

NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc – 14.4 Vdc Input, 0.6 Vdc – 2.0 Vdc /40 A Outputs



Jul. 17, 2015

Bel Power Inc., a subsidiary of Bel Fuse Inc.

SLAN-40E1Ax

RoHS Compliant

Rev.E

Features

- Non-Isolated
- Power Good signal
- Remote On/Off
- Over temperature protection
- Compliant to IPC-9592 (September 2008), Category 2, Class II
- Compliant to RoHS EU Directive 2002/95/EC
- Compatible in a Pb-free or SnPb reflow environment
- Output voltage programmable from 0.6Vdc to 2.0Vdc via external resistor.
- Tunable Loop™ to optimize dynamic output voltage response
- Output overcurrent protection (non-latching)
- Wide operating temperature range [-40°C to 85°C]
- Wide Input voltage range (4.5Vdc-14.4Vdc).
- UL 60950-1 2nd Ed. Recognized, CSA C22.2 No. 60950-1-07 Certified, and VDE (EN60950-1 2nd Ed.) Licensed
- Small size:33.02mm × 13.46mm × 10.9mm(1.3 in × 0.53 in × 0.429 in)
- ISO 9001 and ISO 14001 certified manufacturing facilities
- Cost efficient open frame design
- Ability to sink and source current
- Fixed switching frequency with capability of external synchronization.



Applications

- Distributed power architectures
- Intermediate bus voltage applications
- Telecommunications equipment
- Servers and storage applications
- Networking equipment
- Industrial equipment



Description

The SLAN-40E1Ax modules are non-isolated dc-dc converters that can deliver up to 40A of output current. These modules operate over a wide range of input voltage ($V_{IN} = 4.5Vdc-14.4Vdc$) and provide a precisely regulated output voltage from 0.6Vdc to 2.0Vdc, programmable via an external resistor. Features include remote On/Off, adjustable output voltage, over current and overtemperature protection. The module also includes the Tunable Loop™ feature that allows the user to optimize the dynamic response of the converter to match the load with reduced amount of output capacitance leading to savings on cost and PWB area.

Part Selection

Output Voltage	Input Voltage	Max. Output Current	Max. Output Power	Typical Efficiency	Model Number Active Low	Model Number Active High
0.6 – 2.0 Vdc	4.5 - 14.4 Vdc	40 A	80W	91.5%	SLAN-40E1AL	SLAN-40E1A0

- Notes:**
1. Add “R” suffix at the end of the model number to indicate tape and reel packaging (Standard).
 2. Add “G” suffix at the end of the model number to indicate tray packaging (Option).
 3. For the SLAN-40E1A0, please contact your local Bel representative for availability.

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Ordering Part Number

S LAN – 40 **E** 1A 0 **X**
 1 2 3 4 5 6 7

1---Surface mount

2---Series code

3---Output current (40A)

4---Wide input voltage range (4.5-14.4V)

5---With sequencing

6---Enable, active high, change “0” to “L” means active low;

7---Package

Absolute Maximum Ratings

Parameter	Min	Max	Unit	Notes
Continuous Input Voltage	-0.3	15	V	
Operating Ambient Temperature	-40	85	°C	see Thermal Considerations section
Storage Temperature	-55	125	°C	
Altitude	-	2000	m	

Note: Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only, functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect the device reliability.

Input Specifications

Parameter	Min	Typ	Max	Unit	Notes
Operating Input Voltage	4.5	-	14.4	V	
Input Current (full load)	-	-	24	A	$V_{IN}=4.5V$ to $14V$, $I_O=I_{Omax}$
Input Current (no load)	-	54.7	-	mA	$V_{O,set} = 0.6$ Vdc
	-	104	-	mA	$V_{O,set} = 2$ Vdc
Input Stand-by Current	-	12.5	-	mA	$V_{IN} = 12V$, module disabled
Input Reflected Ripple Current (pk-pk)	-	90	-	mAp-p	5Hz to 20MHz, $1\mu H$ source impedance; $V_{IN} = 0$ to $14V$, $I_O=I_{Omax}$; See Test Configurations
I^2t Inrush Current Transient	-	-	1	A ² s	
Input Ripple Rejection (120Hz)	-	-60	-	dB	

Note: Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions.

Output Specifications

Parameter	Min	Typ	Max	Unit	Notes
Output Voltage Set Point	-1.0	-	+1.0	% $V_{O,set}$	with 0.1% tolerance for external resistor used to set output voltage
Output Voltage	-3.0	-	+3.0	% $V_{O,set}$	Over all operating input voltage, resistive load, and temperature conditions until end of life
Adjustment Range	0.6	-	2.0	V	1. selected by an external resistor 2. Some output voltages may not be possible depending on the input voltage – see Feature Descriptions Section
Remote Sense Range	-	-	0.5	V	
Load Regulation	-	-	10	mV	$I_O=I_{O, min}$ to $I_{O, max}$

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Output Specifications (continued)

Parameter	Min	Typ	Max	Unit	Notes
Line Regulation	-	-	6	mV	$V_{IN}=V_{IN, min}$ to $V_{IN, max}$
Temperature Regulation	-	0.4	-	% $V_{o, set}$	$T_{ref}=T_{A, min}$ to $T_{A, max}$
Ripple and Noise (pk-pk)	-	50	100	mV	5Hz to 20MHz BW, $V_{IN}=V_{IN, nom}$ and $I_O=I_{O, min}$ to $I_{O, max}$ $C_o = 0.1\mu F // 22\mu F$ ceramic capacitors)
Ripple and Noise (rms)	-	20	38	mV	
Output Short-Circuit Current	-	2.1	-	Arms	$V_o \leq 250mV$, Hiccup Mode
Output Capacitance ¹					
ESR $\geq 1\ m\Omega$	6x47	-	6x47	μF	Without the Tunable Loop™
ESR $\geq 0.15\ m\Omega$	6x47	-	7000	μF	With the Tunable Loop™
ESR $\geq 10\ m\Omega$	6x47	-	8500	μF	With the Tunable Loop™
Output Current	0	-	40	A	In either sink or source mode
Output Current Limit Inception	-	150	-	% $I_{o, max}$	1. Hiccup Mode 2. Current limit does not operate in sink mode
Output voltage overshoot	0	1.5	3.0	% $V_{o, set}$	$V_{IN} = V_{IN, min}$ to $V_{IN, max}$, $I_O = I_{O, min}$ to $I_{O, max}$, $T_A=25^\circ C$. With or without maximum external capacitance
Turn-On Delay and Rise Times ($V_{IN}=V_{IN, nom}$, $I_O=I_{O, max}$, V_O to within $\pm 1\%$ of steady state.)	1.0	1.1	1.7	msec	Case 1: On/Off input is enabled and then input power is applied (delay from instant at which $V_{IN} = V_{IN, min}$ until $V_o = 10\%$ of $V_{o, set}$)
	600	700	1800	usec	Case 2: Input power is applied for at least one second and then the On/Off input is enabled (delay from instant at which Von/Off is enabled until $V_o = 10\%$ of $V_{o, set}$)
Output voltage Rise time	1.2	1.5	2.2	msec	Time for V_o to rise from 10% of $V_{o, set}$ to 90% of $V_{o, set}$.

Notes: ¹ External capacitors may require using the new Tunable Loop™ feature to ensure that the module is stable as well as getting the best transient response. See the Tunable Loop™ section for details.

General Specifications

Parameter	Min	Typ	Max	Unit	Notes	
Efficiency	$V_o=0.6V$ $V_o=1.2V$ $V_o=1.8V$	78.0 84.0 85.25	81.3 88.5 91.5	- - -	% % %	$V_{in} = 12Vdc$, $T_A=25^\circ C$ $I_o=I_{o, max}$, $V_o= V_{o, set}$
Switching Frequency	380	400	420	kHz		
Synchronization Frequency Range	350	-	480	kHz		
High-Level Input Voltage	2.0	-	-	V		
Low-Level Input Voltage	-	-	0.4	V		
Input Current, SYNC			100	nA		
Minimum Pulse Width, SYNC	100	-	-	ns		
Maximum SYNC rise time	100	-	-	ns		

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General Specifications(continued)

Parameter	Min	Typ	Max	Unit	Notes
Over Temperature Protection	123	130	137	°C	See Thermal Considerations section
Tracking Accuracy Power-Up: 0.5V/ms Power-Down: 0.5V/ms	- -	- -	100 100	mV mV	$V_{IN, min}$ to $V_{IN, max}$; $I_{O, min}$ to $I_{O, max}$ $V_{SEQ} < V_O$
PGOOD (Power Good) Overvoltage threshold for PGOOD ON Overvoltage threshold for PGOOD OFF Undervoltage threshold for PGOOD ON Undervoltage threshold for PGOOD OFF Pulldown resistance of PGOOD pin Sink current capability into PGOOD pin	103 105 87 85 - -	108 110 92 90 - -	113 115 97 95 50 5	% V_O , set- % V_O , set- % V_O , set- % V_O , set- Ω mA	Signal Interface Open Drain, $V_{supply} \leq 5VDC$
Input Undervoltage Lockout Turn-on Threshold Turn-off Threshold Hysteresis	4.144 3.947 0.25	4.25 3.98 0.3	4.407 4.163 0.35	V V V	
Weight	11.7			g	
MTBF	6,498,438			hours	Calculated MTBF ($I_O=0.8I_{O, max}$, $T_A=40^\circ C$) Telecordia Issue 2 Method 1 Case 3
Dimensions Inches (L x W x H) Millimeters (L x W x H)	1.30 x 0.53 x 0.429 33.02 x 13.46 x 10.9			-	

Note: Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions.

