

## NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.8 Vdc Input, 0.591 Vdc - 5.1 Vdc/30 A Output



Mar. 30, 2010

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

**VRP1-30E1A0**

**RoHS Compliant**

**Rev.F**

### Features

- Non-Isolated
- High Efficiency
- Fixed Frequency
- High Power Density
- Wide Input
- Low Cost
- Class 1, Category 2, Non-Isolated DC/DC Converter (refer to IPC-9592)
- Under Voltage Lockout
- OCP/SCP
- Remote On/Off
- Remote Sense
- Wide Trim
- Power Good Signal



### Applications

- Networking
- Computers and peripherals
- Telecommunications

### Description

The Bel VRP1-30E1A0 is part of the non-isolated dc/dc converter Power Module series. The modules use a SIP package. These converters are available in a range of output voltages from 0.591 Vdc to 5.1 Vdc over a wide range of input voltage ( $V_{in} = 4.5 - 13.8$  Vdc). The efficiency is typically 94% @ 12Vin and 5.0Vout at full load.

### Part Selection

Output Voltage	Input Voltage	Max. Output Current	Max. Output Power	Typical Efficiency	Model Number Active High
0.591 Vdc - 5.1Vdc	4.5 Vdc - 13.8 Vdc	30 A	150 W	94%	VRP1-30E1A0

**Notes:** Add "G" suffix at the end of the model number to indicate Tray Packaging.

### Part Number Explanation

$\frac{V}{1} \frac{R}{2} \frac{P1}{3} - \frac{30}{4} \frac{E}{5} \frac{1A}{6} \frac{0}{7}$

1---Vertical mount

2---RoHS 6, change "R" to "7" means RoHS 5

3---Series name, SIP

4---Series code, 30A output

5--- Wide input range (4.5-13.8V)

6---Wide output range (0.591-5.1V)

7---Suffix

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### Absolute Maximum Ratings

Parameter	Min	Typ	Max	Unit	Notes
Continuous non-operating Input Voltage	-0.3	-	15	V	
Remote On/Off	-0.3	-	5.5	V	
Ambient Temperature	0	-	70	°C	
Storage Temperature	-40	-	125	°C	

**Note:** Ratings used beyond the maximum ratings may cause a reliability degradation of the converter or may permanently damage the device.

### Input Specifications

Parameter	Min	Typ	Max	Unit	Notes
Operating Input Voltage					
Vo<3.45V	4.5	12	13.8	V	
Vo>=3.45V	1.3*Vo	12	13.8	V	
Input Current (full load)	-	-	30	A	
Input Current (no load)	-	150	300	mA	
Remote Off Input Current	-	20	-	mA	
Input Reflected Ripple Current (rms)	-	20	40	mA	With simulated source impedance of 1uH, 5Hz to 20MHz. Use a 1000uF/16V electrolytic capacitor with ESR=1 ohm max, at 200KHz@25°C.
Input Reflected Ripple Current (pk-pk)	-	50	100	mA	
I <sup>2</sup> t Inrush Current Transient	-	-	1	A <sup>2</sup> s	
Turn-on Voltage Threshold	-	4.4	-	V	
Turn-off Voltage Threshold	-	3.9	-	V	

**CAUTION:** This converter is not internally fused. An input line fuse must be used in application.

Recommend a fast-acting fuse with maximum rating of 45A on system board. Refer to the fuse manufacture's datasheet for further information.

- Notes:**
1. This converter has internal C(60uF) filter.
  2. A 30.1K resistor is connected from Enable to Vin.
  3. All specifications are typical at 25 °C unless otherwise stated.

### Output Specifications

Parameter	Min	Typ	Max	Unit	Notes
Output Voltage Set Point	-1.5	-	1.5	%Vo,set	Vin=12V, Iout=half load
Load regulation	-	-	1	%Vo,set	
Line Regulation	-	-	0.5	%Vo,set	
Regulation Over Temperature (0deg.C-70deg.C)	-	-	1	%Vo,set	
Ripple and Noise (pk-pk)	-	50	80	mV	0-20MHz BW, 10uF tantalum cap and 1uF ceramic on output.
Ripple and Noise (rms)	-	20	40	mV	
Ripple and Noise (pk-pk) under worst case	-	-	100	mV	over all operating input voltage, load and ambient temperature condition

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### Output Specifications (continued)

Parameter	Min	Typ	Max	Unit	Notes		
Output Current Range	0	-	30	A			
Output DC Current Limit	-	45	-	A			
Short Circuit Surge Transient	-	1	3	A <sup>2</sup> s			
Rise Time	-	3.3	-	mS			
Turn on Time	-	4	10	mS			
Overshoot at Turn on	-	0	3	%			
Output Capacitance	0	-	1000	uF	unit can work at Vo=1.1V with 2700 uF output Cap		
Transient Response							
△V50%~75% of Max Load	Overshoot	Vo= 1.1V	-	50	70	mV	di/dt=2.5A/us, Vin=12.0Vdc, Ta=25°C, 10uF tantalum cap and 1uF ceramic on output.
	Settling Time		-	30	50	uS	
△V75%~50% of Max Load	Overshoot		-	50	70	mV	
	Settling Time		-	30	50	uS	
△V50%~75% of Max Load	Overshoot	Vo= 2.5V	-	120	150	mV	
	Settling Time		-	30	50	uS	
△V75%~50% of Max Load	Overshoot		-	120	150	mV	
	Settling Time		-	30	50	uS	
△V50%~75% of Max Load	Overshoot	Vo= 5.1V	-	220	300	mV	
	Settling Time		-	30	50	uS	
△V75%~50% of Max Load	Overshoot		-	220	300	mV	
	Settling Time		-	30	50	uS	

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

### General Specifications

Parameter	Min	Typ	Max	Unit	Notes
Efficiency Vo=0.591V Vo=1.1V Vo=2.5V Vo=3.3V Vo=5.1V	- - - - -	72 83 91 92 94	- - - - -	% % % % %	Vin=12.0V, full load
Switching Frequency	-	500	-	kHz	
Output Voltage Trim Range (Wide Trim)	0.591	-	5.1	V	
Remote Sense Compensation	-	-	0.2	V	
Weight	-	10.7	-	g	
FIT	183			-	Calculated Per Bell Core SR-332 (Io=80%load, Ta = 25 °C, FIT=10 <sup>9</sup> /MTBF)
Dimensions Inches (L × W × H) Millimeters (L × W × H)	1.20 x 0.61 x 0.71 30.48 x 15.49 x 18.04			-	

