

## NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.8 Vdc Input

0.85 Vdc – 0.92 Vdc / 10A Output



Jan. 04, 2016

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

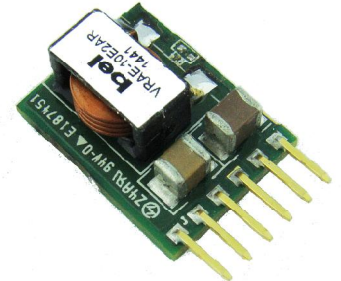
VRAE-10E2AR

RoHS Compliant

Rev.D

### Features

- Non-Isolated
- High Efficiency
- Fixed Frequency
- Low Cost
- Wide Input
- Class 2, Category 2, Non-Isolated DC/DC Converter (refer to IPC-9592B)
- UL60950-1,-2 2nd Edition Recognized (UL/cUL)
- Under-Voltage Lockout
- Wide Trim
- OCP/SCP
- Remote On/Off
- Remote Sense



### Description

The Bel VRAE-10E2AR is part of the non-isolated dc/dc converter Power Module series. These converters are available in a range of output voltages from 0.85 Vdc to 0.92 Vdc over a wide range of input voltage ( $V_{IN} = 4.5$  Vdc - 13.8 Vdc). The efficiency is typically 73% at 0.92Vout ( $V_{in}=12$  Vdc) at full load.

### Part Selection

Output Voltage	Input Voltage	Max. Output Current	Max. Output Power	Typical Efficiency	Model Number
0.85V – 0.92V	4.5 V - 13.8 V	10 A	9.2 W	73%	VRAE-10E2AR

**Notes:** Add “G” suffix at the end of the model numbers listed above to indicate “Tray Packaging”.

### Part Number Explanation

$\frac{V}{1} \frac{R}{2} \frac{AE}{3} - \frac{10}{4} \frac{E}{5} \frac{2A}{6} \frac{R}{7} \frac{x}{8}$

- 1---Vertical mount
- 2---RoHS 6, change “R” to “7” means RoHS 5
- 3---Series name
- 4---Series code
- 5---Wide input range (4.5-13.8V)
- 6---Wide trim
- 7---Suffix
- 8---Package

### Absolute Maximum Ratings

Parameter	Min	Typ	Max	Notes
Input Supply Voltage	-0.3 V	-	15 V	
Ambient Temperature	-40°C	-	85°C	
Storage Temperature	-55 °C	-	125 °C	
Altitude	-	-	2000m	

**Note:** All specifications are typical at 25 °C unless otherwise stated.

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### Input Specifications

Parameter	Min	Typ	Max	Notes
Operating Input Voltage	4.5 V		13.8 V	
Input Current (full load)	-	-	2.7A	An input line fuse must always be used.
Input Current (no load)	-	-	80mA	
Input Standby Current	-	7mA	-	Vin=12V
Input Reflected Ripple Current (pk-pk)	-	10mA	20mA	With simulated source impedance of 1000 nH, 5 Hz to 20 MHz. Use 2*22 uF/16V Ceramic Cap with ESR=0.002 ohm max at 100 kHz@25°C.
Input Reflected Ripple Current (rms)	-	2mA	4mA	
I <sup>2</sup> t Inrush Current Transient	-	-	1 A <sup>2</sup> s	
Turn on Voltage Threshold	4.15 V	4.3 V	4.45 V	A 30.1K resistor is connected from Enable to Vin
Turn off Voltage Threshold	3.7 V	4.1 V	4.3 V	

**Note:** All specifications are typical at 25 °C unless otherwise stated.

### Output Specifications

Parameter	Min	Typ	Max	Notes
Output Voltage Set Point	-2%Vo,set	-	2%Vo,set	Vin= 12 V, Iout=full load
Load Regulation	-0.8% Vo,set	±0.3%Vo,set	0.8%Vo,set	
Line Regulation	-0.8% Vo,set	±0.3%Vo,set	0.8%Vo,set	
Temperature Regulation	-0.8%Vo,set	0.3%Vo,set	0.8%Vo,set	
Output voltage	-3%Vo,set	-	3%Vo,set	At all condition
Output Current	0 A	-	10 A	both sinking and sourcing mode
Output DC Current Limit	12A	14A	17A	
Output Ripple and Noise (pk-pk)	-	10mV	20mV	with a 470 uF polymer capacitor and 2*100 uF+1*22uF ceramic capacitor at the output.
Output Ripple and Noise (rms)	-	3mV	5mV	
Short Circuit Surge Transient	-	-	5 A <sup>2</sup> s	
Rise Time	2mS	3mS	4mS	
Turn on Time	3mS	4mS	6mS	
Overshoot at Turn on	-	-	1%	
Output Capacitance	1*22uf(C)+2*100uf(C)+1*470uf(polymer)			

