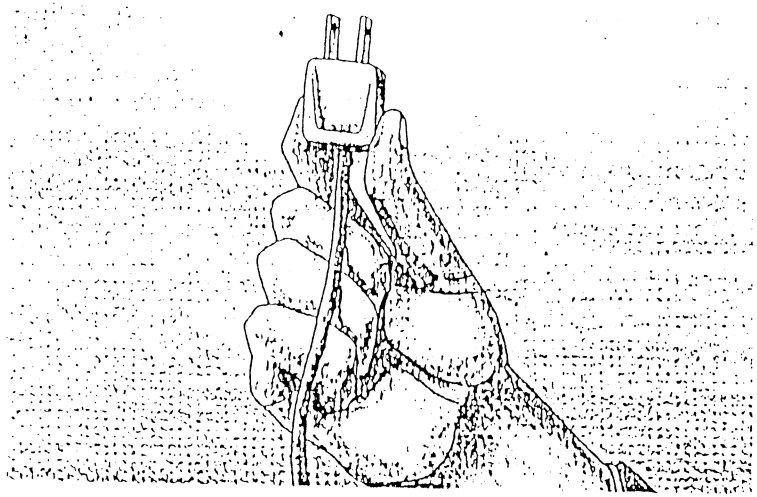

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POWER TECHNOLOGY BY heart interface

OWNER'S MANUAL

EMS

Energy Management System

Your Guide to
the Successful Installation and Operation
of your Heart Interface
Energy Management System

POWER TECHNOLOGY BY heart interface

HEART INTERFACE ENERGY MANAGEMENT SYSTEM

OWNERS MANUAL and INSTALLATION GUIDE

First Revision
May, 1991

heart interface

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Technical Communication
In Plain English

TABLE OF CONTENTS

TECHNICAL APPENDIX

INTRODUCTION

CONGRATULATIONS! You have purchased the finest mobile AC power system available. This manual describes the entire family of Heart Interface Energy Management Systems, including the EMS 1800 and the EMS 2800. These are available in 12, 24 and 32 volt systems. The general principles are the same for each member of the family, only the capacities and voltage values will change. Where these differences are important for use or installation, we will tell you in the discussion. Before you attempt to install your particular EMS, please read this manual thoroughly and completely. Taking a few minutes now with the manual can save you many hours of grief.

The Heart Interface EMS is designed to be installed and forgotten. It will give you many years of uncompromising service, but as with any sophisticated electronic equipment, you must respect its requirements. This manual will explain those demands and guide you through the following procedures:

1. Quick hook-up and check-out
2. Placement and Installation
3. Maintenance, and
4. Troubleshooting.

In addition, we have included a Technical Appendix which contains important information about your battery system. If you have not installed your battery bank yet, please stop and read this information. It will help you select the correct size, type and number of batteries for your needs. There is also a technical description of the EMS which will give you details on the design and operation of the EMS.

AN IMPORTANT NOTE ABOUT THIS MANUAL

NOTES WILL BE IN CAPITAL LETTERS, and will give you tips, and other special information on making the task at hand easier.

A caution will alert you to the possibility of equipment damage if the proper procedure is not followed. A caution will look like this:

CAUTION: A backfeed will damage the unit. This occurs when AC from shore power or generator is connected externally to the AC output of the EMS.

A warning will alert you to the possibility of personal injury if proper procedures are not followed. A warning will look like this:

DO NOT OPERATE THE EMS WITHOUT PROPER GROUNDING. THIS IS A SERIOUS SHOCK HAZARD.

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* WARNING * WARNING * WARNING * WARNING *

GETTING STARTED

Your Heart Interface Energy Management System (EMS) is a member of the most advanced line of mobile AC power systems available. It features a DC to AC power inverter, an electronically controlled 2-step battery charger, and automatic 30 amp transfer switching.

The Heart EMS is used in a wide range of applications, including remote homes, RVs, sail and power boats, and a host of industrial standby power installations. Its versatility is due to its unique combination of high power and precise regulation.

Your EMS will provide AC electric power from a variety of battery sources. It will charge the battery bank when connected to an AC power source such as shore power, a generator or standard household outlet. And it automatically switches between batteries and external power. In order to understand and control these functions effectively, you will need to get acquainted. So take everything out of the box and look all the pieces over. Take this opportunity to inspect for obvious damage from shipping or for missing parts.

In the box you will find the following:

1 EMS
This Owner's Manual
1 Warranty Registration Card
6 10 AWG Wire Terminals

In order to set up the EMS (both for the quick check out and for the installation) you will also need the following tools:

A VOM (electrical volt meter)
A medium-size flat blade screwdriver
A #1 Phillips screwdriver
A wire stripper/terminal crimping tool
Two AC power wires: 1 with male end (plug) and bare wires, and 1 with female end (socket) and bare wires.

You will also need appropriate wrenches for hooking up cables to your battery bank. (Your particular setup will determine these). And you will need certain other tools as dictated by your permanent installation site. Read the section on selecting an installation site before deciding which tools you will need.

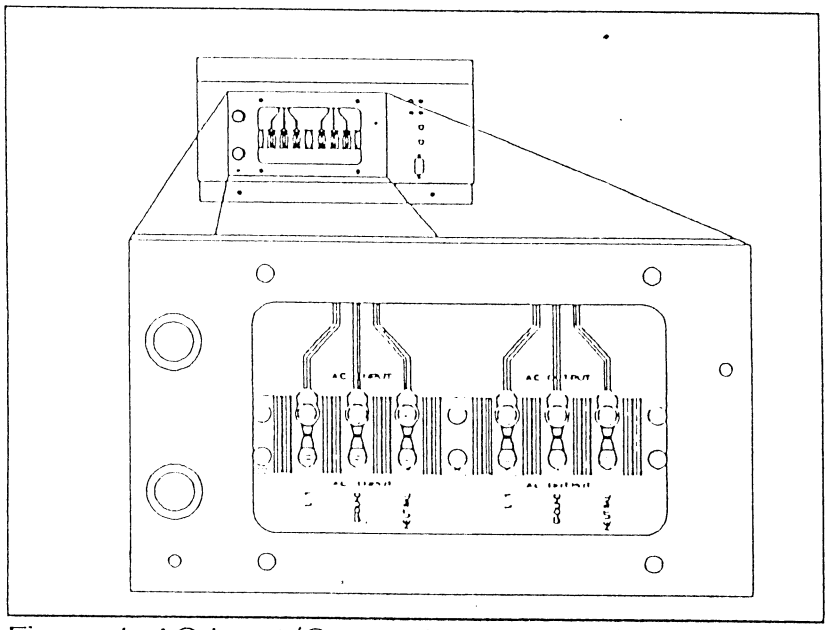

Figure 1 AC Input/Output Access Panel

For these connections, use wires suitable for at least 105 degrees C., and use #10 AWG stranded wire. See text for details.

QUICK HOOK-UP and TESTING

Quick Hook-up Procedure

If you would like to quickly hook up your unit and check its performance before you tackle your installation, please use the following procedure.

1. Unpack and inspect the EMS. Check to see that the power switch is in the off position.

2. Connect an 8 AWG stranded wire from the ground terminal on the rear of the unit to ground, such as a water pipe or the vehicle frame.

3. Use a screwdriver to remove the 4 screws that hold the access panel to the front panel of the unit. You will find the input/output terminal strip.

