



# Data Sheet

# VI-HAM™, VE-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
- RoHS compliant
- For use with Vicor's V375, VI-26x and VI-J6x DC-DC Converters



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

### 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.

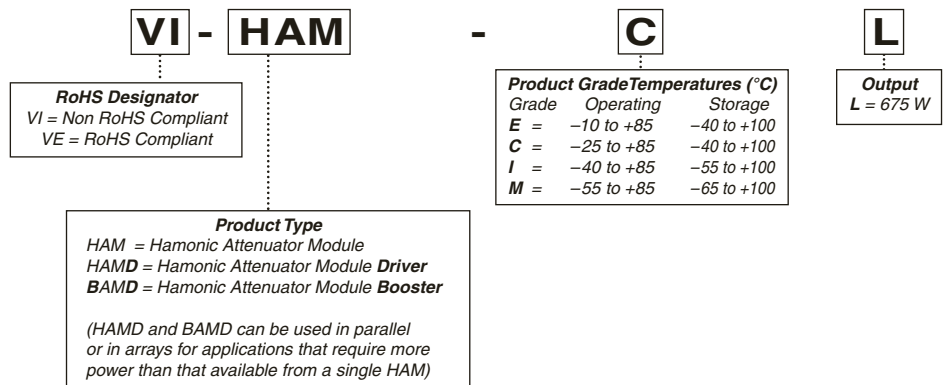
A single high-boost HAM may be used with any combination of V375 series DC-DC converters which are available in Micro, Mini and Maxi packages with up to 600 Watts of output power. Versions without internal diode bridges (HAMD and BAMD) can be operated in parallel to provide power expansion capability. 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).

### Absolute Maximum Ratings

| Parameter                 | Rating      | Unit          | Notes          |
|---------------------------|-------------|---------------|----------------|
| L to N voltage            | 265         | Vac           | Continuous     |
|                           | 280         | Vac           | 100 ms         |
| Mounting torque           | 5 (0.57)    | in- lbs (N-m) | # 6-32 or m3.5 |
| Pin soldering temperature | 750         | °F            |                |
|                           | (400)       | (°C)          |                |
| Operating temperature     | -55 to +85  | °C            | M-Grade        |
| Storage temperature       | -65 to +100 | °C            | M-Grade        |
| Auxiliary output          | 3           | mA            |                |

### Part Numbering



For application information please see the Design Guide at [www.vicorpower.com/mmmguide](http://www.vicorpower.com/mmmguide).

## ELECTRICAL CHARACTERISTICS

Electrical characteristics apply over the specified operating voltage range, 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<br>HAM, HAMD, BAMD  | 85   |      | 264  | Vac  | Rectified AC for HAMD, BAMD                                  |
| AC line frequency                           | 47   |      | 63   | Hz   | Unit will operate at 400 Hz but may not meet PF or THD specs |
| Power factor                                | 0.99 |      |      |      |  |
| Total harmonic distortion<br>(line current) |      |      | 7.5  | %    | 115 Vac sinusoidal input full load                           |
|   |      |      | 8.5  | %    | 230 Vac sinusoidal input full load                           |
| Inrush current                              |      |      | 20   | Amps | 230 Vac, full load   |
| CM Filter Inductance                        | 3    | 6    |      | mH   | External to HAM module (see Fig. 10)                         |
| DM Filter Inductance                        | 0.2  | 0.35 | 0.75 | mH   | External to HAM module (see Fig. 10)                         |

### ■ OUTPUT SPECIFICATIONS

| Parameter                               | Min | Typ | Max   | Unit    | Notes  |
|---|-----|-----|-------|---------|--|
| Maximum output power                    |     |     | 675   | Watts   | See power derating graph, Fig.3  |
| Output voltage                          | 278 | 280 | 282   | Vdc     | 115 Vac In   |
|   | 360 | 365 | 370   | Vdc     | 230 Vac In (see Fig. 3)  |
| Efficiency                              | 90  | 92  |       | %       |  |
| External hold up capacitance<br>per HAM | 500 |     | 3,000 | $\mu$ F | 300 W, 500 $\mu$ F minimum, external to HAM<br>675 W, 1,000 $\mu$ F minimum, external to HAM |
| Ride through / hold up time             | 16  |     |       | ms      | 675 W output with 1,000 $\mu$ F hold up capacitor, external to HAM                           |
| Ripple                                  |     | 7   | 10    | Vp-p    | 115 Vac, full load, 1,000 $\mu$ F hold up capacitor, external to HAM                         |
|   |     | 5   | 6     | Vp-p    | 230 Vac, full load, 1,000 $\mu$ F hold up capacitor, external to HAM                         |
| 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<br>threshold | 240 | 250 | 260 | Vdc  |   |
| Auxiliary output                   | 19  |     | 23  | Vdc  | $\leq$ 3 mA                                 |
|                                    |     |     | 3   | mA   | Do not overload or add external capacitance |

