

# MAC **MILITARY FIELD-GRADE**

**3- $\Phi$  - 1- $\Phi$  AC CHANGER**

## Operator's Guide *MAC-4000 Series*



Made in USA



MAC-4000-1U

***N+M REDUNDANCY***

*(optional)*

**SynQor**  
Advancing The Power Curve®

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## Hazardous Voltages

The **INPUT AND OUTPUT POWER** connectors and cables of the SynQor MAC may have voltages that are unsafe. **INJURY OR DEATH ON CONTACT** may result. Appropriate safety precautions should be taken. All connections should be made in accordance with **LOCAL ELECTRICAL CODES**.

- The **CHASSIS** should be connected to earth or system ground with Ground Stud on the rear panel, see mechanical diagrams.
- For the **AC INPUT** cable and connector:
  - ◆ Do not assume that a hazardous voltage is not present at the terminals of the AC input connector, even if the MAC appears to be “OFF”.
  - ◆ Do not make contact with the terminals of the AC input connector.
  - ◆ Always connect the cable to the MAC before it is connected to the source of AC power.
  - ◆ Always disconnect the AC input cable from the source of AC power before disconnecting it from the MAC.
  - ◆ If the AC input cable is connected to the source of AC power and not connected to the MAC, do not contact the exposed terminals of the AC input cable.
  - ◆ If custom built cables are used to power the MAC unit, verify that the custom input cabling has a reliable ground connection and that the ground connection has not been accidentally swapped with a line connection. Connecting the ground wire to a live line could possibly put hazardous voltages across the chassis.
  - ◆ Connections between the AC input cable and the source of AC power should not be accessible.
- For the **AC OUTPUT** cable and connector:
  - ◆ Do not assume that a hazardous voltage is not present at the terminals of the AC output connector, even if the MAC appears to be “OFF”.
  - ◆ Do not make contact with the terminals of the AC output connector.
  - ◆ Connect the AC output cable to the MAC before the MAC is turned on.
  - ◆ If connection of the load to the AC output cable has exposed conductors, make this connection before connecting the AC output cable to the MAC.
  - ◆ Connections between the AC output cable and the AC load should not be accessible.

### ***Hazardous Energies***

The **INPUT AND OUTPUT POWER** connectors and cables of the SynQor MAC may be a source of high levels of energy. Do not inappropriately make electrical contact between any terminal of a connector and another, or between any wire of a cable and another, or between any terminal or wire and the MAC Unit's chassis or ground. **DAMAGING ELECTRICAL ARCS** may result. Care should be taken to avoid accidental electrical contacts of this sort. The CHASSIS should be connected to earth or system ground through the Ground Stud on the rear panel, see mechanical diagrams.

### ***Protection from the Environment***

The SynQor MAC is a ruggedly built product having its electronics contained in a sealed chamber. It is capable of withstanding harsh levels of mechanical acceleration, shock and vibration, temperature and pressure variations, and exposure to water, salt, sand and dust within the levels specified in the data sheet. **THESE LEVELS SHOULD NOT BE EXCEEDED.**

Do not obstruct the air intake in the front of the MAC or the fan exhausts in the rear panel of the MAC while the MAC is operating.

### ***User Serviceable Parts***

MAC-4000 fans are user replaceable with kits available from SynQor. Please contact the SynQor factory for obtaining fan replacement kits and instructions (Counter-Rotating Replaceable Fan Module , two piece kit, SYN-9452). The SynQor MAC has no other user serviceable parts inside. **DO NOT REMOVE** the cover of the MAC or any of its connectors. Other than fan assembly replacement, only factory trained personnel should perform unit repairs.

### *Product Description*

SynQor's Military 3-Phase AC to Single-Phase AC Power Units are designed for the extreme environmental and demanding electrical conditions of Military/Aerospace applications. SynQor's MAC units incorporate field proven high efficiency designs and rugged packaging technologies. The MAC will accept an AC 3-Phase Input with a voltage and frequency range of 360-528 Vrms (line to line) and 47-65 Hz. The unit will deliver a well-conditioned continuous 4000 W/5000 VA, 115/230 Vrms Single-Phase output to the load. The output is surge-rated to 5250 W/6500 VA for transient durations up to 5 seconds. All MAC units are designed and manufactured in SynQor's USA facilities to comply with a significant set of military standards.

A communication/control port is available to permit monitoring and control through a host computer system. Front panel LEDs provide information on the status of the MAC.

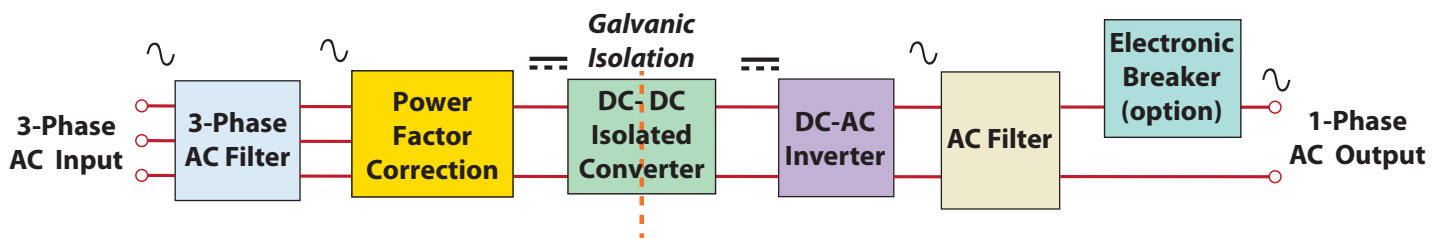
The electronic circuitry within the MAC-4000 Series products is designed, qualified and screened according to SynQor's MIL-COTS Standards. It complies with the requirements of MIL-STD-1399-300B and MIL-STD-461F.

The MAC-4000 Series products are designed and manufactured to withstand the harshest environments and use encountered in military applications. The electronic circuitry is contained in a sealed chamber constructed from a die-cast aluminum chassis that is weather-proof and shock-proof. Redundant, water-proof fans on the rear panel draw cooling air over the heat-sink fins below the sealed chamber. Military-grade circular connectors are used, and optional attached connector covers are available for when the cables are not attached. The MAC-4000 products comply with a wide range of testing according to MIL-STD-810G.

The SynQor MAC-4000 Series products are designed and manufactured in the U.S.A.

### Product Topology

The SynQor MAC-4000 Series products use an isolated topology that provides protection to the load from spikes, noise, surges, brownouts, blackouts, etc. in the input power source. They also provide smoothing of load transients and nonlinear load profiles so that the input power source is not subjected to these disturbances. EMI filters are present at all MAC external inputs and outputs.



Power flows in the MAC unit from the AC INPUT through an AC 3-Phase EMI Line Filter, to a 3-Phase AC-DC converter with Power Factor Correction (PFC). DC power is then passed through an isolated DC-DC converter to create a galvanic isolation layer between the AC input and the DC mid-bus. Bulk energy storage capacitors connected to the mid-bus smooth imbalances in the power flow. The AC OUTPUT is then created by an inverter that draws power from the isolated DC mid-bus. The inverter provides a pure-sinusoidal output voltage waveform. An AC EMI Line Filter located at the output of the inverter provides clean, well-conditioned continuous output power to the load. An optional electronic breaker can be added to the AC OUTPUT. The breaker is a one pole hot side only type, that allows for fault-tolerant, glitch-free operation when several MAC units are placed in parallel.

There is a communication/control port that provides a digital interface to a host computer system.



**Part Numbering Scheme and Options**

This table shows the part numbering scheme for the full line of SynQor MAC products:

Base Models			
Model Number	Power	Height (W x D x H)	Weight
MAC-4000-1U-	4000 W 5000 VA	1U (17.00" x 22.42" x 1.73")	33 lbs.

Base Models	Options								
	Line to Line Input Voltage	Number of Input Phases	Input Freq Range	AC Output Voltage	AC Output Neutral Wire	AC Output Set Point Freq	Output Config	Additional Options	
MAC-4000-1U-	4	T	L	1 2	G F R	5 6 4	S	-E	00 CE

Options	
Line to Line Input Voltage	4 360-528 V
Number of Input Phases	T 3-Phase
Input Freq Range	L 47-65 Hz
AC Output Voltage	1 115 V 2 230 V
AC Output Neutral Wire	G Grounded F Floating* R AC Output Electronic Breaker*
AC Output Set Point Freq	5 50 Hz 6 60 Hz 4 400 Hz
Output Config	S One Single-Phase Output
Additional Options	-E Ethernet/SNMP with Config Loading
	00 No CE Marking
	CE CE Marking

Not all combinations make valid part numbers, please contact SynQor for availability. See the Product Summary web page for more options.

**\*Notes:**

Order "F: Floating" option when configuring the AC output for multi-unit combinations of up to 32 units.

Order "R: AC Output Electronic Breaker" option for fault-tolerant, glitch-free parallel systems of up to 32 units with N+M redundancy. The AC output neutral wire will not be connected to the chassis for either the F option or R option.

**Example:**

MAC-4000-1U-4TL2G6S-E00

The MAC-4000 Series of products provide up to 4000 W (5250W transient) of AC Single-Phase output power.

Options that can be specified according to the part numbering scheme shown in table include:

- A 1U high, 33 lbs. rackmount unit.

Each format has various options that can be specified according to the part numbering scheme shown in the table:

- The AC OUTPUT voltage of the MAC-4000 series can be 115 Vrms or 230 Vrms.
- The AC OUTPUT can be configured with its neutral wire intentionally grounded to the chassis of the MAC or left floating for shipboard and paralleling applications of up to 32 units.
- The initial set-point frequency of the AC OUTPUT voltage can be 50, 60, or 400 Hz. Regardless of the initial set-point frequency, the actual frequency can be set through the communications/control port to 50, 60, or 400 Hz.



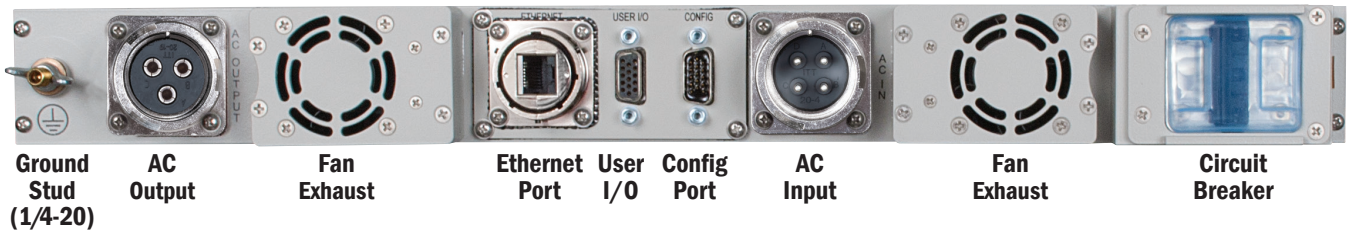
- The Electronic Breaker option adds fault-tolerant, glitch-free multi-unit operation for N+1 or N+M redundancy. This option allows up to 32 units total in Single-Phase, Split-Phase, or 3-Phase systems.
- RS-232 serial port and logic-level I/O communication are included in the standard model. An Ethernet port provides web and SNMP interfaces.

**Product Specifications**

The next pages show the electrical and mechanical specifications of the MAC-4000-1U Series of products. Data sheets showing these specifications and other information can be found at the web site <http://www.synqor.com/MAC>.



