MINV

Operator's Guide

MINV-4000-1U-180 Series

MILITARY-GRADE POWER INVERTER

MINV-4000-1U

Made in USA

SynQor®

Advancing The Power Curve®

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Hazardous Voltages

The ***INPUT AND OUTPUT POWER*** connectors and cables of the SynQor MINV contain 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 MINV ***CHASSIS*** should be connected to earth or system ground with the Ground Stud on the rear panel, see mechanical diagrams.
- For the ***DC INPUT*** cable and connector:
  - The rated DC input voltage of the MINV is above the level considered hazardous.
  - The DC input terminals of the MINV are isolated from the AC output with reinforced safety insulation.
  - However, never assume the terminals of the DC input connector or the wires of the DC input cable are safe to contact, even if the MINV appears to be off.
  - Always connect the cable to the MINV before it is connected to the source of DC power.
  - Always disconnect the DC input cable from the source of DC power before disconnecting it from the MINV.
  - If the DC input cable is connected to the source of DC power and not connected to the MINV, do not contact the exposed terminals of the DC input cable.
  - Do not assume that the source of DC power is not present.
  - Connections between the DC input cable and the source of DC 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 MINV appears to be off.
  - Do not make contact with the terminals of the AC output connector.
  - Connect the AC output cable to the MINV before the MINV 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 UPS.
  - 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 MINV may be the 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 MINV's chassis or ground. ***DAMAGING ELECTRICAL ARCS*** may result. Care should be taken to avoid accidental electrical contacts of this sort.

Protection from the Environment

The SynQor MINV 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 MINV or the fan exhausts in the rear panel of the MINV while the MINV is operating.

No User Serviceable Parts

The SynQor MINV has no user serviceable parts inside of it. ***DO NOT REMOVE*** the cover of the MINV or any of its connectors. Only factory trained personnel should perform repairs.

Product Description

SynQor's Military Inverter units are designed for the extreme environmental and demanding electrical conditions of Military/Aerospace applications. SynQor's MINV incorporates field proven high efficiency designs and rugged packaging technologies. This MINV will accept a wide-range high-voltage DC input while delivering a well-conditioned continuous 4000 W, AC output to the load. It is designed and manufactured in SynQor's USA facilities to comply with a wide range of military standards. Options include a selection of output frequencies and configurations that provide a single output, three single-phase outputs, or a 3-phase output.

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

The electronic circuitry within the MINV-4000 Series products is designed, qualified and screened according to SynQor's MIL-COTS Standards. It complies with the requirements of MIL-STD-704F, MIL-STD-1399-300B, MIL-STD-1275D and MIL-STD-461F, as well as IEC-EN61000 specifications for world-wide commercial utility applications.

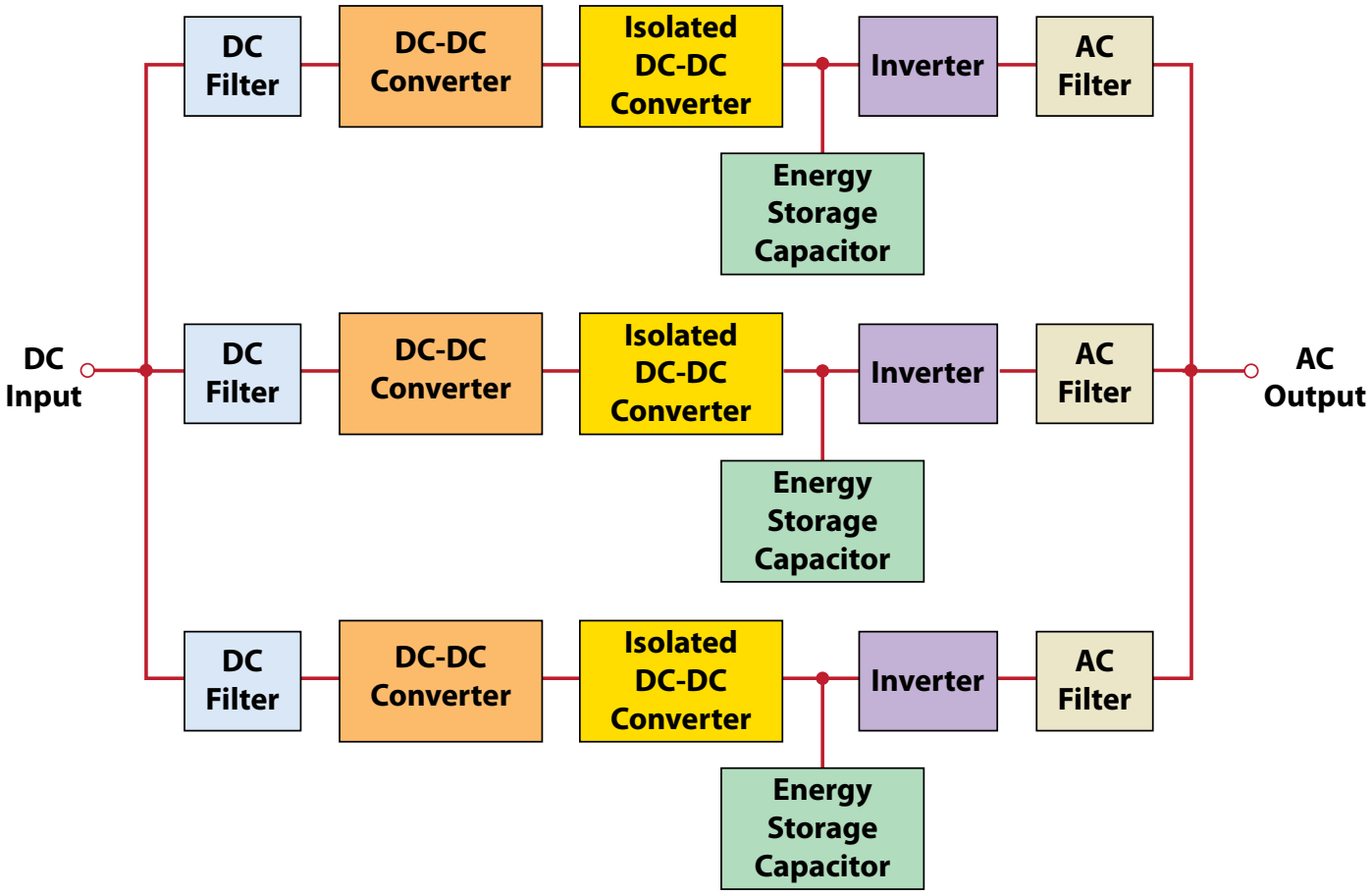
The MINV-4000 Series products are designed and manufactured to withstand the harsh environments and use encountered in military applications. The electronic circuitry is contained in a sealed chamber constructed from a die-cast aluminum chassis that is weather-proof and shock-proof. Redundant, water-proof 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 MINV-4000 Series products comply with a wide range of testing according to MIL-STD-810G.

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

Product Topology

The SynQor MINV-4000 Series products use an isolated topology that provides protection to the load from spikes, noise, surges, brownouts, blackouts, etc. in the input power sources. 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 external inputs and outputs.



Power flows from the DC INPUT through a DC-DC boost converter. The boost converter provides a regulated voltage for the isolated DC-DC converter. The AC OUTPUT is created by an inverter that draws power from the mid-bus. The inverter provides high-frequency safety isolation and a pure-sinusoidal output voltage waveform.

Bulk energy storage capacitors are connected to the mid-bus to help smooth imbalances in power flow between the inputs and outputs of the MINV.

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 SynQor MINV-4000-1U-180 product:

Family	Output Power	Height	DC Input Voltage	AC Output Voltage	AC Output Neutral Wire	AC Output Set Point Frequency	Output Configuration	Additional Options
MINV	4000	1U	180	2	F	5	S	E00
MINV	**4000:** 4000 W 5000 VA	**1U:**1.73"	**180:** 135 - 234 V	**2:** 230 Vrms	**G:** Grounded **F:** Floating	**5:** 50 Hz **6:** 60 Hz **4:** 400 Hz	**S:**One Single-Phase Output **T:**Three Single-Phase Outputs **Y:**One 3-Phase Output	**000:** None **E00:** Ethernet / SNMP

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

Example: MINV-4000-1U-180-2F5S-E00

The MINV-4000 Series of products provide up to 4000 W of total AC output power.

