



# Data Sheet

## 28V Wide Input Maxi Family

### DC-DC Converter Module



#### Features

- RoHS Compliant (with F or G pin option)
- DC input range: 10 – 36 V\*
- Input surge withstand: 50 V for 100 ms
- DC output: 3.3 – 48 V
- Programmable output: 10 to 110%
- Regulation:  $\pm 0.2\%$  no load to full load
- Efficiency: Up to 85%
- Maximum operating temp: 100°C
- Power density: up to 40 W per cubic inch
- Height above board: 0.43 in. (10.9 mm)
- Parallelable, with N+M fault tolerance
- Low noise ZCS/ZVS architecture

#### Product Overview

These DC-DC converter modules use advanced power processing, control and packaging technologies to provide the performance, flexibility, reliability and cost effectiveness of a mature power component. High frequency ZCS/ZVS switching provides high power density with low noise and high efficiency.

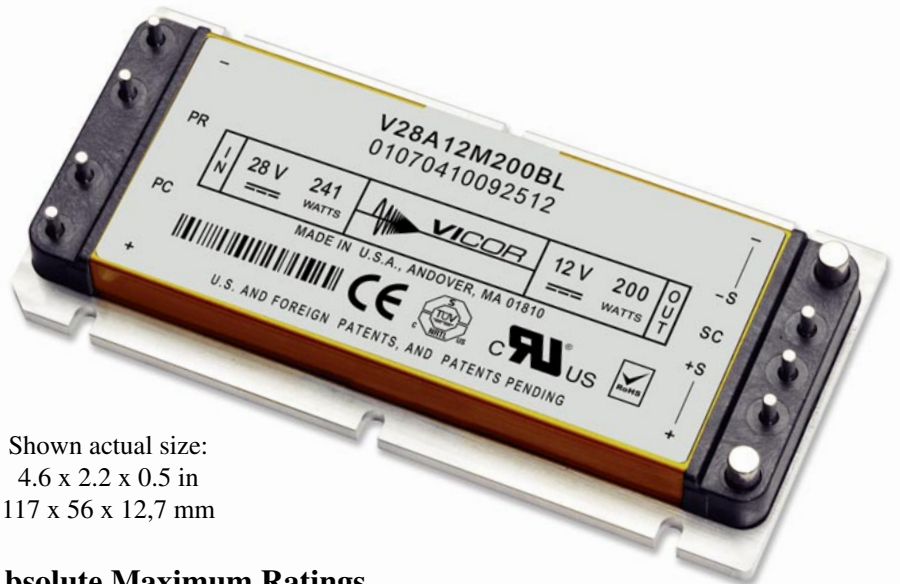
#### Applications

Industrial and process control, distributed power, medical, ATE, communications, defense, aerospace.

\*9-36 V DC input range for 5, 12, 24, and 28 V outputs.

#### Part Numbering

e.g. V28A12T200BL2



Shown actual size:  
4.6 x 2.2 x 0.5 in  
117 x 56 x 12,7 mm

#### Absolute Maximum Ratings

Parameter	Rating	Unit	Notes
+In to -In voltage	-0.5 to +53	Vdc	
PC to -In voltage	-0.5 to +7.0	Vdc	
PR to -In voltage	-0.5 to +7.0	Vdc	
SC to -Out voltage	-0.5 to +1.5	Vdc	
-Sense to -Out voltage	1.0	Vdc	
+Out to -Out, +Sense to -Out			See Module Output Specifications
Isolation voltage			
in to out	3000	Vrms	Test voltage
in to base	1500	Vrms	Test voltage
out to base	500	Vrms	Test voltage
Operating Temperature	-55 to +100	°C	M-Grade
Storage Temperature	-65 to +125	°C	M-Grade
Pin soldering temperature	500 (260)	°F (°C)	<5 sec; wave solder
	750 (390)	°F (°C)	<7 sec; hand solder
Mounting torque	5 (0.57)	in-lbs (N-m)	6 each

V28A    B

Output Voltage
3V3 = 3.3 V
5 = 5 V
6.5 = 6.5 V
8 = 8 V
12 = 12 V
15 = 15 V
24 = 24 V
28 = 28 V
36 = 36 V
48 = 48 V

Product Grade Temperatures (°C)		
Grade	Operating	Storage
C	-20 to +100	-40 to +125
T	-40 to +100	-40 to +125
H	-40 to +100	-55 to +125
M	-55 to +100	-65 to +125

Output Power	
Vout	Pout
3.3 V	150 W
5 V	175 W
6.5 V	200 W
8 V	200 W
12 V	200 W
15 V	200 W
24 V	200 W
28 V	200 W
36 V	200 W
48 V	200 W

Pin Style
Blank: Short Tin/Lead
L: Long Tin/Lead
S: Short ModuMate
N: Long ModuMate
F: Short RoHS
G: Long RoHS

Baseplate
Blank: Slotted
2: Threaded
3: Through-hole

For a description of pin options, see page 8. Baseplate options include slotted flanges, threaded and through-hole. See page 9 for dimensions.

