

### Military COTS AC Line Filter

<b>85 to 264Vrms</b> <b>Input Voltage</b>	<b>11.5Arms</b> <b>Iout</b>	<b>1kW @ 115Vrms</b> <b>2kW @ 230Vrms</b> <b>Output Power</b>	<b>195mΩ @ 100°C</b> <b>Max Series Resistance</b>	<b>&gt;55dB @ 250kHz</b> <b>Differential &amp; Common-mode Attenuation</b>
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**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<sup>™</sup>



*MACF-060-230-HP-N-M Module*

#### Operational Features

- -55°C to +100°C Operation
- 11.5Arms 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 62368-1 requirement for basic insulation (Pending) (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

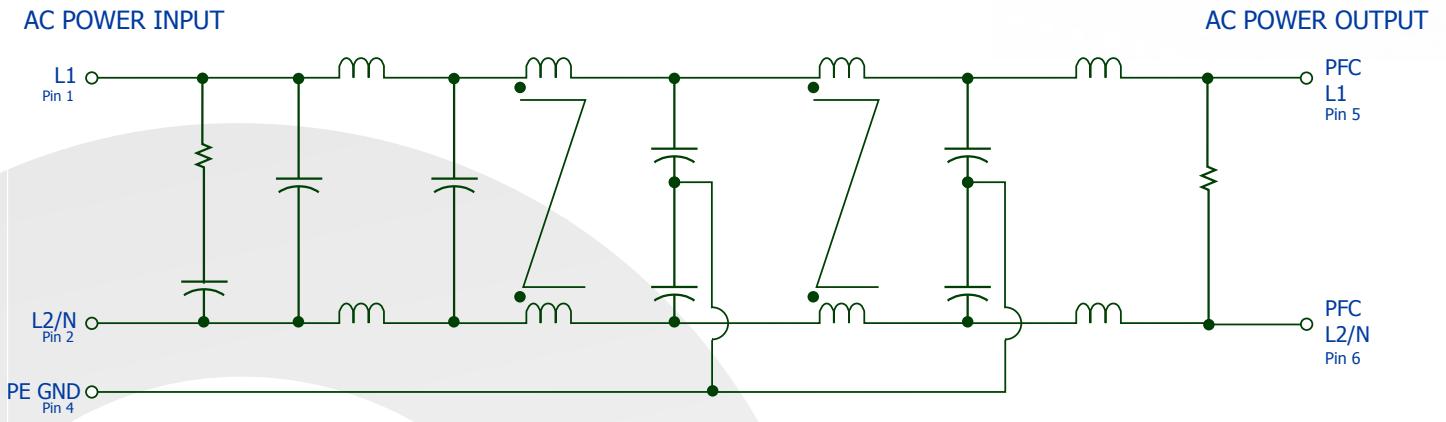
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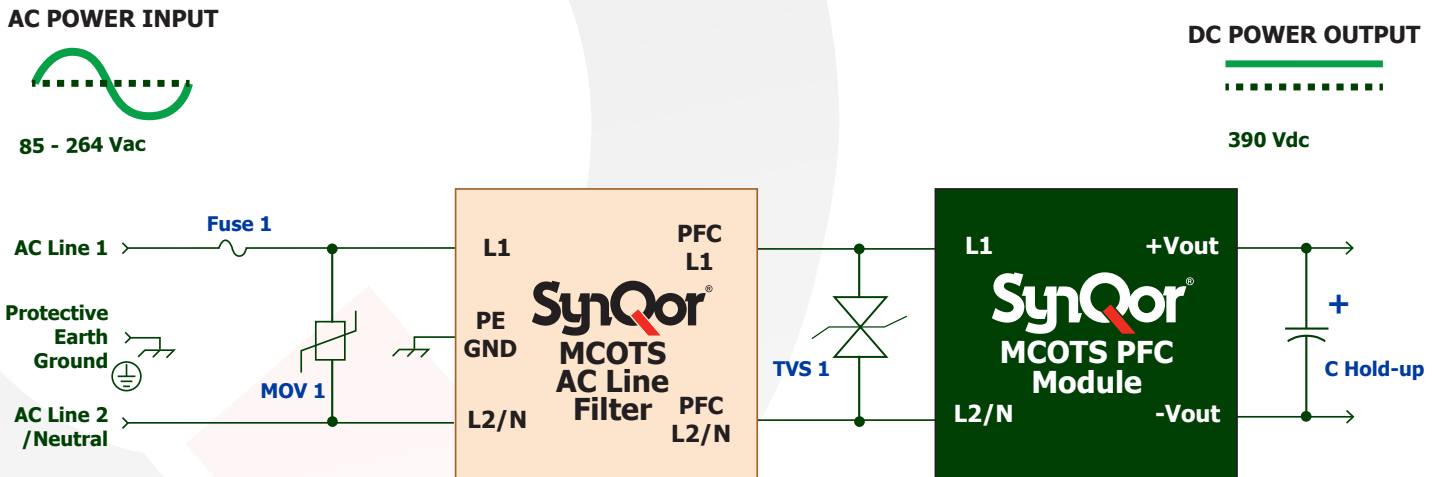