- A 1U high, 30 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 MINV-4000-1U-180 series is 230 Vrms.
- The AC OUTPUT can be configured with its neutral wire intentionally grounded to the chassis of the MINV or left floating for shipboard or paralleling applications.
- The initial set-point frequency of the AC OUTPUT voltage can be 50 Hz, 60 Hz, or 400 Hz. Regardless of the initial set-point frequency, the actual frequency can be set through the communications/ control port.
- The AC OUTPUT can be configured as one single-phase output, three single-phase outputs, or one three-phase output. The total system output power is limited to 4000 W for all options, and is divided equally amongst each output for the three single-phase output option.
- RS232 serial port and logic-level I/O communication are included in the standard model. An optional Ethernet port provides web and SNMP interfaces.

MINV in Transit Case Option

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

Technical Specifications

DC INPUT CHARACTERISTICS	
Steady State Operating Voltage	135 - 234 V
Continuous Maximum Input Current	35 A (full load, 135 V)
Transient Maximum Input Current	50 A
AC OUTPUT CHARACTERISTICS	
Total Output Power Continuous	4000 W (5000 VA)
AC Output Waveform	Pure Sinusoidal
Voltage Line-Neutral	230 Vrms ± 3%
Frequency	60 Hz ± 0.5% 50 Hz ± 0.5% 400 Hz ± 0.5%
Load Power Factor	0-1.0 (leading or lagging)
Total Harmonic Distortion	2% (3000 W resistive load)
Single-Phase Output	
Steady State Load Current	21.7 Arms (230 Vrms)
Peak Load Current	39 Apk (230 Vrms)
Multi-Phase Output	
Steady State Load Current per Phase	7.3 Arms (230 Vrms L-N)
Peak Load Current per Phase	13 Apk (230 Vrms L-N)

ENVIRONMENTAL CHARACTERISTICS MIL-STD-810G	
Temperature Methods 501.5, 502.5	
Operating Temperature	-40 °C — +55 °C
Non-operating Temperature	-40 °C — +70 °C
Altitude Method 500.5	
Operating	0 - 18,000 ft
Non-operating Temperature	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

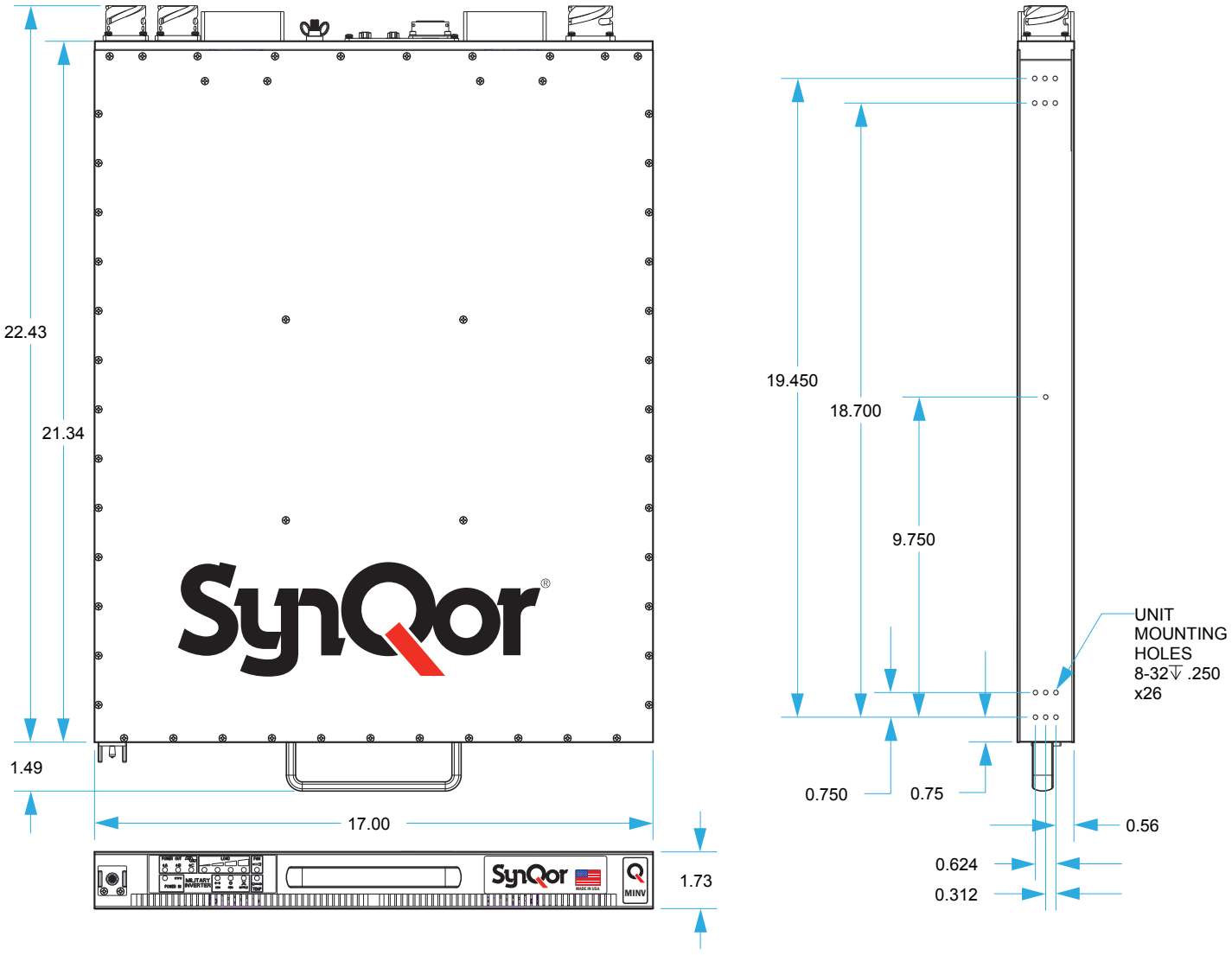
RELIABILITY CHARACTERISTICS MIL-HDBK-217F		
MTBF	TBD kHrs	MIL-217F Ground Benign, Ta=25 °C

ELECTROMAGNETIC CAPABILITY MIL-STD-461F	
CE101	30 Hz - 10 kHz
CE102	10 kHz - 10 MHz
CS101	30 Hz - 150 kHz
CS106	10 kHz - 40 GHz
CS114	10 kHz - 200 MHz
CS116	10 kHz - 100 MHz
RE101	30 Hz - 100 kHz
RE102	10 kHz - 18 GHz
RS101	30 Hz - 100 kHz
RS103	2 MHz - 40 GHz

MECHANICAL CHARACTERISTICS	
1U Standard Chassis	
Chassis Size (W x D x H)	17.00 "W x 22.43 "D x 1.73 "(1U)H
Case Material	Aluminum
Total Weight	30 lbs.
DC Input Connectors	
DC Input Connector	CB2-20-19PXS
AC Output Connectors	
230 V/240 V Single Phase	CB2-20-19SXS
230 V/240 V Multi Single Phase	CB2-20-15SXS
230 V/240 V L-N 3-Phase	CB2-20-15SXS
I/O Ports	
User I/O Ports	HD DB15 Female
Ethernet Port	Amphenol RJF22N00, Code B
Cooling Exhaust Fans	
Sound Pressure Level (SPL)	64 dB(A)
Air Flow	0.92 (m^3/min) 32.5 CFM

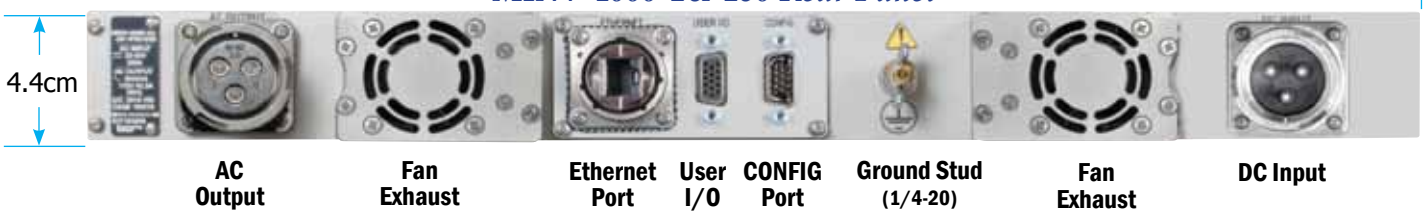
Two fans in system, above specs are for each fan separately.