**MAC-4000-1U with AC Input**



**Transit Case Option**

## Technical Specifications

### AC INPUT OPERATING CHARACTERISTICS

Voltage	3-Phase, 360-528 Vrms L-L
Frequency	47-65 Hz
Input Current Total Harmonic Distortion	<3% (4000 W load)
Input Power Factor (Distortion Component)	>0.99 (4000 W load)
Input Current Balance (Highest - Lowest)	<2%
Max. Input Current Per Phase @ 360 Vrms L-L	9.6 Arms (5250 W load)
Integrated AC Input Circuit Breaker Rating	12 Arms

### AC OUTPUT CHARACTERISTICS

Continuous Output Power	4000 W (5000 VA)
Transient Output Power (15 seconds)	5250 W (6500 VA)
AC Output Waveform	Pure Sinusoidal
Voltage Line-Neutral	115 Vrms $\pm$ 3%
	230 Vrms $\pm$ 3%
Frequency (software selectable)	60 Hz $\pm$ 0.5%
	50 Hz $\pm$ 0.5%
	400 Hz $\pm$ 0.5%
Output Voltage Total Harmonic Distortion	<2%
Load Power Factor	0-1.0 (leading or lagging)
Efficiency	90% (4000 W load)
	88% (2000 W load)

### Single-Phase Output

Steady State Load Current	43.5 Arms (115 Vrms)
	21.7 Arms (230 Vrms)
Transient Load Current (15 seconds)	56.5 Arms (115 Vrms)
	28.3 Arms (230 Vrms)
Peak Load Current (Min. Shutdown Threshold)	104 Apk (115 Vrms)
	52 Apk (230 Vrms)

Specifications subject to change without notice.

### ENVIRONMENTAL CHARACTERISTICS MIL-STD-810G

#### Temperature Methods 501.5, 502.5

Operating Ambient Temperature	
Full Rated Power	-40 °C to +55 °C
Reduced Power	+55 °C to +70 °C
Storage Temperature	-40 °C to +70 °C

#### Altitude Method 500.5

Operating	0 - 18,000 ft
Non-operating	0 - 40,000 ft

#### Environmental Tests

Shock/Drop	Method 516.6, Procedures 1, 4, 6
Temperature Shock	Method 503.5, Procedure 1
Vibration	Method 514.6, CAT 5, 7, 8, 9, 24
Fungus	Method 508.6
Salt Fog	Method 509.5
Sand and Dust	Method 510.5, Procedures 1, 2
Rain	Method 506.5 Procedure 1
Humidity	Method 507.5 Procedure 2
Mechanical Vibrations of Shipboard Equipment	Method 528 Procedure 1

### RELIABILITY CHARACTERISTICS MIL-HDBK-217F

MTBF: 450 kHrs	MIL-217F Ground Benign, Ta=25 °C
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### INTERFACE STD FOR SHIPBOARD SYSTEMS MIL-STD-1399B

Type I 440 V 3-Phase Input Power
Type I 115 V 1-Phase Output Power (Order F / R Option to Float Output)

### ELECTROMAGNETIC CAPABILITY MIL-STD-461F

CE101-2	30 Hz - 10 kHz
CE102	10 kHz - 10 MHz
CS101	30 Hz - 150 kHz
CS106	Pulse Transients
CS114 (Curve #5)	10 kHz - 200 MHz
CS115	Impulse Excitation
CS116	10 kHz - 100 MHz
RE101 (Navy Limit)	30 Hz - 100 kHz
RE102 (Navy Topside Limit)	10 kHz - 1 GHz

### MECHANICAL CHARACTERISTICS

Chassis Size	17.00" W x 22.42" D x 1.73" H (1U)
Case Material	Aluminum
Weight	33 lbs.

#### AC Input Connectors

AC Input Connector	CB2-20-4PHA34-FM
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#### AC Output Connectors

115V Single Phase	CB2-20-19SXA34-FM
230V Single Phase	CB2-20-19SXA34-FM

#### I/O Ports

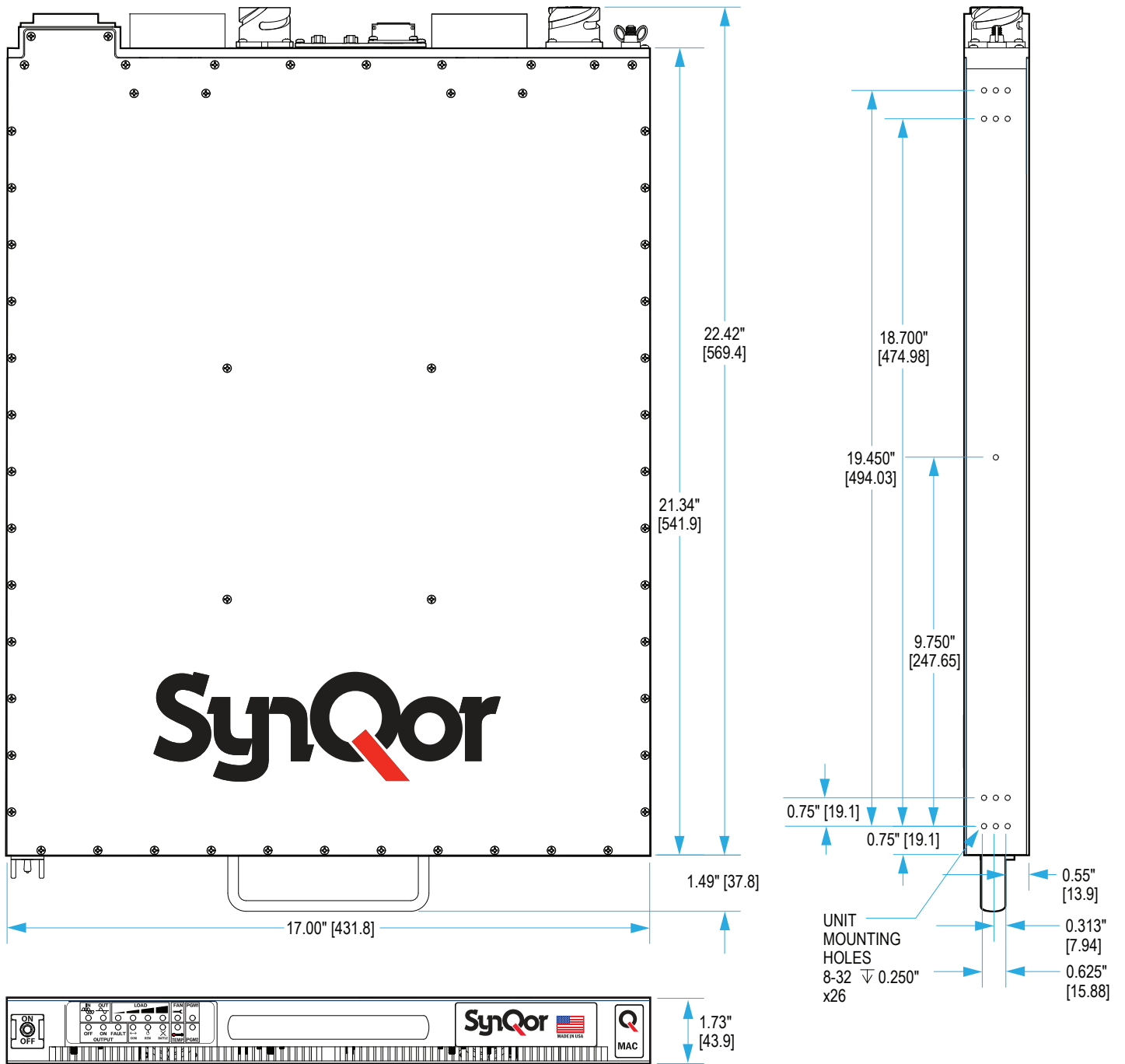
Configuration I/O Port	HD DB15 Male
User I/O Port	HD DB15 Female
Ethernet Port	Amphenol RJF22N00, Code B

#### Cooling Exhaust Fans

Sound Pressure Level (SPL)	64 dB(A)
Air Flow	0.92(m <sup>3</sup> /min) 32.5 CFM

Two fans in system; above specs are for each fan separately.

1U Mechanical Diagram



## Efficiency

Figure 1 shows the typical efficiency with which the MAC-4000 series unit delivers power to its AC OUTPUT load from 60 Hz:

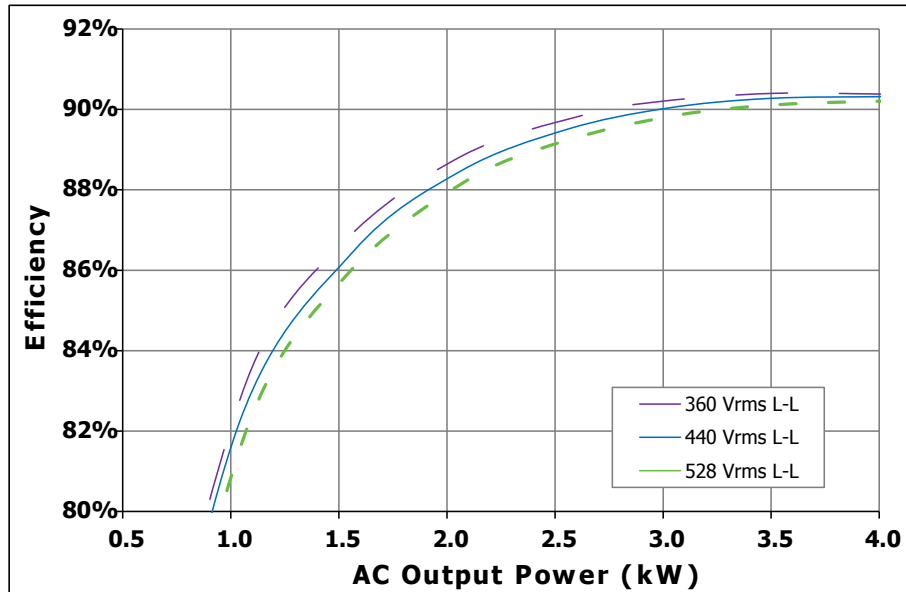


Figure 1

## Total Output Power

The total MAC output power for the MAC-4000 series is rated at 4000 W/5000 VA (Surge-rated to 5250 W/6500 VA for transient durations up to 5 seconds) for an ambient temperature as high as 55°C (131°F).

**Temperature Derating**

The maximum steady-state MAC output power as a function of ambient air temperature and AC input voltage is shown below in Figure 2. (See Section IV).

