Data Sheet
VI-HAM™
High-Boost Harmonic Attenuation Module

Features
- 675 Watts output power
- Unity power factor
- 85 – 264 Vac universal input
- Meets EN61000-3-2
- Short circuit protection
- Input surge limiting
- High efficiency

Product Overview
The high-boost HAM (Harmonic Attenuator Module) is a universal AC input, PFC front-end module that has been optimized for use with Vicor's V375 series of DC-DC converters.

A single high-boost HAM may be used with any combination of V375 series DC-DC converters which are available in quarter, half and full brick packages with up to 600 Watts of output power. Versions without internal diode bridges (HAMD and BAMD) can be operated in parallel to provide power expansion capability. The combination of the high-boost HAM with V375 DC-DC converters results in a power conversion system with twice the power density, fewer components and lower cost compared to previous HAM-based solutions.

In addition, the high-boost HAM is fully compatible with Vicor's VI-26x and VI-J6x series DC-DC converters. This gives designers the freedom to choose from the industry's broadest selection of DC-DC converters with outputs from 2 to 95 Vdc, 50 – 600 Watts. The user need only provide external hold-up capacitors, a few discrete components, and a line filter (available from Vicor).

4.6 x 2.4 x 0.5 in
(116,8 x 61,0 x 12,7 mm)

Absolute Maximum Ratings

Parameter	Rating	Unit	Notes
L to N voltage	265	Vac	Continuous
L to N voltage	280	Vac	100 ms
Output power	750	Watts	
Mounting torque	5 (0.57)	in - lbs (N-m)	# 6-32 or m3.5
Pin soldering temperature	750 (400)	°F (°C)	
Baseplate temperature	85	°C	
Auxiliary output	3	mA	

Part Numbering

VI-HAM - **C** **L**

Product Type

VI-HAM= Hamonic Attenuator Module
*VI-HAM**D**= Hamonic Attenuator Module **Driver***
*VI-**B**AM**D**= Hamonic Attenuator Module **Booster***

(VI-HAMD and VI-BAMD can be used in parrallel or in arrays for applications that require more than the power available from a single VI-HAM)

Product Grade

E = –10°C to +85°C
C = –20°C to +85°C
I = –40°C to +85°C
M = –55°C to +85°C

Output

L = 675 W

ELECTRICAL CHARACTERISTICS

Electrical characteristics apply at the nominal value of input voltage, output load and baseplate temperature, unless otherwise specified. All temperatures refer to the operating temperature of the baseplate. Specifications apply for AC mains having no more than 5% total harmonic distortion.

■ INPUT SPECIFICATIONS (HAM-xL, HAMD-xL, BAMD-xL)

Parameter	Min	Typ	Max	Unit	Notes
Operating input voltage HAM, HAMD, BAMD	85		264	Vac	Rectified AC for HAMD, BAMD
AC line frequency	47		63	Hz	Unit will operate from 400 Hz but may not meet PF or THD specs
Power factor	0.99				
Total harmonic distortion (line current)			7.5	%	Sinusoidal, 115 Vac, full load
Total harmonic distortion (line current)			8.5	%	Sinusoidal, 230 Vac, full load
Inrush current			20	Amps	230 Vac, full load

■ OUTPUT SPECIFICATIONS

Parameter	Min	Typ	Max	Unit	Notes
Maximum output power	675			Watts	See power derating graph, Fig.3
Output voltage	278 360	280 365	282 370	Vdc Vdc	115 Vac In 230 Vac In
Efficiency	90	92		%	
External hold-up capacitance	470		3,000	µF	
Ride through / hold-up time	16			ms	675 W output with 1,000 µF hold-up capacitor
Ripple		7	10	Vp-p	115 Vac, full load, 1,000 µF hold-up capacitor
Ripple		5	6	Vp-p	230 Vac, full load, 1,000 µF hold-up capacitor
Short circuit shut down current			100	mA	Foldback current limiting

■ CONTROL SPECIFICATIONS

Parameter	Min	Typ	Max	Unit	Notes
Power OK threshold		270		Vdc	
Module enable / disable threshold	240	250	260	Vdc	
Auxiliary output	19		23	Vdc	≤ 3 mA
Auxiliary output			3	mA	No overload protection

■ ELECTROMAGNETIC COMPATIBILITY

Parameter	Standard	Notes
Transient / surge immunity	EN61000-4-5	1 kV L-N, 2 kV L-PE with 07818 filter
Line disturbance immunity	EN61000-4-11	Main's interruption or brown out
Flicker / inrush	EN61000-3-3	20 A peak inrush at 230 Vac input
Harmonic current	EN61000-3-2	7.5% THD

