

Actual Size:
2.28 x 1.45 x 0.5in
[57,9 x 36,8 x 12,7mm]

VI-ARM™

VI-ARMx1xx
VI-ARMBx2xx

Autoranging Rectifier Modules Up to 1500 Watts

Features & Benefits

- RoHS Compliant (with F or G pin option)
- Autoranging input
- Microprocessor controlled
- VI-ARM-C1:
  - 500W @ 90 – 132V_{AC}
    750W @ 180 – 264V_{AC}
- VI-ARMB-C2:
  - 750W @ 115V_{AC}
    1500W @ 230V_{AC}
- 96 – 98% efficiency
- 100°C baseplate (no de-rating)
- cULus, cTÜVus, CE Marked
- AC Bus OK, module enable
- Inrush limiting (no external circuitry)
- CE Marked

Typical Applications: systems requiring a rugged, full-featured interface to the AC mains in the smallest possible package.

Product Highlights

The ARM (Autoranging Rectifier Module) is an AC front end module which provides autoranging line rectification and inrush current limiting. The ARM is available in either 500/750W or 750/1500W models in a quarter-brick package measuring only 2.28 x 1.45 x 0.5in.

The ARM interfaces directly with worldwide AC mains and may be used with Vicor 300V input DC-DC converters to realize an autoranging, high-density, low-profile switching power supply. The ARM includes a microcontroller that continuously monitors the AC line to control bridge/doubler operation. The user need only provide external capacitance to satisfy system hold-up requirements.

Vicor Micro series packaging technology offers flexible mounting options for various manufacturing processes. The ARM may be installed as a conventional leaded device for on-board applications, in-board for low-profile, height-restricted applications, socketed or surface mounted with optional ModuMate interconnect products.

Absolute Maximum Ratings

Parameter	Rating	Unit	Notes
L to N	264	V_{AC}	
	280	V_{AC}	100ms
+OUT to –OUT	400	V_{DC}	
B OK to –OUT	16	V_{DC}	
EN to –OUT	16	V_{DC}	
Output power			
VI-ARM	500/750	Watts	115/230V
VI-ARMB	750/1500	Watts	115/230V See page 3 for de-rating
Mounting torque	4 – 6 [0.45 – 0.68]	in·lbs [N·m]	6 each, 4-40 screw
Operating temperature	–40 to +100	°C	H-Grade
Storage temperature	–55 to +125	°C	H-Grade
Pin soldering temperature	500 [260]	°F [°C]	<5sec; wave solder
	750 [390]	°F [°C]	<7sec; hand solder

Thermal Resistance Capacity

Parameter	Min	Typ	Max	Unit
Baseplate to sink				
flat, greased surface		0.24		°C/Watt
with thermal pad (P/N 16495)		0.3		°C/Watt
Baseplate to ambient				
free convection		15		°C/Watt
1000LFM		2.7		°C/Watt
Thermal capacity		48		Watt-sec/°C

Part Numbering

VI-ARM	-	**C**	**1**	**2**		**3**
VI-ARMB	-	**C**	**2**	**1**		

Product

Product Grade Temperatures (°C)

Grade		Operating	Storage
E	=	–10 to +100	–40 to +125
C	=	–20 to +100	–40 to +125
T	=	–40 to +100	–40 to +125
H	=	–40 to +100	–55 to +125

Pin Style
1 = Short
2 = Long
S = Short Modumate [a]
N = Long Modumate [a]
F = Short RoHS [a]
G = Long RoHS [a]
K = Extra Long RoHS [b]

Baseplate
Blank = Slotted
2 = Threaded
3 = Through hole

[a] Pin styles S, N, F & G are compatible with the ModuMate interconnect system for socketing and surface mounting
[b] Not intended for socket or Surfmate mounting

Note: Product images may not highlight current product markings.

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. Specifications apply for AC mains having up to 5% total harmonic distortion.

Input Specifications

	VI-ARM - 1			VI-ARMB - 2				
Parameter	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
Operating input voltage	90		132	90		132	V_{AC}	Autoranging (doubler mode)
	180		264	180		264	V_{AC}	Autoranging (bridge mode)
Input undervoltage			90			90	V_{AC}	No damage
Input surge withstand			280			280	V_{AC}	100ms
AC line frequency	47		63	47		63	Hz	C, E-Grade
	47		880	47		880	Hz	T & H-Grade
Input current, RMS	0		7.4	0		11.1	Amps	$120V_{AC}$
	0		5.4	0		7.2	Amps	$240V_{AC}$
Power factor		0.60			0.60			Dependent on line source impedence, hold-up capacitance, and load
Inrush current			30			30	Amps	$264V_{AC}$ peak line, cold start
Hold-up Capacitance			1600			2400	µF	

Output Specifications

	VI-ARM - 1			VI-ARMB - 2				
Parameter	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
Output power	0		500	0		750	Watts	$105 – 132V_{AC}$ (Figure 1)
	0		750	0		1500	Watts	$210 – 264V_{AC}$ (Figure 2)
Efficiency								
$120V_{AC}$	94	96		94	96		%	
240 V_{AC}	96	98		96	98		%	
Output voltage	200		375	200		375	V_{DC}	$90 – 264V_{AC}$

Control Pin Specifications

Parameter	**Min**	**Typ**	**Max**	**Unit**	**Notes**
AC Bus OK (B OK)					
On-state resistance (low)			15	Ω	To negative output - bus normal
On-state current (low)			–50	mA	Bus normal
Off-state voltage	12	14	16	V_{DC}	Bus abnormal, 27kΩ internal pull up to $15V_{DC}$ (Figure 12)
On-state threshold	235	240	245	V_{DC}	Output bus voltage
Off-state threshold	200	205	210	V_{DC}	Output bus voltage
Module Enable (EN)					
On-state resistance (low)			15	Ω	To negative output - converters are disabled
On-state current (low)			50	mA	
Off-state voltage	12	14	16	V_{DC}	150kΩ internal pull up to $15V_{DC}$ (Figure 11)
On-state threshold	235	240	245	V_{DC}	Output bus voltage
Off-state threshold	185	190	195	V_{DC}	Output bus voltage
Overvoltage shut down	380	390	400	V_{DC}	
AC Bus OK - module enable, differential error*	12	14	16	V_{DC}	AC Bus OK and module enable thresholds track

* Tracking error between BUS OK and Enable thresholds

Electrical Characteristics (Cont.)

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. Specifications apply for AC mains having up to 5% total harmonic distortion.