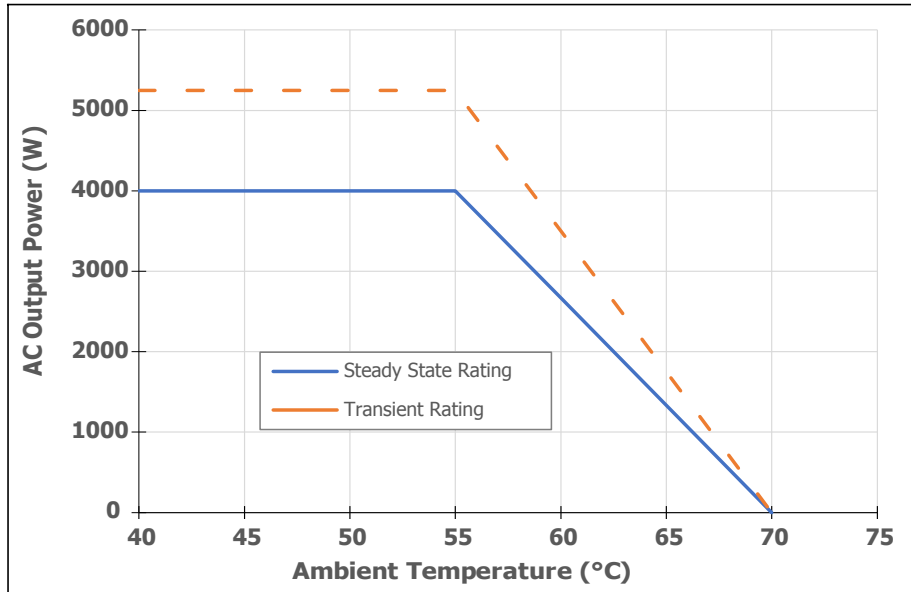
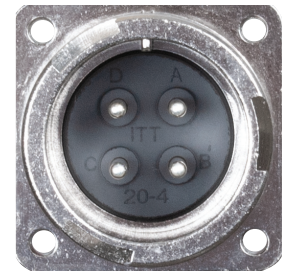
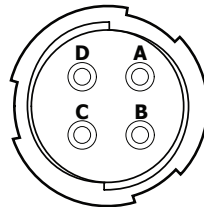


Figure 2: Output Power vs. Ambient Temperature

**Power Cable Wiring Diagram**

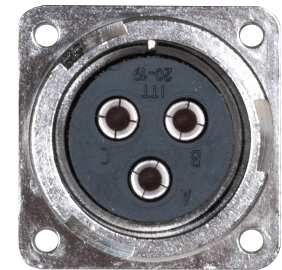
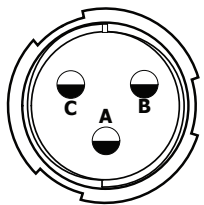
Looking at the rear panel, the MAC connector terminals have the following functions and locations:

AC INPUT	
Pin	Function
A	Line A (360-528)
B	Line B (360-528)
C	Line C (360-528)
D	Ground



Warning: Pin D should never be connected to a line Voltage

AC OUTPUT	
Pin	Function
A	Line 1
B	Line 2
C	Ground



### Set-Up

The recommended procedure for setting up the MAC is the following:

- Make sure the AC BREAKER on the rear panel of the MAC is in the “OFF” position.
- The AC breaker on the rear panel is classified as a supplementary protector and is not designed for branch circuit protection. A suitable circuit breaker should be added externally for the AC input if branch circuit protection is required.
- Connect the ground wire to the ground stud on the rear panel of the MAC.
- Connect the AC OUTPUT cables, first to the MAC and then to the load.
- Connect the USER I/O cables.
- Check that pin D in the input connector is not connected to a line voltage. On input cables provided by SynQor, pin D (input AC ground) is connected to the green color wire.
- Connect the INPUT cables, first to the MAC and then to the AC source.
- Turn on the source (if it has an up-stream breaker).
- Move the AC BREAKER on the rear panel of the MAC to the ON position.

### Start-Up

- VERIFY that all connections to the MAC are correct.
- If the AC source is present and within specifications, a POWER IN LEDs on the front panel will light up green.
- Momentarily push the “ON/OFF” switch on the front panel of the MAC upward. The switch can then be released and it will return to its normal (neutral) position.
- The MAC will immediately enable its outputs (assuming there is no fault condition). The color of the POWER OUT LED(s) on the front panel will change to green. The LOAD LEDs on the front panel will indicate the amount of power being delivered to the load.

### Shut-Down

- Shut down the equipment connected to the MAC.
- Push the “ON/OFF” switch on the front panel of the MAC downward and hold it in this position for 1 second (or more). The switch can then be released to return to its normal position.
- The MAC will disable its outputs.

### Power Cable Connections

**For safety reasons**, the input and output power cables should be connected to the MAC before the source of AC power is turned on, and before the MAC is turned on (see **Section I: Warnings** and the **SET-UP** section above). Similarly, one should first turn “OFF” the MAC and the source of input power before any power cables are disconnected from the MAC .

**ALSO NOTE** that when the MAC is turned “ON” and delivering power to a load, and then another piece of equipment is connected to the same output, it is possible that this connection will momentarily disrupt the quality of the MAC’s output voltage. For instance, consider the case where the AC OUTPUT power cable has a terminal strip that allows several loads to be connected to it. If the MAC is turned “ON” and delivering power to several of these loads and then another load is connected to the terminal strip, it is possible that this new load will momentarily draw a large surge of current as it starts up. If this happens, the output of the MAC could reach its maximum current limit, and the MAC will reduce its output voltage to keep the current from getting any larger. This reduction in voltage will be corrected once the new load reaches its normal mode of operation, but in the meantime the reduction of the MAC’s output voltage might cause one or more of the other loads to malfunction. Whether or not this will be a problem depends on the characteristics of the various loads.

### Programming The Output

The MAC allows the user to adjust the output frequency. The output frequency can be set to 50, 60 and 400 Hz via both the serial and web interfaces. The MAC output frequency cannot be programmed using the SNMP interface.

#### Programming the Output From the RS-232 Interface

- ◆ Ensure RS-232 interface is configured properly. RS-232 must be configured with 115.2k baud, 8 data bits, no parity, and one stop bit.



**Cooling System**

The SynQor MAC-4000 Series products are cooled by fans that draw air into the intake on the front panel and exhaust it out the two fan ports on the rear panel. Care should be taken to ensure there is no obstruction to this airflow, either at the front intake or the rear exhaust ports. Similarly, care should be taken to avoid obstructing the fan blades.

The speed of the cooling fans is automatically controlled to provide adequate MAC cooling while extending the life of the fan bearings. Under low ambient temperature and/or low MAC output power the fans will be driven at a low speed.

If the ambient temperature is low enough (for the level of power being delivered to the load), the fans may not be on. This is not a malfunction. It is done to preserve the life of the fans. If the fans are “OFF”, check the Fan Service Required LED on the front panel of the battery pack. If it is GREEN, the fans are functioning properly and simply not needed under the present conditions.

The fans are weather-proof and water-proof.

The MAC has two fans to provide redundancy for these exposed, moving components. With only a single operating fan the MAC is still able to deliver 100% rated power at an ambient temperature of 25°C, 85% rated power at 40°C, and 70% rated power at 55°C.

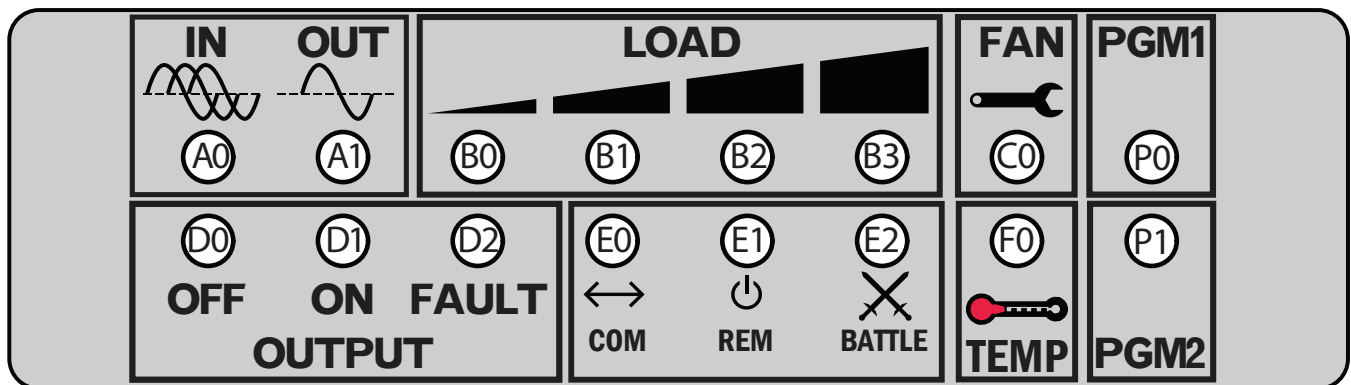
**Note:** The environmentally sealed chassis of the MAC also serves as a heatsink for internal components. As such, it is normal for the outside surface of the chassis to be hot to the touch.

**Front Panel Indicators**

To indicate the status of the MAC there are 16 LEDs on the front panel. These indicators are described in this section.




**LEDs**

Each Unit has 16 LEDs, as shown below, that indicate the status of the operation of the Unit:







- Power-In Indicator (LED in position A0)**

The LED A0 indicates the status of input phases A, B and C:

LED Appearance	Description	Indication
	<b>Green</b>	<i>Input is Ready to Provide Load Power</i>
	<b>Red</b>	<i>Input has Dropped Out of Range</i>
	<b>Off</b>	<i>Unit input power is "OFF" or on Initial Startup Input not in Range</i>






- Power-Out Indicator (LED in position A1)**

The LED in position A1 indicates the status of the AC OUTPUT, according to the table below:

LED Appearance	Description	Indication
	<b>Green</b>	<i>Unit is "On" and the Output Voltage is Within Range</i>
	<b>Amber</b>	<i>Unit is "On" but the Output Voltage is Out of Range</i>
	<b>Red</b>	<i>Unit is "Off" and the Output Voltage is Within Range</i>
	<b>Off</b>	<i>Unit is "Off"</i>




• **Load Power Indicators (LEDs in positions B0 – B3)**

The LEDs in positions B0 through B3 indicate the total output power of the Unit according to the table:

LED Appearance	Description	Indication
	<i>B0 Dimmed Green; B1, B2, B3 "Off"</i>	<i>Total Load Power &lt;25%</i>
	<i>B0 Green; B1 Dimmed Green; B2-B3 "Off"</i>	<i>Total Load Power &lt;50%</i>
	<i>B0, B1 Green; B2 Dimmed Green; B3 "Off"</i>	<i>Total Load Power &lt;75%</i>
	<i>B0, B1, B2 Green; B3 Dimmed Green</i>	<i>Total Load Power &lt;100%</i>
	<i>B0, B1, B2 Green; B3 Blinking Red</i>	<i>Total Load Power ≥100%</i>

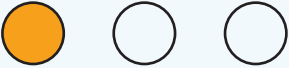



• **Fan service Required Indicator (LED in position C0)**

The LED in position C0 indicates weather the two cooling fans in the rear panel of the MAC are OK or if their performance is degraded. Led colors for the fan status are define in the table below:

LED Appearance	Description	Indication
	<b>Green</b>	<i>Both Fans are "OK"</i>
	<b>Amber</b>	<i>One or Both Fans Have Recently Had Degraded Performance and Diagnostic Tests are Being Performed</i>
	<b>Red</b>	<i>One or Both Fans Presently Have Degraded Performance</i>




• **Output State Indicators (LEDs in positions D0, D1 and D2)**

The LED in position D0 indicates that output is “OFF”. LED in position D1 indicates that the unit is in the “ON” state. LED D2 indicates that presently a fault condition exists in the MAC’s input or output. The LED colors for each LED in this section is defined according to the table below:

LED Appearance	Description	Indication
	<b>D0 Amber</b>	<i>D0 Power is Currently not being Delivered to the Load</i>
	<b>D1 Green</b>	<i>D1 Power is being Delivered to the Load within the Specified Parameters</i>
	<b>D2 Blinking Red</b>	<i>D2 A fault condition exists on the Input or Output of the Device</i>
	<b>D2 Blinking Amber</b>	<i>Over-Temperature in Input Stage, Output will Re-enable when temperature decreases</i>






• **Control Status (LED in positions E0, E1, E2)**

The LED in position E0, E1 or E2 indicates whether RS-232 or Ethernet Port, Remote Enable/Shutdown or Battle Short are active:

LED Appearance	Description	Indication
	<b>Green</b>	<i>E0: RS-232 active or Ethernet Port Active, E1: Remote Enable Active</i>
	<b>Blinking Red</b>	<i>E2: Battle Short Mode Active, Temperature Shutdowns Removed</i>
	<b>Red</b>	<i>E1: Remote Shutdown Active</i>

• **Cooling System Indicator (LED in position F0)**

The LED in position F0 indicates the temperature and status of the cooling system for the Unit according to the table below:

LED Appearance	Description	Indication
	<b>Green</b>	<i>Moderate Temperature (Fans Off or Running at 30%)</i>
	<b>Blinking Green</b>	<i>Warm Temperature (Fans Running at 60%)</i>
	<b>Amber</b>	<i>Elevated Temperature (Fans Running at 90%)</i>
	<b>Red</b>	<i>Maximum Temperature (Fans Running at 100%)</i>
	<b>Blinking Red</b>	<i>Over Temperature Warning</i>

• **Reserved (LEDs in position P0 & P1)**

This section of the LEDs in the panel have been reserved for future use.