4. Prepare 2 AC cables; one for the input and one for the output. The input will have a plug on one end. The output will have an outlet. Install the 2 AC cables on the terminal strip: the one with the plug on one end goes on the AC input, the other, with an outlet on one end, goes on the AC output. The AC output and the AC input will feed up through the strain reliefs in the bottom of the unit. Feed the wires up through the strain reliefs and crimp a terminal on each wire. You may use the terminals included. These are designed for 10 AWG stranded wire.

4a. Refer to Figure 1 and connect the wires to the designated places on the terminal strip. Double check that they are connected correctly.

4b. Replace the access panel before turning on the EMS.

5. Use a volt meter to check the voltage of your battery bank. You must supply the correct battery voltage to the EMS. Because battery voltage is critical to the performance of your EMS, we strongly recommend that you own a simple volt meter.

CAUTION: It is extremely important to observe correct battery polarity when hooking up the EMS. Reverse polarity connection, even for an instant, will result in damage to the unit.

---

6. Securely connect the all black cable from the back of the EMS to the negative terminal of the battery bank.

NOTE: BECAUSE YOU CAN DRAW 165 AMPS AND MORE THROUGH THESE CABLES IT IS IMPORTANT, EVEN FOR A QUICK TEST, TO MAKE A SOLID CONNECTION.

7. Securely connect the cable with the red end from the EMS to the positive battery terminal. Current may flow momentarily when this connection is made and a small arc may occur. This is not cause for alarm, but take care not to make this connection in the presence of flammable fumes.

8. Turn the power switch on the front to the ON position.

You may now test the inverter by plugging an appliance into the outlet. The battery charger may be tested by turning the unit off, plugging the input into a 15 amp AC circuit and turning it back on.

IMPORTANT REMINDERS

Take care to observe correct polarity when connecting the batteries to the EMS. Double check the AC input and output connections. Reversing these can cause backfeeding. This occurs when an AC input is accidentally fed into the AC output of the unit. Backfeeding can result in damage.

Be sure to replace the access panel before activating the EMS. This will prevent electric shock hazard.

There is a BATTERY EQUALIZE switch on the front panel of the EMS. Do not depress this switch if you are using sealed, maintenance free batteries. If the switch is accidentally depressed, the equalizing cycle may stopped by disconnecting from AC power and reconnecting. This is discussed in detail below.

When the EMS is connected to any 120 volt AC input source, the battery charger is operational. This means that the DC output cables are energized whenever the unit is connected to incoming AC power. See the Battery Charger Operation section for more information.

The AC power transfer switch is always engaged even though the power switch is turned OFF. See the Inverter Operation section for important warnings and information.

Reading The LED Indicator Lights

The LED indicator lights will tell you nearly everything you need to know about the status and operational condition of your system. If the system shuts down, the lights will tell you why. The lights will give you battery status, and will tell you the status of your incoming AC power. When charging, the lights will indicate the rate of charge.

There are two normal conditions when power is available to your AC outlets: With and without AC input from outside the system (shore power). This is indicated by the LED marked "AC INPUT". If it is off, there is no AC coming into the system. If it is green, AC is being fed to your outlets from external power through the transfer switch. Any other condition is also told by this light.

If the AC INPUT LED is:	Then the status is:
Off	No AC input
Blinking Red	AC input present, reverse polarity, switchover and battery charger will not engage.
Steady Red	Proper AC input detected. Inverter still running, switchover and battery charger not yet engaged. Stays red for 8 seconds.
Green	Transfer switch engaged, AC input now feeding loads. Battery charger not yet fully engaged.
Yellow	AC input now feeding loads and battery charger fully engaged.
Blinking Green	Along with SHUTDOWN blinking green indicates that inverter was turned on into a backfeed.
Blinking Green and Yellow	With low battery red, this indicates the batteries are disconnected with external AC applied to the AC input.

(NOTE: THE YELLOW LED MAY APPEAR ORANGE IN COLOR.)

CAUTION: Simultaneous blinking green AC input and shutdown indicate a backfeed. Disconnect from AC input and correct backfeed.

If the system shuts down, the "SHUTDOWN" LED will tell you why by its color.

If the LED is:	then:
OFF	Normal operation
Green	Shutdown due to low battery voltage
Blinking Green	Shutdown due to an overload or short circuit. With AC input: Backfeed
Red	High temperature reached
Yellow	Shutdown due to high temperature

The status of the battery system and the charge rate is shown by the two LEDs marked BATTERY STATUS and CHARGE RATE. The battery status indicator is essentially a volt meter.

If the BATTERY STATUS indicator for your

	12 VOLT EMS	24 VOLT EMS	32 VOLT EMS
shows:	then the measured voltage range in the battery is:		
Green	Over 13 volts	Over 26 volts	Over 36.2 volts
Off	12.0-13.0	24.0-26.0	32.0-36.2
Yellow	10.2-12.0	20.4-24.0	27.2-32.0
Red	Below 10.2	Below 20.4	Below 27.2

The charge rate indicator is essentially an amp meter. When your EMS is charging the battery, the LED will tell you the charge rate.

If the CHARGE RATE LED is:	then the rate of charge is:
Off	0-10 amps
Green	10-20 amps
Yellow	20-30 amps
Red	Over 30 amps
Blinking	Equalization charge

INSTALLATION

Selecting an Installation Site

There are several considerations which go into selecting a location to mount your EMS. First is safety, but cable length, ventilation and cooling, and environmental conditions must also be considered.

This product should not be used in the presence of ignitable gases or in any other "Hazardous Location" as defined by the National Electric Code. If in doubt about a particular location, consult a qualified electrician before installing the product.

CAUTION: Do not mount the unit in an airtight compartment with the batteries. Batteries give off corrosive gas when being charged.

Although it is designed to be quite rugged, it is necessary to protect the EMS from the elements. Do not allow water to splash on the unit and avoid temperature extremes. The EMS will work best in an ambient air temperature between 30 and 104 degrees F. (-1 and 40 deg. C.).

The EMS may be mounted horizontally on a shelf or vertically on a wall. It is important that the EMS be secured to a flat surface that will allow air to flow under the unit. You should also provide for some air flow around the unit. This will insure adequate cooling when operating high powered loads.

It is best to locate the unit as close as practical to the batteries so as to keep the DC cables short. It is better to run longer AC wires than longer DC cables. If you must alter the cable length, use the same gauge cable as that provided. Do not exceed a 10 foot DC cable length, due to excessive voltage drop. See the battery connection and fusing section for more information.

If you have a remote control panel, keep in mind that the remote panel cannot be more than 40 feet from the unit. The standard cable length is 20 feet, and one (and only one) extension cable of 20 feet may be added. (See the Remote Panel discussion in the Operation section.)

The EMS is provided with mounting flanges to allow you to secure the unit. Keyhole shaped holes in the mounting flanges will facilitate mounting on a wall or bulkhead. When bolting the unit down, use 1/4 inch stainless steel bolts with lock washers. Tighten to 20-25 ft./lbs. of torque. You will notice that this compresses the rubber feet somewhat. This is intentional.

INSTALLATION PROCEDURES

For marine installations, all cable and wires used in these procedures should be stranded and should meet United States Coast Guard regulations. There are four major steps in the installation procedure. Each step is described and discussed below. Please read the entire procedure before beginning the installation.

FIRST: Connect the Ground.
SECOND:Connect the AC output.
THIRD: Connect the AC input.
LAST: Connect the battery bank.

Ground Connection

DO NOT OPERATE THE EMS WITHOUT PROPER GROUNDING. THIS IS A SERIOUS SHOCK HAZARD.

