NEW Product

SIL25C 12Vin
Single Negative Output

Application Note 148

RoHS 2002/95/EC

ARTESYN® TECHNOLOGIES

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1. Introduction

This application note describes the features and functions of Artesyn Technologies' SIL25C series of high power density DC/DC converters. This 25A negative output module is designed for use in workstation, computing, industrial and communication applications. The SIL series offers great flexibility in board level power distribution when compared to standard brick solutions.

2. Models

The SIL25C series comprise 1 model, as listed in Table 1 .

Model	Input Voltage	Output Voltage	Output Current
SIL25C-12SNEG-VJ	10.2 - 13.8VDC	-4.5 to -5.5V	25A

Table 1 - Available SIL25C Models

RoHS Compliance Ordering Information

RoHS 2002/95/EC

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.

Features

- Trim range (-4.5V to -5.5V)
- High power density design means reduced board space requirement
- Remote sense
- Power good output signal (open collector)
- Operating ambient temperature -40ºC to 80ºC
- Remote ON/OFF (active high)
- Overtemperature protection
- 0A minimum load
- Input undervoltage lockout
- Overcurrent and short-circuit protection
- Available RoHS compliant

3. General Description

3.1 Electrical Description

The SIL25C is implemented using a voltage-mode two-phase Buck/Boost topology.

The output is adjustable over a range of -4.5V to -5.5V by using a resistor from the trim pin to ground or to Vo or by driving the TRIM pin with a voltage. The remote sense feature is able to make up for 500mV drop from the output of the converter to where the sense lines are connected too.

The converter can be shut down via a remote ON/OFF. This input is run with positive logic that is compatible with popular logic devices. 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 power good signal is an open collector output that is pulled low by the pwm controller when it detects the output is not within ±10% of its set value.

The output is monitored for over-current and short circuit conditions. The current flow is monitored through each output inductor and when the pwm controller detects an over-current condition it folds back the output.

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. There is a thermal hysteresis of typically 10ºC, to protect the unit.

3.2 Physical Construction

The SIL25C is constructed using a multi-layer FR4 PCB. SMT power components are placed on one side of the PCB, and all low-power control components are placed on the other side. 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 such as opto-couplers
• **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.

4. Features and Functions

4.1 Wide Operating Temperature Range

The SIL's ability to accommodate a wide range of ambient temperatures is the result of its extremely high power conversion efficiency and resultant low power dissipation, combined with the excellent thermal performance of the PCB substrate. The maximum output power that the module can deliver depends on a number of parameters, primarily:

- Input voltage range
- Output load current
- Air velocity
- Mounting orientation of target application PCB.
- Target application PCB design, especially ground planes. These can be effective heatsinks for the converter.

The SIL25C modules operating temperature range can be extended to 80°C if suitable de-rating and/or forced air cooling is used. Thermal performance is discussed further in Section 7.2.

4.2 Output Voltage Adjustment

The output voltage on all models is adjustable from -4.5V to -5.5V. Details on how to trim all models are provided in Section 7.3.

4.3 Under-voltage Lockout

The modules in this line have built in under-voltage lockout to ensure reliable output power. The lockout prevents the unit from operating when the input voltage is too low.

The SIL25C has an input range of 10.2V to 13.8V with UV lockout occurring between 9.5V to 10.0V. This allows more flexibility in designing and ensures operation on supply lines with large tolerances.

4.4 Current Limit and Short-Circuit Protection

All SIL25C models have a built-in foldback current limit function and full continuous short-circuit protection. The module monitors current through each output inductor of the converter. When over-current condition occurs, the module folds back the output voltage, the unit continues to work in a hiccup manner until the fault condition is removed.

Determining the over-current condition is dependent on the resistance of the inductor windings because the voltage drop across the inductor determines the over-current trip point. The inception point is typically 130% of rated full load at 25°C. Ambient temperature influences the current limit inception point since resistance of copper rises with temperature.

Note that none of the module specifications is guaranteed when the unit is operated in an over-current condition. The unit will not be damaged in an over-current condition because it will be protected by the OTP function, but the converter's lifetime may be reduced.

4.5 Remote ON/OFF

The remote ON/OFF input allows external circuitry to put the SIL25C converter into a low dissipation sleep mode. Active-high remote on/off is available as standard.

Active-high units of the SIL25C series are turned on if the remote ON/OFF pin is high (or floating). Pulling the pin low will turn off the unit. To gaurantee turn-on the enable voltage must be above 2.4V and to turn off the enable voltage must be pulled below 1.2V

Figures in the Long Form Data Sheet show the response of the unit to switching on and off the remote ON/OFF feature. The remote ON/OFF input can be driven in a variety of ways as shown in Figures 1, 2 and 3. If the remote ON/OFF signal originates on the primary side, the remote ON/OFF input can be driven through a discrete device (e.g. a bipolar signal transistor) or directly from a logic gate output. The output of the logic gate may be an open-collector (or open-drain) device. If the drive signal originates on the secondary side, the remote ON/OFF input can be isolated and driven through an optocoupler.

