

Military COTS AC Line Filter

| | | | | |
|--|---------------------------------------|---|--|---|
| 85 to 264Vrms Input Voltage | 9Arms Output Current | 1kW @ 115Vrms 2kW @ 230Vrms Output Power | 195mΩ @ 100°C Max Series Resistance | >55dB @ 250kHz Differential & Common-mode Attenuation |
|--|---------------------------------------|---|--|---|

FULL POWER OPERATION: -55°C TO +100°C

MCOTS series of EMI AC Line Filters brings SynQor's field proven technology and manufacturing expertise to the military and aerospace power applications marketplace. SynQor's innovative packaging approach ensures survivability in the most hostile environments. Compatible with the industry standard format, these filters have high differential-mode and common-mode attenuation and low series resistance. They follow conservative component derating guidelines and they are designed and manufactured to the highest standards.

MilCOTS™



MACF-060-230-HT-N-M Module

Operational Features

- -55°C to +100°C Operation
- 9Arms output current
- Very low series resistance
- >55dB @ 250kHz Differential & Common-mode Attenuation
- All capacitors are safety-rated X7R multi-layer ceramic
- Meets common EMC standards in properly designed system with SynQor's MPFC module and MCOTS 270 converters
- 400Hz and 50/60 Hz versions

Compliance Features

- MACF Series filters (with MPFC & MCOTS converters) are designed to meet:
- MIL-STD-461 for EMC
 - MIL-STD-1399
 - MIL-STD-704

Safety Features

- 2150Vdc input-to-case & input-to-gnd-pin high-potential test
- Safety rated class X2 line-to-line & class Y2 line-to-gnd capacitors
- Certified 60950-1 requirement for basic insulation (see Standards and Qualifications page)

Mechanical Features

- Standard Size: 2.49" x 2.39" x 0.51" (63.1 x 60.6 x 13mm)
- Total weight: 5.0oz (142g)
- Flanged baseplate version available

