

The High-Boost Harmonic Attenuator Module Compatible with V375, VI-26x and VI-J6x Families

The High-Boost Harmonic Attenuation Module (HAM) 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 (Figure 10.1). The incoming AC line is rectified and fed to the boost converter. The control circuitry varies the operating frequency of the boost converter to regulate and 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. A power factor better than 0.99 is achieved (Figure 10.2). Operating efficiency of the boost converter is optimized at any incoming line voltage by an adaptive output voltage control scheme.

The output voltage of the HAM is a function of incoming AC line voltage (Figure 10.3). On a nominal 115V_{AC} line, the output voltage of the HAM is 280V_{DC} – well within the input operating voltage range of Vicor V375 DC-DC converters. Above 180V input, the output voltage linearly increases with input voltage. At 230V_{AC} the delivered voltage will be approximately 365V. 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.

The HAMD version does not contain an internal bridge rectifier and is intended for configuring higher-power arrays with Booster versions, referred to as the VI-BAMD (Figure 10.5).

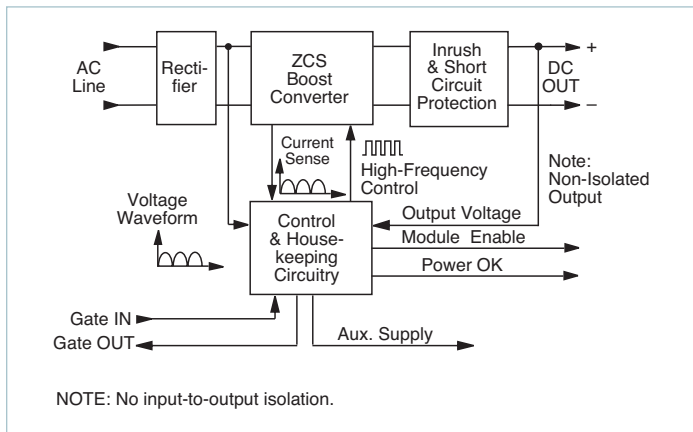


Figure 10.1 — HAM block diagram (HAMD version has the rectifier block deleted)

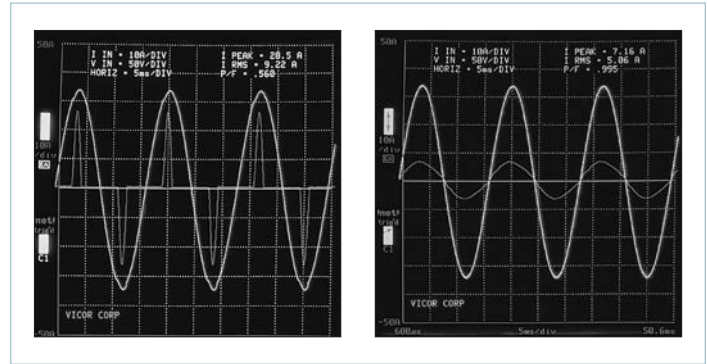


Figure 10.2 — Input voltage and current wave forms without and with power factor correction.

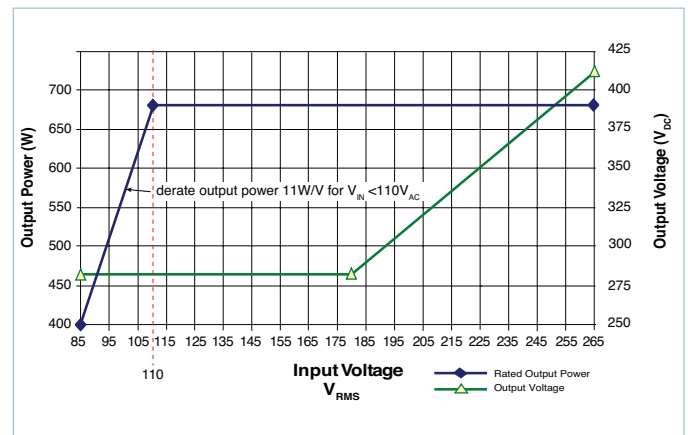


Figure 10.3 — Output voltage and power rating vs. input voltage

L1 and L2/N (HAM) Pin: An appropriate line filter is required to limit conducted emissions and ensure reliable operation of the HAM, see Page 51. Connect single phase AC mains to the input of the line filter via a 10A, 250V 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) Pin: These pins are connected to the output of the external bridge rectifier in HAMD / BAMD configurations (Figure 10.5).

