

NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output



Aug. 13, 2010

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

VRP1-30E2Ax RoHS Compliant PRELIMINARY Rev.C

Features

- Non-Isolated
- High Efficiency
- Fixed Frequency
- High Power Density
- Wide Input
- Low Cost
- Remote On/Off
- Active High
- Class 1, Category 2, Non-Isolated DC/DC Converter (refer to IPC-9592)
- Under Voltage Protection
- OCP/SCP
- Output Over-Voltage Shutdown
- Remote Sense
- 8 Bit VID Trim
- Dynamic VID Technology
- Power Good Signal

Applications

- Networking
- Computers and peripherals
- Telecommunications

Description

The Bel VRP1-30E2Ax is part of the non-isolated dc/dc converter Power Module series. The module uses a SIP package. The modules use a SIP package. These converters are available output voltage trim via the 8 bit VID range from 0.5 Vdc to 1.6 Vdc over a wide range of input voltage (V_{in} = 4.5 - 13.2 Vdc). The modules supports dynamic VID across the entire usable VID table (0.5 - 1.6 Vdc). The efficiency is typically 82% @ 12V_{in} and 1.2V_{out} at full load.

Part Selection

Output Voltage	Input Voltage	Max. Output Current	Max. Output Power	Typical Efficiency	Model Number No droop	Model Number With droop
0.5 Vdc - 1.6 Vdc	4.5 Vdc - 13.2 Vdc	30 A	48 W	82%	VRP1-30E2AD	VRP1-30E2AP

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

Part Number Explanation

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

- 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 (4.5-13.2V)
- 6---Wide trim
- 7---Suffix

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Absolute Maximum Ratings

Parameter	Min	Typ	Max	Unit	Notes
Continuous non-operating Input Voltage	-0.3	-	15	V	
Output Enable Terminal Voltage	-0.3	-	15	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	4.5	12	13.2	V	
Input Current (full load)	-	-	12	A	
Input Current (no load)	-	200	400	mA	
Remote Off Input Current	-	20	-	mA	
Input Reflected Ripple Current (rms)	-	30	50	mA	With simulated source impedance of 10uH, 5Hz to 20MHz. Use a 100uF/100V electrolytic capacitor with ESR=1 ohm max, at 200KHz@25°C.
Input Reflected Ripple Current (pk-pk)	-	75	120	mA	
I ² t Inrush Current Transient	-	-	1	A ² s	
Turn-on Voltage Threshold	-	4.4	-	V	
Turn-off Voltage Threshold	-	4.1	-	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 15A on system board. Refer to the fuse manufacture's datasheet for further information.

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

Output Specifications

Parameter	Min	Typ	Max	Unit	Notes
Output Voltage Set Point	1.211	1.22	1.229	V	VID=01000010, I _o =0A
Load Regulation	-	±8	±12	mV	VRP1-30E2AD
Load Line	-	6	-	mOhm	VRP1-30E2AP
Line Regulation	-	±5	±10	mV	
Regulation Over Temperature (0deg.C-70deg.C)	-	±5	±10	mV	
Ripple and Noise (pk-pk)	-	40	60	mV	0-20MHz BW, 4872uF cap on output.
Ripple and Noise (rms)	-	25	35	mV	
Ripple and Noise (pk-pk) under worst case	-	-	80	mV	over all operating input voltage, load and temperature conditions.
Output Current Range	0	-	30	A	
Output DC Current Limit	-	120	-	%I _{out}	OCP latch off
Turn on Time	-	10	15	mS	
Rise Time	-	5	10	mS	

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Output Specifications (continued)

Parameter	Min	Typ	Max	Unit	Notes
Overshoot at Turn on	-	-	5	%	
Output Capacitance	-	4872	-	uF	12*330uF Tan cap +84*4.7uF + 15*22uF + 4*47uF ceramic cap
Transient Response					
$\Delta V_{50\% \sim 75\%}$ of Max Load	Overshoot	-	-	60	mV
	Settling Time	-	-	50	uS
$\Delta V_{75\% \sim 50\%}$ of Max Load	Overshoot	-	-	60	mV
	Settling Time	-	-	50	uS

di/dt=2.5A/us, Vin=12.0Vdc, Ta=25°C, 4872uF cap on output.

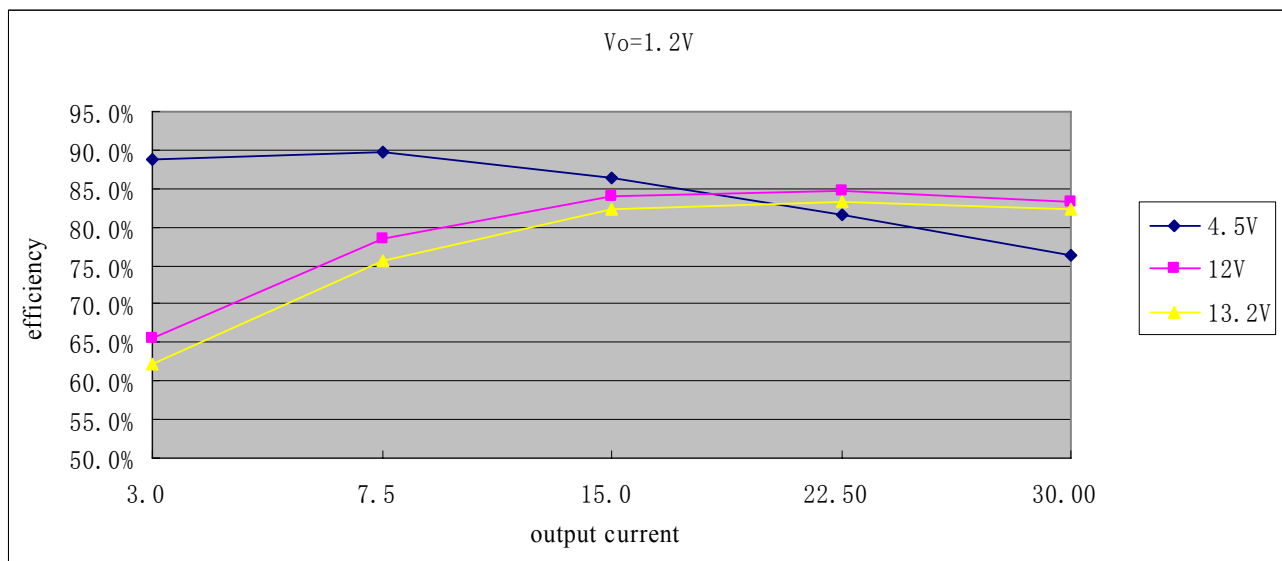
Note: All specifications are typical at nominal input, full load at 25°C unless otherwise stated.