Safety Specifications

Parameter	Min	Typ	Max	Unit	Notes
Isolation voltage (IN to OUT)		None			Isolation provided by DC-DC converter(s)
Dielectric withstand (I/O to baseplate)	1,500			V_{RMS}	
Leakage current			100	µA	No filter

Agency Approvals

Safety Standards	Agency Markings	Notes
ARM1 xxx UL60950, EN60950, CSA 60950	cTÜVus	Baseplate earthed, fast acting line fuse, Bussman ABC10
	CE Marked	Low voltage directive
ARM2 xxx UL60950, EN60950, CSA 60950	cTÜVus	Baseplate earthed, fast acting line fuse, Bussman ABC15
	CE Marked	Low voltage directive

General Specifications

Parameter	Min	Typ	Max	Unit	Notes
MTBF		>1,000,000		hours	25˚C, ground benign
Baseplate material					Aluminum
Cover					Kapton insulated aluminum, plastic molded terminal blocks
Pin material					Copper, tin/lead solder dipped (solder pins) Gold plated nickel copper (Modumate and RoHS)
Weight		1.6 [45]		ounces [grams]	
Size		2.28 x 1.45 x 0.5 [57,9 x 36,8 x 12,7]		inches [mm]	

VI-ARMB De-Rating

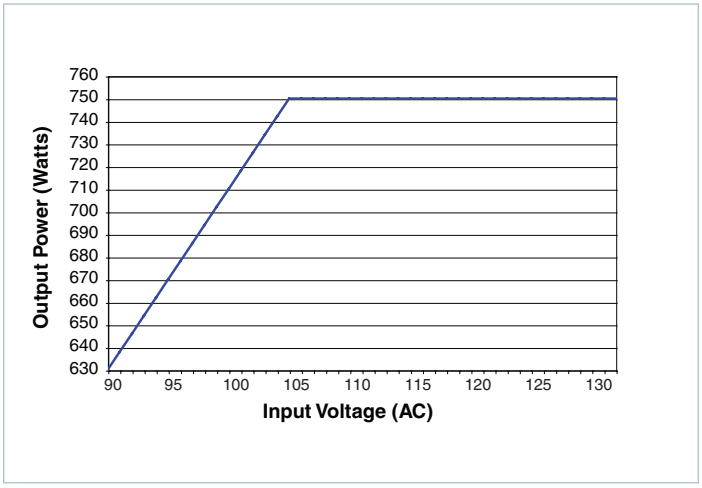


Figure 1 — *90 – 130V_{AC} ARMB output power rating*

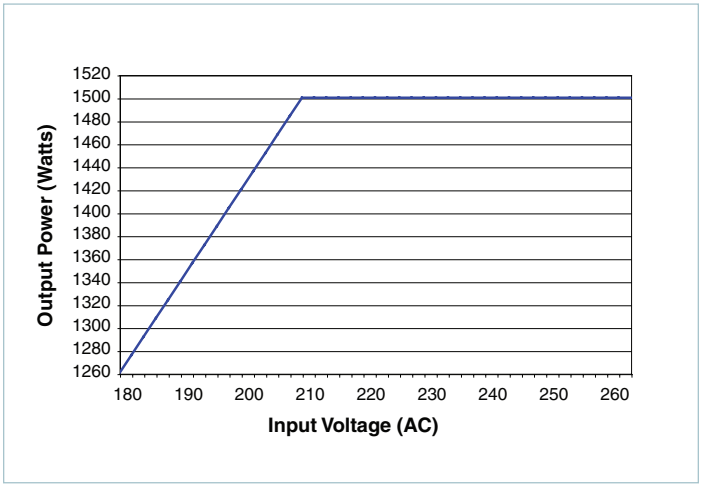


Figure 2 — *180 – 260V_{AC} ARMB output power rating*

Operating Characteristics

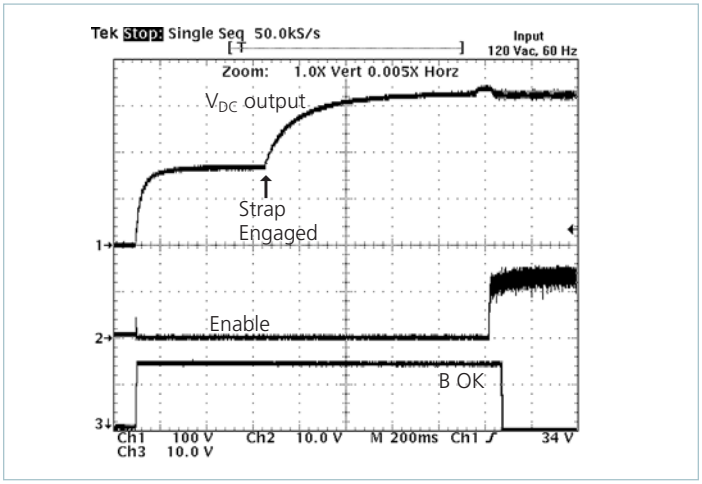


Figure 3 — *Start up at $120V_{AC}$ input*

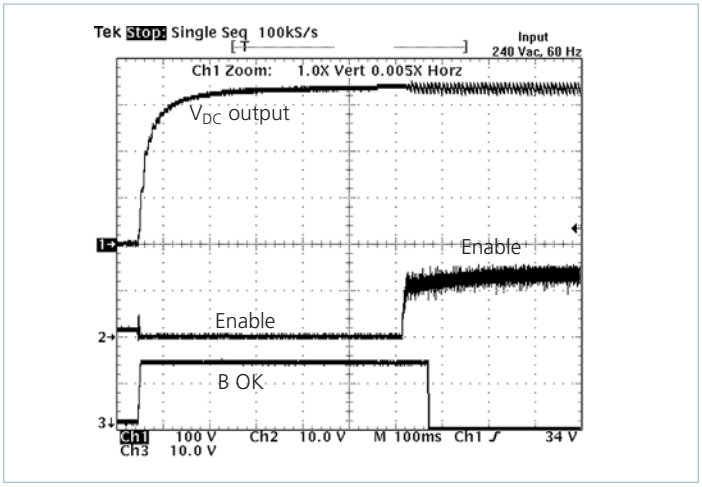


Figure 4 — *Start up at $240V_{AC}$ input*

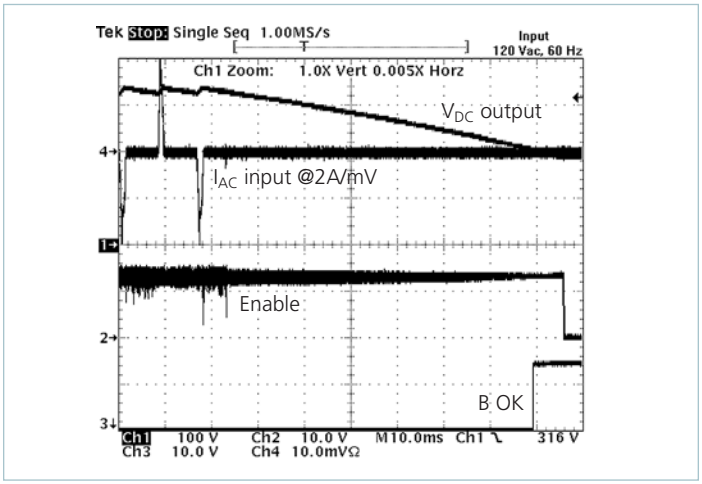


Figure 5 — *Power down, from $120V_{AC}$*

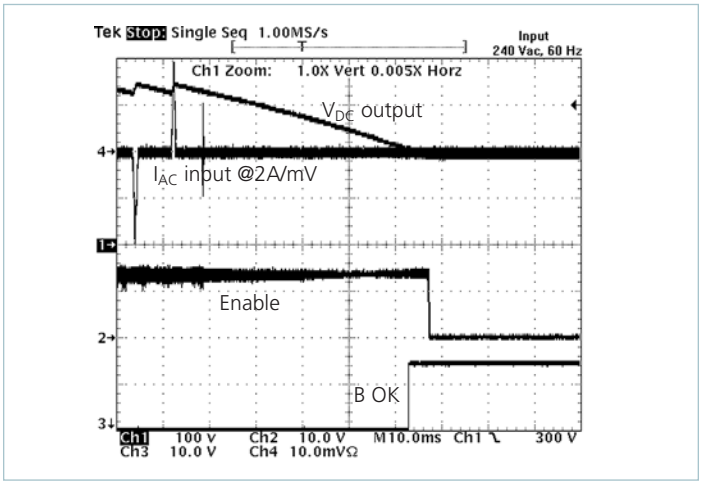


Figure 6 — *Power down, from $240V_{AC}$*

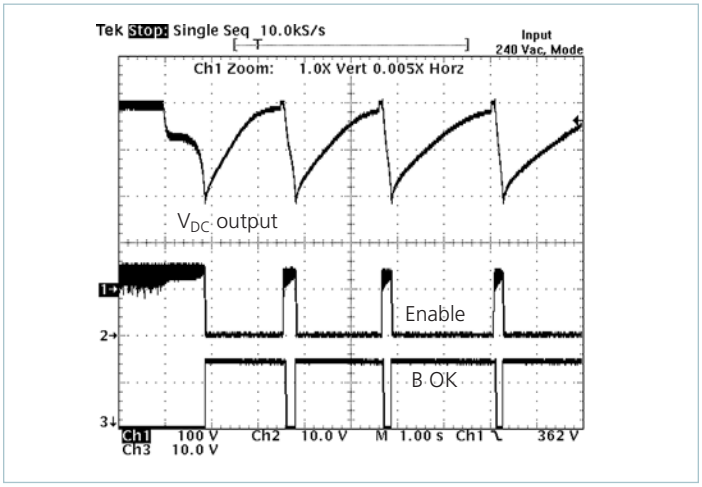


Figure 7 — *Output overvoltage protection $240V_{AC}$ range*

Application Note

The VI-ARM Autoranging Rectifier Module (ARM) provides an effective solution for the AC front end of a power supply designed with Vicor DC-DC converters. This high-performance power system building block satisfies a broad spectrum of requirements and agency standards.

The ARM contains all of the power switching and control circuitry necessary for autoranging rectification, inrush current limiting, and overvoltage protection. This module also provides converter enable and status functions for orderly power up/down control or sequencing. To complete the AC front-end configuration, the user needs only to add hold-up capacitors and a suitable input filter with transient protection.

