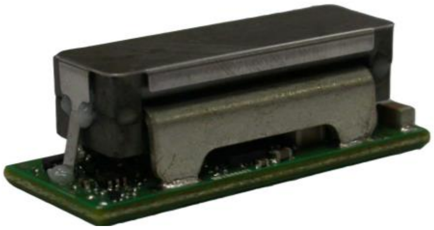
SLAN-40E1A

Non-Isolated DC-DC Converter

The SLAN-40E1A modules are non-isolated DC-DC converters that can deliver up to 40 A of output current. These modules operate over a wide range of input voltage (VIN = 4.5 - 14.4 VDC) and provide a precisely regulated output voltage from 0.6 to 2.0 VDC, 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^{TM} 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.



Key Features & Benefits

- 4.5 – 14.4 VDC Input
- 0.6 – 2.0 VDC / 40 A Output
- Power Good Signal
- Remote On/Off
- Over temperature protection
- Class II, Category 2, Isolated DC/DC Converter (refer to IPC-9592B)
- Compliant to RoHS EU Directive 2002/95/EC
- Compatible in a Pb-free or SnPb Reflow Environment
- Output Voltage Programmable from 0.6 to 2.0 VDC via External Resistor
- Tunable Loop^{TM} to Optimize Dynamic Output Voltage Response
- Output Over-Current Protection (non-latching)
- Wide Operating Temperature Range [-40°C to 85°C]
- Wide Input Voltage Range (4.5 - 14.4 VDC).
- Approved to IEC/EN 60950-1
- Small size:33.02 ×13.46 × 10.9 mm (1.3 × 0.53 × 0.429 inch)
- Cost Efficient Open Frame Design
- Ability to Sink and Source Current
- Fixed Switching Frequency with Capability of External Synchronization

TUNABLE LOOP™
A LINEAGE POWER TRADEMARK

RoHS Compliant

Applications

- Distributed Power Architectures
- Servers and Storage Applications
- Intermediate Bus Voltage Applications
- Networking Equipment
- Telecommunications Equipment
- Industrial Equipment

1. MODEL SELECTION

MODEL NUMBER ACTIVE LOW	MODEL NUMBER ACTIVE HIGH	OUTPUT VOLTAGE	INPUT VOLTAGE	MAX. OUTPUT CURRENT	MAX. OUTPUT POWER	TYPICAL EFFICIENCY
SLAN-40E1ALG	SLAN-40E1A0G	0.6 – 2.0 VDC	4.5 – 14.4 VDC	40 A	80 W	91.5%
SLAN-40E1ALR	SLAN-40E1A0R					

NOTE: 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.

PART NUMBER EXPLANATION

S	LAN	-	40	E	1A	x	x
Mounting type	Series code		Output current	Input voltage range	Sequencing or not	Logic status	Package
Surface mount	SLAN series		40 A	4.5 - 14.4 V	With Sequencing	0 – Active High L – Active Low	G – Tray Package R – Tape & Reel Package

2. ABSOLUTE MAXIMUM RATINGS

PARAMETER	DESCRIPTION	MIN	TYP	UNITS
Continuous Input Voltage		-0.3	15	V
Operating Ambient Temperature	See Thermal Considerations section	-40	85	°C
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.

3. INPUT SPECIFICATIONS

PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNIT
Operating Input Voltage		4.5	-	14.4	V
Input Current	VIN = 4.5 to 14 V, Io= Io max	-	-	24	A
Input Current (no load)	Vo set = 0.6 VDC VIN = 12 VDC, Io = 0, module enabled	-	54.7	-	mA
	Vo set = 2 VDC	-	104	-	
Input Stand-by Current	VIN = 12 V, module disabled	-	12.5	-	mA
Input Reflected Ripple Current (pk-pk)	5 Hz to 20 MHz, 1 µH source impedance; VIN = 0 to 14 V, Io = Io max; See Test Configurations	-	90	-	mAp-p
I^2t Inrush Current Transient		-	-	1	A^2s
Input Ripple Rejection (120 Hz)		-	-60	-	dB

NOTE: Unless otherwise indicated, specifications apply over entire operating input voltage range, resistive load, and temperature conditions.

4. OUTPUT SPECIFICATIONS

PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNIT
Output Voltage Set Point	With 0.1% tolerance for external resistor used to set output voltage	-1.0	-	+1.0	%Vo set
Output Voltage	Over entire operating input voltage range, resistive load, and temperature conditions until end of life	-3.0	-	+3.0	%Vo set
Adjustment Range	1. Selected by an external resistor 2.Some output voltages may not be possible depending on the input voltage – see Feature Descriptions Section	0.6	-	2.0	V
Remote Sense Range		-	-	0.5	V
Line Regulation	VIN = VIN min to VIN max	-	-	6	mV
Load Regulation	Io = Io min to Io max	-	-	10	mV
Temperature Regulation	Tref = Ta min to Ta max	-	0.4	-	%Vo set
Output Current	In either sink or source mode	0	-	40	Adc
Output Ripple and Noise (pk-pk)	5 Hz to 20 MHz BW, VIN = VIN nom and Io = Io min to Io max, Co = 0.1 μF // 22 μF ceramic capacitors	-	50	100	mV
Output Ripple and Noise (rms)		-	20	38	mV
Output Short-Circuit Current	Vo ≤ 250 mV, Hiccup Mode	-	2.1	-	Arms
Turn-On Delay and Rise Times (VIN=VIN nom, Io=Io max, Vo to within ±1% of steady state.)	Case 1: On/Off input is enabled and then input power is applied (delay from instant at which VIN = VIN min until Vo = 10% of Vo set)	1.0	1.1	1.7	ms
	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 Vo = 10% of Vo set)	600	700	1800	μs
Output Voltage Overshoot	VIN = VIN min to Vin max, Io = Io min to Io max, TA = 25°C. With or without maximum external capacitance	-	1.5	3.0	%Vo set.
Output Voltage Rise Time	Time for Vo to rise from 10% of Vo set to 90% of Vo set	1.2	1.5	2.2	msec
Output Capacitance** ESR≥ 1 mΩ	Without the Tunable Loop^{TM}	6x47	-	6x47	μF
ESR≥0.15 mΩ	With the Tunable Loop^{TM}	6x47	-	7000	
ESR≥ 10 mΩ	With the Tunable Loop^{TM}	6x47	-	8500	
Output Current Limit Inception	1. Hiccup Mode 2.Current limit does not operate in sink mode	-	150	-	% Io max

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

NOTE: All specifications are typical at nominal input, full load at 25°C unless noted.