GATE IN (HAM) Pin: The user should not make any connection to this pin.

GATE IN (HAMD) Pin: 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 10.5).

GATE IN (BAMD) Pin: 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 Pin: The GATE OUT pin is a synchronization pin for HAMD/BAMD arrays; the user should not make any other connection to this pin.

+OUT and –OUT Pin: Connect the +OUT of the HAM to the +IN of the respective Vicor DC-DC converters with the recommended fuse. Connect the –OUT of the HAM to the –IN of the converters. In addition, an external hold-up capacitor of 1,000µF with a minimum voltage rating of 450V_{DC}, is required (across the output of the HAM) for 16ms ride through time at full power (500µF for half power, etc.). This capacitor must be in close proximity to the HAM. Do not exceed 3,000µF of total output capacitance. Lower values of capacitance may be used for reduced hold up requirements, but not less than 500µF. Lower capacitance values may degrade power factor specifications.

Auxiliary Supply (A/S) Pin: 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 – 23V_{DC}, referenced to –OUT, at 3mA 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 10.6).

Enable Output (E/O) Pin: 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 10.8). If the AC line fails, E/O goes low when the DC output of the HAM drops below 250V_{DC}.

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 10.4); 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 10.4 and 10.5 provides transient immunity. The illustrated circuitry is the minimum required, see Figures 10.4 and 10.5.

Power OK (P/OK) Pin: 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 (>270V_{DC}) and 20 – 25ms 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 10.9). For momentary interruptions of AC power, the HAM will provide at least 16ms of ride through or hold up time (with 1,000µF output capacitor). On loss of power or brownout, (when the HAM output voltage drops below 270V_{DC}) the P/OK signal will go to an open circuit state (Figure 10.7), signaling an impending loss of input power to the converter modules. P/OK will provide power fail warning at least 1ms prior to converter shut down. When the HAM output voltage drops below 250V_{DC} the converters are disabled via Enable Output (E/O).

NOTE: Acoustic Noise: Audible noise may be emitted from the module under no load, light load or dynamic loading conditions. This is considered normal operation of the module.

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 to 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 Overvoltage Protection: The HAM contains output overvoltage protection. In the event the output voltage exceeds approximately 420V_{DC}, the boost will decrease to maintain 420V_{DC} on the output. When the peak of the AC line exceeds 420V (approximately 293V_{AC}) 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.

