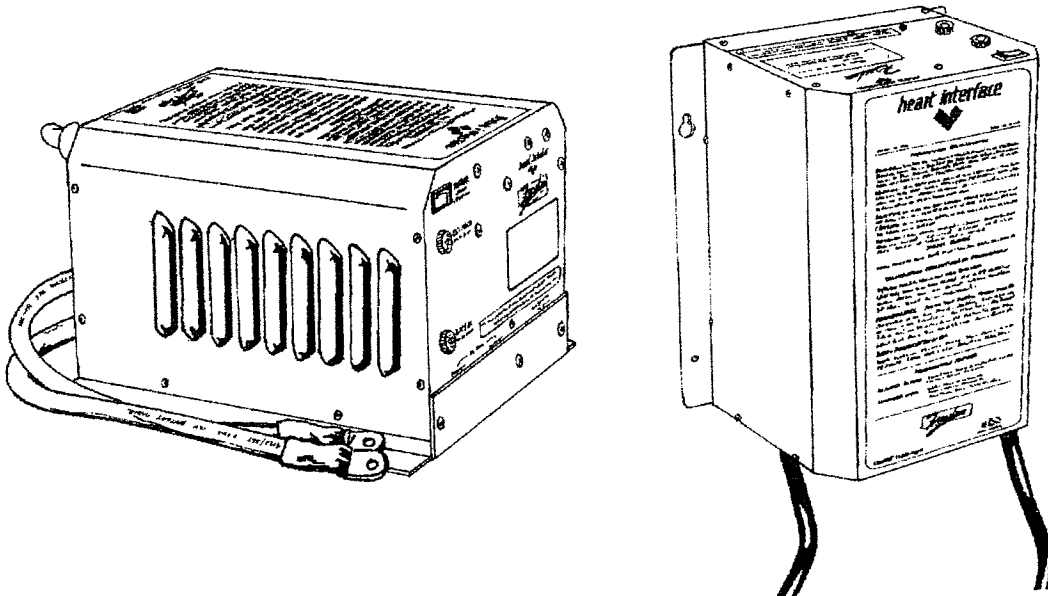


# OWNER'S MANUAL

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## FREEDOM 20 INVERTER / BATTERY CHARGER



# SAFETY SUMMARY

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**General safety information for installation and operation is contained throughout this manual where it applies and is not included in this summary.**

**Definitions** Warning statements identify conditions or practices which could result in personal injury, loss of life, damage to equipment or other property.

**Fuse Replacement** For continued protection against the possibility of

fire, replace the fuse only with a fuse of the specified voltage, current, and type ratings.

**Power Source** To avoid damage, operate the equipment only within the specified AC (mains) and DC (battery) voltages.

**Servicing** To reduce the risk of electric shock do not open this unit, as there are no user serviceable parts inside. Refer all servicing to qualified personnel.

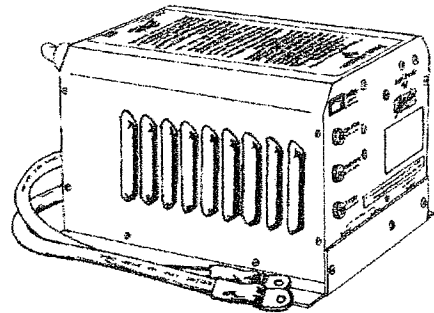
The statements, specifications and instructions in this publication are believed to be correct. No warranty is made, expressed or implied by the seller or manufacturer with respect to any results or lack thereof from the use of information in this publication and no liability is assumed for any direct or consequential damages, personal loss or injury. All statements made herein are strictly to be used or relied on at the user's risk. ©1996 Heart Interface Corporation. All rights reserved.

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# INTRODUCTION

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This owner's manual describes the Freedom 20 from Heart Interface. This unit performs 4 distinct functions:

1. DC to AC power inverting.
2. Automatic transfer switching between inverter power and incoming AC power.
3. Three-stage automatic battery charging plus manual battery equalizing.
4. AC to DC power converter.

- The inverter provides 2000 watts of voltage and frequency regulated AC power from a deep-cycle battery bank. The output is a modified sine wave and is compatible with virtually all consumer appliances. An idle circuit reduces battery power consumption when the inverter is unloaded. There is a low battery cutout circuit and considerable momentary surge power is available for starting electric motors. High efficiency ensures the longest possible battery life between recharges.

- The transfer switch allows the Freedom 20 to be connected to an external AC source. Some of the external AC power is used to operate the battery charger, the rest is switched through the unit to the output. Thus the Freedom 20 operates as a self-contained backup power system, just add batteries. The power sharing feature constantly senses the AC current being used by the battery charger and the appliances connected to the output, and automatically reduces battery

charger power consumption if usage exceeds the input circuit breaker rating.

- The Freedom 20 battery charger is electronically controlled and rated at 100 amps DC (50 amps DC for 24 volts). It is designed to rapidly and optimally recharge either wet or gel cell deep-cycle batteries. Battery charging is accomplished in 3 automatic stages: Bulk Charge, Acceptance and Float Charge. In addition, using the remote control, a manually engaged equalizing charge cycle is possible.

- With an external AC source connected, the Freedom 20 charger also serves the functions of an AC to DC converter to supply all of the DC loads which are connected to the battery.

Simple, automatic operation is made possible by the microprocessor that is the brain of the Freedom 20. In most cases, the unit is left on and no attention or maintenance is required.

The optional Freedom remote control panel provides a power switch, system status LEDs, DC volts and DC amps LED bar graphs. In addition, on the rear of the remote is a set of dip switches which allow adjustment of the following:

Three-Stage or equalize charging, temperature, battery type, charger mode, idle sensitivity and power sharing.

# THINGS YOU SHOULD KNOW

---

## WARNING

*A transfer between inverter and charge modes of operation may temporarily take place when the product is subjected to electrostatic discharge.*

### Intended Use

The Heart Interface Inverter Charger is intended: as a DC to AC inverter/battery charger; for use in recreational vehicles, recreational marine vehicles, and residential solar applications; to be permanently installed, not portable; to be used with a DC fuse as described in the installation section of this manual.

The following technical guidelines have been applied to this product:

- EN55022 Class B
- IEC 801-2 Performance Criteria B
- IEC 801-3 Performance Criteria A
- IEC 801-4 Performance Criteria B

### Circuit Breaker Protection

The 12 amp circuit breaker on the front of the unit protects against sustained inverter overloads over 3000 watts. The breaker is reset by pushing the button back in. The middle circuit breaker on the unit protects the incoming AC leg which is transferred through

to the loads. The top circuit breaker protects the incoming AC leg which feeds the battery charger.

### Electronic Protection

Fast acting electronic circuits protect the inverter from extreme overloads, low and high battery voltage and over-temperature. Reset by turning the power switch OFF and then ON (cycling). The fault condition must be eliminated before reset will occur, for example remove overload, recharge batteries or allow to cool.

### Inverter Idle Circuit

This automatic energy saving feature reduces battery power consumption when no load is present. Response from idle is instant. In most cases the operation of the idle circuit is not noticeable. Use of the remote control panel allows the idle circuit sensitivity to be adjusted.

### Power Sharing

The Freedom 20 can automatically reduce the battery charger output, and therefore the AC power consumption, if appliances are turned on that threaten to trip the incoming circuit breaker. This feature can be adjusted using the remote control panel. This feature is set to protect a 15 amp source by default.

## THINGS YOU SHOULD KNOW

---

### Power Switch

The power switch on the Freedom 20 controls the inverter function. If you turn off the inverter with the switch and later plug into external AC power, the unit will transfer AC power and the battery charger will engage.