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### Output Specifications (continued)

Parameter	Min	Typ	Max	Notes
<b>Transient Response</b>				
50% ~ 100% Max load	Vo=0.85V	-	17 mV	di/dt=2.5 A/uS; Vin= 12 V; with a 470 uF polymer capacitor and 2*100 uF+1*22uF ceramic capacitor at the output.
Settling Time		-	30 uS	
100% ~ 50% Max load		-	17 mV	
Settling Time		-	30 uS	
50% ~ 100% Max load	Vo=0.92V	-	18 mV	di/dt=2.5 A/uS; Vin= 12 V; with a 470 uF polymer capacitor and 2*100 uF+1*22uF ceramic capacitor at the output.
Settling Time		-	30 uS	
100% ~ 50% Max load		-	18 mV	
Settling Time		-	30 uS	

**Note:** All specifications are typical at normal input, full load at Ta= 25°C unless otherwise stated.

### General Specifications

Parameter	Min	Typ	Max	Notes
Efficiency Vo=0.85V Vo=0.92V	69% 71%	71% 73%	-	Vin=12 V, Io=10A
Switching Frequency	-	750KHz	-	
Output Voltage Trim Range (Wide Trim)	0.85V	-	0.92 V	
FIT <sup>2</sup>	-	30.57	-	Calculated Per Bell Core SR-332 (Vin=12V, Vo=0.92V, Io=10A, Ta = 25°C, FIT=10 <sup>9</sup> /MTBF)
Dimensions Inches (L × W × H) Millimeters (L × W × H)	0.65 x 0.49 x 0.32 16.51 x 12.45 x 8.13			
Weight	-	3.5 g	-	

**Note:** All specifications are typical at 25 °C unless otherwise stated.

### Control Specifications

Parameter	Min	Typ	Max	Notes
<b>Remote On/Off</b>				
Signal Low (Unit Off)	-0.3 V	-	0.4 V	Remote On/Off Pin is open, the unit is off.
Signal High (Unit On)	0.6 V	-	5.5 V	

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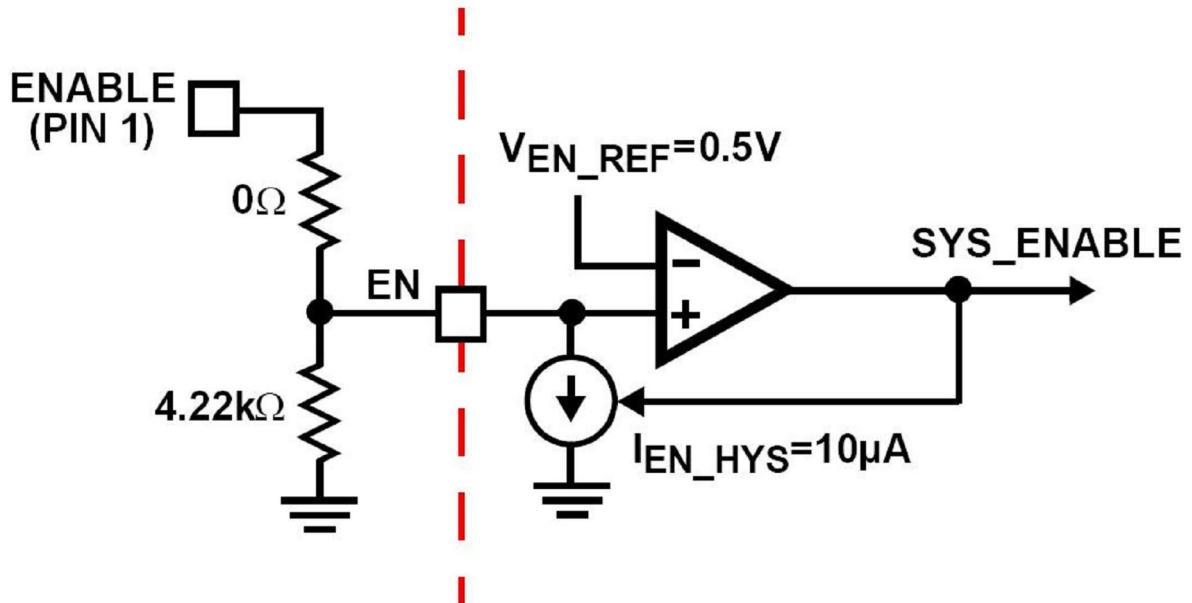