In-Line Manufacturing Process

- AS9100 and ISO 9001 certified facility
- Full component traceability

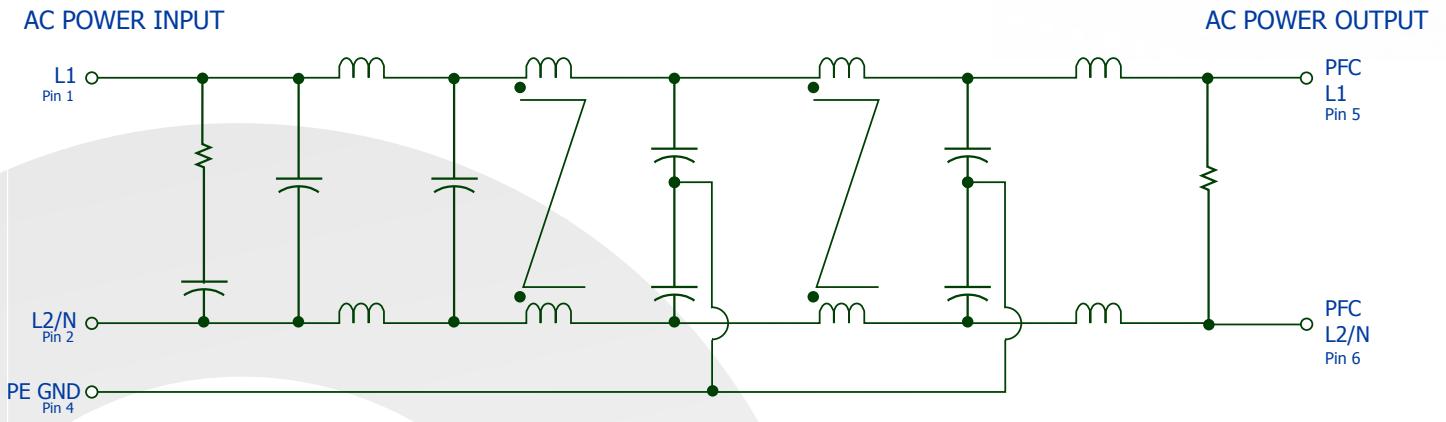
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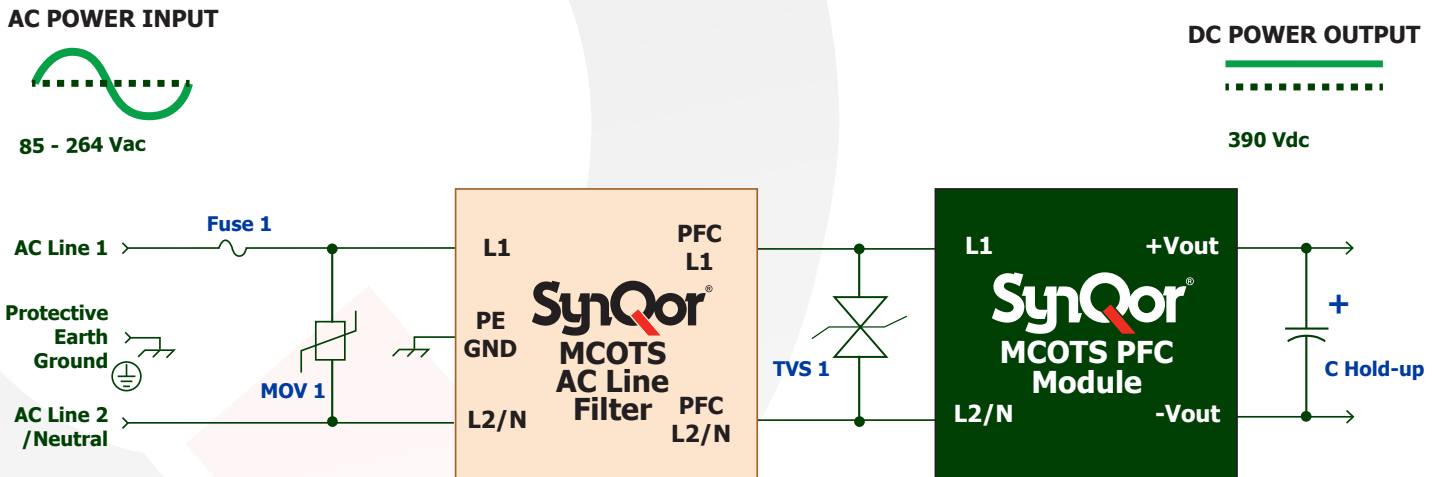


Technical Diagrams

Fundamental Circuit Diagram



Typical Connection Diagram



- MOV 1: 300VAC, 60J; (EPCOS S10K300E2)
- TVS 1: 400V, 3J; (Two VISHAY 1.5KE200CA devices connected in series)
- C Hold-up: 450V, 390 μ F; (United Chemi-Con ELXS451VSN391MR50S)
- Fuse 1: 250VAC, 12.5A; (Littelfuse 021612.5MXEP)



MACF-xxx-230-HT Electrical Characteristics

Vin <= 264Vrms, Iout <= 9Arms unless otherwise specified. Specifications subject to change without notice.