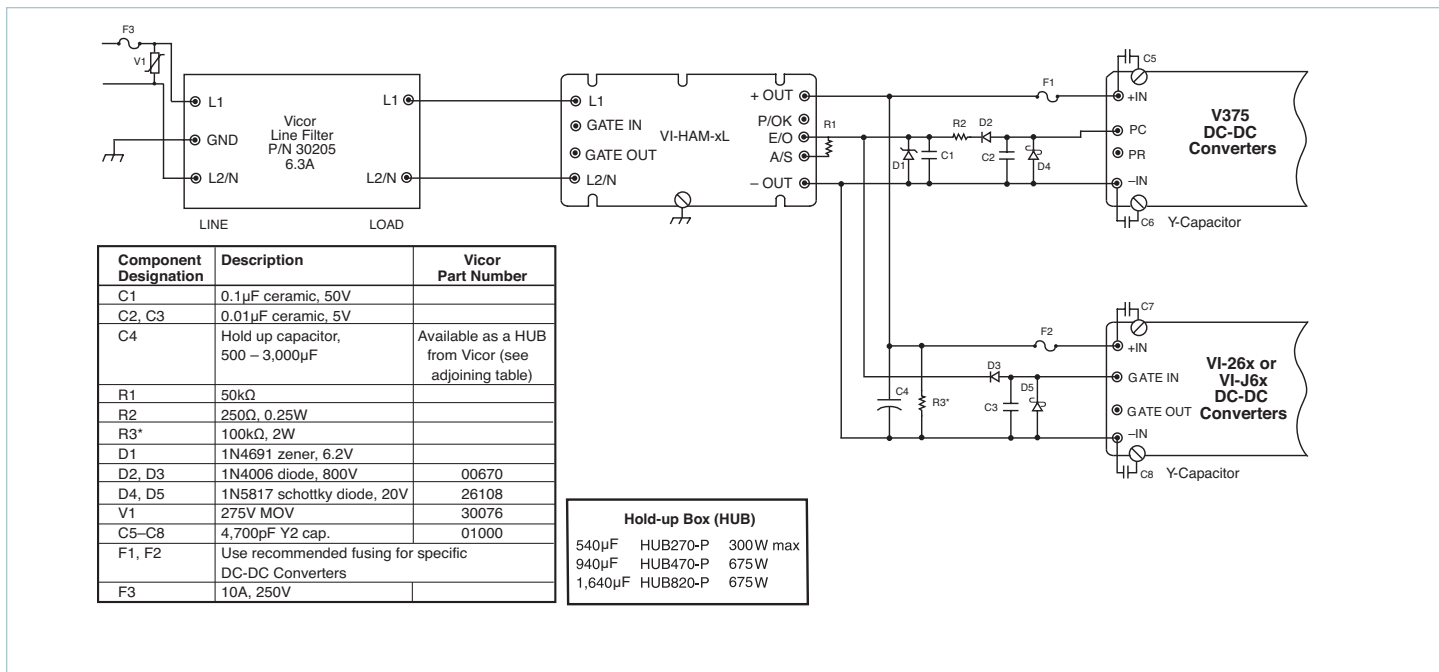


Figure 10.4 — Connection diagram HAM / DC-DC converter

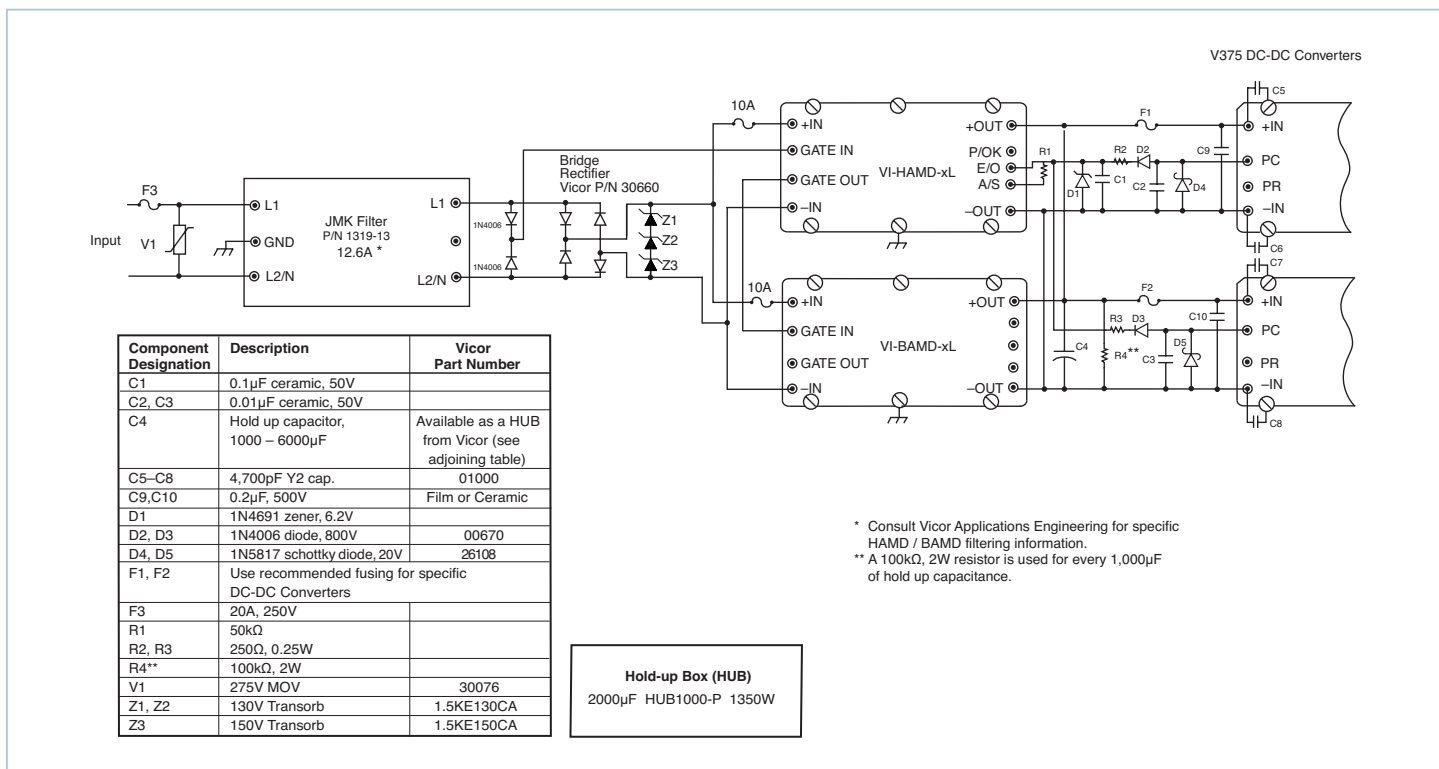


Figure 10.5 — Connection diagram, HAMD / BAMD / V375 DC-DC converters.

HAMD-CL Driver HAM: No internal bridge rectifier or synchronization diodes.