General Specifications

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	-	82	-	%	Vin=12.0V, full load
Switching Frequency	-	500	-	kHz	
Weight	-	14	-	g	
FIT	625			-	Calculated Per Bell Core SR-332 (Io=80%load, Ta = 25 °C, FIT=10 ⁹ /MTBF)
Dimensions				-	
Inches (L x W x H)	1.59 x 0.61 x 0.65			-	
Millimeters (L x W x H)	40.47 x 15.49 x 16.52			-	

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

Efficiency Data



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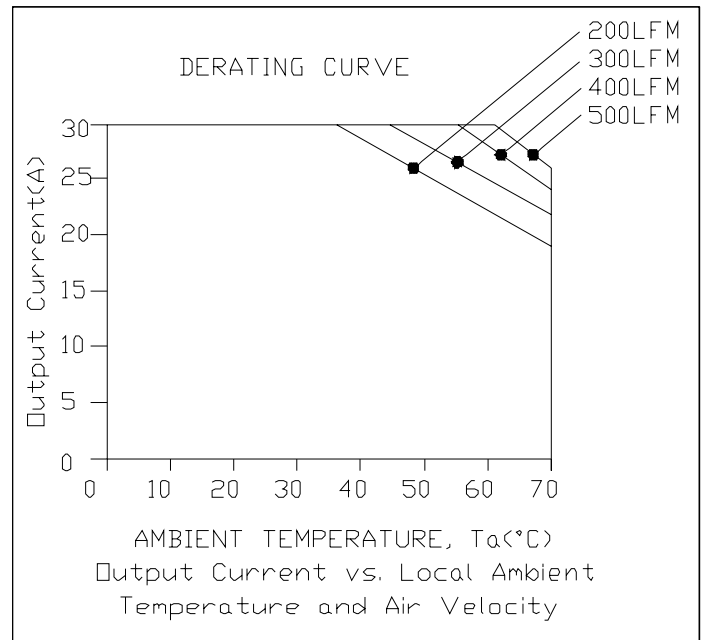
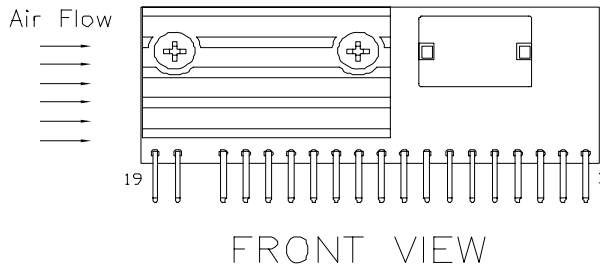
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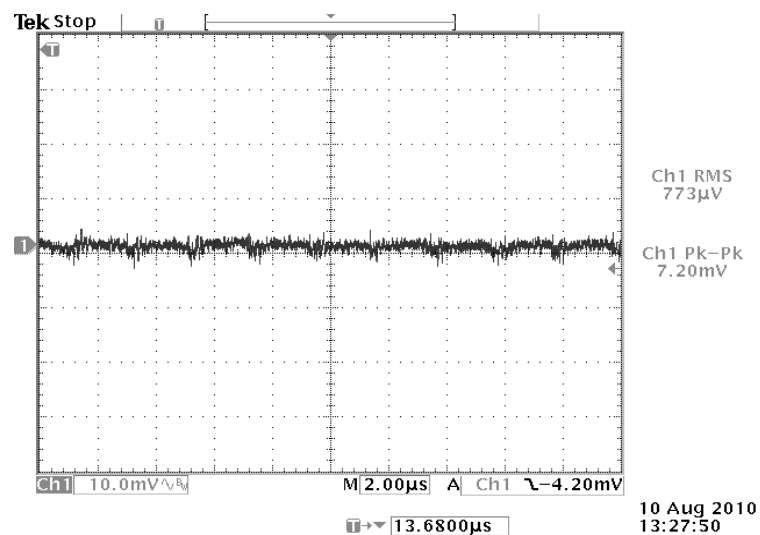
Thermal Derating Curves



$V_{in}=12\text{V}$, $V_o=1.2\text{V}$

maximum junction temperature of semiconductors derated to 120C

Ripple and Noise Waveform



12Vdc input, 1.2V output

Note: Ripple and noise at full load, with 4872uF output cap at output, and $T_a=25$ deg C.

