Operations Manual

for the ASEA Power Systems
Models AC36VHE-1, AC36VHE-3, AC45VHE-1,
AC45VHE-3, AC54HE-1, and AC54VHE-3
Single and Three Phase, Water-Cooled
Shore Power Converters

P/N 604055
Issued 12/13/2013

CERTIFICATION

ASEA Power Systems certifies that this product was thoroughly tested and inspected and found to meet or exceed its published specifications when shipped from the factory.

WARRANTY

ASEA Power Systems warrants each unit to be free from defects in material and workmanship. For a period of 18 months after purchase or 12 months after installation (whichever is shorter), ASEA Power Systems will repair or replace any defective module provided the unit has been installed and operated in a manner according to this manual. A thorough inventory of spare parts & modules is maintained at our factory. Our world-wide sales/support facilities also inventory a complement of spare parts and modules.

ASEA Power Systems is not responsible for consequential damage arising from the use of its equipment. It does not apply to extensively modified or non-standard systems. Debit memos for returned units are not accepted, and will cause return of the system without repair.

LIFE SUPPORT POLICY

ASEA Power Systems does not authorize the use of any of its products or systems for use an AC voltage supply (source) for life support systems. Life support systems are devices which support or sustain life, and whose failure to perform, when properly used in accordance with this Operations Manual, can be reasonably expected to result in significant injury to the user.

1 USING THIS MANUAL

This manual has been written as an Operations Manual. Installation, operations, and preventative maintenance are covered in detail. This manual will cover the following models:

AC36VHE-1	36kVA 1 Phase Shore Power Converter
AC36VHE-3	36kVA 3 Phase Shore Power Converter
AC45VHE-1	45kVA 1 Phase Shore Power Converter
AC45VHE-3	45kVA 3 Phase Shore Power Converter
AC54VHE-1	54kVA 1 Phase Shore Power Converter
AC54VHE-3	54kVA 3 Phase Shore Power Converter

Please note that each converter is capable of being paralleled for higher power applications.

The Model AC36VHE can be paralleled to produce the following models:

AC75VHE-1/2	75kVA 1 Phase Shore Power Converter
AC75VHE-3/2	75kVA 3 Phase Shore Power Converter

The Model AC45VHE can be paralleled to produce the following models:

AC90VHE-1/2	90kVA 1 Phase Shore Power Converter
AC90VHE-3/2	90kVA 3 Phase Shore Power Converter

The Model AC54VHE can be paralleled to produce the following models:

AC105VHE-1/2	108kVA 1 Phase Shore Power Converter
AC105VHE-3/2	108kVA 3 Phase Shore Power Converter

It is important that the operator reads this manual prior to installing and operating the converter. A thorough understanding of the information covered in this manual is required for proper installation and operation. If any questions arise while reading this manual, the user is encouraged to call ASEA Power Systems. ASEA Power Systems is located at:

ASEA Power Systems
15602 Commerce Lane
Huntington Beach, CA. 92649
Phone (714) 896-9695
FAX (714) 896-9679
Web http://www.aseapower.com

TABLE OF CONTENTS

FIGURES

2 SAFETY NOTICES

Each shore power converter is capable of transferring large amounts of electrical energy very quickly. This quality is fundamental to a high performance power converter. International symbols are used throughout this manual to stress important information. Read the text below each symbol carefully and use professional skills and prudent care when performing the actions described by the text.

THE CAUTION SYMBOL (TRIANGLE ENCLOSING AN EXCLAMATION POINT) INDICATES A CONDITION THAT COULD SERIOUSLY DAMAGE EQUIPMENT AND POSSIBLY INJURE PERSONNEL. CAUTIONS WILL BE PRESENTED IN THIS FORM. ALL CAUTIONS SHOULD BE RIGOROUSLY OBSERVED.

THE WARNING SYMBOL (TRIANGLE WITH A LIGHTNING BOLT) IS USED TO SIGNAL THE PRESENCE OF A POSSIBLE SERIOUS, LIFE THREATENING CONDITION. A CONDITION THAT IS HAZARDOUS TO BOTH PERSONNEL AND EQUIPMENT WILL BE ISSUED AS A WARNING. ALL WARNINGS WILL BE PRESENTED IN THIS FORM.

⚠ WARNING ⚠

- **THIS EQUIPMENT CONTAINS HIGH ENERGY, LOW IMPEDANCE CIRCUITS! LETHAL POTENTIALS ARE CONTAINED WITHIN THE SYSTEM EVEN WHEN IT APPEARS NON-OPERATIONAL.**
- **CARE MUST BE EXERCISED WHEN SERVICING THIS EQUIPMENT IN ORDER TO PREVENT SERIOUS OPERATOR INJURY OR EQUIPMENT DAMAGE.**
- **DO NOT WORK ON OR OPERATE THIS EQUIPMENT UNLESS YOU ARE FULLY QUALIFIED TO DO SO. NEVER WORK ALONE.**
- **THE EQUIPMENT IS NOT IGNITION RATED; IT MUST NOT BE OPERATED IN AREAS WHERE COMBUSTIBLE GASES MAY ACCUMULATE.**
- **DO NOT REMOVE THE SHORE CORD FROM THE DOCK PEDESTAL WITHOUT FIRST OPENING THE DOCK OR YACHT BREAKER. FAILURE TO DO SO MAY RESULT IN DAMAGE TO THE CONVERTER AND PEDESTAL.**
- **OBSERVE THE FOLLOWING WHEN SERVICE AND MAINTENANCE ARE REQUIRED:**
  - **REMOVE ALL JEWELRY FROM ARMS AND NECK WHEN SERVICING THIS EQUIPMENT. THIS PREVENTS THE POSSIBILITY OF SHORTING THROUGH THE JEWELRY, OR ELECTROCUTION OF THE OPERATOR.**
  - **WEAR SAFETY GLASSES WHEN SERVICING THIS EQUIPMENT TO PREVENT EYE INJURY DUE TO FLYING PARTICLES CAUSED BY ACCIDENTAL SHORT CIRCUIT CONDITIONS**.
  - **DO NOT REMOVE ANY PANELS OR COVERS WITHOUT FIRST OPENING ALL SHORE POWER AND SWITCHGEAR CIRCUIT BREAKERS DISTRIBUTING POWER TO AND FROM THE CONVERTER, AND THEN REMOVING THE INPUT SERVICE.**
  - **SERVICE SHOULD BE REFERRED TO PERSONNEL AUTHORIZED BY THE FACTORY TO SERVICE THIS EQUIPMENT.**

3 INTRODUCTION TO THE AC36/45/54VHE

The AC36VHE, AC45VHE, and AC54VHE are high performance Shore Power Converters utilizing dual-conversion technology. These converters will accept any single or three phase input service with a frequency between 40-70Hertz, and a voltage between 170-520VAC; the converter will auto-configure for the applied power form. The output power form has been programmed at the factory for the power form (single or three phase), voltage and frequency, required by your yacht.

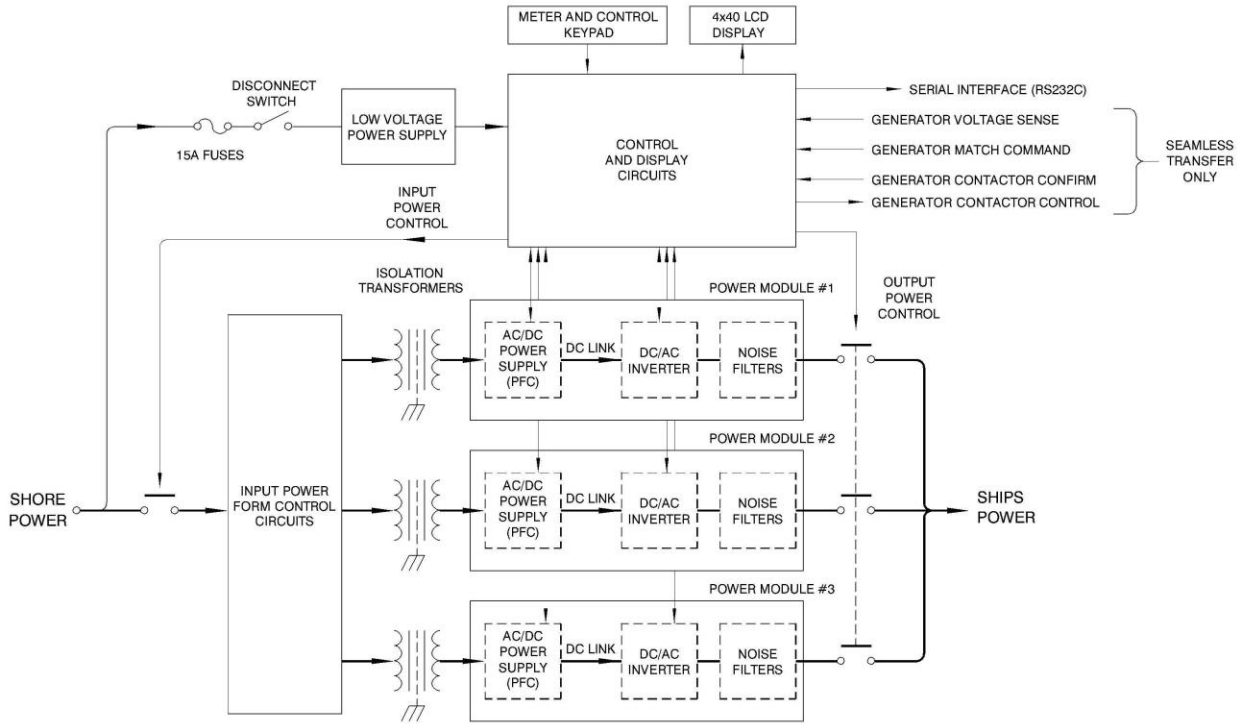


FIGURE 1 SYSTEM BLOCK DIAGRAM

Dual-conversion technology is the preferred technique for AC power conversion, and was chosen for the system design. In this technology, the shore power service is isolated by transformers and then converted to DC power by the Power Factor Correction (PFC) power supplies. The output inverters then convert the DC power back to the AC form required (both voltage and frequency) by the yacht.

These models are a dust-sealed variation of the standard “V” converter series and are cooled via an integrated, liquid-to-air heat exchanger when plumbed to the yacht’s chilled water loop.

The converter is designed to have the heat it introduces into its internal atmosphere cooled via this back -mounted, air-to-liquid heat exchanger. The heat-exchanger is designed for use with chilled water or coolant (not seawater).

Being a converter designed from the ground up specifically for the yachting industry, all efforts have been made to produce a system capable of withstanding the marine environment. All system components are packaged in one drip-proof, dust-resistant stainless steel enclosure. Major components are internally modular, allowing a simple exchange in the unlikely event of failure. Complete maintenance and service can be provided with only front access to the system. Three lightweight power modules can be removed and replaced through the front panel for repair or power level upgrade.

System operation is managed through two basic operators:

A safety disconnect on the front of the enclosure is used for securing input service during periods of disuse, when maintenance and/or service is in-process, or when an emergency shutdown is needed.

Three membrane switch groups in the control console—SHORE POWER, CONVERTER POWER, and SHIP'S POWER—provide normal operation of the system. Each switch group contains an ON and OFF switch with associated LED indicators.

In addition to the basic function of power conversion, each converter provides the user with a sophisticated power analysis and monitoring capacity. All parameters for input and output power, along with operations and status information, are available on the front panel display console. Various displays are selected through a long life, sealed membrane switch panel.

For additional information on controls and indicators, please refer to Section 6.