5. GENERAL SPECIFICATIONS

PARAMETER		DESCRIPTION	MIN	TYP	MAX	UNIT
Efficiency	Vin = 12 VDC, TA = 25°C Io = Io max, Vo = Vo set	Vo = 0.6 V	78.0	81.3	-	%
		Vo = 1.2 V	84.0	88.5	-	
		Vo = 1.8 V	85.25	91.5	-	
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
Over Temperature Protection	See Thermal Considerations section		123	130	137	°C
Tracking Accuracy	Power-Up: 0.5 V/ms		-	-	100	mV
	Power-Down: 0.5 V/ms		-	-	100	
PGOOD (Power Good)	Overvoltage threshold for PGOOD ON	Signal Interface Open Drain, Vsupply ≤ 5VDC	103	108	113	%Vo set
	Overvoltage threshold for PGOOD OFF		105	110	115	%Vo set
	Undervoltage threshold for PGOOD ON		87	92	97	%Vo set
	Undervoltage threshold for PGOOD OFF		85	90	95	%Vo set
	Pulldown resistance of PGOOD pin		-	-	50	Ω
	Sink current capability into PGOOD pin		-	-	5	mA
Weight			-	11.7	-	g
Input Undervoltage Lockout	Turn-on Threshold		4.144	4.25	4.407	V
	Turn-off Threshold		3.947	3.98	4.163	
	Hysteresis		0.25	0.3	0.35	
MTBF*	Calculated MTBF (Io = 0.8 Io max, TA = 40°C) Telecordia Issue 2 Method 1 Case 3			6,498,438		hours
Dimensions (L × W × H)				1.30 ×0.53×0.429		inch
				33.02×13.46×10.9		mm

NOTE: Unless otherwise indicated, specifications apply over entire operating input voltage range, resistive load, and temperature condition.