1U Mechanical Diagram



MINV-4000-1U-180 Front Panel

MINV-4000-1U-180 Rear Panel



MINV Efficiency

Figure 1 shows the typical efficiency with which the MINV-4000-1U-180 series power supply delivers power to its AC OUTPUT from a 135 V DC INPUT, 180 V DC INPUT, and 234 V DC INPUT:

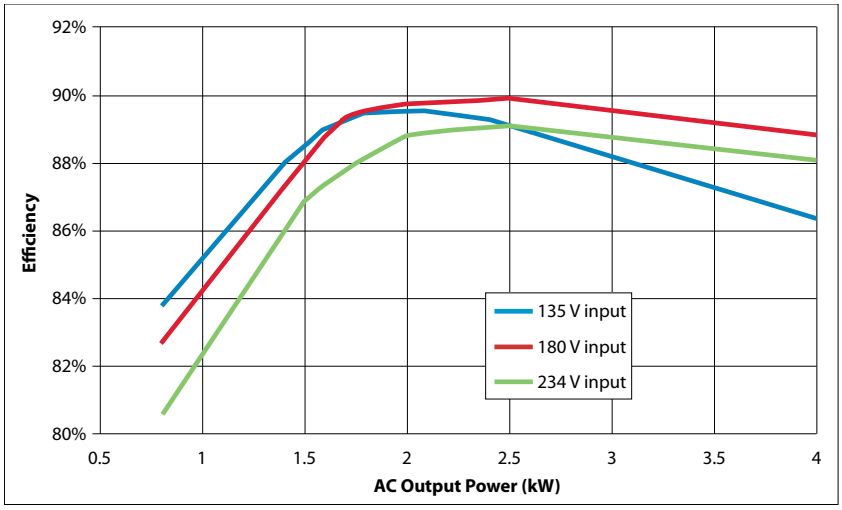


Figure 1

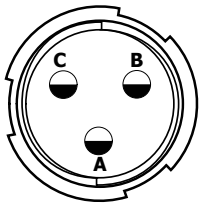
Total Output Power that can be derived from the DC INPUT

The total MINV output power for the MINV-4000 series is rated at 4000 W for an ambient temperature as high as 55 °C (131 °F).

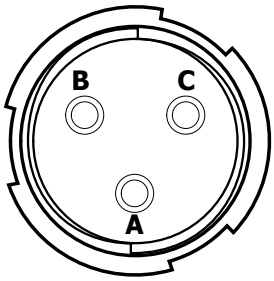
Power Cable Wiring Diagram

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

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



DC INPUT	
Pin	Function
A	Ground
B	+V
C	-V



Set-Up

The recommended procedure for setting up the MINV-4000-1U-180 is the following:

- Connect the ground wire to the ground stud on the rear panel of the MINV.
- Connect the AC OUTPUT cable, first to the MINV and then to the load.
- Connect the USER I/O cables.
- Connect the DC INPUT cable, first to the MINV and then to the DC source.
- An overcurrent protect and disconnect device should be installed on the DC INPUT circuit. An example of a suitable device is a Carling Technologies, CX-series, 60 A 300 Vdc, CX1-B0-14-660-32A-10C circuit breaker. (www.carlingtech.com)
- VERIFY that the DC INPUT cable is connected to the MINV and the source of DC power with the correct polarity.
- Turn on the source (if it has an upstream breaker).

Start-Up

- VERIFY that all connections to the MINV are correct.
- If the DC source is present and within specifications, the single POWER IN LED on the front panel will be green.
- Momentarily push the ON/OFF switch on the front panel of the MINV upward. The switch can then be released and it will return to its normal (neutral) position.
- The MINV will immediately enable its output (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 MINV.
- Push the ON/OFF switch on the front panel of the MINV 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 MINV will disable its output.

Power Cable Connections

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

> ***ALSO NOTE*** that when the MINV 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 MINV'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 MINV 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 MINV could reach its maximum current limit, and the MINV 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 MINV'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.

Cooling System

The SynQor MINV-4000 Series products are cooled by dual counter-rotating 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 MINV cooling while extending the life of the fan bearings. Under low ambient temperature and/or low MINV output power the fans will be driven at a low speed. If the ambient temperature and output power are such that the MINV cannot otherwise maintain its specified maximum temperature for its internal circuitry, the fans will momentarily be driven at a speed that exceeds their rated long-term running 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 MINV has two fans to provide redundancy for these exposed, moving components. With only a single operating fan the MINV is still able to deliver 80% rated power at an ambient temperature of 40°C, and it is able to deliver 60% of its rated power at an ambient temperature as high as 55°C.

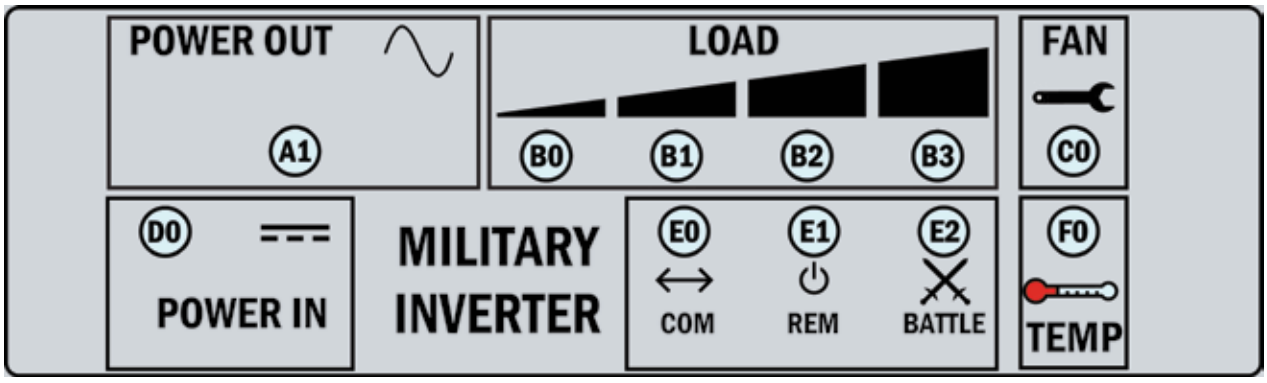
Front Panel Indicators

To indicate the status of the MINV there are 13 LEDs on the front panel. These indicators are described in this section.

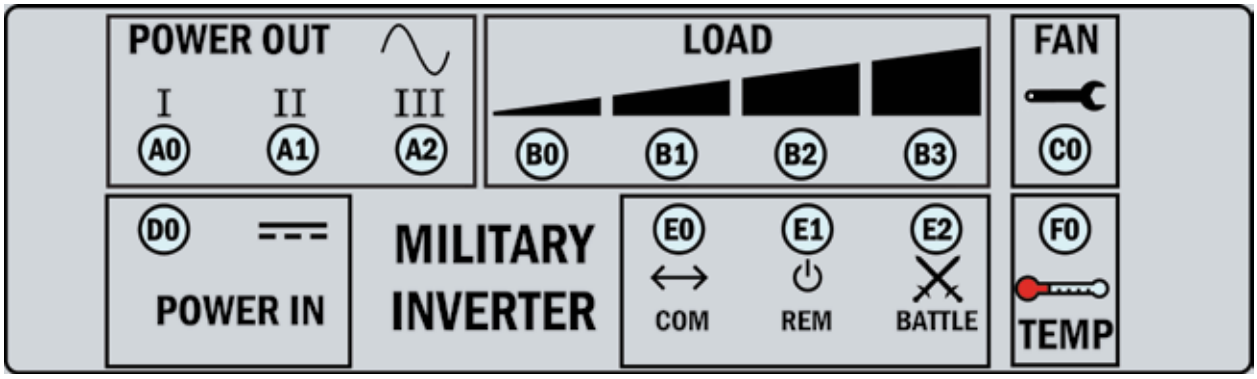
LEDs

Each MINV has up to 13 LEDs, as shown below, that indicate the status of the operation of the MINV:

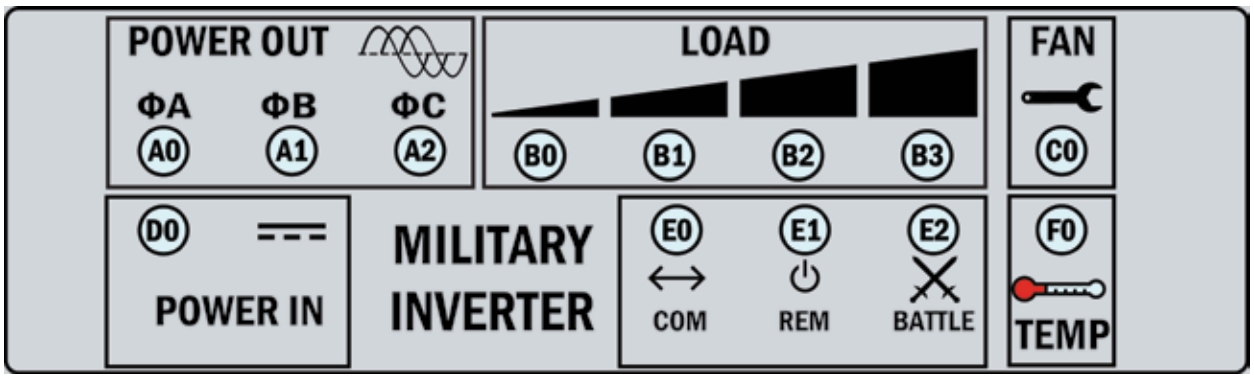
MINV Single Output LED Status Label



MINV Triple Output LED Status Label



MINV 3-Phase LED Status Label



- **Power-In Indicator (LED in position D0)**

The LED D0 indicates the status of the DC INPUT, according to the table below:

LED Appearance	Description	Indication
	**Green**	*Input is Ready to Provide Load Power*
	**Amber**	*Input is Not within Range*
	**Red**	*Input is Not Present*
	**Off**	*MINV is Off*

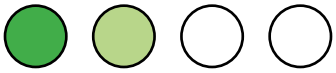
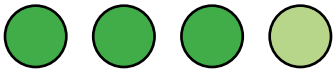
- **Power-Out Indicators (LEDs in positions A0, A1, and A2)**

The LEDs in position A1 (single output), or A0, A1, and A2 (triple or 3-Phase output) indicate the status of the AC OUTPUT, according to the table below

LED Appearance	Description	Indication
	**Green**	*MINV is On and the Output Voltage is Within Range*
	**Amber**	*MINV is On but the Output Voltage is Out of Range*
	**Red**	*MINV is Off and the Output Voltage is Within Range*
	**Off**	*MINV is Off*

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

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

LED Appearance	Description	Indication
	*B0 Dimmed Green;B1-B3 Off*	*Total Load Power <25%*
	*B0 Green; B1 Dimmed Green; B2-B3 Off*	*Total Load Power <50%*
	*B0, B1 Green; B2 Dimmed Green; B3 Off*	*Total Load Power <75%*
	*B0, B1, B2 Green; B3 Dimmed Green*	*Total Load Power <100%*
	*B0; B1; B2 Green; B3 Blinking Red*	*Total Load Power ≥100%*

- **MINV Fan Service Required Indicator (LED in position C0)**

The LED in position C0 indicates whether the two cooling fans in the rear panel of the MINV are OK or if their performance is degraded, according to the table below:

LED Appearance	Description	Indication
	**Green**	*Both Fans are OK*
	**Amber**	*One or Both Fans Have Recently Had Degraded Performance and Diagnostic Tests are Being Performed*
	**Red**	*One or Both Fans Presently Have Degraded Performance*

- **MINV Cooling System Indicator (LED in position F0)**

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

LED Appearance	Description	Indication
	**Green**	*Moderate MINV Temperature (Fans Running at 33%)*
	**Blinking Green**	*Warm MINV Temperature (Fans Running at 67%)*
	**Amber**	*Elevated MINV Temperature (Fans Running at 100%)*
	**Red**	*Maximum MINV Temperature (Fans Running at 110%)*

- **Control Status (LED in position E0, E1, E2)**

The LED in position E0, E1 or E2 indicates whether RS232 or Ethernet Port, Remote Enable/Shutdown or Battle Short are active:

LED Appearance	Description	Indication
	**Green**	*E0: RS232 active or Ethernet Port Active, E1: Remote Enable Active*
	**Blinking Red**	*E2: Battle Short Mode Active, Temperature Shutdowns Removed*
	**Red**	*E1: Remote Shutdown Active*

Operating Environment

The SynQor MINV-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 MINV will shut down if it is too hot and Battle Mode is not active.

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

MIL-STD-810G Test Method	Name	Procedure	Details
500.5	Low Pressure	I, II and III	▪ 18,000 ft. operating ▪ 40,000 ft. storage
501.5	High Temperature	I and II	▪ +55 °C operating ▪ +70 °C storage
502.5	Low Temperature	I and II	▪ -40 °C operating ▪ -40 °C storage
503.5	Temperature Shock	I	▪ 10 cycles; >10 °C/minute
506.5	Rain	I	▪ 4" rain/hour ▪ 40 mph wind velocity
507.5	Humidity	NA	▪ >95%
508.6	Fungus	NA	▪ 28 day test
509.5	Salt Fog	NA	▪ 5% salt solution ▪ 2 cycles (24 hr wet/24 hr dry)
510.5	Sand and Dust	I and II	▪ 20 mph blowing dust ▪ 40 mph blowing sand
514.6	Vibration	Category 5	▪ 5Hz (300 RPM) ▪ Loose Cargo
514.6	Vibration	Category 7	▪ General Exposure
514.6	Vibration	Category 8	▪ C-130 Aircraft level
514.6	Vibration	Category 9	▪ General Exposure
514.6	Vibration	Category 24	▪ PSD = 0.4 g^2/Hz; 1-2000 Hz ▪ Operating
516.6	Shock	I, IV and VI	▪ 20 g/20 ms; 40 g/11 ms; 75 g/6 ms ▪ 48 inch drop in transit case ▪ 30 degree tilt and drop
528	Mechanical Vibrations of Shipboard Equipment	I	▪ Operating

General Considerations

Up to three SynQor MINV units (all having identical model numbers) can be combined in various ways to achieve:

- Higher output power
- Higher output voltage
- Multiple output phases
- A balanced or unbalanced load for a 3-phase ac input source

To implement these configurations, which will be described in more detail in the pages that follow, a configuration-specific CONFIGURATION cable is required to cause the units to work together properly. These CONFIGURATION cables are available from SynQor, and the proper part number for any configuration is given in the pages that follow.

Configuration-specific OUTPUT and/or INPUT cables will also be required. They can be assembled by the user following the wiring diagrams shown below, or they can be ordered from SynQor using the proper part number given in the pages that follow.

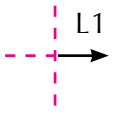
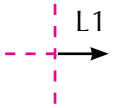
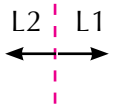
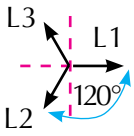
When multiple MINV units are combined, none of them will enable their AC outputs until all of them have been "turned on" (either by actuating their front-panel "on" switches or by sending the appropriate signal over their USER I/O cables). If any MINV unit is "turned off" all of the MINV units will disable their outputs. If any MINV unit cannot deliver output power because it cannot draw power from its AC INPUT, its DC INPUT, or because there is an internal fault, then all of the MINV units will disable their outputs.

Note: When combining MINV units into the configurations described in this section, each MINV must internally have the neutral wire of its AC OUTPUT floating, rather than connected to its chassis. This requires that all the MINV units have the "F" option (rather than the "G" option) regarding the AC OUTPUT neutral wire connection. Check the MINV part numbers to be sure this is the case.