4 SPECIFICATIONS

4.1 ELECTRICAL SPECIFICATIONS

Parameter	**AC36VHE-1, -3**	**AC45VHE-1, -3**	**AC54VHE-1, -3**
4.1.1 Input Service			
Input Power Form	Single of Three Phase	Single or Three Phase	Single or Three Phase
Input Voltage Range	170-520V_{AC}	170-520V_{AC}	170-520V_{AC}
Input Frequency Range	40-70 Hertz	40-70 Hertz	40-70 Hertz
Input Current, Max. Single Phase	150 A_{RMS}	187 A_{RMS}	225 A_{RMS}
or, Max. Three Phase	100 A_{RMS}	125 A_{RMS}	150 A_{RMS}
Input Current, Soft Start, Max.	42 A_{RM}	42 A_{RMS}	42 A_{RMS}
Input Current Distortion	<8% THD @ rated load	<8% THD @ rated load	<8% THD @ rated load
Input Power Factor	>0.98 @ rated load	>0.98 @ rated load	>0.98 @ rated load
4.1.2 Output Service			
Output Power Rating	36kVA @ 0.85 p.f.	45kVA @ 0.85 p.f.	54VA @ 0.80 p.f.
Output Power Form	Single-Phase 220V_{AC}, 230V_{AC}, 240V_{AC}, and Two-Phase 120/240V_{AC}		
or,	Three-Phase 120/208V_{AC}, 127/220V_{AC}, 220/380$V_{AC,}$ 230/400V_{AC}, 240/416V_{AC}, and 254/440V_{AC}		
Output Frequency	50 or 60 Hertz	50 or 60 Hertz	50 or 60 Hertz
Output Frequency Accuracy	0.01%	0.01%	0.01%
Output Voltage Distortion	< 1% THD	< 1% THD	< 1% THD
Output Voltage Line Regulation	0.50%	0.50%	0.50%
Output Voltage Load Regulation	1.0%	1.0%	1.0%
Output Voltage Response Time	0.20 msec.	0.20 msec.	0.20 msec.
Output Current, Continuous	Refer to Table 1 on the following page for basic ratings.		
Output Current, Peak	400% of cont. rating	380% of cont. rating	320% of cont. rating
Output Current, Surge	340% of cont. rating	270% of cont. rating	230% of cont. rating
Conversion Efficiency	91% @ rated load	91% @ rated load	91% @ rated load

4 SPECIFICATIONS

4.1 ELECTRICAL SPECIFICATIONS, cont.

4.1.2 Output Service, cont.

Table 1 - Output Current, Rated Continuous RMS

Output Form	AC36VHE-1	AC45VHE-1	AC54VHE-1
1Ø, 220V_{RMS}	164A_{RMS}/Ø	205A_{RMS}/Ø	245A_{RMS}/Ø
1Ø, 230V_{RMS}	156A_{RMS}/Ø	196A_{RMS}/Ø	235A_{RMS}/Ø
1Ø, 240V_{RMS}	150A_{RMS}/Ø	187A_{RMS}/Ø	225A_{RMS}/Ø
2Ø, 120/240V_{RMS}	150A_{RMS}/Ø	187A_{RMS}/Ø	225A_{RMS}/Ø

Output Form	AC36VHE-3	AC45VHE-3	AC54VHE-3
3Ø, 254/440V_{RMS}	47A_{RMS}/Ø	59A_{RMS}/Ø	71A_{RMS}/Ø
3Ø, 240/416V_{RMS}	50A_{RMS}/Ø	63A_{RMS}/Ø	75A_{RMS}/Ø
3Ø, 230/400V_{RMS}	52A_{RMS}/Ø	65A_{RMS}/Ø	78A_{RMS}/Ø
3Ø, 220/380V_{RMS}	55A_{RMS}/Ø	68A_{RMS}/Ø	82A_{RMS}/Ø
3Ø, 127/220V_{RMS}	94A_{RMS}/Ø	118A_{RMS}/Ø	142A_{RMS}/Ø
3Ø, 120/208V_{RMS}	100A_{RMS}/Ø	125A_{RMS}/Ø	150A_{RMS}/Ø

4 SPECIFICATIONS, cont.

4.1 ELECTRICAL SPECIFICATIONS, cont.

4.1.3 Control, Metering, and Status

Input Power Control	Input Service Disconnect Switch, 2 pos.
Shore Power Control	Membrane Switch, Input ON/OFF Control
Converter Power Control	Membrane Switch, Output ON/OFF Control,
Ship's Power Control	Membrane Switch, Generator/Shore Transfer Control
Shore Power Metering	Voltage, Current, Frequency, kVA, kW, %Load
Converter Power Metering	Voltage, Current, Frequency, kVA, kW, %Load
Generator Power Metering	Generator 1 & 2 Voltage, Frequency, (Optional) Current, kVA, kW, %Load
System Status	Operational status, Diagnostics, Software Calibration

4.1.4 Output Derating: Coolant Temperature

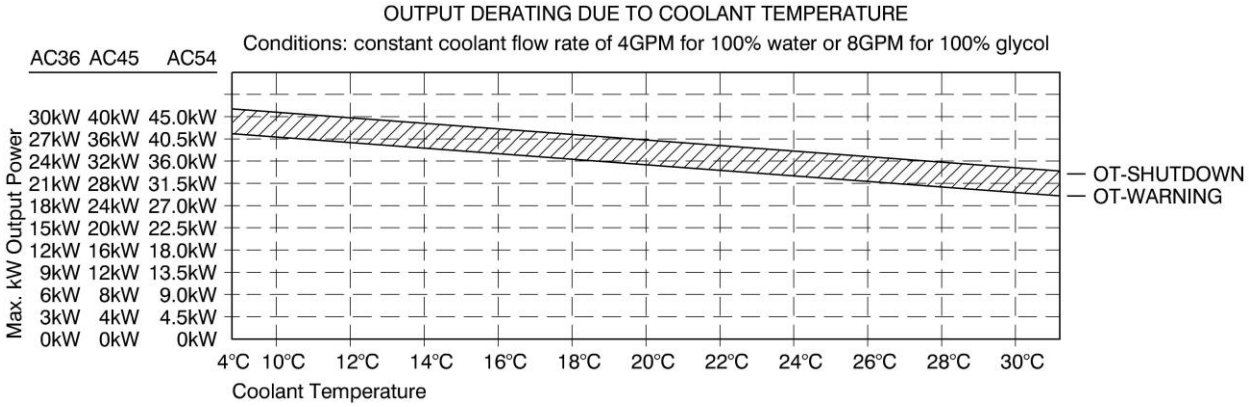


FIGURE 2 OUTPUT DERATING: COOLANT TEMPERATURE

4 SPECIFICATIONS, cont.

4.2 PHYSICAL SPECIFICATIONS

Parameter	AC36VHES-1, -3	AC45VHES-1, -3	AC54VHES-1, -3
4.2.1 Mechanical			
Height	56.13"/142.6cm	56.13"/142.6cm	56.13"/142.6cm
Width, Enclosure	25.2"/64.0cm	25.2"/64.0cm	25.2"/64.0cm
Depth	25"/63.5cm	25"/63.5cm	25"/63.5cm
Weight	836lbs/379kg	836lbs/379kg	840lbs/381kg

4.2.2 Environmental

Ambient Temperature Range	0-50°C non-condensing
Internal Air Exchange Rate	900CFM (ft^3/min) / 1,530 m^3/hour

4.2.3 Coolant Requirements

Water Flow Rate	4-10 GPM range (minimum and maximum, respectively)
Coolant Flow Rate	8-16 GPM range (minimum and maximum, respectively)
Water/Coolant Flow Min. Rate	4 + (4 * Percent Coolant) e.g. 100% coolant mix, 4 + (4 *1.00) = 8 GPM 50% coolant mix, 4 + (4 *0.50) = 6 GPM
Water/Coolant Temperature	4-10°C for full output power capability. See derating chart on the previous page for operation at other temperatures.
Water/Coolant Pressure	150 psi / 10.3 bar maximum
Pressure Drop at 4GPM	0.9 bar

5 INSTALLATION

The installation section is divided into two parts. The first will cover mechanical installation, the second, electrical installation.

Read this manual thoroughly prior to attempting the installation. Improper installation is the most significant cause of system start-up problems and service issues over the product's life. Upon receipt of the equipment, perform an external visual inspection. Verify that nameplate information is consistent with the ship's power requirements (required form, voltage, and frequency).

Proper planning will speed up installation, location, and connection of the equipment. Follow the suggested minimum clearances provided in Table 2. **The thermal load presented by the converter to the chilled water loop will be substantial and approximately 10,500BTU/Hr at maximum continuous load for the AC36VHE; 13,06BTU/Hr for the AC45VHE; and 15,670BTU/Hr for the AC54VHE.**

THE CONVERTERS ARE HEAVY, WEIGHING UP TO 840lbs DEPENDING UPON MODEL AND INSTALLED OPTIONS. EXTREME CAUTION MUST BE EXERCISED IN HANDLING AND INSTALLATION TO AVOID EQUIPMENT DAMAGE OR INJURY TO PERSONNEL. AN ADEQUATE MATERIAL HANDLING DEVICE SHOULD BE USED FOR UNLOADING, MOVING, AND POSITIONING THE SYSTEM.

5.1 MECHANICAL INSTALLATION

5.1.1 General

The converters were designed for deck mount installations and as such are provided with six mounting holes, three per side. Mounting holes have been provided with 1/2" (12.7mm) diameters; stainless steel hardware in the range of 3/8" to 7/16" (10-11mm) diameter is required.

The mounting surface should be flat and dimensionally stable to within 1/16" (1.5mm) to prevent torsional stresses being applied to the structure of the converter. Spacers (shim stock) may be added between the mounting surface and the converter mounting flanges to adjust the mounting plane. If the system is to be mounted in a high vibration/shock environment, then the factory must be consulted concerning the application. Drawings for approved shock mounting assemblies will be supplied.

5.1.2 Clearances

The following recommended clearances must be considered during installation for proper operation:

TABLE 2	FOR PROPER:	
	Operation	Service
Front	18" (Operator Area)	24" min
Sides	0"	0"
Top	0"	0"
Rear	0"	0"

Please contact factory engineers for review of the installation plan if unsure on any specification or requirement.