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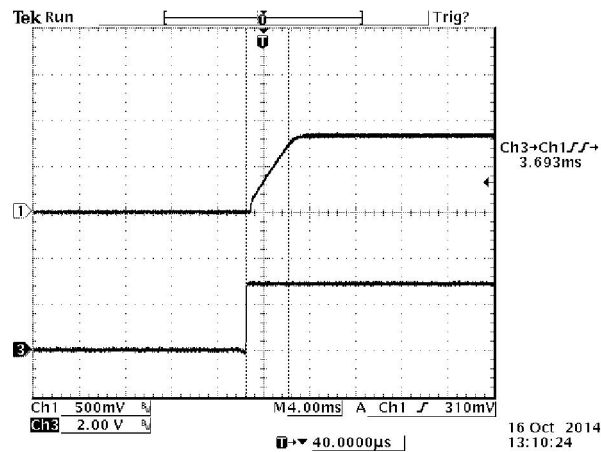
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## Control Specifications (Continued)

The following figure shows the internal circuitry about ENABLE.



The following figure shows the typical rise in the output voltage, following the rise in the ENBALE (Pin1). The waveform was measured with a 10A constant current load. The output voltage is produced within 10msec.



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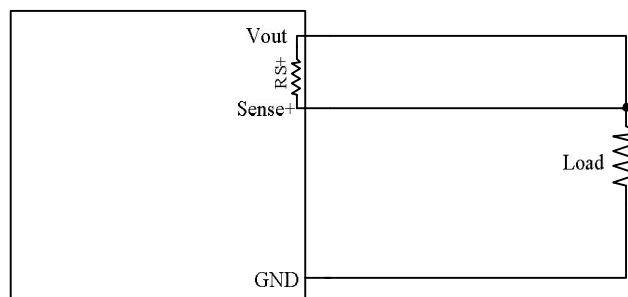
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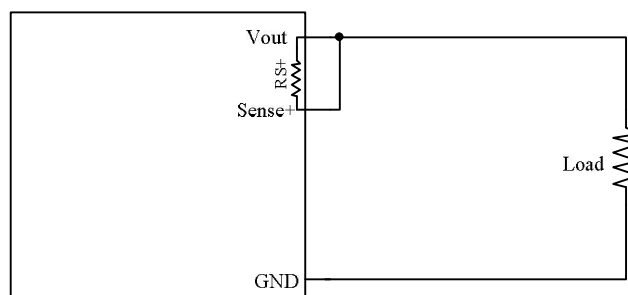
### Remote Sense

This module has remote sense compensation feature. It can minimize the effects of resistance between module's output and load in system layout and facilitates accurate voltage regulation at load terminals or other selected point.

1. The remote sense lines carries very little current and hence do not require a large cross-sectional area.
2. This module compensates for a maximum drop of 10% of the nominal output voltage.
3. If the unit is already trimmed up, the available remote sense compensation range should be correspondingly reduced. The total voltage increased by trim and remote sense should not exceed 10% of the nominal output voltage.
4. When using remote sense compensation, all the resistance, parasitic inductance and capacitance of the system are incorporated within the feedback loop of this module. It can make an effect on the module's compensation, affecting the stability and dynamic response. A 0.1uF ceramic capacitor can be connected at the point of load to de-couple noise on the sense wires.
5. Recommend the connection of remote sense compensation as below figure. There are a resistor RS+ (100 ohm) from Vout to Sense+ inside of this module.



6. If not using remote sense compensation, please connect sense directly to output at module's pin, that is, connect Sense+ to Vout, the shorter the better. See below figure.