## Technical Diagrams

### 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 $\mu$ F; (United Chemi-Con ELXS451VSN391MR50S)

Fuse 1: 250VAC, 12.5A; (Littelfuse 021612.5MXEP)



**MACF-xxx-230-HP Electrical Characteristics**

Vin <= 264Vrms, Iout <= 11.5Arms unless otherwise specified. Specifications subject to change without notice.

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
<b>ABSOLUTE MAXIMUM RATINGS</b>					
Input Voltage (Continuous)			264	Vrms	
Isolation Voltage			2150	Vdc	Input/output to PE GND pin & baseplate
Output Current (Continuous)			11.5	Arms	
Output Current (Surge)			400	A <sup>2</sup> S	
Operating Case Temperature	-55		100	°C	Baseplate temperature
Storage Case Temperature	-65		135	°C	
<b>RECOMMENDED OPERATING CONDITIONS</b>					
Input Voltage (Continuous)			250	Vrms	
Output Current (Continuous)			11.5	Arms	
<b>ELECTRICAL CHARACTERISTICS</b>					
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					11.5Arms output current
Tcase = 25°C		17.2		W	
Tcase = 100°C			25.8	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
<b>RELIABILITY CHARACTERISTICS</b>					
Calculated MTBF (MIL-217) MIL-HDBK-217F		5.9		10 <sup>6</sup> Hrs.	Ground Benign, Tb = 70 °C
Calculated MTBF (MIL-217) MIL-HDBK-217F		0.339		10 <sup>6</sup> 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.

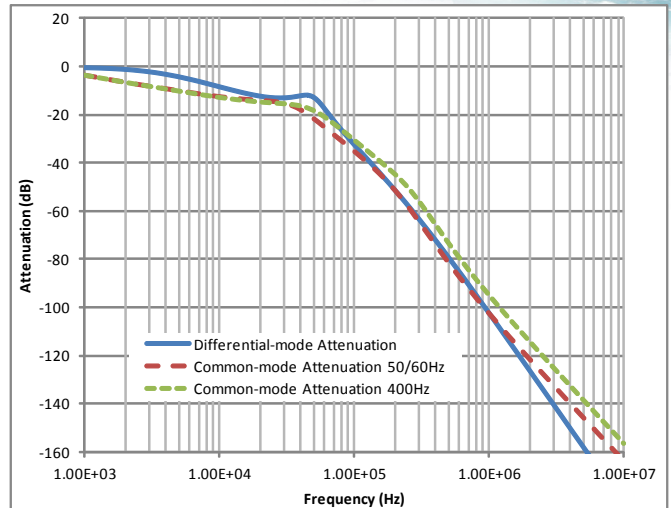


Figure 1: Typical Common Mode and Differential Mode Attenuation provided by the filter as a function of frequency. Source and load resistance are 50Ω.

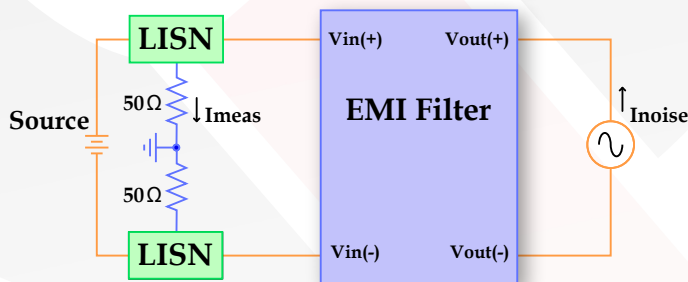


Figure 2: Typical Common Mode and Differential Mode Attenuation provided by the filter as a function of frequency. Source and load resistance are 50Ω.