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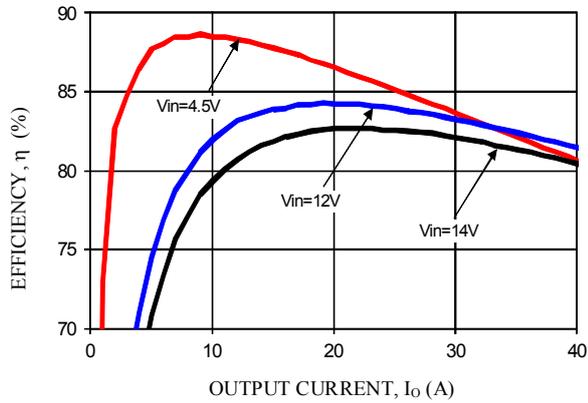
4.5 Vdc – 14.4 Vdc Input, 0.6 Vdc – 2.0 Vdc /40 A Outputs



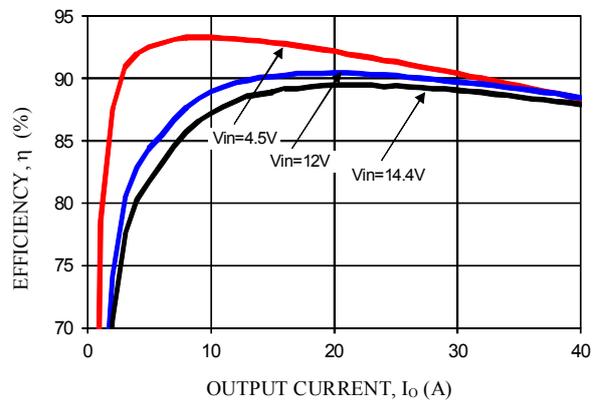
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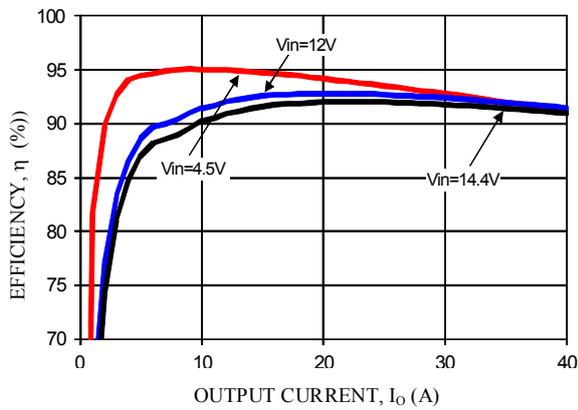
Efficiency Data



$V_o=0.6V$



$V_o=1.2V$



$V_o=1.8V$

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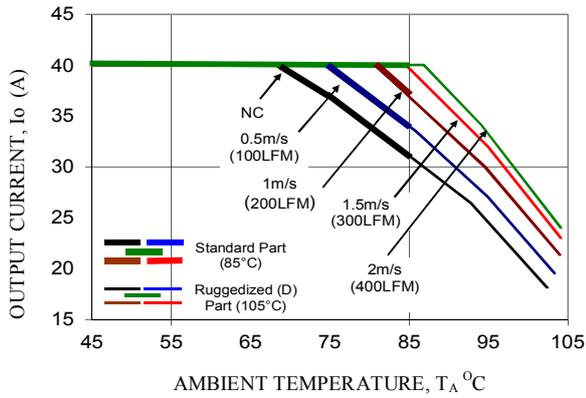
4.5 Vdc – 14.4 Vdc Input, 0.6 Vdc – 2.0 Vdc /40 A Outputs



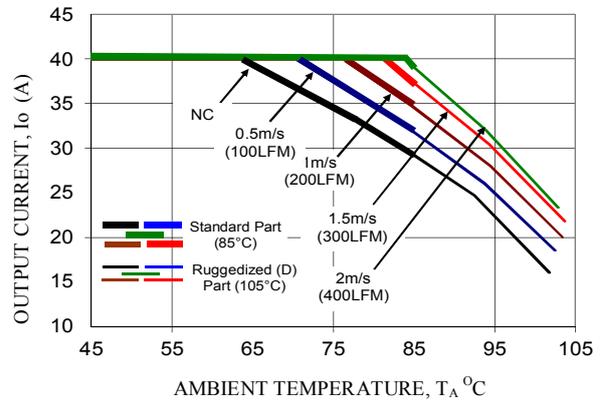
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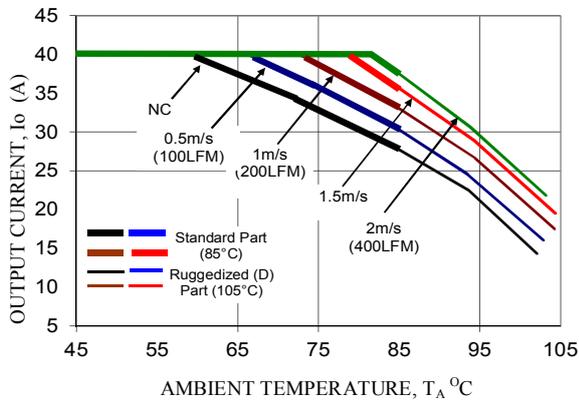
Thermal Derating Curves



$V_o=0.6V$



$V_o=1.2V$



$V_o=1.8V$

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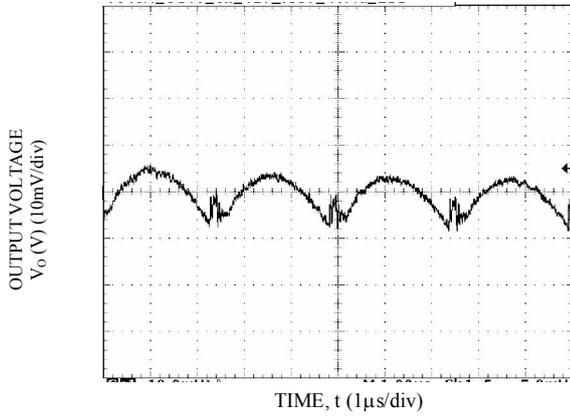
4.5 Vdc – 14.4 Vdc Input, 0.6 Vdc – 2.0 Vdc /40 A Outputs



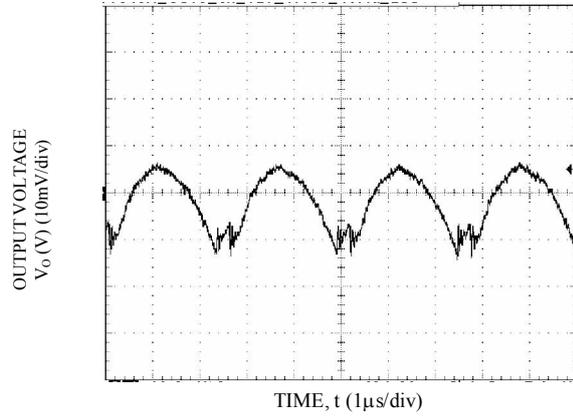
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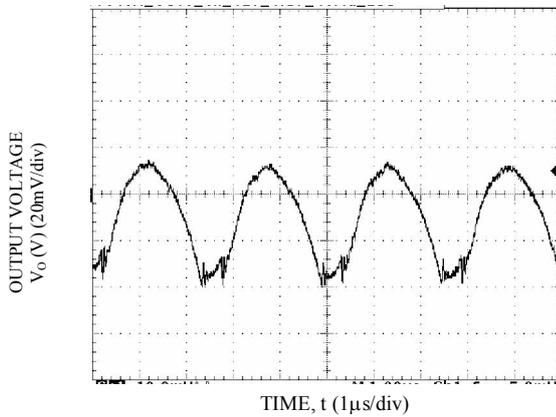
Output ripple and Noise Waveforms