Possible configurations of the AC OUTPUTs

Multi-unit Configurations

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

Number of MINV 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 x V_{rated}	2 x I_{rated}	2 x P_{rated}	SYN-9611
3	Parallel		1	L-N: 1 x V_{rated}	3 x I_{rated}	3 x P_{rated}	SYN-9615
2	Series Split-Phase		2	L-N: 1 x V_{rated} L-L: 2 x V_{rated}	1 x I_{rated}	2 x P_{rated}	SYN-9613
3	3 Phase-Y		3	L-N: 1 x V_{rated} L-L: 1.73 x V_{rated}	1 x I_{rated}	3 x P_{rated}	SYN-9617

Note that the chart shows the SynQor part number for the CONFIGURATION cable required for each configuration.

The chart shown above focuses on how the AC OUTPUTs of multiple MINV units could be connected. Of course, there are multiple ways in which the DC INPUT could be connected, as well. The DC INPUT could be connected to the same source, or it could be connected to separate sources. The possibilities will be discussed at the end of this section.

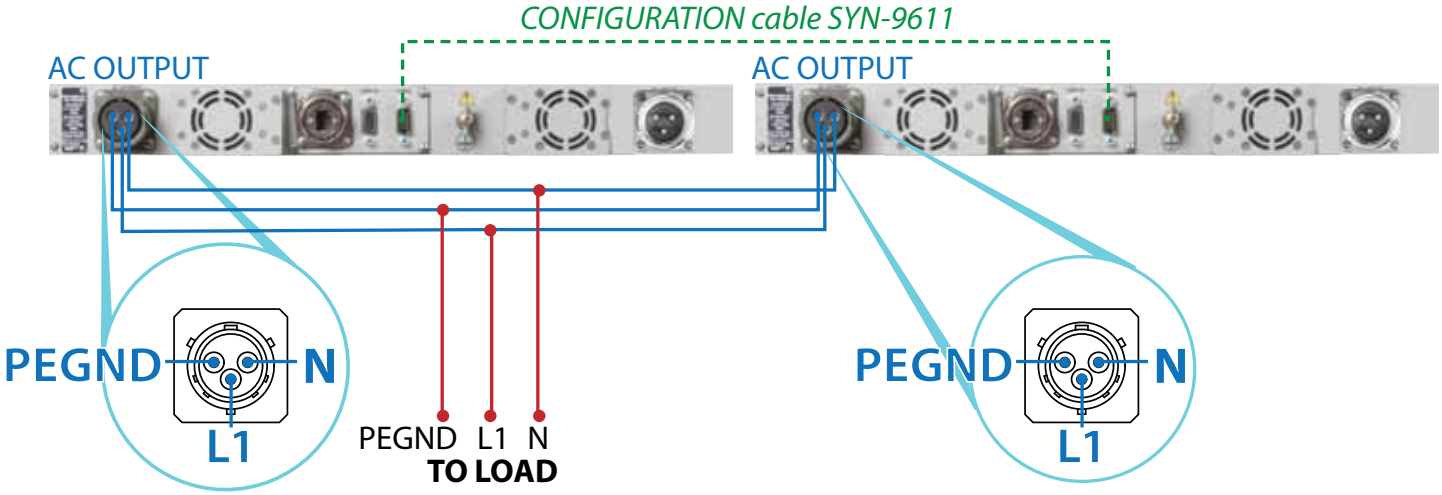
When ordering, select the “F: Floating” and “S: One Single-Phase Output” options for MINV units configured in this manner

Parallel Connection of the AC Outputs

Two or three SynQor MINV units can have their AC OUTPUTs connected in parallel to deliver two or three time the output power and output current of a single unit.

Two MINV units with AC OUTPUTs Paralleled

For two MINV units having their outputs connected in parallel, the wiring diagram for the AC OUTPUT cables and the CONFIGURATION cable is shown below:



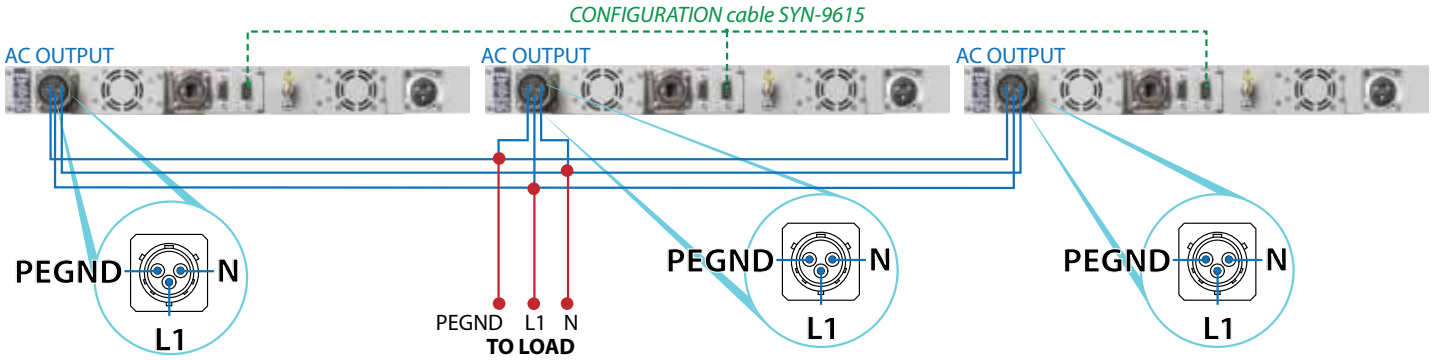
When ordering, select the "F: Floating" and "S: One Single-Phase Output" options for MINV units configured in this manner.

If the user is providing the AC OUTPUT cable, the cable sections shown above in either blue or in red should have the following minimum wire size.

MINV AC Output Voltage	Blue Cable Section Minimum Wire Size	Red Cable Section Minimum Wire Size
230 Vac	#10AWG (6 mm^2)	#6AWG (16 mm^2)

Three MINV units with AC OUTPUTs Paralleled

For three MINV units having their outputs connected in parallel, the wiring diagram for the AC OUTPUT cables and the CONFIGURATION cable is shown below:



When ordering, select the “F: Floating” option for MINV units configured in this manner.

If the user is providing the AC OUTPUT cable, the cable sections shown above in either blue or in red should have the following minimum wire size.

MINV AC Output Voltage	Blue Cable Section Minimum Wire Size	Red Cable Section Minimum Wire Size
230 Vac	#10AWG (6 mm^2)	#4AWG (26 mm^2)

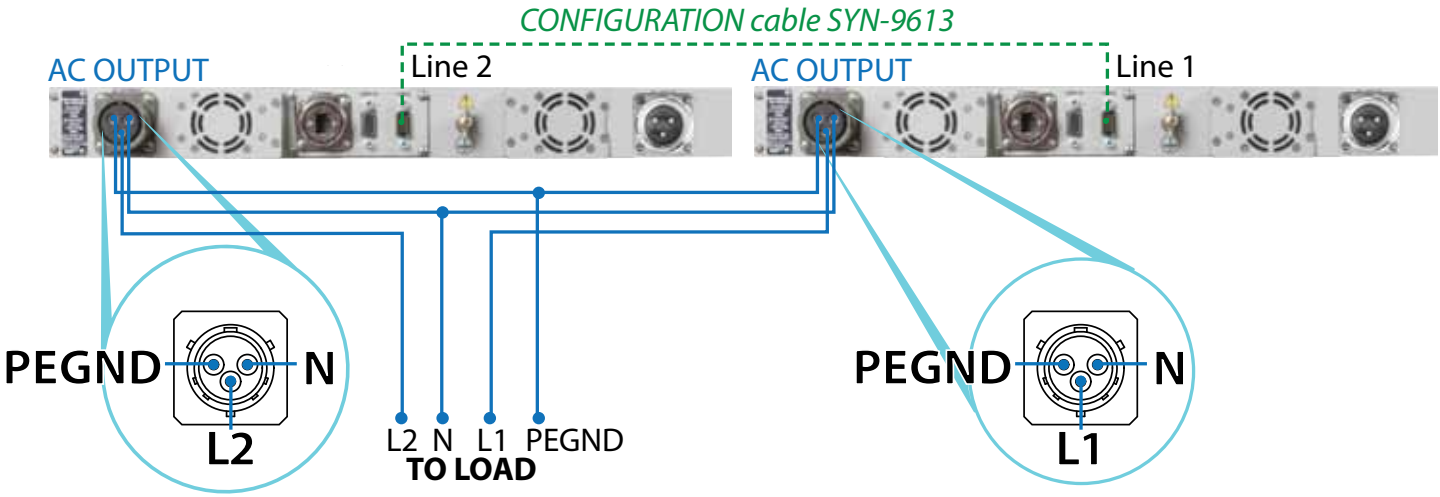
Series Split-Phase Connection of AC Outputs

Two MINV units can have their AC OUTPUTs connected in series to create an output voltage that is twice that of the output voltage of the individual MINV units. For instance, if the MINV units each create a 230 Vac output, the series configuration will create 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, and therefore kept at a potential close to Protective Earth Ground (PEGND).