**Standards & Qualification Testing**

**Mil-COTS MIL-STD-810G Qualification Testing**

MIL-STD-810G Test	Method	Description
<b>Fungus</b>	508.6	Table 508.6-I
<b>Altitude</b>	500.5 - Procedure I	Storage: 70,000 ft / 2 hr duration
	500.5 - Procedure II	Operating: 70,000 ft / 2 hr duration; Ambient Temperature
<b>Rapid Decompression</b>	500.5 - Procedure III	Storage: 8,000 ft to 40,000 ft
<b>Acceleration</b>	513.6 - Procedure II	Operating: 15 g
<b>Salt Fog</b>	509.5	Storage
<b>High Temperature</b>	501.5 - Procedure I	Storage: 135 °C / 3 hrs
	501.5 - Procedure II	Operating: 100 °C / 3 hrs
<b>Low Temperature</b>	502.5 - Procedure I	Storage: -65 °C / 4 hrs
	502.5 - Procedure II	Operating: -55 °C / 3 hrs
<b>Temperature Shock</b>	503.5 - Procedure I - C	Storage: -65 °C to 135 °C; 12 cycles
<b>Rain</b>	506.5 - Procedure I	Wind Blown Rain
<b>Immersion</b>	512.5 - Procedure I	Non-Operating
<b>Humidity</b>	507.5 - Procedure II	Aggravated cycle @ 95% RH (Figure 507.5-7 aggravated temp - humidity cycle, 15 cycles)
<b>Random Vibration</b>	514.6 - Procedure I	10 - 2000 Hz, PSD level of 1.5 g <sup>2</sup> /Hz (54.6 g <sub>rms</sub> ), duration = 1 hr/axis
<b>Shock</b>	516.6 - Procedure I	20 g peak, 11 ms, Functional Shock (Operating no load) (saw tooth)
	516.6 - Procedure VI	Bench Handling Shock
<b>Sinusoidal vibration</b>	514.6 - Category 14	Rotary wing aircraft - helicopter, 4 hrs/axis, 20 g (sine sweep from 10 - 500 Hz)
<b>Sand and Dust</b>	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
<b>Baseplate Operating Temperature</b>		-55 °C to +100 °C	-55 °C to +100 °C
<b>Storage Temperature</b>		-65 °C to +135 °C	-65 °C to +135 °C
<b>Pre-Cap Inspection</b>	IPC-A-610, Class III	•	•
<b>Temperature Cycling</b>	MIL-STD-883F, Method 1010, Condition B, 10 Cycles		•
<b>Burn-In</b>	100 °C Baseplate	12 Hours	96 Hours
<b>Final Electrical Test</b>	100%	25 °C	-55 °C, +25 °C, +100 °C
<b>Final Visual Inspection</b>	MIL-STD-883F, Method 2009	•	•



Parameter	Notes & Conditions
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STANDARDS COMPLIANCE	
UL 62368-1	Pending
CAN/CSA-C22.2 No. 62368-1	Basic Insulation
EN60950-1	Certified by TUV

All Filter versions meet EN62368-1 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.

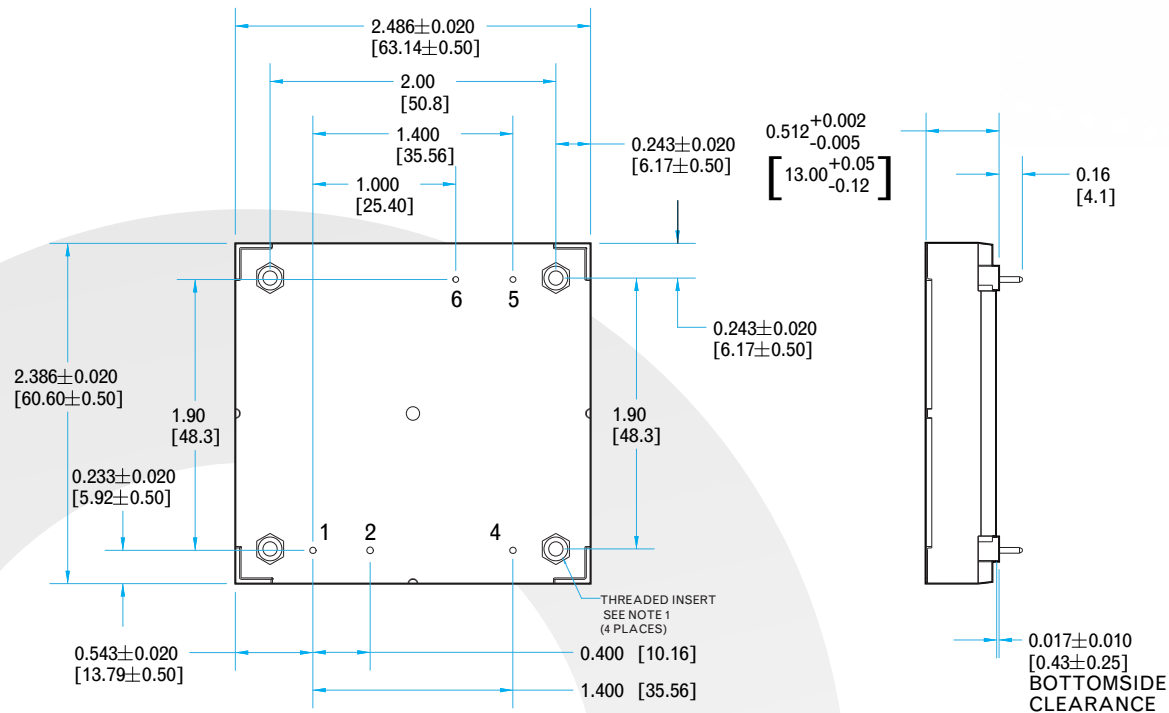
Parameter	# Units	Test Conditions
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QUALIFICATION TESTING		
Life Test	32	95% rated Vin and load, units at derating point, 1000 hours
Vibration	5	10-55 Hz sweep, 0.060" total excursion, 1 min./sweep, 120 sweeps for 3 axis
Mechanical Shock	5	100g minimum, 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