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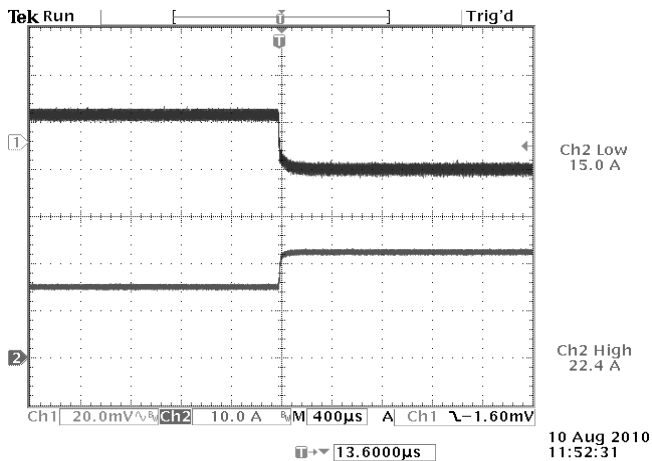
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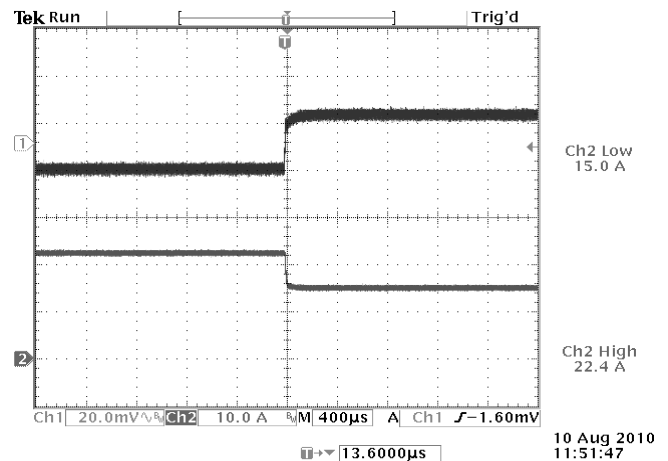
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Transient Response Waveforms



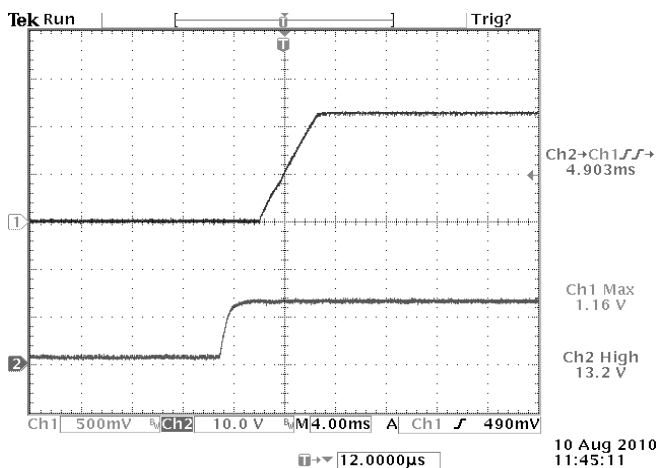
Vin=12V,Vo=1.2V,50%~75% load
di/dt=2.5A/uS, with 4872uF output cap



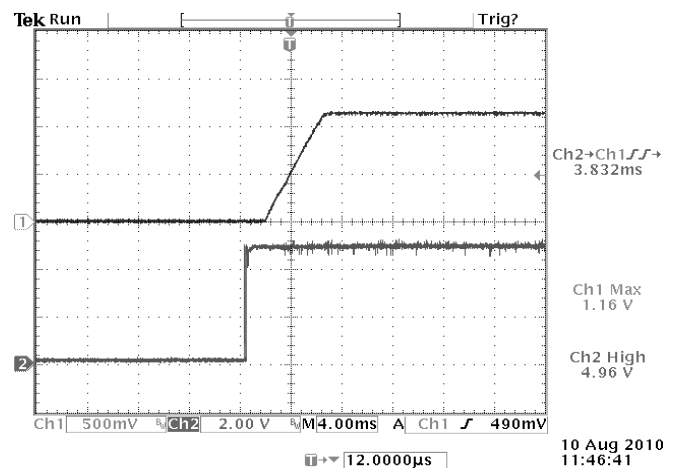
Vin=12V,Vo=1.2V,75%~50% load
di/dt=2.5A/uS, with 4872uF output cap

Startup & Shutdown

Startup time



Startup from Vin
Ch1: Vo
Ch2: Vin
Vin=12V,Vo=1.2V,full load with 4872uF output cap



Startup from on/off
Ch1: Vo
Ch2: on/off
Vin=12V,Vo=1.2V,full load with 4872uF output cap

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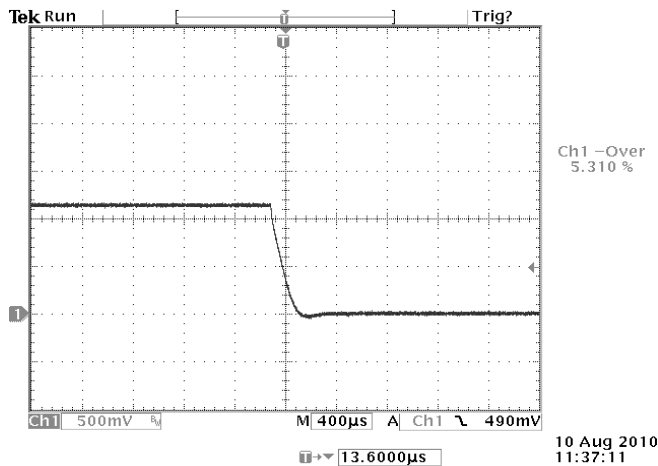


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Startup & Shutdown (continued)

Shutdown

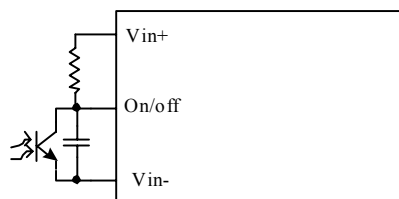
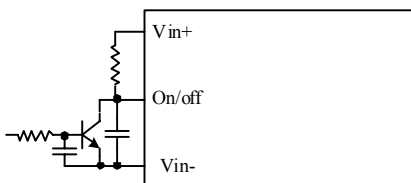