Vo=0.6V, Io = Io,max, Vin=12V



Vo=1.2V, Io = Io,max, Vin=12V



Vo=1.8V, Io = Io,max, Vin=12V

Note: Co=6X47uF ceramic

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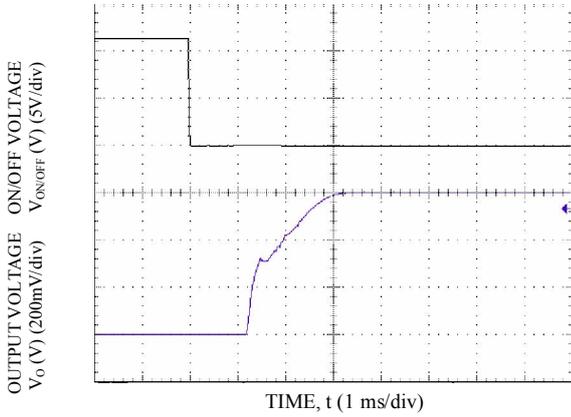
4.5 Vdc – 14.4 Vdc Input, 0.6 Vdc – 2.0 Vdc /40 A Outputs



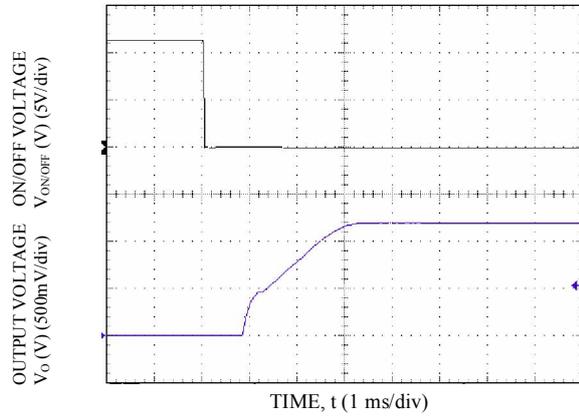
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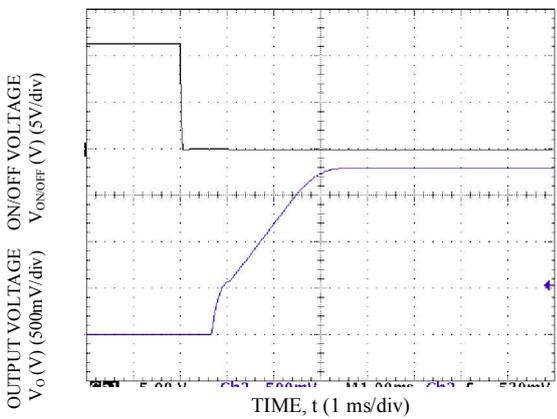
Startup Time



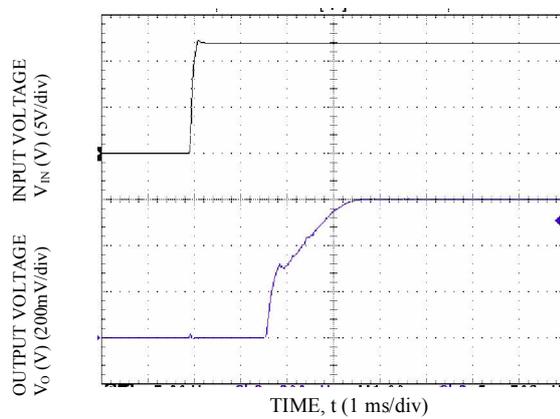
Start-up Using On/Off Voltage ($I_o = I_{o,max}$), $V_o=0.6V$



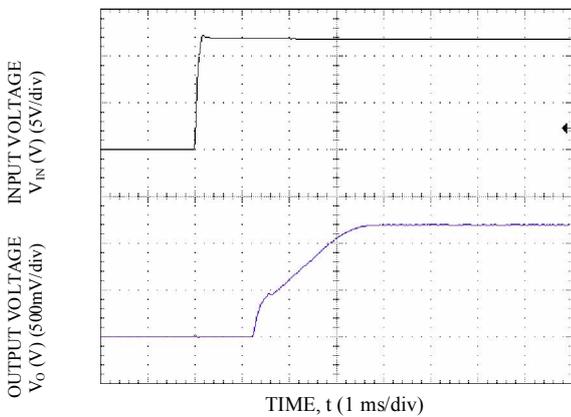
Start-up Using On/Off Voltage ($I_o = I_{o,max}$), $V_o=1.2V$



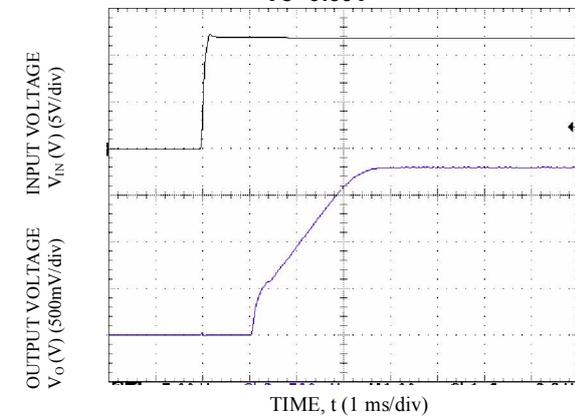
Start-up Using On/Off Voltage ($I_o = I_{o,max}$), $V_o=1.8V$



Start-up Using Input Voltage ($V_{IN} = 12V$, $I_o = I_{o,max}$), $V_o=0.60V$



Start-up Using Input Voltage ($V_{IN} = 12V$, $I_o = I_{o,max}$), $V_o=1.2V$



Start-up Using Input Voltage ($V_{IN} = 12V$, $I_o = I_{o,max}$), $V_o=1.8V$

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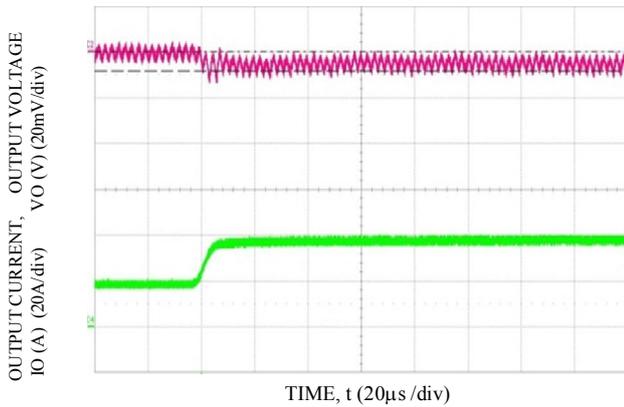
4.5 Vdc – 14.4 Vdc Input, 0.6 Vdc – 2.0 Vdc /40 A Outputs



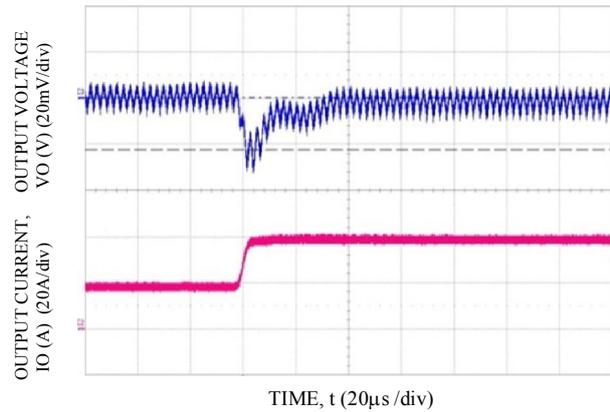
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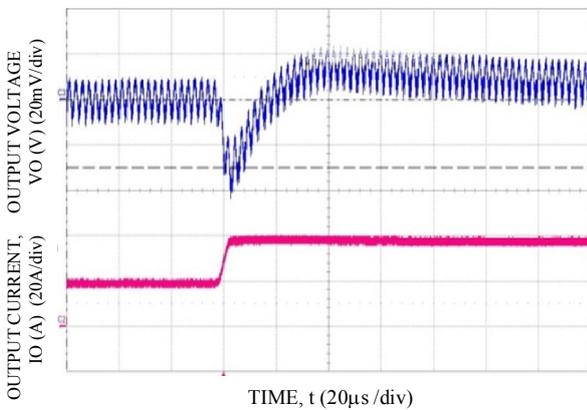
Transient waveforms



Transient Response to Dynamic Load Change from 50% to 100% at 12Vin, Cout= 12x680uF+6x47uF, CTune=47nF, RTune=180 ohms, Vo=0.6V



Transient Response to Dynamic Load Change from 50% to 100% at 12Vin, Cout= 6x330uF, CTune=12nF & RTune= 200 ohms, Vo=1.2V



Transient Response to Dynamic Load Change from 50% to 100% at 12Vin, Cout=6X330uF, CTune=5.6nF & RTune=220 ohms, Vo=1.8V

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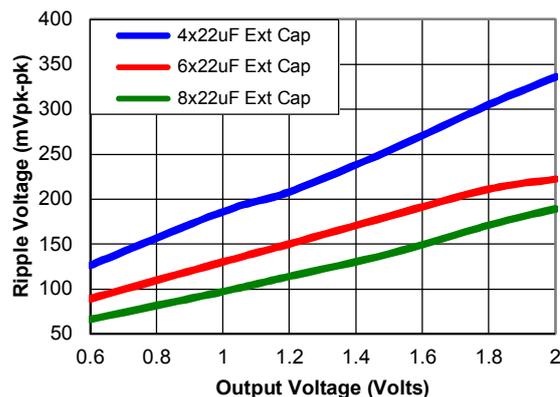
Design Considerations

Input Filtering

The SLAN-40E1Ax module should be connected to a low ac-impedance source. A highly inductive source can affect the stability of the module. An input capacitance must be placed directly adjacent to the input pin of the module, to minimize input ripple voltage and ensure module stability.