### ■ ELECTROMAGNETIC COMPATIBILITY

| Parameter                   | Standard     | Notes   |
|-----------------------------|--------------|---|
| Transient / surge immunity  | EN61000-4-5  | 1 kV L-N, 2 kV L-PE, 30205 filter and 30076 MOV |
| 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  |

## ELECTRICAL CHARACTERISTICS (CONT.)

### ■ SAFETY SPECIFICATIONS

| Parameter                               | Min   | Typ  | Max | Unit | Notes                                  |
|---|-------|------|-----|------|--|
| Isolation (in to out)                   |       | None |     |      | Isolation 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                 |
|-----------------------------------|----------------------------|-----------------------|
| UL60950-1, EN60950-1, CSA 60950-1 | cTÜVus, cURus<br>CE Marked | Low Voltage Directive |

### ■ GENERAL SPECIFICATIONS

| Parameter         | Typ  | Unit       | Notes                       |
|-------------------|--|------------|-----------------------------|
| Size              | 4.6 x 2.4 x 0.5<br>(116,8 x 61,0 x 12,7)   | in<br>(mm) |                             |
| Weight            | 6.4 (180)                                  | oz (g)     |                             |
| Pin material      | Solder plate over copper alloy             |            |                             |
| Cover material    | GE ULtem 2100 black<br>#7310 UL94-VO rated |            |                             |
| 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.

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 V375 DC-DC converters. Above 180 Vac input, the output voltage linearly increases with input voltage. At 230 Vac the delivered voltage will be approximately 365 Vdc. 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.

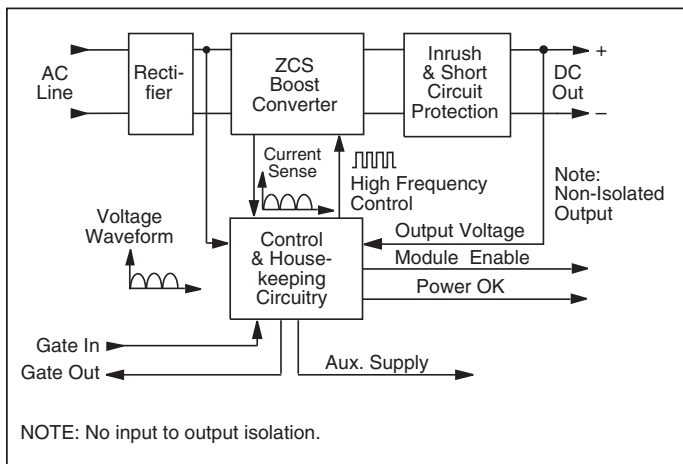


Figure 1 – HAM block diagram

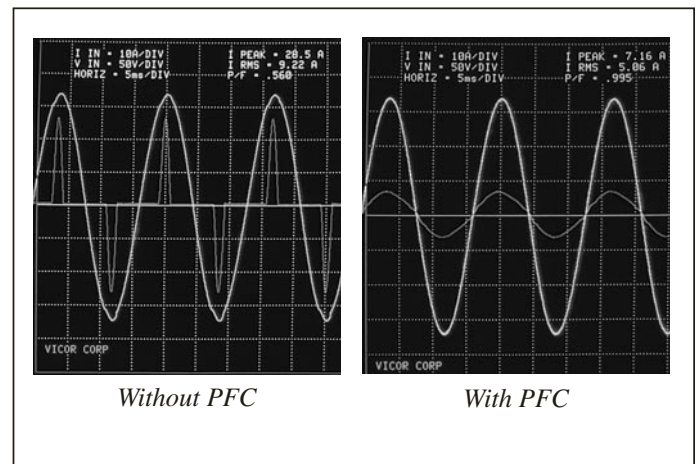


Figure 2 – Input voltage and current wave forms, with and without power factor correction