Functional Description

Initial Conditions: The switch that bypasses the inrush limiting PTC (positive temperature coefficient) thermistor is open when power is applied, as is the switch that engages the strap for voltage doubling (see Figure 8). In addition, the downstream DC-DC modules are disabled via the Enable (EN) line, and Bus-OK (B OK) is high.

Power-Up Sequence (see Figure 9):

1.1. Upon application of input power, the output bus capacitors begin to charge. The thermistor limits the charge current, and the exponential time constant is determined by the hold-up capacitor value and the thermistor cold resistance. The slope (dV/dt) of the capacitor voltage approaches zero as the capacitors become charged to the peak of the AC line voltage.

2.1. If the bus voltage is less than 200V as the slope nears zero, the voltage doubler is activated, and the bus voltage climbs exponentially to twice the peak line voltage. If the bus voltage is greater than 200V, the doubler is not activated.

3.1. If the bus voltage is greater than 235V as the slope approaches zero, the inrush limiting thermistor is bypassed. Below 235V, the thermistor is not bypassed.

4.1. The converters are enabled ~150 milliseconds after the thermistor bypass switch is closed.

5.1. Bus-OK is asserted after an additional ~150 millisecond delay to allow the converter outputs to settle within specification.

Power-Down Sequence: (see Figure 9). When input power is turned off or fails, the following sequence occurs as the bus voltage decays:

1.2. Bus-OK is deasserted when the bus voltage falls below $205V_{DC}$ (Typ).

2.2. The converters are disabled when the bus voltage falls below $200V_{DC}$. If power is reapplied after the converters are disabled, the entire power-up sequence is repeated. If a momentary power interruption occurs and power is reestablished before the bus reaches the disable threshold, the power-up sequence is not repeated.