$V_{in}=12V, V_o=1.2V$, full load with 4872uF output cap

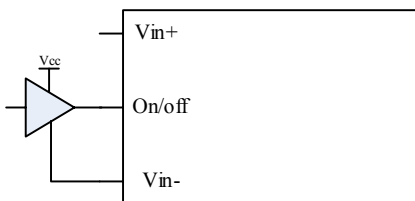
Remote On/Off

Parameter		Min	Typ	Max	Unit	Notes
Signal Low (Unit Off)	Active High	-0.3	-	0.4	V	The remote on/off pin open, Unit off.
Signal High (Unit On)		2	-	5.5	V	
Current Sink		0	-	1	mA	

Recommended remote on/off circuit for active high

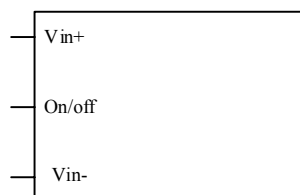


Control with open collector/drain circuit



Control with logic circuit

Control with photocoupler circuit



Permanently off

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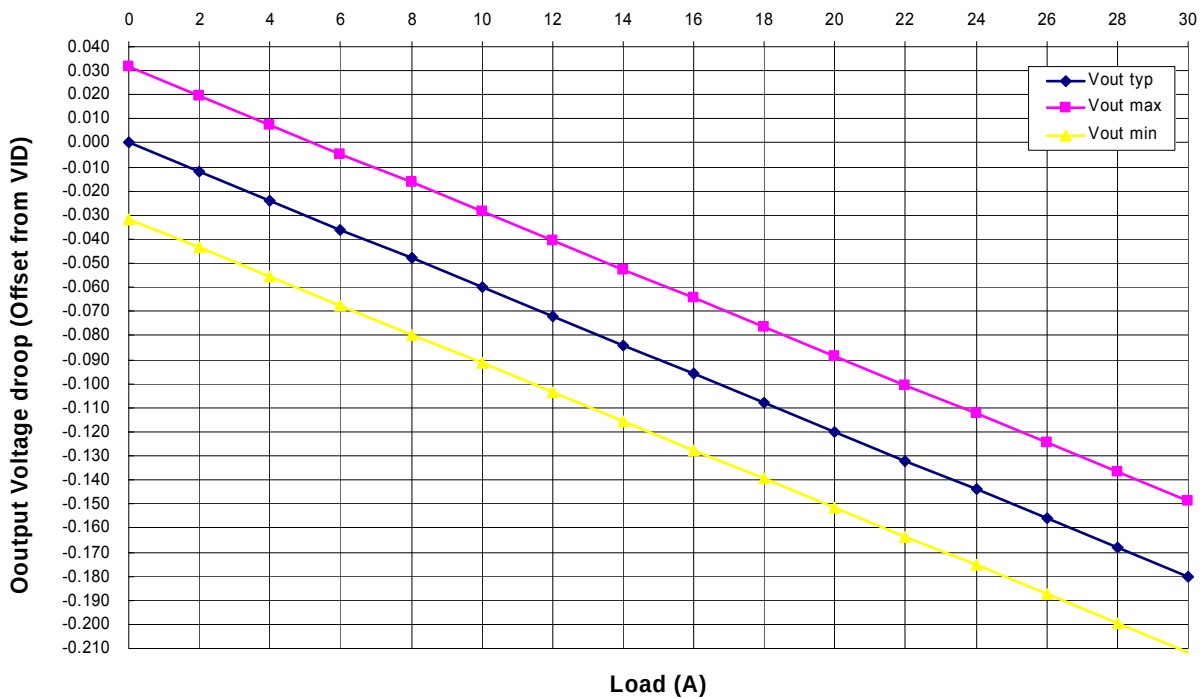
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Load Line

For VRP1-30E2AP only

6 m Ω Load Line with ± 31.5 mV Tolerance Band



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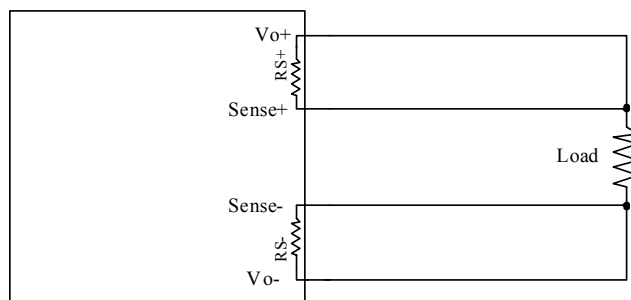
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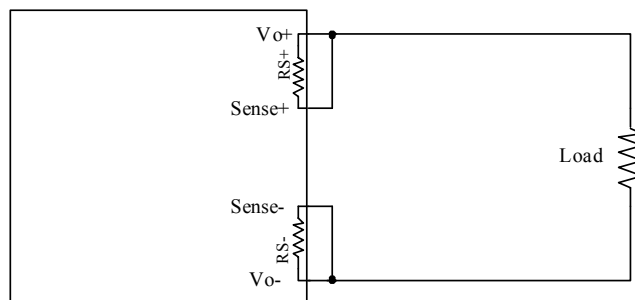
Remote Sense

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+ (51.1 ohm) from Vo+ to Sense+ and a resistor RS- (51.1 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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Output Trim Equations

TRIM CODES (using 8 bit VID: VID0, VID1, VID2, VID3, VID4, VID5, VID6 and VID7)