To minimize input voltage ripple, ceramic capacitors are recommended at the input of the module. Figure 19 shows the input ripple voltage for various output voltages at 40A of load current with 4x22 μ F, 6x22 μ F or 8x22 μ F ceramic capacitors and an input of 12V.

Figure 19



Note: Input ripple voltage for various output voltages with various external ceramic capacitors at the input (40A load). Input voltage is 12V. Scope Bandwidth limited to 20MHz.

Output Filtering

These modules are designed for low output ripple voltage and will meet the maximum output ripple specification with 0.1 μ F ceramic and 47 μ F ceramic capacitors at the output of the module. However, additional output filtering may be required by the system designer for a number of reasons. First, there may be a need to further reduce the output ripple and noise of the module. Second, the dynamic response characteristics may need to be customized to a particular load step change.

To reduce the output ripple and improve the dynamic response to a step load change, additional capacitance at the output can be used. Low ESR polymer and ceramic capacitors are recommended to improve the dynamic response of the module. Figure 20 provides output ripple information for different external capacitance values at various V_o and a full load current of 40A. For stable operation of the module, limit the capacitance to less than the maximum output capacitance as specified in the electrical specification table. Optimal performance of the module can be achieved by using the Tunable Loop™ feature described later in this data sheet.

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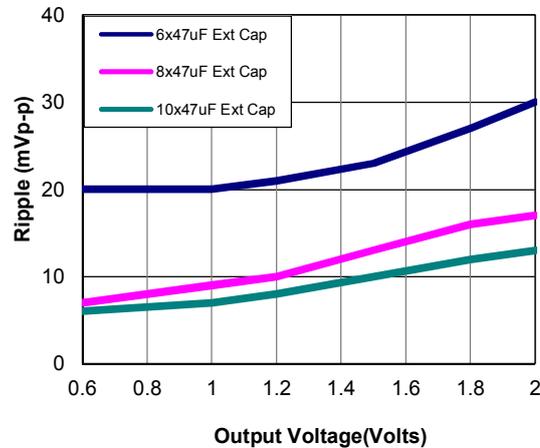


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Output Filtering (continued)

Figure 20



Note: Output ripple voltage for various output voltages with external 6x47 μ F, 8x47 μ F or 10x47 μ F ceramic capacitors at the output (40A load). Input voltage is 12V. Scope Bandwidth limited to 20MHz.

Safety Considerations

For safety agency approval the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standards, i.e., UL 60950-1 2nd, CSA C22.2 No. 60950-1-07, DIN EN 60950-1:2006 + A11 (VDE0805 Teil 1 + A11):2009-11; EN 60950-1:2006 + A11:2009-03.

For the converter output to be considered meeting the requirements of safety extra-low voltage (SELV), the input must meet SELV requirements. The power module has extra-low voltage (ELV) outputs when all inputs are ELV.

The input to these units is to be provided with a fast-acting fuse with a maximum rating of 30A, 100V (for example, Bel Fuse SMM series) in the positive input lead.

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Feature Descriptions

Remote On/Off

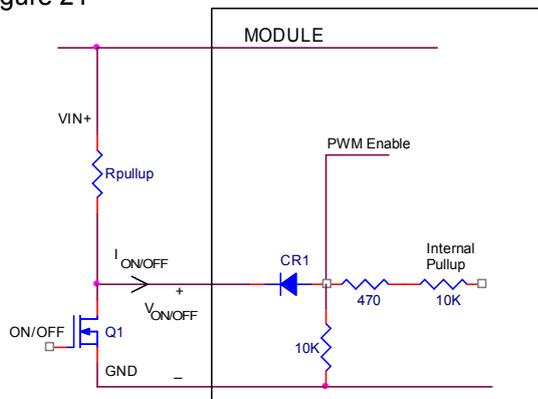
Parameter		Min	Typ	Max	Unit	Notes
Signal Low (Unit On)	Active Low	-0.3	-	0.4	V	The remote on/off pin open, Unit on.
Signal High (Unit Off)		2	-	$V_{in,max}$	V	
Signal Low (Unit Off)	Active High	-0.2	-	0.4	V	The remote on/off pin open, Unit on.
Signal High (Unit On)		3.5	-	$V_{in,max}$	V	

The SLAN-40E1Ax modules feature an On/Off pin for remote On/Off operation. Two On/Off logic options are available. In the Positive Logic On/Off option, (device code suffix "0" – see Ordering Information), the module turns ON during a logic High on the On/Off pin and turns OFF during a logic Low. With the Negative Logic On/Off option, (device code suffix "L" – see Ordering Information), the module turns OFF during logic High and ON during logic Low. The On/Off signal should be always referenced to ground. For either On/Off logic option, leaving the On/Off pin disconnected will turn the module ON when input voltage is present.

For positive logic modules, the circuit configuration for using the On/Off pin is shown in Figure 21.

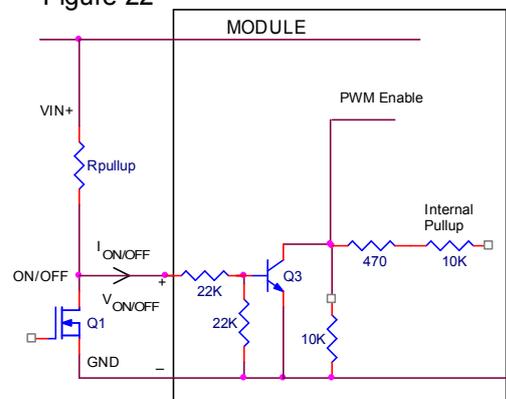
For negative logic On/Off modules, the circuit configuration is shown in Figure. 22.

Figure 21



Circuit configuration for using positive On/Off logic.

Figure 22



Circuit configuration for using negative On/Off logic

Monotonic Start-up and Shutdown

The module has monotonic start-up and shutdown behavior for any combination of rated input voltage, output current and operating temperature range.

Startup into Pre-biased Output

The module can start into a prebiased output as long as the prebias voltage is 0.5V less than the set output voltage.

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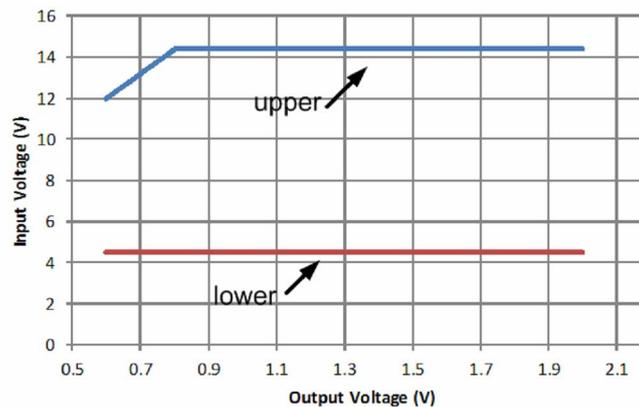
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Analog Output Voltage Programming

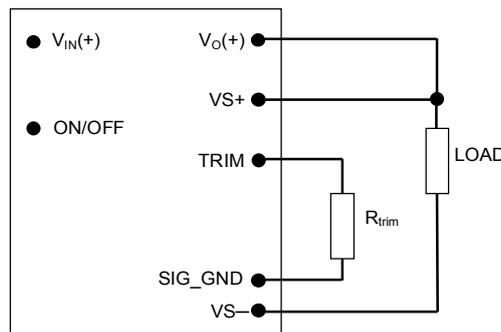
The output voltage of the module is programmable to any voltage from 0.6Vdc to 2.0Vdc by connecting a resistor between the Trim and SIG_GND pins of the module. Certain restrictions apply on the output voltage set point depending on the input voltage. These are shown in the Output Voltage vs. Input Voltage Set Point Area plot in Fig. 23. The Upper Limit curve shows that for output voltages lower than 1V, the input voltage must be lower than the maximum of 14.4Vdc. The Lower Limit curve shows that for output voltages higher than 0.6V, the input voltage needs to be larger than the minimum of 4.5Vdc.