### Freedom Remote Control Panel

An optional remote control panel is available. When the remote is used, the power switch on the unit should be left OFF. The remote control panel provides bar graph LEDs which show system status, battery voltage and current in both inverter and charger modes. These bar graphs can also display dip switch positions and shutdown conditions.

### Link 2000 Remote Control Panel

More advanced remote control panels are also available; the Link 2000 and 2000R.

In addition to providing inverter/charger control, the Link 2000 enables precision monitoring of DC voltage, current, and amp hours for up to two battery banks.

The Link 2000R adds the ability to control an engine driven alternator. This precision regulator transforms

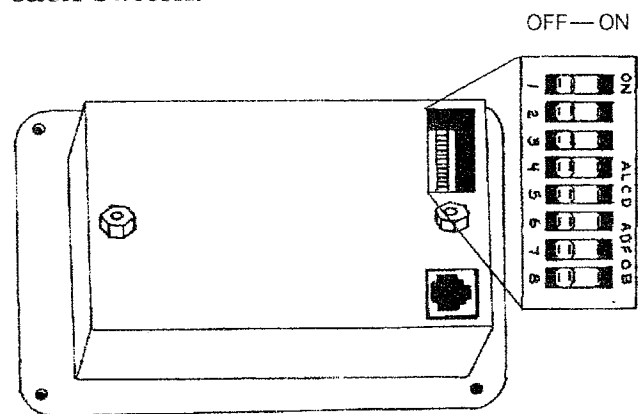
an alternator into a 3 stage battery charging system like the charger in the Freedom 20.

If a Link 2000R Remote is being used to control the inverter/charger, refer to the Link manual for setup and control information.

### Dip Switch Programming

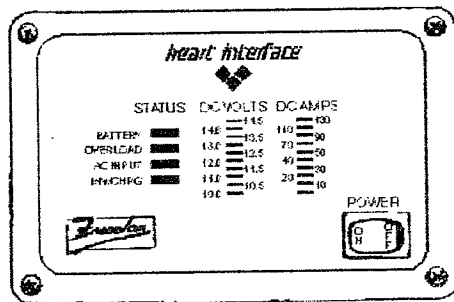
On the rear of the Freedom remote control panel is a set of small dip switches which are used to make several adjustments. The switch settings can be changed at any time, even while the unit is operating.

The following section and the table on page 12 explain the functions of each switch.



# THE REMOTE CONTROL PANEL

There is an optional remote control panel available which offers several features not found on the Freedom 20 itself.



## Power Switch

The switch on the remote is used to control the inverter and can be used to control the battery charger function too. When a remote control is used, the power switch on the unit itself should be left in the OFF position.

## Dip Switch Status

You can check the position of the dip switches (described later in this chapter) by quickly cycling the power switch OFF/ON twice. The DC Volts bar graph will cease to display battery voltage and will indicate the settings of each dip switch. In this mode the bottom LED will illuminate if switch 1 is on, the second LED will illuminate if switch 2 is on, etc. Dip switch settings are indicated for 10 seconds after which time the display returns to indicating battery voltage.

## DC Volts Bar Graph

These LEDs indicate battery voltage as measured inside the Freedom 20. Each LED segment indicates .5 volts on 12 volt models and 1 volt on 24 volt models. The DC volts bar graph will stop indicating battery voltage and display the dip switch settings if the unit shuts down due to an overload. It will return to indicating battery voltage only after the unit has been reset.

## DC Amps Bar Graph

These LEDs approximate DC input current in inverter mode and DC output current in battery charger mode. Two ranges are used, below 50 amps each segment represents a 10 amp increment, above 50 amps each segment represents a 20 amp increment. Each segment that flashes above 30, should have 100 amps added to that (flashing 50 = 150 amps DC). If the inverter is in its idle mode, the bottom LED segment will be out. As soon as the unit is pulled out of idle, the bottom segment will illuminate. This indicator is useful when adjusting the idle sensitivity using the dip switches.

The DC amps bar graph will stop indicating DC amps and will indicate the type of problem if a shutdown occurs. Each LED segment indicates a different problem as described in the

## THE REMOTE CONTROL PANEL

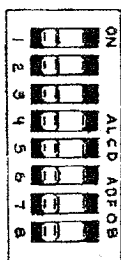
troubleshooting section on page 40.

### System Status LEDs

These 4 LEDs monitor the system as described in the table on page 12.

### Dip Switches

On the rear of the remote control is a series of 8 dip switches. If you look closely at the switch block you will see that each switch is labeled, 1 through 8, and the ON position is indicated. Following is a discussion of each adjustment. See the table on page 12 for dip switch programming.



**Equalize or 3-Stage Charging-** (Switch #1) Cycling this switch ON for 1 second, then OFF, will initiate an equalizing charge cycle. The battery charger must be engaged before cycling the switch. The dip switch must always be left in the OFF position. If it is left ON, an equalizing charge cycle will initiate every time the charger is engaged - this could cause battery damage.

The equalizing cycle is timed to last 8 hours from the time the switch is cycled, at which point the charger resumes normal charging in the float stage.

The BATTERY LED blinks when equalizing. See page 36 for a dis-

cussion of the theory and procedure for battery equalizing.

**Battery Type-** (Switch #2 & 3) Gel cell and wet cell batteries have slightly different charge voltage requirements and optimum battery charging is temperature dependent. For these reasons, the dip switches allow four different battery charger voltage set points, depending on battery type and ambient temperature:

**Cool Wet Cell** ( < 27 degrees C.)

**Warm Wet Cell** ( > 27 degrees C.)

**Cool Gel Cell** ( < 27 degrees C.)

**Warm Gel Cell** ( > 27 degrees C.)

See the table on page 13 for the specific voltages for each setting.

**Auto Charge-** (Switch #4) When turned ON, this switch allows the power ON/OFF switch on the front of the remote to control the battery charger as well as the inverter. With AC input, the transfer function continues to operate with or without the charger engaged.

**Idle Sensitivity-** (Switch #5 & 6) Most installations will be connected to the electrical system, which in itself, with no appliances turned on, represents a small load. This is due to the capacitance of the wires themselves. Using a trial and error process, the idle circuit can be adjusted until the unit will detect small loads



## THE REMOTE CONTROL PANEL

but still drop into idle mode when all loads are shut off.

Please note that some small loads may not pull the unit out of idle mode. In this case you may disable the idle circuit or use an additional load, such as a small incandescent light, to first activate the idle circuitry. You can confirm if the unit is in idle mode by checking the DC Amps bar graph, the lowest LED goes out only when the unit is in idle mode.

A volt meter can also be used to confirm the idle condition. Idle mode output voltage will typically measure between 10 and 55 volts with an averaging AC volt meter. See the Troubleshooting section for a discussion of measuring inverter output voltage with a meter.

**Power Sharing**-(Switch #7 & 8)  
These switches should be set to match the value of the circuit breaker which protects the incoming AC power. For instance, in most RV parks or marinas a 15 amp circuit is available.

Use the 2.5 amp setting for small generators, or for charging deeply discharged batteries.

### Remote Control Wiring

The remote control panel is supplied with 7.62 m or 15.24 m of RJ11

remote cable. The cable supplied may be 6 conductor, however only 4 conductors are required. You may buy standard 4 conductor telephone cable and run up to 15.24 m if desired. Use only a single length of telephone wire, do not splice.

### Link 2000 Remote Control Panel

The Link 2000 and 2000R offer increased monitoring and control options. In addition to providing inverter/charger control, the Link 2000 enable precision monitoring of DC voltage, current, and amp hours for two battery banks.

The Link 2000R adds the ability to control an engine driven alternator. This precision regulator transforms an alternator into a 3 stage battery charging system like the charger in the Freedom 20.