| Parameter | Min. | Typ. | Max. | Units | Notes & Conditions |
|---|-------------------------|---------|------|----------------------|---|
| ABSOLUTE MAXIMUM RATINGS | | | | | |
| Input Voltage (Continuous) | | | 264 | Vrms | |
| Isolation Voltage | | | 2150 | Vdc | Input/output to PE GND pin & baseplate |
| Output Current (Continuous) | | | 9 | Arms | |
| Output Current (Surge) | | | 400 | A ² S | |
| Operating Case Temperature | -55 | | 100 | °C | Baseplate temperature |
| Storage Case Temperature | -65 | | 135 | °C | |
| RECOMMENDED OPERATING CONDITIONS | | | | | |
| Input Voltage (Continuous) | | | 250 | Vrms | |
| Output Current (Continuous) | | | 9 | Arms | |
| ELECTRICAL CHARACTERISTICS | | | | | |
| Output Voltage (Continuous) | Vout = Vin - (Iin x Rs) | | | V | |
| Series Resistance Rs | | | | | Total |
| Tcase = 25°C | | 130 | | mΩ | |
| Tcase = 100°C | | | 195 | mΩ | |
| Power Dissipation | | | | | 9Arms output current |
| Tcase = 25°C | | 10.5 | | W | |
| Tcase = 100°C | | | 15.8 | W | |
| Total Differential-Mode Capacitance | | 1.5 | | μF | Measured across input or output pins |
| Total Common-Mode Capacitance 50/60Hz version | | 2 x 20 | | nF | Measured between PE GND pin and any other pin |
| Total Common-Mode Capacitance 400Hz version | | 2 x 8.3 | | nF | Measured between PE GND pin and any other pin |
| Leakage current in PE GND Pin 50/60Hz version | | | 1.9 | mArms | 250Vac L-N 50Hz, See Note 1 |
| Leakage current in PE GND Pin 400Hz version | | | 2.8 | mArms | 115Vac L-N 400Hz, See Note 1 |
| Noise Attenuation | | | | | See Figure 1 |
| Isolation Resistance | 100 | | | MΩ | Any pin to PE GND pin |
| RELIABILITY CHARACTERISTICS | | | | | |
| Calculated MTBF (MIL-217) MIL-HDBK-217F | | 243 | | 10 ⁶ Hrs. | Ground Benign, Tb = 70 °C |
| Calculated MTBF (MIL-217) MIL-HDBK-217F | | 17 | | 10 ⁶ Hrs. | Ground Mobile, Tb = 70 °C |

Note 1: If the neutral line is interrupted, leakage current may reach twice this level.



BASIC OPERATION AND FEATURES

This module is a multi-stage differential-mode and common-mode passive EMI filter designed to interface an AC power source with a SynQor MCOTS PFC module and one or more SynQor converters (or other loads that create EMI). Each stage of this filter is well damped to avoid resonances and oscillations, and only X7R multi-layer ceramic safety rated capacitors are used.

A typical application would place the MCOTS AC line filter close to the AC input power entry point. The AC line filter PE GND pin would be connected to the chassis ground that is common with AC input power protective earth (PE GND) or other earthed point used for EMI measurement. There are no connections to the metal baseplate, which may also be connected to the chassis ground if desired.

Do not connect the outputs of multiple MCOTS AC line filters in parallel. Connecting filters in this manner may result in slightly unequal currents to flow in the positive and return paths of each filter. These unequal currents will cause the internal common-mode chokes to saturate and thus cause degraded common-mode rejection performance.

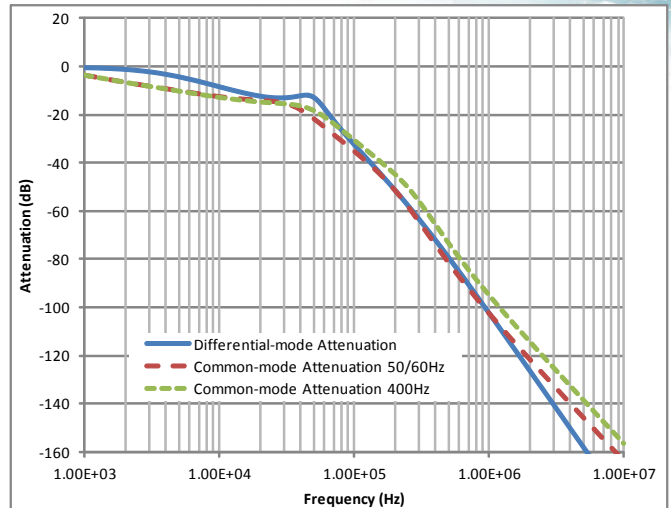


Figure 1: Typical Common Mode and Differential Mode Attenuation provided by the filter as a function of frequency. Source and load resistance are 50Ω.