**Audible alarm**

For critical situations, a pattern of audible tones will be repeated every 5 seconds, according to the table below. This audible alarm can be **silenced** by holding the “ON/OFF” switch on the front panel in the “UP” position while the MAC is operating and its output is running, or in the “DOWN” position while in Standby Mode, until a chirp is heard. A new alarm condition will cause the audible alarm to be reactivated. Contact Factory for instructions on how to permanently silence the alarm.

Number of Tones in Pattern	Indication
<b>One</b>	<i>Input Voltage is Lower than Minimum Operating Level</i>
<b>Two</b>	<i>Load Power is greater than or Approaching 100% Rated Power</i>
<b>Three</b>	<i>Fault Appears on the AC Output MAC Must be Turned “OFF” and Back “ON” to Reset Fault</i>
<b>Four</b>	<i>One or Both Fans have Presently a Degraded Performance</i>

### Operating Environment

The SynQor MAC-4000 Series is designed for the extreme environmental conditions of military and aerospace applications. All the electronic circuitry is contained in a sealed, weather-proof, shock-proof chamber constructed of die-cast aluminum. Only the redundant, water-proof cooling fans are exposed to the environment. The Unit will shut down if it is too hot and Battle Mode is not active.

The MAC (with cables connected or connector covers installed) has been qualified to the following requirements of MIL-STD-810G:

MIL-STD-810G Test Method	Name	Procedure	Details
500.5	Low Pressure	I, II and III	<ul style="list-style-type: none"> <li>• 15,000 ft. operating</li> <li>• 40,000 ft. storage</li> </ul>
501.5	High Temperature	I and II	<ul style="list-style-type: none"> <li>• +55°C operating</li> <li>• +65°C storage</li> </ul>
502.5	Low Temperature	I and II	<ul style="list-style-type: none"> <li>• -20°C operating</li> <li>• -20°C storage</li> </ul>
503.5	Temperature Shock	I	<ul style="list-style-type: none"> <li>• 10 cycles; &gt;10°C/minute</li> </ul>
506.5	Rain	I	<ul style="list-style-type: none"> <li>• 4" rain/hour</li> <li>• 40 mph wind velocity</li> </ul>
507.5	Humidity	NA	<ul style="list-style-type: none"> <li>• &gt;95%</li> </ul>
508.6	Fungus	NA	<ul style="list-style-type: none"> <li>• 28 day test</li> </ul>
509.5	Salt Fog	NA	<ul style="list-style-type: none"> <li>• 5% salt solution</li> <li>• 2 cycles (24 hr. wet/24 hr. dry)</li> </ul>
510.5	Sand and Dust	I and II	<ul style="list-style-type: none"> <li>• 20 mph blowing dust</li> <li>• 40 mph blowing sand</li> </ul>
514.6	Vibration	Category 5	<ul style="list-style-type: none"> <li>• 5 Hz (300 RPM)</li> <li>• Loose Cargo</li> </ul>
514.6	Vibration	Category 7	<ul style="list-style-type: none"> <li>• General Exposure</li> </ul>
514.6	Vibration	Category 8	<ul style="list-style-type: none"> <li>• C-130 Aircraft level</li> </ul>
514.6	Vibration	Category 9	<ul style="list-style-type: none"> <li>• General Exposure</li> </ul>
514.6	Vibration	Category 24	<ul style="list-style-type: none"> <li>• PSD = 0.04 g<sup>2</sup>/Hz; 20-2000 Hz</li> <li>• Operating</li> </ul>
516.6	Shock	I, IV and VI	<ul style="list-style-type: none"> <li>• 20 g/20 ms; 40 g/11 ms; 75 g/6 ms</li> <li>• 48 inch drop in transit case</li> <li>• 30 degree tilt and drop</li> </ul>
528	Mechanical Vibrations of Shipboard Equipment	I	<ul style="list-style-type: none"> <li>• Operating</li> </ul>

### General Considerations

The MAC supports two different paralleling schemes for the AC output: expanded paralleling and redundant paralleling. Both expanded and redundant paralleling configurations allow, up to 32 MAC units to be combined to form high power Single-Phase, Split-Phase and 3-Phase systems. The “redundant” paralleling configuration includes an electronic breaker on the hot AC output wire which provides fault-tolerant, glitch-free operation in case a MAC unit fails in a multi-unit system. The redundant paralleling option allows users to add extra MAC units to the systems in order to create for N+1 redundancy, or more generally, N+M redundancy.

Expanded vs. Redundant paralleling is determined by the “AC Output Neutral Wire” option in the MAC part number. See the table below. Expanded paralleling units cannot be mixed with redundant parallel units in multi-unit systems.

Ordering Information: Expanded Vs Redundant Parallel		
	AC Output Neutral Wire option	Example PN
Single Unit (no paralleling)	G	MAC-4000-1U-4TW1 <b>G</b> 6S-E00
Expanded Parallel	F	MAC-4000-1U-4TW1 <b>F</b> 6S-E00
Redundant Parallel	R	MAC-4000-1U-4TW1 <b>R</b> 6S-E00

**Note:** When combining MAC units into the configurations described in this section, each MAC must internally have the neutral wire of its AC OUTPUT floating, rather than connected to its chassis. This requires that all the MAC units have the “F” option for expanded parallel units and “R” option for redundant parallel units regarding the AC OUTPUT neutral wire connection. Check the MAC part numbers to be sure this is the case before ordering.



### *Expanded Paralleling -F Option*

With expanded paralleling, up to 32 SynQor MAC units with identical “F” type model numbers can be combined in various ways to achieve:

- ◆ Higher output power
- ◆ Higher output voltage
- ◆ Multiple output phases

A configuration-specific CONFIGURATION cable determines each MAC unit’s role in an expanded parallel system. These CONFIGURATION cables are available from SynQor, and the proper part number for any configuration is given in the pages that following sections.

Configuration-specific OUTPUT and/or INPUT power cables are also required. These power cables can be assembled by the user following the wiring diagrams shown in the next sections, or using power cables from SynQor that have the appropriate hardwire terminations.

In an expanded parallel system, the AC output will remain “OFF” until one MAC unit is enabled. This can be done by actuating the front panel switch “ON”, or by sending the appropriate signal over the USER I/O cable. If any MAC unit in the group is “OFF” it will proceed to turn “ON”. The remaining units in the system will maintain their current active state if already “ON”. If during normal operation any one MAC is unable to deliver output power because it cannot draw power from its AC source, or due to an internal fault, all other MAC units in the group will continue to remain active assuming that the rest of the units can handle the load.

### Redundant Paralleling -R Option

The “R” option adds an electronic breaker to the AC output of the MAC to provide fault-tolerant, glitch-free parallel operation. Should one unit experience a fault that could otherwise cause the AC output to collapse, the breaker disconnects the failed unit from the AC bus. This feature allows the remaining units to continue delivering power, provided that the remaining units can support the total load power. This configuration allows users to create N+1 or N+M redundant systems. The redundant parallel units can be arranged to form Single-Phase, Split-Phase, and 3-Phase systems. Systems with multiple phases can also be setup on each phase N+1 or N+M redundant

A failed unit can be removed and replaced while the rest of the units in the system are active. Special consideration must be taken when disconnecting the unit input/output power cables to avoid electric shock or injury. It is strongly recommended that the system AC input and output for the unit be disabled or turned “OFF” before the unit is removed or replaced.

CONFIGURATION cables for two, three, four and five unit and single-phase systems are offered as standard products. See the next sections for further details. Contact the SynQor factory for Single-Phase systems larger than five MAC units, or for Split-Phase and 3-Phase systems.

Systems created using redundant parallel MAC units will be fault-tolerant to the following events:

- ◆ Complete loss of power to a unit (AC INPUT)
- ◆ Hardware failure of the AC output stage of a unit

The enable/disable behavior of systems using redundant paralleling is the same as systems using expanded paralleling; all MAC units will be enabled if one MAC is enabled. Units can be enabled by actuating the front-panel “ON” switches or by sending the appropriate signal over the USER I/O cable.

Note that sending a “OUTPUT DISABLE” command to a MAC over the serial interface, will cause only that particular MAC unit to be disabled. Other MAC units in the group will remain active. Sending a “SYSTEM DISABLE” command over the RS-232 interface to any unit in a system; however, will cause all MAC units in a system to turn “OFF” simultaneously.

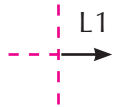
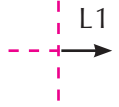
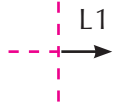
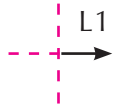
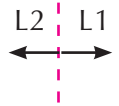
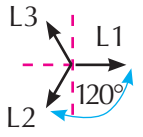
For a detailed description of the terminal interface see the SynQor website.

[http://www.SynQor.com/MAC/documents/MAC\\_User\\_Commands.pdf](http://www.SynQor.com/MAC/documents/MAC_User_Commands.pdf)

## Possible configurations of the AC OUTPUTS

## Multi-unit Configurations

The chart below shows four possible ways the AC OUTPUTS of multiple SynQor MAC units can be connected together. Each configuration will be discussed in more detail in the following pages.

Number of MAC Units	Output Configuration	Phasor Diagram	# of Output Phases	Output Voltage	Output Current per phase	Total Output Power	Configuration Cable
2	Parallel		1	L-N: $1 \times V_{\text{rated}}$	$2 \times I_{\text{rated}}$	$2 \times P_{\text{rated}}$	SYN-9341
3	Parallel		1	L-N: $1 \times V_{\text{rated}}$	$3 \times I_{\text{rated}}$	$3 \times P_{\text{rated}}$	SYN-9343
4	Parallel		1	L-N: $1 \times V_{\text{rated}}$	$4 \times I_{\text{rated}}$	$4 \times P_{\text{rated}}$	SYN-9344
5	Parallel		1	L-N: $1 \times V_{\text{rated}}$	$5 \times I_{\text{rated}}$	$5 \times P_{\text{rated}}$	SYN-9345
2	Series Split-Phase		2	L-N: $1 \times V_{\text{rated}}$ L-L: $2 \times V_{\text{rated}}$	$1 \times I_{\text{rated}}$	$2 \times P_{\text{rated}}$	SYN-9613
3	3 Phase-Y		3	L-N: $1 \times V_{\text{rated}}$ L-L: $1.73 \times V_{\text{rated}}$	$1 \times I_{\text{rated}}$	$3 \times P_{\text{rated}}$	SYN-9617

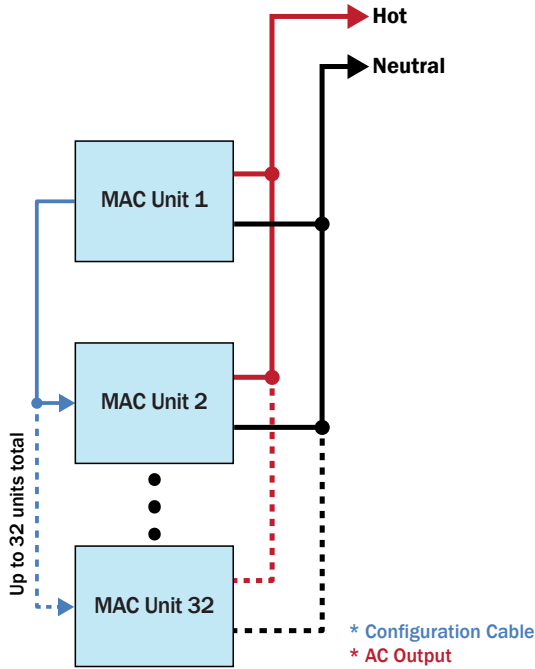
Note that the chart above shows the SynQor part number for the CONFIGURATION cable required to build each multi-unit type system.