Figure 23



Note: Output Voltage vs. Input Voltage Set Point Area plot showing limits where the output voltage can be set for different input voltages.

Figure 24



Caution – Do not connect SIG_GND to GND elsewhere in the layout
Circuit configuration for programming output voltage using an external resistor.

Without an external resistor between Trim and SIG_GND pins, the output of the module will be 0.6Vdc. To calculate the value of the trim resistor, R_{trim} for a desired output voltage, should be as per the following equation:

$$R_{trim} = \left[\frac{12}{(V_o - 0.6)} \right] k\Omega$$

R_{trim} is the external resistor in $k\Omega$
 V_o is the desired output voltage.

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Output Voltage Programming (continued)

Table 1 provides Rtrim values required for some common output voltages.

Table1

$V_{O, set}$ (V)	R_{trim} (K Ω)
0.6	Open
0.9	40
1.0	30
1.2	20
1.5	13.33
1.8	10

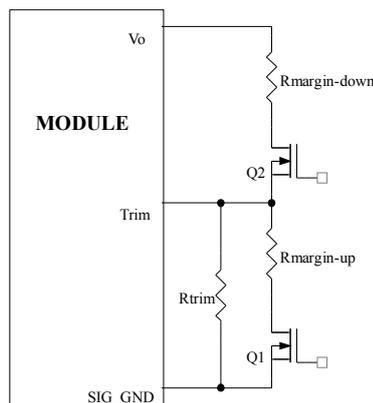
Remote Sense

The power module has a Remote Sense feature to minimize the effects of distribution losses by regulating the voltage between the sense pins (VS+ and VS-). The voltage drop between the sense pins and the VOUT and GND pins of the module should not exceed 0.5V.

Analog Voltage Margining

Output voltage margining can be implemented in the module by connecting a resistor, $R_{margin-up}$, from the Trim pin to the ground pin for margining-up the output voltage and by connecting a resistor, $R_{margin-down}$, from the Trim pin to output pin for margining-down. Figure 25 shows the circuit configuration for output voltage margining. The POL Programming Tool, available at www.belfuse.com under the Downloads section, also calculates the values of $R_{margin-up}$ and $R_{margin-down}$ for a specific output voltage and % margin. Please consult your local Bel representative for additional details.

Figure 25



Circuit Configuration for margining Output voltage.

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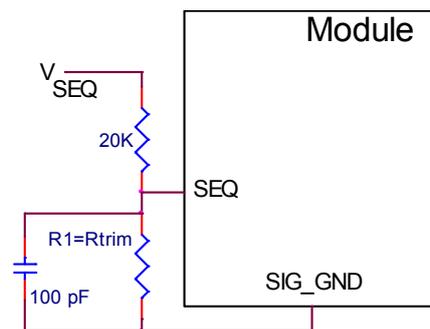
Output Voltage Sequencing

The power module includes a sequencing feature, EZ-SEQUENCE that enables users to implement various types of output voltage sequencing in their applications. This is accomplished via an additional sequencing pin. When not using the sequencing feature, leave it unconnected.

The voltage applied to the SEQ pin should be scaled down by the same ratio as used to scale the output voltage down to the reference voltage of the module. This is accomplished by an external resistive divider connected across the sequencing voltage before it is fed to the SEQ pin as shown in Fig. 26. In addition, a small capacitor (suggested value 100pF) should be connected across the lower resistor R1.

For SLAN-40E1Ax module, the minimum recommended delay between the ON/OFF signal and the sequencing signal is 10ms to ensure that the module output is ramped up according to the sequencing signal. This ensures that the module soft-start routine is completed before the sequencing signal is allowed to ramp up.

Figure 26



Circuit showing connection of the sequencing signal to the SEQ pin.

When the scaled down sequencing voltage is applied to the SEQ pin, the output voltage tracks this voltage until the output reaches the set-point voltage. The final value of the sequencing voltage must be set higher than the set-point voltage of the module. The output voltage follows the sequencing voltage on a one-to-one basis. By connecting multiple modules together, multiple modules can track their output voltages to the voltage applied on the SEQ pin.

The module's output can track the SEQ pin signal with slopes of up to 0.5V/msec during power-up or power-down.

To initiate simultaneous shutdown of the modules, the SEQ pin voltage is lowered in a controlled manner. The output voltage of the modules tracks the voltages below their set-point voltages on a one-to-one basis. A valid input voltage must be maintained until the tracking and output voltages reach ground potential.

Overcurrent Protection

To provide protection in a fault (output overload) condition, the unit is equipped with internal current-limiting circuitry and can endure current limiting continuously. At the point of current-limit inception, the unit enters hiccup mode. The unit operates normally once the output current is brought back into its specified range.

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Overtemperature Protection

To provide protection in a fault condition, the unit is equipped with a thermal shutdown circuit. The unit will shut down if the overtemperature threshold of 145°C (typ) is exceeded at the thermal reference point T_{ref} . Once the unit goes into thermal shutdown it will then wait to cool before attempting to restart.

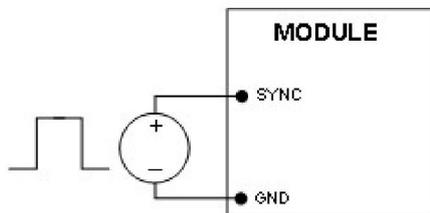
Input Undervoltage Lockout

At input voltages below the input undervoltage lockout limit, the module operation is disabled. The module will begin to operate at an input voltage above the undervoltage lockout turn-on threshold.

Synchronization

The module switching frequency can be synchronized to a signal with an external frequency within a specified range. Synchronization can be done by using the external signal applied to the SYNC pin of the module as shown in Fig. 27, with the converter being synchronized by the rising edge of the external signal. The Electrical Specifications table specifies the requirements of the external SYNC signal. If the SYNC pin is not used, the module should free run at the default switching frequency. **If synchronization is not being used, connect the SYNC pin to GND.**

Figure 27



External source connections to synchronize switching frequency of the module.

Paralleling with Active Load Sharing

For additional power requirements, the SLAN-40E1Ax module is also equipped with paralleling capability. Up to five modules can be configured in parallel, with active load sharing.

To implement paralleling, the following conditions must be satisfied.

1. All modules connected in parallel must be frequency synchronized where they are switching at the same frequency. This is done by using the SYNC function of the module and connecting to an external frequency source. Modules can be interleaved to reduce input ripple/filtering requirements.
2. The share pins of all units in parallel must be connected together. The path of these connections should be as direct as possible.
3. The remote sense connections to all modules should be made that to the same points for the output, i.e. all VS+ and VS- terminals for all modules are connected to the power bus at the same points.
4. For converters operating in parallel, tunable loop components “RTUNE” and “CTUNE” must be selected to meet the required transient specification. For providing better noise immunity, we recommend that RTUNE value to be greater than 300Ω.

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Paralleling with Active Load Sharing (continued)

Some special considerations apply for design of converters in parallel operation:

When sizing the number of modules required for parallel operation, take note of the fact that current sharing has some tolerance. In addition, under transient conditions such as a dynamic load change and during startup, all converter output currents will not be equal. To allow for such variation and avoid the likelihood of a converter shutting off due to a current overload, the total capacity of the paralleled system should be no more than 90% of the sum of the individual converters. As an example, for a system of three converters in parallel, the total current drawn should be less than 90% of (3 x 40A), i.e. less than 108 A.

All modules should be turned ON and OFF together. This is so that all modules come up at the same time avoiding the problem of one converter sourcing current into the other leading to an overcurrent trip condition. To ensure that all modules come up simultaneously, the on/off pins of all paralleled converters should be tied together and the converters enabled and disabled using the on/off pin. Note that this means that converters in parallel cannot be digitally turned ON as that does not ensure that all modules being paralleled turn on at the same time.

If digital trimming is used to adjust the overall output voltage, the adjustments need to be made in a series of small steps to avoid shutting down the output. Each step should be no more than 20mV for each module. For example, to adjust the overall output voltage in a setup with two modules (A and B) in parallel from 1V to 1.1V, module A would be adjusted from 1.0 to 1.02V followed by module B from 1.0 to 1.02V, then each module in sequence from 1.02 to 1.04V and so on until the final output voltage of 1.1V is reached.