6. EFFICIENCY DATA

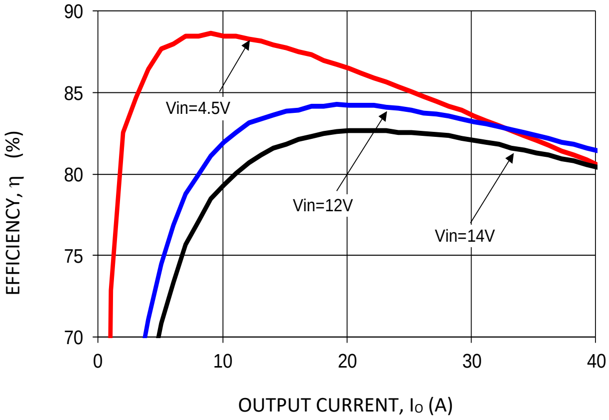


Figure 1. Vo = 0.6 V

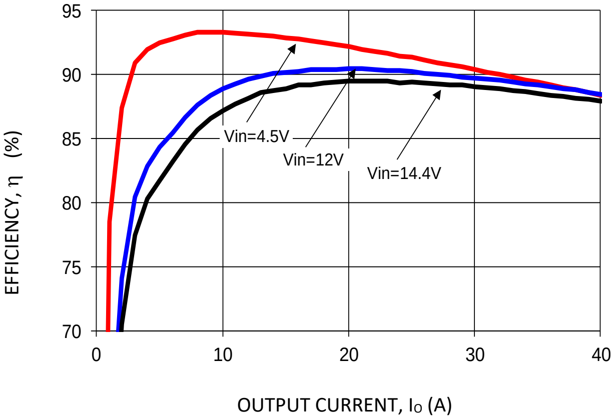


Figure 2. Vo = 1.2 V

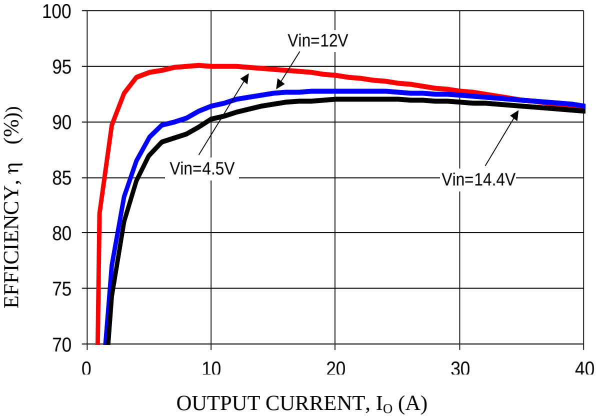


Figure 3. Vo = 1.8 V

7. THERMAL DERATING CURVES

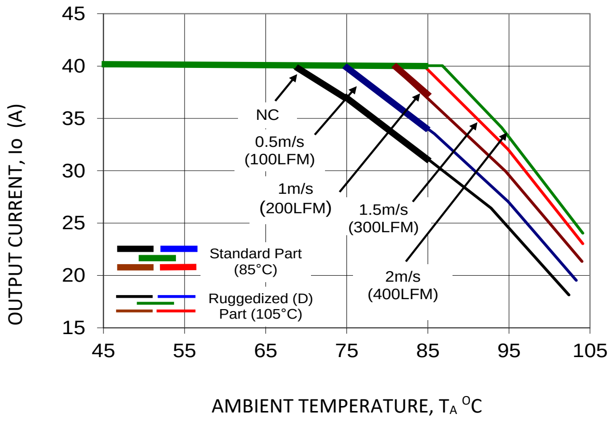


Figure 4. Vo = 0.6 V

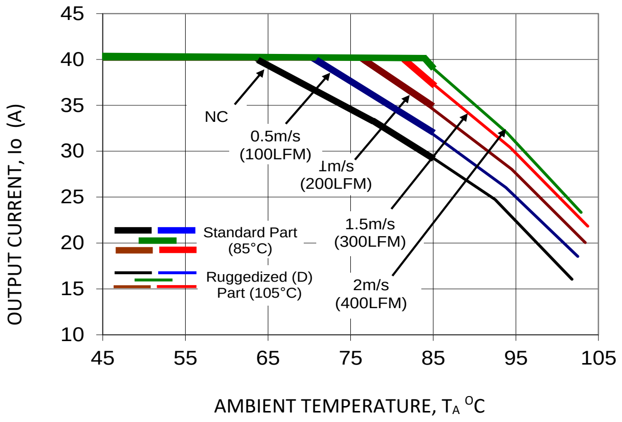


Figure 5. Vo = 1.2 V

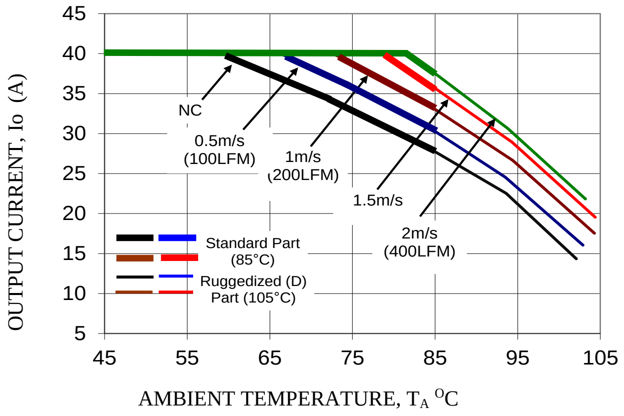


Figure 6. Vo = 1.8 V

8. OUTPUT RIPPLE AND NOISE WAVEFORMS

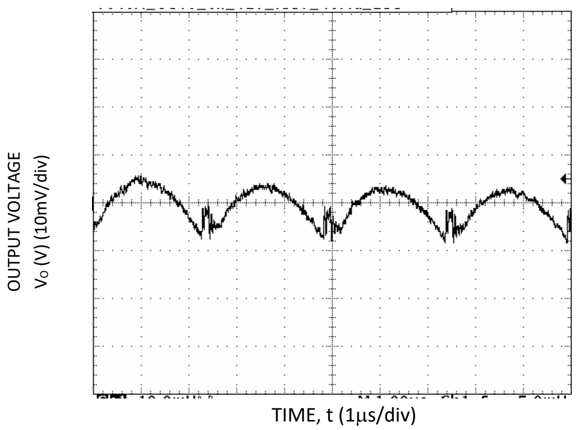


Figure 7. Vo = 0.6 V, Io = Io, max, Vin = 12 V

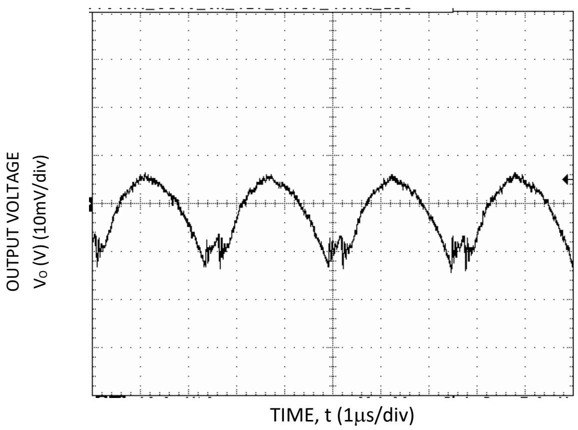


Figure 8. Vo = 1.2 V, Io = Io, max, Vin = 12 V

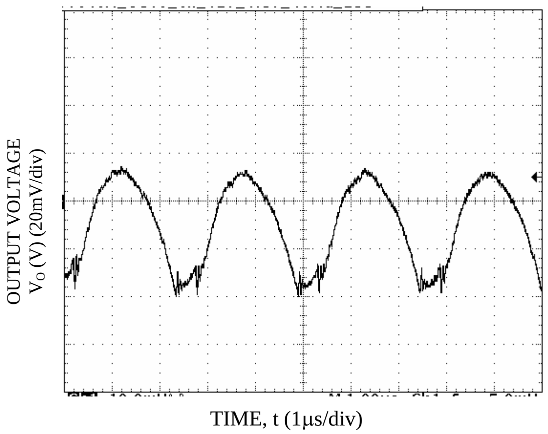


Figure 9. Vo = 1.8 V, Io = Io, max, Vin = 12 V

NOTE: Co = 6x 47 µF ceramic.