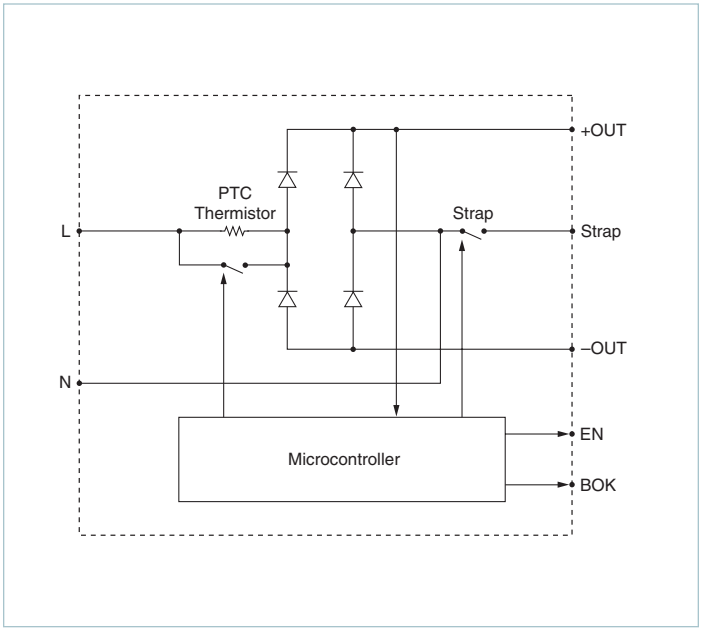


Figure 8 — *Functional block diagram*

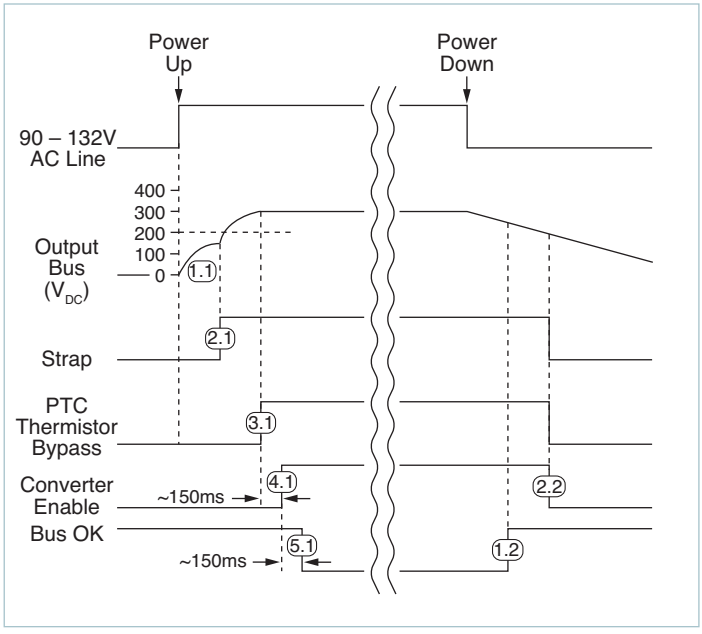


Figure 9 — *Timing diagram: power up/down sequence*

Application Note (Cont.)

Off-Line Power Supply Configuration

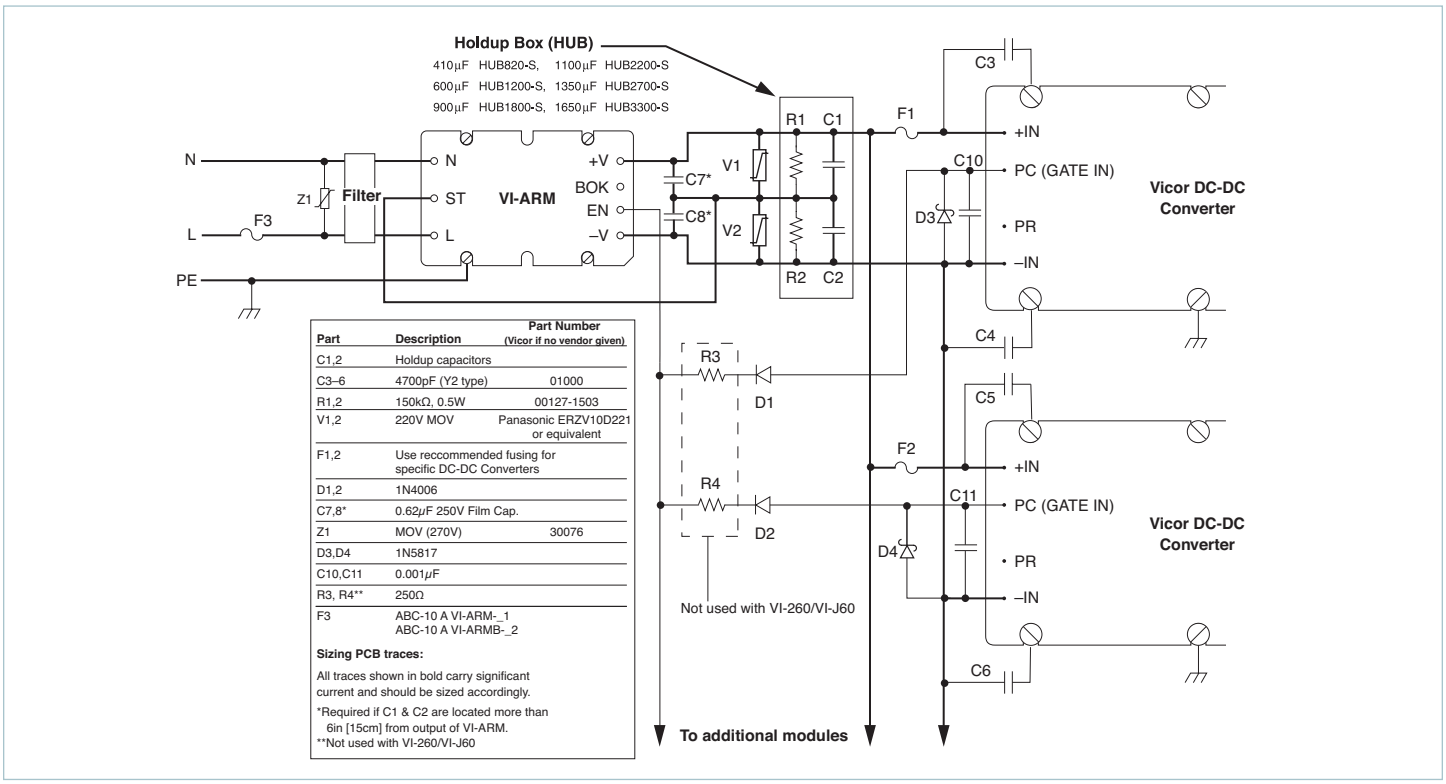
The ARM maintains the DC output bus voltage between 200 and 375V_{DC} over the entire universal input range, this being compatible with Vicor VI-260 series and VI-J60 series DC-DC converters, as well as Vicors Maxi, Mini, Micro 300V input Vicor converters. The ARM automatically switches to the proper rectification mode (doubled or undoubled) depending on the input voltage, eliminating the possibility of damage due to improper line connection. The VI-ARM-x1 is rated at 500W in the low range (90 – 132V_{AC} input), and 750W in the high range (180 – 264V_{AC} input). The VI-ARMB-x2 is rated for 750W and 1500W for the low and high input ranges respectively. Either of these modules can serve as the AC front end for any number and combination of compatible converters as long as the maximum power rating is not exceeded. See VI-ARMB de-rating curves. (Figures 1, and 2)

Strap (ST) Pin: In addition to input and output power pin connections, it is necessary to connect the Strap pin to the junction of the series hold-up capacitors (C1, C2, Figure 10) for proper (autoranging) operation. Varistors across the capacitors provide input transient protection. The bleeder resistors (R1, R2, Figure 10) discharge the hold-up capacitors when power is switched off.