If the Sequencing function is being used to start-up and shut down modules and the module is being held to 0V by the tracking signal then there may be small deviations on the module output. This is due to controller duty cycle limitations encountered in trying to hold the voltage down near 0V.

The share bus is not designed for redundant operation and the system will be non-functional upon failure of one of the units when multiple units are in parallel. In particular, if one of the converters shuts down during operation, the other converters may also shut down due to their outputs hitting current limit. In such a situation, unless a coordinated restart is ensured, the system may never properly restart since different converters will try to restart at different times causing an overload condition and subsequent shutdown. This situation can be avoided by having an external output voltage monitor circuit that detects a shutdown condition and forces all converters to shut down and restart together.

When not using the active load share feature, share pins should be left unconnected.

Power Good

The module provides a Power Good (PGOOD) signal that is implemented with an open-drain output to indicate that the output voltage is within the regulation limits of the power module. The PGOOD signal will be de-asserted to a low state if any condition such as over-temperature, overcurrent or loss of regulation occurs that would result in the output voltage going outside the specified thresholds.

The default value of PGOOD ON thresholds are set at $\pm 8\%$ of the nominal Vset value, and PGOOD OFF thresholds are set at $\pm 10\%$ of the nominal Vset. For example, if the nominal voltage (Vset) is set at 1.0V, then the PGOOD ON thresholds will be active anytime the output voltage is between 0.92V and 1.08V, and PGOOD OFF thresholds are active at 0.90V and 1.10V respectively.

The PGOOD terminal can be connected through a pull-up resistor (suggested value 100K Ω) to a source of 5VDC or lower.

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Dual Layout

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Identical dimensions and pin layout of Analog and Digital modules permit migration from one to the other without needing to change the layout. In both cases the trim resistor is connected between trim and signal ground.

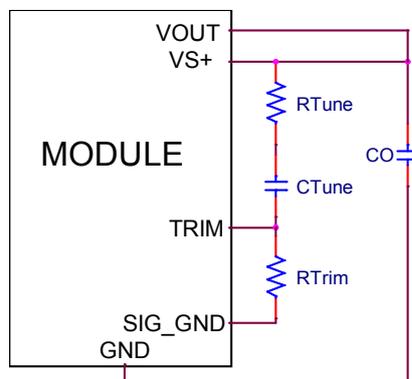
Tunable Loop™

The module has a feature that optimizes transient response of the module called Tunable Loop™.

External capacitors are usually added to the output of the module for two reasons: to reduce output ripple and noise (see Figure 20) and to reduce output voltage deviations from the steady-state value in the presence of dynamic load current changes. Adding external capacitance however affects the voltage control loop of the module, typically causing the loop to slow down with sluggish response. Larger values of external capacitance could also cause the module to become unstable.

The Tunable Loop™ allows the user to externally adjust the voltage control loop to match the filter network connected to the output of the module. The Tunable Loop™ is implemented by connecting a series R-C between the VS+ and TRIM pins of the module, as shown in Fig. 28. This R-C allows the user to externally adjust the voltage loop feedback compensation of the module.

Figure 28



Circuit diagram showing connection of R_{TUNE} and C_{TUNE} to tune the control loop of the module.

Recommended values of R_{TUNE} and C_{TUNE} for different output capacitor combinations are given in Table 2. Table 2 shows the recommended values of R_{TUNE} and C_{TUNE} for different values of ceramic output capacitors up to 1000uF that might be needed for an application to meet output ripple and noise requirements. Selecting R_{TUNE} and C_{TUNE} according to Table 2 will ensure stable operation of the module.

In applications with tight output voltage limits in the presence of dynamic current loading, additional output capacitance will be required. Table 3 lists recommended values of R_{TUNE} and C_{TUNE} in order to meet 2% output voltage deviation limits for some common output voltages in the presence of a 20A to 40A step change (50% of full load), with an input voltage of 12V.

Please contact your Bel Power technical representative to obtain more details of this feature as well as for guidelines on how to select the right value of external R-C to tune the module for best transient performance and stable operation for other output capacitance values.

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Tunable Loop™ (continued)

Table 2

Co	6x47µF	8x47µF	10x47µF	12x47µF	20x47µF
R _{TUNE}	330Ω	330Ω	330Ω	330Ω	200Ω
C _{TUNE}	330pF	820pF	1200pF	1500pF	3300pF

General recommended values of R_{TUNE} and C_{TUNE} for Vin=12V and various external ceramic capacitor combinations.

Table 3

Vo	1.8V	1.2V	0.6V
Co	4x47uF + 6x330µF polymer	4x47uF + 11x330µF polymer	4x47uF + 12x680µF polymer
R _{TUNE}	220 Ω	200 Ω	180 Ω
C _{TUNE}	5600pF	12nF	47nF
ΔV	34mV	22mV	12mV

Recommended values of R_{TUNE} and C_{TUNE} to obtain transient deviation of 2% of Vout for a 20A step load with Vin=12V.

Note: The capacitors used in the Tunable Loop tables are 47 µF/3 mΩ ESR ceramic, 330 µF/12 mΩ ESR polymer capacitor and 680µF/12 mΩ polymer capacitor.

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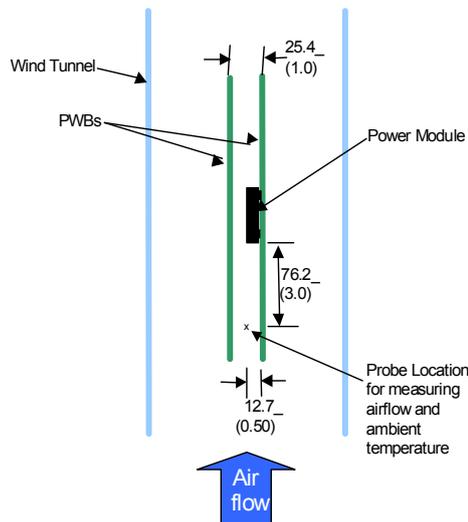
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Thermal Consideration

Power modules operate in a variety of thermal environments; however, sufficient cooling should always be provided to help ensure reliable operation.

Considerations include ambient temperature, airflow, module power dissipation, and the need for increased reliability. A reduction in the operating temperature of the module will result in an increase in reliability. The thermal data presented here is based on physical measurements taken in a wind tunnel. The test set-up is shown in Figure 29. The preferred airflow direction for the module is in Figure 30.

Figure 29

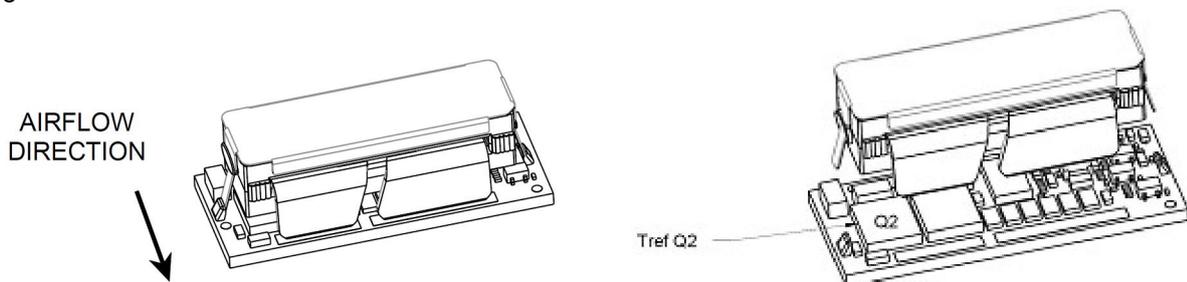


Thermal Test Setup

The thermal reference points, T_{ref} used in the specifications are also shown in Figure 30. For reliable operation the temperatures at these points should not exceed 130°C. The output power of the module should not exceed the rated power of the module ($V_{o,set} \times I_{o,max}$).

Please refer to the Application Note “Thermal Characterization Process For Open-Frame Board-Mounted Power Modules” for a detailed discussion of thermal aspects including maximum device temperatures.

Figure 30



Preferred airflow direction and location of hot-spot of the module (T_{ref}).

