°C
- 0.8V to 3.63V output voltage adjustability
- No minimum load requirement
- Remote ON/OFF
- Remote sense compensation
- Fixed switching frequency
- Continuous short-circuit protection
- Overtemperature protection (OTP)
- Available RoHS compliant

3. General Description

3.1 Electrical Description

A block diagram of the converter is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of synchronous rectification techniques.

The POL topology is a non-isolated three terminal synchronous buck converter. The control of the synchronous rectifiers are optimized for high efficiency power conversion.

The output is adjustable over a range of 0.8V to 3.63V by means of an external resistor from trim pin to ground. The output voltage default is 0.8V, which can be trimmed up to any required set-point within the range. See Section 9.1 for details.

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 disabled if the remote ON/OFF input is ≤ 0.8V, and enabled if it is high (≥2.8V) or floating.

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 until the temperature falls below a minimum threshold.

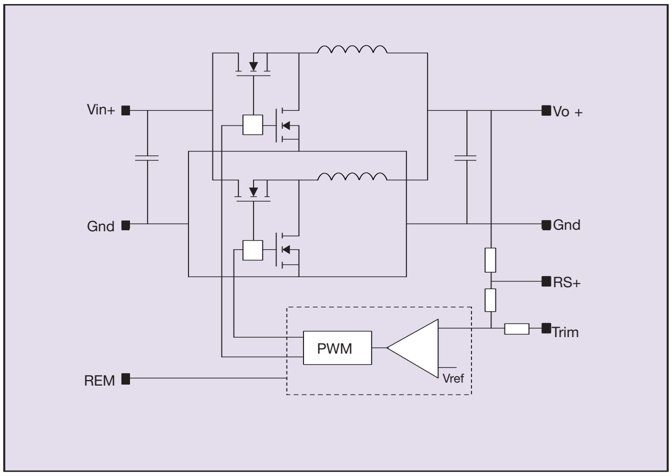

Figure 1 - Electrical Block Diagram

3.2 Physical Construction

The SIL30E are constructed using a multi-layer FR4 PCB. 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:

- **Cost:** no potting compound, case or associated process costs involved.
- **Thermals:** the heat is removed from the heat generating components without heating more sensitive, less tolerant components.
- **Environmental:** some encapsulants are not kind to the environment and create problems in incinerators. Further more open-frame converters are more easily re-cycled.
- **Reliability:** open-frame modules are more reliable for a number of reasons, including improved thermal performance and reduced TCE stresses.

A separate paper discussing the benefits of open-frame DC/DC converters (Design Note 102) is available at www.artesyn.com

4. System Interface Information

4.1 Input Characteristics

The SIL30E 12V series has an input voltage range of 8V to 14V. The wide input voltage range gives designers more flexibility in choosing an Intermediate Bus Converter to operate the Point-of-Load converter.

4.1.1 Reflected Ripple Current

Because of the switching operation of the design, there is an AC current generated at the input of the unit. This is referred to as input reflected ripple current.

The typical ripple current for the SIL30E series is approx 1.3A peak to peak at full load, with the output trimmed up to 3.3V.

4.1.2 Input Source Impedance and Input Capacitance

The SIL30E converter must be connected to a low AC source impedance. High source inductance can affect the loop stability. Input capacitance should be placed close to the converter input pins to decouple distribution inductance. The external input capacitors must be chosen for suitable ripple current rating. Electrolytic capacitors should be avoided. Recommended input capacitors are ceramics such as 10μF 20V 1812 or similar.

4.2 Output Characteristics and Output Capacitance

The SIL30E series has been designed for stable operation without the need for external capacitance at the output terminals. However, when powering loads with dynamic current requirements, improved voltage regulation can be obtained by inserting capacitors as close as possible to the load. The most effective technique is to locate low ESR ceramic capacitors (for example 100μF or greater GRM series from Murata or similar) as close to the load as possible. These ceramic capacitors will handle the short duration high frequency components of the dynamic current requirement.