## MODULE FAMILY ELECTRICAL CHARACTERISTICS

Electrical characteristics apply over the full operating range of input voltage, output load (resistive) and baseplate temperature, unless otherwise specified. All temperatures refer to the operating temperature at the center of the baseplate.

### ■ MODULE INPUT SPECIFICATIONS

Parameter	Min	Typ	Max	Unit	Notes
Operating input voltage	10	28	36	Vdc	9 to 36 V input operation (from 9 to 10 V input, available power is reduced to 75% of max rating) is present on the following output voltages: 5, 12, 24, and 28 V.
Input surge withstand			50	Vdc	<100 ms
Undervoltage turn-on		9.75	9.9	Vdc	For 5, 12, 24 and 28 V modules, undervoltage turn-on is 8.9 Vdc max.
Undervoltage turn-off		9.5		Vdc	For 5, 12, 24 and 28 V modules, undervoltage turn-off is 8.5 Vdc typ.
Oversvoltage turn-off/on	36.3	37.8	39.6	Vdc	
Disabled input current			4.0	mA	PC pin low

### ■ MODULE OUTPUT SPECIFICATIONS

Parameter	Min	Typ	Max	Unit	Notes
Output voltage set point		±1%	Vout nom		Nominal input; full load; 25°C
Line regulation	±0.02	±0.20	%		Low line to high line; full load
Temperature regulation	±0.002	±0.005	% / °C		Over operating temperature range
Power sharing accuracy	±2	±5	%		10 to 100% of full load
Programming range	10	110	%		Of nominal output voltage. For trimming below 90% of nominal, a minimum load of 10% of maximum rated power may be required.
<b>+Out to -Out, +Sense to -Out – Absolute Maximum Ratings</b>					
3.3 V		-0.5 to 4.7	Vdc		Externally Applied
5 V		-0.5 to 7.0	Vdc		Externally Applied
6.5 V		-0.5 to 9.0	Vdc		Externally Applied
8 V		-0.5 to 10.9	Vdc		Externally Applied
12 V		-0.5 to 16.1	Vdc		Externally Applied
15 V		-0.5 to 20.0	Vdc		Externally Applied
24 V		-0.5 to 31.7	Vdc		Externally Applied
28 V		-0.5 to 36.9	Vdc		Externally Applied
36 V		-0.5 to 47.2	Vdc		Externally Applied
48 V		-0.5 to 62.9	Vdc		Externally Applied

### ■ THERMAL RESISTANCE AND CAPACITY

Parameter	Min	Typ	Max	Unit
Baseplate to sink; flat, greased surface		0.08		°C/Watt
Baseplate to sink; thermal pad (P/N 20265)		0.07		°C/Watt
Baseplate to ambient		4.9		°C/Watt
Baseplate to ambient; 1000 LFM		1.1		°C/Watt
Thermal capacity		165		Watt-sec/°C

## MODULE FAMILY ELECTRICAL CHARACTERISTICS (CONT.)

### ■ MODULE CONTROL SPECIFICATIONS

Parameter	Min	Typ	Max	Unit	Notes
<b>PRIMARY SIDE</b> (PC = Primary Control; PR = Parallel)					
PC bias voltage	5.50	5.75	6.00	Vdc	PC current = 1.0 mA
current limit	1.5	2.1	3.0	mA	PC voltage = 5.5 V
PC module disable	2.3	2.6	2.9	Vdc	Must be able to sink 4 mA. See Fig. 1
PC module enable delay		4	7	ms	
PC module alarm			0.5	Vavg	UV, OV, OT, module fault. See Figs. 2 and 4
PC resistance	0.9	1.0	1.1	MΩ	See Fig. 2
PR emitter amplitude	5.7	5.9	6.1	Volts	PR load >30 Ω, <30 pF
PR emitter current	150			mA	
PR receiver impedance	375	500	625	Ω	25°C
PR receiver threshold	2.4	2.5	2.6	Volts	Minimum pulse width: 20 ns
PR drive capability			12	modules	Without PR buffer amplifier
<b>SECONDARY SIDE</b> (SC = Secondary Control)					
SC bandgap voltage	1.21	1.23	1.25	Vdc	Referenced to –Sense
SC resistance	990	1000	1010	Ω	
SC capacitance		0.033		μF	
SC module alarm		0		Vdc	With open trim; referenced to –Sense. See Fig. 6

### ■ MODULE GENERAL SPECIFICATIONS

Parameter	Min	Typ	Max	Unit	Notes
Remote sense (total drop)			0.5	Vdc	0.25 V per leg (senses must be closed)
Isolation voltage (in to out)	3000			Vrms	Complies with reinforced insulation requirements
Isolation voltage (in to base)	1500			Vrms	Complies with basic insulation requirements
Isolation voltage (out to base)	500			Vrms	Complies with operational insulation requirements
Isolation resistance (in to out)		10		MΩ	
Weight	7.4 (209.3)	8.2 (232.5)	9.0 (255.7)	ounces (grams)	
Temperature limiting	100	115		°C	See Figs. 2 and 4
<a href="#">Agency approvals</a>		cURus, TÜV, CE			UL60950-1, EN60950-1, CSA60950-1, IEC60950-1 With a fuse in series with the +Input

**Note:**

Specifications are subject to change without notice.