5.1 MECHANICAL INSTALLATION, cont.

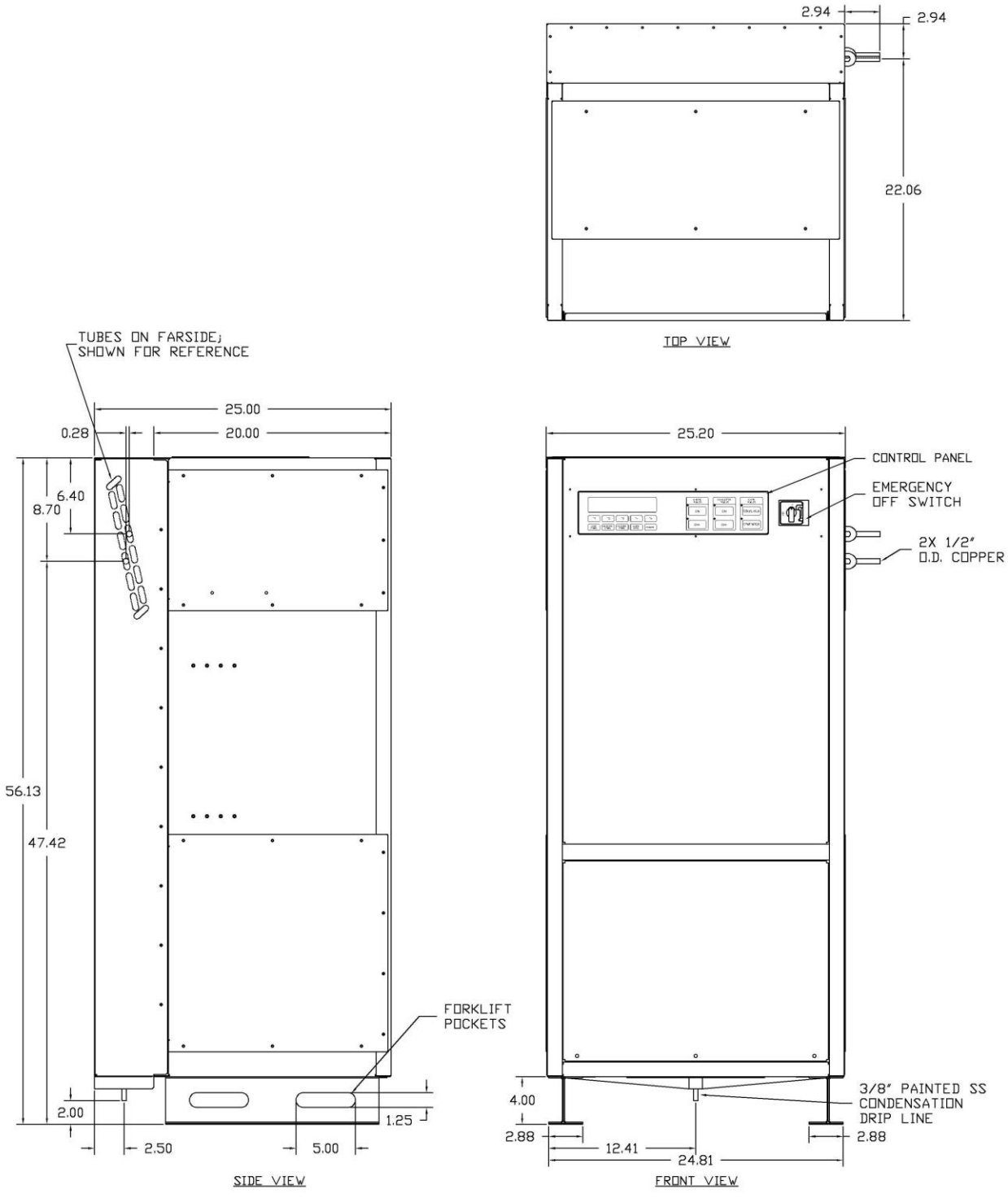


FIGURE 3 MECHANICAL OUTLINE

5.1 MECHANICAL INSTALLATION, cont.

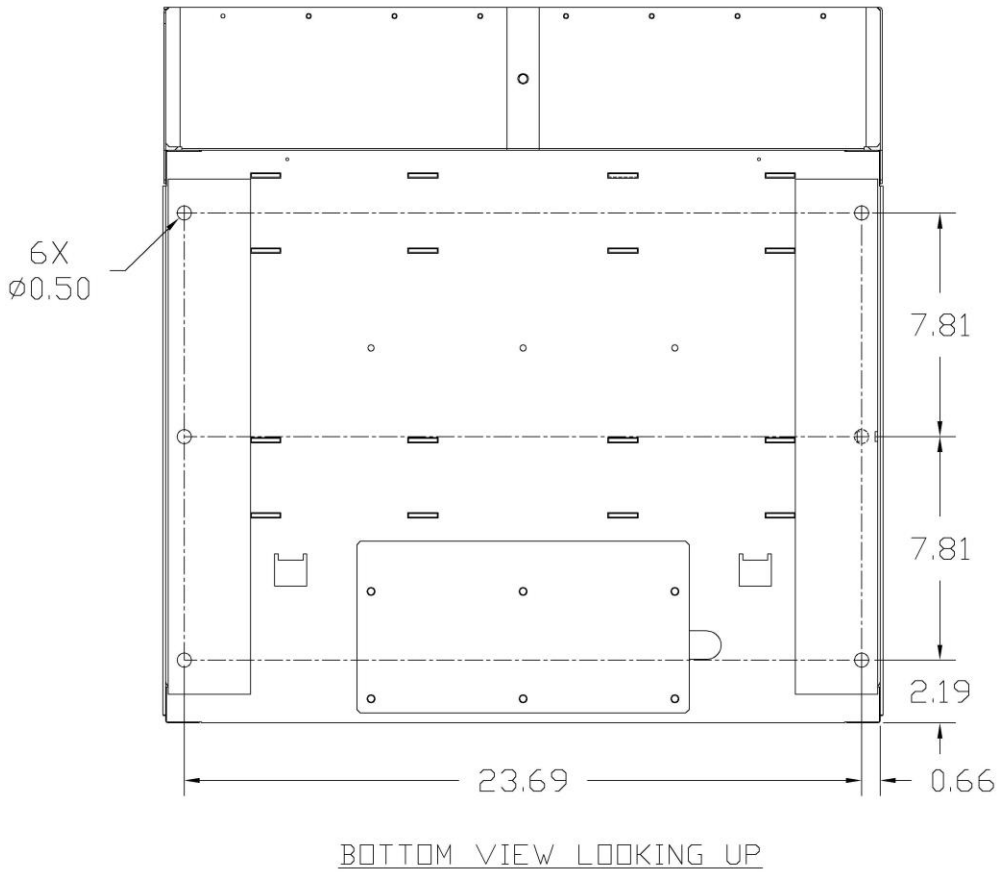


FIGURE 4 DECK MOUNTING PATTERN

5.1 MECHANICAL INSTALLATION

5.1.3 Chilled Water Loop Requirements

1. Coolant lines

a. The two coolant line connections are to 1/2" diameter copper pipes.

b. Use Teflon sealant to ensure that no leakage will occur.

2. Coolant line valves

a. Manual isolation valves must be installed locally so that shutoff can occur in the event maintenance or a leak.

b. A flow control solenoid must be installed to halt coolant flow when the converters are not in use. Without such, condensation can be created within the converter.

c. A flow control solenoid may be controlled by wiring its coil through a NO auxiliary switch added to the converter's K2 contactor. This way, flow will only be present when the converter is switched to SHORE POWER ON.

3. Rear-bottom condensation drip line

a. The rear-bottom condensation drip line connection is made to a 3/8" diameter painted steel pipe.

b. Use Teflon sealant to ensure that no leakage will occur.

4. Maintenance

a. No maintenance need be performed on the heat exchange unit when it is used in a chilled, fresh water or ethylene glycol system.

5. Flow

a. A coolant flow rate greater than 16 GPM (Gallons Per Minute) is wasteful and can accelerate water erosion of the heat exchange unit's copper piping and sweated junctions.

5.2 ELECTRICAL INSTALLATION

This procedure assumes the physical installation of the converter has been completed.

It is the installer's responsibility to provide input service over-current protection and disconnect means.

It is recommended that connection be made to the distribution bus through a manually operated disconnect device such as a molded case switch or circuit breaker (rated for the total system amperage) to ease disconnection and provide a safe servicing environment in the event of converter failure.

Follow the table below when considering shore power input cabling.

MAXIMUM CURRENTS UNDER LOW-LINE CONDITIONS:

Model	**AC36VHE**	**AC45VHE**	**AC54VHE**
Input Current Single Phase, 170-290V_{AC}	190A	233A	288A
Single Phase, 330-520V_{AC}	95A	116A	144A
Three Phase, 170-290V_{AC}	110A	135A	166A
Three Phase, 330-520V_{AC}	55A	67A	84A

MAXIMUM OUTPUT CURRENTS: Refer to Table 1, page 11

All power wiring requires the removal of the front panel. The front cover is secured with 3 ea #10 stainless steel screws.

5.2 ELECTRICAL INSTALLATION, cont.

⚠ WARNING ⚠

INPUT WIRING MUST BE PERFORMED BY A QUALIFIED ELECTRICIAN FAMILIAR WITH STANDARD SAFEGUARDS AND PROCEDURES REQUIRED BY THE INSTALLATION OF THIS TYPE OF EQUIPMENT. POWER MUST BE REMOVED FROM THE INPUT DISTRIBUTION SYSTEMS SUPPLYING POWER TO THE CONVERTER PRIOR TO THE START OF THE FOLLOWING STEPS. INPUT POWER MUST BE SECURED (LOCKED) IN THE OFF (DE-ENERGIZED) STATE UNTIL INSTRUCTED OTHERWISE BY THIS DOCUMENT. ALSO SECURE IN THE OFF STATE ANY CIRCUIT BREAKER(S) IN THE SWITCHGEAR PANEL THAT MAY BE SUPPLYING SHIP'S BUS POWER TO THE CONVERTER OUTPUT TERMINAL BLOCK. FAILURE TO FOLLOW THESE PROCEDURES CAN RESULT IN DAMAGE TO THE EQUIPMENT, AND CAN PRESENT THE RISK OF INJURY OR DEATH TO THE INSTALLER OR THE OPERATOR.

5.2.1 Input Power Connections

The converter is supplied with compression type terminal blocks for input power connections. These terminal blocks accept wires in the range of 250MCM to 6AWG (approximately 120mm^2 to 16mm^2). Refer to the applicable standards for selection of required wire gauge and type. If single phase shore power is to be used, it must be applied between the SHORE POWER Phase A ad Phase B terminal block positions. In two or more cabinet systems, one shore cord is connected to each converter shore power terminal block. Please refer to Figure 5 on page 22 for more details.

5.2.2 Output Power Connections

The converter is supplied with compression type terminal blocks for output power connections. These terminal blocks accept wires in the range of 250MCM to 6AWG (approximately 120mm^2 to 16mm^2). Refer to the applicable standard for selection of the required wire gauge and type. The output ground wire must be connected to a 3/8-16 UNC stud. Please refer to Figure 5 on page 22 for more details.

5.2 ELECTRICAL INSTALLATION, cont.

5.2.2 Output Power Connections, cont.

Three phase WYE output forms such as 120/208VAC and 230/400VAC use a 4-wire plus ground wiring configuration. In the case of those power forms, the Converter Output ØA, ØB, ØC, and N terminals are used.

Three phase DELTA output forms such as 220VAC and 400VAC use a 3-wire plus ground wiring configuration. In the case of those power forms, the Converter Output ØA, ØB, and ØC terminals are used. (Note that the "N" neutral terminal is not used but is still electrically live.)

Two or "split" phase output forms such as 120/240VAC use a 3-wire plus ground wiring configuration. In the case of this power form, the Converter Output ØA (L1), ØB (L2), and N terminals are used.

One or "single" phase output forms such as 220VAC use a 2-wire plus ground wiring configuration. In the case of this power form, the Converter Output ØA (L1) and ØB (L2) terminals are used. (Note that the "N" neutral terminal is not used but is still electrically live.)

5.2 ELECTRICAL INSTALLATION, cont.

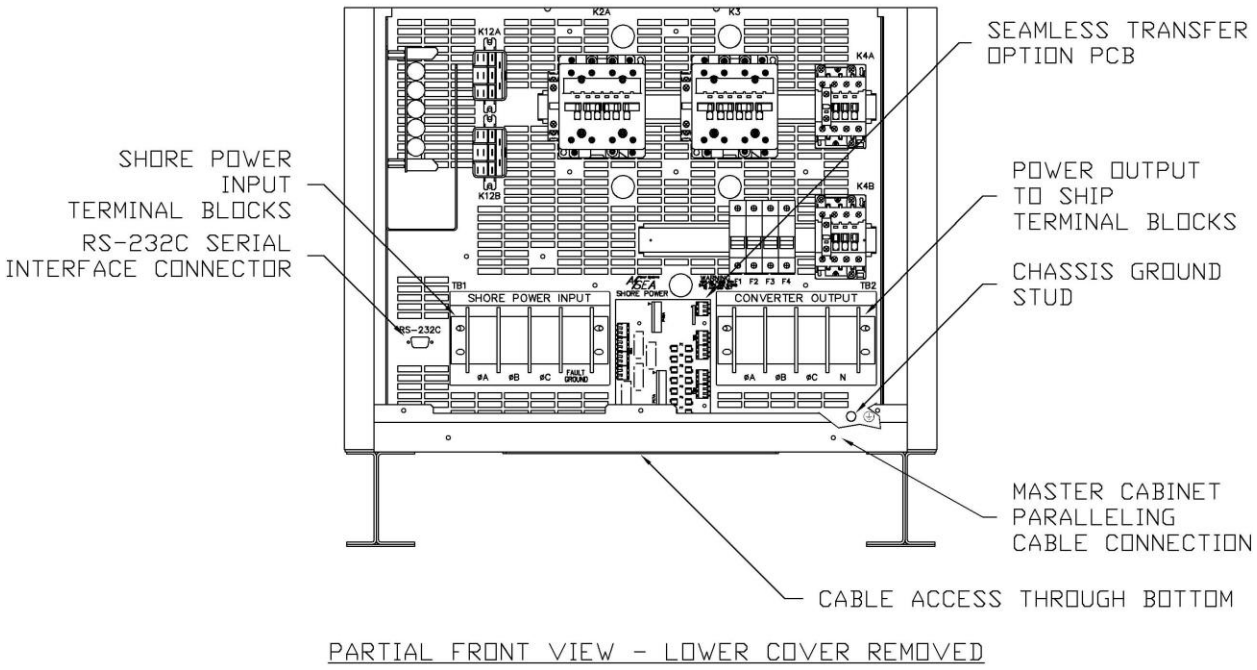


FIGURE 5 INPUT AND OUTPUT CONNECTIONS

Prepare the power cables by removing approximately 6" of the outer cable insulation (in the case of SO type portable cables). Strip the insulation back exposing 1" of the bare conductor for all input, output, and grounding conductors. Insert the prepared cables and strain relief assemblies into the prepared holes in the cable access cover. Insert the terminated wire ends (use of ferrules is recommended) into the appropriate input/output terminal block and tighten. Replace the power cable access cover and front panel using the removed hardware.

5.2 ELECTRICAL INSTALLATION, cont.

5.2.3 Grounding

The FAULT GROUND terminal on the Shore Power Input Terminal Block is for termination of the shore cord ground. The terminal is internally connected to a copper shield placed between the primary and secondary coil of the three input isolation transformers. This configuration serves to address standards for marine isolation transformers such as those expressed by ABYC.

The converter chassis ground MUST be connected to the ship's hull or common ground point via the compression fitting terminal adjacent to the output power connections. Failure to do so may create conditions that may in turn cause injury or death to operators; failure to do so will also result in the voiding of the equipment warranty. In the case of paralleled converter systems, and where such ground connections are not local and directly adjacent to the paralleled converters, the chassis ground connections must be interconnected between the paralleled converters as well as connected to the remote ship's common ground point.

THE CONVERTER ISOLATES THE OUTPUT POWER FROM THE INPUT POWER AND EQUIPMENT (SAFETY) GROUNDS SIMILAR TO AN ISOLATION TRANSFORMER. THE INSTALLER MUST RE-ESTABLISH THE GROUND REFERENCE FOR THE EQUIPMENT AT TIME OF INSTALLATION. NEUTRAL AND EQUIPMENT (SAFETY) GROUNDS TO BE CONNECTED PER THE APPROPRIATE CLASS STANDARD

5.2 ELECTRICAL INSTALLATION, cont.

5.2.4 Multi-Cabinet Connections

Multi-cabinet systems should have each cabinet's output connections paralleled at the switchgear panel. The converters' terminal blocks are sized for a single, appropriated sized cable per phase, neutral, and grounding conductor.

Multi-cabinet systems are constructed from one cabinet which serves as the system Master, and an additional cabinet(s) which serves as the Slave(s). A paralleling cable assembly (*P/N 605150*) is shipped pre-connected to the Slave cabinet and coiled at the base of the cabinet near the Input and Output connection terminal blocks. It must be connected to the interface connector at the base of the Master cabinet (see Figure 5 on page 22 for details). Do not substitute cable assemblies. If a longer cable is needed for a given installation, contact the factory for the appropriate cable.

5.2 ELECTRICAL INSTALLATION, cont.

5.2.5 Seamless Transfer Connections

If the Seamless Transfer Option was ordered with the system, connections must be made between the generator/switchgear and converter. These connections are used by the converter to successfully manage Seamless Transfer operation and are comprised of control, signal, and feedback functions. These connections are only required in the Master cabinet of a multi-cabinet installation. Use of 14-18AWG wire is recommended for signal and control wiring.