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

## NON-ISOLATED DC/DC CONVERTERS

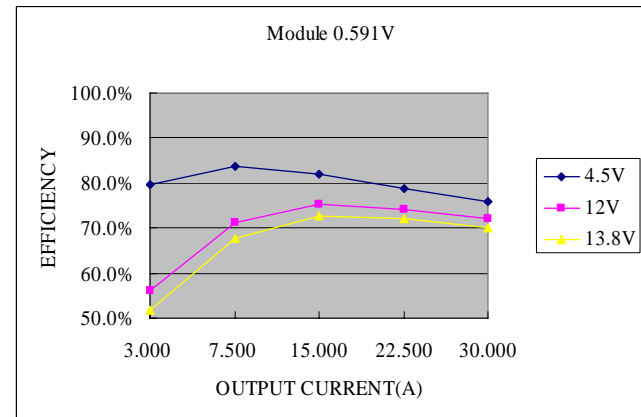
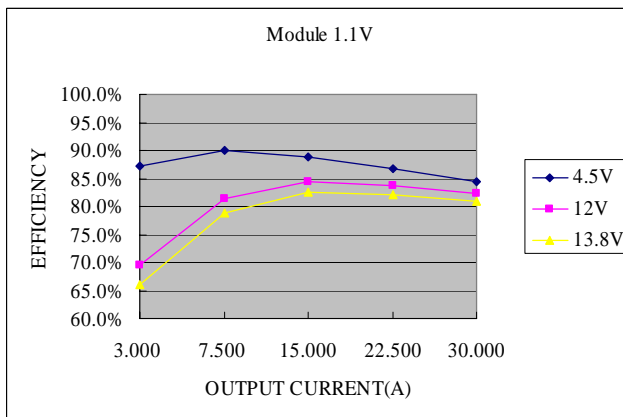
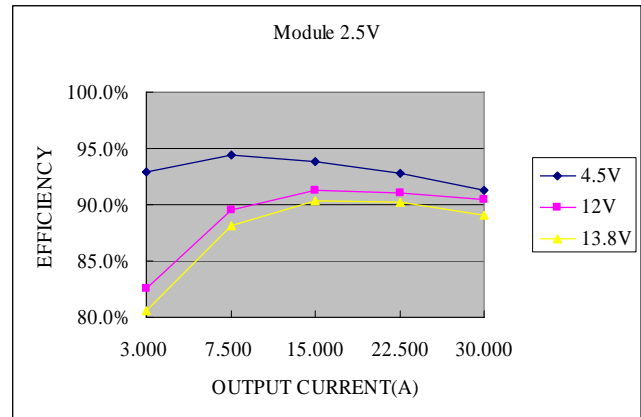
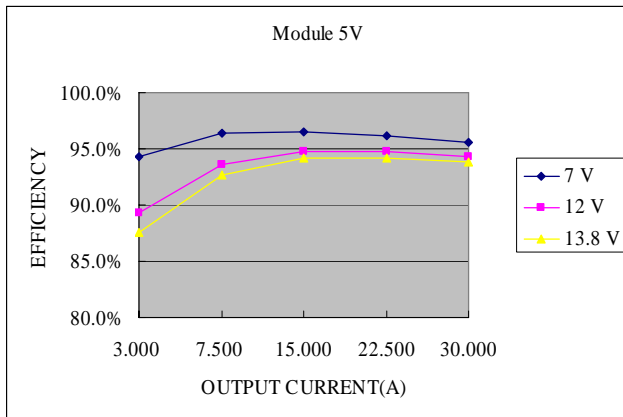
4.5 Vdc - 13.8 Vdc Input, 0.591 Vdc - 5.1 Vdc/30 A Output



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### Efficiency Data



## NON-ISOLATED DC/DC CONVERTERS

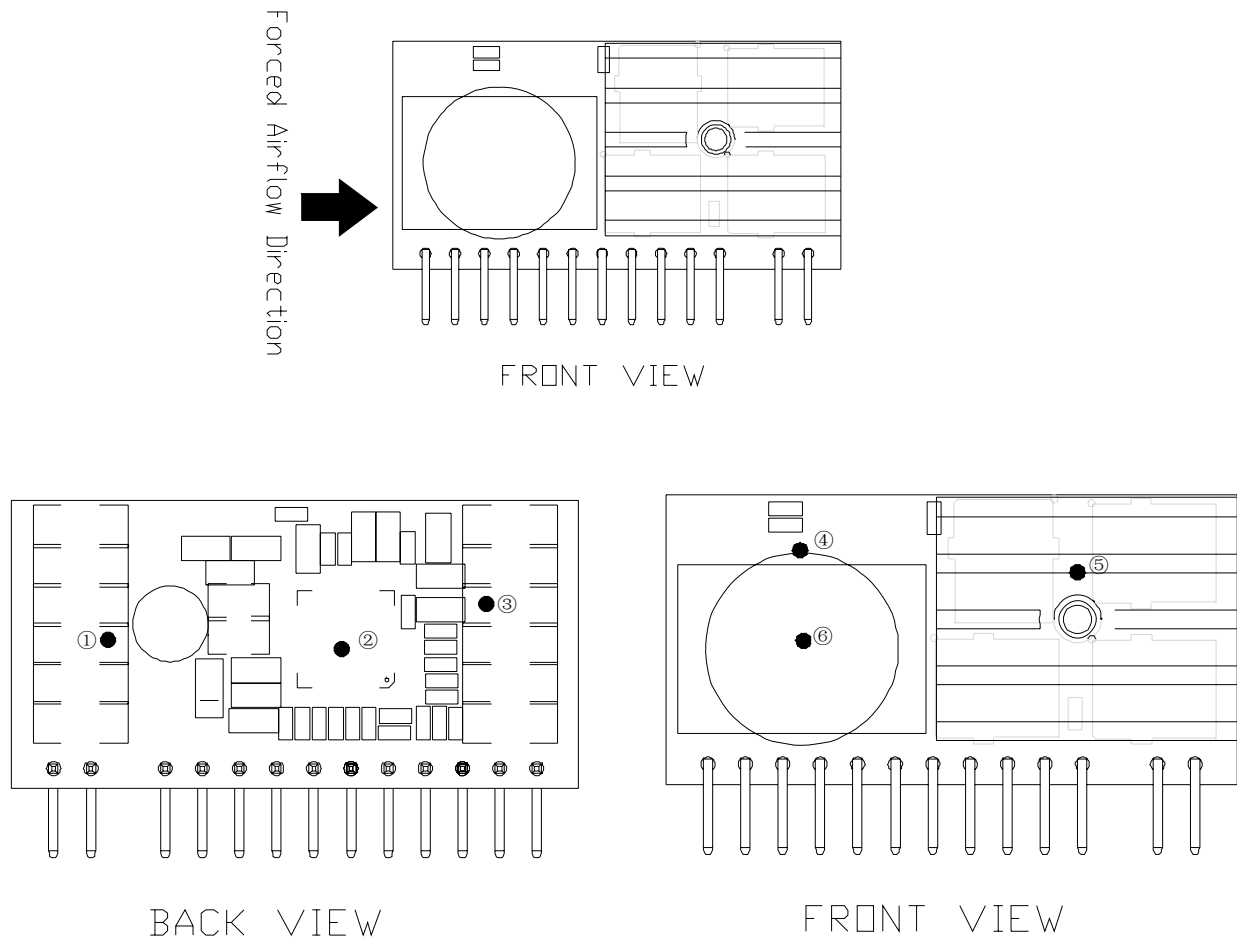
4.5 Vdc - 13.8 Vdc Input, 0.591 Vdc - 5.1 Vdc/30 A Output