## ■ MODULE SPECIFIC OPERATING SPECIFICATIONS

### 3.3 Vout, 150 W (e.g. V28A3V3C150BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	77.3	78.6		%	Nominal input; full load; 25°C
Ripple and noise		80	100	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	4.14	4.30	4.46	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		11.4	12.7	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		45.45	Amps	
Current limit	46.4	52.3	61.5	Amps	Output voltage 95% of nominal
Short circuit current	31.8	52.3	61.5	Amps	Output voltage <250 mV

### 5 Vout, 175 W (e.g. V28A5C175BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	75.7	76.8		%	Nominal input; full load; 25°C
Ripple and noise		280	350	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	6.03	6.25	6.47	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		14.4	15.5	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		35	Amps	
Current limit	35.7	40.3	49.0	Amps	Output voltage 95% of nominal
Short circuit current	24.5	40.3	47.3	Amps	Output voltage <250 mV

### 6.5 Vout, 200 W (e.g. V28A6V5C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	76.8	78.8		%	Nominal input; full load; 25°C
Ripple and noise		275	344	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP setpoint	7.7	7.98	8.26	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, standby		11.6	12.2	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Output Current	0		30.77	Amps	
Current limit	31.4	35.4	41.6	Amps	Output voltage 95% of nominal
Short circuit current	21.5	35.4	41.6	Amps	Output voltage <250 mV

### 8 Vout, 200 W (e.g. V28A8C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	79.5	80.9		%	Nominal input; full load; 25°C
Ripple and noise		325	407	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP setpoint	9.36	9.7	10.1	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, standby		15.6	16.5	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Output Current	0		25	Amps	
Current limit	25.5	28.8	33.8	Amps	Output voltage 95% of nominal
Short circuit current	17.5	28.8	33.8	Amps	Output voltage <250 mV

### 12 Vout, 200 W (e.g. V28A12C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	81.0	83.0		%	Nominal input; full load; 25°C
Ripple and noise		280	350	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	13.7	14.3	14.9	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		11.0	12.2	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		16.67	Amps	
Current limit	17.0	19.2	22.6	Amps	Output voltage 95% of nominal
Short circuit current	11.6	19.2	22.6	Amps	Output voltage < 250mV

## ■ MODULE SPECIFIC OPERATING SPECIFICATIONS

### 15 Vout, 200 W (e.g. V28A15C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	82.2	83.5		%	Nominal input; full load; 25°C
Ripple and noise		220	275	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	17.1	17.8	18.5	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		12.7	13.7	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		13.33	Amps	
Current limit	13.5	15.3	20.6	Amps	Output voltage 95% of nominal
Short circuit current	9.31	15.3	20.6	Amps	Output voltage <250 mV

### 24 Vout, 200 W (e.g. V28A24C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	82.8	84.8		%	Nominal input; full load; 25°C
Ripple and noise		315	394	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	27.1	28.1	29.1	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		12.3	13.5	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		8.33	Amps	
Current limit	8.49	9.6	11.3	Amps	Output voltage 95% of nominal
Short circuit current	5.83	9.6	11.3	Amps	Output voltage <250 mV

### 28 Vout, 200 W (e.g. V28A28C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	84.0	85.0		%	Nominal input; full load; 25°C
Ripple and noise		200	250	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	31.5	32.7	33.9	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		15.5	18.0	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		7.14	Amps	
Current limit	7.28	8.2	10.0	Amps	Output voltage 95% of nominal
Short circuit current	4.99	8.2	10.0	Amps	Output voltage <250 mV

### 36 Vout, 200 W (e.g. V28A36C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	80.9	82.6		%	Nominal input; full load; 25°C
Ripple and noise		225	282	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	40.4	41.9	43.4	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		14.4	16.8	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		5.56	Amps	
Current limit	5.67	7.7	8.06	Amps	Output voltage 95% of nominal
Short circuit current	3.89	6.9	7.5	Amps	Output voltage <250 mV

### 48 Vout, 200 W (e.g. V28A48C200BL)

Parameter	Min	Typ	Max	Unit	Notes
Efficiency	81.0	82.5		%	Nominal input; full load; 25°C
Ripple and noise		360	450	mV	p-p; Nominal input; full load; 20 MHz bandwidth
Output OVP set point	53.7	55.7	57.7	Volts	25°C; recycle input voltage to restart (>100 ms off)
Dissipation, stand-by		15.6	18.3	Watts	No load
Load regulation		±0.02	±0.2	%	No load to full load; nominal input
Load Current	0		4.17	Amps	
Current limit	4.25	4.4	5.84	Amps	Output voltage 95% of nominal
Short circuit current	2.92	4.8	5.43	Amps	Output voltage <250 mV

# CONTROL FUNCTIONS - PC PIN

## Module Enable / Disable

The module may be disabled by pulling PC below 2.3 V with respect to the -Input. This may be done with an open collector transistor, relay, or optocoupler. Multiple converters may be disabled with a single transistor or relay either directly or via "OR'ing" diodes. See Figure 1.