■ SAFETY SPECIFICATIONS

Parameter	Min	Typ	Max	Unit	Notes
Isolation (in to out)		None			Provided by DC-DC converters
Dielectric withstand (I/O to baseplate)	2,121			Vdc	Baseplate earthed
Capacitance		150		pF	Input to baseplate

■ AGENCY APPROVALS

Safety Standards	Markings	Notes
UL 60950-1, EN60950-1, CSA 60950-1	cTÜVus	
Low Voltage Directive	CE	

■ GENERAL SPECIFICATIONS

Parameter	Typ	Unit	Notes
Size	4.6 x 2.4 x 0.5 (116,8 x 61,0 x 12,7)	in (mm)	
Weight	6.4 (180)	oz (g)	
Pin material	Solder plate over copper alloy		
Cover material	GE ULtem 2100 black #7310 UL94-VO rated		
Storage temperature			
E- & C-Grade	-40 to +100	°C	
I-Grade	-55 to +100	°C	
M-Grade	-65 to +100	°C	
Operating temperature			
E-Grade	-10 to +85	°C	Baseplate temperature
C-Grade	-25 to +85	°C	Baseplate temperature
I-Grade	-40 to +85	°C	Baseplate temperature
M-Grade	-55 to +85	°C	Baseplate temperature
Thermal shut down	90	°C	Baseplate temperature (Min)
MTBF			
HAM	>420,000	hrs	GB, 25°C
HAMD	>424,000	hrs	GB, 25°C
BAMD	>818,000	hrs	GB, 25°C

TECHNICAL DESCRIPTION

The HAM (Figure 1) consists of a full-wave rectifier, a high-frequency zero-current switching (ZCS) boost converter, active inrush current limiting, short-circuit protection, control and housekeeping circuitry.
The incoming AC line is rectified and fed to the boost converter. The control circuitry varies the operating frequency of the boost converter to maintain the output voltage of the HAM above the peak of the incoming line, while forcing the input current to follow the waveshape and phase of the line voltage. The AC input current follows the voltage waveform and a power factor better than 0.99 is achieved. Operating efficiency of the boost converter is optimized at any incoming line voltage by an adaptive output voltage (Figure 3) control scheme.

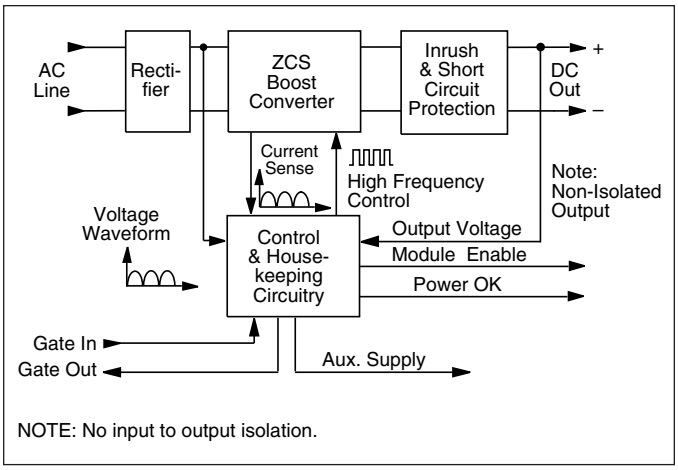


Figure 1 *— HAM Block Diagram*

Oscilloscope photos showing input voltage and current waveforms.

Figure 2a – Without power factor correction
Figure 2b – With power factor correction

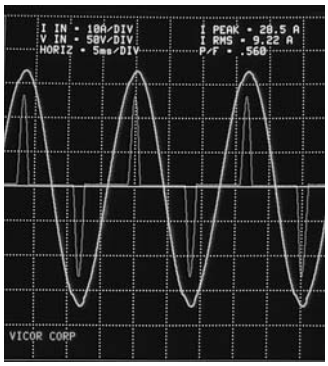


Figure 2a *— Without PFC*

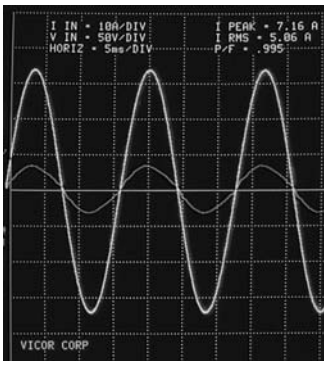


Figure 2b *— With PFC*

The output voltage of the HAM is a function of incoming AC line voltage (Figure 3). On a nominal 115 Vac line, the output voltage of the HAM is 280 Vdc — well within the input operating voltage range of Vicor DC-DC converters. Above 180 V input, the output voltage linearly increases with input voltage. At 230 Vac the delivered voltage will be aproximatly 365 V. For any given input line voltage, the HAM maintains enough headroom between the output voltage and peak input voltage to ensure high quality active power factor correction without sacrificing operating efficiency.