Enable (EN) Pin: (see Figure 11) The Enable pin must be connected to the GATE-IN or PC pin of all converter modules to disable the converters during power-up. Otherwise, the converters would attempt to start while the hold-up capacitors were being charged through an un-bypassed thermistor, preventing the bus voltage from reaching the thermistor bypass threshold thus disabling the power supply. The Enable output (the drain of an N channel MOSFET) is internally pulled up to 15V through a 150kΩ resistor.

A signal diode should be placed close to and in series with the PC/GATE-IN pin of each converter to eliminate the possibility of control interference between converters. The Enable pin switches to the high state (15V) with respect to the negative output power pin to turn on the converters after the power-up inrush is over. The Enable function also provides input overvoltage protection for the converters by turning off the converters if the DC bus voltage exceeds 400V_{DC}. The thermistor bypass switch opens if this condition occurs, placing the thermistor in series with the input voltage, which reduces the bus voltage to a safe level while limiting input current in case the varistors conduct. The thermistor bypass switch also opens if a fault or overload reduces the bus voltage to less than 180V_{DC}.

CAUTION: There is no input-to-output isolation in the ARM, hence the –OUT of the ARM and thus the –IN of the downstream DC-DC converter(s) are at a high potential. If it is necessary to provide an external enable/disable function by controlling the DC-DC converter's PC pin (referenced to the –IN) of the converter an opto-isolator or isolated relay should be employed.



Part	Description	Part Number (Vicor if no vendor given)
C1,2	Holdup capacitors	
C3–6	4700pF (Y2 type)	01000
R1,2	150kΩ, 0.5W	00127-1503
V1,2	220V MOV	Panasonic ERZV10D221 or equivalent
F1,2	Use reccommended fusing for specific DC-DC Converters	
D1,2	1N4006	
C7,8*	0.62µF 250V Film Cap.	
Z1	MOV (270V)	30076
D3,D4	1N5817	
C10,C11	0.001µF	
R3, R4**	250Ω	
F3	ABC-10 A VI-ARM-_1 ABC-10 A VI-ARMB-_2	

Sizing PCB traces:

All traces shown in bold carry significant current and should be sized accordingly.

*Required if C1 & C2 are located more than 6in [15cm] from output of VI-ARM.

**Not used with VI-260/VI-J60

Figure 10 — *Converter connections*

Application Note (Cont.)

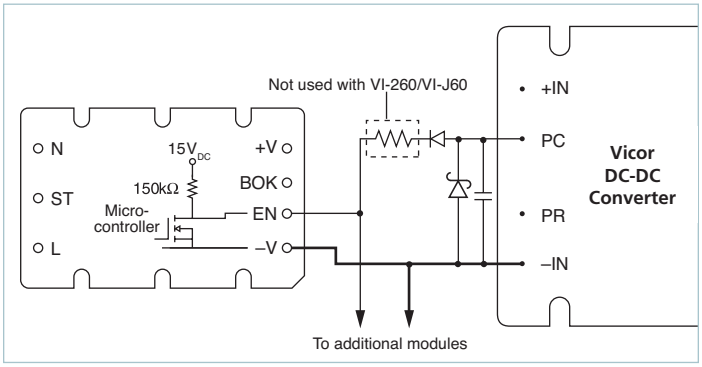


Figure 11 — *Enable (EN) function; see Figure 8 for details*

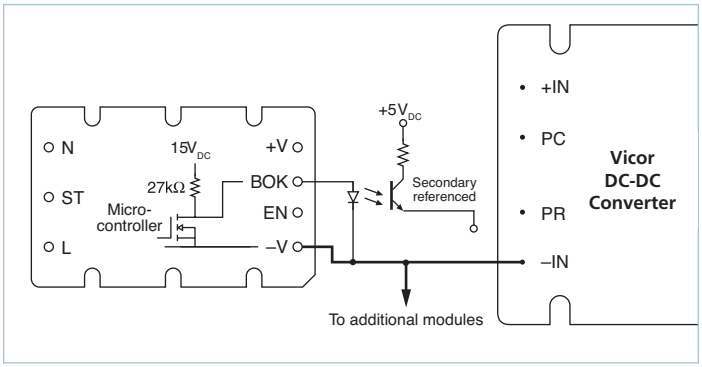
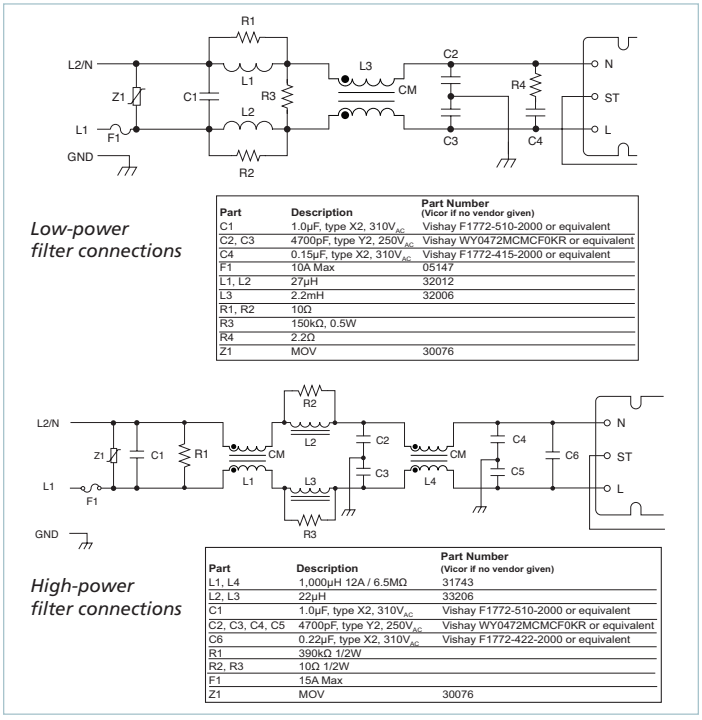


Figure 12 — *Bus OK (B OK) isolated power status indicator*



Low-power filter connections

Part	Description	Part Number (Vicor if no vendor given)
C1	1.0µF, type X2, 310V$_{AC}$	Vishay F1772-510-2000 or equivalent
C2, C3	4700pF, type Y2, 250V$_{AC}$	Vishay WY0472MCMCF0KR or equivalent
C4	0.15µF, type X2, 310V$_{AC}$	Vishay F1772-415-2000 or equivalent
F1	10A Max	05147
L1, L2	27µH	32012
L3	2.2mH	32006
R1, R2	10Ω	
R3	150kΩ, 0.5W	
R4	2.2Ω	
Z1	MOV	30076

High-power filter connections

Part	Description	Part Number (Vicor if no vendor given)
L1, L4	1,000µH 12A / 6.5MΩ	31743
L2, L3	22µH	33206
C1	1.0µF, type X2, 310V$_{AC}$	Vishay F1772-510-2000 or equivalent
C2, C3, C4, C5	4700pF, type Y2, 250V$_{AC}$	Vishay WY0472MCMCF0KR or equivalent
C6	0.22µF, type X2, 310V$_{AC}$	Vishay F1772-422-2000 or equivalent
R1	390kΩ 1/2W	
R2, R3	10Ω 1/2W	
F1	15A Max	
Z1	MOV	30076

Figure 13 — *Filter connections*

Bus-OK (B OK) Pin: (see Figure 12) The Bus-OK pin is intended to provide early-warning power fail information and is also referenced to the negative output pin.