If a Link 2000R remote is being used to control the inverter/charger, refer to the Link manual for setup and control information.

System current consumption vs. idle mode

Idle Mode	W/Remote	WO/Remote
Normal Idle	181 mA	120 mA
Idle Circuit Disabled	496 mA	NA
Unit Shut Off	16 mA	7 mA

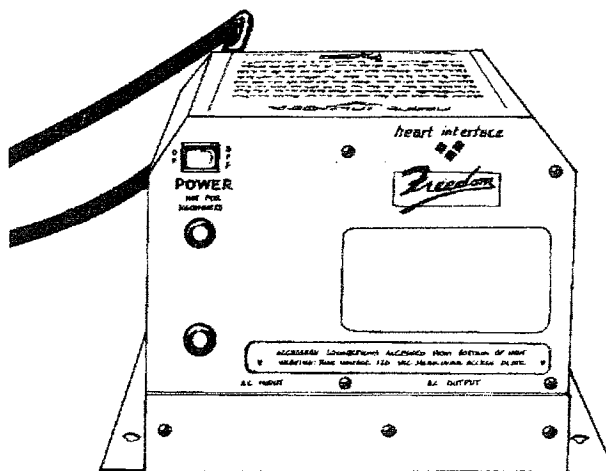
# OPERATION

The only control on the Freedom 20 itself is the power switch. This switch controls ON/OFF and RESET for the inverter. Expect a 3 second delay when the power switch is turned ON before the unit is activated.

If installed with the remote control panel, the power switch on the unit itself should be left in the OFF position. Refer to Remote Control Panel, page 7.

If the unit is connected to external AC power, the power switch may be turned off, the battery charger will continue to function (refer to page 8) Remote Control Dip Switch Function (switch #4). The internal transfer switch will continue to be engaged with the switch off and AC power will be available at the output of the unit. If AC power is removed the unit will not come on as an inverter.

Inverter overload protection, idle mode circuitry, transfer switching, power sharing and battery charger regulation will all function automatically.



## WARNING

*The power switch controls the inverter function. Placing the switch in the "OFF" position disables the inverter and connects mains to the output.*

## STATUS LEDs

Status LED	Appearance	Purpose
INV/CHRG (Inverter/Charger)	On Steady	Power on light. It will be illuminated whenever the power switch is on (inverter on) or when there is incoming AC power and the charger comes on.
AC Input	On Steady	Illuminates when incoming AC power has been applied and the transfer relays have engaged. There is a 7-12 second delay from the time the AC is applied and this LED illuminates.
Overload	On Steady	Indicates an over-temperature condition, the unit is shut down.
Overload	On Blinking	Inverter mode- Shutdown, diagnose problem with DC Amps bar graph. Charger mode- Thermal shutdown, after cooling reset by cycling power switch.
Battery (12 volt model)	On Steady	This is High/Low Battery warning condition. Inverter mode: Battery > 15.25 or < 10.50 volts Charger mode: Battery > 15.25 or < 10.00 volts
Battery (12 volt model)	On Blinking	Indicates either a shutdown or equalizing. Battery > 15.50 volts will auto-reset at 15.25. Inverter mode: Battery < 10.00 volts, will auto reset at charger float voltage or upon AC input. Charger mode: Battery < 8.00 volts for 1 minute, remove all DC loads and manually reset by cycling the power switch.
Battery (24 volt model)	On Steady	This is High/Low Battery warning condition. Inverter mode: Battery > 30.5 or < 21 volts Charger mode: Battery > 30.5 or < 20 volts
Battery (24 volt model)	On Blinking	Indicates either a shutdown or equalizing. Battery > 31 volts will auto-reset at 30.5. Inverter mode: Battery < 20 volts, will auto reset at charger float voltage or upon AC input. Charger mode: Battery < 16 volts for 1 minute, remove all DC loads and manually reset by cycling the power switch.

# DIP SWITCH PROGRAMMING

Feature	Switch Number		Set Point
Equalize or 3 Stage Charging	1		
	Toggle On/Off		Equalize (Do not leave on.)
	Off		3 Stage Charging*
Battery Type**	2	3	
	On	On	Warm Gel Cell (>27 deg. C.)
	Off	On	Cool Gel Cell (<27 deg. C.)
	On	Off	Warm Wet Cell (>27 deg. C.)
	Off	Off	Cool Wet Cell (<27 deg. C.)*
Auto Charge	4		
	On		Disable: Charger responds to On/Off switch.
	Off		Enable: Charger on when AC connected.*
Idle Sensitivity	5	6	
	On	On	Idle Disabled
	Off	On	15 Watts
	On	Off	6 Watts
	Off	Off	4 Watts*
Power Sharing	7	8	
	On	On	2.5 Amps
	Off	On	7.5 Amps
	On	Off	10 Amps
	Off	Off	15 Amps*

\* indicates factory default setting

# BATTERY CHARGER VOLTAGE SETTINGS

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Battery Type and Temperature	Acceptance Voltage**	Float Voltage	Equalize Voltage
12 Volt Wet Cell Warm Temperature	13.9**	13.3	15.8
12 Volt Wet Cell Cool Temperature	14.3**	13.4	16.3
12 Volt Gel Cell Warm Temperature	14.1**	13.8	14.1*
12 Volt Gel Cell Cool Temperature	14.4**	13.8	14.4*
24 Volt Wet Cell Warm Temperature	27.8**	26.6	31.6
24 Volt Wet Cell Cool Temperature	28.6**	26.8	32.6
24 Volt Gel Cell Warm Temperature	28.2**	27.6	28.2
24 Volt Gel Cell Cool Temperature	28.8**	27.6	28.8

\* When switch #2 & #3 are set for gel cells, the equalize mode is effectively disabled.

\*\* Bulk charge at maximum current until acceptance voltage is reached.

*If using TC 2+2 refer to page 43 for voltage settings*

# INSTALLATION PRECAUTIONS

---

**CAUTION** This equipment is **not ignition protected** and employs components that tend to produce arcs or sparks. To reduce the risk of fire or explosions, **do not install in compartments containing batteries or flammable materials** or areas in which ignition-protected equipment is required.

## WARNING

For continued protection against risk of electric shock, **use only the residual current circuit breaker (RCCB) type receptacles.** Other types may fail to operate properly when connected to this inverter, resulting in a potential shock hazard.

**CAUTION** To reduce the risk of electric shock and prevent premature failure due to corrosion, **do not mount where exposed to rain or spray.**

**CAUTION** To prevent fire, **do not obstruct ventilation openings. Do not mount in a zero clearance compartment,** overheating may result.

**NOTICE** The **output of this device is not sinusoidal.** It has a maximum total harmonic distortion of 47% and a maximum single harmonic of 34%.

**CAUTION Risk of electrical shock. Both AC & DC voltage sources are terminated inside this equipment.** Each circuit must be individually opened before servicing. When solar array is exposed to light it supplies a DC voltage to the battery and this equipment.

**CAUTION** Risk of electrical shock. **Do not remove cover, no user serviceable parts inside.** Refer servicing to qualified service personnel.

**APPLICATION INFORMATION** Provided with **integral electronic protection against AC & DC overloads.**

# INSTALLATION

The Freedom 20 is appropriate for installation in recreational vehicle (RV), residential solar installations and marine applications. The installation instructions for each application will be discussed separately. Refer to the separate installation guide for typical installation examples.