It is equally important to use good design practices when configuring the DC distribution system. Low resistance and low inductance PCB layout traces should be utilized, particularly in the high current output section. Remember that the capacitance of the distribution system and the associated ESR are within the feedback loop of the power module. This can have an effect on the module's compensation capabilities and its resultant stability and dynamic response performance. With large values of capacitance, the stability criteria depend on the magnitude of the ESR with respect to the capacitance. As much of the capacitance as possible should be outside the remote sensing loop and close to the load.
Note that the maximum rated value of output capacitance for all models is 10,000μF. Contact your local Artesyn Technologies representative for further information if larger output capacitance values are required in the application.

4.2.1 Converter Stability

The SIL30E series has been designed to meet a minimum criteria of at least 45° at unity gain over all line and load operating conditions. The selection of compensation components ensure the design is unconditionally stable for all operating conditions. Bode plot measurements have been taken to prove out theoretical analysis of the design. Because of the high DC gain, the bode plots were carried out with the unit in closed loop operation. A sample measurement is shown in Figures 2 and 3. These were taken at nominal input voltage, full output current and Vout set to 1.5V.

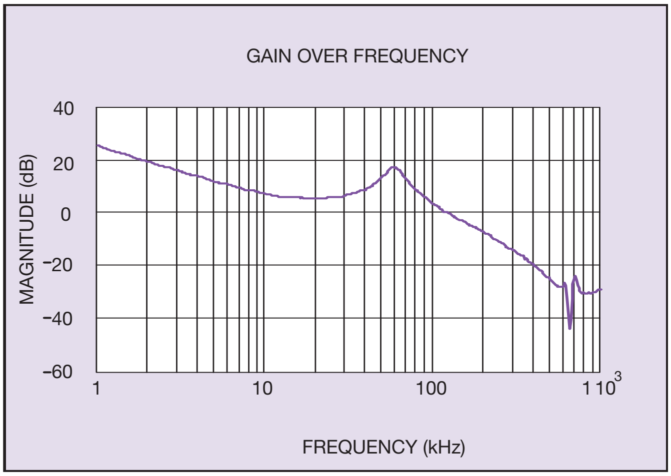

Figure 2 - Converter Stability Plot

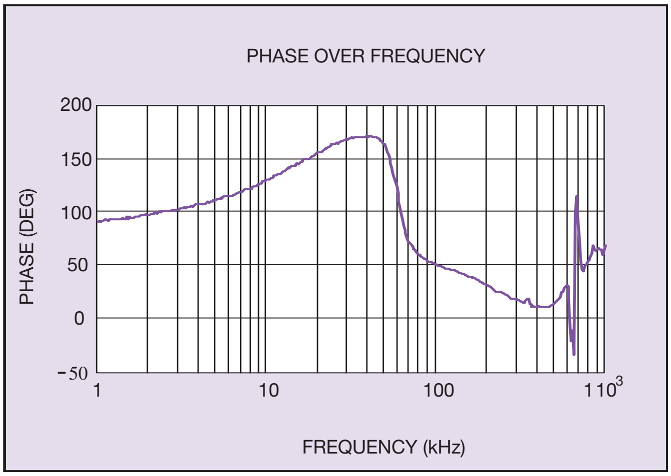

Figure 3 - Converter Stability Plot

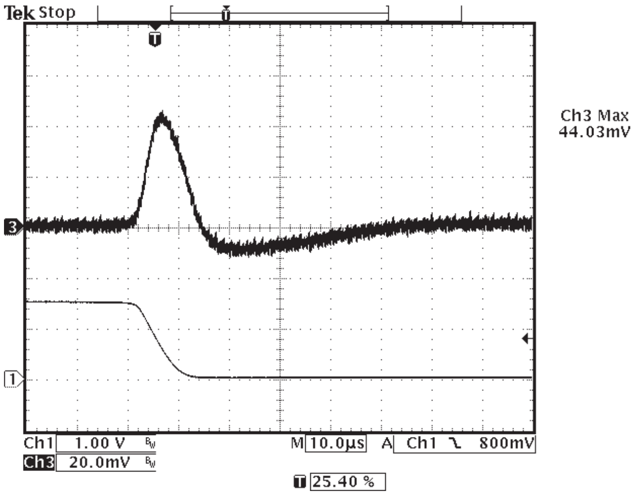

Figure 4 - Typical Transient Response for 75% to 50% (500mA/µs) Load Step

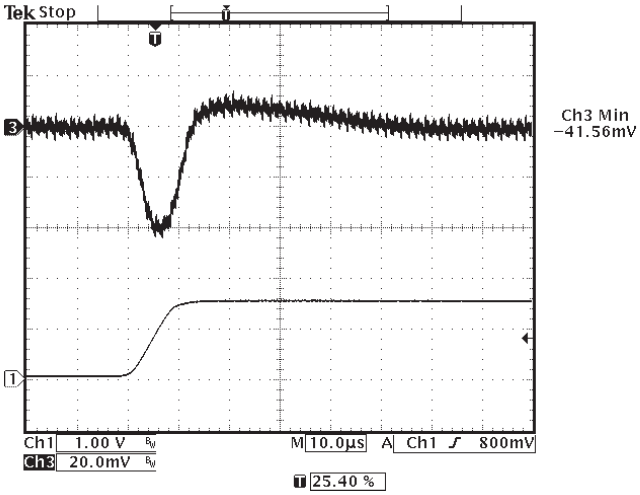

Figure 5 - Typical Transient Response for 75% to 50% (500mA/µs) Load Step

4.2.2 Ripple and Noise

The measurement set-up outlined in Figure 6 has been used for output voltage ripple and noise measurements on SIL30E series converters. When measuring output ripple and noise, a 50Ω coaxial cable with a 50Ω termination should be used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies.

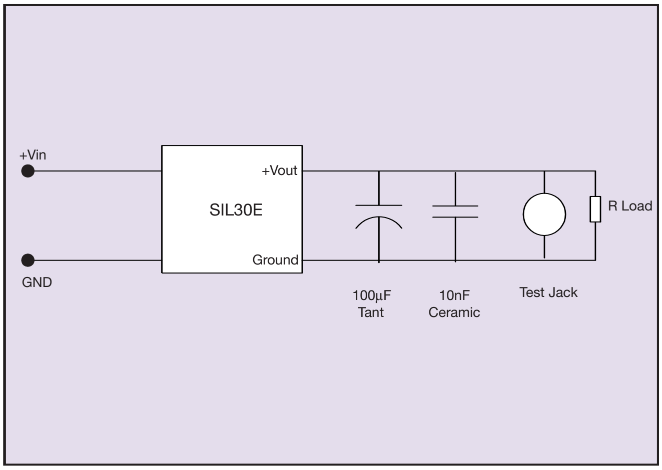

Figure 6 - Ripple and Noise Measurement Set-up

4.3 EMC

The SIL30E series has been designed to comply with the EMC requirements of EN61000. It has been tested and has passed radiated noise immunity (EN61000-4-3) and conducted noise immunity (EN61000-4-4) both with normal performance.

5. Mechanical Information

5.1 Mechanical Outline Drawing

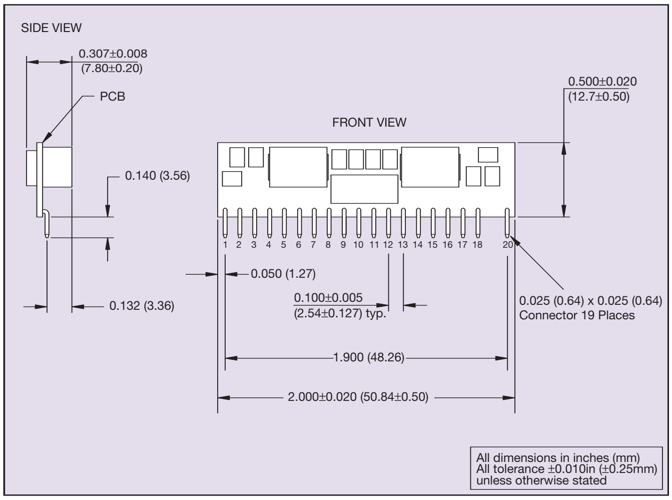

Figure 7 - SIL30E Mechanical Outline

5.2 Pin-out Table

PIN CONNECTIONS			
PIN NO.	**FUNCTION**	**PIN NO.**	**FUNCTION**
1	Vin	11	Vout
2	Vin	12	Vout
3	Ground	13	Remote ON/OFF
4	Ground	14	Ground
5	Trim	15	Ground
6	Remote Sense+	16	Ground
7	Ground	17	Ground
8	Ground	18	Vin
9	Vout	19	N/C
10	Vout	20	Vin