The “**F**” and “**R**” options allows up to 32 MAC units to be installed in a single parallel or redundant system. The “**R**” option adds a single pole electronic breaker to the hot wire of the AC OUTPUT. This breaker allows for fault-tolerant, glitch-free operation of up to 32 MAC units in a redundant N+1 or N+M multi MAC system. Therefore, “**R**” option allows customers to build redundant, Single-phase, Split-phase, and 3-Phase with SynQor’s MAC units. Each of these MAC systems can also be configured to be N+1 or N+M redundant on each phase.

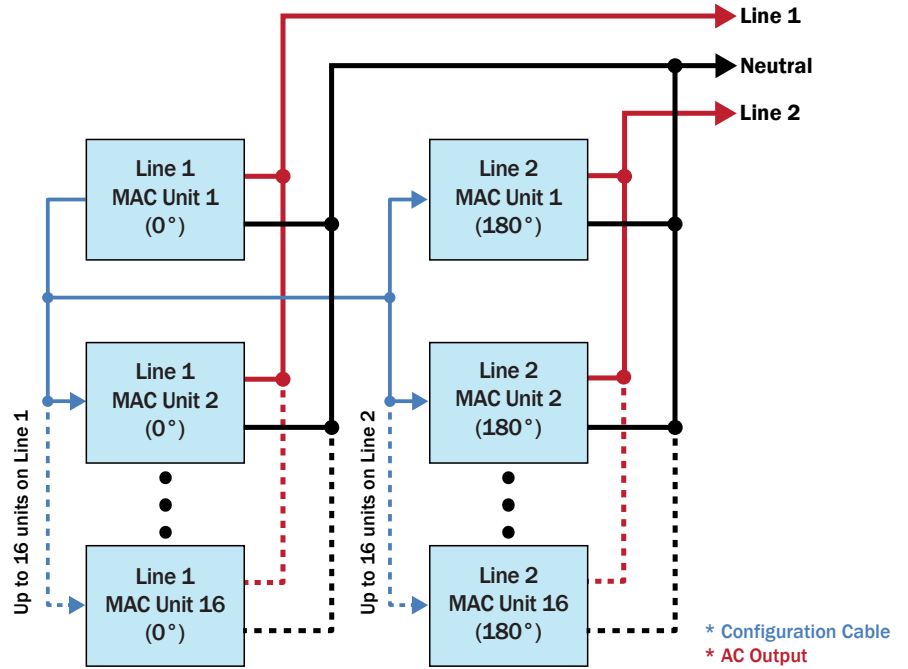
The block diagrams below show a summary of the different system configuration that can be made using units with the “**R**” and “**F**” option. Please note that each multi-unit system requires its own unique system CONFIGURATION (Single-phase, Split-phase, and 3-Phase) cable. Configuration cables are the same for the “**R**” and the “**F**” options. Contact the SynQor factory to purchase the system specific configuration cables. Note that configuration cables for two, three, four and five unit Single-Phase parallel systems are offered as standard products.

Contact the SynQor factory for redundant Split-Phase systems, redundant 3-Phase systems, or Single-Phase systems with more than five units.

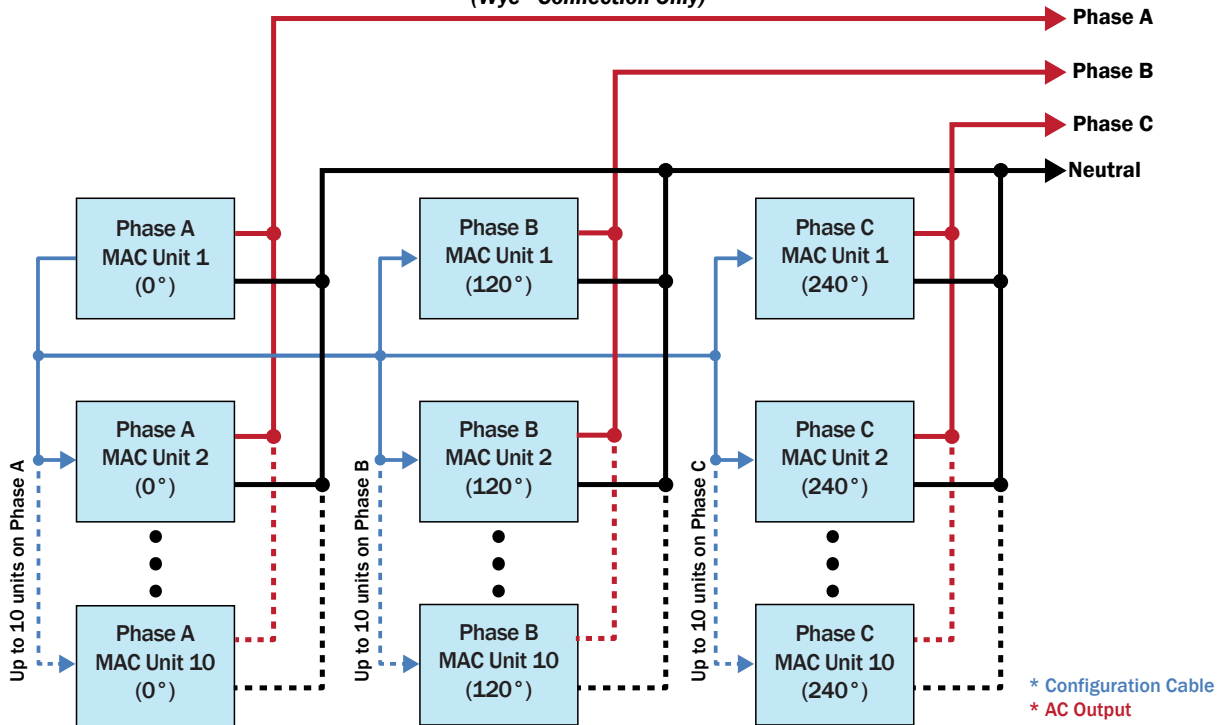
**Single Phase Output System**



**Split Phase Output System**



**3-Phase Output System  
(Wye - Connection Only)**

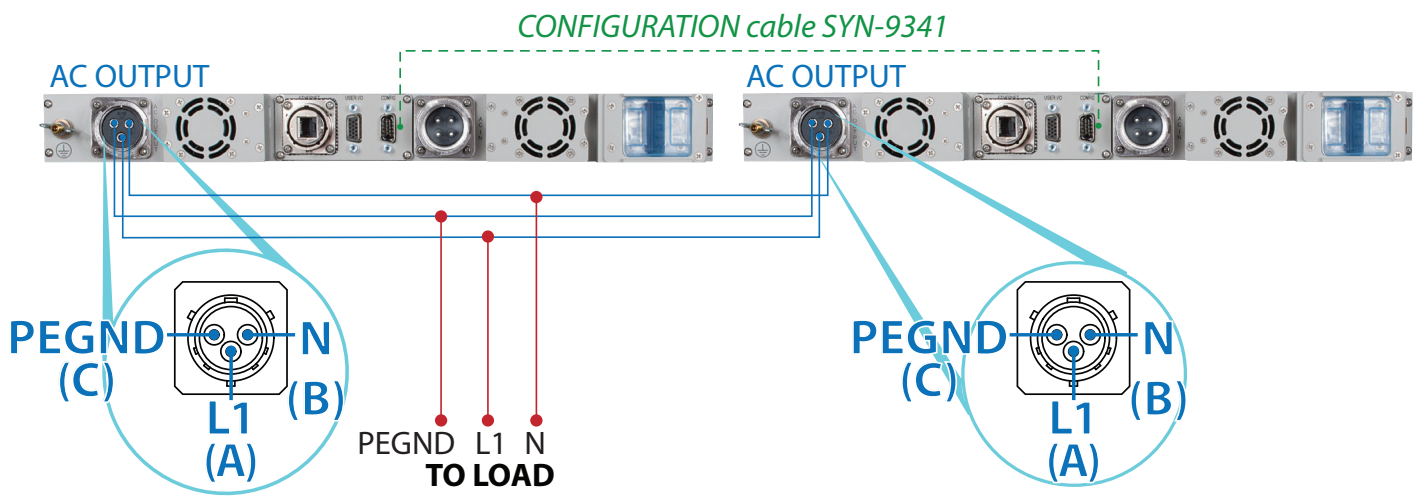


**Parallel Connection of the AC Outputs**

Multiple MAC units can have their AC OUTPUTs connected in parallel to deliver to the load the sum of their combined output power and current. This configuration allows redundant parallel units (type “R”) to form N+1 or N+M redundant systems.

**Two MAC units with AC OUTPUTs Paralleled**

The following diagram shows how to connect two MACs in an expanded parallel or redundant parallel configuration. The wiring diagram explains how the AC OUTPUT cables and the CONFIGURATION cable need to be connected:



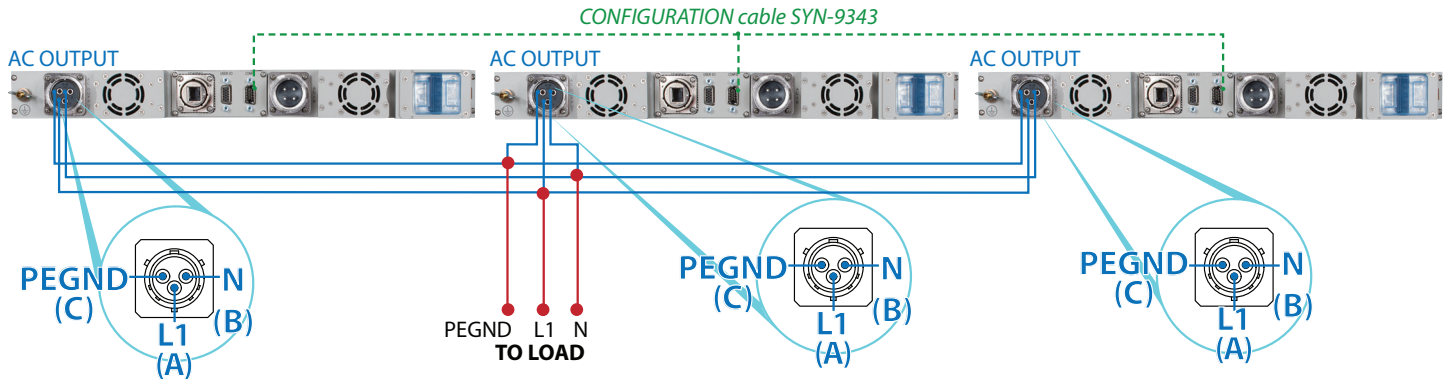
When ordering units for this setup, be sure to select the “F: Floating” or “R: AC Output Electronic Breaker” option for the MAC units configured in this manner.

If the user is providing its own AC OUTPUT cable, the cable size for the blue and red cable sections shown above, should follow the guide lines in the table below depending on AC OUTPUT voltage of the MAC units.

MAC AC Output Voltage	Blue Cable Section Minimum Wire Size	Red Cable Section Minimum Wire Size
115 Vac	#8AWG (10 mm <sup>2</sup> )	#2AWG (41 mm <sup>2</sup> )
230 Vac	#10AWG (6 mm <sup>2</sup> )	#6AWG (16 mm <sup>2</sup> )

**Three MAC units with AC OUTPUTs Paralleled**

The following diagram shows how to connect the output of three MAC units in an expanded parallel or redundant parallel configuration. The wiring diagram explains how the AC OUTPUT cables and the CONFIGURATION cable need to be connected:



When ordering this type of configuration, make sure you select the “F: Floating” or “R: AC Output Electronic Breaker” option for MAC units configured in this manner.