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### Thermal Derating Curves



The thermal reference point is shown above. For reliable operation this temperature should not exceed 110°C. The output power of the module should not exceed the rated power for the module.

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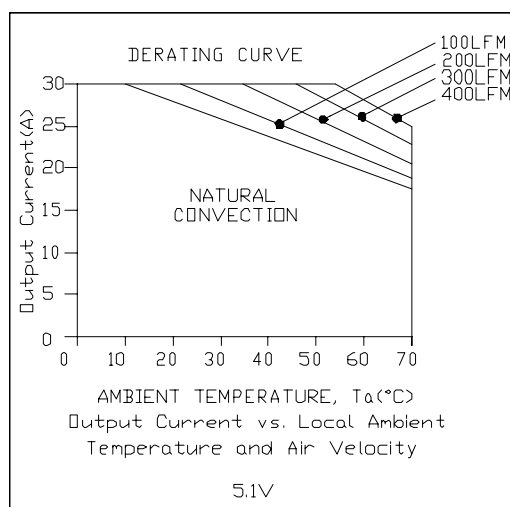
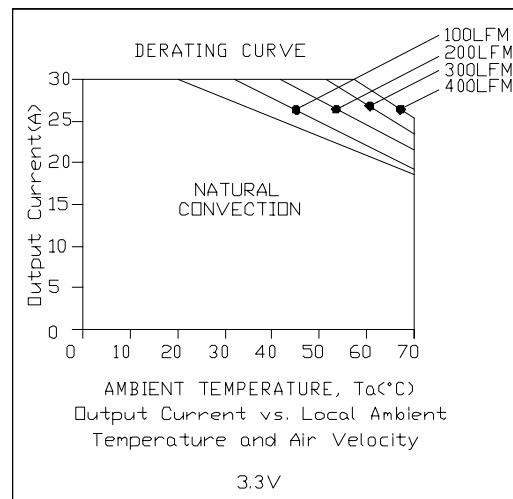
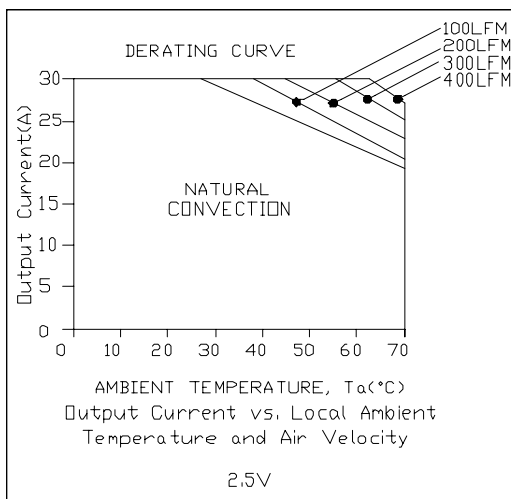
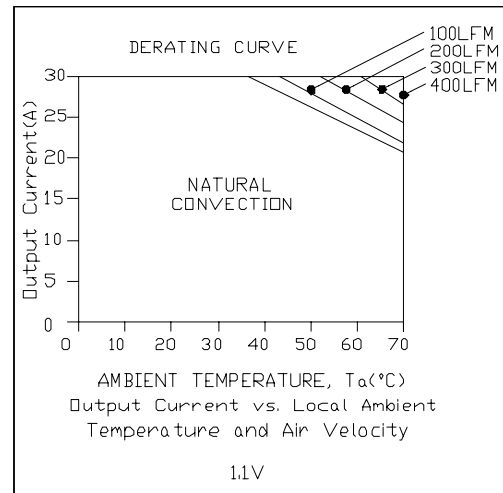
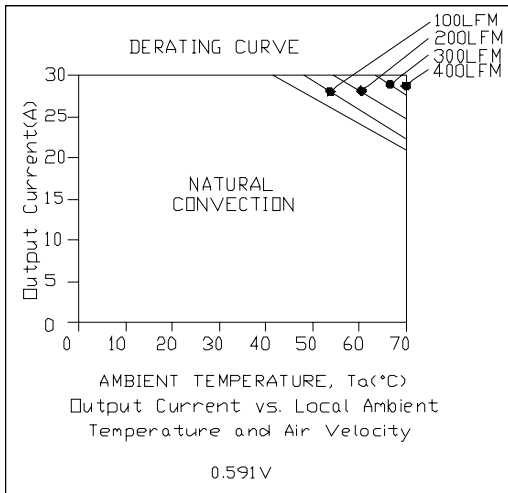
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### Thermal Derating Curves (continued)