A variety of Seamless Transfer Option types exist. These include two generator, three and four generator, Hybrid (switchgear cooperative), and Clean Bus types. Installation requirements for such options vary in accordance with switchgear design and hence are beyond the scope of this Operations Manual.

Contact the factory for complete and specific system wiring drawings. These can be supplied in either printed or electronic format.

The Seamless Transfer Option uses momentary control signals to operate switchgear contactors or circuit breakers that mange generator connection to the ship's distribution bus. The control pulse width for these momentary control signals is 0.6 seconds for both the open and close commands. The contacts used for generator control are rated for a maximum of 8A @250VAC or 5A @24VDC.

The generator contactor or circuit breaker must be equipped with an auxiliary switch contact set—closed when the main contacts are closed.

Generator voltage sense wires are used by the converter to match its output voltage, frequency, and phase angle to the generator's and should be fused at the generator/switchgear.

5.2 ELECTRICAL INSTALLATION, cont.

5.2.6 Other Optional Connections

In support of the Seamless Transfer Option, or in support of switchgear and/or power monitoring integration, other options may be ordered and installed in a converter. Installation requirements for such options vary in accordance with switchgear design and hence are beyond the scope of this Operations Manual.

Contact the factory for complete and specific system wiring drawings. These can be supplied in either printed or electronic format.

6 OPERATION

6.1 POWER TURN-ON PROCEDURE

Close the shore power (input) circuit breaker or switch to the converter. Turn the disconnect **(14)** switch to the ON position. After 1-3 seconds, fans will be heard, and the display will become active. Allow the converter to initialize (the display LOAD LEVEL field will change from 0.0 % to a small reading after initialization) before attempting to operate it.

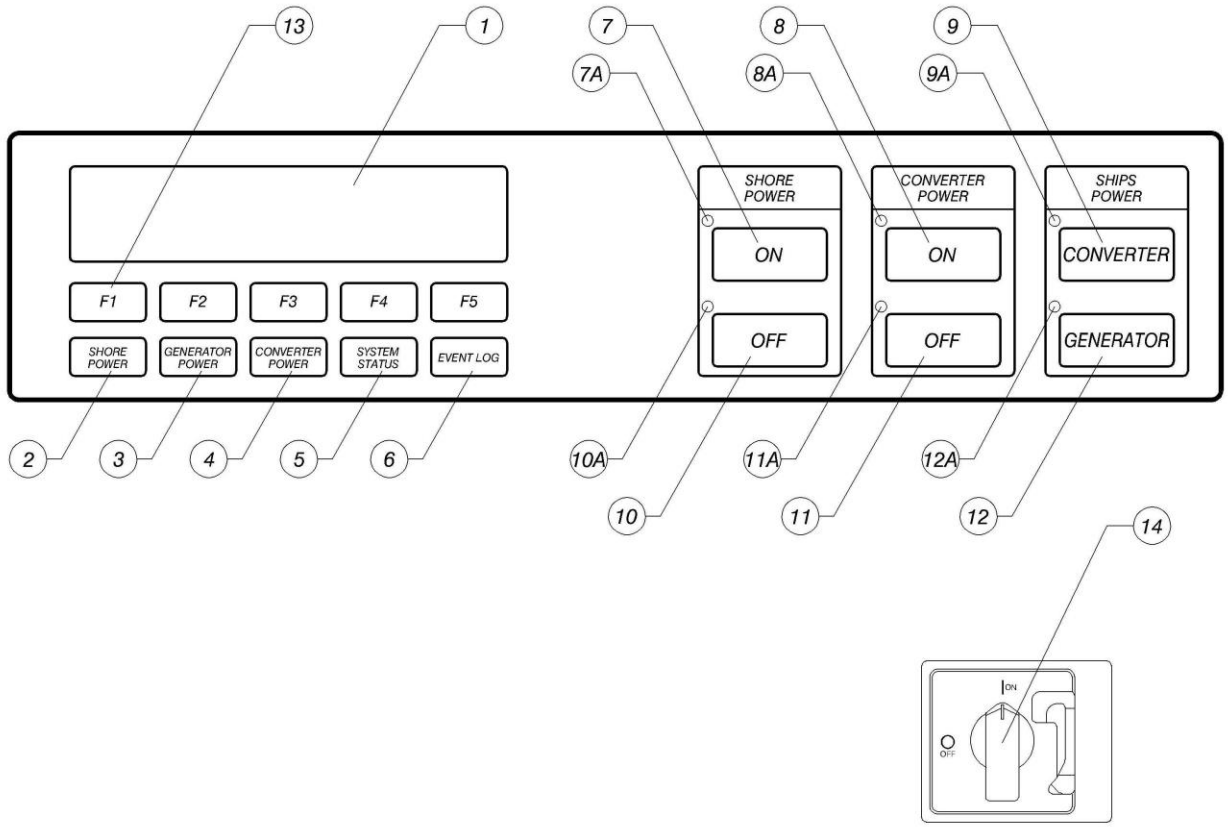


FIGURE 6 FRONT PANEL CONTROLS

6.1 POWER TURN-ON PROCEDURE, cont.

The display will sequence to the SUMMARY DISPLAY indicating the converter's operational state. Both input and output (converter) should indicate OFFLINE at this time. Press the INFO **(13)** button to review the Shore Power state if desired. The INFO screen will either list the Shore Power as ONLINE or give a reason for its being off if it was previously on. A press of the F3 **(13)** button in the INFO screen will display the last known converter failure. Return to the SUMMARY DISPLAY at any time by pressing the SYSTEM STATUS **(5)** button.

```
SUMMARY DISPLAY              AC36  MASTER
INPUT: OFFLINE          CONVERTER: OFFLINE
LOAD LEVEL: 0.0 %         AUTO-RESTART: ON
INFO   STATUS
```

At this time both of the red LED indicators next to the OFF buttons **(10A & 11A)** should be lit. If the system has been ordered with the Seamless Transfer option, and the generator is on-line, the green LED **(12A)** to the left of the GENERATOR **(12)** button will be lit.

Press the SHORE POWER **(2)** display button. The display will indicate basic shore power information: voltage, current, and kVA. Press the F2 **(13)** button to view kW, Power Factor, frequency, and form. Verify the displayed voltages indicate the expected voltages and frequency. If not, do not proceed until contacting factory personnel. Additional SHORE POWER information can be obtained by pressing the F3 and F4 **(13)** buttons: peak currents and crest currents, percent of system rating, and kVAR. Return to the primary screen by pressing the F1 **(13)** button.

```
INPUT #1  PHASE A-B PHASE B-C PHASE C-A
  VOLTAGE:      400V       400V       400V
  CURRENT:        0A         0A         0A
     LOAD:  0.0 kVA    0.0 kVA    0.0 kVA
```

6.1 POWER TURN-ON PROCEDURE, cont.

Press the CONVERTER POWER **(4)** button and the screen will now change. As with the shore power displays, the F1-F4 **(13)** buttons will cycle through a variety of converter power data. Output voltages and currents should indicate zero.

CONVERTER	PHASE A	PHASE B	PHASE C
VOLTAGE:	0/0V	0/0V	0/0V
CURRENT:	0A	0A	0A
LOAD:	0.0 kVA	0.0 kVA	0.0 kVA

To turn on the converter, press the SHORE POWER ON **(7)** button. The converter will begin a soft-start procedure which requires approximately 2 seconds to complete. At the conclusion of this process, the indicator LEDs **(10A & 7A)** in the SHORE POWER control area of the display should change from red to green. View the display information for CONVERTER POWER **(4)** and verify that the displayed voltage is at the desired potential, frequency, and form. The system is now in the Standby State.

NOTE: *It is normal under no load conditions for the currents to indicate 5-10 Amps flowing. This level of current is due to the internal filters and will not reduce the converter's power rating.*

6.1.1 Systems Not Equipped With The Seamless Transfer Option

When ready to transfer the ship's load to the converter, press the CONVERTER POWER ON **(8)** button on the control panel. This will place voltage at the output terminals of the converter. The green ON indicator LED **(8A)** should now be lit. The ship's load may be transferred to the converter at this time if additional, external switchgear is involved. The transfer must be performed in a "*break-before-make*" method to prevent damage to the converter or generator(s). The converter and generator(s) may not be operated in parallel at any time.

6.1 POWER TURN-ON PROCEDURE, cont.

6.1.2 Systems Equipped With The Seamless Transfer Option

With the converter in the Standby State (as left at the end of Section 6.1), press the GENERATOR POWER **(3)** display button. The generator voltage and form will now be displayed. If two generators are installed, select Generator #1 or Generator #2 by pressing the F1 **(13)** or F2 **(13)** button after selecting the GENERATOR metering screen.

NOTE: Unlike the converter and shore power displays, generator load current is not measured by the system, and as such no data can be displayed for current, kW, or kVA.

To determine generator status to the electrical system, observe the SHIP'S POWER button group. Two LEDs are included in this group, one next to the SHIP'S POWER - CONVERTER **(9)** button, the other next to the SHIP'S POWER - GENERATOR **(12)** button. The LED **(9A)** next to the CONVERTER button will be lit when the converter is on and supplying power to the ship's distribution grid. The LED **(12A)** next to the GENERATOR button will be lit when the generator is supplying power. The SHIP'S POWER LEDs should never be lit at the same time: only one source of energy should be connected to the ship's distribution system at any point in time. If the GENERATOR LED is lit, but the GENERATOR metering display indicates no power present, then the GENERATOR is connected to the distribution grid through its circuit breaker, but the generator is off.

⚠ WARNING ⚠

NEVER ASSUME A CIRCUIT IS INACTIVE *(WITHOUT VOLTAGE*) BY RELYING UPON THE SHORE POWER CONVERTER'S METERING SYSTEM. DO NOT ACCESS THE ELECTRICAL SYSTEM WITHOUT PROPERLY VERIFYING THE SAFETY OF THE SITUATION USING ALTERNATE MEANS.

6.1 POWER TURN-ON PROCEDURE, cont.

6.1.2 Systems Equipped With The Seamless Transfer Option, cont.

If the generator is supplying power to the ship, the SHIP'S POWER - GENERATOR LED **(12A)** is lit, and the GENERATOR metering display indicates approximately the same voltage as the CONVERTER metering display, then proceed by pressing the SHIP'S POWER - CONVERTER **(9)** button. In dual generator installations, the converter will determine the appropriate transfer generator and the transfer will proceed. The converter will match the generator in voltage, frequency, and phase. When the two power forms are matched, the converter will place itself momentarily in parallel with the generator, and then open the generator circuit breaker removing the generator from the distribution grid. The entire process may take up to 5 seconds to complete. The generator can now be secured from operation.

If the generator is off-line as indicated by the SHIP'S POWER - GENERATOR LED **(12A)** being off, the converter will immediately place itself on the ships distribution system, with no synchronization period required, when the CONVERTER **(9)** button is pushed.

When attempting transfer from the converter to the generator and the generator is off, or if its voltage is outside the allowed voltage or frequency limits, the transfer will be aborted.

When load has been transferred to the converter, monitor the converter load currents and voltages. Ensure the load is within the system ratings as indicated by the STATUS display. Monitor the shore power voltage and current levels with load applied to avoid tripping shore power breakers. Refer to published rating curves for maximum current, kVA, and kW levels. Additional loading information may be obtained on shore power and converter loading by selecting the desired source button **(2, 4)**, then pressing F2, F3, and F4 **(13)**. To return to the default metering display, press F1 **(13)**.

6.2 MULTI-CABINET OPERATION

Multi-cabinet systems are operated from the Master's control panel. Each cabinet retains its own control panel and metering display for individual monitoring. A load management option exists that allows individual cabinets to load according to shore cord size (see section 7 for details).

Apply shore power to both cabinets and turn the disconnect switch **(14)** on each cabinet to the on position. Within 1-3 seconds each cabinet will start, fans will be heard, and the display will become active. Using the SHORE POWER **(2)** button on each cabinet, verify the applied shore power measures the expected form. Use the Figure 6, Front Panel Controls on page 27 for button references.

Press the SHORE POWER ON **(7)** button on the Master cabinet, bringing the Master and Slave cabinets to the standby state. The green shore power LED **(7A)** on the Master and Slave cabinets should now be lit. Measure the voltage being produced by the system by pressing the CONVERTER POWER **(4)** buttons on the Master and Slave cabinets: they should indicate the desired form and be within 5% of each other.

When ready to place the converter onto the ship's distribution system, press the CONVERTER POWER ON **(8)** button on the Master cabinet. This will close the output contactors of both the Master and Slave cabinets simultaneously. The green LED **(8A)** should light on the Master and Slave cabinets. With the ship's loads now supplied by the converter, measure the load power being supplied by each cabinet to ensure compliance to the system ratings. The system status display will indicate a summary load percentage, based upon a worst case measurement of all parameters.

If the system is equipped with the Seamless Transfer option, press the SHIP'S POWER - CONVERTER **(9)** button on the Master cabinet to transfer power from the generator to the converter. The system will operate as per the description in Section 6.1.2.