Table 2 - SIL30E Pin-Out

5.3 PCB Layout Information

The PCB acts as a heat sink and draws heat from the unit via conduction through the pins and through radiation. The end user must ensure that other components and metal in the vicinity of the SIL30E meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces should be used where possible, particularly when high currents are flowing (e.g. the output side). A low impedance track should connect input ground and output ground to maximize efficiency of the unit. See section 11.3 for the recommended land patterns.

6. Packaging Information

6.1 Labels and Part Numbering Sequence

All units in the series will be clearly marked to allow ease of identification for the end user as shown in Figure 8.

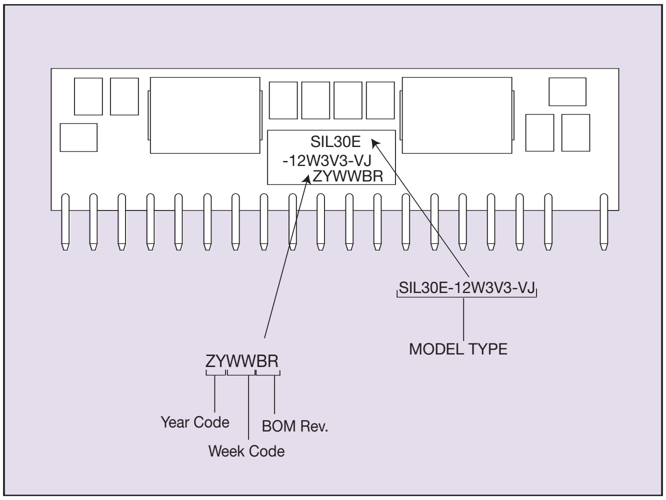

Figure 8 - SIL30E Part Numbering

7. Safety Information

7.1 Safety Standards and Approvals

All models will have full international safety approval including EN60950-1 and UL/cUL60950-1. Models have been submitted to independent safety agencies for approval.

7.2 Fuse Information

In order to comply with safety requirements the user must provide a fuse in the unearthed input line. This is to prevent earth being disconnected in the event of a failure.

A 20A fast blow fuse should be used for all models. Recommended fuse: Bussman ABC-V-20.

7.3 Safety Considerations

The converter must be installed as per guidelines outlined by the various safety agency approvals, if safety agency approval is required for the overall system.

8. Operating Information

8.1 Over-temperature Protection (OTP)

The 12V non-isolated Point-of-Load range is equipped with non-latching over-temperature protection. A temperature sensor monitors the temperature of the power switches. If the temperature exceeds a threshold of 120°C (typical) the converter will shut down, disabling the output. When the case temperature has decreased, the converter will automatically restart.

The unit might experience over-temperature conditions during a persistent overload on the output. Overload conditions can be caused by external faults. OTP might also be entered due to a loss of control of the environmental conditions (e.g. an increase in the converter's ambient temperature due to a failing fan).

8.2 Short Circuit Protection

In the event of a short circuit the unit will enter a hiccup mode, to provide fault protection. Once the source of the short circuit has been removed the unit will auto-recover, and will remain undamaged while in a short circuit mode. This design is protected only against extreme short circuits. The unit is protected in an over-load condition by an over-temperature protection device. We do not recommend operating this unit in a heavy over-load condition as it may reduce the lifetime of the converter.

9. Feature Set

9.1 Trimming the Output Voltage

The SIL30E 12V series have an output setpoint default of 0.8V.

This setpoint can be set by the user to any required voltage of 0.8V to 3.63V. When trimmed up by the user, the unit can deliver an output load of 30A or 99W whichever is the lesser of the two.

The output can be trimmed up by placing an external resistor between the Trim pin and Ground.