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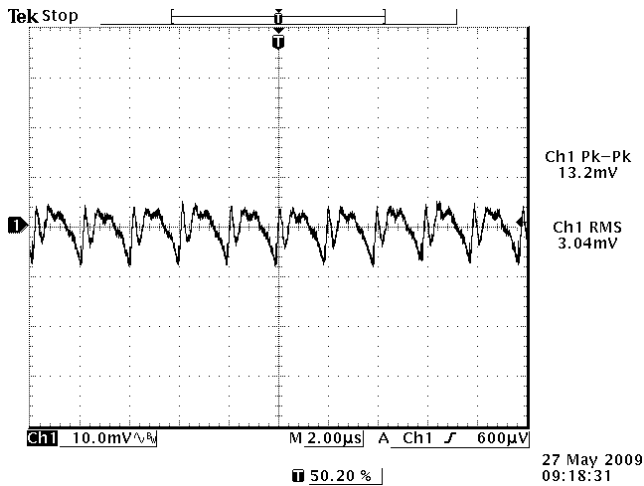
4.5 Vdc - 13.8 Vdc Input, 0.591 Vdc - 5.1 Vdc/30 A Output



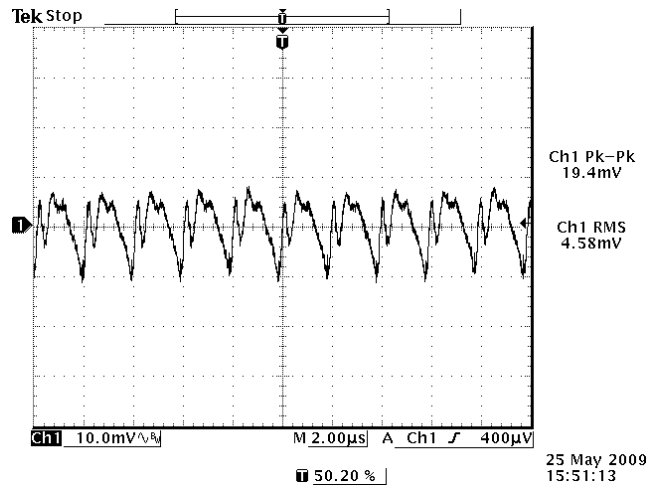
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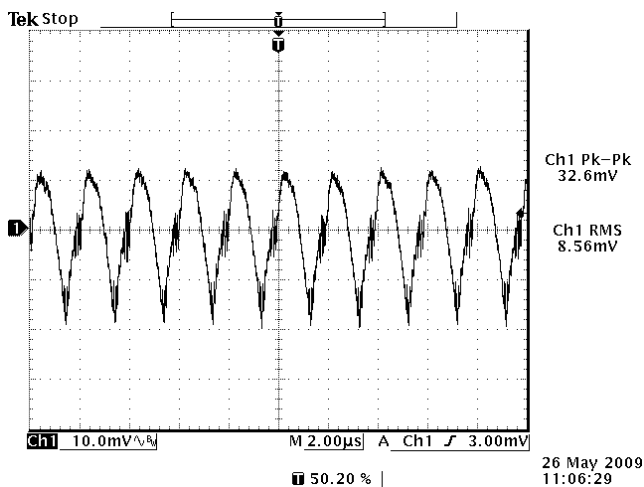
### Ripple and Noise Waveforms



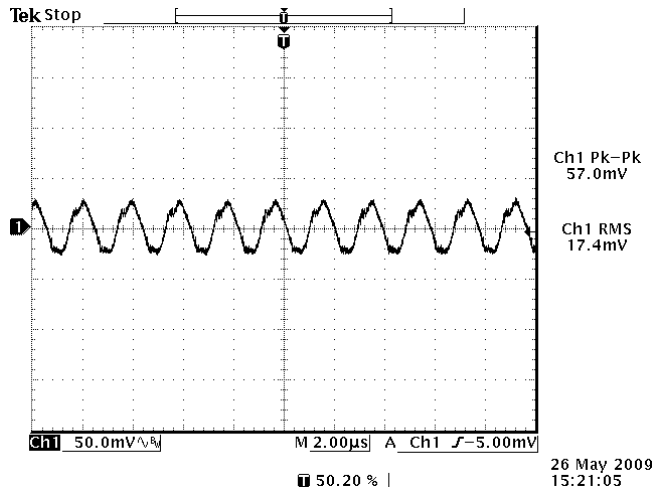
12Vdc Input 0.591Vdc output



12Vdc Input 1.1Vdc output



12Vdc Input 2.5Vdc output



12Vdc Input 5.0Vdc output

**Note:** Ripple and noise at full load, 0-20MHz BW, with a 10uF tantalum cap and 1uF ceramic on output, and Ta=25 deg C.