The other two AC OUTPUT wires (one from each MINV 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" and "S: One Single-Phase Output" options for MINV units configured in this manner.

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



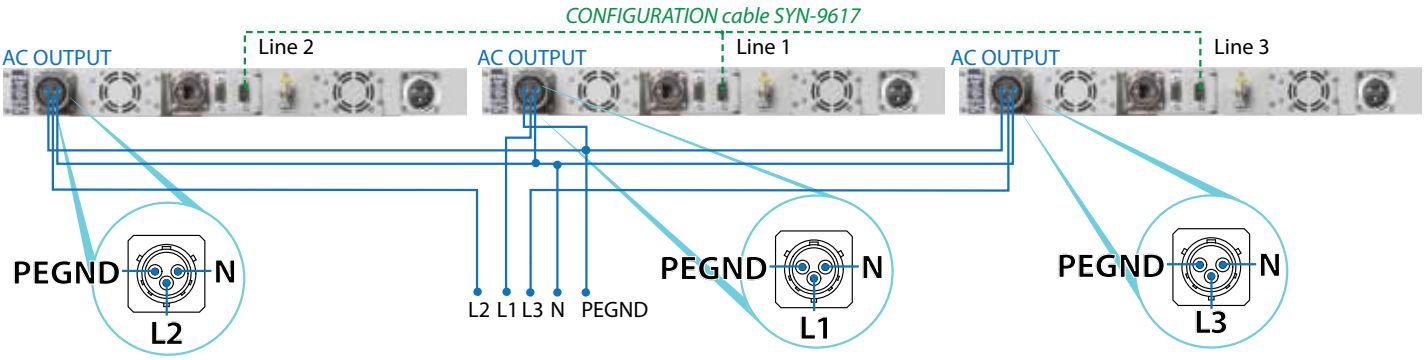
If the user is providing the AC OUTPUT cable, all the cable sections should have the following minimum wire size.

MINV AC Output Voltage	Cable Minimum Wire Size
230 Vac	#10AWG (6 mm^2)

Series 3-Phase Connection of AC Outputs

Three MINV units can have their AC OUTPUTs connected such that they share a common "neutral" and then controlled such that their output voltages are phased by 120 degrees (one- third cycle) from each other. This creates a three-phase output where the line-to-neutral voltage is the rated voltage of the individual MINV units (e.g. 230 Vac line-to-neutral) and the line-to-line voltage is 1.73 times higher (e.g. 400 Vac line-to-line). When ordering, select the "F: Floating" and "S: One Single-Phase Output" options for MINV units configured in this manner.

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 the AC OUTPUT cable, all the cable sections should have the following minimum wire size.

MINV AC Output Voltage	Cable Minimum Wire Size
230 Vac	#10AWG (6 mm²)

The "neutral" wire of the 3-phase AC OUTPUT 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 MINV unit that receives the "Line 1" connector will have an AC OUTPUT that is phased 120 degrees (one-third cycle) ahead of the MINV 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 MINV 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.

Connection of the AC and/or DC INPUTS

Whether there are two or three MINV units in the multiple-unit configuration, there are several ways that the DC INPUTS can be connected to sources of power:

- They could be connected to the same DC source.
- They could be connected to different DC sources.

All that is necessary is to ensure that the input voltage falls within the specified range of the DC INPUTS of the individual MINV units.

Furthermore, the individual DC INPUT cables can be first combined into a single cable (of appropriate minimum wire size), or they can be left as separate cables, each connected to the desired DC source.

Multi-unit AC Output On/Off Control

In multi-unit operation, all combined front panel "on" switches must be actuated before any AC output will turn on. Any "off" front panel switch actuation will cause all AC outputs to turn off. In addition, the "remote-on" or "remote-off" rear panel signal inputs may be utilized for coordinated AC output on/off control. If any single MINV no longer has a valid input power source (e.g., no AC or DC input), the combined AC output will shutdown.

AC Output Neutral Grounding

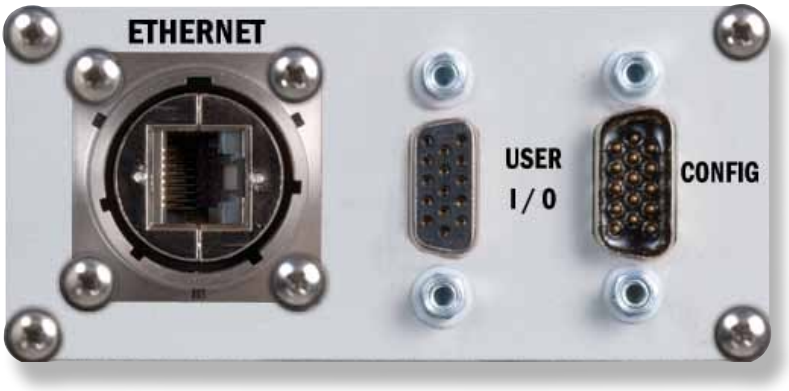
MINV units combined in multi-unit configurations must have the neutral floating "F" factory option to prevent the possibility of circulation protective earth currents. If a grounded output neutral is required, then the output neutral should be connected to protective earth ground (PEGND) in one spot. The size of the neutral-to-PEGND connecting conductor must be sized to match the largest combined AC output neutral conductor specified in the following wiring diagrams.

Wiring Caution

WARNING: *LETHAL VOLTAGES MAY BE PRESENT ON MINV AC OUTPUT CONNECTIONS. ALL AC OUTPUT CABLE CONNECTORS MUST BE INSTALLED DURING OPERATION AS A DISCONNECTED CABLE CONNECTOR MAY HAVE EXPOSED VOLTAGE PRESENT FROM ANOTHER UNIT IN THE GROUP .*