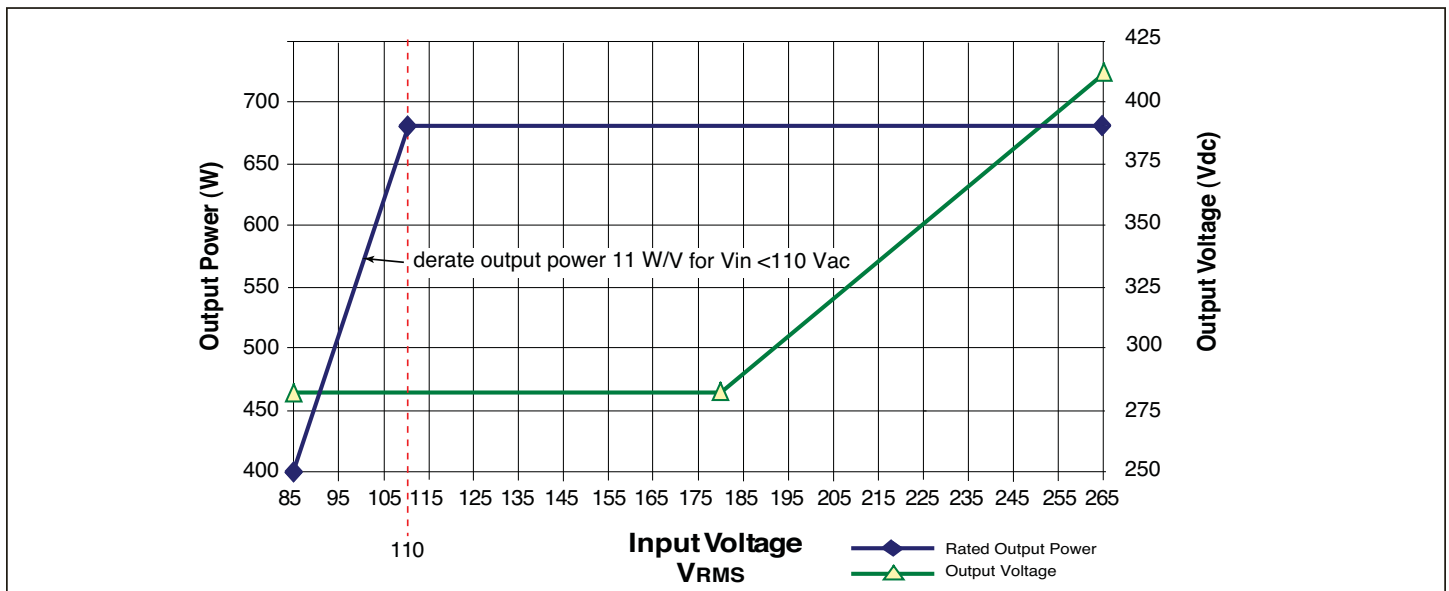
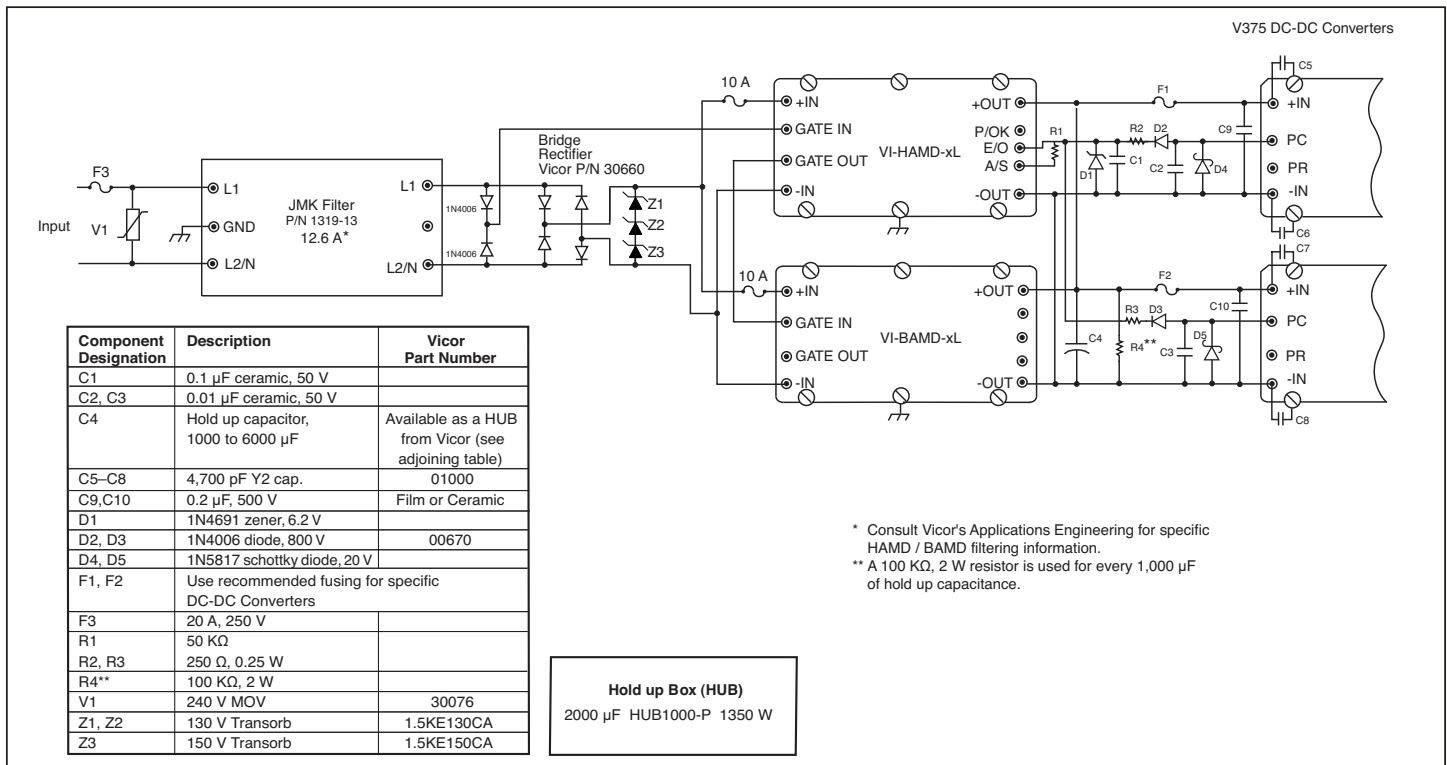