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* WARNING * WARNING * WARNING * WARNING *

You must begin the electrical installation by grounding the unit to either an earth ground (for non-mobile land installations), or the vehicle chassis (for RV installations) or the vessel's grounding system (for marine applications). On the back of the EMS you will find a connector labeled CHASSIS GROUND. This is for the purpose of connecting the chassis of the EMS to ground. You will also find an identical connector labeled EQUIPMENT GROUND. This is for connecting any equipment to the grounding system. The CHASSIS GROUND and EQUIPMENT GROUND are electrically bonded together. Use a green insulated 8 AWG stranded copper wire for your ground wire.

PROCEDURE:

1. Measure and cut the required length of ground wire for your particular application.

2. Remove 1/4 inch of insulation from one end of the ground wire and insert the bare copper wire into the hole in the ground connector. Use a flat blade screwdriver to tighten down on the connector. Be sure the connection is very solid.

3. Attach the other end of the green wire to the selected grounding location. This will vary depending on the installation.

Discussion

In a stationary installation you should connect the ground wire to an earth ground. This will be either a water pipe or a copper rod pounded into the ground or an existing ground rod.

In a vehicle, connect the wire to the vehicle chassis. Make sure the connection is electrically sound. Also make sure that your selected site is electrically attached to the chassis itself. Some metal parts on some vehicles are electrically isolated from the frame by rubber or plastic mountings.

In marine applications, you will connect to the existing AC grounding system.

The ground lugs in the electrical outlets of your AC system are connected to the ground (green) terminal of the AC terminal strip. (See Figure 1.) This is connected to the EMS chassis ground. This means that when you use an appliance with a standard 3 wire grounded plug with the EMS, the ground from the appliance is connected through the EMS to ground.

The neutral wire of the AC output of the inverter is also attached to ground in the unit. This means that when you connect the chassis to ground, you are also connecting the neutral leg to ground. Neutral is bonded to ground only when in the inverter mode. With the EMS, incoming AC neutral is not bonded to ground inside the unit. This allows the unit to be installed in Ground Fault Circuit Interrupter (GFCI) protected systems.

The battery cables from the EMS are not connected internally to the chassis. You may use the EMS in either a positive or negative ground system.

It is very important for safe operation that grounding be carefully done. Do not operate the EMS without the protection afforded by proper grounding of the chassis.

AC Output Connection

CAUTION: The AC connections must be made correctly to avoid damage. Follow the polarity instructions very carefully and ensure that each wire matches the color of the wire it joins at the terminal strip.

PROCEDURE:

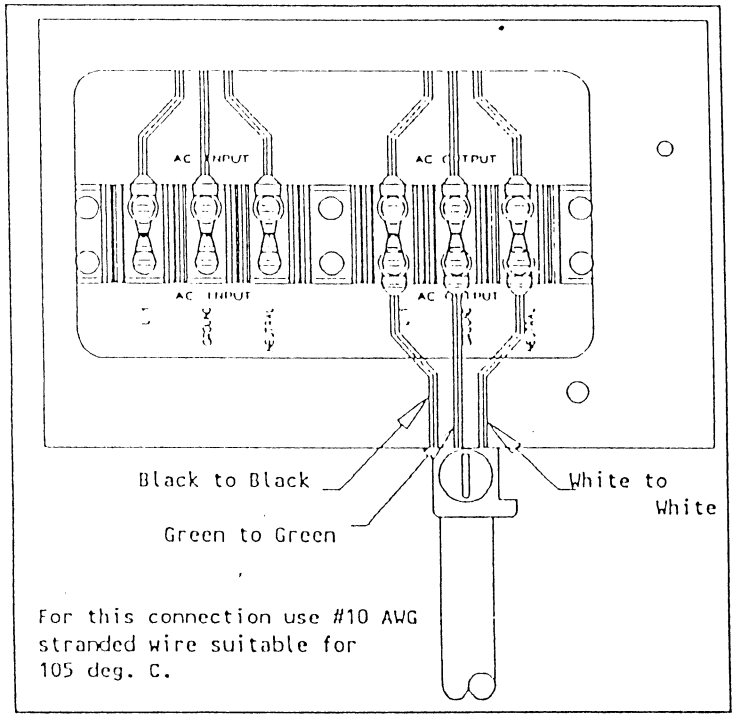

Figure 2 Wiring the AC Output

1. Use a screwdriver to remove the 4 screws that attach the access panel to the front of the unit.

2. Feed the AC output wire up through the strain relief on the right. This wire must be 10 AWG stranded.

3. Crimp one of the terminals included with the unit onto each wire and attach each wire to its corresponding terminal: Green to green, white to white and black to black.

4. Replace the access panel and securely tighten.

Discussion:

The strain reliefs supplied with the unit may not be appropriate for the wire you intend to use. Prior to feeding the AC wires through the hole in the bottom of the access, remove the strain reliefs and replace them with the proper type for your installation. Do not install the unit without the proper strain reliefs.

In order to conform to the National Electrical Code, certain branch circuits must be equipped with a Ground Fault Circuit Interrupter (GFCI). Any such branch circuit must be protected by a circuit breaker consistent with the GFCI rating.

AC Input Connection

The EMS incorporates a battery charger and an automatic 30 amp transfer switch. AC power is brought into the unit through the 30 amp circuit breaker on the front. Some of this power will go to the battery charger, up to 12 amps if the charger is putting out full power. The rest of the 30 amps is available at the AC output connection of the unit.

CAUTION: A backfeed will damage the unit. This occurs when AC from shore power or generator is connected externally to the AC output of the EMS.

PROCEDURE:

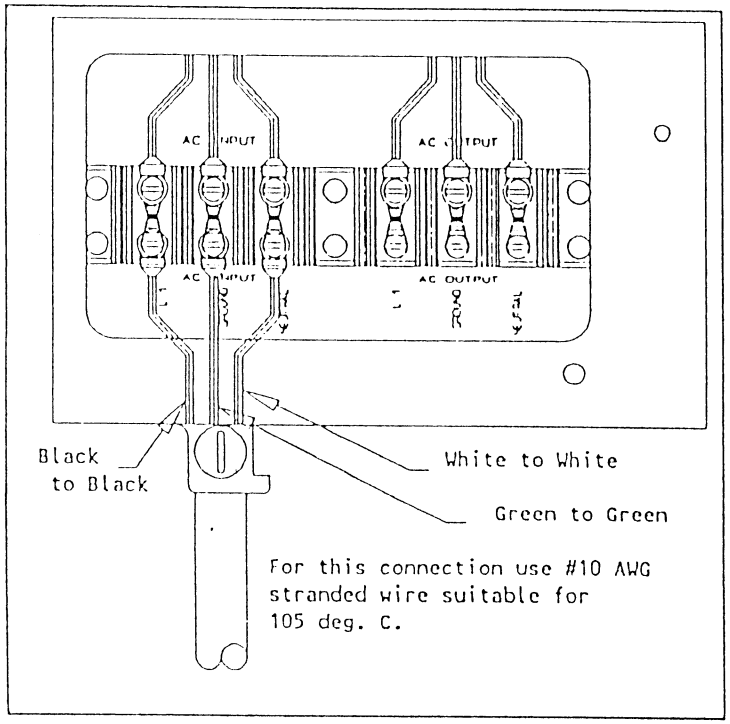

Figure 3 Wiring the AC Input

1. Feed the AC input wire up through the strain relief on the left. This wire must be 10 AWG stranded. Typically this wire will come from either shore power, a generator, or a transfer switch between shore power and generator.