Control Cable Connections

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

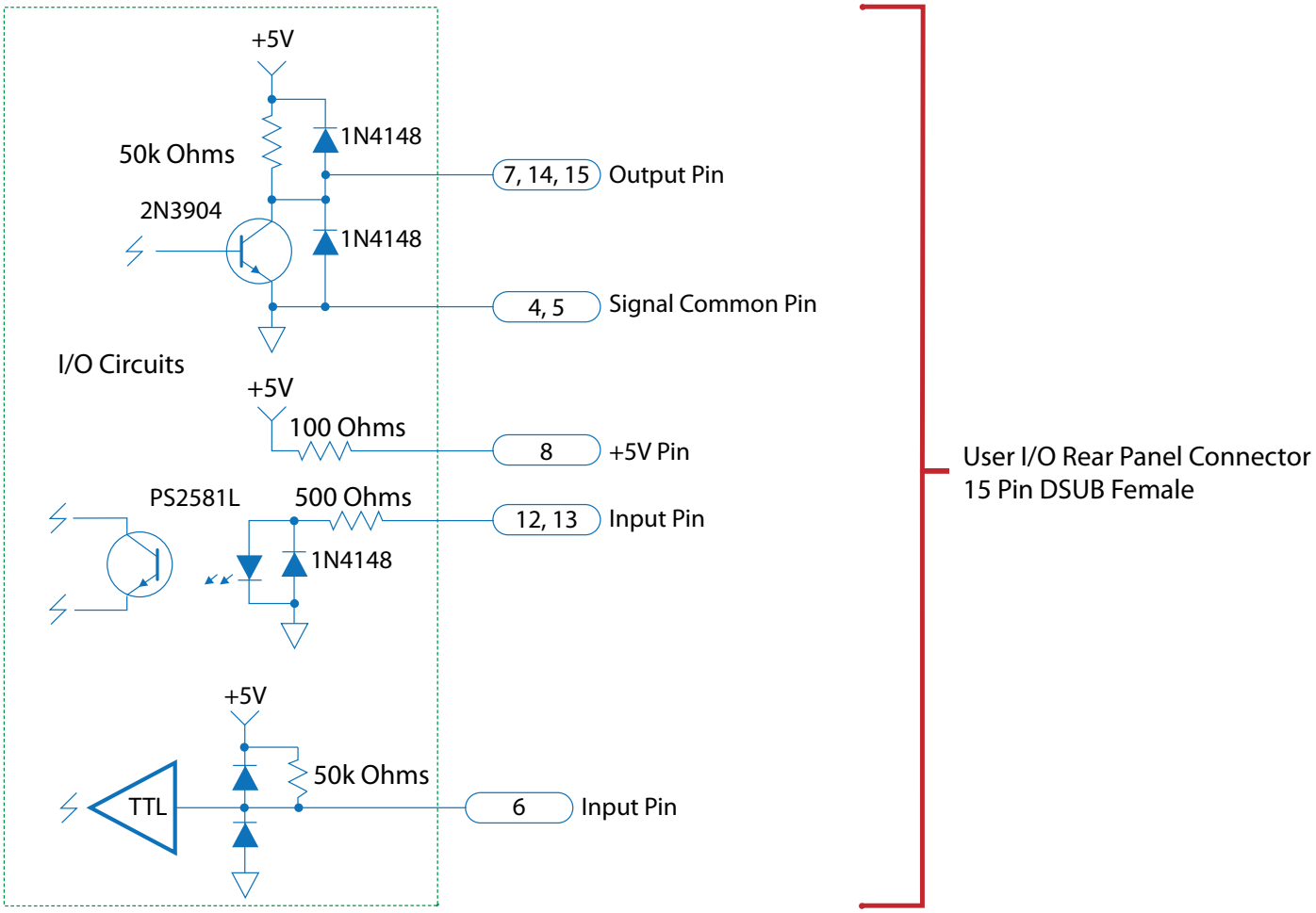


The User I/O female DB15 connector above center is for an optional connection to a host/system computer so that it can control the MINV and receive information regarding the status of the MINV.

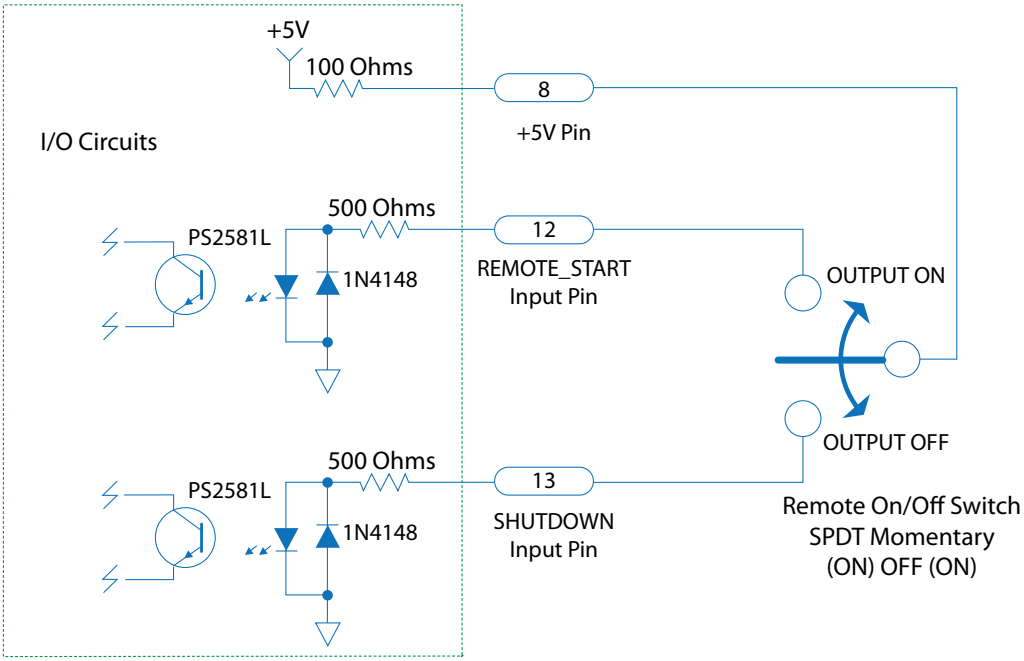
The Configuration male DB15 connector above right provides for synchronized startup and shutdown operation of multiple interconnected units, using the SYN-9697 or SYN-9695 cable. See the description on page 29.

The designation/location of the pins for the User I/O female high-density DB15 connector is 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 MINV 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 Number	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 disable internal over temperature protection, has internal pull-up to +5 V.
DCIN_GOOD	7	Open collector* output where "low" indicates DC 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 "high" with ≥ 5 mA to enable MINV outputs
SHUTDOWN	13	Drive this line "high" with ≥ 5 mA to disable MINV outputs
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 MINV 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 MINV hardware. Battle Mode is indicated with a flashing red light in panel postion E2. This mode can be commanded by pulling low on to I/O Port Pin 6, or via serial command *BS ON*.

RS232 Serial Interface

The same User I/O female high-density DB15 connector also provides for an RS232 interface between the MINV and the host/system computer. The interface has a 115.2k baud with eight data bits, no parity bit and one stop bit. The pin assignments and functions for this RS2332 interface are as follows:

Signal	Pin Number	Function
GND	4 and 5	Ground reference for RX and TX signals
RX	3	RS232 DCE/MINV Device Receive signal
TX	2	RS232 DCE/MINV Device Transmit signal

The RS232 port provides readback of MINV's state, as well as the configuration and control of the MINV's operation. The port can be used from a standard terminal interface, or from a custom computer application.

Readback information that is available:

- DC Input Voltage
- AC Output Voltage
- AC Output Current
- AC Output Power
- AC Output Frequency
- Total Output Power
- External Switch Input Status
- Fan RPM
- Internal Temperatures

Parameters that are controllable through the interface:

- Battle Mode
- Fan diagnostics
- Fault Shutdown Synchronization Control
- On/Off Synchronization
- Output enable / disable

For a detailed description of the terminal interface see the SynQor website at:
http://www.SynQor.com/MINV/documents/MINV_User_Commands.pdf

Ethernet Interface

The optional Ethernet interface provides a web page based user interface for monitoring and control of the MINV. The user can configure email alerts for MINV alarm conditions. The interface also exposes an SNMP interface compliant to RFC-1628.

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 done via DHCP or user entry of a static address. The interface also supports a direct connection between the MINV and a host computer by including a DHCP server internal to the MINV.

For a detailed description of the Ethernet port and SNMP implementation see the SynQor website at: **http://www.synqor.com/MINV/documents/MINV_Ethernet_SNMP_UG.pdf**

Synchronized Operation of Multiple Units

Interconnecting multiple units via the Configuration port using the various CONFIGURATION cables enables synchronized start-up, shutdown, restart, and fault behavior of connected units.

Turn-On, Turn-Off, Restart Control:

When a MINV device is in the Standby Mode (input power applied but output not enabled), and its output is enabled via the front panel switch, remote enable input, or serial command, all other MINV devices that are also in the Standby Mode will enable their outputs at the same time. Likewise, when a unit is operating and its output is running, if its output is disabled via the front panel switch, remote shutdown input, or serial command, all other MINV devices that are also operating will disable their outputs at the same time. Finally, when an MINV restarts after a fault event, it will coordinate its restart to be simultaneous with other MINV devices restarting during the same interval. These features are enabled by default when the CONFIGURATION cables are utilized to interconnect multiple MINV devices. The features can be disabled via the serial interface using the *SYNCCON OFF* command, and this setting is stored in non-volatile memory. These features can also be disabled via the web interface.

Fans

The fans on the rear panel have sealed bearings that do not require any maintenance.

Cleaning

The MINV-4000 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 connectors the connectors should have their covers installed. If they are not, then care should be taken to not get excess liquid on the connector terminals. **ALSO NOTE** that care should be taken to not get excess liquid on the switch of the AC BREAKER on 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.