Figure 3 – Output voltage and power rating versus input voltage





**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.)

### A/S

The HAM provides a low voltage non isolated 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).

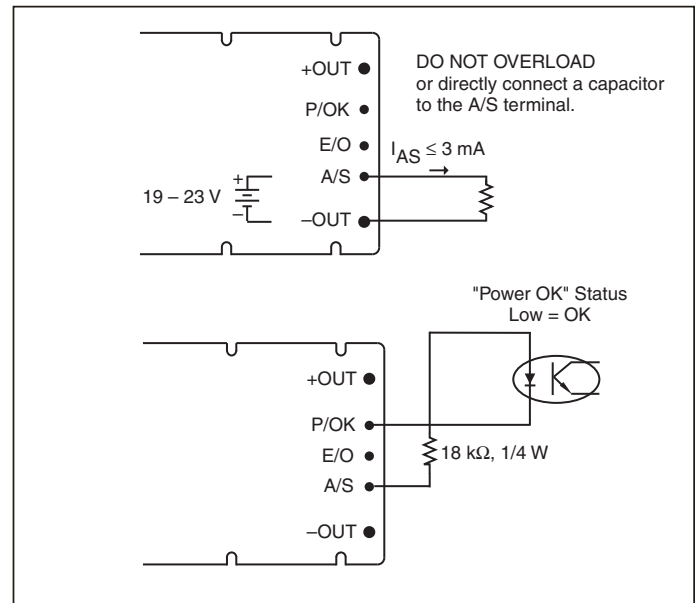
### E/O

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.

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 (Figure 4); failure to do so may cause the converters to toggle on and off. 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-26x 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 illustrated circuitry is the minimum required, see Figures 4 and 5.



**Figure 6** — Auxiliary Supply (A/S)



## 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 9). For momentary interruptions of AC power, the HAM will provide at least 16 ms of ride through or hold up time (with 1,000  $\mu$ F output capacitor). On loss of power or brownout,

(when the HAM output voltage drops below 270 Vdc) the P/OK signal will go 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 Enable Output (E/O).