2. Crimp one of the terminals included with the unit onto each wire and attach each wire to its corresponding terminal: Green to green, white to white and black to black.

3. Tighten the strain reliefs to secure all wires.

4. Replace the access panel and securely tighten the four screws.

Battery Connection and Fusing

Prior to performing this procedure, you should be familiar with parallel and series hook-ups. The basics of these concepts are described below, and more detail is given in the appendix.

CAUTION: Do not arrange batteries in a configuration that will exceed the rated input voltage of your EMS.

CAUTION: Connecting the EMS to the batteries with reverse polarity, even for an instant, can cause damage. Ensure correct polarity before connecting the DC lines.

Battery Connections

Your EMS is supplied with two battery cables, each 36" in length. Both cables are black, but the positive (+) cable has a red end. If you need to extend the cables beyond 36", you must extend the cables supplied with an identical gauge (size) stranded cables of up to 7 feet. Again, do not exceed 10 feet of battery cable, as you will incur excessive voltage drop. You must be absolutely certain to maintain correct polarity when changing to a longer cable. Always install a red cable or a red cable end marker on the positive (+) cable. Typical battery bank configuration diagrams are found in the battery section of the Technical Appendix.

Fusing

Some members of the EMS family may be UL listed as indicated by the UL mark on the unit. Underwriters' Lab listing may be as a marine power inverter or as a recreational vehicle power inverter. The listings for each application are nullified if installation is not accompanied by appropriate battery fusing, as per 33 CFR-183.460 for marine applications, and as per NEC 551-51(e) for RV applications.

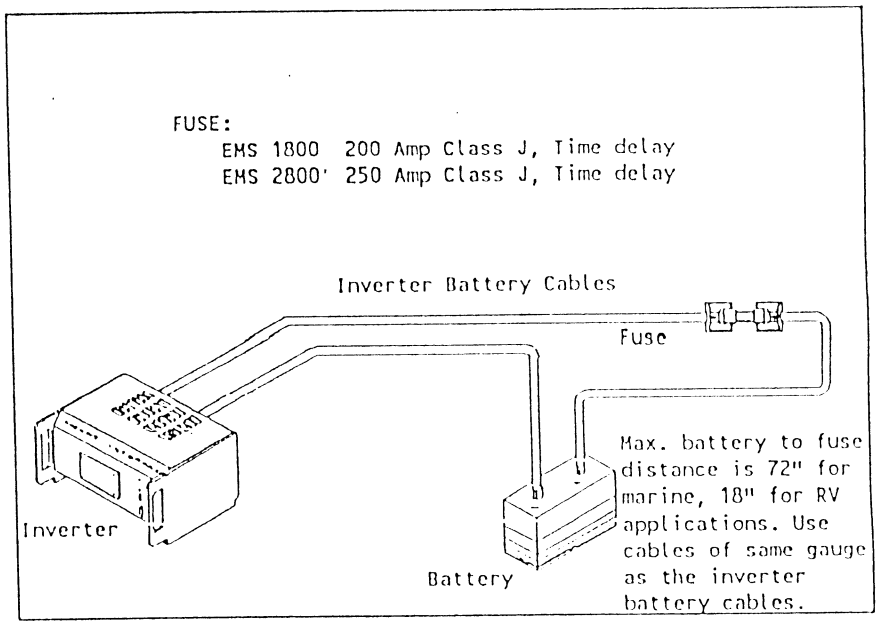

Figure 4 Battery Bank Wiring and Fusing

For marine applications, a fuse is required if battery cables exceed six feet (1.8 meters). For RV applications the fuse must be readily accessible and be within 18 inches (.45 meter) of the battery. Figure 4 illustrates proper installation of the battery fuse and fuse ratings.

Current may flow momentarily when the battery connection is made, as a result of charging a capacitor inside the unit. This is not cause for alarm, however, do not make the final connection in the presence of flammable gas such as that from charging batteries.

SPECIFIC APPLICATIONS

Below you will find notes and diagrams to assist you in selecting an appropriate installations.

Basic Configuration

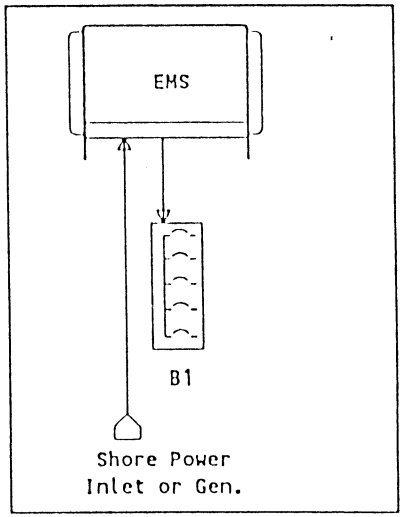

Figure 5

For systems with a 30 amp shore power inlet and a 4KW generator or smaller, or no generator at all. In systems with a generator, a transfer switch must exist between shore power and the generator. The 30 amp internal transfer switch in the EMS is used to feed the entire circuit breaker panel from either the inverter or the shore power/generator.

Split Bus Configuration

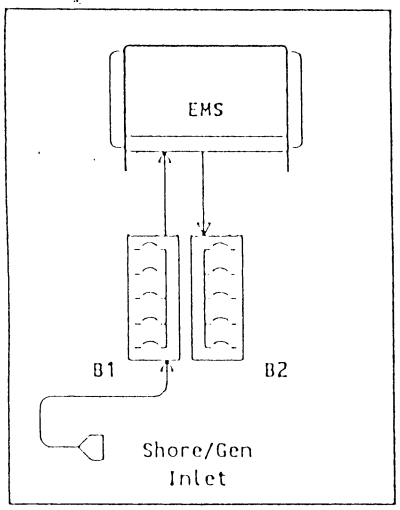

Figure 6

For systems with two separate rows of circuit breakers. Shore power and generator can be of any size. B1 circuits are non-inverter loads such as air conditioning. A 30 amp circuit breaker on B1 feeds into the EMS. B2 contains the inverter circuits.

Twin Shore Power Configuration

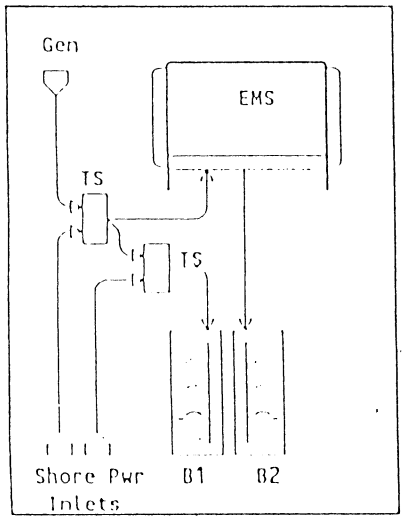

Figure 7

For systems with two shore power inlets and any size generator. Two external transfer switches (TS) are used. B1 contains non-inverter loads, and B2 contains inverter loads.

OPERATION OF THE EMS

INVERTER OPERATION

Initial Turn-on Procedure

After completing your installation, you must perform the following initial turn-on procedure. This procedure will detect a backfeed without damaging the unit. Once this procedure has been successfully performed the unit can safely be switched from inverter to charger while turned on.

1. Turn the unit off.
2. Plug in the AC input.
3. Turn the unit on.

If the AC input LED turns red for 9 seconds then turns green, there is no back feed. If the AC INPUT and SHUTDOWN LEDs blink green simultaneously, there is a backfeed. Disconnect the AC input; correct the backfeed, and perform this procedure again.