Booster HAM: Companion module to HAMD-CM used for additional output power. No internal bridge rectifier.

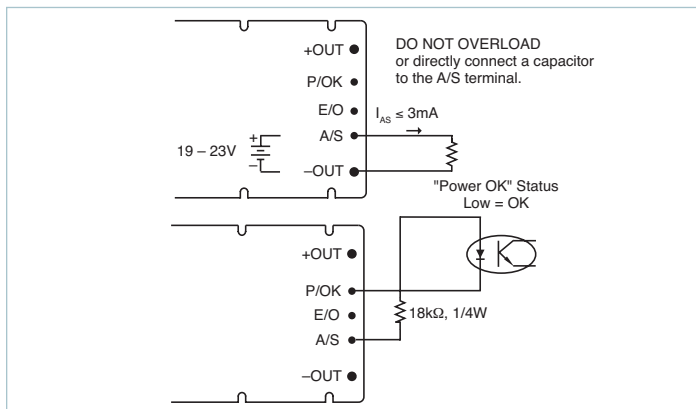


Figure 10.6 — Auxiliary supply (A/S)

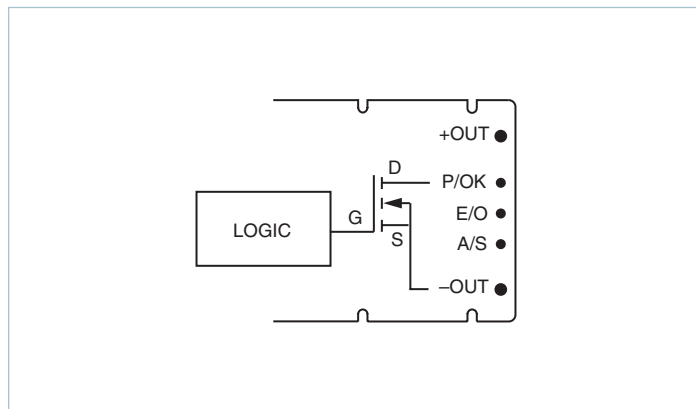


Figure 10.7 — Power OK (P/OK)