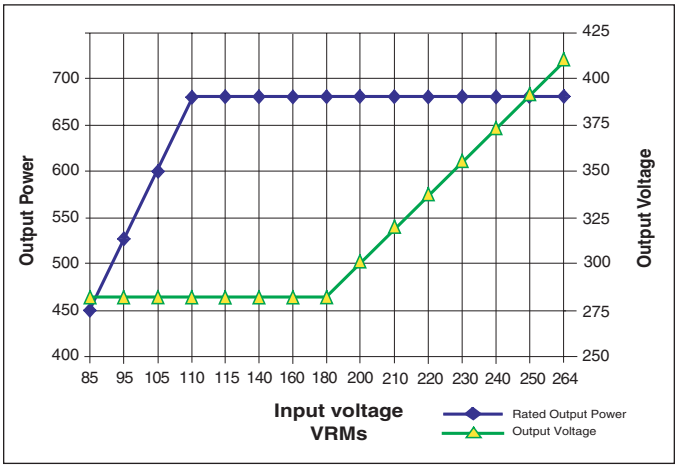
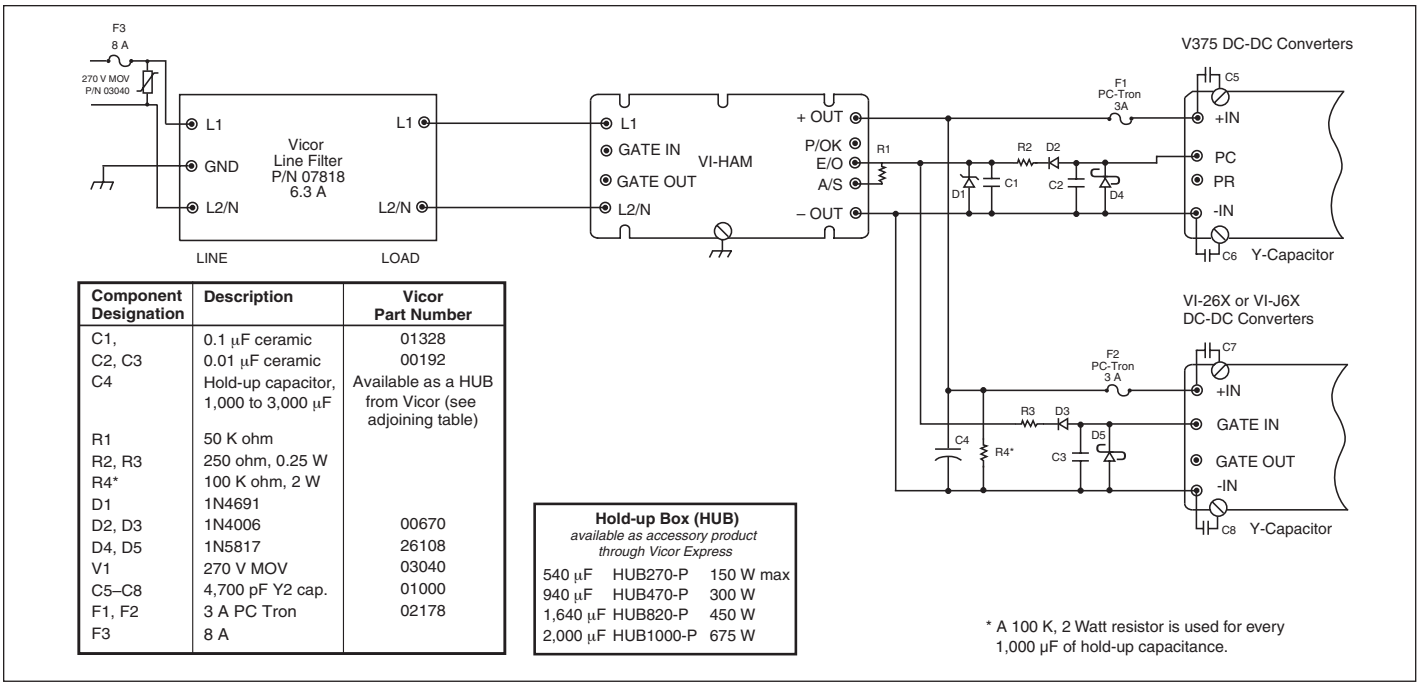


Figure 3 *— Output voltage and power rating versus input voltage*



Component Designation	Description	Vicor Part Number
C1,	0.1 µF ceramic	01328
C2, C3	0.01 µF ceramic	00192
C4	Hold-up capacitor, 1,000 to 3,000 µF	Available as a HUB from Vicor (see adjoining table)
R1	50 K ohm	
R2, R3	250 ohm, 0.25 W	
R4*	100 K ohm, 2 W	
D1	1N4691	
D2, D3	1N4006	00670
D4, D5	1N5817	26108
V1	270 V MOV	03040
C5–C8	4,700 pF Y2 cap.	01000
F1, F2	3 A PC Tron	02178
F3	8 A	