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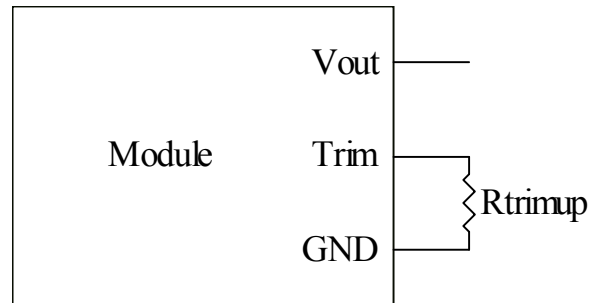
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### Output Trim Equations

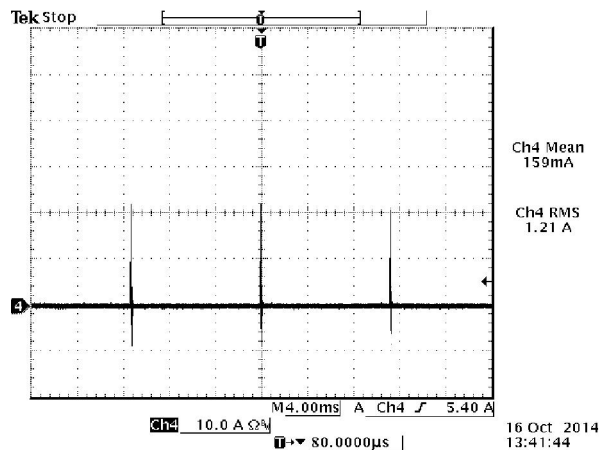
Equation for calculating the trim resistor given the desired output voltage ( $V_o$ ) is shown below. The  $R_{trim}$  resistor should be connected between the trim pin and GND pin.

$$R_{trim} = \frac{1.182}{V_o - 0.591} k\Omega$$



### Sourcing Over Current Protection

To provide protection in a fault output overload condition, the module is equipped with internal current-limiting circuitry and can endure current limiting for a few milli-seconds. If the over current condition persists beyond a few milliseconds, the module will shut down into hiccup mode and restart. The module operates normally when the output current goes into specified range. The typical average output current is about 0.2A during hiccup.



### Sinking Over Current Protection

A sinking over current condition will cause the low side MOSFET in the synchronous buck converter to be disabled for three clock cycles. This effectively makes the module a non-synchronous buck, meaning the module will not sink current. It will still switch and keep a regulated output voltage. After three clock cycles, the fault is cleared and normal operation is restored. If the over current condition is still present, the process will be repeated. The current limit threshold is the same for both sourcing and sinking conditions.

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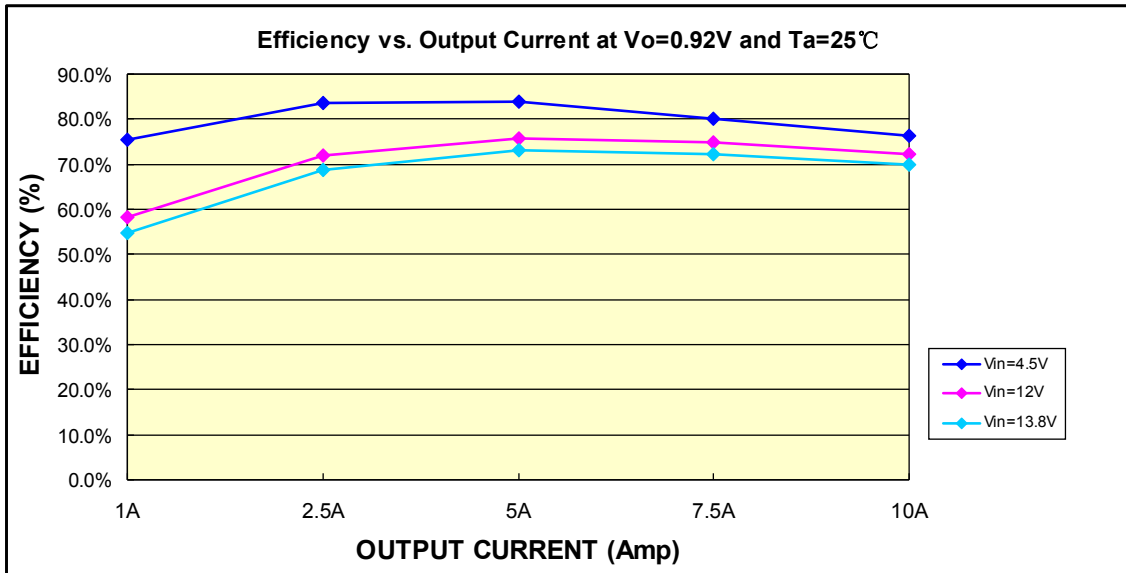
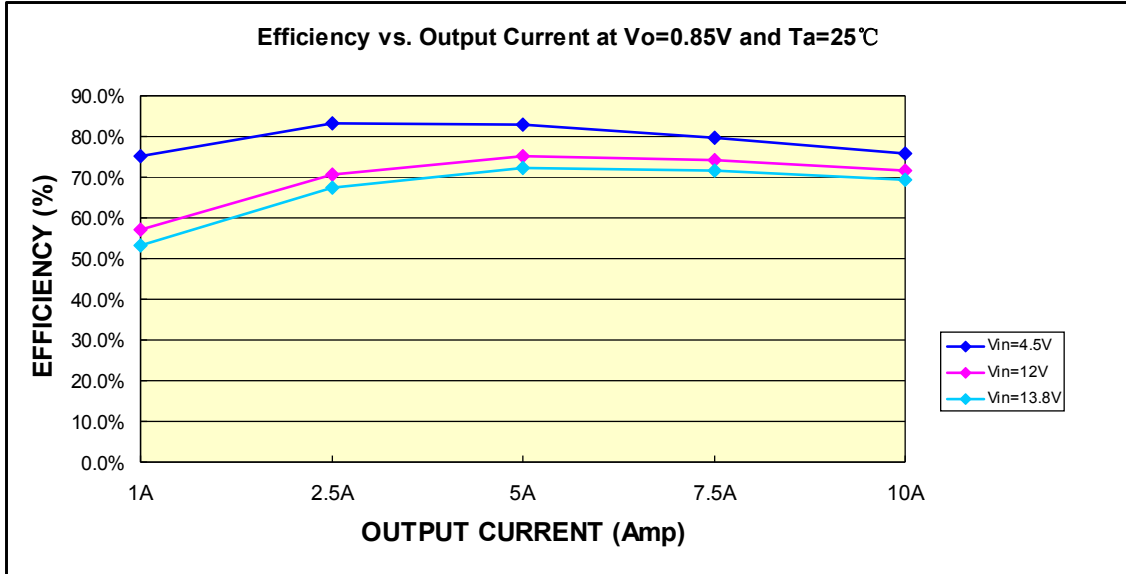
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Jan. 4, 2016