## Key Installation Points

1. **Observe proper polarity** when connecting batteries. Reverse DC polarity will result in damage to the Freedom 20.
2. **Do not back feed the AC output of the inverter with incoming AC power.** Double check all aspects of your AC wiring for the possibility of back-feeding. A back feed will cause significant damage to your unit.
3. **Do not connect the AC input to the AC output.** In effect, this would be plugging the battery charger into the inverter. This could occur if the Freedom 20 is connected to the entire leg of a circuit breaker panel, then a circuit breaker on that leg is used to feed the battery charger. This will cause the unit to oscillate on and off when the unit is in inverter mode.
4. **Always use proper wire and connectors,** keeping in mind that considerable amperage flows in the DC circuit. Fusing the positive DC

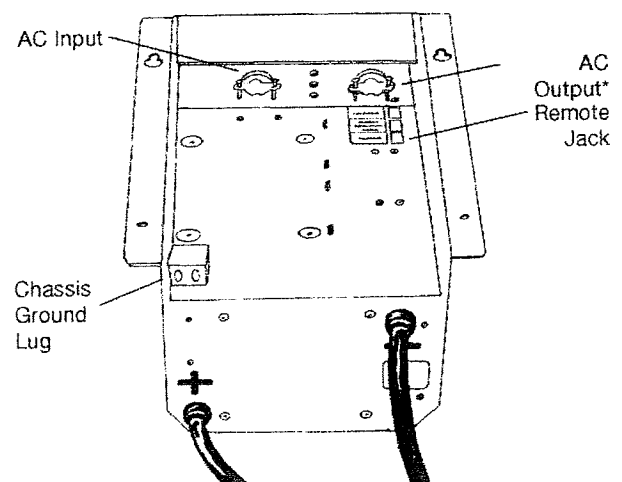
cable is required.

5. **Keep the Freedom 20 out of the elements and out of direct contact with water.** Remember that the unit is a piece of electronic equipment and treat it accordingly.
6. **Mount the unit as close to the batteries as possible** but not in the presence of flammable fumes or in an enclosed battery compartment.
7. **Do not bolt the unit down until the AC, remote and ground wiring is completed.**

## RECREATIONAL VEHICLE INSTALLATION

### Location

1. **The connectors for the remote control and the chassis ground bonding lug, as well as for the AC**



## RV INSTALLATION

---

wires, are located on the bottom of the unit. Be sure to make these connections before bolting the unit down.

**2. Always mount the unit in a dry area**, out of direct contact with water or spray.

**3. You may mount the unit horizontally** (on a shelf) **or vertically** (on a wall or bulkhead). If mounted vertically, you must orient the unit so the switch and circuit breakers are facing up and the fan and battery cables are facing down.

**4. Allow 13 cm of (minimum) clearance** around the unit and allow for a supply of fresh air to the cooling fan. Do not block any of the vents or louvers. The fan pulls air from outside the unit. It blows the air across the internal components, particularly the transformer and heat sinks, then out the side vents.

**5. The mounting location should be as close to the batteries as possible.** The battery cables can be extended, however each cable must not be over 3.04 m in total length. Do not use the RV chassis as a negative conductor.

### WARNING

*Do not mount the unit in an enclosed battery compartment. Take precautions to keep road dirt and spray off the unit.*

## Grounding

For safety purposes, **the chassis of the Freedom 20 must be connected to your AC ground system.** The chassis ground bonding lug is located on the bottom of the unit. This connector can accept two wires, the first is used to connect the unit to AC ground, the second can be used to connect other AC equipment to ground.

Use **16 mm<sup>2</sup> ES (Euro Standard) green insulated wire**, strip one end and use a screwdriver to secure it to the chassis ground bonding lug. This wire will connect to the ground in your AC electrical system, typically the vehicle chassis. Make sure the connection is clean and tight.

This procedure will connect the chassis of your Freedom 20 to AC ground. In addition, the AC input and AC output green/yellow wires are connected to chassis ground. It is important to connect these wires to the AC ground bus in the circuit breaker panel.

Please note that the battery cables are not connected to ground or the chassis of the Freedom 20.

## Neutral Bonding

For safety purposes, the Freedom 20 internally bonds the blue AC output neutral wire to the green/yellow AC ground wire when the unit is OFF or in



the inverter mode. When incoming AC power is applied and the transfer switch is engaged, the internal Neutral-to-Ground bond is automatically lifted.

This means that when the RV is in a campground, the grounding system is connected to the shore power ground, where neutral and earth ground are bonded together. This technique insures safety in all conditions and conforms to the requirements of numerous electrical codes.

### AC Wiring

Use a screwdriver to remove the screws which secure the AC wiring compartment cover plate. Inside you will see the compartment is divided into 2 sections, one labeled AC INPUT the other labeled AC OUTPUT. The AC input side contains 3 pigtails: blue, brown, green/yellow. The AC output side contains 1 each brown, blue, green/yellow and solid green pigtails. In addition wire nut connectors are provided.

**Brown = Hot or Line**

**Blue = Neutral**

**Green/Yellow = Ground**

**Solid Green (AC output only) = Internal output neutral to ground bonding conductor.**

Note that at the AC output, the green/yellow and solid green wires are already connected together.

Conventional metal strain reliefs are provided. These can be replaced by plastic strain reliefs for additional corrosion resistance or 2 cm conduit fittings if the wiring will be routed through conduit. Flexible conduit is recommended.

You must use 6.0 mm<sup>2</sup> ES copper wire with insulation rated for 60 degrees centigrade or higher for both the AC input and AC output.

**AC Input:** Feed the 3 conductor AC input wires through the strain reliefs and into the AC input compartment. You should have about 15 cm of individually insulated brown, blue and green/yellow wire. Strip about 1 cm of insulation off each conductor and connect to the Freedom 20 pigtails: Brown to Brown, Blue to Blue and Green/Yellow to Green/Yellow.

Use the wire nuts provided to make the wire connections.

**AC Output:** Feed the 3 conductor AC output wire through its strain relief and into the AC output compartment. You should have about 15 cm of individually insulated brown, blue and green/yellow wire. Strip about 1 cm of insulation off each

## RV INSTALLATION

### WARNING

*Do not connect incoming AC from any source to the AC output of the inverter. This is known as back-feeding and will damage the unit and void the warranty.*

conductor and connect the Freedom 20 pigtails; Brown to Brown; Blue to Blue; and Green/Yellow to Green/Yellow to solid Green (three wires connected together).

In addition if internal output Neutral-to-Ground bond is not required, remove the solid Green wire from the Green/Yellow wires and cap with a wire nut.

Tug firmly on each connection to test it. These connections are the first thing to check if the unit seems not to be operating properly.

Carefully and neatly tuck the wires into the AC wiring compartment. Replace the cover plate.

### Residual Current Circuit Breaker

In order to conform to the numerous electrical codes, certain branch circuits must be equipped with a Residual Current circuit breaker (RCCB). Please consult the code or a qualified electrician for details. Any

such branch circuit must be protected by a circuit breaker consistent with the (RCCB) rating.

### Remote Control Wiring

The remote control is supplied with a 7.62 m or 15.24 m of RJ11 - remote cable for connection to the unit. Simply plug one end of the cable into the remote connector on the bottom of the unit and the other end into the connector on the back of the remote control panel.

Routing the remote cable away from AC and DC wires will minimize the potential for interference which may affect the LED bar displays.

The remote control cable can be extended up to 15.24 m if required. Use standard 4 remote RJ11 cable. Use a single length of cable with no connectors or in-line splices.

If some remote RJ11 cable is left over, coil it up and store it in an area away from AC equipment to prevent electrical interference.

Once the above steps have been completed the unit can be bolted down.