Hold-up Box (HUB)
available as accessory product through Vicor Express

540 µF	HUB270-P	150 W max
940 µF	HUB470-P	300 W
1,640 µF	HUB820-P	450 W
2,000 µF	HUB1000-P	675 W

Figure 4 *— Connection diagram HAM / DC-DC converters*

Pin Function / Description

• L1 and L2/N (HAM)
The HAM requires Vicor's P/N 07818 line filter or equivalent.** Connect single phase AC mains to the input of the line filter via a standard 8 A, 250 V fuse. Connect the output of the filter to L1 and L2/N of the HAM. Do not put an X capacitor across the input of the HAM or use a line filter with an X capacitor on its output as power factor correction may be impacted.

• +IN, –IN (HAMD, BAMD):
These pins are connected to the output of the external bridge rectifier in HAMD / BAMD configurations (Figure 5).

• GATE IN (HAM):
The user should not make any connection to this pin. This pin disables the boost converter only. Rectified line current may still be present on the output. This pin does not provide the same function as the Gate Input pin of VI-200 / VI-J00 modules.

• GATE IN (HAMD):
This pin provides line voltage envelope and phase information for power factor correction. This connection must be made through the synchronization diodes between the line filter and bridge rectifier (Figure 5).

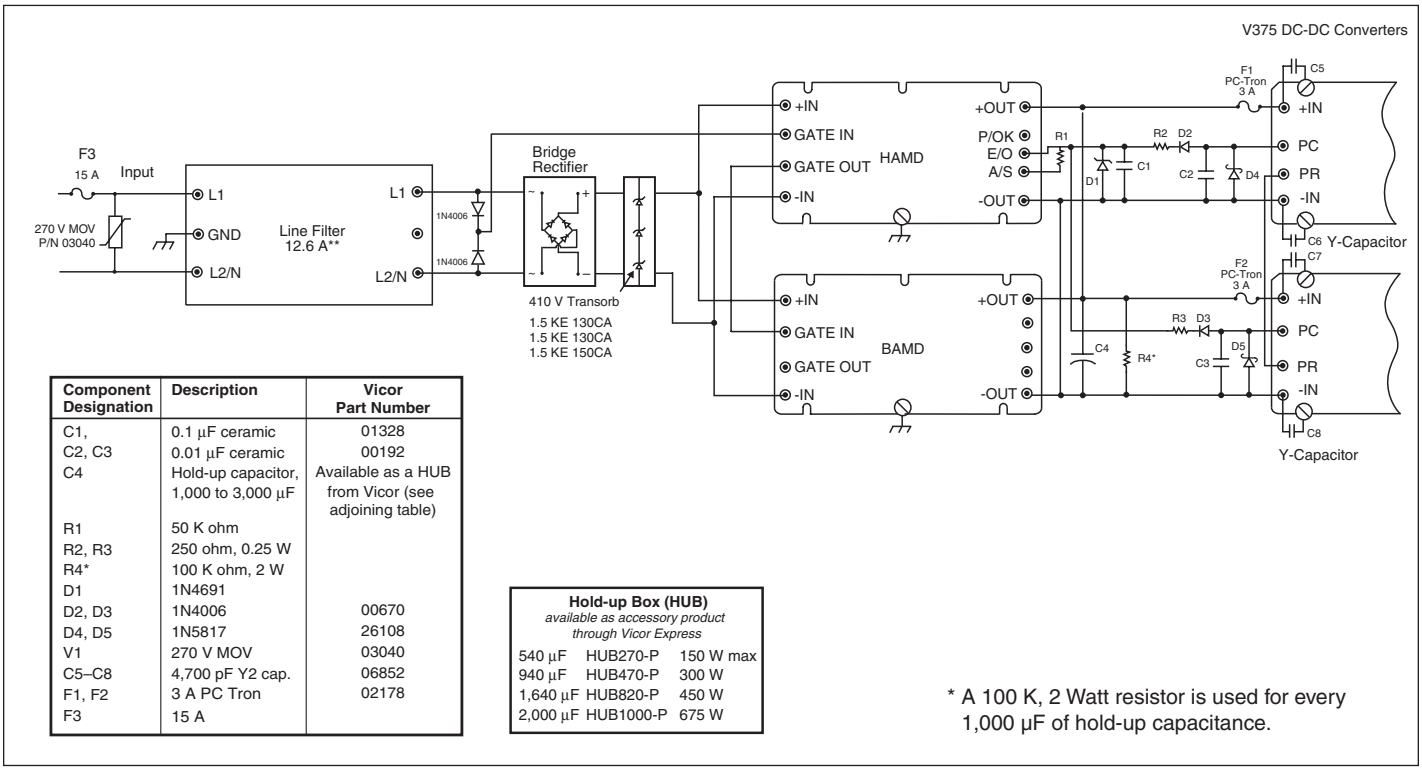
** *Contact the Vicor technical support center at* ***800-927-9474*** *for filter substitutes.*

• GATE IN (BAMD):
The Gate In pin is an interface pin to the Gate Out pin of a HAMD or BAMD depending on configuration. The user should not make any other connection to this pin.