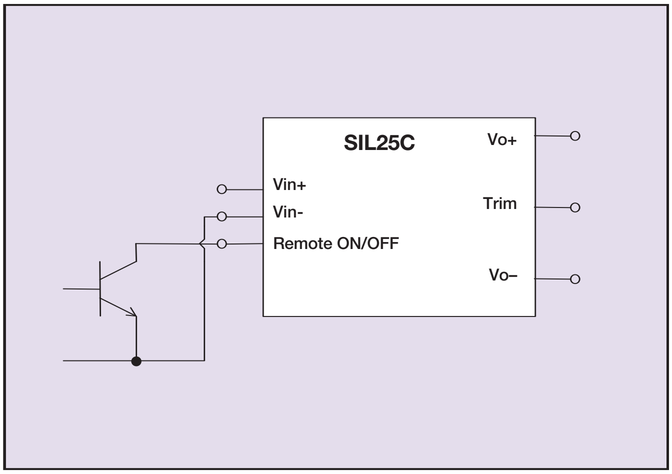


Figure 1 - Remote ON/OFF Input Drive Circuit for Non-Isolated Bipolar

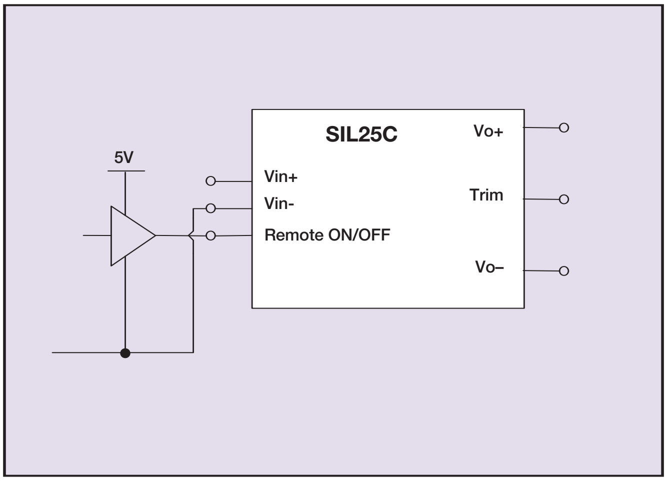


Figure 2 - Remote ON/OFF Input Drive Circuit for Logic Driver

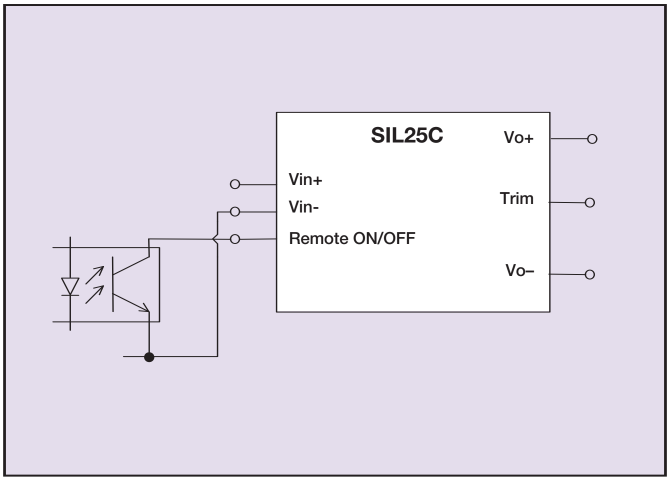


Figure 3 - Remote ON/OFF Input Drive Circuit using an Optocoupler to maintain the isolation barrier from primary to secondary

4.6 POWER GOOD Signal
The SIL25C modules have a power good indicator output. This output pin uses positive logic and is open collector. Also, the power good output is able to sink 5mA. The power good signal should not be pulled any higher than 11V.

When the output of the module is within ±10% of the nominal set point, the power good pin can be pulled high. Figures in the Long Form Data Sheet show how the power good signal behaves when the remote ON/OFF feature is used to turn the module on and off.

4.7 Over Temperature Protection (OTP)
The SIL25C is equipped with non-latching over-temperature protection. A temperature sensor monitors the temperature of the PCB near one of the main FETS. If the temperature exceeds a threshold of 130°C (typical) the converter will shut down, disabling the output. When the substrate temperature has decreased by 10ºC the converter will automatically restart.

The converter 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).

5. Safety

5.1 Input Fusing
It is recommended the user provide a fuse in the input line. The amperage rating of the fuse will depend on the output voltage setpoint and the output current in the application.