### DC Wiring

Two battery cables are provided with the unit. Both are black, the positive cable has a piece of red heat shrink insulation on the end. Keep

**WARNING**

*The Freedom 20 is not DC reverse polarity protected. Be very careful to connect the negative and positive cables correctly, otherwise damage will result and the warranty will be void.*

in mind that high current will pass through the DC wiring. All wires must be properly sized and all connections clean and tight.

It is recommended that the battery cables not be lengthened at all, however it is possible to extend the cables if necessary. Extension cables must be 70.0 mm<sup>2</sup> ES, the same type of wire, and the total length for each battery cable must not exceed 3.04 m.

Make sure the connections to the extension cables are tight and properly insulated. Do not attempt to open the case and replace the battery cables.

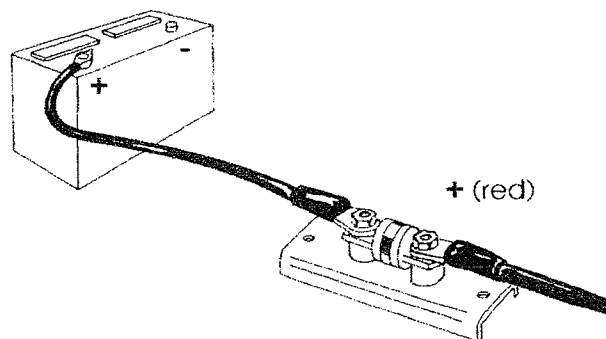
The negative cable should be connected directly to the negative post of the battery bank or the ground side of a current shunt. Do not use the RV frame as the negative conductor. Tighten securely.

The positive battery cable must be fused and connected to the positive post of the battery bank, or through a selector switch to one or more battery banks.

**Battery Cable Fusing**

A spark may be generated when the final battery connection is made. This is normal and do not be alarmed. However, do not make the final connection in the presence of flammable fumes.

A fuse is required for safety reasons to protect the battery and cables. The fuse must be installed in the positive battery cable, within 45.7 cm of the battery.

**Recommended fuse:****Littlefuse Class T JLLN 300 amp**

This fuse with fuse holder is available from your dealer or Heart Interface.

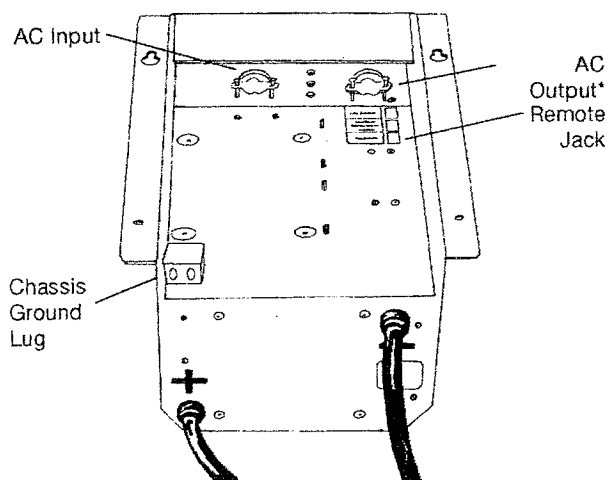
Fuse and Holder	PN# 84-4156-00
Fuse only	PN# 84-4151-00

## MARINE INSTALLATION

### MARINE INSTALLATION

#### Location

1. **The connectors for the remote control and the chassis ground bonding lug, as well as for the AC wires, are located on the bottom of the unit.** Be sure to make these connections before bolting the unit down.
2. **Always mount the unit in a dry area**, out of direct contact with water or spray.
3. **You may mount the unit horizontally** (on a shelf) **or vertically** (on a wall or bulkhead). If mounted vertically, you must orient the unit so the switch and circuit breakers are facing up and the fan and battery cables are facing down.



4. **Allow 13 cm (minimum) of clearance** around the unit and allow for a supply of fresh air to the cooling fan. Do not block any of the vents or louvers. The fan pulls air from outside the unit. It blows the air across the internal components, particularly the transformer and heat sinks, then out the side vents.

5. **The mounting location should be as close to the batteries as possible.** The battery cables can be extended, however each cable must not be over 3.04 meters in total length.

#### Grounding

For safety purposes, **the chassis of the Freedom 20 must be connected to your AC ground system.** The chassis ground bonding lug is located on the bottom of the unit. This connector can accept two wires, the first is used to connect the unit to **AC** ground, the second can be used to connect other **AC** equipment to ground.

### WARNING

*Do not mount the unit in a gasoline powered engine compartment or in an enclosed battery compartment. **Diesel engine compartments are acceptable locations**, but take precautions to keep dirt and spray off the unit.*

Use **5.0 mm<sup>2</sup> ES (Euro Standard) green insulated wire**, strip one end and use a screwdriver to secure it to the chassis ground bonding lug. This wire will connect to the ground in your AC electrical system. Make sure the connection is clean and tight.

This procedure will connect the chassis of your Freedom 20 to AC ground. In addition, the AC input and AC output green/yellow wires are connected to chassis ground. It is important to connect these wires to the AC ground bus in the circuit breaker panel.

Please note that the battery cables are not connected to ground or the chassis of the Freedom 20.

### Neutral Bonding

For safety purposes, the Freedom 20 internally bonds the blue AC output neutral wire to the green/yellow AC ground wire when the unit is OFF or in the inverter mode. When incoming AC power is applied and the transfer switch is engaged, the internal neutral to ground bond is automatically lifted.

This means that when the boat is in a marina, the grounding system is connected to the shore power ground, where neutral and earth

ground are bonded together. This technique insures safety and conforms to the requirements of numerous electrical codes.

Refer to other applicable electrical codes regarding connections between AC ground and DC ground for marine applications.

### AC Wiring

Use a screwdriver to remove the screws which secure the AC wiring compartment cover plate. Inside you will see the compartment is divided into 2 sections, one labeled AC INPUT the other labeled AC OUTPUT. The AC input side contains 3 pigtails: brown, blue and green/yellow. The AC output side contains 1 each brown, blue, green/yellow and solid green pigtails. In addition wire nut connectors are provided.

**Brown = Hot or Line**

**Blue = Neutral**

**Green/Yellow = Ground**

**Solid green (AC output only) = Internal output neutral to ground bonding conductor.**

Note that at the AC output, the green/yellow and solid green wires are already connected together.

Conventional metal strain reliefs are provided. These can be replaced by plastic strain reliefs for additional

## MARINE INSTALLATION

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corrosion resistance or 2 cm conduit fittings if the wiring will be routed through conduit. Flexible conduit is recommended.

You must use 2.5 mm<sup>2</sup> ES copper wire with insulation rated for 60 degrees centigrade or higher for both the AC input and AC output.

**AC Input:** Feed the 3 conductor AC input wires through the strain reliefs and into the AC input compartment. You should have about 15 cm of individually insulated brown, blue and green/yellow wire. Strip about 1.2 cm of insulation off each conductor and connect to the Freedom 20 pigtails: Brown to Brown, Blue to Blue and Green/Yellow to Green/Yellow.

To meet marine electrical codes, you may want to use butt splices instead of the wire nuts provided to make the wire connections.

### WARNING

*Do not connect incoming AC from any source to the AC output of the inverter. This is known as back-feeding and will damage the unit and void the warranty.*

**AC Output:** Feed the 3 conductor AC output wire through its strain relief and into the AC output compartment. You should have about 15 cm of individually insulated brown, blue and green/yellow wire. Strip about 1 cm of insulation off each conductor and connect the Freedom 20 pigtails: Brown to Brown; Blue to Blue; and Green/Yellow to Green/Yellow to solid Green (three wires connected together).

In addition if internal output Neutral-to-Ground bond is not required, remove the solid Green wire from the Green/Yellow wires and cap with a wire nut.