• GATE OUT:
The Gate Out pin is an interface pin to BAMDs; the user should not make any other connection to this pin.

• +OUT and -OUT
Connect the +OUT of the HAM to the +IN of the respective Vicor DC-DC converters via a 3 A PC Tron DC fuse. Connect the -OUT of the HAM to the -IN of the converters. In addition, an external hold-up capacitor of 1,000 µF with a minimum voltage rating of 450 Vdc, is required (across the output of the HAM) for 16 ms ride through time at 600 W (500 µF for 300 W, etc). This capacitor must be in close proximity to the HAM. Do not exceed 3,000 µF of total output capacitance. Lower values of capacitance may be used for reduced hold-up requirements, but not less than 470 µF. Lower capacitance values may degrade power factor specifications.

• E/O
The Enable Output (E/O) is used to inhibit the DC-DC converters at start up until the hold-up capacitors are charged, at which time Enable is asserted high (open state, Figure 8). If the AC line fails, E/O goes low when the DC output of the HAM drops below 250 Vdc.



Component Designation	Description	Vicor Part Number
C1,	0.1 µF ceramic	01328
C2, C3	0.01 µF ceramic	00192
C4	Hold-up capacitor, 1,000 to 3,000 µF	Available as a HUB from Vicor (see adjoining table)
R1	50 K ohm	
R2, R3	250 ohm, 0.25 W	
R4*	100 K ohm, 2 W	
D1	1N4691	
D2, D3	1N4006	00670
D4, D5	1N5817	26108
V1	270 V MOV	03040
C5–C8	4,700 pF Y2 cap.	06852
F1, F2	3 A PC Tron	02178
F3	15 A	

Hold-up Box (HUB)
available as accessory product through Vicor Express

540 µF	HUB270-P	150 W max
940 µF	HUB470-P	300 W
1,640 µF	HUB820-P	450 W
2,000 µF	HUB1000-P	675 W

Figure 5 *— Connection Diagram, HAMD / BAMD / V375 DC-DC Converters*
HAMD-CL Driver HAM: No internal bridge rectifier or synchronization diodes.
BAMD-CL Booster HAM: Companion module to HAMD-CM used for additional output power. No internal bridge rectifier.

Pin Function Description (cont.)

E/O must be connected to the Gate Input of all VI-26x and VI-J6x drivers and / or the PC pin of the V375 DC-DC converters; failure to do so may cause the converters to toggle on and off. (Figure 4) If an external load is connected directly to the output of the HAM, do not apply the load until the output hold-up capacitor(s) are fully charged.

In applications using VI-26x drivers and VI-J6x boosters, the E/O pin should be connected to the Gate In pin of the driver module only, it is not necessary to connect this pin to boosters as they are controlled by their respective driver.

The E/O pin ancillary circuitry illustrated in Figures 4 and 5 provides transient immunity. The aforementioned connections are the minimum required. In addition, there are other features available.

• A/S

The HAM provides a low voltage output Auxiliary Supply (A/S) that may be used to power primary side control and monitoring circuitry. This output is 19 – 23 Vdc, referenced to -OUT, at 3 mA max. Do not overload or short this output as the HAM will fail. A typical use for A/S is to power an optical coupler that isolates the Power OK signal (Figure 6).