# NON-ISOLATED DC/DC CONVERTERS

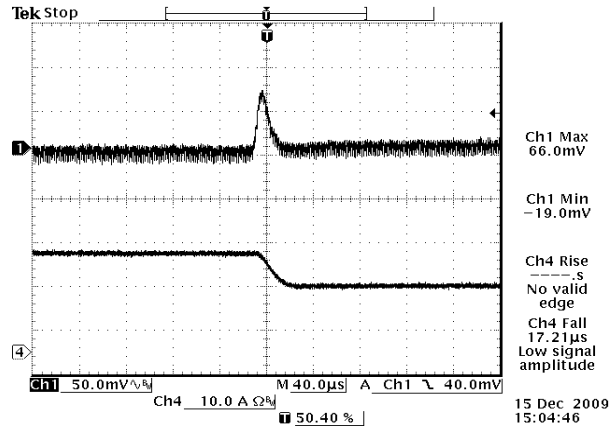
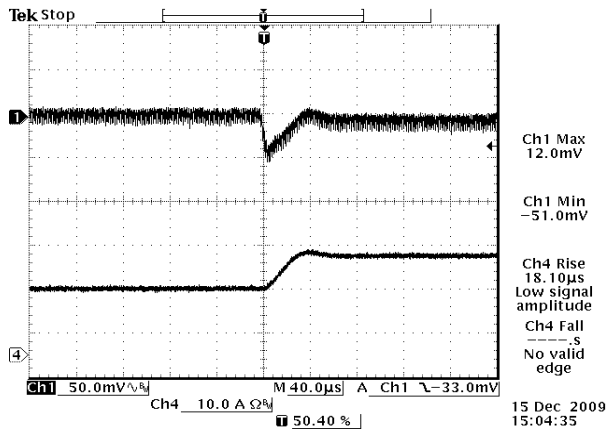
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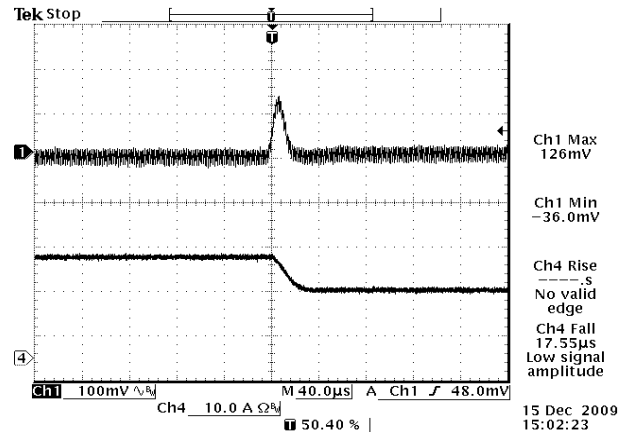
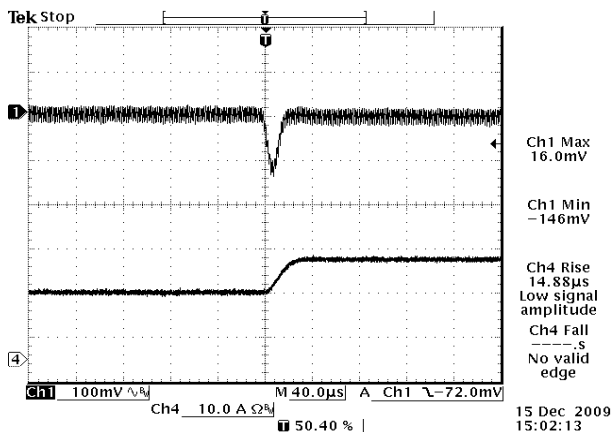
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## Transient Response Waveforms



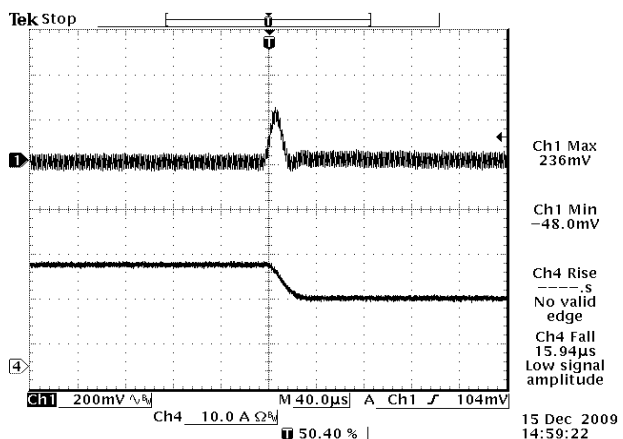
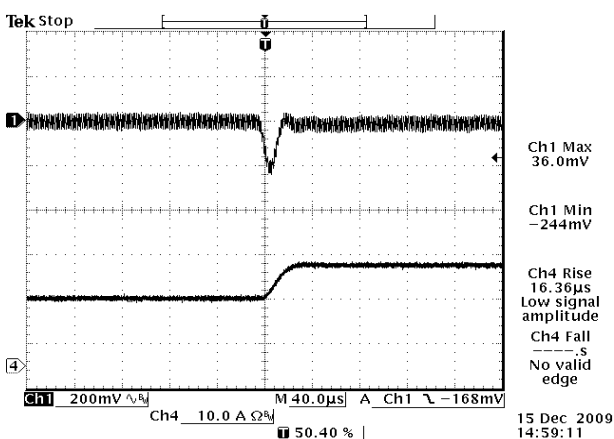
Vout=1.1 V 50%-75% Load Transients

Vout=1.1 V 75%-50% Load Transients



Vout=2.5 V 50%-75% Load Transients

Vout=2.5 V 75%-50% Load Transients



Vout=5.0 V 50%-75% Load Transients

Vout=5.0 V 75%-50% Load Transients

**Note:** Ripple and noise at full load, 0-20MHz BW, with a 10uF tantalum cap and a 1uF ceramic cap, normal input and Ta=25deg C.



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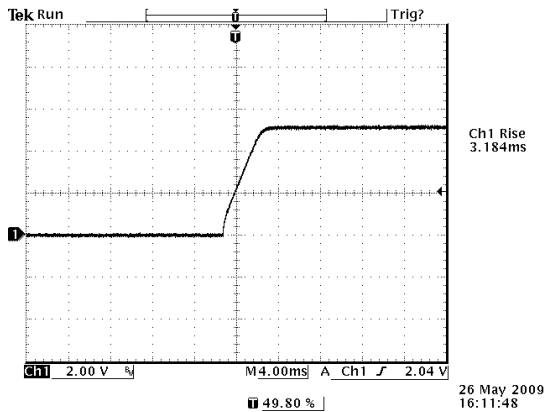


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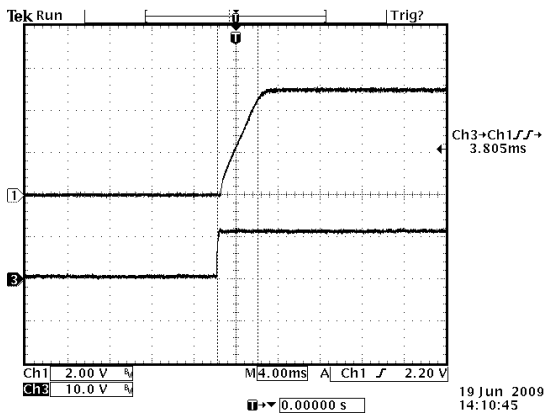
### Startup & Shutdown