6. Use in a Manufacturing Environment

6.1 Resistance to Soldering Heat
The SIL25C series 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 7. 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 2 . 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 2 - Wave Solder Test Conditions

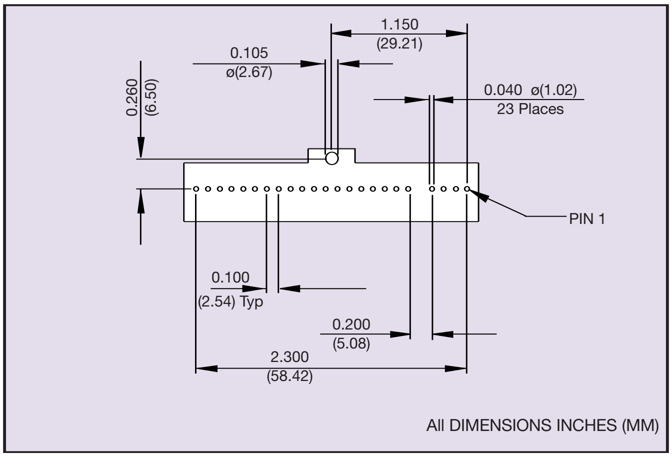
6.2 Water Washing
Where possible, a no-clean solder paste system should be used for solder attaching the SIL product onto application boards. The SIL is suitable for water washing applications, however, the user must ensure that the drying process is sufficient to remove all water from the converter after washing - never power the converter unless it is fully dried. The user's process must clean the soldered assembly in accordance with ANSI/J-STD-001.

6.3 ESD Control
SIL25C 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 could affect the lifetime of the converter.

7. Applications

7.1 PCB Layout
The pin diagrams for the SIL25C is detailed in Figure 4

VIEW IS FROM TOP SIDE
THERMAL RELIEF IN CONDUCTOR PLANES



REFERENCE IPC-D-275 SECTION 5.3.2.3

ALL DIMENSIONS IN INCHES (mm)
ALL TOLERANCES ARE ±0.004 (0.10)

Figure 4 - Recommended Footprint

7.2 Thermal Performance
The electrical operating conditions of the SIL25C, 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

In order to simplify the thermal design, a number of thermal de-rating plots are provided in the longform datasheet. The SIL25C de-rating curve is repeated in Figure 5. The derating curve shows the load current of the SIL25C versus the ambient air temperature and forced air velocity. 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 a thermocouple or an IR camera. In order to comply with stringent Artesyn derating criteria the ambient temperature should never exceed 120°C. Please contact Artesyn Technologies for further support.

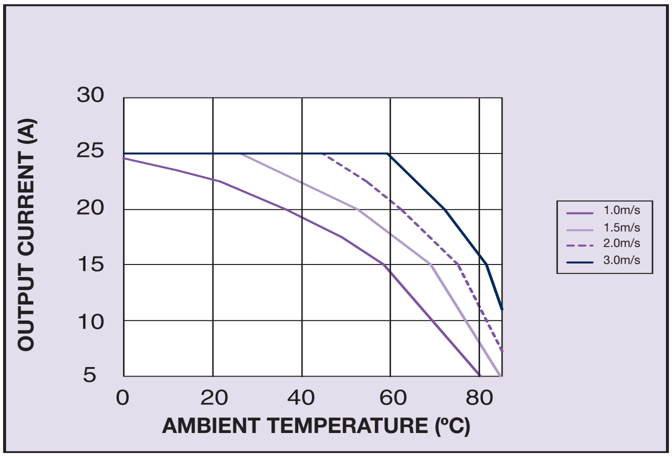


Figure 5 - Thermal De-rating Curve, Airflow Direction From Pin 24 to Pin 1

The maximum acceptable temperature measured at the thermal reference point is 120ºC. This is shown in Figure 6.

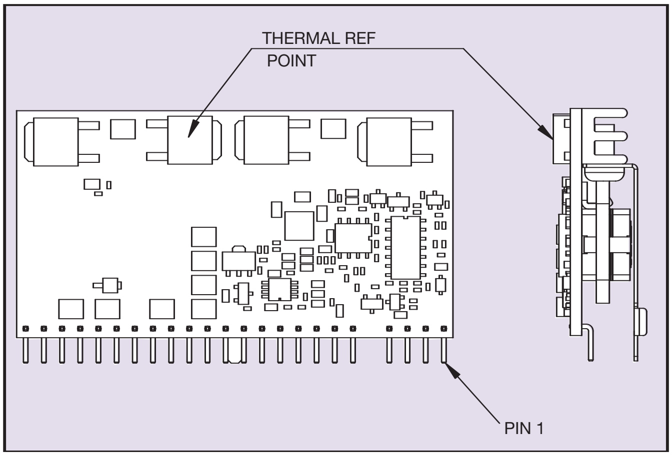


Figure 6 - Thermal Reference Point Location

7.3 Output Voltage Adjustment
Connecting an external resistor between the TRIM pin and Vo increases the output voltage i.e. more negative. The output voltage can be reduced by connecting the resistor to the GND as shown in Figure 8.