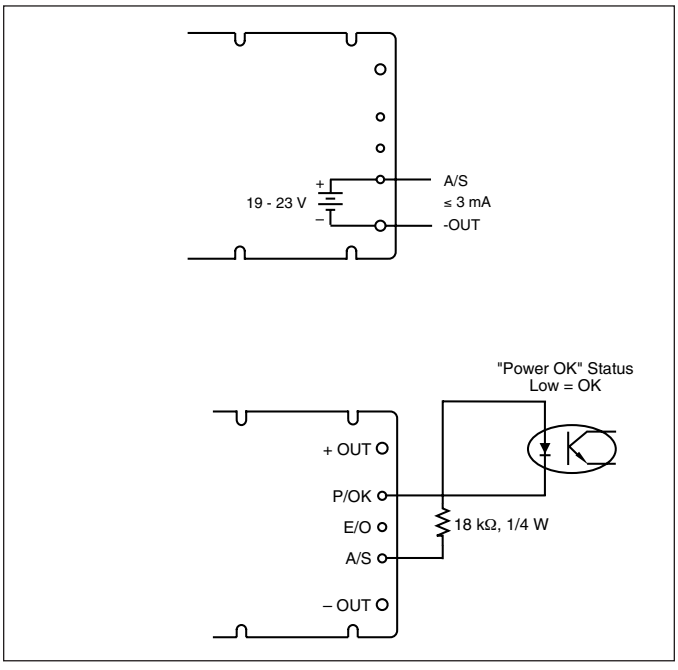


Figure 6 *— Auxiliary Supply (A/S)*

*** Consult Vicor's technical support center at **800-927-9474** for specific HAMD / BAMD filtering information.*

PIN FUNCTION DESCRIPTION (cont.)

• P/OK

Power OK is a monitor signal that indicates the status of the AC mains and the DC output voltage of the HAM. P/OK is asserted (active low) when the output bus voltage is within normal operating range (>270 Vdc) and 20 – 25 ms after DC-DC converters are enabled by the E/O signal of the HAM. This provides sufficient time for the converters to turn on and their output(s) to stabilize prior to P/OK being asserted (Figure 6). For momentary interruptions of AC power, the HAM will provide at least 16 ms of ride through or hold-up time (with 1,000 µF output capacitor). On loss of power or brownout, (when the HAM output voltage drops below 270 Vdc) the P/OK signal will go high, to an open circuit state, (Figure 7) signaling an impending loss of input power to the converter modules. P/OK will provide power fail warning at least 1 ms prior to converter shut down. When the HAM output voltage drops below 250 Vdc the converters are disabled via the Module Enable. (Figures 7–9)

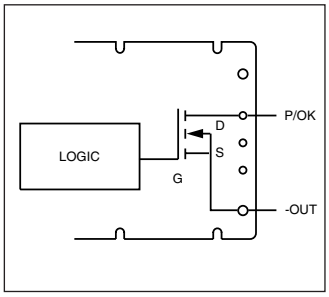


Figure 7 *— Power OK (P/OK)*

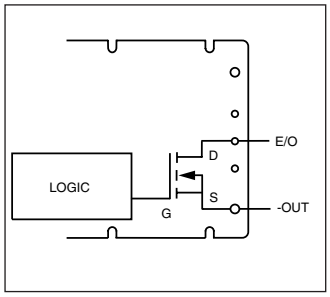


Figure 8 *— Enable / Output (E/O)*

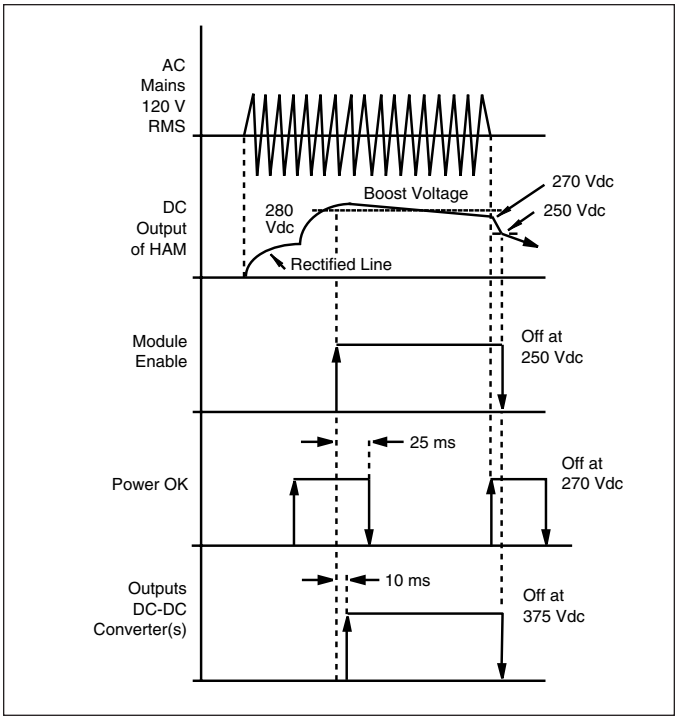


Figure 9 *— Start up / shut down timing diagram*

Applications Notes

• ThermMates or thermal compound should be used between the heat sink and baseplate of the HAM, HAMD and BAMD to insure adequate heat transfer.

• The HAM output is not isolated from the line input; isolated probes must be used when making scope measurements.

Protective Features

Over Temperature Shut Down

The HAM incorporates over temperature shut down, and is designed to shut down when the temperature of the baseplate exceeds 90°C. The HAM should not be operated for extended periods above its maximum operating temperature of 85°C.