VID Hex	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0	DAC Voltage (V)	Output Voltage Set Point (V) (offset voltage=20mv, Io=0A)
0	0	0	0	0	0	0	0	0	OFF	OFF
1							0	1	OFF	OFF
2							1	0	1.60000	1.62000
3							1	1	1.59375	1.61375
4				0	0	1	0	0	1.58750	1.60750
5							0	1	1.58125	1.60125
6							1	0	1.57500	1.59500
7							1	1	1.56875	1.58875
8				0	1	0	0	0	1.56250	1.58250
9							0	1	1.55625	1.57625
0A							1	0	1.55000	1.57000
0B							1	1	1.54375	1.56375
0C				0	1	1	0	0	1.53750	1.55750
0D							0	1	1.53125	1.55125
0E							1	0	1.52500	1.54500
0F							1	1	1.51875	1.53875
10				1	0	0	0	0	1.51250	1.53250
11							0	1	1.50625	1.52625
12							1	0	1.50000	1.52000
13							1	1	1.49375	1.51375
14				1	0	1	0	0	1.48750	1.50750
15							0	1	1.48125	1.50125
16							1	0	1.47500	1.49500
17							1	1	1.46875	1.48875
18				1	1	0	0	0	1.46250	1.48250
19							0	1	1.45625	1.47625
1A							1	0	1.45000	1.47000
1B							1	1	1.44375	1.46375
1C				1	1	1	0	0	1.43750	1.45750
1D							0	1	1.43125	1.45125
1E							1	0	1.42500	1.44500
1F							1	1	1.41875	1.43875

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Trim Continued

VID Hex	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0	DAC Voltage (V)	Output Voltage Set Point (V) (offset voltage=20mv, Io=0A)
20	0	0	1	0	0	0	0	0	1.41250	1.43250
21							0	1	1.40625	1.42625
22							1	0	1.40000	1.42000
23							1	1	1.39375	1.41375
24				0	0	1	0	0	1.38750	1.40750
25							0	1	1.38125	1.40125
26							1	0	1.37500	1.39500
27							1	1	1.36875	1.38875
28				0	1	0	0	0	1.36250	1.38250
29							0	1	1.35625	1.37625
2A							1	0	1.35000	1.37000
2B							1	1	1.34375	1.36375
2C				0	1	1	0	0	1.33750	1.35750
2D							0	1	1.33125	1.35125
2E							1	0	1.32500	1.34500
2F							1	1	1.31875	1.33875
30				1	0	0	0	0	1.31250	1.33250
31							0	1	1.30625	1.32625
32							1	0	1.30000	1.32000
33							1	1	1.29375	1.31375
34				1	0	1	0	0	1.28750	1.30750
35							0	1	1.28125	1.30125
36							1	0	1.27500	1.29500
37							1	1	1.26875	1.28875
38				1	1	0	0	0	1.26250	1.28250
39							0	1	1.25625	1.27625
3A							1	0	1.25000	1.27000
3B							1	1	1.24375	1.26375
3C				1	1	1	0	0	1.23750	1.25750
3D							0	1	1.23125	1.25125
3E							1	0	1.22500	1.24500
3F							1	1	1.21875	1.23875

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Trim Continued

VID Hex	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0	DAC Voltage (V)	Output Voltage Set Point (V) (offset voltage=20mv, Io=0A)
40	0	1	0	0	0	0	0	0	1.21250	1.23250
41							0	1	1.20625	1.22625
42							1	0	1.20000	1.22000
43							1	1	1.19375	1.21375
44				0	0	1	0	0	1.18750	1.20750
45							0	1	1.18125	1.20125
46							1	0	1.17500	1.19500
47							1	1	1.16875	1.18875
48				0	1	0	0	0	1.16250	1.18250
49							0	1	1.15625	1.17625
4A							1	0	1.15000	1.17000
4B							1	1	1.14375	1.16375
4C				0	1	1	0	0	1.13750	1.15750
4D							0	1	1.13125	1.15125
4E							1	0	1.12500	1.14500
4F							1	1	1.11875	1.13875
50				1	0	0	0	0	1.11250	1.13250
51							0	1	1.10625	1.12625
52							1	0	1.10000	1.12000
53							1	1	1.09375	1.11375
54				1	0	1	0	0	1.08750	1.10750
55							0	1	1.08125	1.10125
56							1	0	1.07500	1.09500
57							1	1	1.06875	1.08875
58				1	1	0	0	0	1.06250	1.08250
59							0	1	1.05625	1.07625
5A							1	0	1.05000	1.07000
5B							1	1	1.04375	1.06375
5C				1	1	1	0	0	1.03750	1.05750
5D							0	1	1.03125	1.05125
5E							1	0	1.02500	1.04500
5F							1	1	1.01875	1.03875

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VID Hex	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0	DAC Voltage (V)	Output Voltage Set Point (V) (offset voltage=20mv, Io=0A)
60	0	1	1	0	0	0	0	0	1.01250	1.03250
61							0	1	1.00625	1.02625
62							1	0	1.00000	1.02000
63							1	1	0.99375	1.01375
64				0	0	1	0	0	0.98750	1.00750
65							0	1	0.98125	1.00125
66							1	0	0.97500	0.99500
67							1	1	0.96875	0.98875
68				0	1	0	0	0	0.96250	0.98250
69							0	1	0.95625	0.97625
6A							1	0	0.95000	0.97000
6B							1	1	0.94375	0.96375
6C				0	1	1	0	0	0.93750	0.95750
6D							0	1	0.93125	0.95125
6E							1	0	0.92500	0.94500
6F							1	1	0.91875	0.93875
70				1	0	0	0	0	0.91250	0.93250
71							0	1	0.90625	0.92625
72							1	0	0.90000	0.92000
73							1	1	0.89375	0.91375
74				1	0	1	0	0	0.88750	0.90750
75							0	1	0.88125	0.90125
76							1	0	0.87500	0.89500
77							1	1	0.86875	0.88875
78				1	1	0	0	0	0.86250	0.88250
79							0	1	0.85625	0.87625
7A							1	0	0.85000	0.87000
7B							1	1	0.84375	0.86375
7C				1	1	1	0	0	0.83750	0.85750
7D							0	1	0.83125	0.85125
7E							1	0	0.82500	0.84500
7F							1	1	0.81875	0.83875