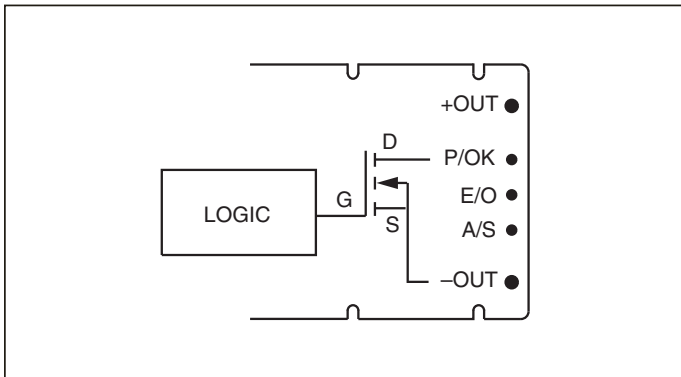


Figure 7 – Power OK (P/OK)

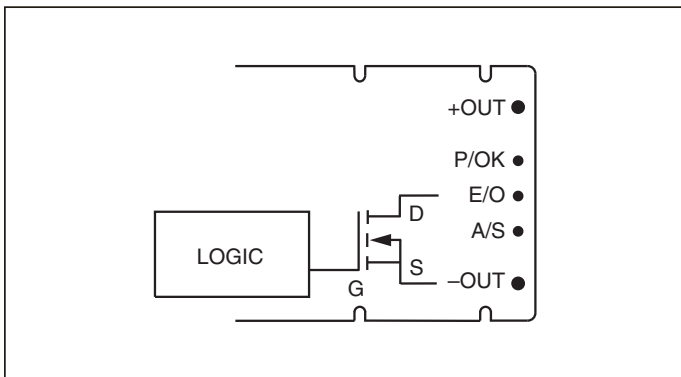


Figure 8 – Enable / Output (E/O)

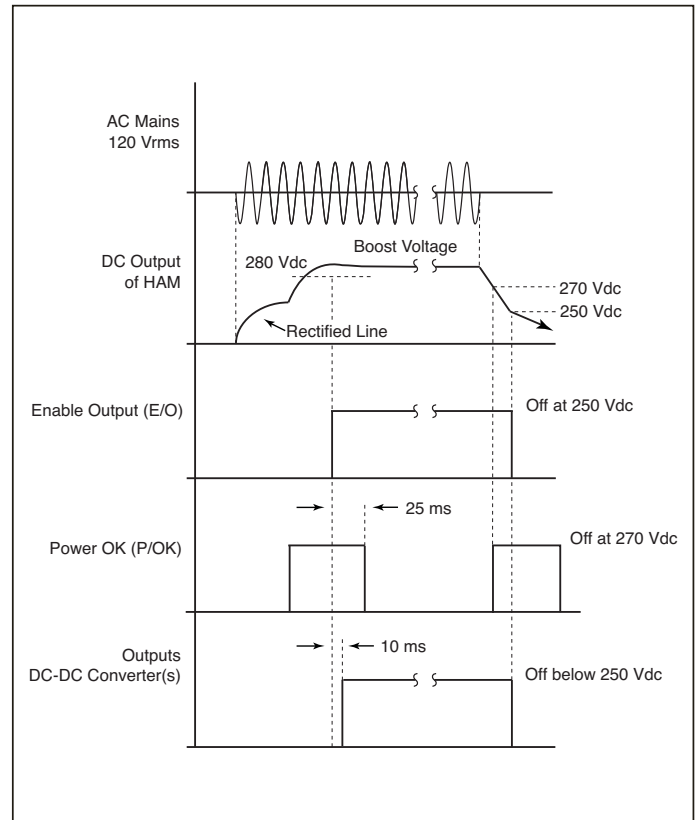


Figure 9 – Start up / shut down timing diagram

## PIN FUNCTION / DESCRIPTION (CONT.)

### Line Filter for High Boost HAM

A line filter is required to provide attenuation of conducted emissions generated by the HAM module and to protect it from line transients. It also presents a well defined high frequency AC line impedance to the input of the HAM. To meet the listed specifications, Vicor's P/N 30205 line filter/transient suppressor or equivalent must be used, see Figure 10. The addition of a MOV external to this filter is required to meet normal mode transient surge requirements.