Once it is properly connected, you may turn on the inverter by moving the power/reset switch to the ON (up) position. The unit is now running and ready to supply AC power. Note that turning the power switch OFF does not disconnect external AC power from the outlets connected to the EMS. The transfer switch relays will remain engaged, and AC power will be available to the outlets as long as external power is connected to the unit. In this condition, the LEDs will remain illuminated but will not be as bright as when the unit is on.

There are virtually no limitations to what will operate on your EMS, within the rating of the unit. You may operate fluorescent and incandescent lights, microwave ovens, refrigerators and freezers, computers, televisions, etc. The list is virtually endless. Some types of loads are not appropriate for inverter power. Primarily these are large AC equipment such as air conditioners and converters or battery chargers. If you have any doubts as to the appropriateness of a particular type of load, consult your dealer.

Types of Loads

A "load" is any device that draws power in an electrical system. Electrical appliances fall into 2 broad groups, resistive and inductive. Resistive loads are simple ones in which the electricity creates heat and no motion. Typical resistive loads that you may operate include incandescent lights or electric heaters. It is easy to determine what resistive loads will work on the EMS, any resistive load within the rating will operate fine.

Inductive loads are generally those in which the electricity goes through a coil of wire. These loads are usually motors, such as fans and refrigerators; or transformers, which are found in most electronics such as TVs, computers and fluorescent lights. Inductive loads require a larger amount of power to get them started than to run them, sometimes up to 6 times as much power.

This inductive surge must be taken into account when determining what will operate on the EMS. Your EMS incorporates a special motor starting circuit that provides a unique ability to overcome inertia, and start inductive motors. An analogy of this circuit is the downshifting of your car to get up a hill. A good rule of thumb is to figure that an EMS 1800 will operate a 1/2 horsepower induction motor, and an EMS 2800 will operate a 1 HP motor.

Capacitor-start motors require less surge to get started and are therefore recommended when possible.

The Load Detection Circuit

Your EMS features a unique load detection circuit that allows it to be left on and to draw very little power if it is not actually operating any loads. This circuit is automatic and virtually instantaneous. While in idle or no-load the unit draws 65 milliamps (.065 amp) from the battery bank and is putting out about 55 volts RMS. This will typically be measured as 20-30 volts on an averaging volt meter.

The load detection circuit is set to detect a 7.5 watt load. If you attempt to operate an appliance which draws less than 7.5 watts you will have to run an additional load simultaneously to insure that the EMS will come out of idle. Occasionally a small inductive load that draws around 7.5 watts will fail to bring the unit out of idle. An example might be an electric shaver. If this happens you must simply operate a resistive load in conjunction with the shaver. A 15 watt light bulb will be enough to force the unit out of idle if you are running a very small inductive load.

Inverter Mode Protection Circuits

The EMS has 3 levels of protection against overloads and a circuit which protects against excessively high or low battery voltage.

Electronic Protection: There is a very fast electronic overload protection circuit in the EMS to protect against short circuits. This is activated if there is a short circuit in your wiring or if you attempt to start a large induction motor in excess of the surge rating of the EMS. The electronic protection circuit is indicated by the SHUTDOWN LED on the front of the unit. This LED will blink green if an overload condition occurs.

The electronic circuit will quickly shut down the output of the EMS when activated. If the short circuit or inductive overload is removed within 10 seconds, the unit will automatically reset and continue normal operation. If the overload condition persists for more than 10 seconds the unit will completely turn itself off, leaving the green

SHUTDOWN LED blinking. If this situation occurs you must discover and eliminate,the cause of the overload. Once the overload is removed, you may restart the EMS by turning the power switch off and back on.

Circuit Breaker Protection: The circuit breaker on the front of the EMS protects the output of the inverter and is a relatively slow breaker which will allow the unit to provide ample power to start inductive loads.

When the breaker trips it will pop out, extending out about 1/4 inch. To reset simply push the breaker back in firmly and the unit will restart.

Protection From Overheating: Because the EMS is not quite 100% efficient, heat will build up in the unit during the operation of loads which are close to the rated output. If a load close to the rating is run long enough, the thermal protection in the EMS will come into play.

A heat sensor will shut down the EMS if internal temperatures approach the maximum rating of the components. If this happens the SHUTDOWN LED will come on, glowing red for 9 seconds. After 9 seconds the will shut down and the LED will turn yellow.

When this occurs you must give the unit time to cool down before re-starting. After cooling, you may restart the unit by turning the power switch off then back on. In the unlikely event that the unit shuts down due to overtemperature in the charging mode, after cooling it will reset itself automatically and resume charging.

High and Low Battery Voltage Protection

The low battery cut out is designed to prevent the battery bank from discharging totally and thereby incurring permanent damage. There is a time delay built into this circuit which allows the battery voltage to momentarily drop below the cut off point. This will allow the voltage to dip substantially while starting an induction motor.

If the battery voltage dips below the cutoff point for over 9 seconds the unit will shut itself off. The SHUTDOWN LED will come on green. You must turn the unit off and then back on to resume operation. If the low battery cutout circuit is activated you should recharge the batteries before resetting the EMS.

The high battery cut out is designed to protect the EMS from excessive input voltage. High battery cutout will shut the unit down if the battery voltage gets above 2.66 volts per cell. When this circuit is activated the SHUTDOWN LED will come on green, same as the low battery cutout.

If the SHUTDOWN LED comes on green you should measure the battery voltage to determine if it is high or low. If it is high you are probably overcharging the battery and should check both the charging system and the water level in the battery. If the battery voltage is low then it is time to recharge. When checking for low battery voltage bear in mind that the voltage will rebound when the load is removed. If the low battery protection circuitry shuts the unit down it is quite likely that the battery voltage will measure higher than the cutoff point with no load. Put a load on the battery bank and recheck the voltage. The chart below shows the cut off voltages for both high and low battery conditions.

	Low Battery Cut Out	High Battery Cut Out
EMS-12	10.2 volts	16 volts
EMS-24	20.4 volts	32 volts
EMS-32	27.2 volts	43 volts

Measuring the Output Voltage

You may measure the output voltage of the EMS with your volt meter, however, it is possible that you will not measure the 119-121 AC volts RMS that the unit provides. This is due to the output wave shape of the EMS, which can only be accurately measured with a true RMS volt meter, a rather specialized instrument. Do not be concerned about measuring output voltage that varies with load and battery voltage. This is normal and should be expected unless you have a true RMS volt meter. When measured with a standard volt meter you can expect readings somewhere between 90 and 140 volts. Since some meters have different measuring circuits it is impossible to predict the exact reading you may get.

If you measure the output voltage with nothing plugged into the front of the EMS you will get a very low reading, usually between 20 and 30 volts AC. This is the no-load or idle state of the unit and is perfectly normal. True RMS voltage in idle is about 55 volts AC. A good way to confirm that your voltage regulation circuit in the EMS is working is to observe the brightness of an incandescent light bulb. If the brightness appears about the same as the light plugged into utility power or a generator, then you know the voltage regulation is correct. A relatively small change in voltage will produce a noticeable change in light output.

THE EMS 30 AMP TRANSFER SWITCH

The EMS will automatically switch between the inverter output and the AC input to the unit, whether this input is from shore power or a generator. This means that the need for an external transfer switch is eliminated. The transfer switch is automatic and switches from inverter to the incoming AC whenever the AC INPUT LED is green or yellow.