If the user is providing its own AC OUTPUT cable, the size of the blue and red cable sections shown above, should follow the guidelines shown in the table below depending on AC OUTPUT voltage of the MAC units.

MAC AC Output Voltage	Blue Cable Section Minimum Wire Size	Red Cable Section Minimum Wire Size
115 Vac	#8AWG (10 mm <sup>2</sup> )	#0AWG (65 mm <sup>2</sup> )
230 Vac	#10AWG (6 mm <sup>2</sup> )	#4AWG (26 mm <sup>2</sup> )



**Series Split-Phase Connection of AC Outputs**

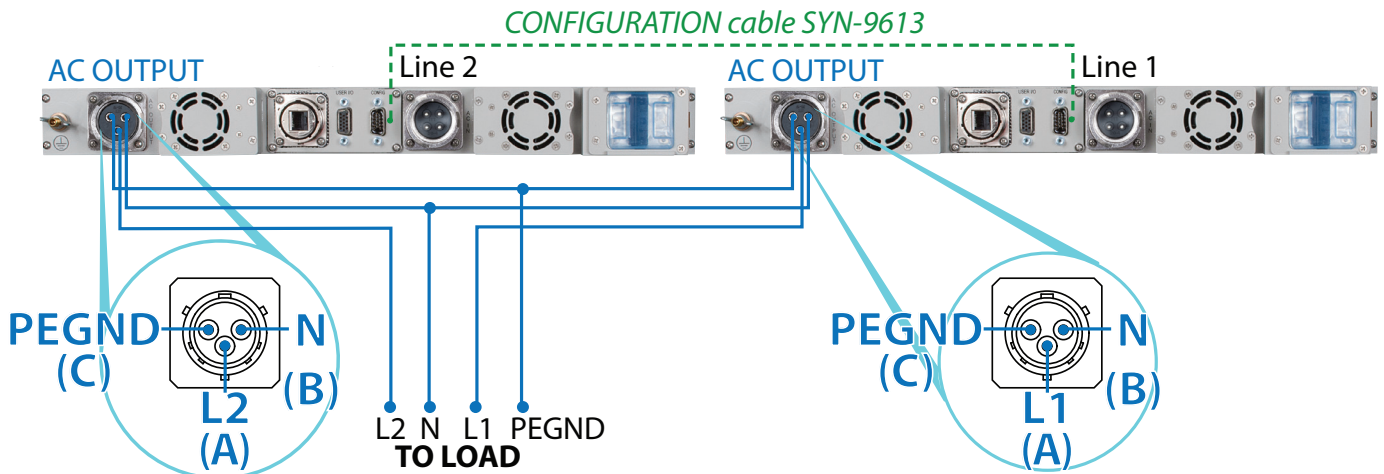
Two MAC units can double the AC OUTPUT voltage by connecting both units in series. For instance, if each MAC unit is able to provide 115 Vac output, a series configuration would deliver a 230 Vac output at twice the power level of a single unit. Similarly, if the MAC units are able to provide 230 Vac output, the series configuration would deliver a 460 Vac output at twice the power level of a single unit.

The center node between the two outputs in the series configuration should be considered the “neutral” wire (Both output Pin Bs of the MAC units are tied together), and therefore kept at a potential close to Protective Earth Ground (PEGND).

The other two AC OUTPUT wires (output Pin A on each MAC unit) are electrically “hot” (meaning at a high potential relative to the neutral or PEGND). One will be phase-shifted by 180 degrees (one-half cycle) from the other, meaning that when one hot wire is at its positive peak the other is at its negative peak, and vice versa. The voltage between these two hot wires is therefore twice that of either hot wire compared to the neutral wire. This configuration is called “Split-Phase”. When ordering, select the “F: Floating” or “R: AC Output Electronic Breaker” option for the MAC units.

Contact the SynQor factory for N+1 redundant Split-Phase systems.

The wiring diagram for the AC OUTPUT cables and the CONFIGURATION cable for the Split-Phase configuration is shown below:



If the user is providing its own AC OUTPUT cable, all the cable sections should have the following minimum wire size, depending on whether the AC OUTPUT of the individual MAC units is 115 Vac or 230 Vac.

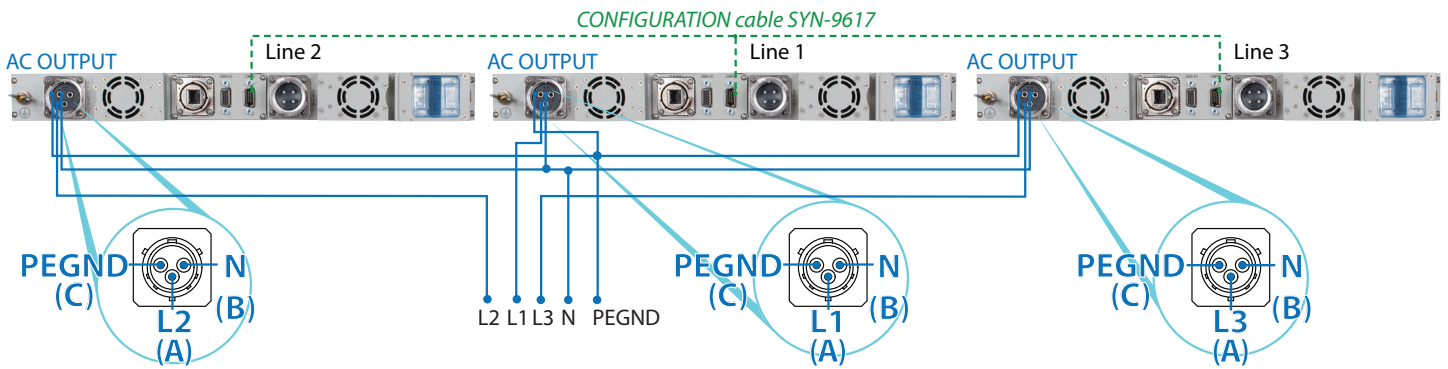
MAC AC Output Voltage	Cable Minimum Wire Size
115 Vac	#8AWG (10 mm <sup>2</sup> )
230 Vac	#10AWG (6 mm <sup>2</sup> )

**Series 3-Phase Connection of AC Outputs**

Three expanded or redundant parallel MAC units can be setup so that their AC OUTPUTs can share a common “neutral” and deliver output voltages that are phased by 120 degrees (one-third cycle) from each other. This configuration delivers a 3-Phase output where the line-to-neutral voltage is the rated voltage of the individual MAC units (e.g. 115 Vac or 230 Vac line-to-neutral) and the line-to-line voltage is 1.73 times higher (e.g. 200 Vac or 400 Vac line-to-line). When ordering units for this configuration, make sure you select the “F: Floating” or “R: AC Output Electronic Breaker” option for the MAC units.

Contact the SynQor factory for N+1 redundant 3-Phase systems.

The wiring diagram for the AC OUTPUT cables and the CONFIGURATION cables for the 3-Phase configuration is shown below:



If the user is providing its own AC OUTPUT cable, all the cable sections should have the following minimum wire size, depending on whether the AC OUTPUT of the individual MAC unit is 115 Vac or 230 Vac.

MAC AC Output Voltage	Cable Minimum Wire Size
115 Vac	#8AWG (10 mm <sup>2</sup> )
230 Vac	#10AWG (6 mm <sup>2</sup> )

Note that the “neutral” wire of the 3-phase AC OUTPUT (All the output Pin Bs of all the MAC units are tied together) should be kept at a potential close to Protective Earth Ground (PEGND).

**Note:** The three connectors of the SYN-9617 CONFIGURATION CABLE are labeled “Line 1”, “Line 2” and “Line 3”. The MAC unit that receives the “Line 1” connector will have an AC OUTPUT that is phased 120 degrees (one-third cycle) ahead of the MAC unit that receives the “Line 2” connector, which in turn will have an AC OUTPUT that is phased 120 degrees (one-third cycle) ahead of the MAC unit that receives the “Line 3” connector. Connecting the three AC OUTPUTs to the three line wires of the AC OUTPUT cable in the proper order may be important for some loads, such as motors.

### **Multi-Unit AC OUTPUT On/Off Control – Expanded/Redundant Parallel (-F/-R option)**

In multi-unit operation, a single front panel “ON” switch actuation, “REMOTE-ON” rear panel signal input, or *OUTPUT ENABLE* serial command will cause all MAC devices to enable their outputs. Redundant parallel units (“R” option) come with a floating neutral wire by default. Any “OFF” front panel switch actuation, “REMOTE-OFF”, or “*OUTPUT DISABLE*” serial command will only disable that specific MAC. Sending the “*SYSTEM DISABLE*” serial command to any MAC system in a multi-unit configuration will cause a coordinated shutdown of all AC OUTPUTs. If any single MAC no longer has a valid input power source (e.g., no AC input), it will shut down while the AC OUTPUTs of the remaining systems stay active.

### **AC OUTPUT Neutral Grounding**

MAC units combined in multi-unit configurations must have the neutral floating “F” factory option to prevent the possibility of circulation protective earth currents. Redundant parallel units (“R” option) come with a floating neutral wire by default. If a grounded output neutral is required, then the output neutral should be connected to protective earth ground (PEGND) in one spot. The size of the neutral-to-PEGND connecting conductor must be sized to match the largest combined AC output neutral conductor specified in the wiring diagrams.

### **Connecting AC INPUTs**

Whether there are two, three or more MAC units in the multiple-unit configuration, there are several ways that the 3-Phase AC INPUTs can be connected to power sources:

- ◆ All units could be connected to the same 3-Phase AC source/panel.
- ◆ Units could be connected to different 3-Phase AC sources/panels.

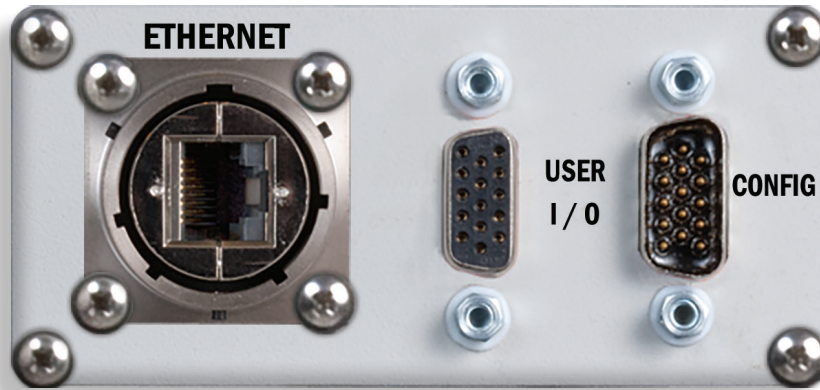
The only requirement is that the MAC units have input voltages and frequencies that fall within the specified ranges of the 3-Phase AC INPUTs of the individual MAC units.

### **Wiring Caution**

**WARNING:** LETHAL HIGH VOLTAGES MAY BE PRESENT ON MAC AC INPUT AND OUTPUT CONNECTIONS. ALL AC INPUT AND OUTPUT CABLE CONNECTORS MUST BE INSTALLED PRIOR OPERATION. DISCONNECTED CABLE CONNECTORS MAY HAVE VOLTAGES PRESENT FROM ANOTHER UNITS IN A GROUP AND COULD POTENTIALLY BE HARMFUL.