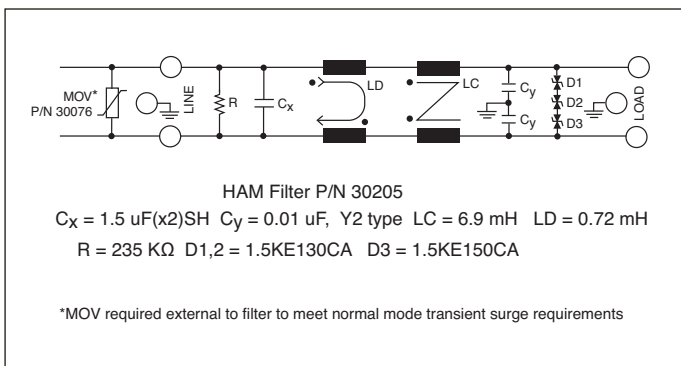


Figure 10 – Required HAM filter, Vicor part # 30205

For applications using HAMD + BAMD or where the user desires to construct a custom HAM filter, the filter should be designed following Figure 10, the schematic of Vicor's P/N 30205 filter. The current carrying capability of the inductors must be scaled proportionally to the number of HAM modules used. Inductance values must be selected according to Table 1. These limits are to ensure proper operation of the HAM and do not guarantee a system will meet conducted emissions specifications.

| Parameter                         | Min | Typ  | Max  | Unit |
|-----------------------------------|-----|------|------|------|
| Differential Mode Inductance (LD) | 0.2 | 0.35 | 0.75 | mH   |
| Common Mode Inductance (LC)       | 3   | 6    |      | mH   |

Table 1 – HAM filter inductance range

For applications requiring magnetic field shielding, do not place a ferrous EMI shield over the plastic cover of the HAM module. This can cause thermal problems due to induction heating effects.