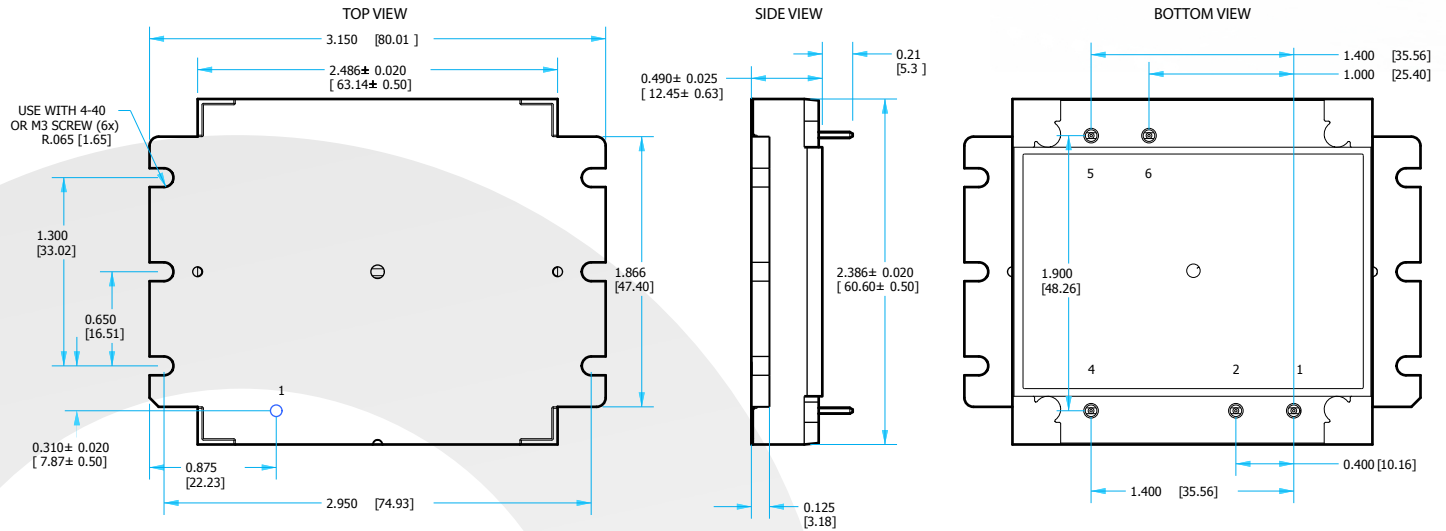
- Applied torque per M3 screw should not exceed 6in-lb. (0.7 Nm).  
Non-Threaded: Dia 0.125" (3.18 mm)
- Baseplate flatness tolerance is 0.004" (.10 mm) TIR for surface.
- Pins are 0.040" (1.02mm) diameter, with 0.080" (2.03mm) diameter standoff shoulders.
- All Pins: Material - Copper Alloy  
Finish: Matte Tin over Nickel plate
- Undimensioned components only for visual reference.
- Total weight: 5.0oz (142g)
- Threaded and Non-Threaded options available
- 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.
- 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

- Applied torque per screw should not exceed 6in-lb. (0.7 Nm).
- Baseplate flatness tolerance is 0.01" (.25 mm) TIR for surface.
- Pins are 0.040" (1.02mm) diameter, with 0.080" (2.03mm) diameter standoff shoulders.
- All Pins: Material - Copper Alloy  
Finish: Matte Tin over Nickel plate
- Undimensioned components only for visual reference.
- Weight: 5.2oz (148g)
- 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.
- 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-HP**

**Technical Specification**

**Ordering Specifications**

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

Part Number Example: **MACF-060-230-HP-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](mailto:power@synqor.com)  
**Web:** [www.synqor.com](http://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:

6,927,987    7,050,309    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.