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## Efficiency Data



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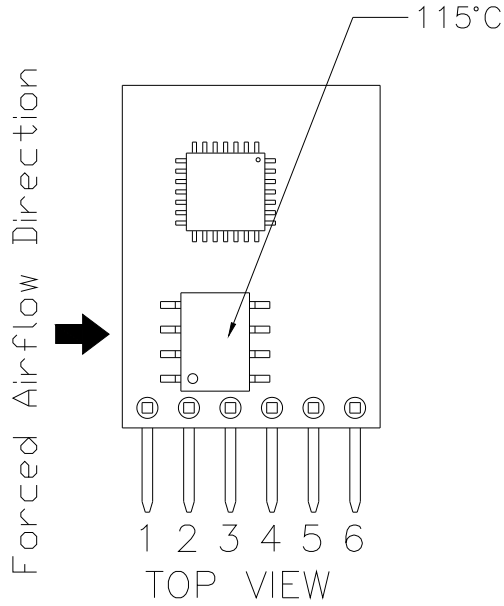
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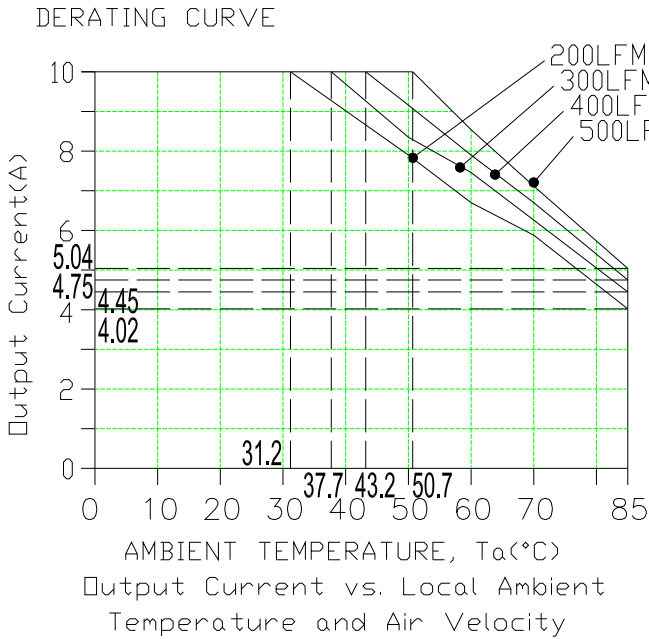
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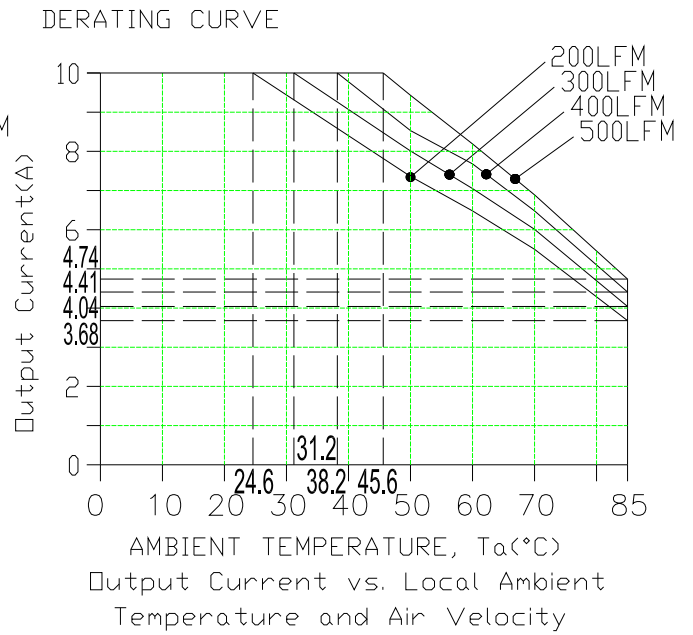
## Thermal Derating Curves