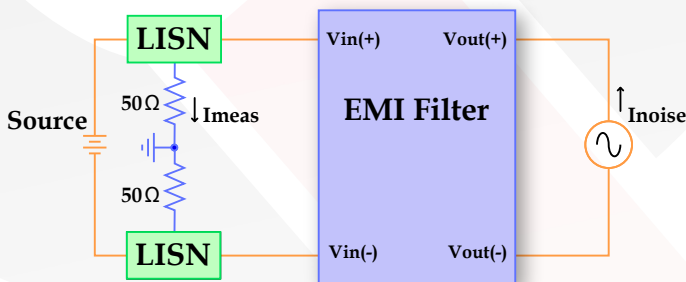


Figure 2: Typical Common Mode and Differential Mode Attenuation provided by the filter as a function of frequency. Source and load resistance are 50Ω.



Standards & Qualification Testing

Mil-COTS MIL-STD-810G Qualification Testing

| MIL-STD-810G Test | Method | Description |
|-----------------------------|-------------------------|--|
| Fungus | 508.6 | Table 508.6-I |
| Altitude | 500.5 - Procedure I | Storage: 70,000 ft / 2 hr duration |
| | 500.5 - Procedure II | Operating: 70,000 ft / 2 hr duration; Ambient Temperature |
| Rapid Decompression | 500.5 - Procedure III | Storage: 8,000 ft to 40,000 ft |
| Acceleration | 513.6 - Procedure II | Operating: 15 g |
| Salt Fog | 509.5 | Storage |
| High Temperature | 501.5 - Procedure I | Storage: 135 °C / 3 hrs |
| | 501.5 - Procedure II | Operating: 100 °C / 3 hrs |
| Low Temperature | 502.5 - Procedure I | Storage: -65 °C / 4 hrs |
| | 502.5 - Procedure II | Operating: -55 °C / 3 hrs |
| Temperature Shock | 503.5 - Procedure I - C | Storage: -65 °C to 135 °C; 12 cycles |
| Rain | 506.5 - Procedure I | Wind Blown Rain |
| Immersion | 512.5 - Procedure I | Non-Operating |
| Humidity | 507.5 - Procedure II | Aggravated cycle @ 95% RH (Figure 507.5-7 aggravated temp - humidity cycle, 15 cycles) |
| Random Vibration | 514.6 - Procedure I | 10 - 2000 Hz, PSD level of 1.5 g ² /Hz (54.6 g _{rms}), duration = 1 hr/axis |
| Shock | 516.6 - Procedure I | 20 g peak, 11 ms, Functional Shock (Operating no load) (saw tooth) |
| | 516.6 - Procedure VI | Bench Handling Shock |
| Sinusoidal vibration | 514.6 - Category 14 | Rotary wing aircraft - helicopter, 4 hrs/axis, 20 g (sine sweep from 10 - 500 Hz) |
| Sand and Dust | 510.5 - Procedure I | Blowing Dust |
| | 510.5 - Procedure II | Blowing Sand |

Mil-COTS Converter and Filter Screening

| Screening | Process Description | S-Grade | M-Grade |
|--|---|-------------------|-------------------------|
| Baseplate Operating Temperature | | -55 °C to +100 °C | -55 °C to +100 °C |
| Storage Temperature | | -65 °C to +135 °C | -65 °C to +135 °C |
| Pre-Cap Inspection | IPC-A-610, Class III | • | • |
| Temperature Cycling | MIL-STD-883F, Method 1010, Condition B, 10 Cycles | | • |
| Burn-In | 100 °C Baseplate | 12 Hours | 96 Hours |
| Final Electrical Test | 100% | 25 °C | -55 °C, +25 °C, +100 °C |
| Final Visual Inspection | MIL-STD-883F, Method 2009 | • | • |



| Parameter | Notes & Conditions |
|-----------|--------------------|
|-----------|--------------------|

STANDARDS COMPLIANCE

| | |
|---------------------------|------------------|
| UL 60950-1 | Basic Insulation |
| CAN/CSA-C22.2 No. 60950-1 | |
| EN60950-1 | Certified by TUV |

All Filter versions meet EN60950-1 leakage current requirements with a 250Vrms L-N 50/60Hz input.

The 400Hz filter version also meets EN60950-1 leakage current requirements with a 115 Vrms L-N 400Hz input but not with a 250Vrms L-N 400Hz input.

Note: An external input fuse must always be used to meet these safety requirements, see the Typical Connection Diagram.