Short Circuit Protection

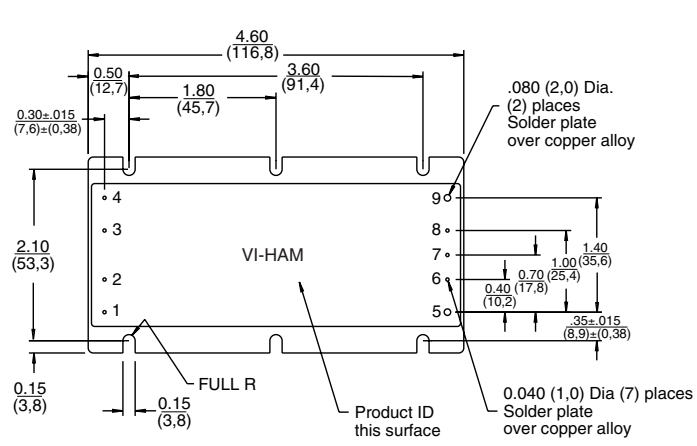
The HAM contains output short circuit protection. Operation of this function does not clear the input fuse and the output will resume normal operation after removal of the fault. A short period of time may be required to allow for cooling of an internal temperature sensor.

Output Over Voltage Protection

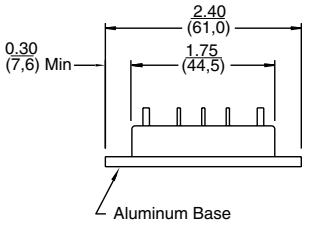
The HAM contains output over voltage protection. In the event the output voltage exceeds approximately 420 Vdc, the boost will decrease to maintain 420 Vdc on the output. When the peak of the AC line exceeds 420 V (approximately 293 Vac) the boost will have been reduced to zero. Beyond this the protection circuit will be enabled and the output voltage will decrease.

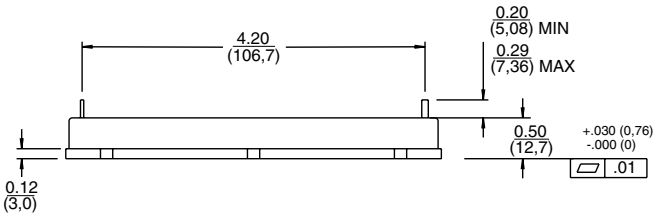
Over current protection is provided by the Vicor DC-DC converters.

VI-HAM / HAMD / BAMD Mechanical Diagram



Pin #	HAM	HAMD	BAMD
1	L1	+IN	+IN
2	GATE IN	GATE IN	GATE IN
3	GATE OUT	GATE OUT	GATE OUT
4	L2/N	–IN	–IN
5	+OUT	+OUT	+OUT
6	P/OK	P/OK	N/C
7	E/O	E/O	N/C
8	A/S	A/S	A/S
9	–OUT	–OUT	–OUT



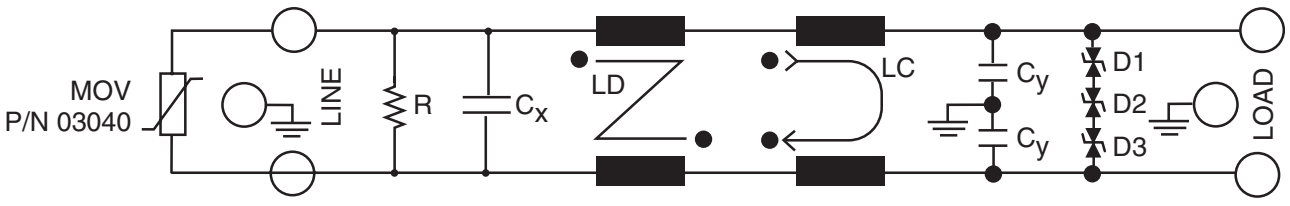


Typical HAM Filter Applications

Operating voltage = 85 to 250 Vac
Operating current = 6.3 A
Operating frequency = 50/60 Hz

Operating temperature = 20 to 50˚C
Diel. withstanding (line - case) = 1500 Vac
Diel. withstanding (line - line) = 1500 Vac

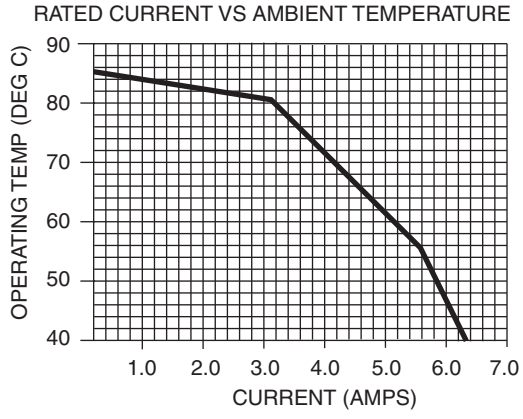
Leakage current = 1.0 ma at 220 Vac, 50 Hz
Max residual voltage after 1 sec. = 34 V
Agency approvals = UL, CSA, TÜV