The relay in the transfer switch will remain engaged even if the EMS is turned off. Thus, there will be AC power available from the output whenever the EMS is connected to external AC power. When the battery charger is on, it will consume some of the 30 amps that are available. When charging at full output, the 1800 charger consumes 12 amps and the 2800 charger consumes 22 amps maximum. This consumption decreases as the charge rate ramps down, and will be less than 1 amp if the batteries are fully charged and no DC appliances are being used.

With a remote panel installed, you may use the LOW CHARGE setting. This allows the use of other appliances while charging. See the discussion of the remote panel for more information.

THE EMS BATTERY CHARGER OPERATION

The battery charger in the EMS is a unique design that makes use of both constant current and constant voltage modes to provide rapid and complete recharging and precise floating of the battery bank. In addition, an equalizing mode is available to periodically remove residual sulfate from the plates of liquid electrolyte deep-cycle batteries.

How To Use The Battery Charger

The battery charger is activated any time that AC is fed to the AC input of the unit. The power switch must be on for the battery charger to function.

DO NOT APPLY 120 VAC EXTERNAL POWER TO THE EMS UNTIL ALL BATTERY CABLES ARE SECURELY AND CORRECTLY CONNECTED. ARCING BETWEEN THE CABLE ENDS CAN CAUSE SERIOUS BURNS.

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* WARNING * WARNING * WARNING * WARNING *

CAUTION: Arcing between cable ends may cause serious damage to the EMS.

Immediately when AC is applied, the AC INPUT LED on the front panel will come on red. For 9 seconds the EMS will analyze the incoming AC power. If the power is connected in reverse polarity (hot and neutral reversed) the AC INPUT LED will start blinking red and the unit will not switch the faulty power through nor activate the battery charger. If polarity is correct you will hear the internal relay switch and the AC INPUT LED will turn green. At this time the inverter is disabled and the incoming power, up to 30 amps, is switched through the 30 amp circuit breaker on the front of the unit and to the AC output.

After 17 seconds in this phase, the AC INPUT LED will turn yellow and the battery charger will slowly ramp up its output current. This can be monitored by watching the CHARGE RATE LED.

All charging functions are fully automatic and protect the batteries against over charging. Watch the CHARGE RATE and BATTERY STATUS LEDs to monitor the unit.

Battery Charging

In our discussion of batteries and charging there will be reference to cells. Every battery is made up of cells, which have a nominal voltage of 2 volts. A 12 volt battery is made up of 6 cells.

To fully recharge deep-cycle batteries current must flow into them until the voltage reaches the gassing point. This is the point at which the liquid in the battery begins to bubble and discharge hydrogen gas. That is why there is a warning about putting the EMS unit in a sealed compartment with the batteries. It is not until this point that the battery bank has reached full charge. The charge voltage must be reduced at this time.

The EMS battery charger is fully regulated, which means that the digital circuitry is constantly sensing battery voltage and adjusting the output in response to this. When a battery bank is discharged, its voltage is low and the EMS will put out full current. If the voltage comes up very fast, as may be the case in small battery banks, the EMS will reduce its output. This prevents overcharging small battery banks. This constant current phase is in contrast to most battery chargers, which rapidly taper their output, taking a relatively long time to recharge.

Most chargers also stop charging below 14 volts, never reaching the gassing point, and therefore never completely recharging the battery bank.

The battery charger will bulk charge the battery bank up to 2.38 volts per cell. It will do this at a constant current until it reaches the end of the charge cycle, when the current will gradually ramp down. This ramping down of the charger current can be followed by watching the BATTERY CHARGING LED. During this ramping down phase the battery bank is accepting its final charge, which

needs to be completed at a reduced rate to prevent over charging. Once the battery voltage reaches 2.38 volts per cell and the current has ramped down to 1/2 its full output, the charger automatically goes from bulk charge mode to float mode. In the float mode the battery bank is held at precisely 2.22 volts per cell.

The constant current phase is timed and will not exceed 9 hours. At the end of 9 hours the unit will automatically go into the lower voltage float mode, regardless of battery voltage. If the battery bank is large enough to require more than 9 hours to completely recharge, you must unplug the AC input and reconnect it to reset the 9 hour constant current charge phase. Once the battery voltage has reached 2.38 volts per cell and the current has ramped down, the unit will go into the float mode, even if less than 9 hours has elapsed. Once the unit has gone into the float mode it will stay there, holding the batteries at 2.22 volts per cell until the unit is shut off and turned back on. If DC loads, such as lights, radios, or refrigerators, are turned on, the unit will provide up to 65 amps to operate these loads and still maintain 2.22 volts per cell. If the DC loads are in excess of 65 amps then the battery voltage may drop.

	Volts/cell	EMS-12	EMS-24	EMS-32
Float Mode	2.22	13.3	26.6	35.5
Bulk Charge	2.38	14.3	28.6	38.1

The Battery Equalizing Cycle

Liquid electrolyte deep-cycle batteries (as opposed to sealed, maintenance free batteries) benefit from a periodic equalizing charge. This charge is applied after the batteries have reached their fully charged state, and is a high voltage controlled over-charge. The purpose of this equalizing charge is to remove any residual sulfate from the battery plates, bring all the cells up to the same voltage, and thoroughly mix up the electrolyte.

We recommend that an equalizing charge be applied every few months. Consult your battery manufacturer for specific recommendations. While equalizing is not absolutely necessary, periodic use of this feature will extend the life and useful capacity of the battery bank. Do not equalize a sealed battery, damage may result.

The EMS is equipped with a spring loaded switch on the front panel to initiate a 9 hour timed equalizing cycle. After AC power is connected,wait approximately 30 seconds for the AC INPUT LED to turn yellow. Then push the BATTERY EQUALIZE switch down and release to begin the cycle. The CHARGE RATE LED will blink continuously during the equalizing charge. The equalizing cycle will end and the unit will float when less than 10 amps are drawn. Battery voltage will increase to the following point:

EMS-12: 16.3 volts EMS-24: 32.6 volts EMS-32: 43.45 volts

During the equalizing charge the electrolyte will bubble and the batteries will gas. Be sure to ventilate the battery area at this time. If the equalizing cycle is accidentally engaged, it may be defeated by disconnecting the AC input and reconnecting.

BATTERY EQUALIZATION GENERATES LARGE QUANTITIES OF POTENTIALLY HARMFUL FUMES. EQUALIZATION SHOULD BE PERFORMED IN A WELL VENTILATED AREA.

* WARNING * WARNING * WARNING * WARNING *

CAUTION: Voltages in excess of 15 volts may damage 12 VDC appliances. Disconnect all such loads prior to equalization.

NOTE: TOP OFF THE BATTERIES WITH DISTILLED WATER BEFORE THE EQUALIZING CHARGE IS APPLIED, AND CHECK THE ELECTROLYTE LEVEL AFTERWARDS. WE RECOMMEND THAT THE BATTERIES BE MONITORED DURING THE EQUALIZING CHARGE CYCLE.

CAUTION: Do not equalize sealed, maintenance free batteries!!! Sealed batteries do not require equalizing and the high voltage may damage them.

THE REMOTE CONTROL

There is a flush mount remote control operating panel available for the EMS. It is supplied with a 20 foot cable, and an additional 20 foot extension is available. As stated in the installation section, 40 feet is the maximum extension distance. Exceeding this distance will result in malfunction of the indicators. This panel features a power on/off switch, which includes a feature described on the panel as LOW CHARGE. In this position, the battery charger charges at only 10 amps, allowing more AC shore power to be used for appliances on the AC system.