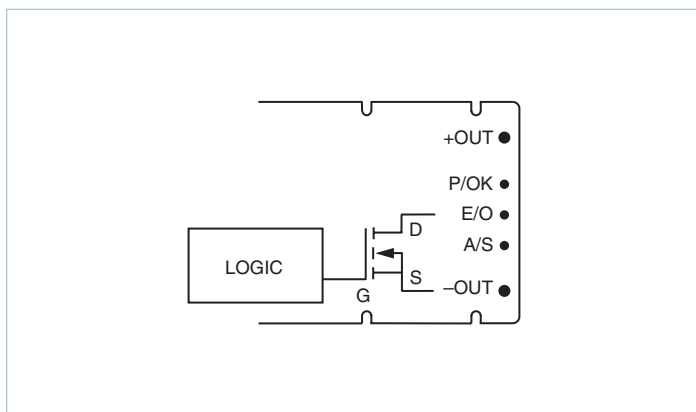


Figure 10.8 — Enable Output (E/O)

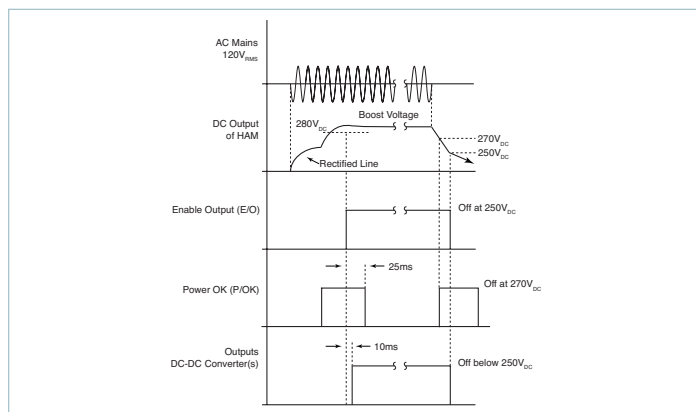


Figure 10.9 — Start-up / shut-down timing diagram

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 P/N 30205 line filter / transient suppressor or equivalent must be used, see Figure 10.10. The addition of a MOV external to this filter is required to meet normal mode transient surge requirements.

For applications using HAMD + BAMD or where the user desires to construct a custom HAM filter, the filter should be designed following Figure 10.10, the schematic of Vicor 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 10.1. These limits are to ensure proper operation of the HAM and do not guarantee a system will meet conducted emissions specifications.

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.

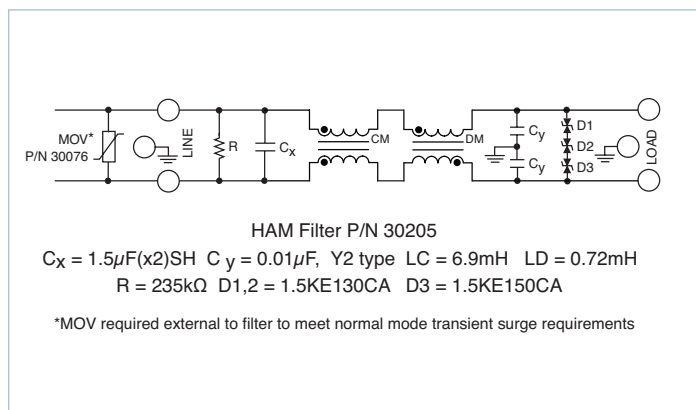


Figure 10.10 — Recommended HAM filter

Parameter	Min	Type	Max	Unit
Differential Mode Inductance (LD)	0.2	0.35	0.75	mH
Common Mode Inductance (LC)	3	6	—	mH