#### Rise time

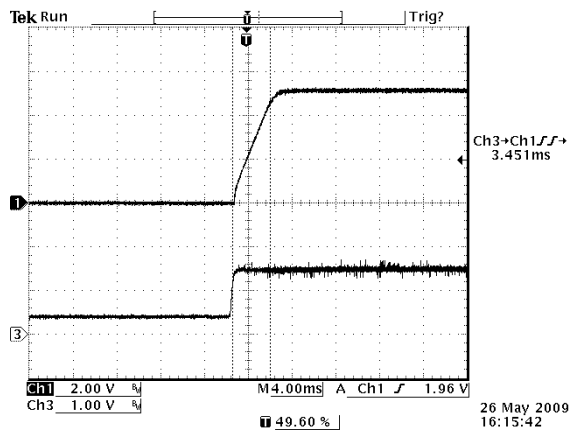


Test Condition:  
Vin=12V, Vo=5V,  
full load with 1000uF cap

#### Startup time

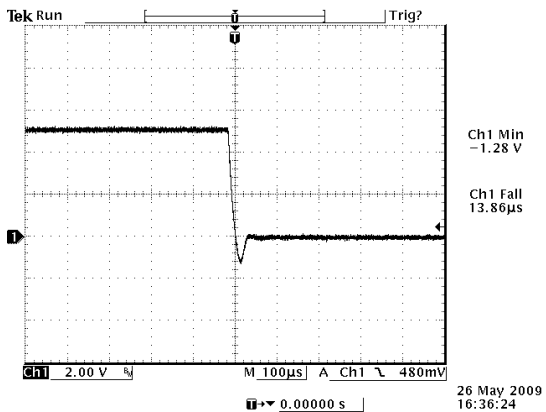


Startup from Vin  
CH1:Vo  
CH3:Vin  
Vin=12V, Vo=5V,full load with 1000uF cap



Startup from Remote ON/OFF  
CH1:Vo  
CH3:Remote ON/OFF  
Vin=12V, Vo=5V,full load with 1000uF cap

#### Shutdown



Test Condition:  
Vin=12V, Vo=5V, full load

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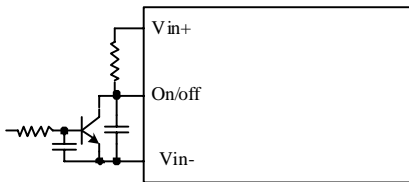
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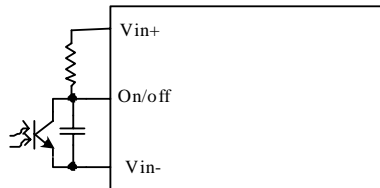
### Remote On/Off

Parameter		Min	Typ	Max	Unit	Notes
Signal Low (Unit Off)	Active High	-0.3	-	0.4	V	Remote On/Off pin is open, the module is off. If a 30.1k resistor is connected from Enable to Vin and Remote On/Off pin is open, the module is on
Signal High (Unit On)		2	-	5.5	V	
Current Sink		0	-	1	mA	

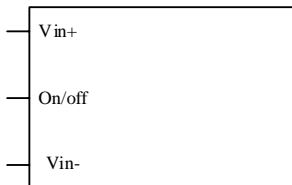
### Recommended remote on/off circuit for active high



Control with open collector/drain circuit



Control with photocoupler circuit



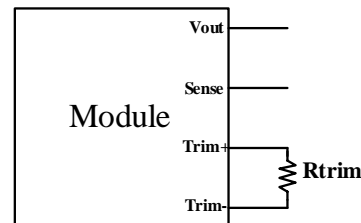
Permanently off

### Output Trim Equations

Equations for calculating the trim resistor are shown below.

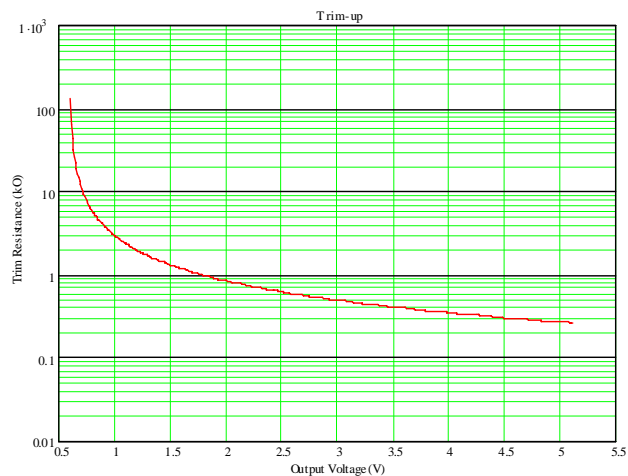
Minimum trim down voltage is 0.591V

Maximum trim up voltage is 5.1V.



$$R_{trim} = \left[ \frac{1.182}{V_o - 0.591} \right]$$

$V_o$  is the desired output voltage.  
 $R_{trim}$  is the required resistance between Trim+ and Trim-



## NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.8 Vdc Input, 0.591 Vdc - 5.1 Vdc/30 A Output



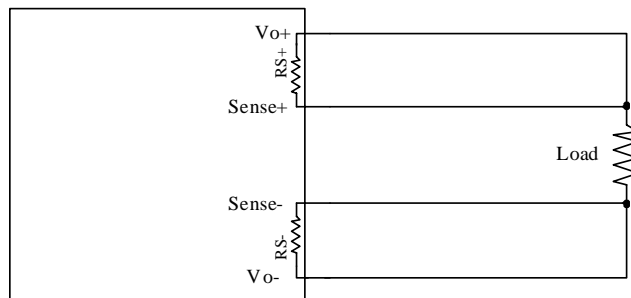
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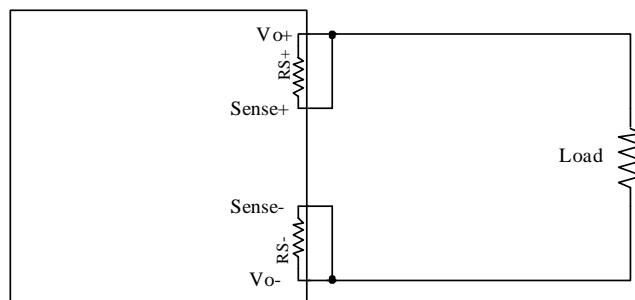
### Remote Sense

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+ (10 ohm) from Vo+ to Sense+ and a resistor RS- (10 ohm) from Vo- 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 Vo+ and sense- to Vo- at module's pin, the shorter the better. See below figure.