Caution: There is no input-to-output isolation in the ARM. It is necessary to monitor Bus-OK via an optoisolator if it is to be used on the secondary (output) side of the converters. A line isolation transformer should be used when performing scope measurements. Scope probes should never be applied simultaneously to the input and output as this will destroy the module.

Filter: Two input filter recommendations are shown for low-power VI-ARM-x1 and high-power VI-ARMB-x2 (see Figure 13). Both filter configurations provide sufficient common mode and differential mode insertion loss in the frequency range between 100kHz and 30MHz to comply with the Level B conducted emissions limit.

Hold-Up Capacitors: Hold-up capacitor values should be determined according to output bus voltage ripple, power fail hold-up time, and ride-through time (see Figure 14). Many applications require the power supply to maintain output regulation during a momentary power failure of specified duration, i.e., the converters must hold-up or ride-through such an event while maintaining undisturbed output voltage regulation. Similarly, many of these same systems require notification of an impending power failure in order to allow time to perform an orderly shut down.

The energy stored on a capacitor which has been charged to voltage V is:

$$\varepsilon = 1/2(CV^2) \qquad (1)$$

Where: ε = *stored energy*
C = *capacitance*
V = *voltage across the capacitor*

Energy is given up by the capacitors as they are discharged by the converters. The energy expended (the power-time product) is:

$$\varepsilon = P\Delta t = C(V_1^2 - V_2^2) / 2 \qquad (2)$$

Where: P = *operating power*
Δt = *discharge interval*
V_1 = *capacitor voltage at the beginning of* Δt
V_2 = *capacitor voltage at the end of* Δt

Rearranging Equation 2 to solve for the required capacitance:

$$C = 2P\Delta t / (V_1^2 - V_2^2) \qquad (3)$$

Application Note (Cont.)

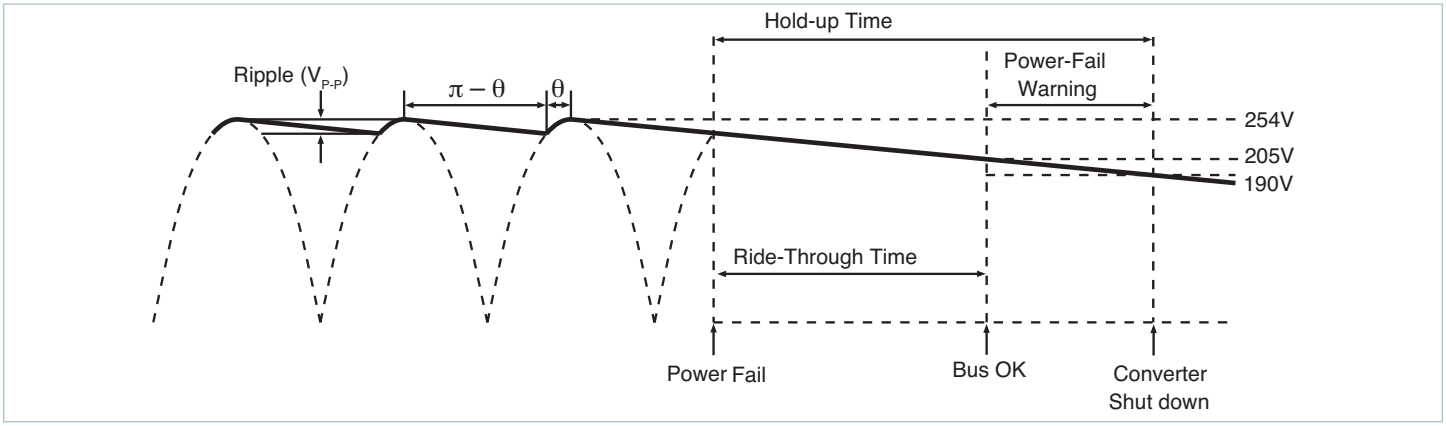


Figure 14 — *Hold-up time*

The power fail warning time (Δt) is defined as the interval between (B OK) and converter shut down (EN) as illustrated in Figure 12. The Bus-OK and Enable thresholds are 205V and 190V, respectively. A simplified relationship between power fail warning time, operating power, and bus capacitance is obtained by inserting these constants:

$$C = 2P\Delta t / (205^2 - 190^2)$$

$$C = 2P\Delta t / (5{,}925)$$

It should be noted that the series combination (C1, C2, Figure 10) requires each capacitor to be twice the calculated value, but the required voltage rating is reduced to 200V.

Allowable ripple voltage on the bus (or ripple current in the capacitors) may define the capacitance requirement. Consideration should be given to converter ripple rejection and resulting output ripple voltage.

For example, a converter whose output is 15V and nominal input is 300V will provide 56dB ripple rejection, i.e., $10V_{P-P}$ of input ripple will produce $15mV_{P-P}$ of output ripple (see Figure 18). Equation 3 is again used to determine the required capacitance.
In this case, V1 and V2 are the instantaneous values of bus voltage at the peaks and valleys (see Figure 14) of the ripple, respectively. The capacitors must hold up the bus voltage for the time interval (Δt) between peaks of the rectified line as given by:

$$\Delta t = (\pi - \theta) / 2\pi f \qquad (4)$$

Where: f = *line frequency*
θ = *rectifier conduction angle*

The approximate conduction angle is given by:

$$\theta = Cos^{-1} V_2 / V_1 \qquad (5)$$

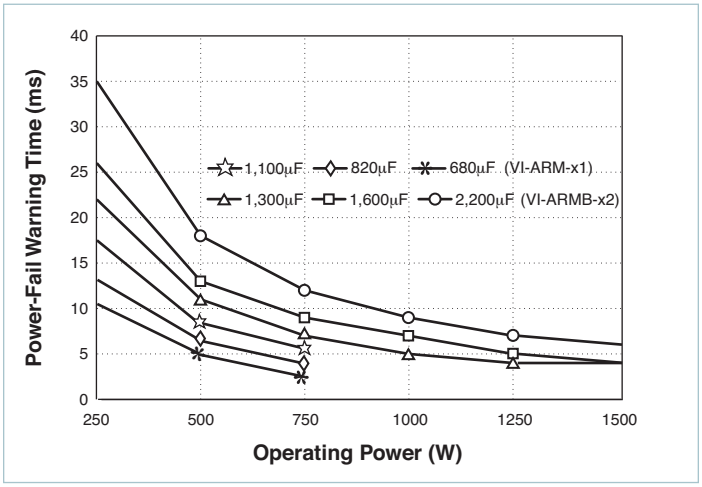


Figure 15 — *Power fail warning time vs. operating power and total bus capacitance, series combination of C1, C2 (see Figure 10)*