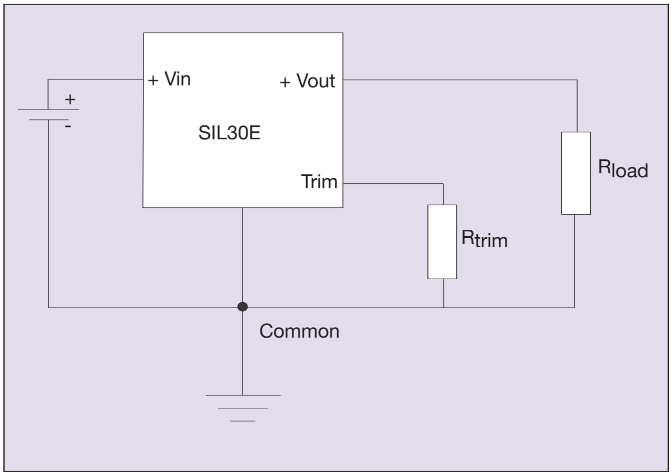

Figure 9 - Output Trim-up Resistor to Ground

The output set-point can be set with an external resistor as governed by the following equation:

$$R_{trim} = \left[\frac{9680}{V_{out} - 0.8} - 715\right]$$

Where Vout is the required output setpoint
R_{trim} is given in Ohms

For example to set the output voltage to 1.8V, R_{trim} is calculated as follows:

$$R_{trim} = \left[\frac{9680}{1.8 - 0.8} - 715\right]$$

$$R_{trim} = 8.965k\Omega$$

V_O (V)	R_{trim} (KΩ)
0.8	Open
1.2	23.4
1.5	13.2
1.8	8.96
2.0	7.32
2.5	4.99
3.3	3.16

Table 3 - E-192 Value Resistors

Table 3 shows the E-192 value resistors that can be used to trim some standard voltage output setpoints.

Care needs to be taken when placing the external trim resistor. Poor grounding on the layout for this resistor may result in an increase of load regulation for the unit. The resistor should be placed directly between the trim pin and ground of the unit.

The trim curve can be graphed as shown below:

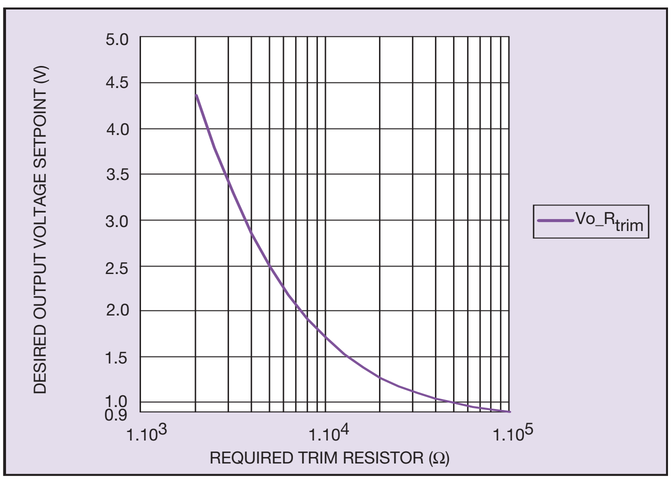

Figure 10 - Trim Up

9.2 Remote ON/OFF

The remote ON/OFF input allows external circuitry to put the SIL30E converters into a low dissipation sleep mode. 'Positive Logic' remote ON/OFF is available as standard.

'Positive Logic' units of the SIL30E series are turned on if the remote ON/OFF pin is high, or leaving it floating. Pulling the pin low will turn off the unit. The signal level of the remote ON/OFF input is defined with respect to ground. The unit is guaranteed ON if this voltage level exceeds 2.8V. The unit is guaranteed OFF if this voltage level is equal to or less than 0.8V.

To simplify the design of the external control circuit, logic signal. The remote ON/OFF input can be driven as shown in Figure 11.