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VID Hex	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0	DAC Voltage (V)	Output Voltage Set Point (V) (offset voltage=20mv, Io=0A)
80	1	0	0	0	0	0	0	0	0.81250	0.83250
81							0	1	0.80625	0.82625
82							1	0	0.80000	0.82000
83							1	1	0.79375	0.81375
84				0	0	1	0	0	0.78750	0.80750
85							0	1	0.78125	0.80125
86							1	0	0.77500	0.79500
87							1	1	0.76875	0.78875
88				0	1	0	0	0	0.76250	0.78250
89							0	1	0.75625	0.77625
8A							1	0	0.75000	0.77000
8B							1	1	0.74375	0.76375
8C				0	1	1	0	0	0.73750	0.75750
8D							0	1	0.73125	0.75125
8E							1	0	0.72500	0.74500
8F							1	1	0.71875	0.73875
90				1	0	0	0	0	0.71250	0.73250
91							0	1	0.70625	0.72625
92							1	0	0.70000	0.72000
93							1	1	0.69375	0.71375
94				1	0	1	0	0	0.68750	0.70750
95							0	1	0.68125	0.70125
96							1	0	0.67500	0.69500
97							1	1	0.66875	0.68875
98				1	1	0	0	0	0.66250	0.68250
99							0	1	0.65625	0.67625
9A							1	0	0.65000	0.67000
9B							1	1	0.64375	0.66375
9C				1	1	1	0	0	0.63750	0.65750
9D							0	1	0.63125	0.65125
9E							1	0	0.62500	0.64500
9F							1	1	0.61875	0.63875

NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output



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Trim Continued

VID Hex	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0	DAC Voltage (V)	Output Voltage Set Point (V) (offset voltage=20mv, Io=0A)
A0	1	0	1	0	0	0	0	0	0.61250	0.63250
A1							0	1	0.60625	0.62625
A2							1	0	0.60000	0.62000
A3							1	1	0.59375	0.61375
A4				0	0	1	0	0	0.58750	0.60750
A5							0	1	0.58125	0.60125
A6							1	0	0.57500	0.59500
A7							1	1	0.56875	0.58875
A8				0	1	0	0	0	0.56250	0.58250
A9							0	1	0.55625	0.57625
AA							1	0	0.55000	0.57000
AB							1	1	0.54375	0.56375
AC				0	1	1	0	0	0.53750	0.55750
AD							0	1	0.53125	0.55125
AE							1	0	0.52500	0.54500
AF							1	1	0.51875	0.53875
B0				1	0	0	0	0	0.51250	0.53250
B1							0	1	0.50625	0.52625
B2							1	0	0.50000	0.52000
FE	1	1	1	1	1	1	1	0	OFF	OFF
FF							1	1	OFF	OFF

Dynamic VID (dVID)

The module supports dynamic VID across the entire usable VID table above (0.5V-1.6V)

Voltage levels transitioning from a standard operational VID levels to the minimum VID=0.5 V by stepping down or up sequentially through the table is as follows:

1. 6.25 mV VID steps every 1.25 μ s.
2. 12.5 mV VID steps every 2.5 μ s.
3. Vout slew rate response to a single (>25 mV) dVID step upwards =10 mV/ μ s minimum.
4. Settle within $\pm$ 5 mV of final value (nominal Vdroop load line including no load offset from VID) within 15 μ s for dVID event $\geq$ 50 mV.
5. Settle within < 5 μ s for dVID event < 50 mV.
6. Skew on each VID line $\leq$ 200 ns Max.

NON-ISOLATED DC/DC CONVERTERS

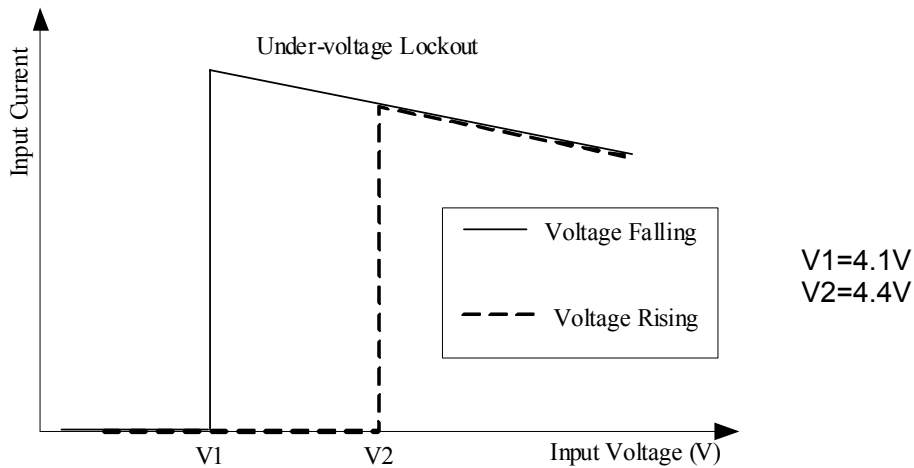
4.5 Vdc - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output



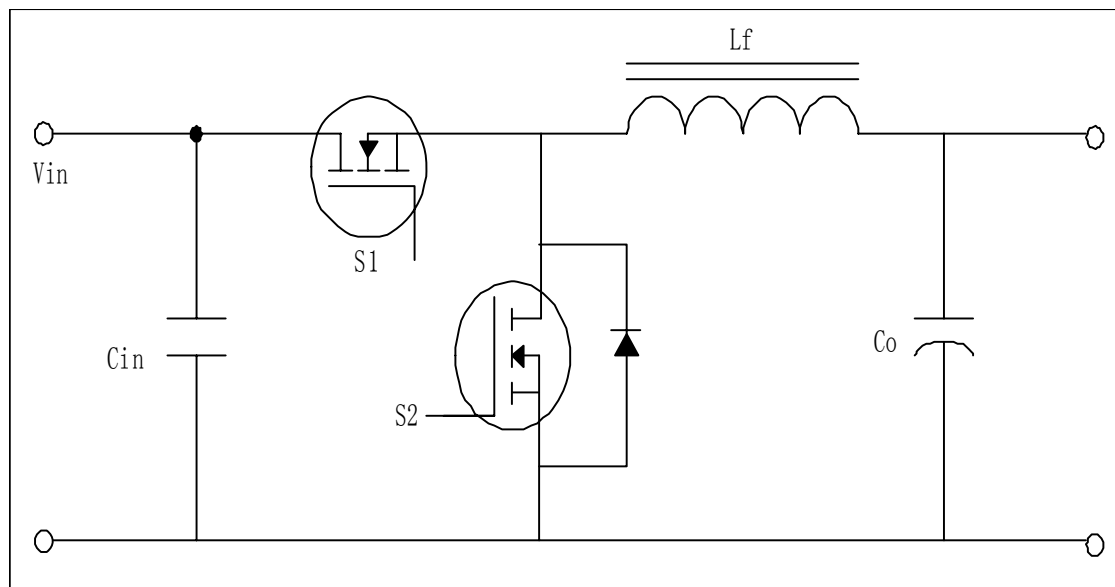
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Input Under-voltage Lockout