9. STARTUP TIME

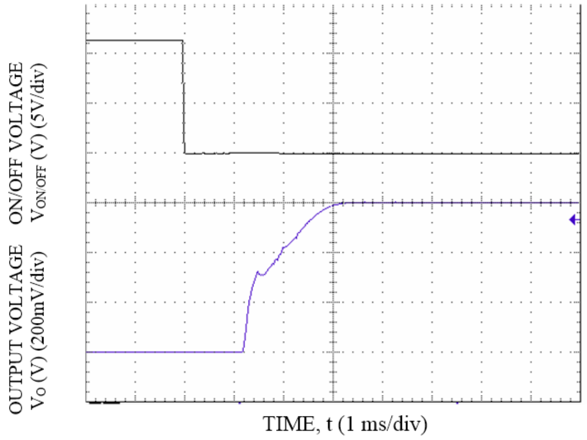


Figure 10. Start-up Using On/Off Voltage (Io = Io max), Vo = 0.6 V

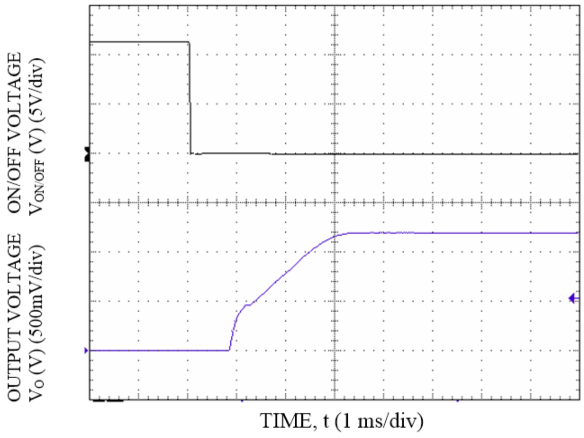


Figure 11. Start-up Using On/Off Voltage (Io = Io max), Vo = 1.2 V

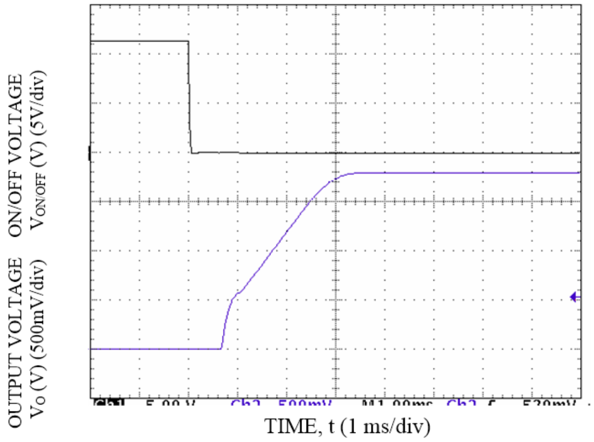


Figure 12. Start-up Using On/Off Voltage (Io = Io max), Vo = 1.8 V

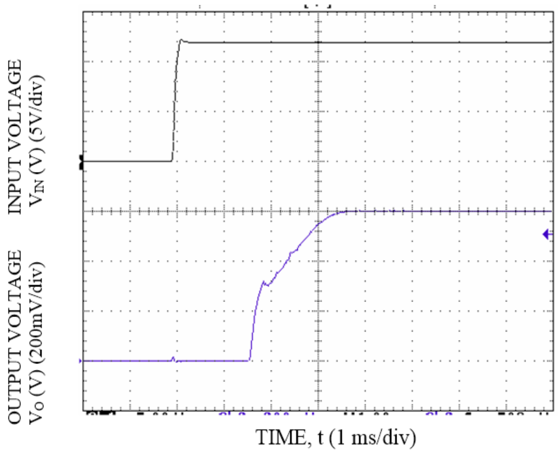


Figure 13. Start-up Using Input Voltage (VIN = 12V, Io = Io max), Vo = 0.6 V

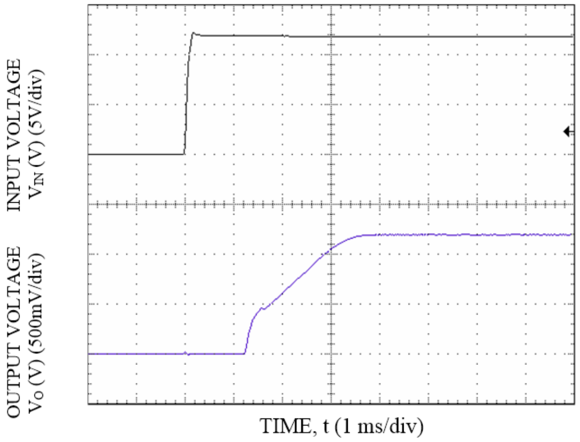


Figure 14. Start-up Using Input Voltage (VIN = 12V, Io = Io max), Vo = 1.2 V

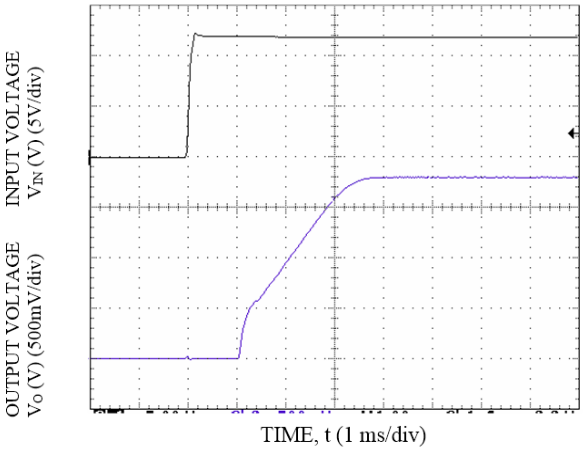


Figure 15. Start-up Using Input Voltage (VIN = 12V, Io = Io max), Vo = 1.8 V

10. TRANSIENT RESPONSE WAVEFORMS

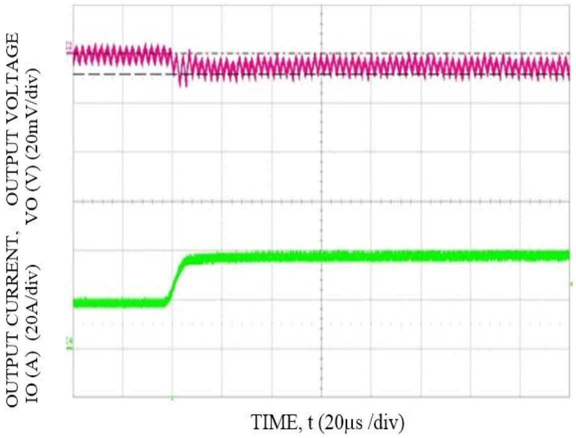


Figure 16. Transient Response to Dynamic Load Change from 50% to 100% at 12Vin, Cout = 12x 680 µF + 6x 47 µF, CTune = 47 nF, RTune = 180 ohms, Vo = 0.6 V

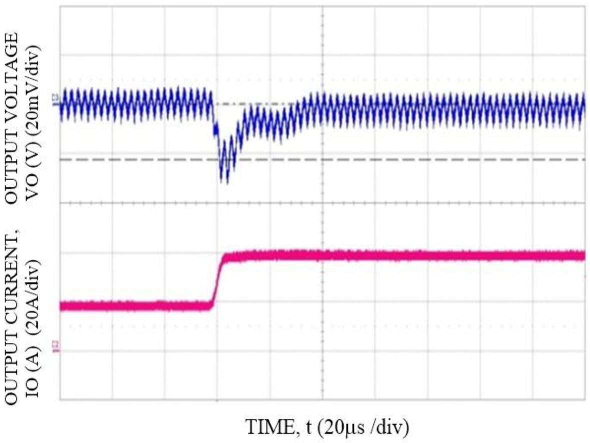


Figure 17. Transient Response to Dynamic Load Change from 50% to 100% at 12Vin, Cout = 6x 330 µF, CTune = 12 nF & RTune = 200 ohms, Vo = 1.2 V

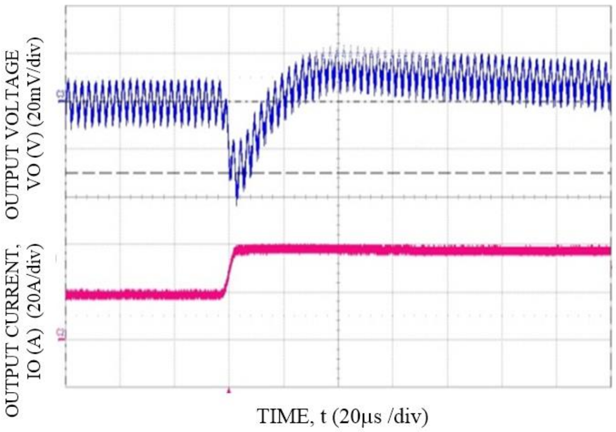


Figure 18. Transient Response to Dynamic Load Change from 50% to 100% at 12Vin, Cout = 6x 330 µF, CTune = 5.6 nF & RTune = 220 ohms, Vo = 1.8 V

11. 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 40 A of load current with 4x22 µF, 6x22 µF or 8x22 µF ceramic capacitors and a 12 V input.

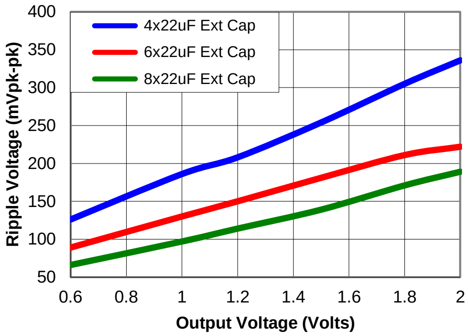


Figure 19.