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Example Application Circuit

Requirements:

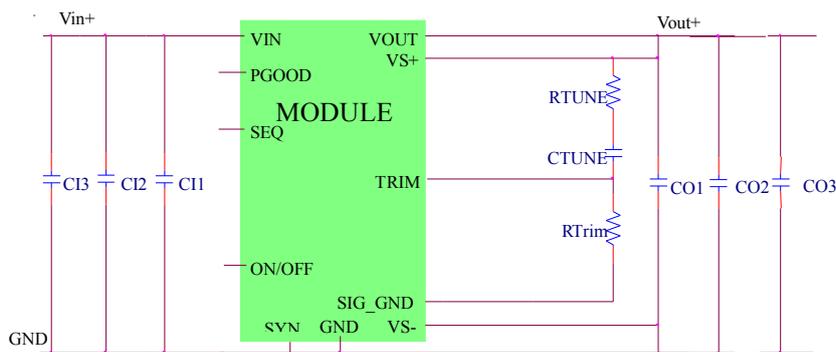
Vin: 12V

Vout: 1.8V

Iout: 30A max., worst case load transient is from 20A to 30A

ΔV_{out} : 1.5% of Vout (27mV) for worst case load transient

Vin, ripple: 1.5% of Vin (180mV, p-p)



C11	Decoupling cap - 1x0.01 μ F/16V ceramic capacitor (e.g. Murata LLL185R71E103MA01)
C12	3x22 μ F/16V ceramic capacitor (e.g. Murata GRM32ER61C226KE20)
C13	470 μ F/16V bulk electrolytic
CO1	Decoupling cap - 1x0.01 μ F/16V ceramic capacitor (e.g. Murata LLL185R71E103MA01)
CO2	4 x 47 μ F/6.3V ceramic capacitor (e.g. Murata GRM31CR60J476ME19)
CO3	6 X330 μ F/6.3V Polymer (e.g. Sanyo Poscap)
CTune	5600pF ceramic capacitor (can be 1206, 0805 or 0603 size)
RTune	220 ohms SMT resistor (can be 1206, 0805 or 0603 size)
R _{Trim}	10k Ω SMT resistor (can be 1206, 0805 or 0603 size, recommended tolerance of 0.1%)

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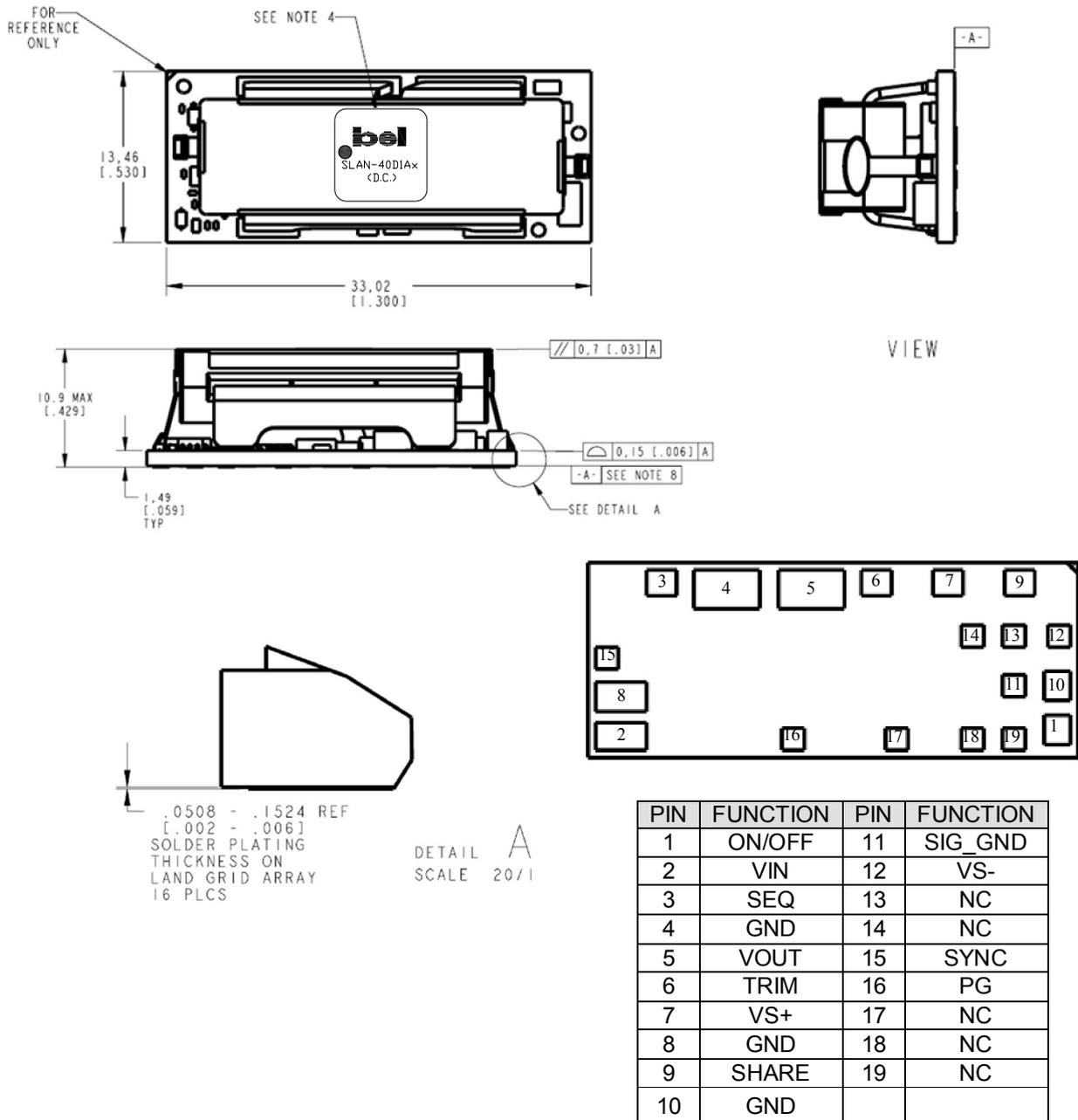
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Mechanical Outline

Dimensions are in millimeters and (inches).

Tolerances: x.x mm ± 0.5 mm (x.xx in. ± 0.02 in.) [unless otherwise indicated]

x.xx mm ± 0.25 mm (x.xxx in ± 0.010 in.)



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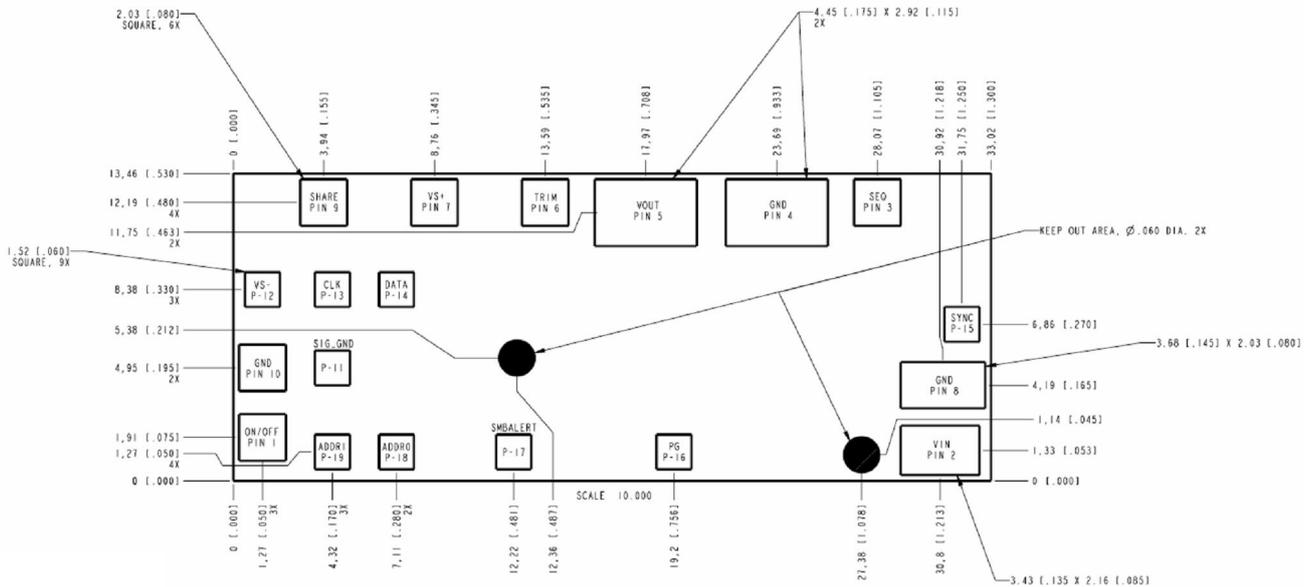
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Recommended Pad Layout

Dimensions are in millimeters and (inches).

Tolerances: x.x mm ± 0.5 mm (x.xx in. ± 0.02 in.) [unless otherwise indicated]

x.xx mm ± 0.25 mm (x.xxx in ± 0.010 in.)