The thermal reference point  $T_{ref}$  is shown above. For reliable operation this temperature should not exceed 115°C. The output power of the module should not exceed the rated power for the module.



$V_{in}=12V, V_o=0.85V$



$V_{in}=12V, V_o=0.92V$

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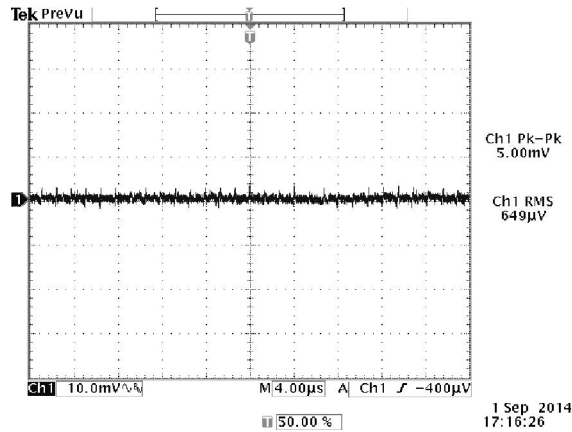
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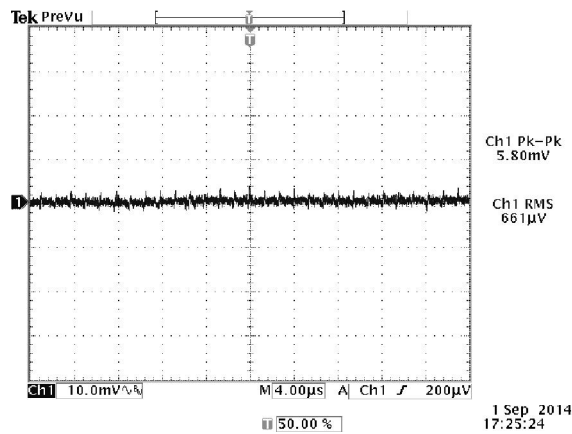
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## Ripple and Noise Waveform



Vin=12V, Vout=0.85V, Io=10A



Vin=12V, Vout=0.92V, Io=10A

**Note:** Ripple and noise at full load, 0-20MHz BW, with a 470uF polymer capacitor and 2\*100uF+1\*22uF ceramic capacitor at the output.