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

OUTPUT FILTERING

These modules are designed for low output ripple voltage and will meet the maximum output ripple specification with 0.1 µF ceramic and 47 µF 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 Vo 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^{TM} feature described later in this data sheet.

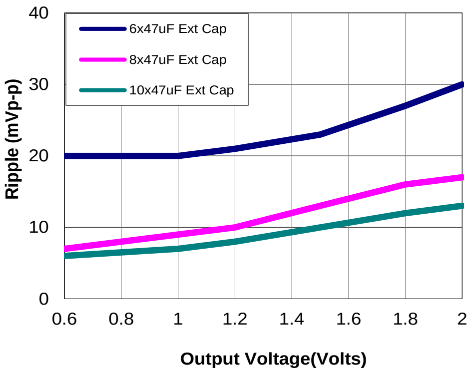


Figure 20.

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

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.

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 30 A, 100 V (for example, Bel Fuse SMM series) in the positive input lead.

12. FEATURE DESCRIPTIONS

REMOTE ON/OFF

PARAMETER		DESCRIPTION	MIN	TYP	MAX	UNIT
Signal Low (Unit On)	Active Low	The remote on/off pin open, Unit on.	-0.2	-	0.4	V
Signal High (Unit Off)			2	-	VIN, max	
Signal Low (Unit Off)	Active High	The remote on/off pin open, Unit on.	-0.3	-	0.4	V
Signal High (Unit On)			3.5	-	VIN, max	

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.

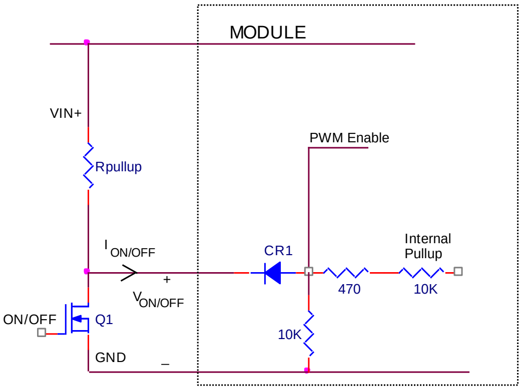


Figure 21. Circuit configuration for using positive On/Off logic

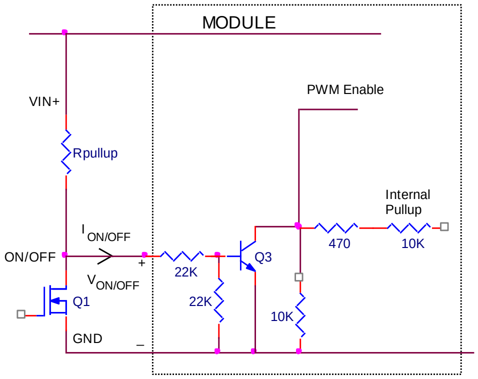


Figure 22. Circuit configuration for using negative On/Off logic

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 pre-biased output as long as the pre-bias voltage is 0.5 V less than the set output voltage.

ANALOG OUTPUT VOLTAGE PROGRAMMING

The output voltage of the module is programmable to any voltage from 0.6 to 2.0 VDC 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 Figure 23. The Upper Limit curve shows that for output voltages lower than 1V, the input voltage must be lower than the maximum of 14.4 VDC. The Lower Limit curve shows that for output voltages higher than 0.6V, the input voltage needs to be larger than the minimum of 4.5 VDC.

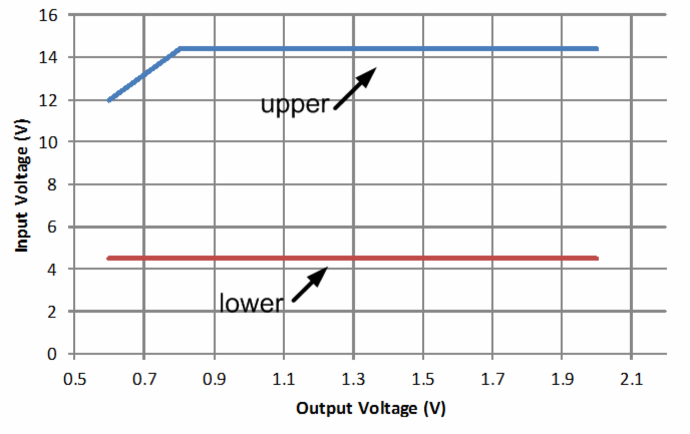


Figure 23.

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

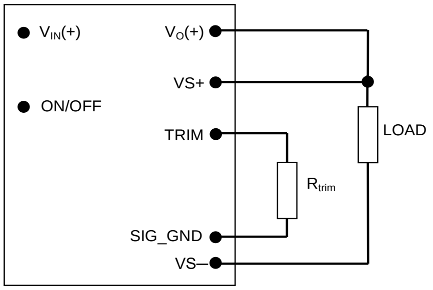


Figure 24.

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 0.6 VDC. To calculate the value of the trim resistor, Rtrim for a desired output voltage, should be as per the following equation:

$$Rtrim = \left[\frac{12}{(Vo - 0.6)} \right] k\Omega$$

Rtrim is the external resistor in kΩ.
Vo is the desired output voltage.
Table 1 provides Rtrim values required for some common output voltages.

VO SET (V)	RTRIM (KΩ)
0.6	Open
0.9	40
1.0	30
1.2	20
1.5	13.33
1.8	10

Table 1.

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, Rmargin-up, from the Trim pin to the ground pin for margining-up the output voltage and by connecting a resistor, Rmargin-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 Rmargin-up and Rmargin-down for a specific output voltage and % margin. Please consult your local Bel representative for additional details.

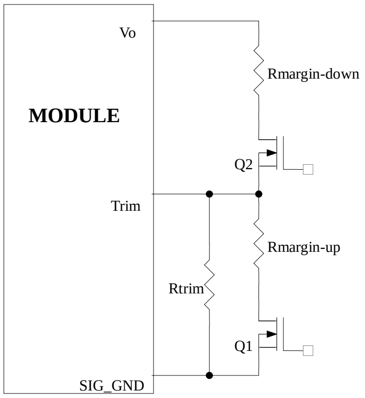


Figure 25. Circuit Configuration for margining Output voltage

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 100 pF) 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 10 ms 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.

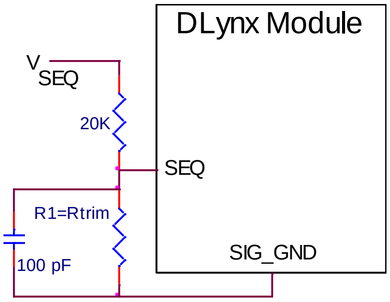


Figure 26. Circuit showing connection of the sequencing signal to the SEQ pin

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 0.5 V/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.