### Control Cable Connections

There are two high-density (three-row) DB15 connectors located on the rear panel of the MAC:



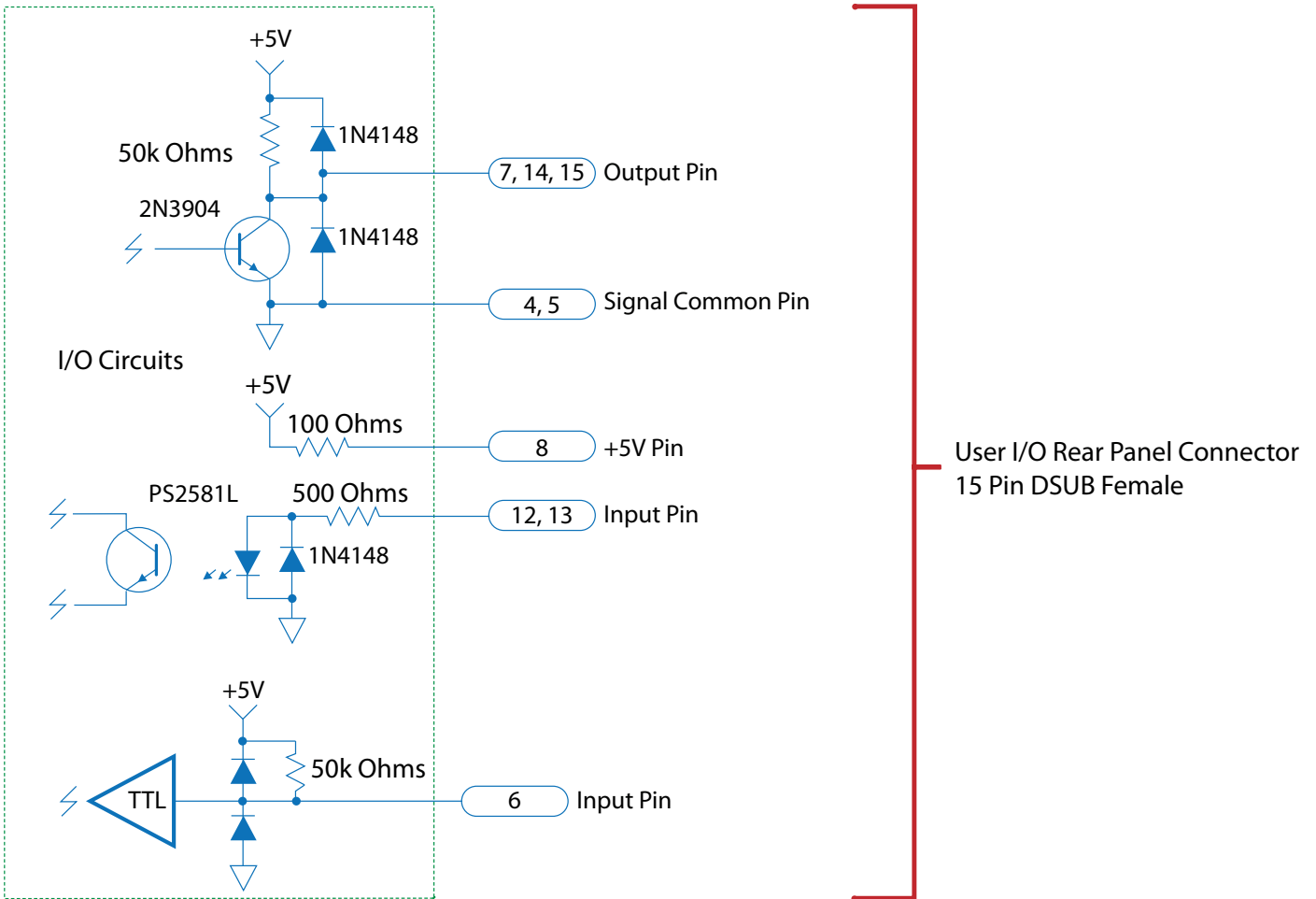
The User I/O female DB15 connector on the left is for an optional connection to a host/system computer so that it can control the MAC and receive information regarding the status of the MAC.

The Configuration male DB15 connector on the right provides for synchronized startup and shutdown operation of multiple interconnected units, using the SYN-9341, SYN-9343, SYN-9344, SYN-9345, SYN-9613 or SYN-9617 cables. See the “Possible configurations of the AC OUTPUTs” on page 22 for supported configurations details.

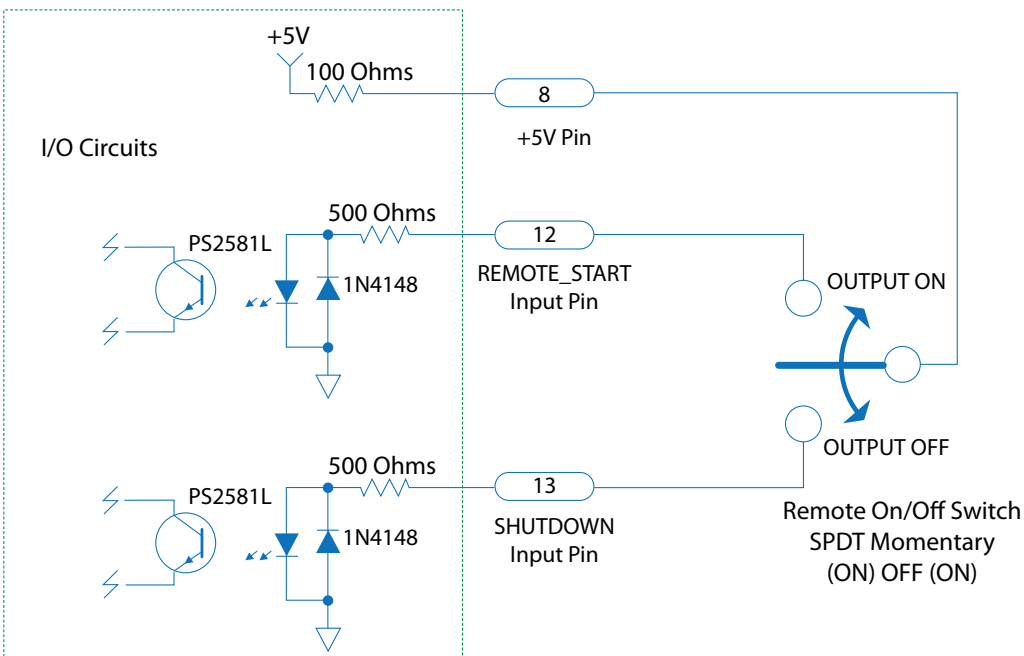
The designation/location of the pins for the User I/O female high-density DB15 connector are shown below:



**Internal User I/O Circuits**



**Remote On/Off Switch Connections**



Note: A 2PDT or 3PDT switch may be substituted for single control of 2 or 3 MAC machines, respectively.



### Digital Input/Output Control Signals

There are 3 input and 4 output digital signals available on the User I/O female high-density DB15 connector. The pin assignments and functions of these digital I/O signals are as follows:

#### High Density DB15 Female (15 Pin Connector)

Signal	PIN	Function
TX	2	RS232 DCE Device Transmit
RX	3	RS232 DCE Device Receive
GND	4, 5	Ground reference for all digital inputs and outputs
BATTLE_MODE	6	TTL-Input*, pull "low" to engage Battle Mode to disable internal over temperature protection, has internal pull-up to +5 V
ACIN_GOOD	7	Open collector* output where "low" indicates AC Input voltage is within range
+5 V	8	Vout with minimal current drive usable as a pull-up voltage for open collector output signals. Load must be < 35 mA
REMOTE_START	12	Drive this line to +5 V with $\geq 5$ mA to enable MAC output
SHUTDOWN	13	Drive this line to +5 V with $\geq 5$ mA to disable MAC output
OUT_OK	14	Open collector* output where "low" indicates AC Output voltage is within range
OVER_TEMP	15	Open collector* output where "low" indicates that the MAC is at or above its maximum temperature

\*With an internal 50 k Pull-up Resistor to 5 V and ESD Protection Diodes

Battle Mode disables internal over-temperature shutdown limits in the MAC hardware. Battle Mode is indicated with a flashing red light in panel position E2. This mode can be commanded by pulling low on to I/O Port Pin 6, or via serial command "BS ON".

### Ethernet Interface

The Ethernet interface provides a web page based user interface for monitoring and control of the MAC. The user can use this interface to set the output frequency. The Ethernet interface also provides a RFC-1628 compliant remote SNMP monitoring interface for the unit.

The Ethernet interface supports 10BASE-T and 100BASE-T standards. It utilizes a standard RJ-45 connector, also allowing a metallic sealable circular military outer housing. The interface supports auto-negotiation, polarity correction, and Auto-MDIX (detection and use of straight through or cross-over cables).

IP address assignment can be configured to be acquired by the unit automatically via DHCP or set up through a static address entry via the web interface. The Ethernet interface also provides a local DHCP server that allows direct MAC to host computer connections.

For a detailed description of the Ethernet port and SNMP implementation see the SynQor website at: [http://www.synqor.com/MAC/documents/MAC\\_Ethernet\\_SNMP\\_UG.pdf](http://www.synqor.com/MAC/documents/MAC_Ethernet_SNMP_UG.pdf)

### RS-232 Serial Interface

The female high-density DB15 User I/O connector also provides for an RS-232 interface between the MAC and the host/system computer. The interface has a 115.2 kbaud with eight data bits, no parity bit and one stop bit. The pin assignments and functions for this RS-232 interface are as follows:

Signal	Pin Number	Function
GND	4 and 5	Ground reference for RX and TX signals
RX	3	RS-232 DCE/MAC Device Receive signal
TX	2	RS-232 DCE/MAC Device Transmit signal

The RS-232 port provides read back of Unit's state, as well as the configuration and control of the MAC's operation. The port can be used from a standard terminal interface, or from a custom computer application. For MAC Units, this port can be used to program the output voltage characteristics.

#### **Readback information that is available:**

- ◆ AC Output Voltage
- ◆ AC Output Power
- ◆ Battle Mode
- ◆ On/Off Synchronization
- ◆ Internal Temperatures
- ◆ External Switch Input Status
- ◆ Total Output Power
- ◆ AC Output Current
- ◆ AC Output Frequency
- ◆ Fan diagnostics
- ◆ Output enable / disable
- ◆ AC Input Frequency
- ◆ Fan RPM

#### **Parameters that are controllable through the interface:**

- ◆ On/Off Synchronization
- ◆ Battle Mode
- ◆ Output enable / disable
- ◆ AC Output Frequency
- ◆ Alarm enable / disable
- ◆ Fan Diagnostics

For a detailed description of the terminal interface see the SynQor website.