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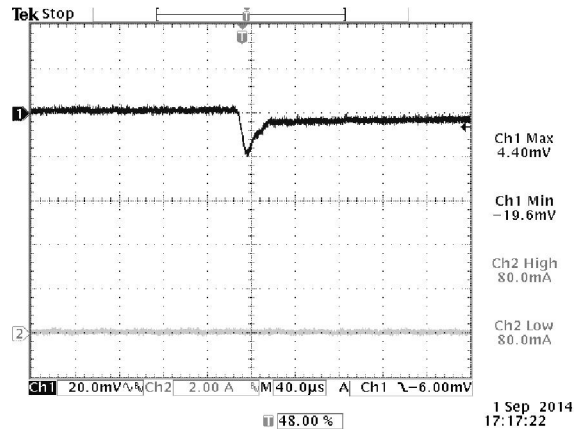
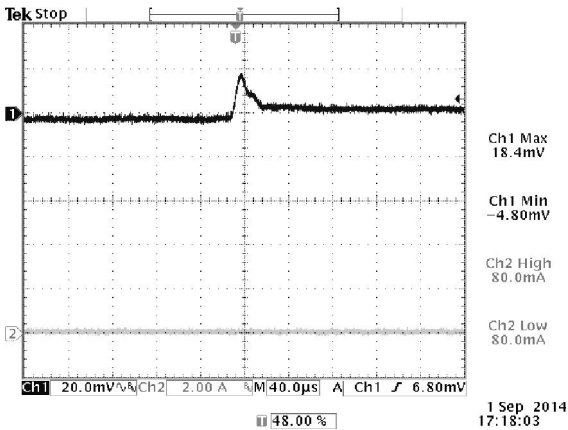
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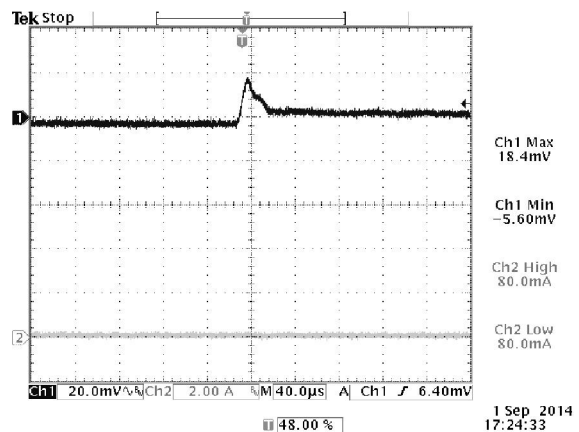
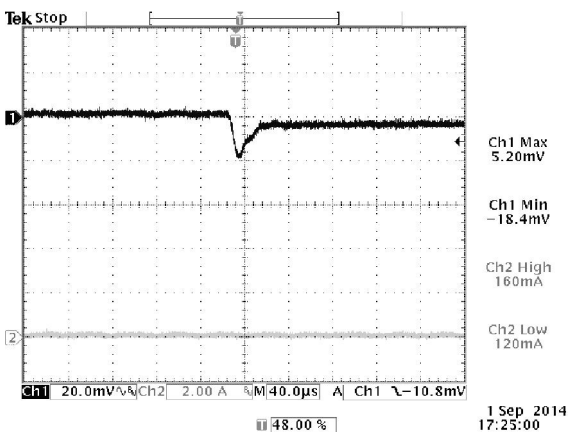
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## Transient Response Waveforms



6A-3.5A load step at Vin=12V, Vout=0.85V

3.5A-6A load step at Vin=12V, Vout=0.85V



6A-3.5A load step at Vin=12V, Vout=0.92V

3.5A-6A load step at Vin=12V, Vout=0.92V

**Note:** Transient response at  $di/dt=2.5$  A/ $\mu$ S, with a 470 $\mu$ F polymer capacitor and 2\*100 $\mu$ F+1\*22 $\mu$ F ceramic capacitor at the output.

## Soldering Guidelines

Bel Power recommends the soldering specifications below. Exceeding these specifications may cause damage to the product. Be cautious when there is high atmospheric humidity. It is recommended a mild pre-bake (100°C, for 30minuts). Your production environment may differ; therefore please thoroughly review these guidelines with your process engineers.

Pb free wave soldering:

Maximum preheat temperature	150°C
Maximum preheat temperature rate	3°C/Sec
Maximum pot temperature	260°C
Maximum solder dwell time	5Sec