6.3 AUTO-RESTART FEATURE

The Auto-Restart feature will safely and automatically bring the shore power converter back on-line following a power failure and recovery event. Highlights include:

- Automatically routes power from the dock to the ships power buss.
- Front panel controls allow auto-restart to be enabled or disabled.
- Auto-Restart status displayed on the LCD STATUS screen.
- Fault tolerant to guarantee safe operation.
- Valid shore power verified prior to restart.
- Handles repeated power failures without operator intervention.

- **LETHAL VOLTAGES ARE AUTOMATICALLY ROUTED WITHIN THE CONVERTER WHEN (1) INPUT POWER IS PRESENT, (2) THE DISCONNECT SWITCH IS IN THE "ON" POSITION, AND (3) AUTO-RESTART IS ENABLED.**
- **LETHAL VOLTAGES WILL BE AUTOMATICALLY ROUTED TO THE CONVERTER OUTPUT AND THE OUTPUT CONTACTOR WILL AUTOMATICALLY CLOSE WHEN (1) INPUT POWER IS PRESENT, (2) THE DISCONNECT SWITCH IS IN THE "ON" POSITION, AND (3) AUTO-RESTART IS ENABLED.**
- **NEVER REMOVE ANY PANELS OR COVERS WITHOUT SECURING (REMOVING) SHORE POWER WHEN AUTO-RESTART IS ENABLED.**
- **NEVER PERFORM MAINTENANCE OR SERVICE WHILE AUTO-RESTART IS ENABLED.**
- **NEVER ASSUME AUTO-RESTART IS DISABLED.**
- **NEVER USER THE DISCONNECT SWITCH TO TURN THE CONVERTER OFF WITH AUTO-RESTART ENABLED. THE CONVERTER CANNOT DISTINGUISH BETWEEN A VALID POWER FAILURE AND IMPROPER USE OF THE DISCONNECT SWITCH.**

6.3 AUTO-RESTART FEATURE, cont.

6.3.1 Operation

Auto-Restart must be enabled from the converter front panel by simultaneously pressing two buttons. Anytime the system status is "FAILURE," the converter will disable the Auto-Restart feature. The converter must be ON and ONLINE before Auto-Restart may be enabled. Pressing the SYSTEM STATUS button **(5)** will display the SUMMARY DISPLAY which will indicate the Auto-Restart status.

CONVERTER ACTION	FRONT PANEL OPERATION
Enable Auto-Restart	CONVERTER POWER **(4)** & F1 **(13)**
Disable Auto-Restart	CONVERTER POWER **(4)** & F2 **(13)**

6.4 TURN-OFF PROCEDURE

6.4.1 Systems Not Equipped With The Seamless Transfer Option

Transfer power from the converter to the generator. This must be performed in a "break-before-make" method. That is to say that at no time can the generator(s) and shore power converter be operated in parallel.

Disable the Auto-Restart feature if enabled.

Press the CONVERTER POWER OFF **(11)** button. The red Converter Power OFF indicator LED **(11A)** should now be lit. If the SUMMARY DISPLAY is active, it should indicate CONVERTER: OFFLINE. Power has now been removed from the output, but the system remains active. The system is now in the "standby" state.

Next press the SHORE POWER OFF **(10)** button. The red Shore Power indicator LED **(10A)** should now be lit. This will initiate the inverter shutdown. The system will complete the shutdown process within 10 seconds.

Turn the Disconnect Switch **(14)** to the OFF position. Open the shore power (input) circuit breaker or switch to the converter.

The converter is now shut down.

6.4.2 Systems Equipped With The Seamless Transfer Option

The generator must be started and be prepared to accept the ship's electrical loads.

Measure the generator voltage using the converter's metering display, selecting the GENERATOR POWER **(3)** function. The voltage and frequency must be the same as the converter's output in order for the seamless transfer option to successfully transfer power. The SHORE POWER LED **(7A)** must be lit at this time.

When the generator is ready to accept the ship's loads, press the SHIP'S POWER - GENERATOR button **(12)**. In dual-generator installations, a display will appear requesting that the appropriate generator be selected via the F1 and F2 **(13)** buttons. In single-generator installations, the transfer will proceed. The converter will match the generator in frequency, voltage, and phase over a several second period. When the power forms are matched, the converter will close the generator circuit breaker, then open the converter output contactor, with both briefly operating in parallel. The SHIP'S POWER - CONVERTER LED **(9A)** should now be off, and the SHIP'S POWER - GENERATOR LED **(12A)** should now be lit.

With the ship's loads now being serviced by the generator, the converter may be shut down. Press the CONVERTER POWER OFF button **(11)**. The red OFF LED **(11A)** should now be lit. The converter is now in the standby state.

Next press the SHORE POWER OFF button **(10)**. The red OFF LED **(10A)** should now be lit, and the converter will begin an orderly shutdown. The complete shutdown process will take about 10 seconds. The converter power metering display, if observed during the process, will indicate a slow decay in the output voltage to zero. Rotate the disconnect switch **(14)** to the OFF position. The system is now off and power can be removed from the equipment.

6.5 REMOTE COMMUNICATIONS

The converter can be controlled remotely and be queried for alarm, electrical, and status data through its RS-232C port. The port's hardware configuration is by default RS-232C unless modified by the inclusion of the Modbus Option—which converts the default hardware protocol to the RS-485 standard via a din-rail mounted converter/optical-isolator.

The two software protocols supported by the converter are SCPI and Modbus. Please contact an ASEA Power Systems authorized distributor or the factory for additional information and comprehensive command/query listings.

The Baud Rate and fixed serial port settings can be viewed in the REMOTE INTERFACE CONFIGURATION DISPLAY (as depicted below) by pressing the SYSTEM STATUS **(5)** and F3 **(13)** buttons simultaneously. The software protocol in use is indicated in the lower-right corner (SCPI or Modbus). The software protocol is auto-detected by the converter based on the incoming command/query formatting.

```
     REMOTE INTERFACE CONFIGURATION
BAUD: 19000   8-DATA BITS,1 START,1 STOP
PARITY: NONE    EOS: CR/LF  DEVICE:  DCE
HANDSHAKING: NONE                   SCPI
```

```
     REMOTE INTERFACE CONFIGURATION
BAUD: 19000   8-DATA BITS,1 START,1 STOP
PARITY: NONE    Node Id: 3  DEVICE:  DCE
HANDSHAKING: NONE                 Modbus
```

The Baud Rate can be increased by pressing the F1 **(13)** button, and decreased by pressing the F2 **(13)** button. Press the F3 **(13)** button to change the Node Id while the software protocol is set for Modbus mode. Press the F4 **(13)** button to manually move between the SCPI and Modbus modes.

Press the SYSTEM STATUS **(5)** button to save settings and exit.

Standard baud rates are 1200, 2400, 4800, 9600, 19200, and 38400 where 19200 is the standard for communication with ASEA Power Systems Touch Screens.

6.5 REMOTE COMMUNICATIONS, cont.

6.5.1 RS-232C/SCPI

The RS-232C serial port is located in the upper-left corner of the Input/Output connection panel (see Figure 5 on page 22).

The RS-232C TxD signal originating in the converter is approximately +15V when "High" and -15V when "Low." The RS-232C GND (ground) wire is connected to the low voltage DC common of the converter power supply system, which is normally also connected to the chassis-ground of the converter. When the Metering Isolation Option is installed in the converter, the link to the chassis ground is removed.

The RS-232C serial port is a DE9S (female, 9-pin D-subminiature connector). The pinout of the connector is standard for an RS-232C DCE. Figure 7 below demonstrates connection from a DCE to a DTE. Use of a shielded, jacketed, four-wire (two twisted pairs), color-coded cable for each converter in the system is required.

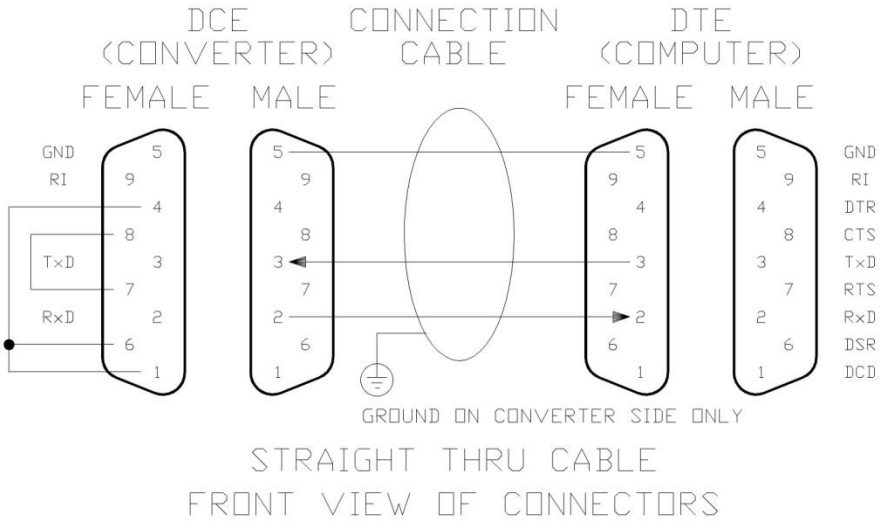


FIGURE 7 RS-232C PINOUT

It is strongly recommended that an RS-232C optical isolation be included in any RS-232C/SCPI protocol integration to avoid the creation of ground-loops and ground-fault paths through the remote communication port; such isolation is not included with the standard product.

6.5 REMOTE COMMUNICATIONS, cont.

6.5.2 RS-485/Modbus

If included in the converter, a Modbus Option converter/optical-isolator will be located adjacent to the RS-232C serial port (see Figure 5 on page 22).

The Modbus Option included converter/optical-isolator connections are depicted in Figure 8 below.

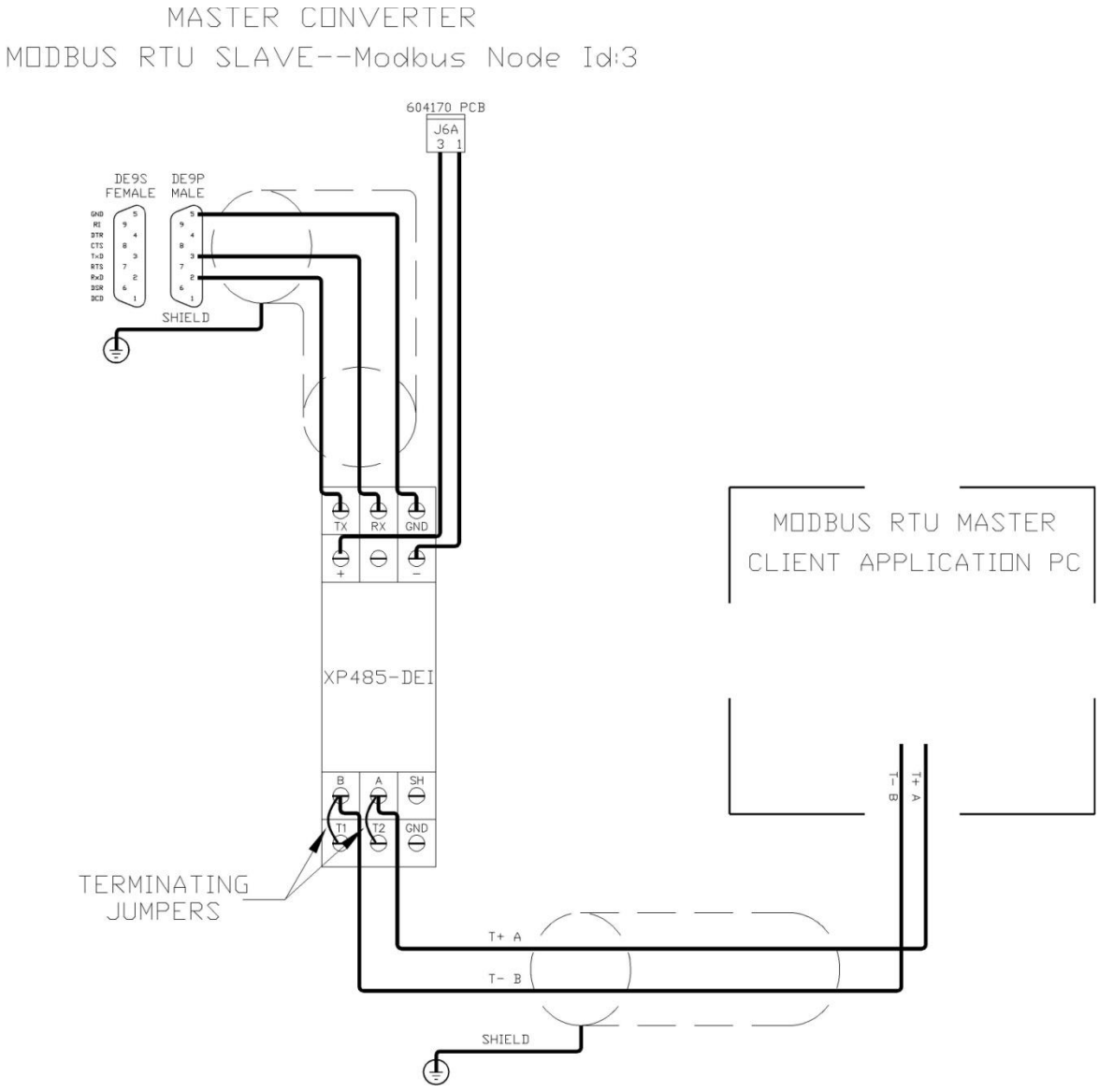


FIGURE 8 RS-485 CONNECTIONS

6.5 REMOTE COMMUNICATIONS, cont.

6.5.2 RS-485/Modbus, cont.

All wiring between the converter's RS-232C port and the Modbus Option converter/optical-isolator is included and wired at the factory. RS-485 bus wiring between a master converter and slave converter(s) and ultimately to the customer side connections is the responsibility of the customer. Such wiring should be shielded as depicted in Figure 8 on the previous page.