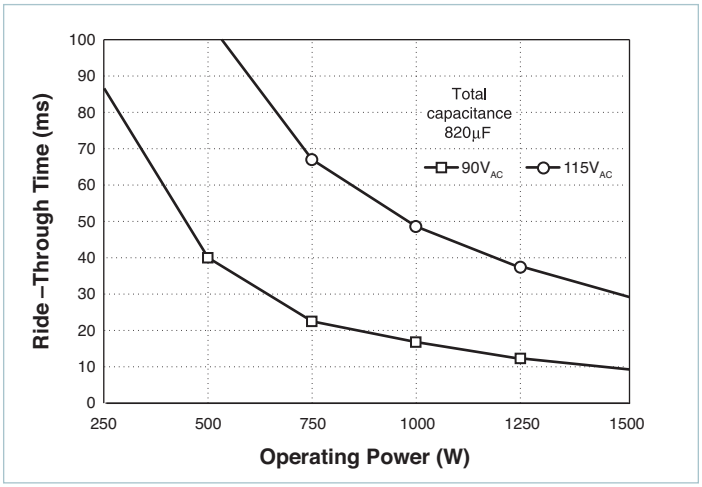


Figure 16 — *Ride-through time vs. operating power*

Application Note (Cont.)

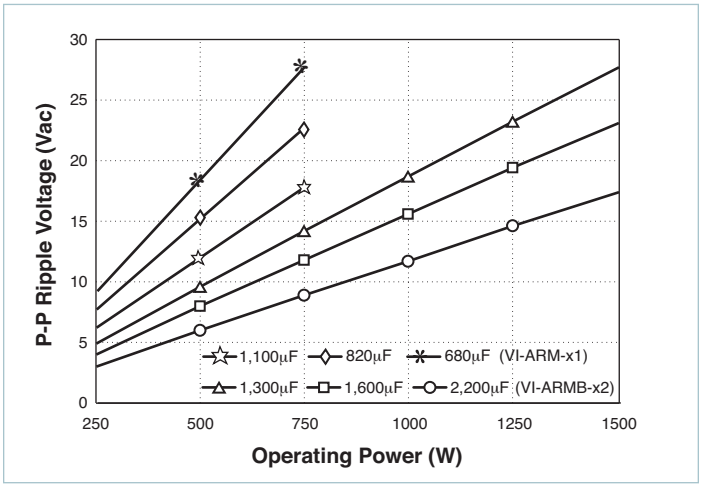


Figure 17 — *Ripple voltage vs. operating power and bus capacitance, series combination of C1, C2 (see Figure 10)*

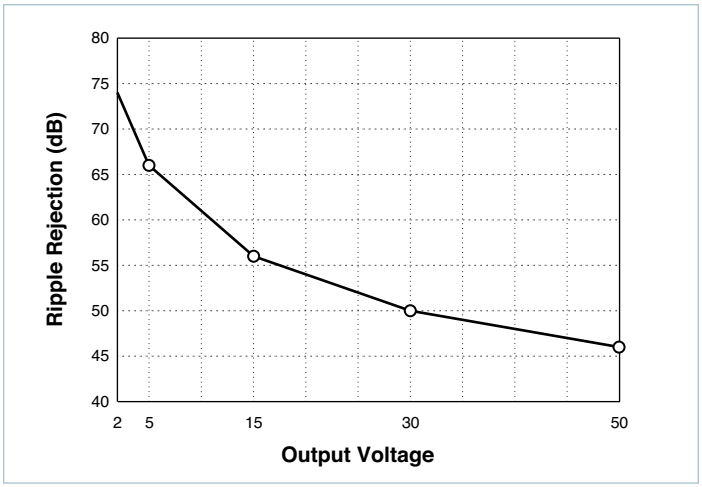


Figure 18 — *Converter ripple rejection vs. output voltage (typical)*

Another consideration in hold-up capacitor selection is their ripple current rating. The capacitors' rating must be higher than the maximum operating ripple current. The approximate operating ripple current (RMS) is given by:

$$I_{RMS} = 2P/V_{AC} \qquad (6)$$

Where: P = *operating power level*
V_{AC} = *operating line voltage*

Calculated values of bus capacitance for various hold-up time, ride-through time, and ripple voltage requirements are given as a function of operating power level in Figures 15, 16 and 17, respectively.

Example

In this example, the output required at the point of load is $12V_{DC}$ at 320W. Therefore, the output power from the ARM would be 375W (assuming a converter efficiency of 85%). The desired hold-up time is 9ms over an input range of 90 to $264V_{AC}$.

Determining Required Capacitance for Power Fail Warning: Figure 15 is used to determine hold-up capacitance for a given power fail warning time and power level, and shows that the total bus capacitance must be at least 820µF. Since two capacitors are used in series, each capacitor must be at least 1,640µF.

Note: The warning time is not dependent on line voltage. A hold-up capacitor calculator is available on the Vicor website, at vicorpower.com/hubcalc.

Determining Ride-through Time: Figure 16 illustrates ride-through time as a function of line voltage and output power, and shows that at a nominal line of $115V_{AC}$, ride-through would be 68ms. Ride-through time is a function of line voltage.

Determining Ripple Voltage on the Hold-up Capacitors: Figure 17 is used to determine ripple voltage as a function of operating power and bus capacitance, and shows that the ripple voltage across the hold-up capacitors will be $12V_{AC}$.

Determining the Ripple on the Output of the DC-DC Converter: Figure 18 is used to determine the ripple rejection of the DC-DC converter and indicates a ripple rejection of approximately 60dB for a 12 Volt output. If the ripple on the bus voltage is $12V_{AC}$ and the ripple rejection of the converter is 60dB, the output ripple of the converter due to ripple on its input (primarily 120Hz) will be $12mV_{P-P}$.