Contact SynQor for official safety certificates on new releases or download from the SynQor website.

| Parameter | # Units | Test Conditions |
|-----------|---------|-----------------|
|-----------|---------|-----------------|

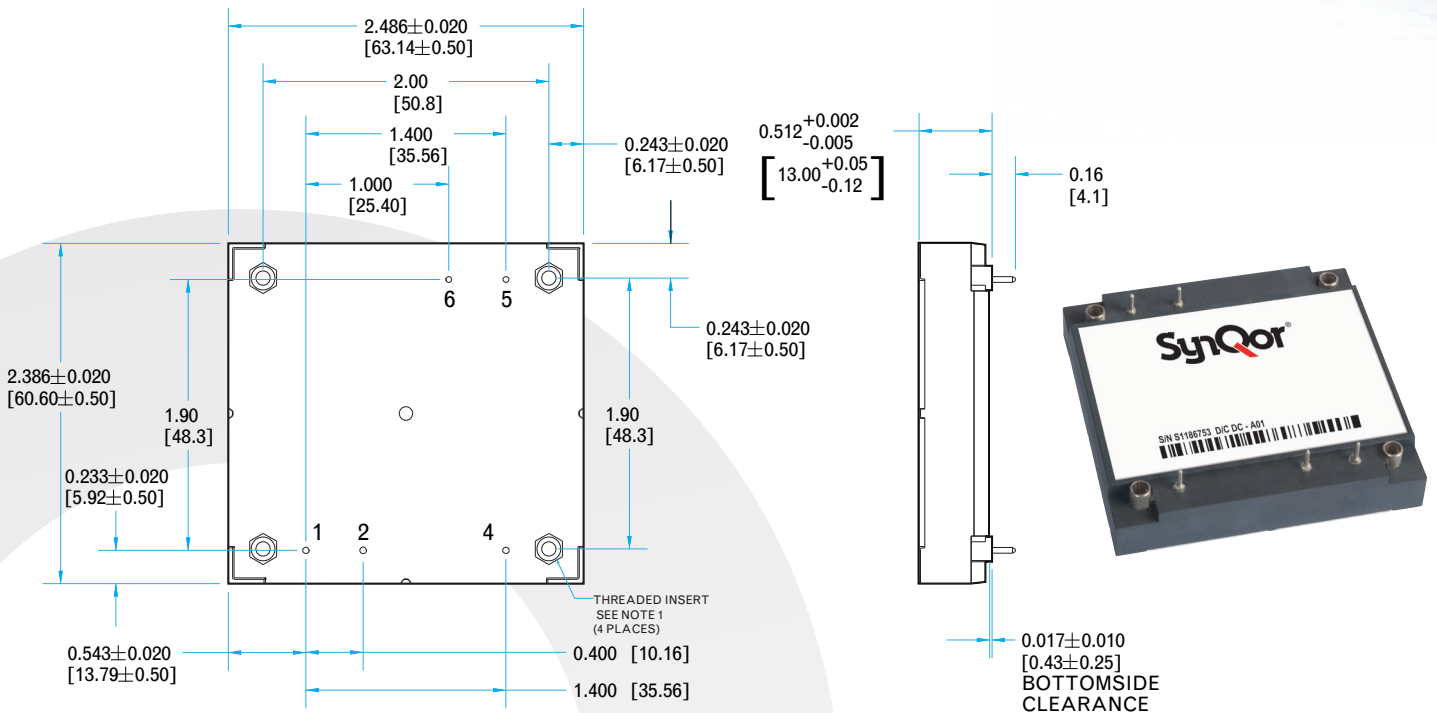
QUALIFICATION TESTING

| | | |
|-----------------------|---------|---|
| Life Test | 32 | 95% rated Vin and load, units at derating point, 1000 hours |
| Vibration | 5 | 10-55 Hz sweep, 0.060" total excursion, 1 min./sweep, 120 sweeps for 3 axis |
| Mechanical Shock | 5 | 100g minimum, 2 drops in x, y, and z axis |
| Temperature Cycling | 10 | -55 °C to 100 °C, unit temp. ramp 15 °C/min., 500 cycles |
| Power/Thermal Cycling | 5 | Toperating = min to max, Vin = min to max, full load, 100 cycles |
| Design Marginality | 5 | Tmin-10 °C to Tmax+10 °C, 5 °C steps, Vin = min to max, 0-105% load |
| Humidity | 5 | 85 °C, 95% RH, 1000 hours, continuous Vin applied except 5 min/day |
| Solderability | 15 pins | MIL-STD-883, method 2003 |
| Altitude | 2 | 70,000 feet (21 km), see Note |

Note: A conductive cooling design is generally needed for high altitude applications because of naturally poor convective cooling at rare atmospheres.