Each converter/optical-isolator contains terminating jumpers used to link the T1 and T2 terminals to the B and A terminals, respectively, and provide internal terminating resistances. Install such jumpers as indicated in Figure 8 at the first and last device in daisy-chained RS-485 bus, but remove the jumpers for any intermediately connected devices.

A master converter's Node Id is factory set for 3; a slave converter's is set for 4. These are the default values for communication with ASEA Power Systems designed Touch Panel computers. Additional slave converters can be set for Node Id numbers greater than 4 (5-8 recommended). As ASEA Power Systems uses Node Id numbers 9-13 for GMM products, use of these should be avoided.

7 SOFTWARE FEATURES

7.1 GENERAL

ASEA Power Systems' shore power converters provide a variety of software-based resources. Each major function is described in detail in the following pages.

BOLD upper-case text indicates when a display button is being referenced. Where two buttons are given as **BUTTON + BUTTON**, the buttons must be pressed simultaneously.

7.2 LOAD MANAGEMENT

ASEA Power Systems' shore power converters now provide a comprehensive Load Management System. Additionally, paralleled shore power converters now provide a Load Sharing system that manages the use of different capacity shore cords. The various features are discussed in detail below.

Shore Cord Alarm

The Shore Cord Alarm drives the Voltage Droop and Automatic Transfer to Generator features of the Load Management System. The user selects a percentage between 50% and 100% at which to begin alarming. This feature may be enabled or disabled by the user.

Shore Cord Setup

The actual shore cord amperage is selected by the user from a table of available, international shore cord sizes. This selection causes the converter to now display load level and alarm based on the true available shore cord energy. The new, actual converter capacity (if less than the converter’s capacity) is displayed for reference.

7.2 LOAD MANAGEMENT, cont.

Load Sharing

The slave converter of a paralleled converter system can be forced to draw less current than the master converter, if attached to a shore cord with lesser available power due to lower amperage, lower voltage, or different form (i.e. 1-Phase vs. 3-Phase). This is accomplished via Load Sharing which causes a sharing ratio between the converters identical to the ratio between the two shore cords (up 2:1).

Voltage Droop

If the yacht's electrical system does not include a power management system that allows for automatic load-shed, the converter's Voltage Droop feature may be used to save up to 10% capacity by reducing the converter output voltage up to 5% (1% to 5% range). This feature may be enabled or disabled by the user and droops upon Shore Cord Alarm.

Automatic Transfer to Generator

The converter system may be set to automatically transfer to generator (assuming the existence of the Seamless Transfer Option) upon Shore Cord Alarm. The Automatic Transfer would only occur after the Voltage Droop had taken effect if both were enabled. This feature may be enabled or disabled by the user. A signal generated by the converter may be used to start the selected generator. Also, a programmable warm-up delay is available.

7.3 LOAD MANAGEMENT OPERATION

7.3.1 **Shore Cord Alarm**, Single, Master, and Slave converters

If the yacht's electrical system includes a power management or load-shed feature, the Shore Cord Alarm can be used to effect a change in loading when the converter reaches a programmed load threshold, or simply draw the yacht engineer's attention.

The Shore Cord Alarm drives a relay's normally open contact pair that is provided at a terminal block near the converter's Shore Power Input terminal block. The contact pair is rated for 8A @ 250VAC or 5A @ 24VDC.

From the front panel, press the **SHORE POWER** + **F2** buttons to access the following screen (The DROOP and TRANSFER choices do not apply to a Slave converter):

```
     LOAD MANAGEMENT CONFIGURATION
SHORE CORD RATING = 100 AMPS
ALARM AT 100% OF RATING, ALARM ENABLED
Cord    Droop  Transfer  Cursor   Exit
```

The Shore Cord Alarm may be Enabled on both the Master and Slave Converters. An alarm signal will be issued whenever the Alarm is enabled and the converter's input current equals or exceeds the Alarm Level (percentage) of the shore cord Rating. Note that the Alarm MUST be Enabled for the Droop and/or Automatic Transfer to Generator features to function. Press Cord (**F1**) for the Shore Cord Setup screen, Droop (**F2**) for the Voltage Droop screen, Transfer (**F3**) for the Automatic Transfer to Generator screen, Cursor (**F4**) to move the cursor between the ALARM AT % and ALARM enable settings, and Exit (**F5**) to save the settings and exit the screen. When the cursor is on the ALARM AT % or ALARM enable settings, the Cord/Droop buttons will change to More/Less and Enable/Disable respectively to allow for setting adjustment.

	Default	Range	Units
ALARM AT %	100%	50 - 100%	% of cord capacity
ALARM enable	DISABLED	Disabled, Enabled	

SHORE CORD RATING is displayed for reference and adjusted in the Shore Cord Setup screen.

7.3 LOAD MANAGEMENT OPERATION, cont.

7.3.2 **Shore Cord Setup**, Single, Master, or Slave Converters

The Shore Cord Setup screen is used to set the actual shore cord ampacity based on the marina's dock or pedestal circuit breaker. The converter's new, programmed CONV. CAPACITY is then displayed for reference. The converter's Load Level and Power indicators for Shore Power and Converter Power will then display the actual converter capacity usage based on the programmed CONV. CAPACITY.

It is important to understand that this is an indication device, and affects reporting and alarming only. The peak and average overload capabilities are not affected by this setting. Dynamic response to loading and equipment startup surges is unaffected. The intent here is to prevent tripping of dockside circuit breakers by average loading when a smaller than desired shore supply is used.

From the front panel, press the **SHORE POWER** + **F2** buttons, and then Cord (**F1**) to access the following screen:

```
SHORE CORD SETUP   CONV.CAPACITY:36.0kVA
MASTER CORD CAPACITY: 100 Amps
VOLTAGE: 208 Vac, FORM: 3Ø, Freq.: 60Hz
 More    Less                      Exit
```

Press More (**F1**) or Less (**F2**) to adjust the MASTER CORD CAPACITY, and Exit (**F5**) to save the settings and exit the screen.

	Default	Range	Units
CONV. CAPACITY	true capacity	based on cord capacity, voltage, and form	kVA
CORD CAPACITY	250	30, 32, 50, 60, 63, 100, 125, 150, 200, 250	Amps

The CONV. CAPACITY is calculated as: $V_{L\text{-}L} \cdot A \cdot \sqrt{3}$ and is never greater than the converter's actual rating if the shore supply size has a greater capacity than the converter.

7.3 LOAD MANAGEMENT OPERATION, cont.

7.3.3 **Load Sharing**, Slave converters with Shore Cord Management Option

The function of this special Slave converter screen includes those functions of the normal Shore Cord Setup screen described on the previous page with one addition: Load Sharing between the two converters of a paralleled converter system is controlled by entering the MASTER CAPACITY here.

The slave converter of a paralleled converter system can be forced to draw less current than the master converter, if connected to a shore supply with lesser available power due to lower amperage, lower voltage, or a different form (e.g. 1-Phase vs. 3-Phase). The ratio between the two shore cords can be up to 2:1. Further difference will continue to be handled at the maximum 2:1 ratio. The Slave converter MUST always have the smaller of the two shore supplies. This way, peak demands that could possibly trip the Master's dockside circuit breaker, which would shutdown the paralleled set, would trip the Slave's dockside circuit breaker instead preserving Master converter operation. Load Sharing output impedance will take precedence over the Slave's programmable Converter Output Impedance Control settings if used in a manual adjustment mode.

For example, a Master converter connected to a 120/208Vac, 100A, 3-Phase shore supply has an available capacity of 36kVA. A Slave converter connected to a 240Vac, 100A, 1-Phase shore supply has an available capacity of 24kVA. By programming this information into the converters, the slave will then share at a 1.5:1 ratio using its true available capacity at the same rate that the Master converter uses its available capacity. Using this method, the Slave converter would not trip the dockside breaker when the converter system power exceeds 48kVA. Instead, the paralleled set can draw the full 60kVA available from the two shore supplies.

7.3 LOAD MANAGEMENT OPERATION, cont.

7.3.3 Load Sharing, Slave converters with Shore Cord Management Option, cont.

From the front panel, press the **SHORE POWER** + **F2** buttons, and then Cord (**F1**) to access the following screen:

```
LOAD SHARING     MASTER CAPACITY:36.0kVA
SLAVE CORD CAPACITY: 100 Amps -> 24.0kVA
VOLTAGE: 240 Vac, FORM: 1Ø, Freq.: 60Hz
 More    Less     Forward   Back   Exit
```

Press More (**F1**) or Less (**F2**) to adjust the MASTER CAPACITY and SLAVE CORD CAPACITY, Forward (**F3**) to advance the cursor to the SLAVE CORD CAPACITY, Back (**F4**) to advance the cursor to the MASTER CAPACITY, and Exit (**F5**) to save the settings and exit the screen.

	Default	Range
MASTER CAPACITY	Slave's max. rating	5kVA - Slave's max. rating
SLAVE CORD CAPACITY	250	30, 32, 50, 60, 63, 100, 125, 150, 200, 250

7.3 LOAD MANAGEMENT OPERATION, cont.

7.3.4 **Voltage Droop**, Single or Master Converters

Upon Shore Alarm, the Voltage Droop feature may be used to save up to 10% converter capacity by reducing the converter output voltage up to 5%. This is offered as a solution where the yacht does not already have power management and load-shed capabilities that can be triggered with the Shore Cord Alarm signal. A recovery time is provided so that the system does not alarm and droop in an oscillatory manner as the load level moves above and below the alarm threshold. 30 minutes is the default setting and can be adjusted as appropriate to the yacht's conditions. This recovery time is the time the droop will remain in place, regardless of alarm or load level, until returning to the nominal converter output voltage. Voltage Droop will take precedence over Programmable Output Voltage settings if used.

From the front panel, press the **SHORE POWER** + **F2** buttons, and then Droop (**F2**) to access the following screen:

```
     LOAD MANAGEMENT DROOP CONTROL
Droop  5% of Vout at Shore Cord Alarm
Droop: DISABLED, Recovery in 30 minutes
More    Less    Forward   Back    Exit
```

Press the **F1** or **F2** buttons to adjust the DROOP %, DROOP enable, and Recovery settings; Forward (**F3**) to advance the cursor through the three settings; Back (**F4**) to return the cursor through the three settings, and Exit (**F5**) to save the settings and exit the screen. When the cursor is on the DROOP % or Recovery settings, the **F1**/**F2** buttons will read More/Less. When the cursor is on the DROOP enable setting, the **F1**/**F2** buttons will read Enable/Disable.

	Default	Range	Units
DROOP %	5%	1 - 5% in 1% increments	% of Vout
DROOP enable	DISABLED	DISABLED/ENABLED	
Recovery	30 minutes	1 - 60 min in 1 min incrementminutes	

7.3 LOAD MANAGEMENT OPERATION, cont.

7.3.5 **Automatic Transfer to Generator**, Single or Master Converters (Seamless Transfer installed)

Upon Shore Alarm, the Automatic Transfer to Generator feature may be used to perform a Seamless Transfer to a pre-selected generator. This implies connection and setting of the Generator Autostart Control feature (needed to signal a generator to start and hold the set warm-up time before transferring). The transfer is not initiated until Voltage Droop has occurred as the load savings afforded may have taken the converter out of Shore Cord Alarm.

From the front panel, press the **SHORE POWER** + **F2** buttons, and then Transfer (**F3**) to access the following screen:

```
      TRANSFER ON OVERLOAD CONTROL
 Feature: Disabled, Select Genset: 1

Enable  Disable  Forward   Back    Exit
```

Press the **F1** or **F2** buttons to adjust the Feature or Select Genset settings; Forward (**F3**) to advance the cursor to the Select Genset setting; Back (**F4**) to return the cursor to the Feature setting, and Exit (**F5**) to save the settings and exit the screen. When the cursor is on the Feature setting, the **F1**/**F2** buttons will read Enable/Disable. When the cursor is on the Select Genset setting, the **F1**/**F2** buttons will read More/Less.