Tug firmly on each connection to test it. These connections are the first thing to check if the unit seems not to be operating properly.

Carefully and neatly tuck the wires into the AC wiring compartment. Replace the cover plate.

### Residual Current Circuit Breaker

In order to conform to the numerous electrical codes, certain branch circuits must be equipped with a Residual Current circuit breaker (RCCB). Please consult the code or a qualified electrician for details. Any such branch circuit must be protected by a circuit breaker consistent with the (RCCB) rating.

### Remote Control Wiring

The remote control is supplied with a 7.62 m or 15.24 m of RJ11 remote cable for connection to the unit. Simply plug one end of the cable into the remote connector on the bottom of the unit and the other end into the connector on the back of the remote control panel.

Routing the remote cable away from AC and DC wires will minimize the potential for interference which may affect the LED bar displays. The remote control cable can be extended up to 15.24 m if required. Use standard 4 conductor remote RJ11 cable. Use a single length of cable with no connectors or in-line splices. If some remote RJ11 cable is left over, coil it up and store it in an area away from AC equipment to prevent electrical interference.

Once the above steps have been completed the unit can be bolted down.

### WARNING

*The Freedom 20 is not DC reverse polarity protected. Be very careful to connect the negative and positive cables correctly, otherwise damage will result and the warranty will be void.*

### DC Wiring

Two battery cables are provided with the unit. Both are black, the positive cable has a piece of red heat shrink insulation on the end. Keep in mind that high current will pass through the DC wiring. All wires must be properly sized and all connections clean and tight.

It is recommended that the battery cables not be lengthened at all, however it is possible to extend the cables if necessary. Extension cables must be 70.0 mm<sup>2</sup> ES, the same type of wire, and the total length for each battery cable must not exceed 3.04 m.

Make sure the connections to the extension cables are tight and properly insulated. Do not attempt to open the case and replace the battery cables.

The negative cable should be connected directly to the negative post of the battery bank or the ground side of a current shunt. Do not use a negative bus or bonding system as the negative conductor. Tighten securely.

The positive battery cable must be fused and connected to the positive post of the battery bank, or through a selector switch to one or more battery banks.

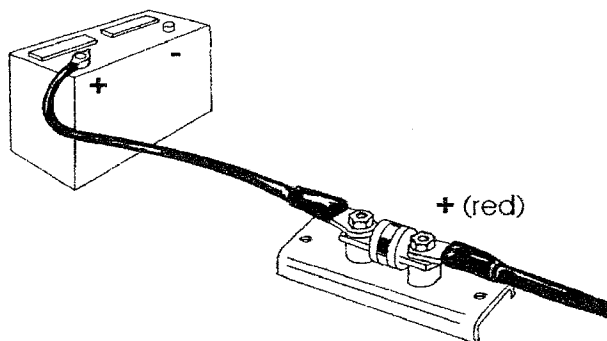
## MARINE INSTALLATION

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A spark may be generated when the final battery connection is made. This is normal. Do not be alarmed, however, do not make the final connection in the presence of flammable fumes.

### BATTERY CABLE FUSING

A fuse is required for safety reasons to protect the battery and cables. The fuse must be installed in the positive battery cable, within 45.7cm of the battery.



#### **Recommended fuse:**

#### **Littlefuse Class T JLLN 300 amp**

This fuse with fuse holder is available from your dealer or Heart Interface.

Fuse and Holder	PN# 84-4154-00
Fuse only	PN# 84-4151-00

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## RESIDENTIAL SOLAR INSTALLATION

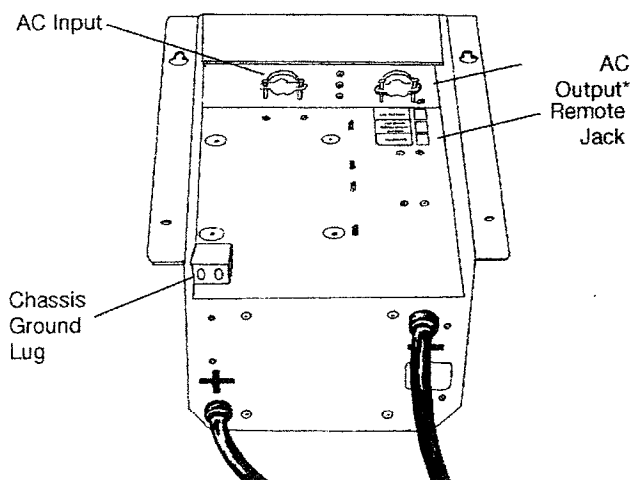
### RESIDENTIAL SOLAR INSTALLATION

#### Location

**1. The connectors for the remote control and the grounding electrode terminal, as well as one option for the AC wires, are located on the bottom of the unit.** Be sure to make these connections before bolting the unit down.

**2. Always mount the unit in a dry area,** out of direct contact with water or spray.

**3. You may mount the unit horizontally** (on a shelf) **or vertically** (on a wall). If mounted vertically, you must orient the unit so the switch and circuit breakers are facing up and the fan and battery cables are facing down.



**4. Allow 13 centimeters (minimum) of clearance** around the unit and allow for a supply of fresh air to the cooling fan. Do not block any of the vents or louvers.

**5. The mounting location should be as close to the batteries as possible.** The battery cables can be extended, however each cable must not be over 3.04 centimeters in total length.

## WARNING

*Do not mount the unit in an area exposed to flammable fumes or in an enclosed battery compartment.*

#### Grounding

For safety purposes **the chassis of the Freedom 20 must be connected to your AC grounding system.** The chassis grounding terminal is located on the bottom of the unit. This connector can accept two wires, the first is used to connect the unit to the earth grounding system, the second can be used to connect other equipment to the grounding system, through the unit.

Use a **16.0 mm<sup>2</sup> ES (Euro Standard) green insulated or bare copper wire** if no other equipment is

## RESIDENTIAL SOLAR INSTALLATION

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grounded through the unit. If additional equipment is connected to the chassis grounding terminal larger wire may be required. Consult local electrical codes for details.

Strip one end of the wire and use a screwdriver to secure it to the chassis grounding terminal. This wire will connect to the equipment ground system either at the earth ground electrode or at an electrical equipment enclosure ground bonding terminal. In either case you must insure that the ground bonding wire does not become smaller between the Freedom 20 and the earth ground point. Make sure each connection is clean and tight.

This procedure will connect the chassis of your Freedom 20 to ground. In addition, the AC input and AC output green wires are connected to chassis ground. It is important to connect these wires to the AC ground bus in the circuit breaker panel.

Please note that neither of the battery cables is connected to ground or the chassis of the Freedom 20.

### Neutral Bonding

For safety purposes, the Freedom 20 internally bonds the blue AC output neutral wire to the green/yellow

AC ground wire when the unit is OFF or in the inverter mode. When incoming AC power is applied and the transfer switch is engaged, the internal neutral to ground bond is automatically lifted.

This technique meets safety requirements of numerous Electrical Codes. Refer to other applicable electrical codes regarding connections between AC ground and DC ground.

### AC Wiring

Use a screwdriver to remove the screws which secure the AC wiring compartment cover plate. Inside you will see the compartment is divided into 2 sections, one labeled AC INPUT the other labeled AC OUTPUT. The AC input side contains 3 pigtails: brown, blue and green/yellow. The AC output side contains 1 each brown, blue, green/yellow and solid green pigtails. In addition wire nut connectors are provided.

**Brown = Hot or Line**

**Blue = Neutral**

**Green/Yellow = Ground**

**Solid green (AC output only) = internal output neutral to ground bonding conductor.**

Note that at the AC output, the green/yellow and solid green wires are already connected together.