Note: Maxi, Mini, Micro converters have greater ripple rejection then either VI-200s or VI-J00s.

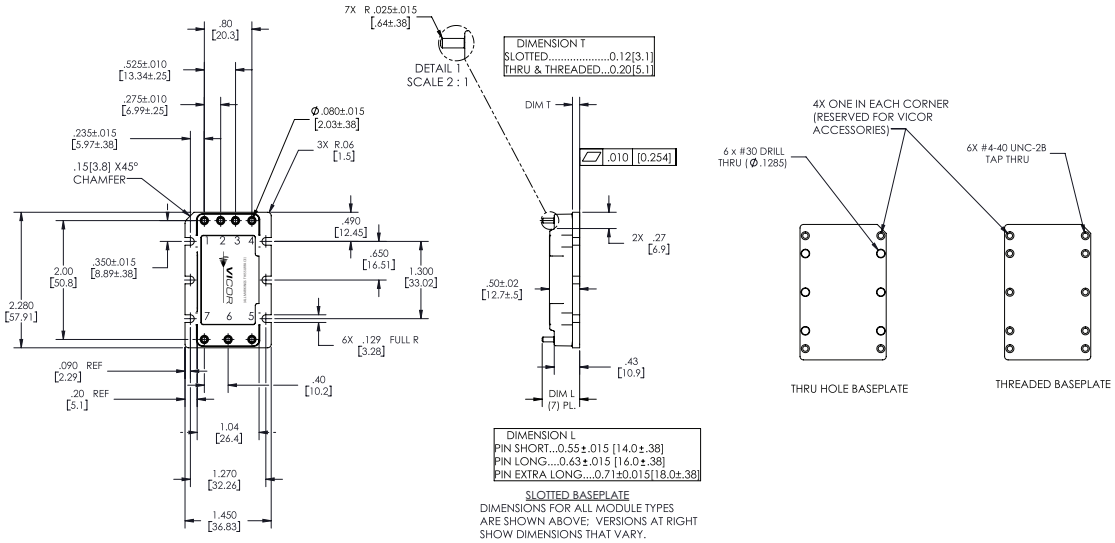
For more information about designing an autoranging AC input power supply using the ARM and Vicor DC-DC converter modules, contact Vicor Applications Engineering at the nearest Vicor Technical Support Center (see back cover), or send an E-mail to: apps@vicorpower.com.

Storage

Vicor products, when not installed in customer units, should be stored in ESD safe packaging in accordance with ANSI/ESD S20.20, "Protection of Electrical and Electronic Parts, Assemblies and Equipment" and should be maintained in a temperature controlled factory/ warehouse environment not exposed to outside elements controlled between the temperature ranges of 15°C and 38°C. Humidity shall not be condensing, no minimum humidity when stored in an ESD compliant package.

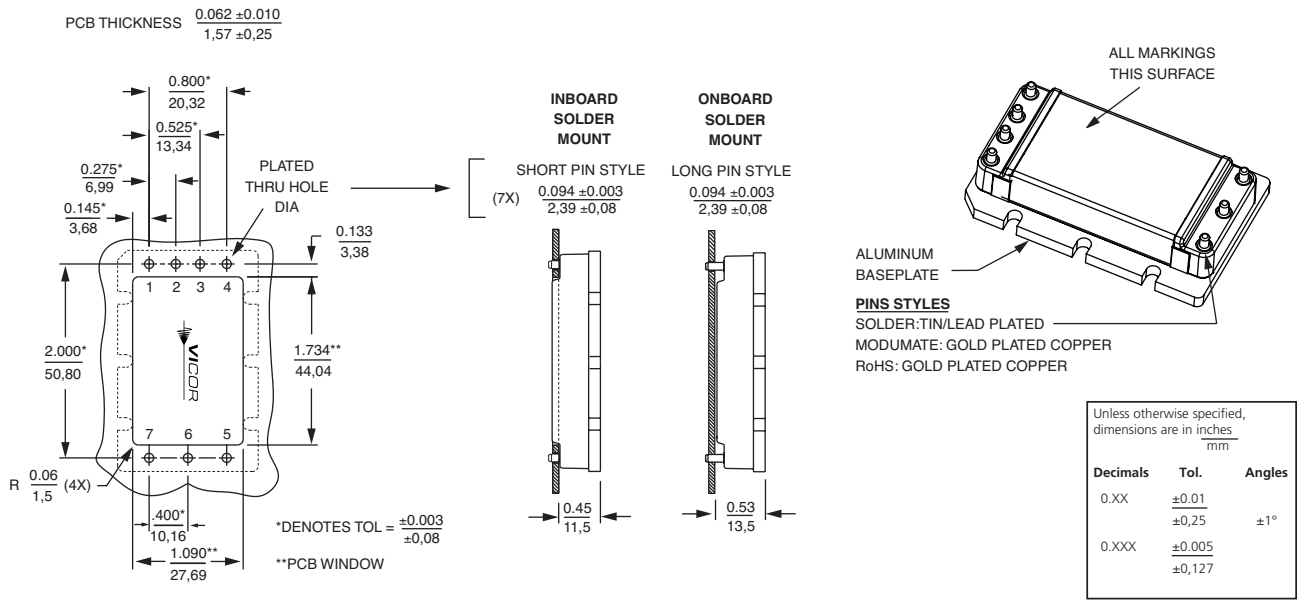
Mechanical Drawings

Converter Pins		
No.	*Function*	*Label*
1	–OUT	–V
2	Enable	EN
3	Bus OK	B OK
4	+OUT	+V
5	Neutral	N
6	Strap	ST
7	Line	L



NOTES:
1. MATERIAL:
   BASE: 6000 SERIES ALUMINUM
   PIN PLATING: NICKEL BARRIER FOLLOWED BY
   (RoHS PINS) GOLD PLATE (30 MICRO INCH MIN); OR PALLADIUM (35 UIN MIN), FOLLOWED BY 3 TO 5 UIN GOLD.
   (NON-RoHS PINS) TIN/LEAD 90/10 BRIGHT
2. DIMENSIONS AND VALUES IN BRACKETS ARE METRIC
3. MANUFACTURING CONTROL IS IN PLACE TO ENSURE THAT THE SPACING BETWEEN THE MODULES LABEL SURFACE TO THE PRINTED CIRCUIT BOARD OF THE APPLICATION RANGES FROM DIRECT CONTACT (ZERO), TO THE MAXIMUM GAP AS CALCULATED FROM THE TOLERANCE STACK-UP AND IS NOT SUBJECT NEGATIVE TOLERANCE ACCUMULATION

Module outline



PCB mounting specifications

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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