OVER TEMPERATURE 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 (type) is exceeded at the thermal reference point Tref. 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.

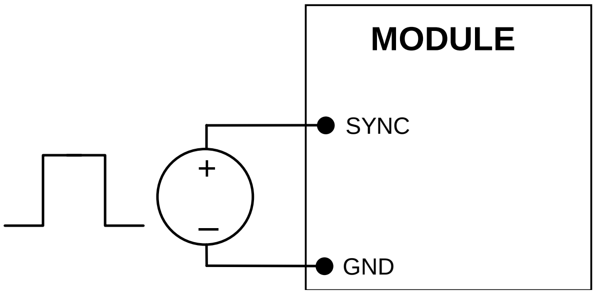


Figure 27. External source connections to synchronize switching frequency of the module

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 300 Ω.

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 40 A), 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 20 mV for each module. For example, to adjust the overall output voltage in a setup with two modules (A and B) in parallel from 1 to 1.1 V, module A would be adjusted from 1.0 to 1.02 V followed by module B from 1.0 to 1.02 V, then each module in sequence from 1.02 to 1.04 V and so on until the final output voltage of 1.1 V 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 0 V.

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

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

DUAL LAYOUT

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^{TM}

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

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^{TM} 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^{TM} 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.

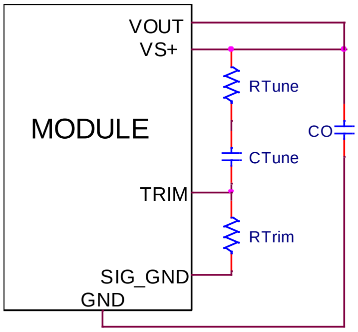


Figure 28. Circuit diagram showing connection of R_{TUNE} and C_{TUNE} to tune the control loop of the module

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 1000μF 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 20 to 40 A step change (50% of full load), with an input voltage of 12 V.

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.

Co	**6x 47 μF**	**8x 47 μF**	**10x 47 μF**	**12x 47 μF**	**20x 47 μF**
R_{TUNE}	330 Ω	330 Ω	330 Ω	330 Ω	200 Ω
C_{TUNE}	330 pF	820 pF	1200 pF	1500 pF	3300 pF

Table 2.

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

Vo	**1.8 V**	**1.2 V**	**0.6 V**
Co	4x 47 μF + 6x 330 μF polymer	4x 47 μF + 11x 330 μF polymer	4x 47 μF + 12x 680 μF polymer
R_{TUNE}	220 Ω	200 Ω	180 Ω
C_{TUNE}	5600 pF	12 nF	47 nF
ΔV	34 mV	22 mV	12 mV

Table 3.

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

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

13. 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.

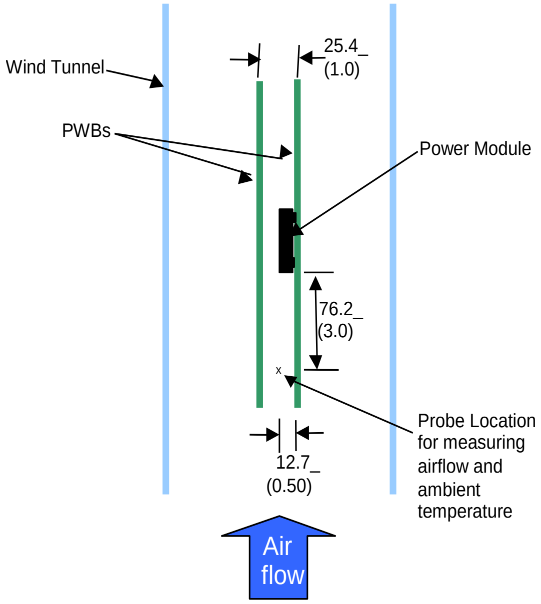


Figure 29. Thermal Test Setup

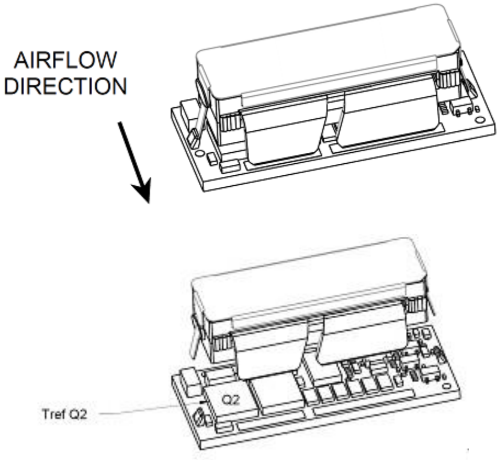


Figure 30. Preferred airflow direction and location of hot-spot of the module (Tref)

14. EXAMPLE APPLICATION CIRCUIT

Requirements:

Vin:	12 V
Vout:	1.8 V
Iout:	30 A max., worst case load transient is from 20 A to 30 A
∆Vout:	1.5% of Vout (27 mV) for worst case load transient
Vin, ripple	1.5% of Vin (180 mV, p-p)

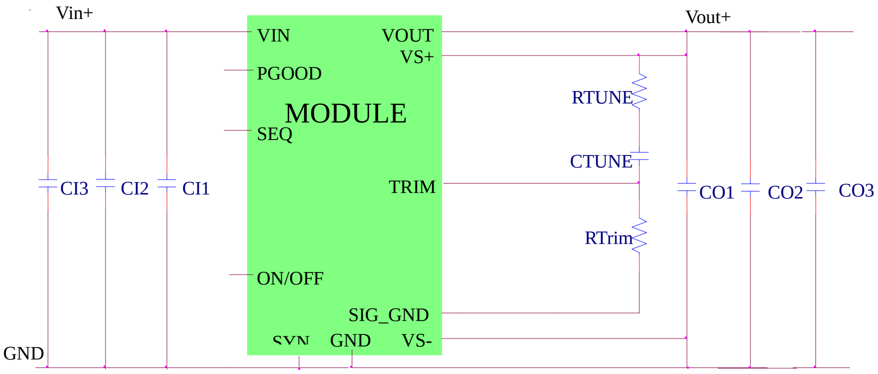


Figure 31.