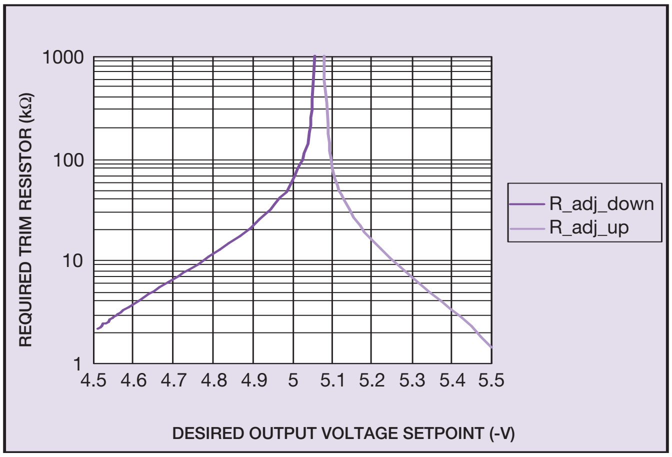


Figure 7 - Typical Trim Curves

The resistor equations are as follows:

$$R\_{adj\_up} = \frac{28 - 4.99 \times V_{out}}{V_{out} - V_{outnom}} \; k\Omega$$

$$R\_{adj\_down} = \frac{28 - 6.488 \times V_{out}}{V_{out} - V_{outnom}} \; k\Omega$$

Where Vout is the desired output voltage and V_{outnom} is the nominal output voltage.

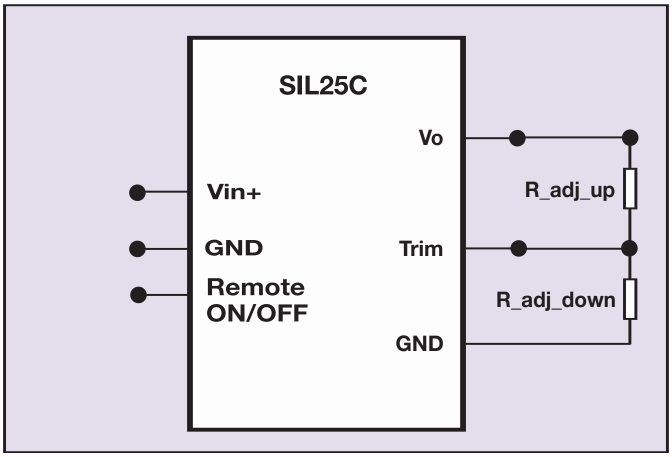


Figure 8 - Trimming the Output Voltage

7.4 Remote Sense Compensation
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 lines will carry very little current and hence do not require a large cross-sectional area. However, if the sense lines are routed on a PCB, they 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 400mV. 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 modules compensation capabilities, affecting its stability and dynamic response.

7.5 Output Capacitance
The SIL25C has some low value output ceramic capacitors on the converter. Therefore, external output capacitors are required for stable operation. Also, when powering loads with large 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 as close to the load as possible, using several capacitors to lower the overall ESR. These ceramic capacitors will handle the short duration high frequency components of the dynamic current requirement. In addition, higher values of electrolytic capacitors should be used to handle the mid-frequency components.

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 modules 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.

7.6 Reflected Ripple Current and Output Ripple and Noise Measurement
The measurement set-up outlined in Figure 9 has been used for both input reflected/terminal ripple current and output voltage ripple and noise measurements on the SIL25C.

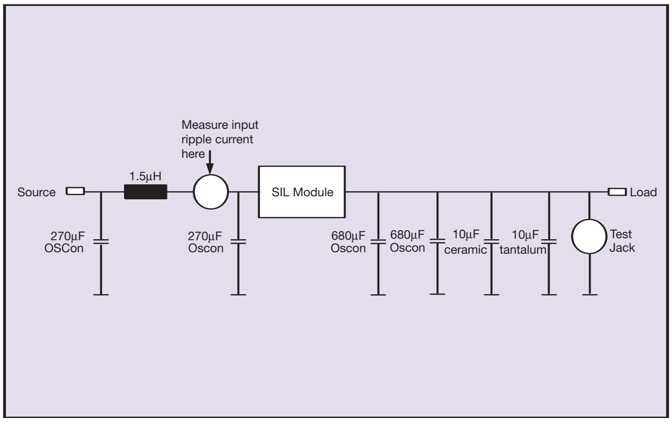


Figure 9 - Input Reflected Ripple/Capacitor Ripple Current and Output Voltage Ripple and Noise Measurement Set-Up