Fundamental Circuit Diagram



NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output

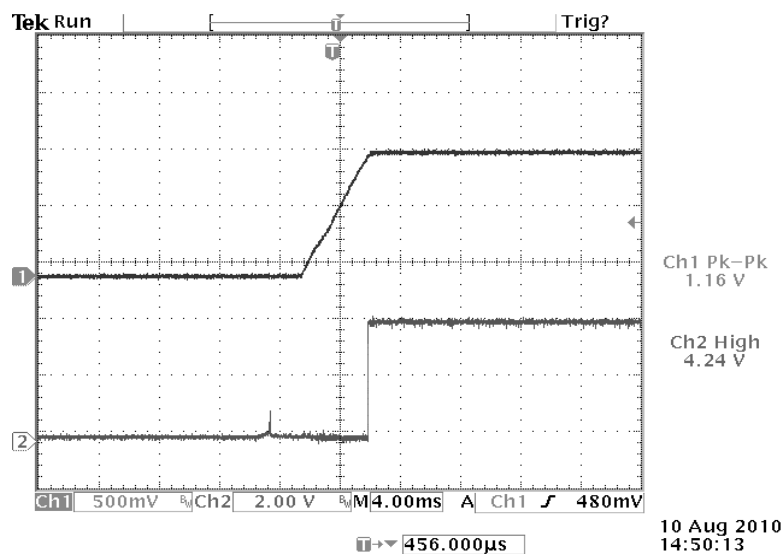


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Power Good

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.



CH1: Output Voltage CH2: Power Good
Typical Start-up Using Remote ON/OFF(Vin=12.0V, Vout=1.2V, Io=30A)

NON-ISOLATED DC/DC CONVERTERS

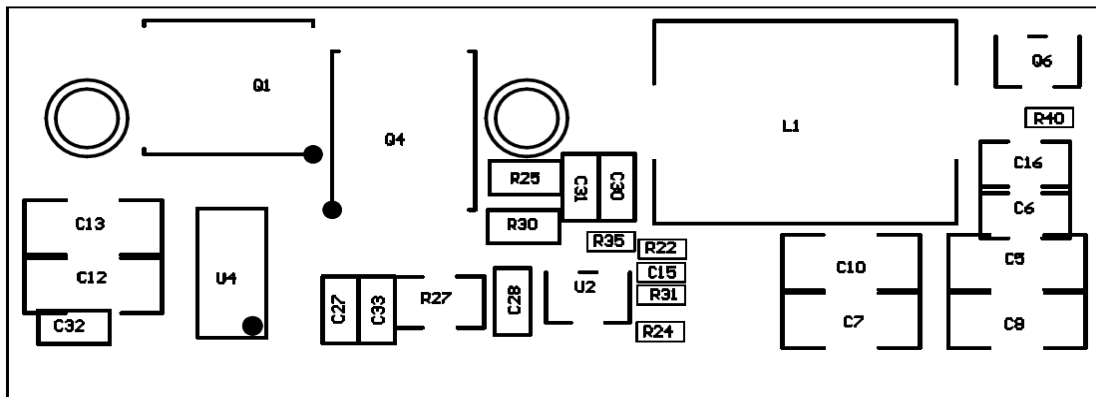
4.5 Vdc - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output



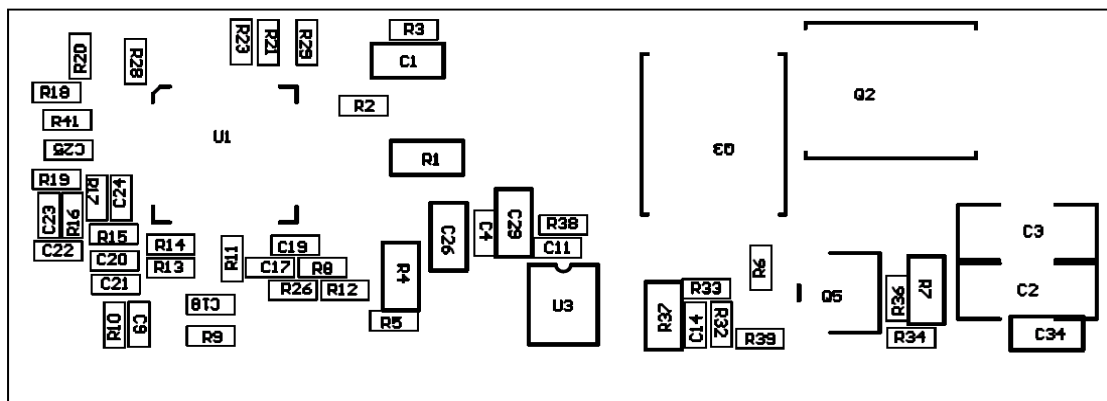
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Layout