To operate the unit from the remote control, you must leave the power switch on the unit in the off position.

LED indication is the same for the remote as it is on the unit itself with the following exceptions.

SHUTDOWN

Off	Normal operation
Red	Shutdown due to high temperature
Green	Shutdown due to overload

HIGH TEMP

Off	Normal operation
Red	Temperature too high. The unit shuts down after 8 seconds.

AC OUTPUT POWER ON

Off	No AC power output
Green	AC power available

MAINTENANCE

The EMS is a solid-state electronic device that requires no direct electronic maintenance. We do recommend that you keep the unit clean and wipe it down periodically with a damp cloth.

Keep the EMS dry at all times. If water gets inside the unit, immediately disconnect from the batteries and dry it out. Make sure it is completely dry before attempting to use the unit.

While the EMS does not require any maintenance, it is very important to perform regular maintenance on the battery bank.

This includes checking the electrolyte level and filling with distilled water as necessary, and cleaning all battery connections. Keeping the tops of the batteries clean will help reduce their tendency to-self discharge.

In order to allow you to maintain your batteries, we have included a battery information section in the technical appendix of this manual. Please read it carefully to get the most out of your batteries.

TROUBLESHOOTING

Most problems will fall into one of three categories, abnormal operation of your appliance (load), motors that won't start, and no output from the unit. If a problem occurs please refer to the following guidelines before you call for assistance.

LOAD BEHAVING ABNORMALLY

Most loads will run on the EMS just like they do on utility power. Occasionally certain inductive loads will emit a slightly louder hum than normal. This is due to the EMS output wave shape.

If a small load will not start and run it may be due to the load demand circuit. Turn on an incandescent light bulb of at least 15 watts and try the load again.

Digital clocks will ordinarily keep good time on the EMS but occasionally we encounter one that runs 2 or 3 times faster than normal. This problem is due to the modified sine wave output.

It is possible that the start-up of a large inductive load such as a 1/2 horsepower induction motor will interfere with the operation of sensitive electronics such as computers. What may happen is that while the EMS is surging to start the big motor, the computer will crash. If you will be starting a motor which requires the full current that the EMS is capable of delivering, such as a 1/2 horsepower induction motor, do not operate sensitive electronics at the same time.

Microwave ovens depend on high peak AC voltage to cook at full speed. The peak AC voltage output of the EMS is dependent on the input battery voltage. The higher the battery voltage the faster the microwave will cook. Do not be surprised if your microwave oven takes 15% to 25% longer to cook when operated with the EMS. Cooking speed will be increased by raising the battery voltage.

MOTORS NOT STARTING

Because of the large surge required to get them started, it is sometimes difficult to predict exactly which induction motors are within the capacity of the EMS. We have found that 1/2 horsepower capacitor-start motors will reliably work on the EMS 1800 and 1 HP capacitor-start motors will work with the EMS 2800. If a problem is encountered getting a motor started, the first thing to do is confirm that your battery voltage is adequate.

This must be done while the motor is attempting to start. Use a volt meter and watch the momentary voltage drop while you start the motor. If the voltage is dropping significantly this may be why the motor will not start. Check all the battery connections and the state of charge of the battery bank.

If the connections appear solid and the battery bank is fully charged, but the voltage drops significantly, you may want to consider a larger battery bank.

If the battery voltage drop is acceptable but the motor will not start, the addition of a capacitor across the motor may help. Use a motor-run capacitor of about 3 microfarads.

NO OUTPUT FROM THE EMS

If you are unable to get any output voltage from the EMS the first thing you need to check is the battery voltage. Confirm that neither dead batteries nor bad connections are the source of the problem.

If the EMS does not hum at all, puts out no power, and displays the green shutdown LED continuously, you should contact your dealer or Heart Interface.

WARRANTY INFORMATION

Your Heart Interface EMS is under limited warranty for a period of one year or two and a half years from the date of purchase.

Terms of the warranty are spelled out on the warranty registration card. Please fill this card out completely and return it to Heart Interface in order to validate your warranty.

Heart Interface will pay return shipping if your unit requires service within the warranty period. After this time the customer is responsible for all shipping costs. Please keep the original box and hard foam packing material in case you need to ship the EMS for any reason. Please ship the unit freight prepaid and, within the warranty period, it will be returned freight prepaid to you. NOTE: If you ship the unit freight collect it will be refused.

If you think that your EMS requires servicing please contact the factory for a Return Authorization Number. Call us at (800) 446-6180. Heart Interface cannot accept units in for service without this number.

To obtain a Return Authorization Number you must first provide the serial number of your EMS. Please have the serial number and model number ready before you place your call. Depending on your location, you will be directed to return the unit to a factory authorized service center or to the factory itself.

Please be prepared to show proof of purchase date on any warranty claim.

TECHNICAL APPENDIX

TECHNICAL APPENDIX

ABOUT BATTERIES

You must use a battery bank with the EMS. It will not operate on the charging system alone. The performance of your EMS Interface will be highly dependent on the battery bank that you use. The following information will help you to understand how to size and maintain your battery bank. Remember to use the correct voltage for your particular unit.

12 Volt Battery Banks

If you will be using more than one battery to power the EMS it is important that the battery interconnections be made correctly. Refer to the illustrations for proper battery bank connections. When connecting several batteries together to form your battery bank use only identical types. Under no circumstances should you mix sealed, maintenance free batteries with liquid electrolyte batteries in the same battery bank.

When using 6 volt batteries you must hook up pairs in series to get 12 volts. In a series configuration you connect the positive post of one battery to the negative post of the other. Twelve volts will be available from the remaining two posts. If more than one pair of 6 volt batteries is used you must connect them in a combination of series and parallel.

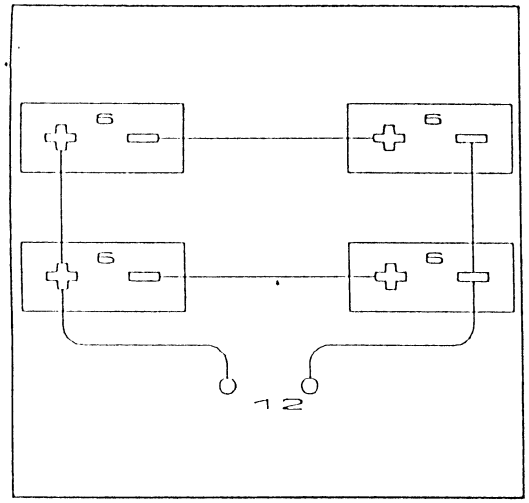
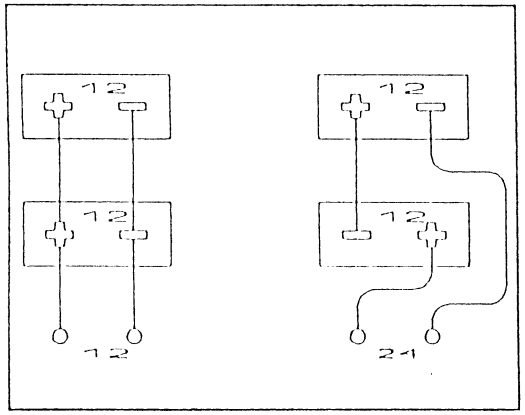


Figure 8



When using 12 volt batteries, you hook them up in parallel by connecting all the positive posts together and all the negative posts together. You may connect the EMS to any pair of positive and negative posts.