CI1	Decoupling cap - 1x0.01µF/16V ceramic capacitor (e.g. Murata LLL185R71E103MA01)
CI2	3x22µF/16V ceramic capacitor (e.g. Murata GRM32ER61C226KE20)
CI3	470µF/16V bulk electrolytic
CO1	Decoupling cap - 1x0.01µF/16V ceramic capacitor (e.g. Murata LLL185R71E103MA01)
CO2	4 x 47µF/6.3V ceramic capacitor (e.g. Murata GRM31CR60J476ME19)
CO3	6 X330µF/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}	10kΩ SMT resistor (can be 1206, 0805 or 0603 size, recommended tolerance of 0.1%)

15. MECHANICAL DIMENSIONS

OUTLINE

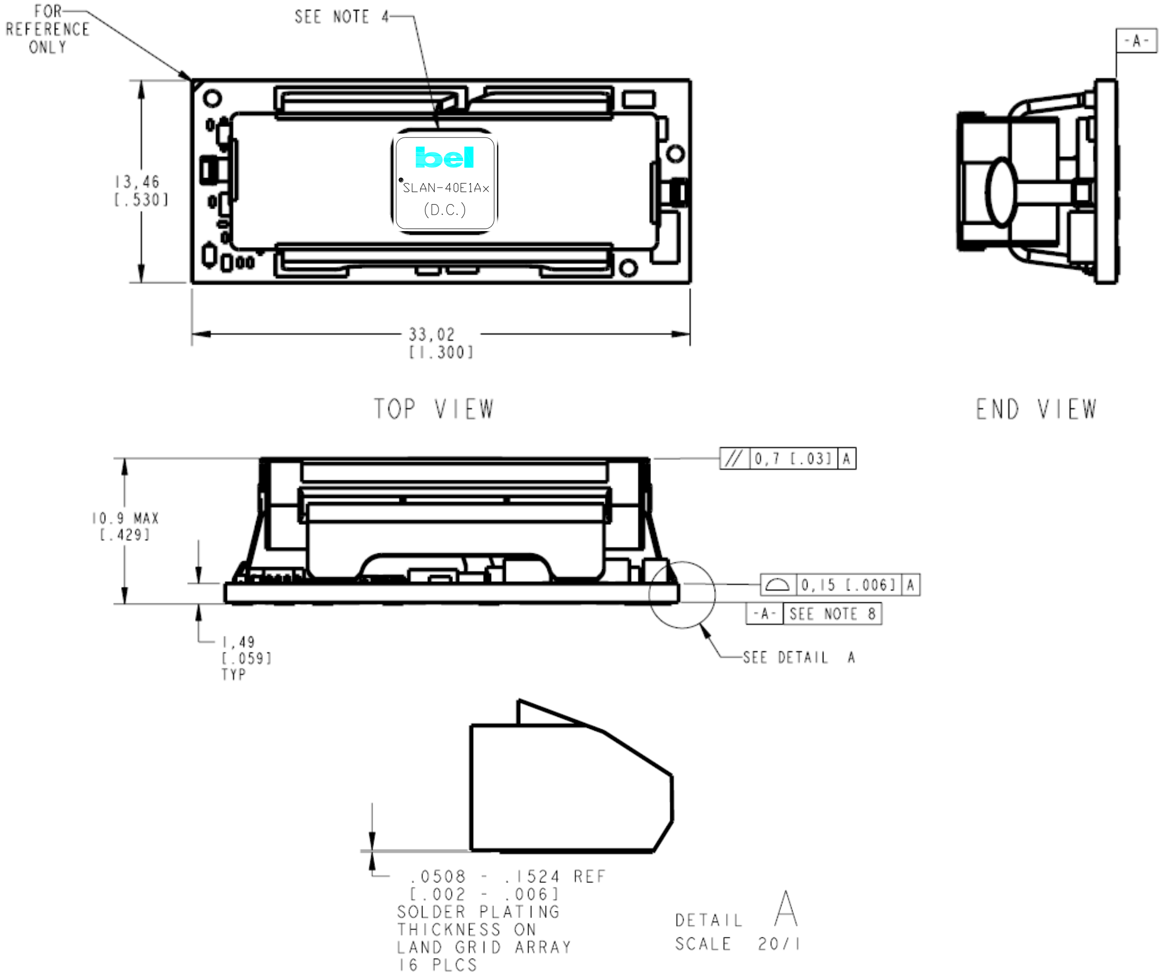


Figure 32.

Notes:

Dimensions are in mm [inch].

Tolerances: x.x mm ± 0.5 mm [± 0.02 inch] [unless otherwise indicated]

x.xx mm ± 0.25 mm [± 0.010 inch]

PIN DEFINITIONS

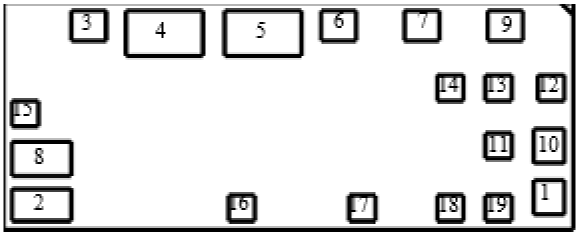


Figure 33. Pins

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		

RECOMMENDED PAD LAYOUT

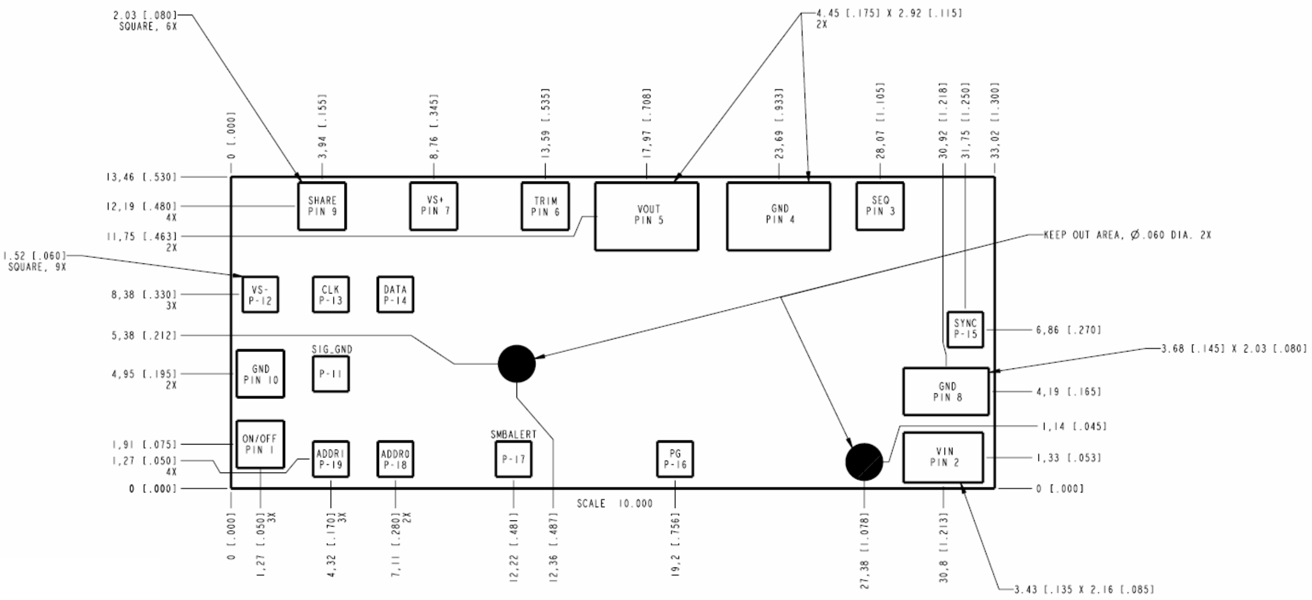


Figure 34. Recommended pad layout

16. PACKAGING DETAILS

The SLAN-40E1Ax modules are supplied in tape & reel as standard.