## Primary Auxiliary Supply

At 5.7 V, PC can source up to 1.5 mA. In the example shown in Figure 3, PC powers a module enabled LED.

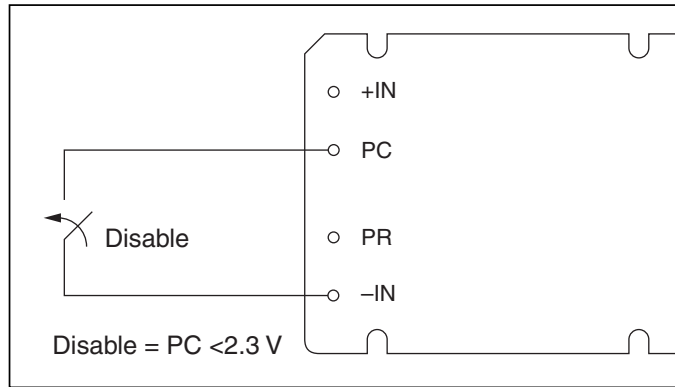


Figure 1 — Module enable / disable.

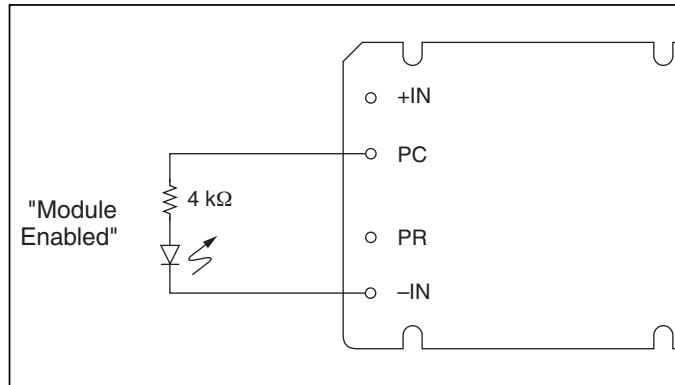


Figure 3 — LED on-state indicator.

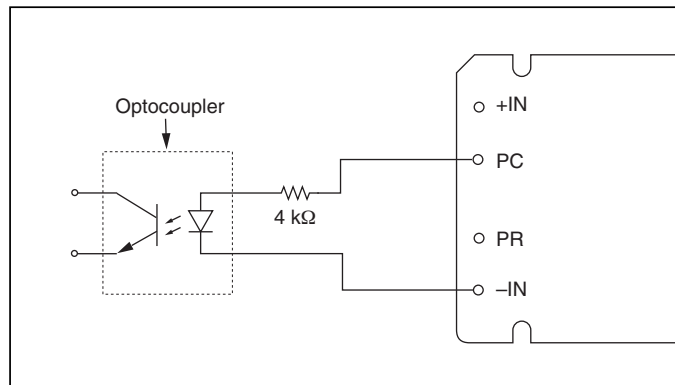


Figure 5 — Isolated on-state indicator.

## Module Alarm

The module contains "watchdog" circuitry which monitors input voltage, operating temperature and internal operating parameters. In the event that any of these parameters are outside of their allowable operating range, the module will shut down and PC will go low. PC will periodically go high and the module will check to see if the fault (as an example, overtemperature) has cleared. If the fault has not been cleared, PC will go low again and the cycle will restart. The SC pin will go low in the event of a fault and return to its normal state after the fault has been cleared. See Figures 2 and 4.

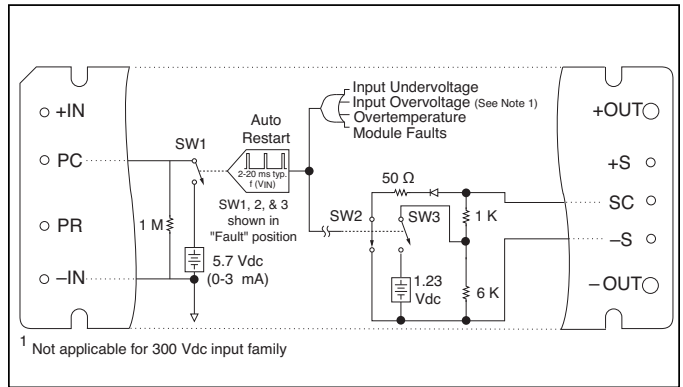


Figure 2 — PC/SC module alarm logic.