PIN	FUNCTION	PIN	FUNCTION
1	ON/OFF	11	SIG_GND
2	VIN	12	VS-
3	SEQ	13	NC
4	GND	14	NC
5	VOUT	15	SYNC
6	TRIM	16	PG
7	VS+	17	NC
8	GND	18	NC
9	SHARE	19	NC
10	GND		

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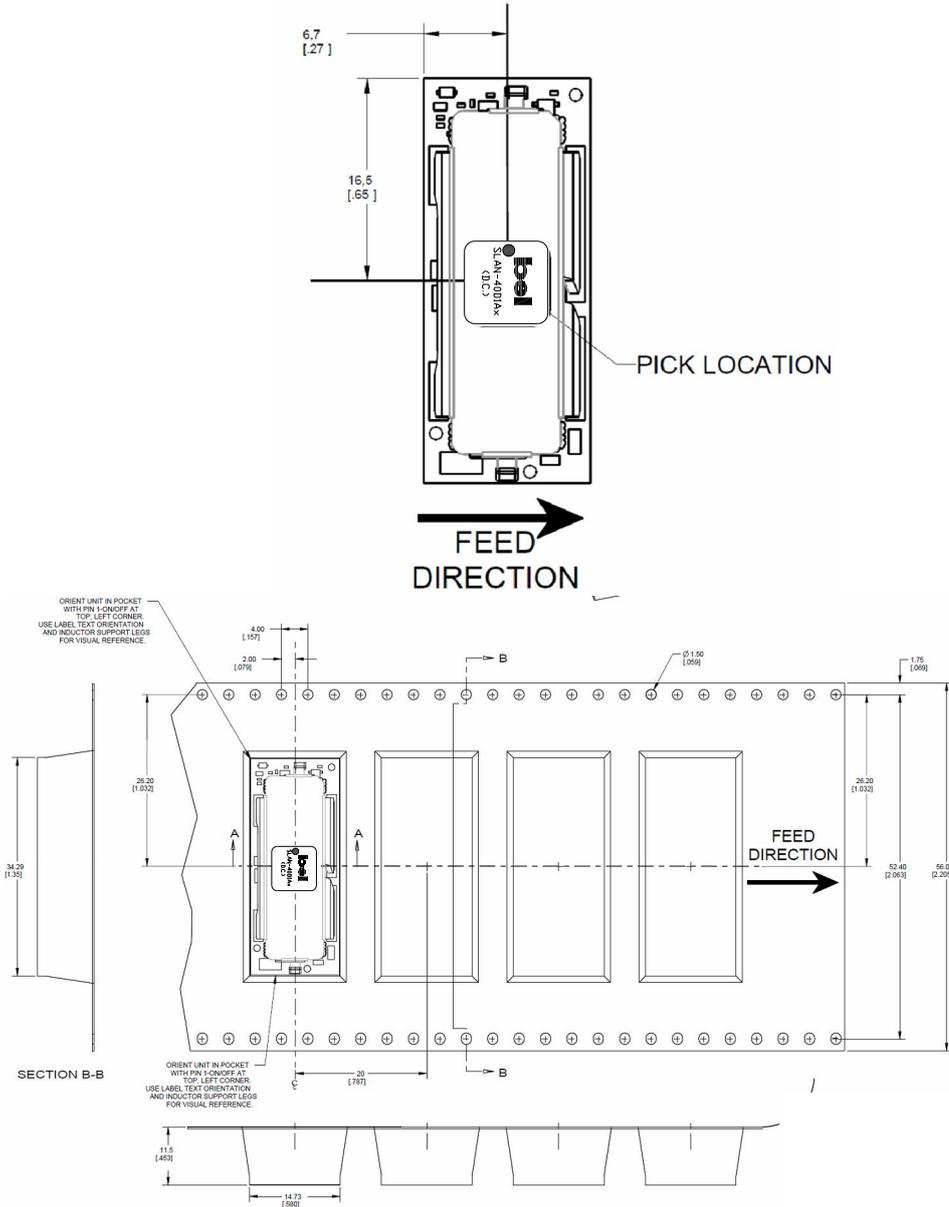


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Packaging Details

The SLAN-40E1Ax modules are supplied in tape & reel as standard.
All Dimensions are in millimeters and (in inches)



Reel Dimensions:

Outside Dimensions: 330.2 mm (13.00)

Inside Dimensions: 177.8 mm (7.00")

Tape Width: 56.00 mm (2.205")

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Surface Mount Information

Pick and Place

The SLAN-40E1Ax modules use an open frame construction and are designed for a fully automated assembly process. The modules are fitted with a label designed to provide a large surface area for pick and place operations. The label meets all the requirements for surface mount processing, as well as safety standards, and is able to withstand reflow temperatures of up to 300°C. The label also carries product information such as product code, serial number and the location of manufacture.

Nozzle Recommendations

The module weight has been kept to a minimum by using open frame construction. Variables such as nozzle size, tip style, vacuum pressure and placement speed should be considered to optimize this process. The minimum recommended inside nozzle diameter for reliable operation is 3mm. The maximum nozzle outer diameter, which will safely fit within the allowable component spacing, is 7 mm.

Bottom Side / First Side Assembly

This module is not recommended for assembly on the bottom side of a customer board. If such an assembly is attempted, components may fall off the module during the second reflow process.

Lead Free Soldering

The modules are lead-free (Pb-free) and RoHS compliant and fully compatible in a Pb-free soldering process. Failure to observe the instructions below may result in the failure of or cause damage to the modules and can adversely affect long-term reliability.

Pb-free Reflow Profile

Power Systems will comply with J-STD-020 Rev. C (Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices) for both Pb-free solder profiles and MSL classification procedures. This standard provides a recommended forced-air-convection reflow profile based on the volume and thickness of the package (table 4-2). The suggested Pb-free solder paste is Sn/Ag/Cu (SAC). The recommended linear reflow profile using Sn/Ag/Cu solder is shown in Fig. 31. Soldering outside of the recommended profile requires testing to verify results and performance.

MSL Rating

The SLAN-40E1Ax modules have a MSL rating of 2A.

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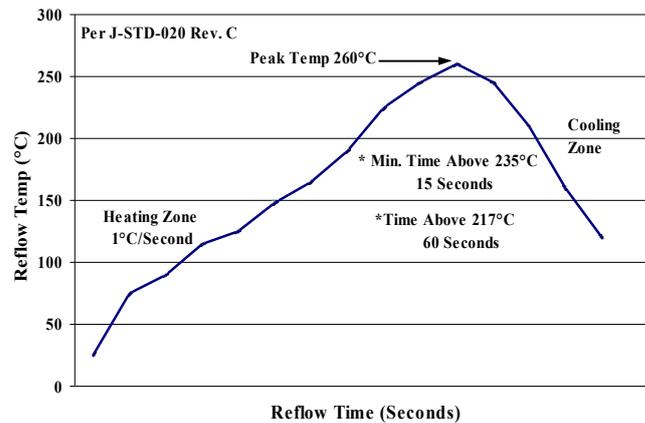
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Storage and Handling

The recommended storage environment and handling procedures for moisture-sensitive surface mount packages is detailed in J-STD-033 Rev. A (Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices). Moisture barrier bags (MBB) with desiccant are required for MSL ratings of 2 or greater. These sealed packages should not be broken until time of use. Once the original package is broken, the floor life of the product at conditions of $\leq 30^{\circ}\text{C}$ and 60% relative humidity varies according to the MSL rating (see J-STD-033A). The shelf life for dry packed SMT packages will be a minimum of 12 months from the bag seal date, when stored at the following conditions: $< 40^{\circ}\text{C}$, $< 90\%$ relative humidity.

Figure31



Recommended linear reflow profile using Sn/Ag/Cu solder.

Post Solder Cleaning and Drying Considerations

Post solder cleaning is usually the final circuit-board assembly process prior to electrical board testing. The result of inadequate cleaning and drying can affect both the reliability of a power module and the testability of the finished circuit-board assembly. For guidance on appropriate soldering, cleaning and drying procedures, refer to Board Mounted Power Modules: Soldering and Cleaning Application Note (AN04-001).

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Revision History

Date	Revision	Changes Detail	Approval
2012-09-11	A	First release	HL LU
2012-12-11	B	Update paralleling with active load sharing.	HL LU
2013-07-16	C	Update output capacitance, synchronization frequency range, safety considerations, analog output voltage programming, Tunable Loop, example application circuit, MSL rating; add transient waveforms, power good section.	XF Jiang
2013-08-01	D	Update the Over temperature Protection	XF Jiang
2015/7/17	E	Update part selection, absolute maximum ratings, output specifications, general specifications, paralleling with active load sharing, tunable loop and packaging details.	XF Jiang

RoHS Compliance

Complies with the European Directive 2011/65/EU, calling for the elimination of lead and other hazardous substances from electronic products.



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