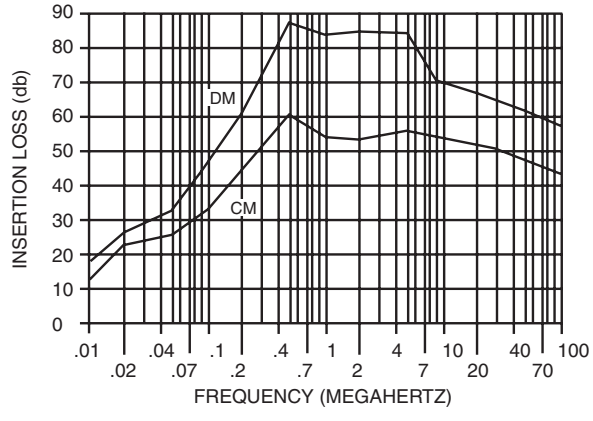


HAM Filter P/N 07818

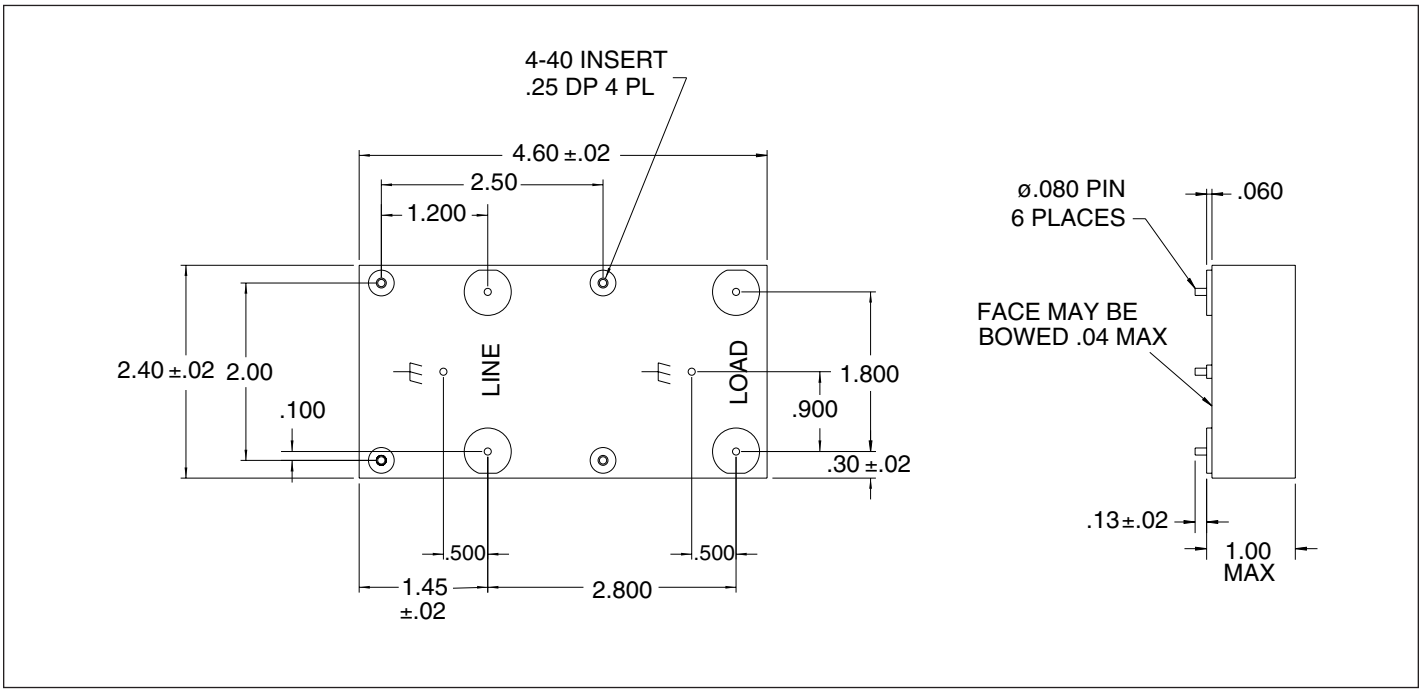
C_x = 1.5 uF(x2)SH C_y = .01 uF SH LC = 6.9mH LD = .72mH

R = 235K OHM D1,2 = 1.5KE130CA D3 = 1.5KE150CA





HAM Filter Mechanical Diagram



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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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Specifications are subject to change without notice.

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