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4.5 Vdc - 13.8 Vdc Input, 0.591 Vdc - 5.1 Vdc/30 A Output

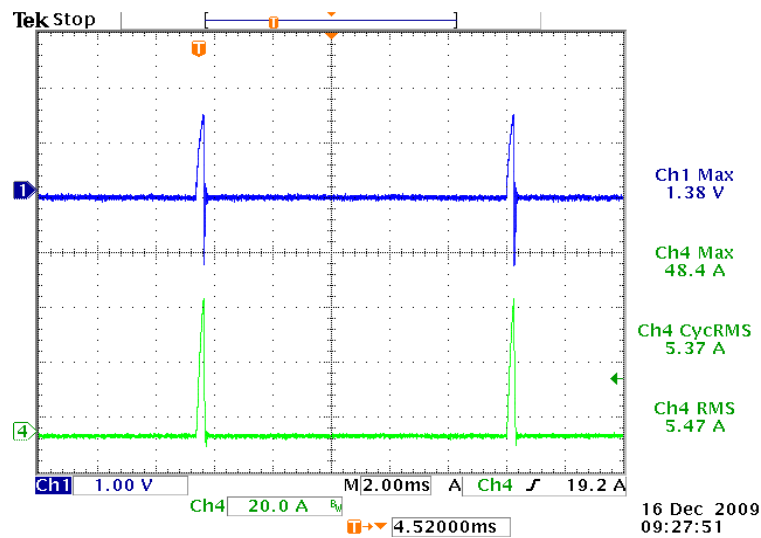


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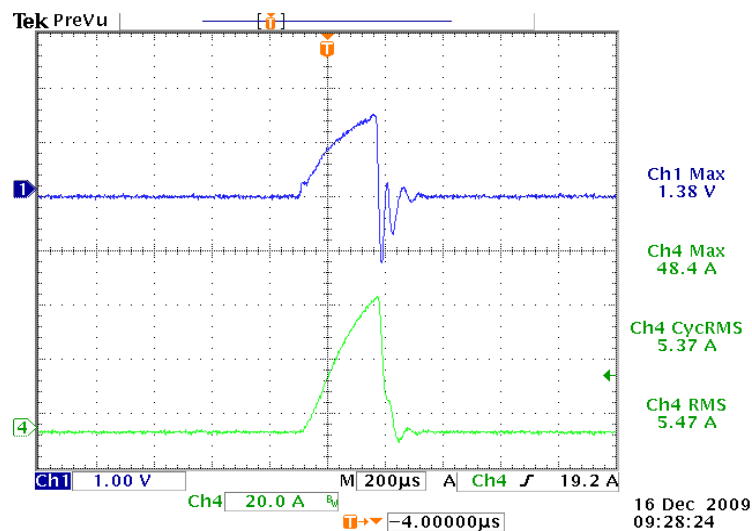
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### Over Current Protection

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 once every 10mS. The module operates normally when the output current goes into specified range. The typical average output current is 5A during hiccup.



Vin=12V, Vout=5V, Rout=0.06Ω, Ta=25°C, with 10uF tantalum cap and 1uF ceramic on output



Expansion of on time portion of above figure

## NON-ISOLATED DC/DC CONVERTERS

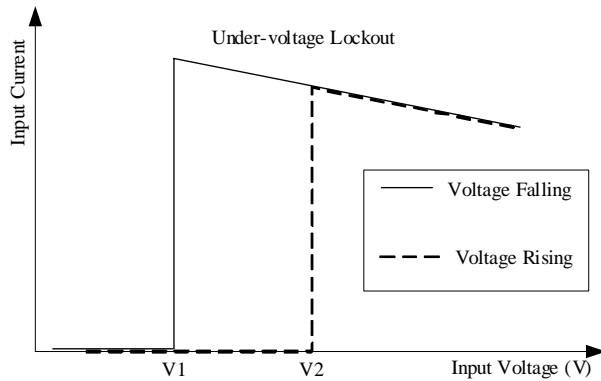
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### Input Under-voltage Lockout



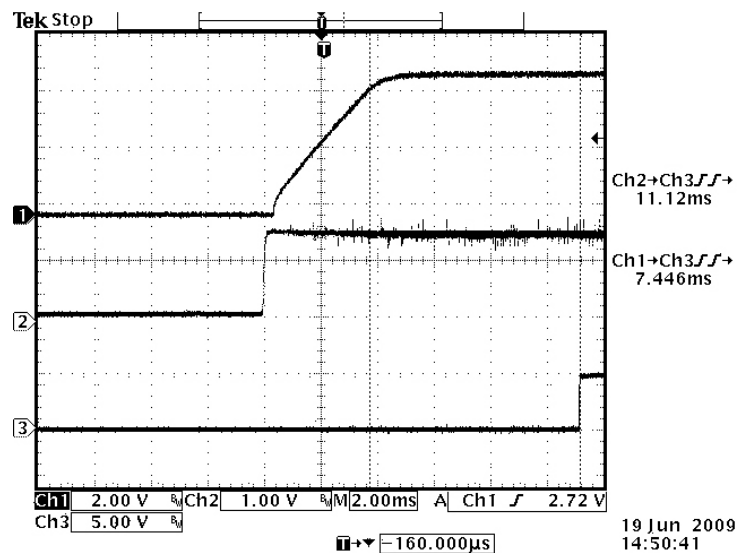
V1=3.9V

V2=4.4V

A 30.1k resistor is connected from Enable to Vin

### Power Good

1. This module has a power good indicator output. Power good pin used positive logic and is open collector.
2. Power good pin can sink 10mA.
3. The maximum voltage pulled up externally on Power Good pin should not exceed 6V.
4. When a successful soft-start is completed, the power good pin will be pulled high after 7ms delay.