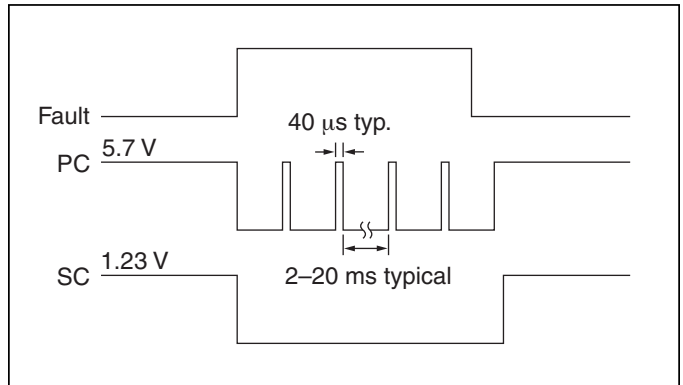


Figure 4 — PC/SC module alarm timing.

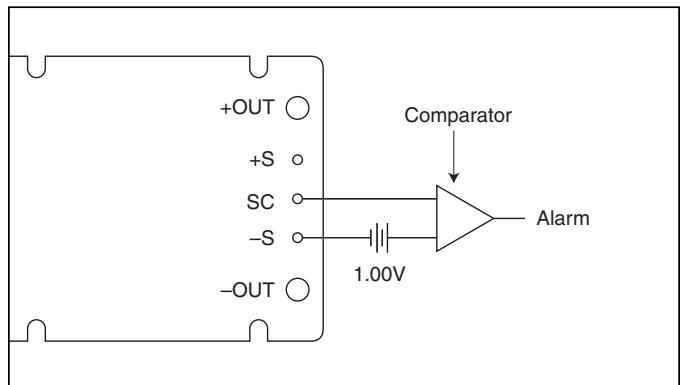


Figure 6 — Secondary side on-state indicator.

## Output Voltage Programming

The output voltage of the converter can be adjusted or programmed via fixed resistors, potentiometers or voltage DACs. See Figures 7 and 8.

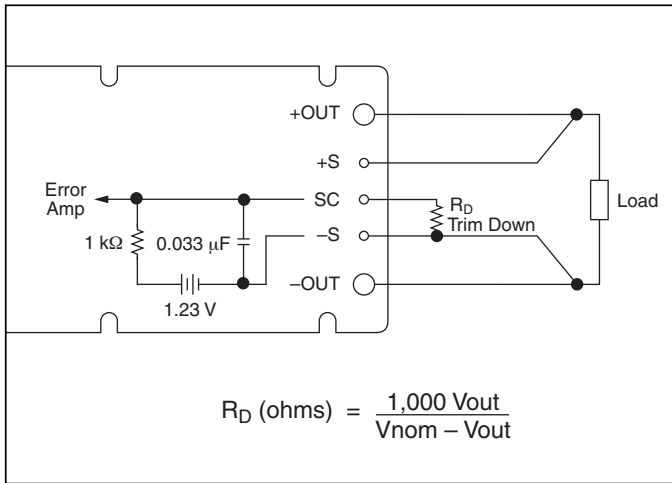


Figure 7 — Output voltage trim down circuit.

### Trim Down

1. This converter is not a constant power device – it has a constant current limit. Hence, available output power is reduced by the same percentage that output voltage is trimmed down. Do not exceed maximum rated output current.
2. The trim down resistor must be connected to the –Sense pin.

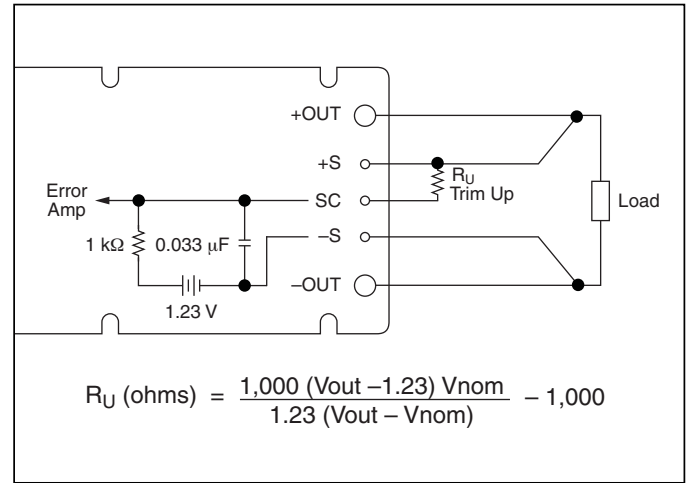


Figure 8 — Output voltage trim up circuit.

### Trim Up

1. The converter is rated for a maximum delivered power. To ensure that maximum rated power is not exceeded, reduce maximum output current by the same percentage increase in output voltage.
2. The trim up resistor must be connected to the +Sense pin.
3. Do not trim the converter above maximum trim range (typically +10%) or the output over voltage protection circuitry may be activated.