Figure 9

When batteries are connected in series, the voltage of the battery bank is equal to the sum of the voltage of each battery. If you connect two 6 volt batteries in series you get 12 volts. Be careful that (for a 12 volt EMS) you do not connect 12 volt batteries in series. You will then have 24 (or more) volts, and your EMS will shut down due to over voltage. The amp-hour capacity of the battery bank is equal to the amp-hour capacity of one of the batteries. For example, if you connect a pair of 6 volt 250 amp-hour golf cart batteries in series you get a 12 volt 250 amp-hour battery bank.

When batteries are connected in parallel the voltage of the battery bank is the same as that of each battery. The amp-hour capacity is equal to the sum of the amp-hour capacity of each battery. For example, if you connect two 105 amp-hour 12 volt batteries in parallel you get a 12 volt 210 amp-hour battery bank.

For a final example, if you connect four 6 volt 250 amp-hour golf cart batteries in a series/parallel configuration you get a 12 volt 500 amp-hour battery bank.

For your battery bank interconnections, use the same size of stranded copper cable that came on your EMS unit. Be sure they are fitted with the proper terminals. Make sure that all connections are clean and tight.

24 & 32 Volt Battery Banks

The EMS is also available for 24 and 32 volt DC inputs. Use the series/parallel principles above to create the proper battery bank for your unit. Be sure to check the voltage with your meter before connecting the unit to the battery bank.

Battery Types and Sizing

The size of your battery bank will depend entirely on the loads that you operate and the time between recharges.

We recommend that you use true deep-cycle batteries with your EMS. Golf cart batteries are a good choice. RV or marine deep-cycle batteries are acceptable, but do not have the life expectancy of the golf cart battery. Do not use automotive starting batteries as they will last only a very few deep discharge cycles. Even the 8D type diesel starting batteries will not hold up under deep discharging. There is no substitute for a true heavy-duty deep-cycle battery.

The gel-cell type battery is increasing in popularity. Several features make these gel-cells attractive, including no maintenance, no chance of spills, and some types are capable of accepting a very high charge current for rapid recharging. In addition the internal resistance of these batteries is lower than that of conventional lead-acid batteries. This means that the battery voltage stays higher under load, which adds a measure of performance to the EMS.

Battery capacity is expressed in amp-hours, usually this number will refer to a 20 hour discharge cycle. For example, a 100 amp-hour battery will deliver 5 amps for 20 hours.

If the discharge rate is greater than 5 amps the overall amp-hours available will be reduced. Drawing 20 amps, a 100 amp-hour battery will deliver only about 80 amp-hours. Drawing 100 amps the battery will deliver about 45 amp-hours.

Deep-cycle batteries can be discharged 80% without permanent damage. This means that a 100 amp-hour battery has 80 amps of useful capacity. The number of discharge cycles in the life of a battery is directly dependent on how deeply they are discharged. If you only draw 50% of the battery capacity each time before you recharge, your battery bank will last much longer than a bank of batteries which is discharged 80% each time.

To size your battery bank you need to determine approximately how many amp-hours you will consume between charging cycles. Start by looking on each of your appliances for the number of watts that it consumes. Then figure out how many hours the appliance will run between charging cycles. For example, a small refrigerator consumes 240 watts. It will operate for about 10 hours per day. This means it will consume about 2400 watt-hours per day. Watt's law tells us that watts equals volts times amps.

Therefore, if we divide the watt-hours by our battery voltage we get the number of amp-hours consumed. Figure in about 10% extra for inefficiency. With an EMS -12, this refrigerator will draw about 220 amp-hours per day from your battery bank. With an EMS-24 the draw will be about 110 amp-hours per day.

A minimum of a 280 amp-hour 12 volt battery bank will be necessary to power the above refrigerator for one day, assuming that we discharge the battery bank to 80%. A larger bank will allow for less deep discharging and longer battery life.

Using Batteries

The EMS will operate within the following range of DC input voltage.

EMS-12 10.2 - 16.0
EMS-24 20.4 - 32.0
EMS-32 27.2 - 43.0

Within this range, the output voltage of the EMS will remain constant at 119-121 volts RMS. Battery bank output voltage will drop under load. The larger the battery bank the smaller the voltage drop will be. For this reason it is advantageous to have as large a battery bank as practical, especially if you will be starting inductive loads such as refrigeration motors. In most cases, inductive loads will

start easier if the battery voltage is relatively high. As you use your EMS you will find it useful to monitor the state of charge of your battery bank. This will let you know when it is time to recharge without letting the low battery cutout circuitry shut the unit down unexpectedly. The BATTERY STATUS LED functions at all times if the unit is turned on and will give you a rough idea of your battery voltage.

The state of charge of a battery can be measured by two instruments, a hydrometer or a volt meter. Hydrometers measure the specific gravity of the electrolyte in the battery. This gives you a very accurate measurement of the state of charge but has two significant disadvantages. For one, the temperature of the electrolyte will affect the reading that you get. Unless you measure the electrolyte temperature and make appropriate adjustments you will not get accurate state of charge readings from your hydrometer. The other disadvantage to taking hydrometer readings is that the process tends to be messy. Not only do you risk getting battery acid on your clothes but you also risk contaminating the battery electrolyte with dirt. Contamination in the battery can seriously impair the performance and longevity.

If you would like to monitor the state of charge of your battery bank more accurately than allowed by the BATTERY STATUS LED, the use of a digital volt meter is recommended. The ambient air temperature will have an effect on battery performance. Expect reduced performance from very cold batteries. The rated specifications of a battery are true at about 77 degrees F. At 30 degrees F. the capacity of a battery is reduced by about 30%. At 0 degrees F. the battery capacity is reduced to about 50% of its potential.

Battery Charging

You may charge your battery bank from several different charging sources including engine alternators, photovoltaic solar panels, hydro or wind systems, and standard AC operated battery chargers. It is not uncommon for more than one of these sources to charge the batteries at the same time. You may operate the EMS at all times, whether charging simultaneously or not.

EMS TECHNICAL DESCRIPTION

The EMS Interface is made up of a pulse width modulation control circuitry that drives two banks of Field Effect Transistors (FETs) and a large transformer.

DC power enters the EMS through the battery cables and is connected directly to each bank of FETs. DC is also fed to the main circuit board. The FET banks act as high current switches, one bank switches on to create the positive half of the output and the other bank switches the negative half. Heart Interface uses the latest in ruggedized FETs, which have a very low resistance when they are turned on. This allows for high surge capability and efficiency.

Custom made in the Heart Interface factory, the transformer is exceptionally low in resistance and very efficient. The two power modules consist of ten FETs soldered in parallel on a circuit board which is fitted with extruded heat sinks. The heat sinks are mounted on the sides of the chassis with silicon insulating pads, in this way the entire heavy gauge chassis is used as a heat sink for the power modules.

The main circuit board uses the most advanced digital technology available to control the functions of the unit. It is mounted to the front panel. The switch, LED indicator lights and remote control connector are mounted on the

main circuit board. The main board sends a signal to the power modules, turning the FETs off and on. A crystal oscillator on the main board insures that the frequency is kept stable at 60 Hz and, by constantly monitoring the output, the voltage is regulated at 120 volts RMS. Also contained on the main circuit board are the protection circuits, the relays and the battery charger control circuit.

The battery charger makes use of many of the same components as the inverter. When activated by the presence of AC power the relays are energized and up to 30 amps AC is available at the output of the unit. Current is reversed through the transformer and rectified by the FETs. The charger is electronically controlled by the digital circuitry on the board.