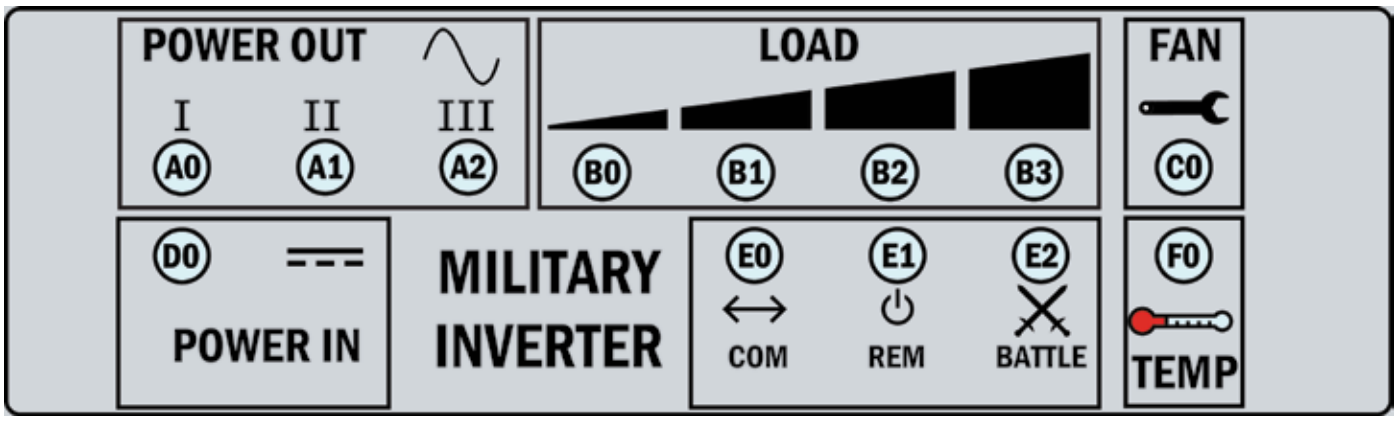
Fault Conditions

The SynQor MINV has no user-serviceable parts within it. If it has an internal malfunction only factory trained personnel should attempt to repair it.

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

The 13 LEDs on the front panel are the best and first place to look to determine what might be wrong with the MINV. 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 Triple Output front panel LED array is shown below. The designations of the 13 LEDs in this array are used in the following table.



LED	Indication	Possible Problem(s)
D0: **DC INPUT Power LED**	LED is OFF	•The DC INPUT power source is not turned on. •The DC INPUT cable is not connected or it is wired wrong. •The MINV is OFF and needs to be turned ON.
	LED is AMBER	•The DC INPUT voltage is either too low or too high.
	LED is RED	•The DC INPUT voltage is missing at least one phase on its source.
A0, A1, A2: **AC OUTPUT Power LED**	LED is OFF	•The MINV is OFF and needs to be turned ON.
	LED is AMBER	•The AC OUTPUT load is higher than 4000W or 5000VA by enough to trigger the power limit circuitry. •The AC OUTPUT load crest factor is too high. •The AC OUTPUT is shorted within the cable or a load. •Some other source of power is connected to the AC OUTPUT.
	LED is RED	•The MINV has been turned OFF, but due to a malfunction within the MINV it is still running and providing an AC OUTPUT voltage. •Some other source of voltage is connected to the AC OUTPUT and is powering it when the MINV is disabled.

LED	Indication	Possible Problem(s)
B0 – B3: **LOAD POWER LEDs**	B3 is BLINKING RED	•Total MINV load power is greater than or approaching 4000W. The MINV may still be delivering its specified output voltage because the load power is not high enough to trigger the power limit circuitry.
	B0 – B3 are all OFF	•No power is being delivered to the load. •The MINV is OFF and needs to be turned ON. •The loads or output cables are not connected. •The loads are all turned off. •The loads are simply not drawing any appreciable power at the time.
C0: **Fan Service Required LED**	LED is AMBER	•One or both fans have recently had degraded performance but seem to be ok now. The MINV is running a diagnostic test.
	LED is RED	•One or both fans presently have degraded performance, even if they are running, and service is recommended at the earliest convenient time. •Ensure that the fan blades are not obstructed from turning
F0: **MINV Cooling System LED**	LED is BLINKING GREEN	•Indicates that the fans are running at 67% of their rated speed. There is no problem.
	LED is AMBER	•Indicates that the fans are running at 100% of their rated speed. There is no problem, but the unit is operating at a high ambient temperature and a high load combination.
	LED is RED	•Fans are running at 110% 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.
All LEDs:	All LEDs are OFF	•The MINV is OFF and needs to be turned ON. •The DC INPUT power is not turned ON.

Two other conditions should be mentioned:

- **The fans are off when the MINV is running**

  It is normal for the fans to be off, even if the MINV is running and delivering power to the load, as long as the temperature of the MINV is low enough. If the Fan Service Required LED (C0) is green, both of the fans are OK, even if they are not running.

- **The MINV 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 MINV does not respond to this signal for approximately 1 second. This is done to ensure that the MINV is not accidently turned off. If the user does not hold the ON/OFF switch in the OFF position for a full second before releasing it, the MINV 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**

  Some AC loads draw a very large amount of current when an input voltage is first applied to them. This might happen when the MINV is first turned on if the load is already connected to the MINV. Or it may happen when the load itself is turned on and/or connected to the AC OUTPUT of a MINV 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:

- **The MINV fails to start the load:**

  The SynQor MINV 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 routing) that are tried. If the load is not started after these five routines are attempted, the MINV will turn OFF. To get the MINV to try again, the user should again push the ON/OFF switch on the front panel to the ON position.

  If the MINV 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 of the AC OUTPUT that displays this start-up surge characteristic, and the MINV is not capable of starting with all of them connected and switched on, it may be possible to switch on each load in turn. For instance, if the MINV cannot start up with a load consisting of a large bank of incandescent lights, then it may be able to start if various sections of the lights are switched on in sequence.

- **A newly started load disturbs the existing MINV loads.**

  A common problem can occur when the MINV is running and powering one or more loads connected to its AC OUTPUT, and then an additional load of the AC OUTPUT is turned on. If this newly started load draws a large surge current at start-up, it can cause the current limit of the MINV's AC OUTPUT to be triggered, and the AC OUTPUT voltage will then drop. This drop could cause the existing loads to be disturbed. Furthermore, if the voltage drops far enough, the MINV will turn off its AC OUTPUT and initiate a new start-up sequence (after 0.1 seconds.) This latter action would cause power flow to the existing loads to be interrupted.

  If this disruption of existing loads is a problem, then the solution is to make sure the loads that display this start-up surge characteristic are all started first, or that all loads are started at the same time.

- **Cable wire resistance is too high:**

  As mentioned in the section "Power Cable Wire Size," the resistance of a power cable's wires gives a voltage drop from the upstream to the downstream end of the cable. This voltage drop, if large enough, will cause the MINV to determine that the voltage at its DC INPUT is below its minimum specified value, even though the corresponding voltage at the source of DC power is within the specified range.

  This phenomenon that may be displayed is the following:

  - The MINV, before it turns on, does not draw any power or current from the DC INPUT, and therefore the voltage drop across the DC INPUT cable is zero.
  - The MINV sees that the voltage at the DC INPUT is within its specified range, and enables its outputs.
  - As the load then draws power, the MINV begins to draw current from the DC INPUT cable. This current causes a voltage drop to appear across the table.
  - If the voltage drop at the DC source is close to, but still above, its 135 V minimum, but the voltage drop across the cable is large enough for the voltage at the DC INPUT of the MINV to fall below 135 V, then the MINV may determine that the DC INPUT is out of range and shut down.
  - Since the MINV no longer draws current from the DC INPUT, the voltage drop across the DC INPUT cable goes back to zero volts.
  - After a while, the MINV decides the DC INPUT voltage is back within its proper range, and begins to draw a current from the DC INPUT.
  - The cycle above repeats itself for a total of three times, at which point the MINV stops trying to draw power from the DC INPUT for one minute. After this one minute another set of 3 cycles are repeated, followed by another stop for one minute, and so on.

The solution to this problem is to make sure that the cable has wires of sufficient diameter, or "gauge" for the length of cable. The longer the cable, the bigger diameter the wire should have.

See the section "Power Cable Wire Size" for recommended cable wire sizes.

MINV Operator's Guide

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006-0006909 09/29/16 Rev A

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