### Resistor Values for Fixed Output Voltage Trimming

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**Vicor product:**  VI-200  VI-J00  Maxi, Mini, and Micro

**Notes:** VI-200 and VI-J00 — Minimum preload of 1% should be maintained  
Maxi, Mini, and Micro — Consult factory when trimming below –10%

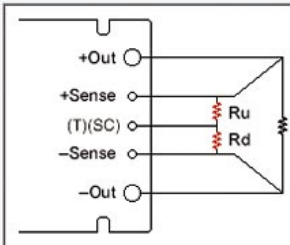
**Nominal output voltage:** 12V

**Trim range:** 1.2 to 13.2 V or  $V_{nom}$  -90 to +10 %

**Desired output voltage:** 9 V or  $V_{nom}$  +25 %

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Trim resistor value: 3 K ohm



$R_u$  = Trim up resistor  
K ohm

$R_d$  = Trim down resistor  
3 K ohm

### Trim resistor values calculated automatically:

On-line calculators for trim resistor values are available on the vicor website at: [vicorpower.com/tools](http://vicorpower.com/tools).

Resistor values can be calculated for fixed trim up, fixed trim down and for variable trim up or down.

In addition to trimming information, the web site and the Applications Manual also include design tips, applications circuits, EMC suggestions, thermal design guidelines and PDF data sheets for all available Vicor products.

## CONTROL FUNCTIONS - PR PIN

### Parallel Operation

The PR pin supports paralleling for increased power with N+1 (N+M) redundancy and phased array capability. Modules of the same input voltage, output voltage, and power level will current share if all PR pins are suitably interfaced.

Compatible interface architectures include the following:

**DC coupled single-wire interface.** All PR pins are directly connected to one another. This interface supports current sharing but is not fault tolerant. Minus In pins must be tied to the same electric potential. See Figure 9.

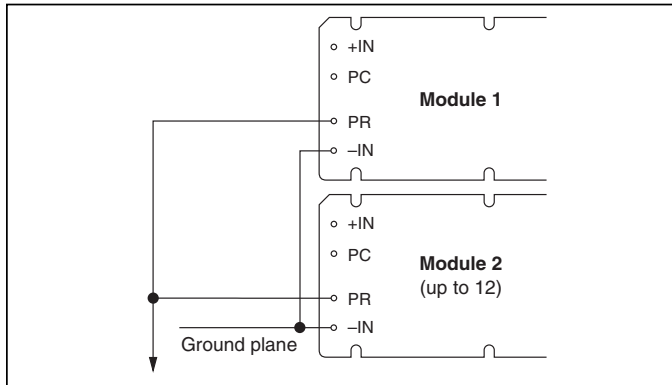


Figure 9 — DC coupled single-wire interface.

**AC coupled single-wire interface.** All PR pins are connected to a single communication bus through 0.001  $\mu\text{F}$  (500 V) capacitors. This interface supports current sharing and is fault tolerant except for the communication bus. See Figure 10.

### Technical Information

For additional technical information contained in the *Design Guide and Applications Manual for Maxi, Mini, Micro Family DC-DC Converters and Accessory Modules*, click on the link below:

<http://www.vicorpower.com/mmmguide>

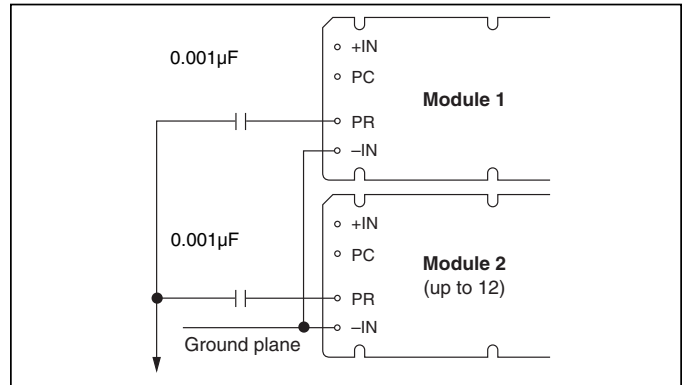


Figure 10 — AC coupled single-wire interface.

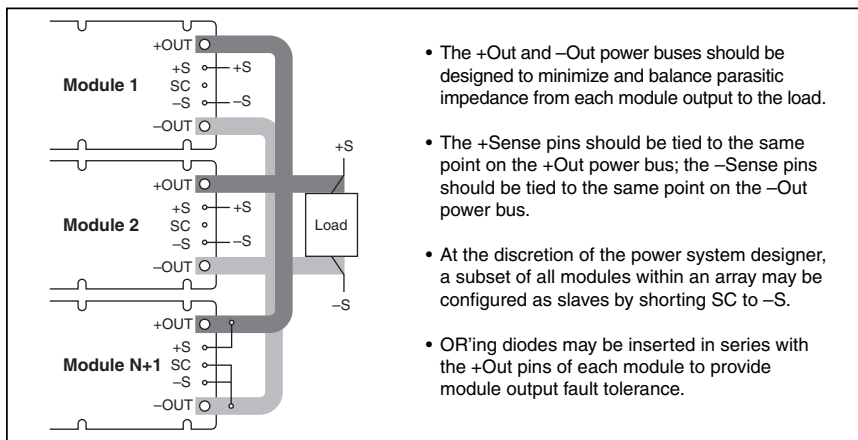


Figure 11 — N+1 module array output connections.