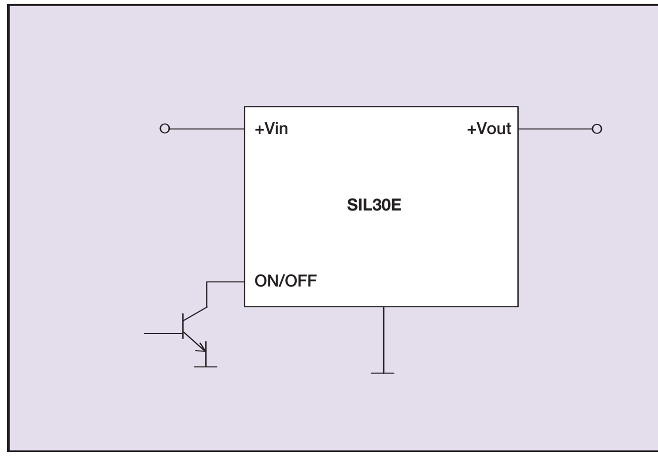

Figure 11 - Remote ON/OFF

9.3 Remote Sense

The remote sense compensation feature minimizes the effect of resistance in the distribution system and facilitates accurate voltage regulation at the load terminals or another selected point. The remote sense line will carry very little current and hence does not require a large cross-sectional area. However, if the sense line is routed on a PCB, it should be located close to a ground plane in order to minimize any noise coupled onto the lines that might impair control loop stability. A small 100nF ceramic capacitor can be connected at the point of load to decouple any noise on the sense wires. The module will compensate for a maximum drop of 10% of the nominal output voltage. However, if the unit is already trimmed up, the available remote sense compensation range will be correspondingly reduced. Remember that when using remote sense compensation, all the resistance, parasitic inductance and capacitance of the distribution system are incorporated into the feedback loop of the power module. This can have an effect on the module's compensation capabilities, affecting its stability and dynamic response.

9.4 Parallel and Series Operation

Parallel operation of multiple converters is not recommended. If unavoidable, some de-coupling techniques must be incorporated onto the users design. It should be noted that this measure will adversely effect power conversion efficiency.

10. Thermal Information

10.1 Thermal Reference Points
The electrical operating conditions namely:

- Input voltage, V_{in}
- Output voltage, V_o
- Output current, I_o

determine how much power is dissipated within the converter. The following parameters further influence the thermal stresses experienced by the converter:

- Ambient temperature
- Air velocity
- Thermal efficiency of the end system application
- Parts mounted on system PCB that may block airflow
- Real airflow characteristics at the converter location

The maximum acceptable temperature measured at the thermal reference points is 115ºC. The thermal reference point is shown in Figure 12.

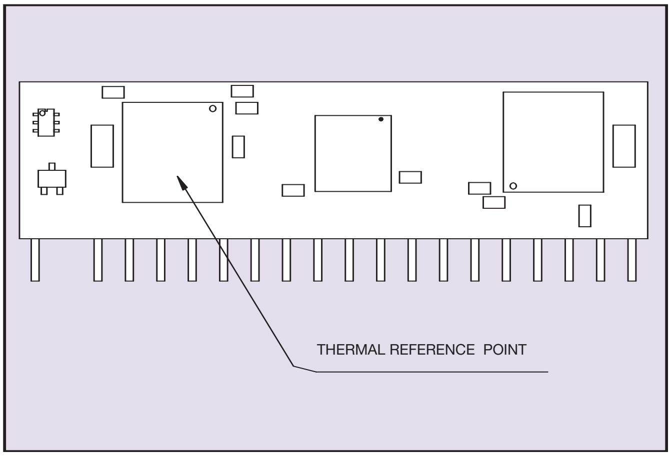

Figure 12 - Thermal Reference Point Location on SIL30E Converters

10.2 Thermal Derating Curves
Thermal characterization data is presented in the datasheet in a thermal derating graph of which one is repeated here in Figure 13. This derating graph shows the load current versus the ambient air temperature and velocity.