Table 10.1 — HAM filter inductance range

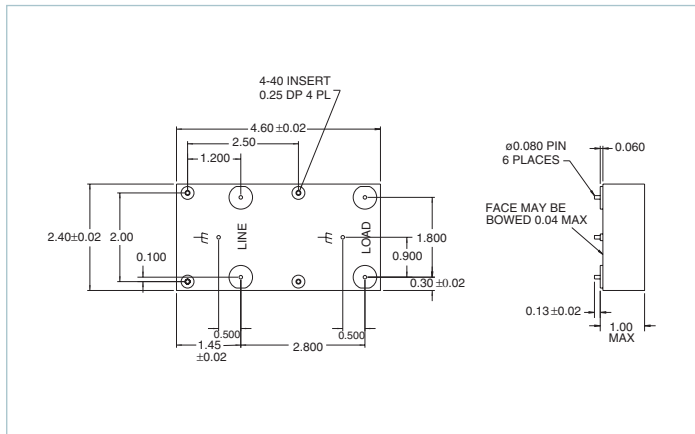


Figure 10.11 — HAM filter mechanical diagram

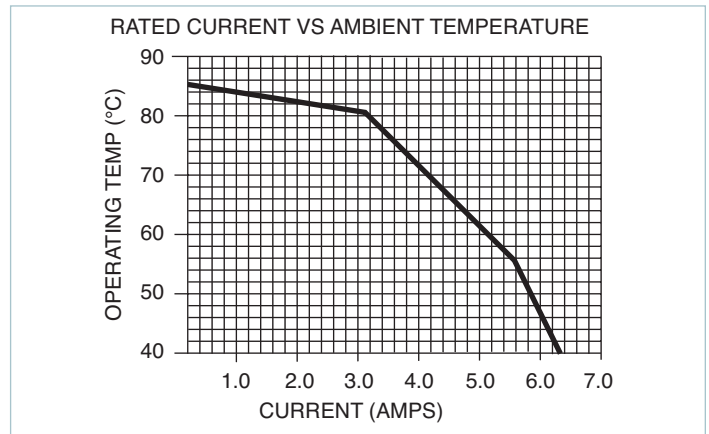


Figure 10.12 — HAM filter's current rating vs. temperature

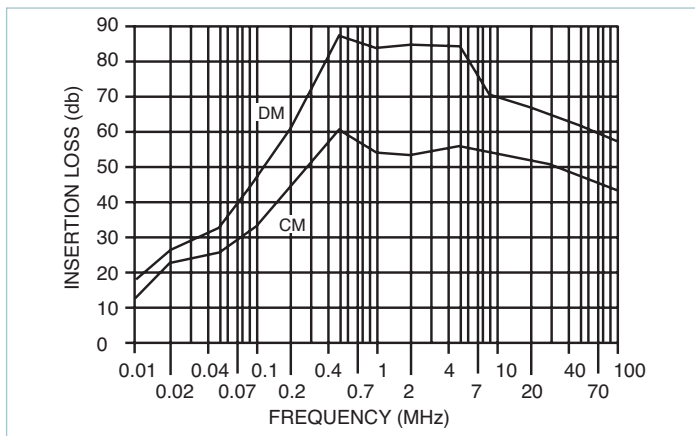


Figure 10.13 — HAM filter insertion loss vs. frequency, typical

Parameter	Min	Type	Max	Unit
Operating Voltage	85		250	V _{AC}
Operating Temperature (See Figure 10.12)	-40		40	°C
Leakage Current at 264V _{AC} , 63Hz (either line to earth)			1.2	mA
Operating Current			6.3	A
Dielectric Withstand (line – case)			1500	V _{AC}
Residual Voltage after 1s			34	V
Operating Frequency	50		60	Hz
Agency Approvals		UL, CSA, TÜV		

Table 10.2 — HAM filter part #30205 specifications