Conventional metal strain reliefs are provided. These can be replaced by plastic strain reliefs for additional corrosion resistance or 2 cm conduit fittings if the wiring will be routed through conduit. Flexible conduit is recommended.

You must use 6.0 mm<sup>2</sup> ES copper wire with insulation rated for 60 degrees centigrade or higher for both the AC input and AC output.

**AC Input:** Feed the 3 conductor AC input wires through the strain reliefs and into the AC input compartment. You should have about 15 cm of individually insulated brown, blue and green/yellow wire. Strip about 1.2 cm of insulation off each conductor and connect to the Freedom 20 pigtails: Brown to Brown, Blue to Blue and Green/Yellow to Green/Yellow.

Use wire nuts provided to make the wire connections.

**AC Output:** Feed the 3 conductor AC output wire through its strain relief and into the AC output compartment. You should have about 15 cm of individually insulated brown, blue and green/yellow wire. Strip about 1 cm of insulation off each conductor and connect the Freedom 20 pigtails; Brown to Brown; Blue to Blue; and Green/Yellow to Green/

### WARNING

*Do not connect incoming AC from any source to the AC output of the inverter. This is known as back-feeding and will damage the unit and void the warranty.*

Yellow to solid Green (three wires connected together).

In addition, if internal output Neutral-to-Ground bond is not required, remove the solid Green wire from the Green/Yellow wires and cap with a wire nut.

Tug firmly on each connection to test it. These connections are the first thing to check if the unit seems not to be operating properly.

Carefully and neatly tuck the wires into the AC wiring compartment. Replace the cover plate.

### Residual Current Circuit Breaker

In order to conform to the numerous electrical codes, certain branch circuits must be equipped with a Residual Current circuit breaker (RCCB). Please consult the code or a qualified electrician for details. Any such branch circuit must be protected by a circuit breaker consistent with the (RCCB) rating.

## RESIDENTIAL SOLAR INSTALLATION

### Remote Control Wiring

The remote control is supplied with a 7.62 m or 15.24 m of RJ11 remote cable for connection to the unit. Simply plug one end of the cable into the remote connector on the bottom of the unit and the other end into the connector on the back of the remote control panel.

Routing the remote cable away from AC and DC wires will minimize the potential for interference which may affect the LED bar graphs.

The remote control cable can be extended up to 15.24 m if required. Use standard 4 conductor remote RJ11 cable. Use a single length of cable with no connectors or in-line splices.

If some remote RJ11 is left over, coil it up and store it in an area away from AC equipment to prevent electrical interference.

Once the above steps have been completed the unit can be bolted down.

### DC Wiring

Two battery cables are provided with the unit. Both are black, the positive cable has a piece of red heat shrink insulation on the end. Keep in mind that high current will pass through the DC wiring. All wires must be properly sized and all connections clean and tight.

## WARNING

*The Freedom 20 is not DC reverse polarity protected. Be very careful to connect the negative and positive cables correctly, otherwise damage will result and the warranty will be void.*

It is recommended that the battery cables not be lengthened at all, however it is possible to extend the cables if necessary. Extension cables must be 70.0 mm<sup>2</sup> ES, the same type of wire, and the total length for each battery cable must not exceed 3.04 m.

Make sure the connections to the extension cables are tight and properly insulated. Do not attempt to open the case and replace the battery cables.

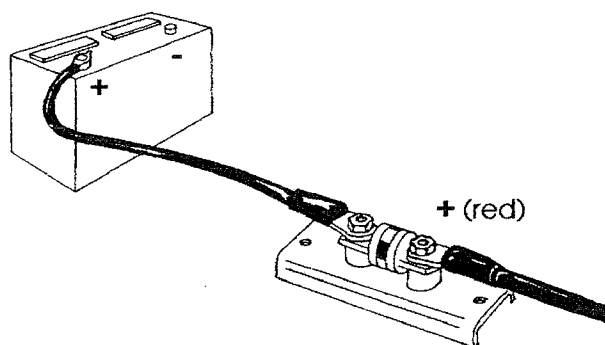
The negative cable should be connected directly to the negative post of the battery bank or the ground side of a current shunt. Tighten securely.

The positive battery cable must be fused and connected to the positive post of the battery bank, or through a selector switch to one or more battery banks.

A spark may be generated when the final battery connection is made. This is normal and do not be alarmed, however, do not make the final connection in the presence of flammable fumes.

### BATTERY CABLE FUSING

A fuse is required for safety reasons to protect the battery and cables. The fuse must be installed in the positive battery cable, within 45.7 cm of the battery.



#### **Recommended fuse:**

#### **Littlefuse Class T JLLN 300 amp**

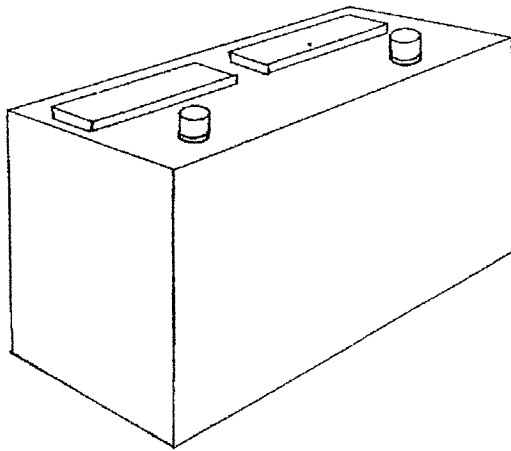
This fuse with fuse holder is available from your dealer or Heart Interface.

Fuse and Holder	PN# 84-4154-00
Fuse only	PN# 84-4151-00

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# BATTERIES

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## BATTERY TYPES

Use only deep-cycle batteries with your Freedom inverter/charger. These fall into two broad categories, wet cell and gel cell.

### Wet Cell Batteries

True deep-cycle wet cell batteries are characterized by relatively thick plates that are alloyed with antimony. Look for batteries with plates at least .100 inch thick and with antimony content of around 4-6%.

**Common marine/RV deep-cycle batteries are the least expensive and lowest quality** battery that is acceptable. **Golf cart batteries are much better** in terms of performance and life, these are 6 volt batteries that must be used in series pairs. **High quality marine deep-cycle batteries offer good performance**

and are available in a wide variety of sizes. Floor sweeper, fork lift or large 2 volt cells can also offer excellent performance if their large size can be accommodated.

It should be noted that high antimony deep-cycle batteries will give off gas as a natural result of charging and will experience some water loss. **It is very important that the electrolyte level be checked frequently** and topped off with distilled water when necessary. Never allow the tops of the plates to be exposed to air, as contamination of the cell will result. Keeping the tops of the batteries clean will reduce self-discharging. Always provide ventilation for the battery storage compartment.

**Do not use car batteries or engine starting batteries of any kind** with your inverter/charger. Beware of any battery that is rated in Cold Cranking Amps (CCA), as this is a rating which applies only to engine starting batteries. In general, most wet cell batteries that are described as hybrid batteries, suitable for either engine starting or deep-cycle applications are a compromise and will give limited life if deeply discharged. **Beware of 8-D batteries** which are commonly used for starting diesel engines, these batteries are often not deep-cycle.

Also **beware of so-called maintenance-free batteries.** These batteries have calcium alloyed with the lead and hold the liquid electrolyte in a sponge-like material. They are sealed and water cannot be added. Do not confuse them with true gel cell batteries, they will not hold up to deep discharging.

### Gel Cell Batteries

These are lead-acid batteries similar in many ways to the common wet cell battery, but differences in the chemistry and construction provide some unique features.

**No Maintenance-** There is no need to add water and the tops of the batteries stay clean. Also the batteries can be used in any position and are Coast Guard approved for use without a battery box.