Encased Mechanical Diagram



NOTES

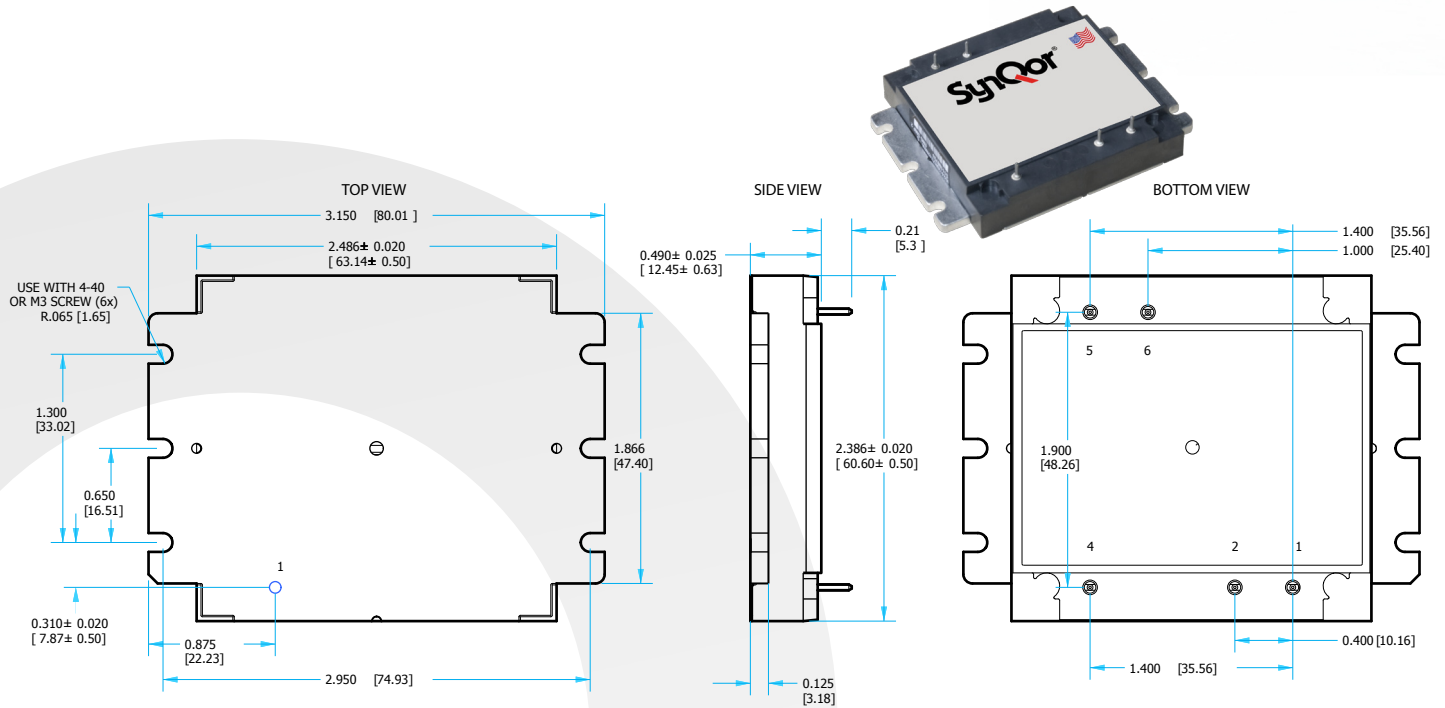
- 1) Applied torque per M3 screw should not exceed 6in-lb. (0.7 Nm).
Non-Threaded: Dia 0.125" (3.18 mm)
- 2) Baseplate flatness tolerance is 0.004" (.10 mm) TIR for surface.
- 3) Pins are 0.040" (1.02mm) diameter, with 0.080" (2.03mm) diameter standoff shoulders.
- 4) All Pins: Material - Copper Alloy
Finish: Matte Tin over Nickel plate
- 5) Undimensioned components only for visual reference.
- 6) Total weight: 5.0oz (142g)
- 7) Threaded and Non-Threaded options available
- 8) All dimensions in inches (mm)
Tolerances: x.xx +/-0.02 in. (x.x +/-0.5mm)
x.xxx +/-0.010 in. (x.xx +/-0.25mm)
- unless otherwise noted.
- 9) Workmanship: Meets or exceeds current IPC-A-610 Class II