	Default	Range
Feature	DISABLED	DISABLED/ENABLED
Genset		1 - 4

7.3 LOAD MANAGEMENT OPERATION, cont.

7.3.6 Quick Setup of Shore Cord Alarm, Single, Master, or Slave Converters

1. Turn on the red Disconnect switch of both converters and wait 15-20 seconds for initialization.
2. Press the **SHORE POWER** + **F2** buttons on both converters.
3. Press the Cursor (**F4**) button to advance to the ALARM AT % setting.
4. Set the converter ALARM AT % using the More/Less (**F1**/**F2**) buttons.
5. Press the Cursor (**F4**) button to advance to the ALARM enable setting.
6. Set the converter ALARM enable using the Enable/Disable (**F1**/**F2**) buttons.
7. Press the Exit (**F5**) button to save the settings and exit.
8. Turn on the converters and place online as usual. Alarm will occur when loading reaches the ALARM AT % setting.

Quick Setup of Load Sharing, paralleled Converters

1. Turn on the red Disconnect switch of both converters and wait 15-20 seconds for initialization.
2. Press the **SHORE POWER** + **F2** buttons on both converters.
3. Press CORD (**F1**) on both converters.
4. Set the Master's SHORE CORD AMPACITY in amps using the More/Less (**F1**/**F2**) buttons.
5. Set the Slave's MASTER CAPACITY in kVA (read from the Master's Shore Cord Setup screen) using the More/Less (**F1**/**F2**) buttons.
6. Advance to the Slave's SLAVE CORD AMPACITY using the Forward (**F3**) button and set the amps using the More/Less (**F1**/**F2**) buttons.
7. Press the Exit (**F5**) button twice on both converters to save the settings and exit.
8. Turn on the converters and place online as usual, and verify an imbalanced share in Load Level % or individual Converter Output Amps at a ratio approximate to that ratio between the converter's programmed capacities.

7.3 LOAD MANAGEMENT OPERATION, cont.

7.3.7 **Expert Load Sharing Use**, Paralleled Converters

The Load Sharing system described in this document has been programmed for simple use and comprehensive gathering of all pertinent data into a few, simple screens. However, the controls can be bypassed and Load Sharing implemented by the user directly via the Slave's programmable Converter Output Impedance Control. At the users discretion, Load Sharing may be implemented with smaller cords connected to the Master than the Slave converter as well as the reverse, or at ratios somewhat larger than those implemented in the Load Sharing system. This can be accomplished via manual adjustment of the Slave converter's Converter Output Impedance Control or integrated using RS-232C serial commands.

Please contact the factory regarding this feature and we will be happy to instruct the user in this matter.

7.4 GENERATOR FREQUENCY ANALYSIS

Press the **SYSTEM STATUS + GENERATOR POWER** buttons to access the Generator Frequency Analysis Display. Used for observing lifetime generator frequency range.

```
  GENERATOR FREQUENCY ANALYSIS DISPLAY
Generator MIN Frequency:  XX.XXHz
Generator MAX Frequency:  XX.XXHz
Refresh                          Exit
```

7.5 CONVERTER OUTPUT IMPEDANCE CONTROL

Press the **SHORE POWER + F3** (Master converter) buttons to access the CONVERTER OUTPUT IMPEDANCE CONTROL display.

```
   CONVERTER OUTPUT IMPEDANCE CONTROL
Nominal Impedance (Zo)  Duty Cycle:  50
Transfer Impedance      Duty Cycle: 100%
 More    Less    Forward   Back    Exit
```

Press the More **(F1)** button to increase the setting, the Less **(F2)** button to decrease the setting, the Forward **(F3)** button to advance to the Transfer Impedance setting, the Back **(F4)** button to return to the Nominal Impedance setting, and the Exit **(F5)** button to save the settings and exit.

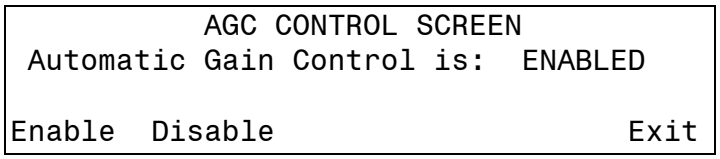
	Default	Range	Increments
Nominal Impedance Duty Cycle	50%	0 - 100%	1%
Transfer Impedance Duty Cycle	100%	0 - 100%	1%

Application: if loading-based, line-drop losses in a yacht are such that locations remote of the converter and Ship's Bus experience undesirable, lower-than-expected voltages, the Nominal Impedance Duty Cycle can be lowered via this control to increase output voltage. AGC (Automatic Gain Control-see page 49) must be disabled when using this function or the modified voltage level will be re-compensated by it. Initially, a small change (start with 5%) should be

used in conjunction with re-measurement at the remote location to determine the correction needed. Drastic changes in Duty Cycle will result in equally drastic voltage changes. Transfer Impedance is usually only modified by factory trained personnel when commissioning a converter. It can be used to fine-tune the Seamless Transfer function.

7.6 AGC CONTROL

Press the **SHORE POWER + F4** buttons to access the Automatic Gain Control (AGC) CONTROL display.



This function enables or disables AGC. Press the Enable **(F1)** button to enable the feature, the Disable **(F2)** button to disable the feature, and the Exit **(F5)** button to save the settings and exit.

	Default	Range
Automatic Gain Control	Enabled	Enabled, Disabled

Application: this function will compensate for changes in output voltage not already corrected by hardware and software calibration such as load-dependent output voltage variances. This function should be disabled before calibrating the hardware oscillator and current compensation pots on the Control PCB (usually only done when initially setting the output voltage configuration at the factory). It must be disabled when using Converter Output Impedance Control (see page 48).

7.7 kW-HOUR METER AND MAXIMUM POWER LEVEL DISPLAY

Press the **SHORE POWER + CONVERTER POWER** buttons to access the Automatic KW-HOUR METER and maximum power level display.

```
                KW-HOUR METER
kW-Hours:XXXXXXX.XX Run Time. XX:XX:XX:XX
 Max. Level: XXX.X%   Max. Power: XX.XXkW
  Clear                              Exit
```

Press the Clear **(F1)** button to clear all data and the Exit **(F5)** button to exit.

Application: this reference kW-hour meter can be used to check the billing received in a marina. Immediately after connecting shore power and turning the converter's red disconnect switch, clear the data in this screen. When ready to leave, take down the kW-hours and run time before disconnecting the shore power. Additionally, this screen can be used to diagnose converter shutdowns. Since the Max. Level and Max. Power data are updated with slow-response metering (approximately 1 second), only average use data are represented. Instantaneous motor-start surges and such will not be represented by the data. If the Max. Level exceeds 110%, and a shutdown of the Shore Power has occurred, it is very likely the average loading is exceeding the converter's capacity. The Max. Power is provided since Max. Level is affected by Shore Cord Setup settings.

7.8 CONVERTER OUTPUT VOLTAGE CONTROL

Press the **CONVERTER POWER + F5** buttons to access the CONVERTER OUTPUT VOLTAGE CONTROL display.

```
   CONVERTER OUTPUT VOLTAGE CONTROL
Vout = XXX.X

More    Less     XXXV             Exit
```

This function allows the user to increase or decrease the converter output voltage (Vout). Press the More **(F1)** button to increase the Vout, the Less **(F2)** button to decrease the Vout, the XXXV **(F3)** button to return Vout to the factory programmed setting, and the Exit **(F5)** button to save the setting and exit.

	Default	Range	Increments
Vout	factory prog. Voltage	+/-5%	0.5 volts

Application: if the line-drop losses in a yacht are such that locations remote of the converter and Ship's Bus experience undesirable, lower-than-expected voltages, the programmed Vout can be raised up to 5% via this function. Also, to decrease total power usage, the Vout could be reduced up to 5%. The new, programmed Vout will be used as the basis for AGC, Seamless Transfer, and all other voltage dependent functions.

7.9 EVENT LOG

Press the **EVENT LOG** (or **CALIBRATE** on older converters) button to access the EVENT LOG display.

```
        EVENT LOG CONTROL SCREEN
F1: EVENT LOG VIEWER        XXXX Events
F2: EVENT LOG TRACKER
F3: EVENT LOG REGISTRY
```

This is for monitoring internal converter logic operation. Press the **SYSTEM STATUS** button in any screen to exit.

Press the **F1** button to access the EVENT LOG VIEWER display.

```
            EVENT LOG VIEWER
XXX:XX:XX:XX:XX  ****START_LOG****
XXX:XX:XX:XX:XX
XXX:XX:XX:XX:XX
```

This is for reviewing all past events (1000 max.) since the log was last cleared. Press the **F1** button to scroll down (newer events). Press the **F2** button to scroll up (older events).

Press the **F2** button to access the EVENT LOG TRACKER display.

```
XXX:XX:XX:XX:XX
XXX:XX:XX:XX:XX
XXX:XX:XX:XX:XX
XXX:XX:XX:XX:XX
```

This is for reviewing events as they occur.

7.9 EVENT LOG, cont.

Press the **F3** button to access the EVENT LOG REGISTRY display.

```
        EVENT LOG REGISTRY
PRESS: 'SHORE POWER' to edit Registry,
The 'F1' for log On & 'F2' for log Off.
Press: 'F4' to CLEAR EVENT LOG.
```

This is for accessing the editing display and for clearing the log.

Press the **SHORE POWER** button to access the EVENT LOG REGISTRY edit display.

```
          EVENT LOG REGISTRY
Event Name:  Ev VOID             ID: 0
 Logging for the Event is : ON
Press: 'F4' to CLEAR EVENT LOG.
```

This is for editing which events are logged and clearing the log. Press the **F1** button to turn logging ON for the Event. Press the **F2** button to turn logging OFF for the Event.

Press the **F4** button to access the EVENT LOG REGISTRY CLEARED display.

```
        EVENT LOG REGISTRY
PRESS: 'SHORE POWER' to edit Registry,
The 'F1' for log On & 'F2' for log Off.
ALL EVENT LOG ENTRIES CLEARED.
```

8 TROUBLE-SHOOTING AND DIAGNOSTICS

8.1 COMMON PROBLEMS

When encountering difficulty in achieving successful operation of the converter, there are some problems which are easily identified and solved. The following list is not intended to be exhaustive.

SYMPTOM	POSSIBLE CAUSE/SUGGESTED ACTION
Upon initial power-up, the converter does not behave in accordance with the Section 6.1 description (no display, LEDs, or fans).	• Ensure dock power is available. Check pedestal and shore cord circuit breakers. • Have input power to the converter checked by a qualified electrician. • Have the power supply fuses located above the SHORE POWER connections checked by a qualified electrician. • Have the main power supply checked by a qualified electrician.
Upon initial power-up, no fan activity is heard or otherwise detected.	• Have the fan power supply checked by a qualified electrician.
The converter powers-up in accordance with the Section 6.1 description, but does not accept a SHORE POWER ON button press.	• Review SHORE POWER metering at the converter for a single (between the AØ and BØ inputs) or three phase input between 170-520VAC.
The converter does not accept a CONVERTER POWER ON button press.	• Review CONVERTER POWER metering at the converter for the correct and expected output voltages.
The converter does not accept a SHIP'S POWER CONVERTER or SHIP'S POWER GENERATOR button press (if the Seamless Transfer Option is present).	• Ensure that no active and un-cleared FAILURE or WARNING messages are present (press F1 and F2 simultaneously to clear).

8.2 FAILURE AND WARNING MESSAGES

The converter can display various FAILURE or WARNING messages under certain circumstances. If the event causing such as message has subsided, pressing buttons F1 **(13)** and F2 **(13)** simultaneously will clear the FAILURE or WARNING message. Common messages are:

D86 LVDC FAULT	(low voltage power fault, control or fan power supply)
INPUT_OVERLOAD	(input overload trip has occurred)
INPUT POWER CORRUPT	(control power to the computer has dropped out of range)
INV_X_OT	(the affected power module has exceeded its max. temp.)
T1_OT	(the input transformer has exceeded its max. temp.)

If either the D86 LVDC FAULT or INPUT POWER CORRUPT message appears and cannot be cleared, please turn the converter completely OFF using its red/yellow disconnect switch and contact an authorized service center or the factory for assistance. Leaving the red/yellow disconnect switch in the ON position with these messages present could cause further damage to the converter.

8.3 INFO DISPLAY

Pressing the F4 **(13)** button below the INFO field while in the SUMMARY DISPLAY (see Section 6.1 on page 26) will result in a message describing the reason that SHORE POWER is currently OFFLINE (or state that it is on-line). A list of all potential messages is given below (the messages are fairly self-explanatory):

```
CONVERTER SHUTDOWN INFO DISPLAY

INPUT is ONLINE
```

BLACKOUT OR RED-EMERGENCY SWITCH
DOCK POWER BROWNOUT SHUTDOWN
HVDC > 210 SHUTDOWN
INPUT is ONLINE
INPUT POWER FORM CHANGE SHUTDOWN
LOW-VOLTAGE DC SHUTDOWN
OVERLOAD SHUTDOWN
OVERTEMPERATURE SHUTDOWN
SHORE POWER OFF KEY PRESSED
REMOTE SHORE POWER OFF
REMOTE EMERGENCY POWER OFF

8.4 STATUS WORDS

To aid in system diagnostics, three STATUS WORDs have been provided in the STATUS WORD DISPLAY, which is accessed by pressing the SYSTEM STATUS **(5)** and F2 **(13)** buttons simultaneously. These STATUS WORDs contain information about internal logic levels and change dynamically in accordance with the converter's operational state.

```
BIT: FEDCBA9876543210        CON: XXXXXXXX
SW1: XXXXXXXXXXXXXXXX        STATUS1: XXXX
SW2: XXXXXXXXXXXXXXXX        STATUS2: XXXX
SW3: XXXXXXXXXXXXXXXX        STATUS3: XXXX
```

Each word is comprised of 16 digits—each indicating a separate internal logic term (see Figure 9 on the following page for a description of the individual bits). On the right-hand side of the STATUS WORD DISPLAY, the same information is given in HEX format. If reporting problems to an authorized service center or the factory, please use the HEX format (example... STATUS 1: DF85) to reduce the chance of transcription error.