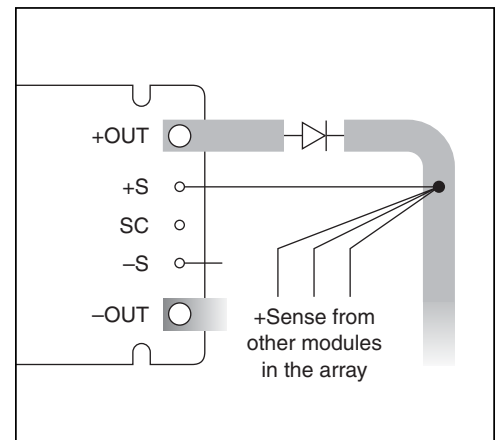


Figure 12 — OR'ing diodes connections.

### ■ PIN STYLES\*

Designator	Description	Notes
(None)	Short Tin/Lead	Requires inboard, mounting
L	Long Tin/Lead	Onboard mounting for 0.065" boards
S	Short ModuMate	SurfMate or inboard socket mounting
N	Long ModuMate	Onboard socket mounting
F	Short RoHS	Select for RoHS compliant inboard solder, socket, or SurfMate mounting
G	Long RoHS	Select for RoHS compliant onboard solder or socket mounting

\* Pin style designator follows the "B" after the output power and precedes the baseplate designator.