CH1: Output Voltage CH3: PG CH2: Remote ON/OFF  
Typical Start-up Using Remote ON/OFF (Vin=12V, Vout=5V, Io=30A)

# NON-ISOLATED DC/DC CONVERTERS

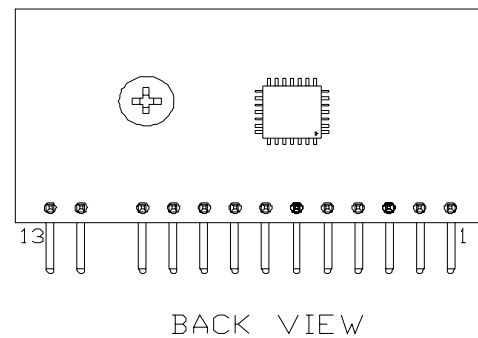
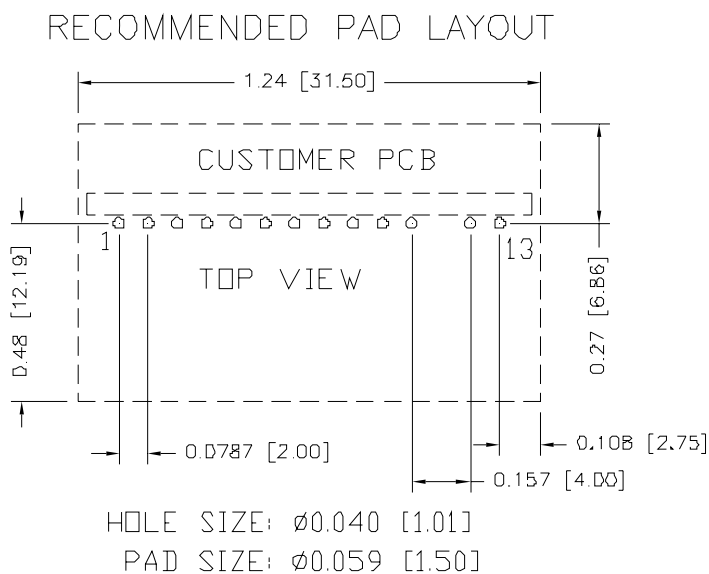
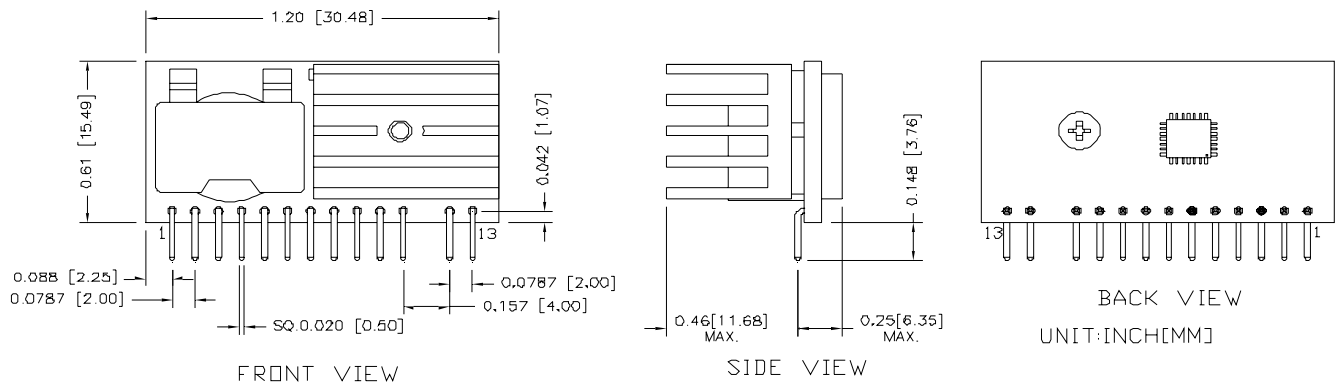
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## Mechanical Outline



Pin	Function	Pin	Function
1	Vout	8	Trim+
2	Vout	9	PGRGD
3	Vout	10	Vsense-
4	GND	11	Vsense+
5	GND	12	Vin
6	Enable	13	Vin
7	Trim-		

**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. (x.x +/-0.5mm) x.xxx +/-0.010 in. (x.xx +/-0.25mm).

## NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.8 Vdc Input, 0.591 Vdc - 5.1 Vdc/30 A



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### Revision History

Date	Revision	Changes Detail	Approval
2009-3-30	A	First release	HL LU
2009-4-28	B	1. Updated mechanical drawing; 2. Correct error in part number explanation; 3. Add NR, TR, PG and startup time waveforms; 4. Remove some "TBD" information.	HL LU
2009-5-5	C	1. Update OCP and Remote sense	HL LU
2009-6-30	D	1. Input spec: Update no load input current, ripple and noise, turn on/off voltage, add note 1&2; 2. Output spec: Update ripple and noise, turn on time, transient response, add note of output capacitance; 3. General spec: Update efficiency data, add FIT and weight; 4. Add Efficiency curves, TD curves, NR, TR, Startup & shutdown, trim curve, OCP, Update PG and UVLO	HL LU
2010-3-23	E	1. Absolute Maximum Ratings: Add remote on/off voltage; 2. Input spec: Update note for reflected ripple current and input C filter; 3. Output spec: Add ripple and noise under worst case and rise time; update current limit, overshoot at turn on and transient response; 4. Update efficiency data and efficiency curves, transient response waveforms, OCP figure; 5. Update MD(top and bottom view).	Jack Fan
2010-3-30	F	1. Remove "Preliminary".	Jack Fan

### RoHS Compliance

Complies with the European Directive 2002/95/EC, calling for the elimination of lead and other hazardous substances from electronic products.



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