8.5 GATHERING DATA

If a converter problem has occurred, carefully record any FAULT or WARNING messages, the contents of the INFO display, and the STATUS WORDs before removing power to the system. When calling an authorized service center or the factory for assistance, please have the above mentioned data and the converter model number, serial number, and software version ready.

8.6 SOFTWARE TOOLS

The EVENT LOG described in Section 7.9 on pages 55-56 can assist in determining the cause of unexpected behavior. Several software tools exist which can be downloaded from the aseapower.com website to aid in trouble-shooting—including an EVENT LOG VIEWER used to download the converter EVENT LOG for analysis. Contact an authorized service center or the factory for additional assistance with these tools.

8 DIAGNOSTICS, cont.

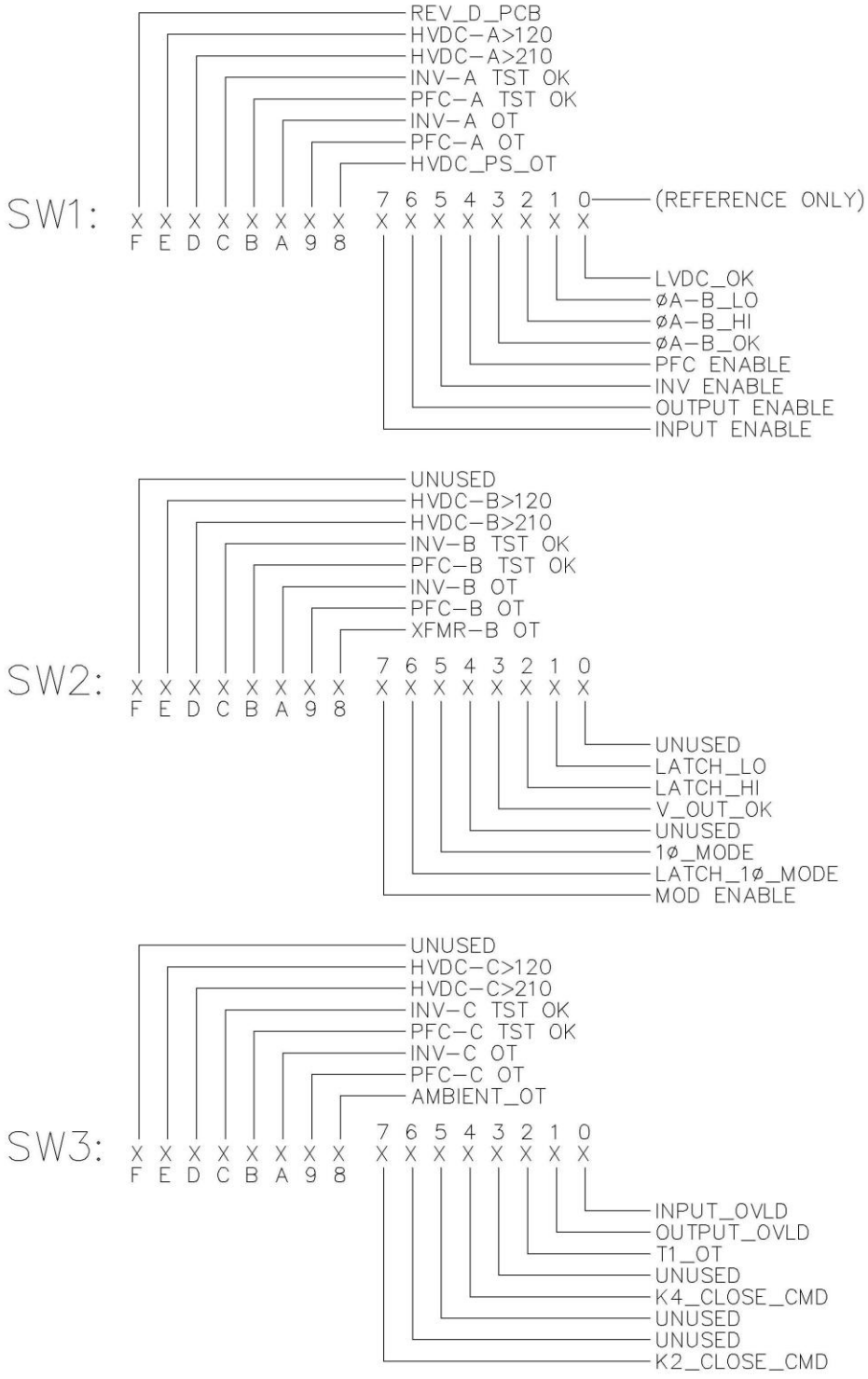


FIGURE 9 STATUS WORD BIT DEFINITIONS

9 CALIBRATION

In an uncalibrated state the input and output voltage and input current metering system should be within 5%. The uncalibrated output current meter is normally 10% low. For calibration an external reference voltmeter will be required along with a calibrated current transformer or probe. If the system is to be calibrated on board using the yacht's loads, attempt to shut down all transient (fluctuating) loads if possible. Cyclic loads will complicate the current meter calibration process.

This procedure must also be followed after replacing the battery on a maintenance basis

1) Turn the system off and secure input power. Remove the front cover.

2) Remove the lower front protective panel from the system, and set it aside. The input and output power terminal blocks will be located at the bottom of the power panel located in the lower compartment. Refer to the installation section of the Operations Manual for additional information. Re-apply power to the system and bring the system on-line. Transfer the yacht's load *(or external test load bank)* to the converter.

3) **Shore Power Calibration** - Press the **SHORE POWER** (2) button under the LCD (1) display. Use an external reference meter and current transformer or clamp to measure the input *(shore power*) power at the input terminal block. To enter the meter calibration screen, press and hold the **SHORE POWER** (2) button down for 7 seconds, or until the calibration display appears, then release the button. Use the **SHORE POWER** (2) button to move the cursor to the parameter to be calibrated, voltage or current. Change the selected parameter by pressing the **F1** button to increment and the **F2** button to decrement the displayed value. When all displayed values equal the values measured by the reference meter, pressing the **SYSTEM STATUS** (5) button will store the new calibration values and return the display to the System Status display. Press the **SHORE POWER** (2) button to verify proper shore power meter calibration.

4) **Converter Power Calibration** - The CONVERTER POWER calibration works in a fashion similar to the SHORE POWER calibration described above. Press and hold the **CONVERTER POWER** (4) button for 7 seconds, or until the converter power calibration display appears. Move the reference meter probes from the input to the output terminal blocks. Then use the **CONVERTER POWER** (4) button to move the cursor to the parameter to be calibrated. The **F1** button will increment the displayed value, the **F2** button will decrement it. Press the **SYSTEM STATUS** (5) button to exit the calibration function. Select the **CONVERTER POWER** (4) display to verify the calibration correction factors have been stored.

9 CALIBRATION, cont.

5) **Generator Power Calibration** - Use an external reference voltmeter to measure the generator voltage at the generator terminals located on TB12-1, 2, 3, 4. To enter the meter calibration screen, press and hold the **GENERATOR POWER** (3) button down for 7 seconds, or until the calibration display appears, then release the button. Use the **GENERATOR POWER** (3) button to move the cursor to the voltage phase to be calibrated. Calibrate the selected parameter by pressing the **F1** button to increment and the **F2** button to decrement the displayed value. When all displayed values equal the values measured by the reference meter, pressing the **SYSTEM STATUS** (5) button will store the new calibration values and return the display to the System Status display. Press the **GENERATOR POWER** (3) button to verify proper shore power meter calibration.

NOTE: Calibration of the Generator Metering Display is required only when the Seamless Transfer option is installed

10 MAINTENANCE

Due to the design and construction of the converter, preventative maintenance is held to a modest level. The following table lists minimum recommended tasks and frequency.

TASK	FREQUENCY	COMMENTS
Tighten electrical connections ⚠ WARNING ⚠	Every 6 months	Must be adjusted by the user based upon experience in the environment. Frequency will vary due to wire gauge, wire type, and applied vibration. **Refer to licensed electrician or factory authorized technician.**
CPU Battery replacement ⚠ WARNING ⚠	Every 3 years	May require greater frequency with elevated ambient temperature, or extended periods of non-operation. **Refer to factory authorized technician.**
Calibration ⚠ WARNING ⚠	Every year	May require additional calibration after battery replacement. Lack of calibration may result in a 5% decrease in metering and voltage programming accuracy. **Refer to factory authorized technician.**

11 INTERNATIONAL POWER FORM REFERENCE

Country	Frequency	Nominal Voltage	Comments
American Samoa	60Hz	120/240 277/480	
Antigua	60Hz	230/400	
Argentina	50Hz	220/380	
Aruba	60Hz	127/220 115/230	
Australia	50Hz	240/415 250/435	
Azores	50Hz	110/190 220/380	
Bahamas	60Hz	120/240 120/208	
Bahrain	50Hz 60Hz	230/400 110/220	
Balearic Islands	50Hz	127/220 220/380	
Barbados	50Hz	115/230 115/200	
Belgium	50Hz	220/380	
Belize	60Hz	110/220	

		250/440	
Benin	50Hz	220/380	
Bermuda	60Hz	120/240 120/208	
Brazil	60Hz	115/230 127/220 220/380	
Brunei	50Hz	240/415	
Bulgaria	50Hz	220/380	
Burma	50Hz	230/400	
Canada	60Hz	120/240 120/208 277/480	
Canary Islands	50Hz	127/220 220/380	
Cape Verde	50Hz	220/380	
Cayman Islands	60Hz	120/240 120/208	
Chile	50Hz	220/380	
China (PRC)	50Hz	220/380	
Columbia	60Hz	110/220 120/208 150/260	

Costa Rica	60Hz	120/240 120/208	
Cyprus	50Hz	240/415	
Denmark	50Hz	220/380	
Dominica	50Hz	230/400	
Dominican Republic	60Hz	120/240 120/208	
Ecuador	60Hz	120/240 120/208	
Fiji	50Hz	240/415	
Finland	50Hz	220/380	
France	50Hz	115/230 115/200 220/380	
Gibraltar	50Hz	240/415	
Greece	50Hz	220/380	
Greenland	50Hz	220/380	
Grenada	50Hz	230/400	
Guadelupe	50Hz	220/380	
Guam	60Hz	110/220 120/208	
Guatemala	60Hz	120/240	

		120/208	
Haiti	60Hz	110/220 120/208	
Honduras	60Hz	110/220 120/208	
Hong Kong	50Hz	220/380	
Ireland	50Hz	220/380	
Israel	50Hz	230/400	
Italy	50Hz	127/220 220/380	
Jamaica	50Hz	110/220	
Japan	50Hz 60Hz	100/200 100/200	
Korea	60Hz	110/220 220/380	
Kuwait	50Hz	240/415	
Madagascar	50Hz	127/220 220/380	
Malaysia	50hz	240/415	
Maldives	50Hz	230/400	
Malta	50Hz	240/415	
Martinique	50Hz	220/380	

Mauritius	50Hz	230/400	
Mexico	60Hz	127/220	
Monaco	50Hz	127/220 220/380	
Montserrat	60Hz	230/400	
Morocco	50Hz	127/220 220/380	
Netherlands	50Hz	220/380	
Netherlands Antilles	50Hz 60Hz	127/220 220/380 120/240	
New Caledonia	50Hz	220/380	
New Zealand	50Hz	230/400	
Norway	50Hz	230/400	
Panama	60Hz	110/220 120/208	
Philippines	60Hz	115/230	
Portugal	50Hz	220/380	
Puerto Rico	60Hz	120/240 120/208	
St. Kitts	60Hz	230/400	
St. Lucia	50Hz	240/415	

St. Vincent	50Hz	230/400	
Saudi Arabia	60Hz	127/220	
Seychelles	50Hz	240/415	
Sierra Leone	50Hz	230/400	
Singapore	50Hz	230/400	
South Africa	50Hz	220/380	
Spain	50Hz	127/220 220/380	
Sweden	50Hz	220/380	
Tahiti	60Hz	127/220	
Taiwan	60Hz	110/220 120/208	
Thailand	50Hz	220/380	
Togo	50Hz	127/220 220/380	
Trinidad	60Hz	115/230 230/400	
Tunisia	50Hz	127/220 220/380	
United Arab Emirates	50Hz	230/400	
United Kingdom	50Hz	240/415	

Uruguay	50Hz	220/380	
Venezuela	60Hz	120/240 120/208	
Amer. Virgin Islands	60Hz	120/240 120/208	

12 INDEX