All Dimensions are in mm [inch].

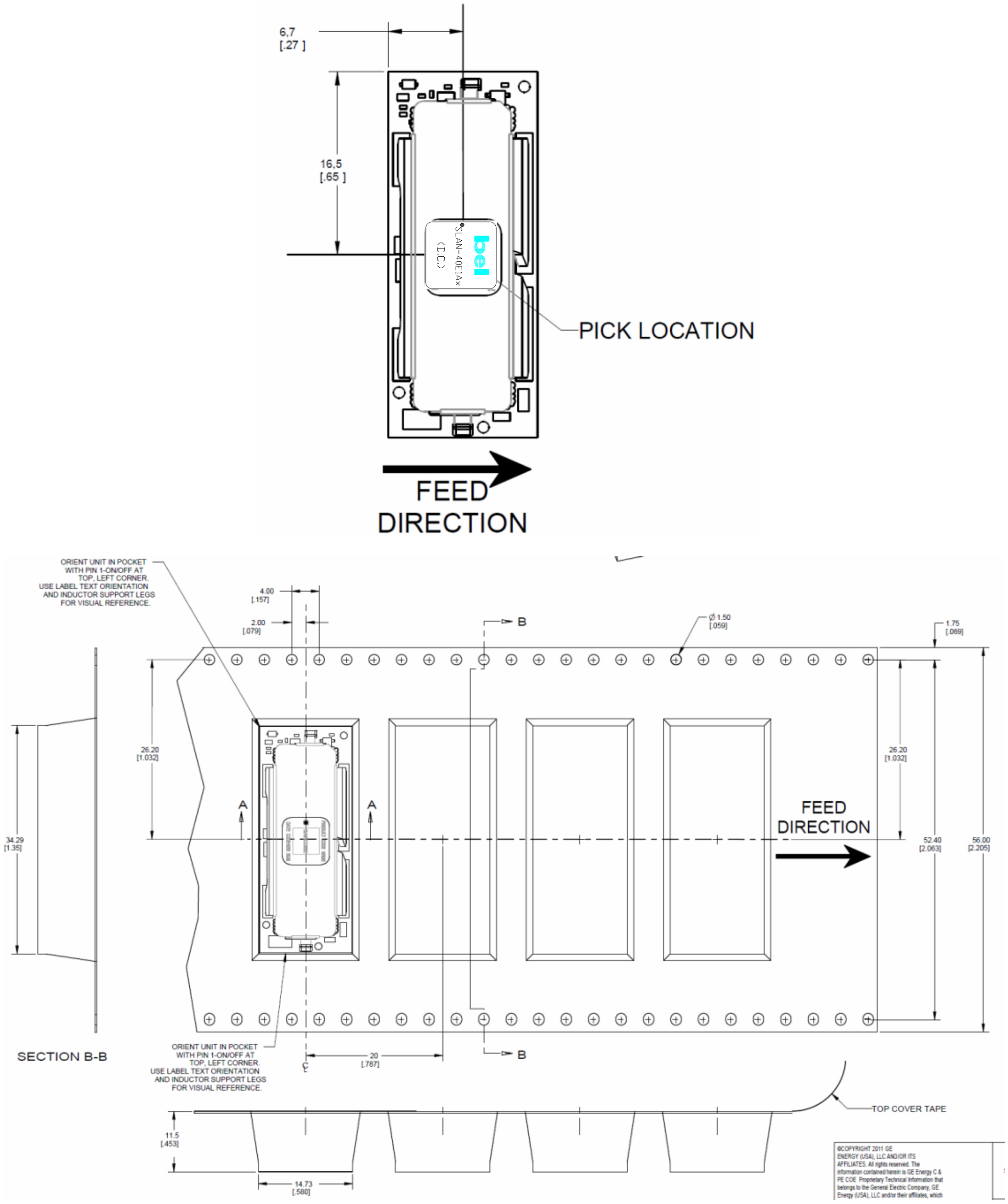


Figure 35. Packaging details

Reel Dimensions:

Outside Dimensions: 330.2 mm (13.00”)
Inside Dimensions: 177.8 mm (7.00”)
Tape Width: 56.00 mm (2.205”)

17. 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.

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). For questions regarding LGA, solder volume; please contact Bel power for special manufacturing process instructions.
The recommended linear reflow profile using Sn/Ag/Cu solder is shown in Fig. 48. 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.

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 ≤ 30°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° C, < 90% relative humidity.

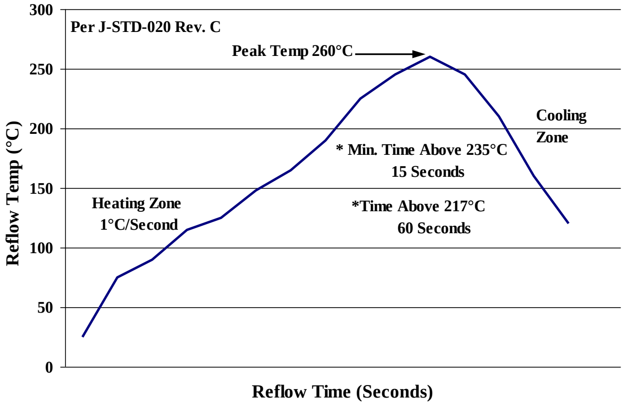


Figure 36. Recommended linear reflow profile using Sn/Ag/Cu solder

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).

18. 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
2015-07-17	E	Update part selection, absolute maximum ratings, output specifications, general specifications, paralleling with active load sharing, tunable loop and packaging details.	XF.Jiang
2018-06-21	AF	Update Output Specs and Remote on/off. add Power Good	XF.Jiang
2021-05-27	AG	Add object ID. Delete safety considerations about VDE information.	XF.Jiang

For more information on these products consult: tech.support@psbel.com