Ex. V28A12T200BN2 — Long ModuMate Pins



# MECHANICAL DRAWINGS

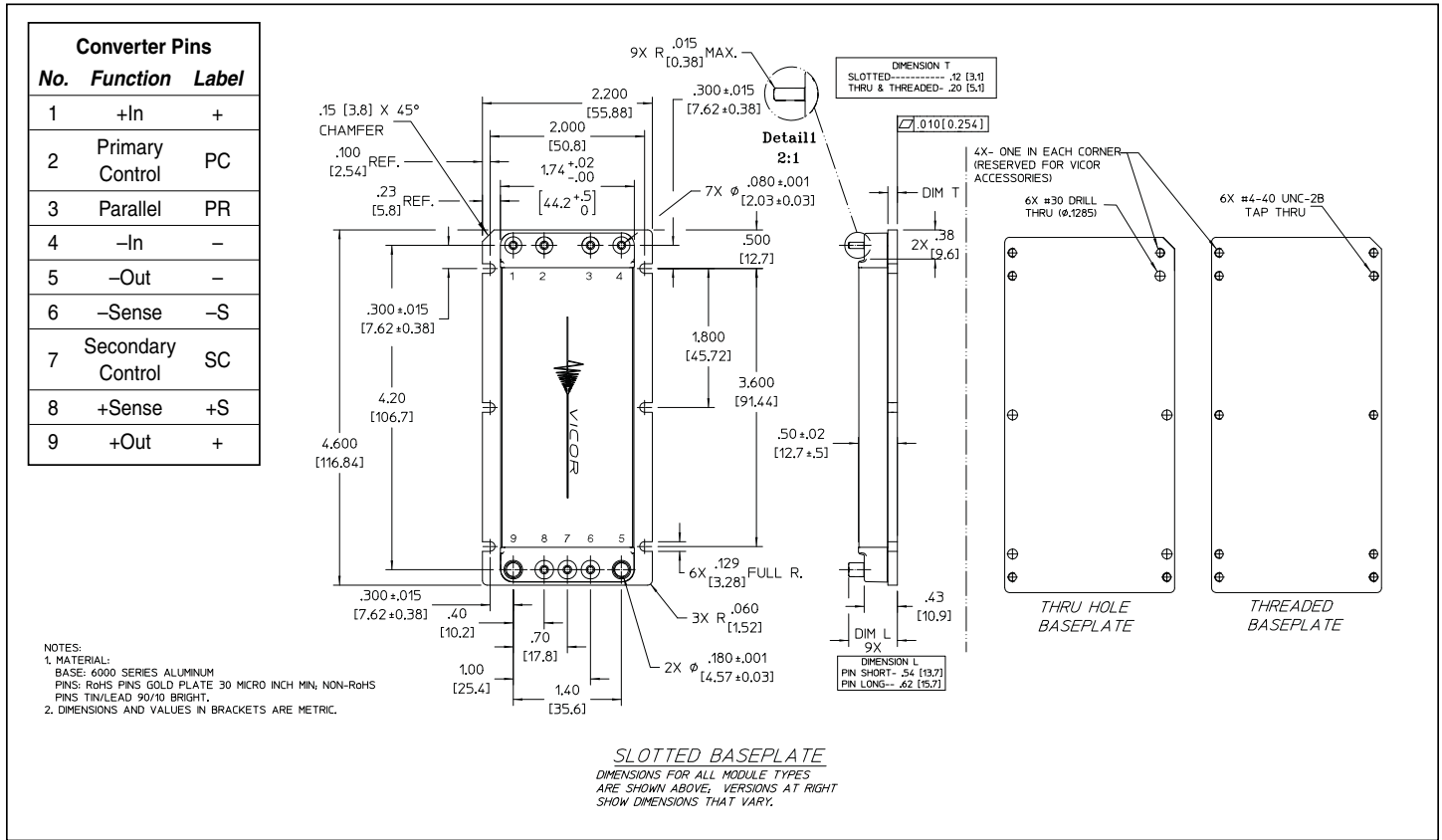


Figure 13 — Module outline

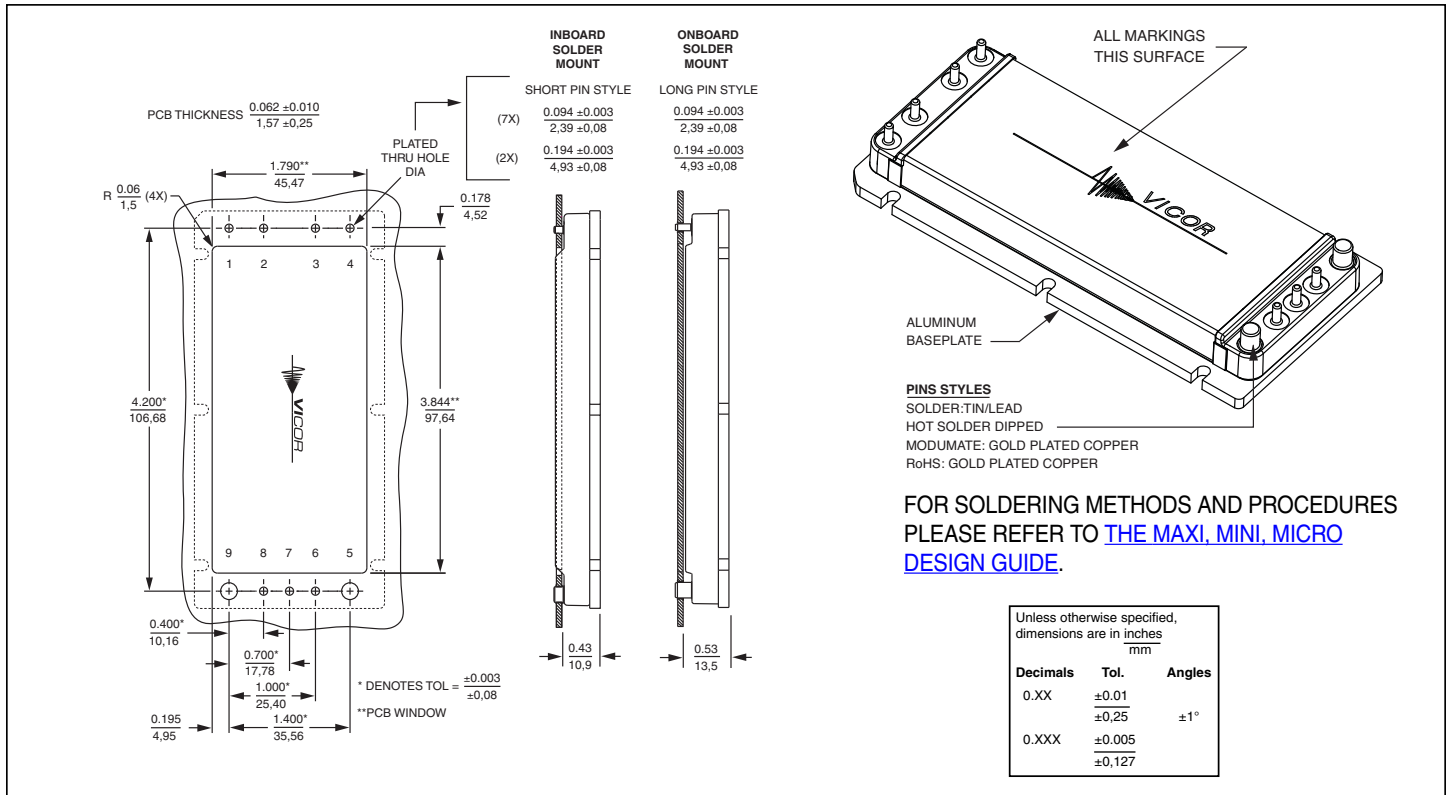


Figure 14 — PCB mounting specifications

## **Warranty**

Vicor products are guaranteed for two years from date of shipment against defects in material or workmanship when in normal use and service. This warranty does not extend to products subjected to misuse, accident, or improper application or maintenance. Vicor shall not be liable for collateral or consequential damage. This warranty is extended to the original purchaser only.

EXCEPT FOR THE FOREGOING EXPRESS WARRANTY, VICOR MAKES NO WARRANTY, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Vicor will repair or replace defective products in accordance with its own best judgement. For service under this warranty, the buyer must contact Vicor to obtain a Return Material Authorization (RMA) number and shipping instructions. Products returned without prior authorization will be returned to the buyer. The buyer will pay all charges incurred in returning the product to the factory. Vicor will pay all reshipment charges if the product was defective within the terms of this warranty.

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## **Vicor's comprehensive line of power solutions includes high density AC-DC and DC-DC modules and accessory components, fully configurable AC-DC and DC-DC power supplies, and complete custom power systems.**

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