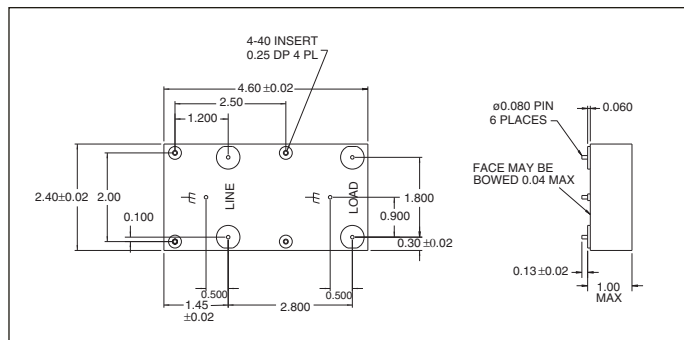


Figure 11 – HAM filter #30205 mechanical diagram

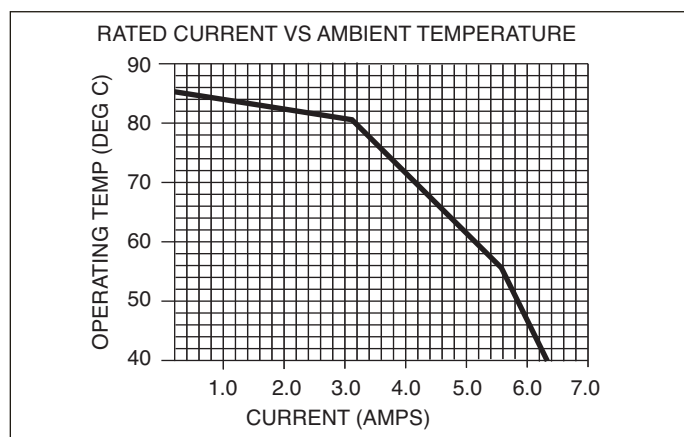


Figure 12 – HAM filter #30205 current rating vs. temperature

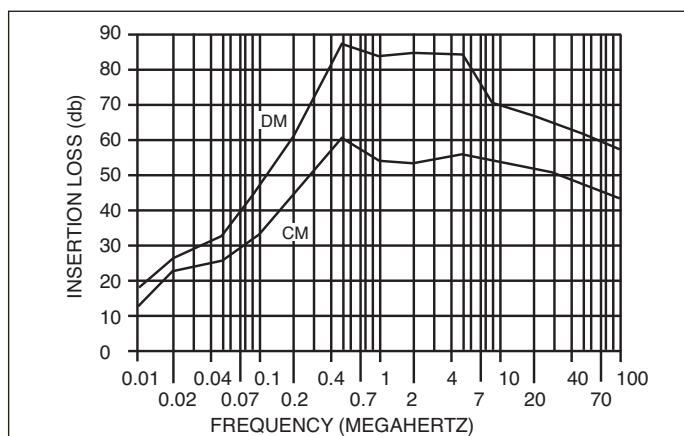


Figure 13 – HAM filter #30205 insertion loss vs. frequency



## PIN FUNCTION / DESCRIPTION (CONT.)

| Parameter   | Min | Typ          | Max  | Unit |
|---|-----|--------------|------|------|
| Operating voltage   | 85  |              | 250  | Vac  |
| Operating temperature (See Fig.12)                          | -20 |              | 50   | °C   |
| Leakage current at 264 Vac, 63 Hz<br>(Either line to earth) |     |              | 1.2  | mA   |
| Operating current   |     |              | 6.3  | A    |
| Dielectric withstand (line – case)                          |     |              | 1500 | Vac  |
| Residual voltage after 1 sec.                               |     |              | 34   | V    |
| Operating frequency   | 50  |              | 60   | Hz   |
| Agency Approvals  |     | UL, CSA, TÜV |      |      |

Table 2 – HAM filter part #30205 specifications

### Safety Notes

Each HAM, HAMD or BAMD module must be preceded by a safety agency recognized fast-blow 10A 3AG fuse.

The HAM is not isolated from the line – either input or output; a line isolation transformer must be used when making scope measurements. HAMs do not provide input to output isolation. Differential probes should be used when probing the input and output simultaneously to avoid destructive ground loops.

### Protective Features

#### Over Temperature Shut Down

The HAM is designed to shut down when the temperature of the baseplate exceeds 90°C. Do not operate the HAM 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 and the E/O line will be pulled low shutting down the converters. Beyond this the protection circuit will be enabled and the output voltage will decrease.

## MECHANICAL DRAWING

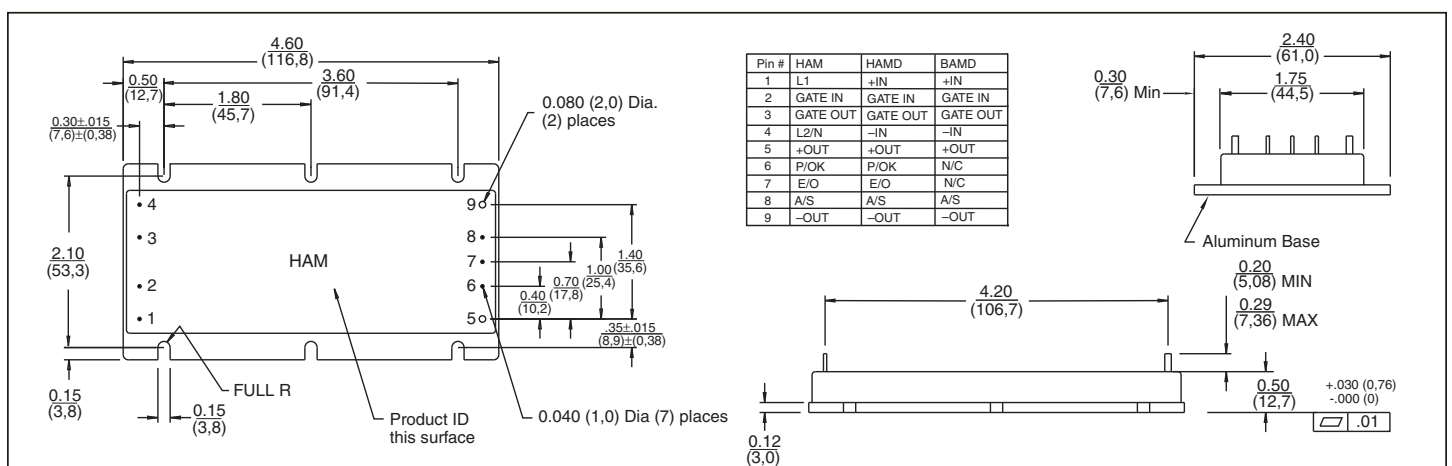


Figure 14 – HAM / HAMD / BAMD Module Outline

**Note:** Mounting a High Boost HAM and Maxi, Mini or Micro DC-DC converter to the same heat sink will require the use of custom length standoffs or a step in the heat sink mounting surface. This is due to a mechanical stack up difference between the HAM and Maxi, Mini, and Micro converters that leads to incompatible baseplate height above the PCB.

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