[http://www.SynQor.com/MAC/documents/MAC\\_User\\_Commands.pdf](http://www.SynQor.com/MAC/documents/MAC_User_Commands.pdf)



## Fans

*The fans on the rear panel have sealed bearings that do not require any regular maintenance. Fan assemblies are user replaceable with kits available from SynQor. Please contact the SynQor factory for obtaining fan replacement kits.*

## Cleaning

*The MAC Unit has a sealed chamber for its electronics that is weather-proof. Only the fans on the rear panel are exposed to the environment, and these fans are also weather-proof. The Unit can therefore be cleaned without concern of getting liquids inside the chamber. **NOTE**, however, that if the cables have been removed from the unit then the unit connectors should have their covers installed to protect the connector from damage, contamination or corrosion. If connectors are not protected, then care should be taken to prevent physical or liquid damage to the connector terminals. **ALSO NOTE**, care should be taken to not get excess liquid on the AC BREAKER switch in the back panel.*

*Cleaning should be done either with soap and water or with an Isopropyl alcohol and water mixture. A soft cloth should be used.*

*Do not immerse the Unit in water to clean it.*

*Rust corrosion in connectors could be an issue.*

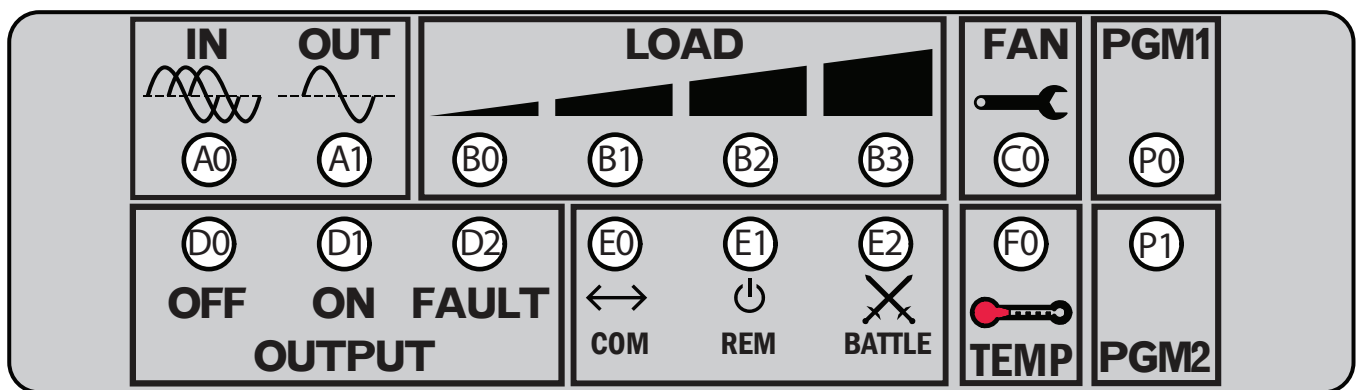
**Fault Conditions**

The SynQor MAC has no user-serviceable parts within it other than the cooling fans. If the unit has an internal malfunction only factory trained personnel should attempt to repair it.

There are, however, several external conditions that could cause the MAC to not operate as desired. These external conditions can likely be corrected by the user.

The 16 LEDs on the front panel are the best and first place to look to determine what might be wrong with the Unit. The table on the next several pages is therefore organized by what these LEDs indicate, and for each indication there is a listing of what might possibly be wrong.

The front panel LED array is shown below. The designations of the 16 LEDs in this array are used in the following table.



LED	Indication	Possible Problem(s)
<b>A0:</b> AC INPUT Power LED	LED is OFF	<ul style="list-style-type: none"> <li>•The AC INPUT power source is not turned “ON”.</li> <li>•The AC INPUT cable is not connected or it is wired wrong.</li> <li>•The AC Breaker on the rear panel is “OFF”.</li> <li>•The MAC Unit is “OFF” and needs to be turned “ON”.</li> </ul>
	LED is Red	<ul style="list-style-type: none"> <li>•The AC INPUT voltage has dropped out of Range.</li> </ul>
	LED is OFF	<ul style="list-style-type: none"> <li>•Unit has no input power or on Initial Startup Input not in Range”.</li> <li>•The AC Breaker on the rear panel is “OFF”.</li> </ul>
<b>A1:</b> AC OUTPUT Power LED	LED is OFF	<ul style="list-style-type: none"> <li>•The Unit is “OFF” and needs to be turned “ON”.</li> </ul>
	LED is AMBER	<ul style="list-style-type: none"> <li>•The AC OUTPUT load is higher than 4000W or 5000VA by enough to trigger the power limit circuitry.</li> <li>•The AC OUTPUT load crest factor is too high.</li> <li>•The AC OUTPUT is shorted within the cable or a load.</li> <li>•Some other source of power is connected to the AC OUTPUT.</li> </ul>
	LED is RED	<ul style="list-style-type: none"> <li>•The Unit has been turned “OFF”, but due to a malfunction within the Unit it is still running and providing an AC OUTPUT voltage.</li> <li>•Some other source of voltage is connected to the AC OUTPUT and is powering it when the Unit is disabled.</li> </ul>

LED	Indication	Possible Problem(s)
<b>B0 – B3: LOAD POWER LEDs</b>	B3 is BLINKING RED	<ul style="list-style-type: none"> <li>Total load power is greater than or approaching 4000 W. The Unit may still be delivering its specified output voltage because the load power is not high enough to trigger the power limit circuitry.</li> </ul>
	B0 – B3 are all OFF	<ul style="list-style-type: none"> <li>No power is being delivered to the load.</li> <li>The Unit is “OFF” and needs to be turned “ON”.</li> <li>The loads or output cables are not connected.</li> <li>The loads are all turned “OFF”.</li> <li>The loads are simply not drawing any appreciable power at the time.</li> </ul>
<b>C0: Fan Service Required LED</b>	LED is AMBER	<ul style="list-style-type: none"> <li>One or both fans have recently had degraded performance but seem to be OK now. The Unit is running a diagnostic test.</li> </ul>
	LED is RED	<ul style="list-style-type: none"> <li>One or both fans presently have degraded performance, even if they are running, and service is recommended at the earliest convenient time.</li> <li>Ensure that the fan blades are not obstructed from turning.</li> </ul>
<b>F0: Cooling System LED</b>	LED is BLINKING GREEN	<ul style="list-style-type: none"> <li>Indicates that the fans are running at 60% of their rated speed. There is no problem.</li> </ul>
	LED is AMBER	<ul style="list-style-type: none"> <li>Indicates that the fans are running at 90% of their rated speed. There is no problem, but the Unit is operating at a high ambient temperature and a high load combination.</li> </ul>
	LED is RED	<ul style="list-style-type: none"> <li>Fans are running at 100% of rated speed to keep the Unit cool. The maximum recommended temperature may be exceeded, but the fans are keeping things cool enough to avoid triggering the over-temperature shut-down circuitry.</li> </ul>
	LED is BLINKING RED	<ul style="list-style-type: none"> <li>The maximum recommended temperature may be exceeded and the system is approaching over-temperature protection. The load and / or ambient temperature should be reduced if possible.</li> </ul>
<b>All LEDs:</b>	All LEDs are OFF	<ul style="list-style-type: none"> <li>The AC INPUT power is not turned “ON”.</li> <li>The AC Breaker on the rear panel is “OFF”.</li> </ul>
<b>Audible Alarm: (pattern repeats every 5 seconds)</b>	One tone	<ul style="list-style-type: none"> <li>The AC INPUT voltage is lower than the minimum operating level.</li> <li>Raise the AC INPUT voltage above the minimum level or verify the wiring is appropriate for the input current so as not to cause an excessive voltage drop.</li> </ul>
	Two tones	<ul style="list-style-type: none"> <li>The total Unit load power is above 4000W.</li> <li>Loads should be reduced if the condition persists.</li> </ul>
	Three tones	<ul style="list-style-type: none"> <li>The AC OUTPUT has experienced either a short circuit or a load having a start-up surge current characteristic that the Unit could not start. The AC OUTPUT has therefore turned “OFF”.</li> <li>To reset, the Unit OUTPUT must be turned “OFF” and then “ON”.</li> </ul>
	Four tones	<ul style="list-style-type: none"> <li>One or more fans have encountered a fault or degraded performance.</li> <li>The Unit may still operate with degraded fan performance, but should be serviced soon. Ensure the fan blades are not obstructed.</li> </ul>

***Two other conditions should be mentioned:*****◆ The fans are “OFF” when the MAC Unit is running**

It is normal for the fans to be “OFF”, even if the Unit is running and delivering power to the load, as long as the temperature of the Unit is low enough. If the Fan Service Required LED (F0) is green, both of the fans are OK, even if they are not running.

**◆ The MAC Unit does not turn “OFF” when the “ON/OFF” switch is pushed down**

When the “ON/OFF” switch on the front panel is pushed down, the Unit does not respond to this signal for approximately 1 second. This is done to ensure that the Unit is not accidentally turned “OFF”. If the user does not hold the “ON/OFF” switch in the “OFF” position for a full second before releasing it, the Unit will not turn “OFF”.

***Other possible situations that are the result of external issues that a user could likely correct are related to:*****◆ Loads that draw a large surge of current at start-up**

Several problems could arise with such a load:

Some AC loads draw a very large amount of current when an input voltage is first applied to them. This may also happen when the Unit is first turned “ON” if the load is already connected to the Unit. Or it may happen when the load itself is turned “ON” and/or connected to the AC OUTPUT of a Unit that is already running. Common examples of such loads are motors and incandescent lights, but some electronic equipment can also display this characteristic.

***Several problems could arise with such a load:*****◆ Loads that draw a large surge of current at start-up:**

The SynQor's MAC is designed to try various start-up routines when it is first turned "ON" to overcome the problem of surge currents with some loads. There are five such routines (or repetitions of a given routine) that are tried. If the load is not started after these five routines are attempted, the MAC will turn "OFF". To get the MAC to try again, the user should again push the "ON/OFF" switch on the front panel to the "ON" position. If the MAC cannot start the load, then it may be possible that a custom start-up routine could be devised to work with this particular load. Contact the factory for more information.

If there is more than one load connected to the AC OUTPUT that displays this start-up surge characteristic, and the MAC is not capable of starting all the loads at once, it may be possible to switch on the loads in a specific sequence, one by one allowing for a complete successful system power-up. For instance, if the MAC cannot start up a load consisting of lights and an induction motor that has a startup current 5 times larger than the operating current, it may be possible to start the induction motor first. Once the motor has reached its normal operating speed and current, then the lights can be turned "ON" without triggering the MACs current limit protection.

**◆ A newly started load disturbs the existing Unit loads.**

A common problem can occur when the MAC is running and powering one or more loads connected to its AC OUTPUT, and then an additional load is turned "ON". If this newly started load draws a large surge current at start-up, it can cause the current limit of the MAC's AC OUTPUT to be triggered, which in turn causes the output voltage to drop. The drop could cause the existing loads to be disturbed. Furthermore, if the voltage drops is far enough below the rated limit, the MAC will turn "OFF" its AC OUTPUT and initiate a new start-up sequence. This latter action could cause an interruption of existing running loads. If this disruption in the loads is a problem, then the solution is to make sure that loads with large startup surges are started first, and then proceed to start the rest of the loads.

**◆ Input Cable wire resistance is too high:**

The resistance of the input power cable is too high due to an excessive cable length combined with an inappropriate cable size, loose panel/breaker terminals, connector contamination or corrosion. The accumulated resistance in the cable, drops the input voltage into the MAC below the rated limit during normal load condition. The phenomenon that may be displayed is as follows:

In standby mode, the MAC draws very little power/current from the AC INPUT. The voltage drop across the AC INPUT cable from the source to the MAC is therefore negligible at this point. The MAC sees that the voltage at the AC INPUT is within the specified range, and enables the output; the load begins to draw power which in turn requires the MAC to draw current via the AC Input cables and terminals. As the input current rises, a large voltage drop appears across the input cable and terminals. If the voltage into the MAC drops below the minimum rated value, the MAC may determine that the AC INPUT is out of range and proceed to shut down. After this occurs, no current is being drawn through the input cables and terminals once again, the MAC detects that the AC INPUT voltage is back to normal, and begins the startup sequence once again after a 1 second delay. The cycle will continue to repeat over and over, until voltage drop in the input circuit is corrected. The following are possible solutions to this problem: 1) make sure that the cable diameter for the required length is sufficient to deliver the full amperage to the MAC unit, 2) tighten the distribution panel/breaker terminals or 3) clean any contamination or corrosion buildup on all terminals and connectors.





# MAC **MILITARY FIELD-GRADE**

**3- $\phi$  - 1- $\phi$  AC CHANGER**

## Operator's Guide *MAC-4000 Series*



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Advancing The Power Curve<sup>®</sup>