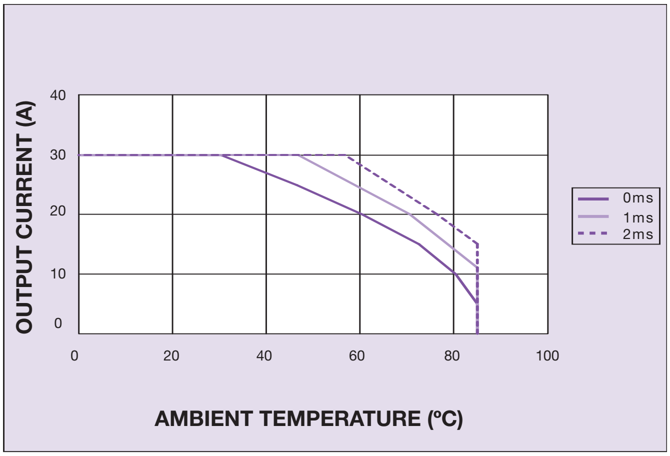

Figure 13 - Thermal Derating Curve Vin = 12V, Output Voltage = 3.3V

10.3 Thermal Test Set-up
All of the data was taken with the converter soldered to a test board which closely represents a typical application. The test board is a 1.6 mm, eight layer FR4 PCB with the inner layers consisting of 2oz power and ground planes. The top and bottom layers contain a minimal amount of metalization. A board to board spacing of 1 inch was used. The data represented by the 0m/s curve indicates a natural convection condition i.e. no forced air. However, since the thermal performance is heavily dependent upon the final system application, the user needs to ensure the thermal reference point temperatures are kept within the recommended temperature rating. It is recommended that the thermal reference point temperatures are measured using either AWG #36 or #40 gauge thermocouples or an IR camera. In order to comply with stringent Artesyn derating criteria, the ambient temperature should never exceed 85°C. Please contact Artesyn Technologies for further support.

11. Use in a Manufacturing Environment

11.1 Resistance to Solder Heat
These converters are intended for PCB mounting. Artesyn Technologies has determined how well the product can resist the temperatures associated with soldering of PTH components without affecting its performance or reliability. The method used to verify this is MIL-STD-202 method 210D. Within this method two test conditions were specified, Soldering Iron Condition A and Wave Solder Condition C.

For the soldering iron test, the UUT was placed on a PCB with the recommended PCB layout pattern shown section 11.3. A soldering iron set to 350ºC±10ºC was applied to each terminal for 5 seconds. The UUT was then removed from the test PCB and examined under a microscope for any reflow of the pin solder or physical change to the terminations. None was found.

For the wave solder test, the UUT was again mounted on a test PCB. The unit was wave soldered using the conditions shown in Table 4. The UUT was inspected after soldering and no physical change was found on the pin terminations.

Temperature	Time	Temperature Ramp
260°C±5°C	10sec±1	Preheat 4°C/sec to 160°C. 25mm/sec rate

Table 4 - Wave Solder Test Profile

11.2 ESD Requirements
All units are manufactured in an ESD controlled environment and supplied in conductive packaging to prevent ESD damage occurring before or during shipping. It is essential that they are unpacked and handled using approved ESD control procedures. Failure to do so may affect the lifetime of the converter.

11.3 Optimum PCB Layout
The PCB acts as a heat sink and draws heat from the unit via conduction through the pins and through radiation. The end user must ensure that other components and metal in the vicinity of the SIL30E-12 meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces should be used where possible, particularly when high currents are flowing (e.g. the output side). A low impedance track should connect input ground and output ground to maximize efficiency of the unit.

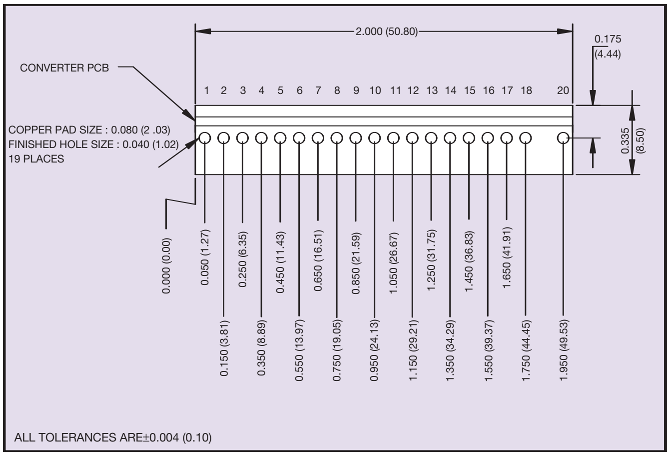

Figure 14 - Recommended Land Pattern

11.4 Storage
All plastic encapsulated semiconductor components are qualified to IPC/JEDEC J-STD-020A level 1 and are classed as not moisture sensitive. No special storage conditions are required.