Layout of components on top side



Layout of components on bottom side

NON-ISOLATED DC/DC CONVERTERS

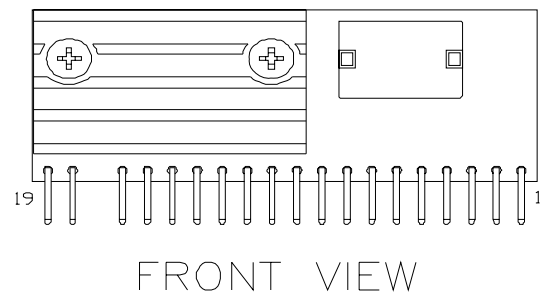
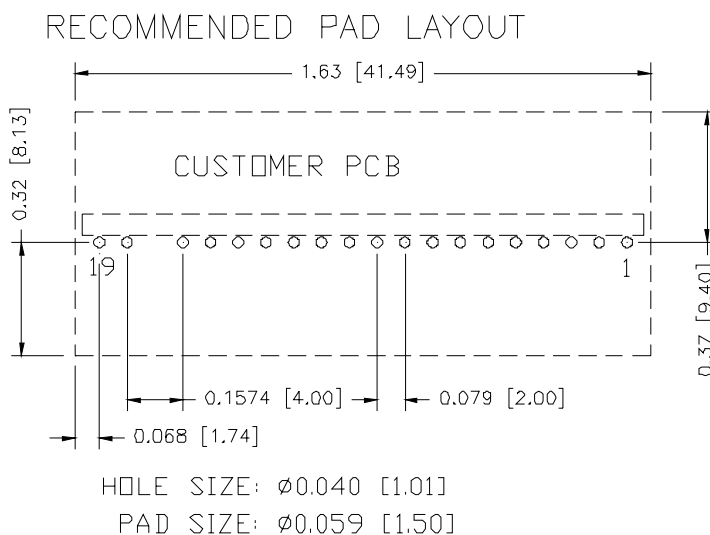
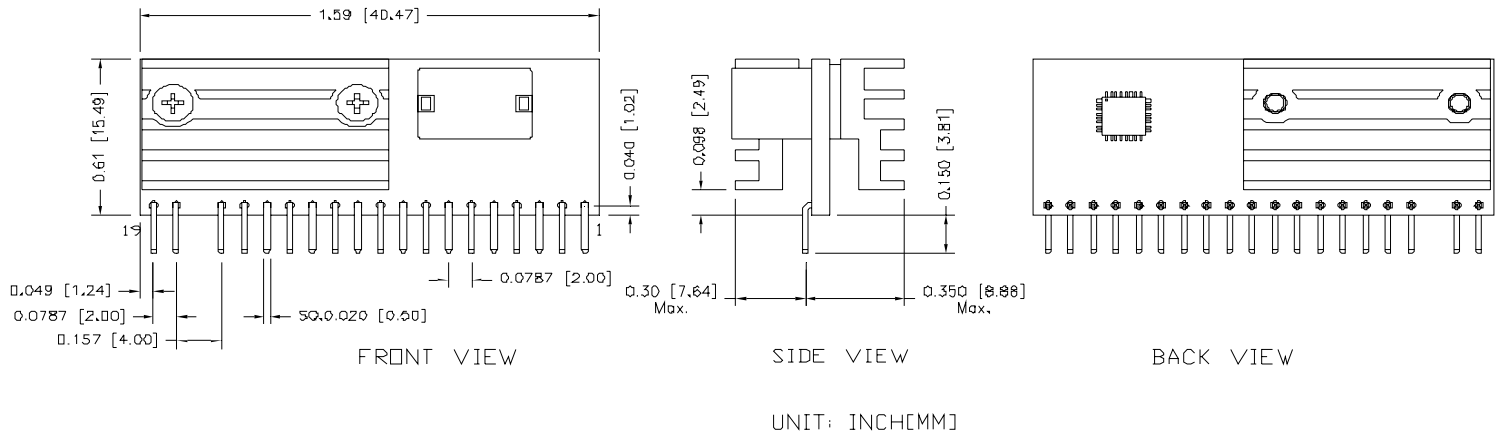
4.5 Vdc - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output



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Mechanical Outline



Pin	Function	Pin	Function
1	GND	11	VID2
2	GND	12	VID3
3	Vout	13	VID4
4	Vout	14	VID5
5	Vout	15	VID6
6	PWRGD	16	VID7
7	Vsense-	17	Enable
8	Vsense+	18	Vin
9	VID0	19	GND
10	VID1		

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 - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output



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Signal Definitions

Pin Name	Pin Description
GND	Common return for both input and output.
Vout	Output voltage of the converter.
PWRGD	PWRGD indicates that soft-start has completed and the output voltage is within the regulated range around VID setting.
Vsense-	Negative remote sense.
Vsense+	Positive remote sense.
VID0,VID1, VID2,VID3, VID4,VID5, VID6,VID7	Logic level inputs used to set the output voltage, refer to VID table. Connect VID0 thru VID1 pins to open-drain outputs with external pull-up resistors or to active-pull-up outputs. Valid logic low is -0.3V to 0.4V, valid logic high level is 0.8V to 5.3V.
Enable	Logic level input used to enable the converter when high.
Vin	Input voltage of the converter.

NON-ISOLATED DC/DC CONVERTERS

4.5 Vdc - 13.2 Vdc Input, 0.5 Vdc - 1.6 Vdc/30 A Output



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Revision History

Date	Revision	Changes Detail	Approval
2010-4-22	PA	First release	YF SUN
2010-4-27	PB	1. Input voltage range changes to 4.5-13.2V, and update related turn on/off voltage threshold, UVLO. 2. Add Dynamic VID statement in Trim section.	YF SUN
2010-8-13	PC	1. Updated turn-on voltage threshold. 2. Updated turn-off voltage threshold. 3. Add load regulation 4. Output Capacitance 5. Change the picture of efficiency, NR, TD, TR, Startup&Shutdown, UVLO, PG, MD 6. Add VRP1-30E2AP and only this P/N has the function of load line 7. Update trim table	YF SUN

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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