PIN DESIGNATIONS

| Pin | Name | Function |
|-----|----------|----------------------------|
| 1 | L1 | AC Line 1 |
| 2 | L2/N | AC Line 2 / Neutral |
| 4 | PE GND | Protective Earth |
| 5 | PFC L1 | PFC Input Line 1 |
| 6 | PFC L2/N | PFC Input Line 2 / Neutral |



Flanged Mechanical Diagram



NOTES

- 1) Applied torque per screw should not exceed 6in-lb. (0.7 Nm).
- 2) Baseplate flatness tolerance is 0.004" (.10 mm) TIR for surface.
- 3) Pins are 0.040" (1.02mm) diameter, with 0.080" (2.03mm) diameter standoff shoulders.
- 4) All Pins: Material - Copper Alloy
Finish: Matte Tin over Nickel plate
- 5) Undimensioned components only for visual reference.
- 6) Weight: 5.2oz (148g)
- 7) All dimensions in inches (mm)
Tolerances: x.xx +/-0.02 in. (x.x +/-0.5mm)
x.xxx +/-0.010 in. (x.xx +/-0.25mm)
- unless otherwise noted.
- 8) Workmanship: Meets or exceeds current IPC-A-610 Class II

PIN DESIGNATIONS

| Pin | Name | Function |
|-----|----------|----------------------------|
| 1 | L1 | AC Line 1 |
| 2 | L2/N | AC Line 2 / Neutral |
| 4 | PE GND | Protective Earth |
| 5 | PFC L1 | PFC Input Line 1 |
| 6 | PFC L2/N | PFC Input Line 2 / Neutral |



MACF-xxx-230-HT

Technical Specification

Ordering Specifications

| Family | Input Frequency | Input Voltage | Package | Thermal Design | Screening Level |
|-----------------------------|--|---------------------------|----------------------------|---|--|
| MACF | 060 | 230 | HT | N | S |
| MACF: AC Line Filter | 060: 50/60 Hz 400: 400 Hz | 230: 85 to 264Vrms | HT: Half-Brick Tera | N: Encased Threaded D: Non-Threaded F: Flanged | S: Standard M: Military |

Part Number Example: **MACF-060-230-HT-N-M**

APPLICATION NOTES

A variety of application notes and technical white papers can be downloaded in pdf format from our website.

ORDERING INFORMATION

Not all combinations make valid part numbers, please contact SynQor for availability.

Contact SynQor for further information and to order:

Phone: 978-849-0600
Toll Free: 888-567-9596
Fax: 978-849-0602
E-mail: power@synqor.com
Web: www.synqor.com
Address: 155 Swanson Road
 Boxborough, MA 01719
 USA

PATENTS

SynQor holds numerous U.S. patents, one or more of which apply to most of its power conversion products. Any that apply to the product(s) listed in this document are identified by markings on the product(s) or on internal components of the product(s) in accordance with U.S. patent laws. SynQor's patents include the following:

| | | | |
|-----------|-----------|-----------|-----------|
| 6,896,526 | 6,927,987 | 7,050,309 | 7,085,146 |
| 7,765,687 | 7,787,261 | 8,149,597 | 8,644,027 |

Warranty

SynQor offers a two (2) year limited warranty. Complete warranty information is listed on our website or is available upon request from SynQor.