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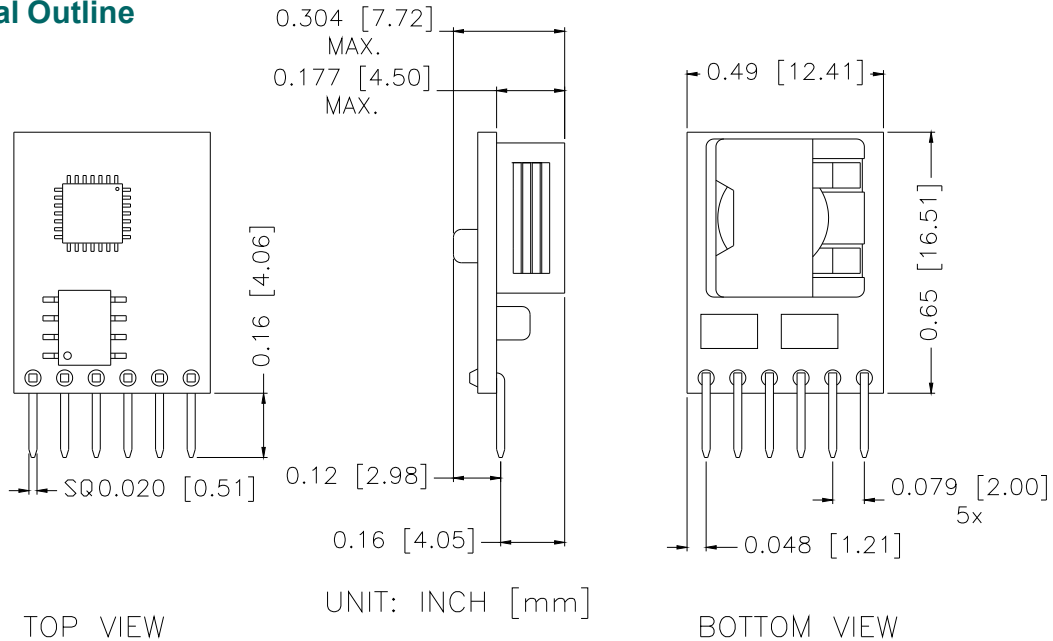
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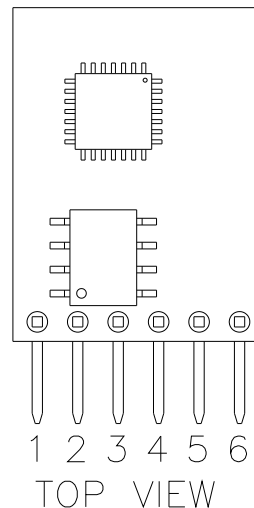
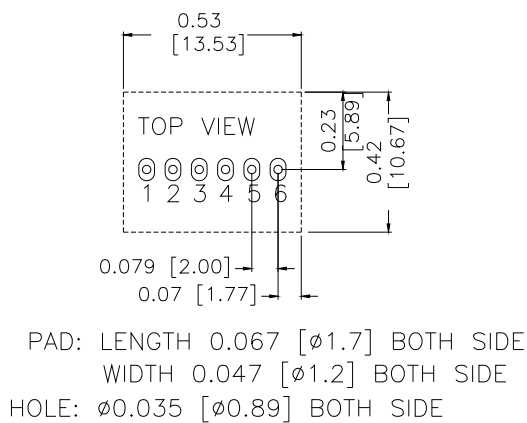
## Assembly Note

Modules were designed for vertical insertion into host board. Experiments should be performed to make sure that the units meet the intended tilt specification. A fixture may be needed to make the module stand upright in assembly

## Mechanical Outline



## RECOMMENDED PAD LAYOUT



## Pin Connections

Pin	Function
1	ENABLE
2	Vin
3	GND
4	Vout
5	Trim
6	Sense+

HOLE SIZE:  $\Phi 0.035 \pm 0.003$  [0.89 ± 0.08] BOTH SIDE

PAD SIZE: LENGTH 0.067 [ø1.7] BOTH SIDE

WIDTH 0.047 [ø1.2] BOTH SIDE

**Note: This module is recommended and compatible with Pb-Free Wave Soldering and must be soldered using a peak solder temperature of no more than 260°C for less than 5 seconds.**

### Note:

1) All Pins: Material – Copper Alloy;

Finish – 3 micro inches minimum Gold over 50 micro inches minimum Nickel plate.

2) Undimensioned components are shown for visual reference only.

3) All dimensions in inches (mm); Tolerances: x.xx +/-0.02 in[0.5mm], x.xxx +/-0.010 in[0.25mm].

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### Revision History

Date	Revision	Changes Detail	Approval
2014-9-16	A	First release	XF JIANG
2014-12-1	B	Update ambient temperature, efficiency data.	XF JIANG
2015-1-29	C	Update line regulation, load regulation, temperature regulation, ripple and noise, transient response, output capacitance, efficiency, thermal derating curve, mechanical outline.	XF JIANG
2016-01-04	D	Add Assembly Note. Update mechanical drawing.	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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