**Low Self-Discharging-** Unlike wet cell batteries, the gel cell will hold its charge for months if left sitting with no load and no float charge. They can be stored in the off-season without a constant float charge and without fear of freezing.

**Low Internal Resistance-** The result of this is a higher battery voltage under load, which will result in better inverter performance on demanding high power loads. In addition

this allows the gel cell to accept a high rate of charge, a plus for rapid recharging.

**No Sulfation-** The combination of acids in the gel cell prevents sulfation and eliminates the need for battery equalization.

The result of these features is a battery that solves many common problems. Cycle life is high, even under constant deep discharging. For all these reasons **the gel cell is highly recommended.**

### BATTERY INTERCONNECTION

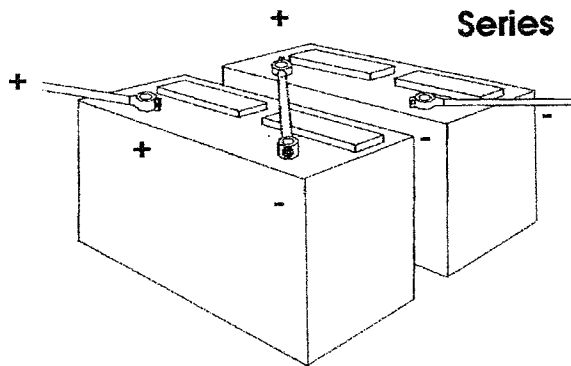
In most cases you will be using a bank of two or more batteries with your inverter/charger. You may connect batteries together in two configurations, series and parallel.

#### Series

**Connecting 2 batteries in series will double the voltage of the battery bank.** For instance, two 6 volt batteries connected in series will produce 12 volts, 4 in series will produce 24 volts. The amp hour capacity of the battery bank will be the same as each individual battery. As an example, two 6 volt 220 amp hour batteries in series will produce one 12 volt 220 amp hour battery bank.

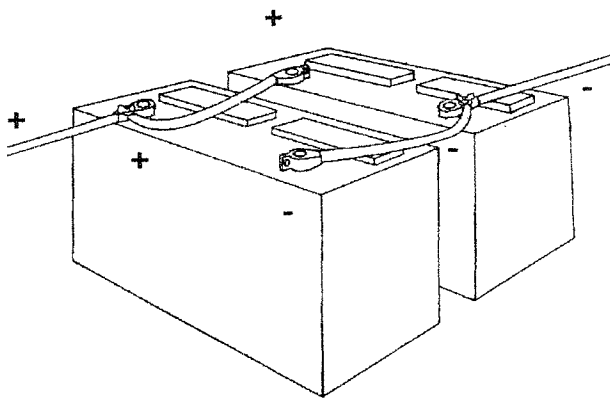
## BATTERIES

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### Parallel

**Connecting 2 batteries in parallel will double the amp hour rating of the battery bank, while the voltage will be the same as each individual battery.** For example, two 12 volt 105 amp hour batteries in parallel will produce one 12 volt 210 amp hour battery bank.



**Only similar batteries should be connected together in one bank.** Do not connect old and new batteries together or wet and gel cell batteries together. In the above drawing, note

that the load is connected to the positive terminal of the first battery and the negative terminal of the last battery. This practice helps to balance the battery bank.

**Always use proper terminals for your interconnecting battery cables and cable which is 00 AWG or larger.**

### Battery Bank Ratings and Sizing

Deep-cycle batteries are usually rated in **amp hours**. The amp hour rating is based on a 20 hour discharge cycle, therefore a 100 amp hour battery can deliver 5 amps for 20 hours. If the discharge rate is greater than 5 amp, the available amp hours are decreased. If the load is increased to 100 amps, only about 45 amp hours will be available.

Another common rating is **reserve capacity** expressed in minutes. This is derived by placing a 25 amp load on the battery and measuring the time until the battery voltage reaches 10.5 volts.

Deep-cycle batteries can be discharged about 80% before permanent damage occurs, though shallower cycling will result in much longer battery life. 50% cycling is generally considered to be a good compromise between long battery life and a reasonably sized battery bank.



## BATTERIES

To achieve 50% cycling you should calculate your amp hour consumption between charging cycles and use a battery bank with twice that capacity.

To calculate amp hour consumption first look at the rating plate on your AC appliances. Each appliance will be rated in either AC amps or AC watts or AC VA (volt-amps) apparent power. Use one of the following formulas to calculate the DC amp hour draw for a 12 volt system:

**$(AC \text{ amps} \times 9) \times 1.1 \times \text{hours of operation} = DC \text{ amp hours} *$**  (Assumes 230 VAC system)

**$(AC \text{ watts} \div 12) \times 1.1 \times \text{hours of operation} = DC \text{ amp hours} *$**

**$(AC \text{ VA} \div 12) \times 1.1 \times \text{hours of operation} = DC \text{ amp hours} *$**  (Assumes load power factor = 1.)

In all formulas, 1.1 is the factor for inverter efficiency.

Calculate the above for every AC appliance you intend to use on your inverter. This will give you the total number of amp hours used between recharges. Size your battery bank using this number as a guideline. A good rule to follow is to size the battery bank about 2 times larger than your total amp hour load requirement. Plan on recharging when 50% discharged.

\* Divide amp hours by two for 24 volt systems.

Typical Power Consumption									
Appliance	Typical Wattage	Appliance Run Times / Amp Hours *							
		5 Min.	15 Min.	30 Min.	1 Hr.	2 Hr.	3 Hr.	8 Hr.	24 Hr.
13" Color TV	50	.33	1	2	4	8	12	32	96
19" Color TV	100	.66	2	4	8	16	24	64	192
VCR	50	.33	1	2	4	8	12	32	96
Lamp	100	.66	2	4	8	16	24	64	192
Blender	300	2	6	12					
Curling Iron	50	.33	1	2					
3/8 Power Drill	500	3.3	10	20					
Icemaker*	200			2.6	5.2	10.4	15.6	41.6	83.2
Coffee Maker	1000	6.6	20	40	80	160			
3 cu' Refrigerator*	150			2	4	8	12	32	96
20 cu' Refrigerator*	750			21	42	84	126	336	672
Compact Microwave	750	5	15	30	60	120	180		
Full Size Microwave	1500	10	30	60	120	240	360		
Vacuum	1100	7.3	22	44	88	176	264		

The Number in each box represents the total Amp hours used (@ 12 volt DC) based on various continuous run times.

\*Note refrigeration is typically calculated using a 1/3-duty cycle.

# BATTERY CHARGING

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## Battery Charging

Completely recharging wet cell deep-cycle batteries requires that the battery voltage be raised beyond what is known as the gassing point. This is the voltage at which the battery begins to bubble and gas is given off. If charging stops short of this point, sulfate is left on the plates and deterioration of the battery begins. The gassing point will vary with battery temperature. At 25 degrees C, the gassing point of a 12 volt battery is about 14.0 volts. Once the gassing point has been reached, the battery voltage must be reduced, to prevent overcharging. This lower voltage charging is known as float charging.

Gel cell batteries must not be charged to their gassing point, in fact high voltage charging which gasses these batteries is harmful to them. However, the chemistry of the gel cell raises the gassing point and requires a similar voltage as the wet cell for a complete recharge. Because these batteries do not give off water vapor, the float voltage can be higher than that of wet cell batteries.

## Conventional Battery Chargers

Most conventional battery chargers are single stage constant voltage chargers, as such they must stop

short of the gassing point or they will overcharge the battery bank. Therefore, most 12 volt battery chargers bring the battery voltage up to about 13.8 volts.

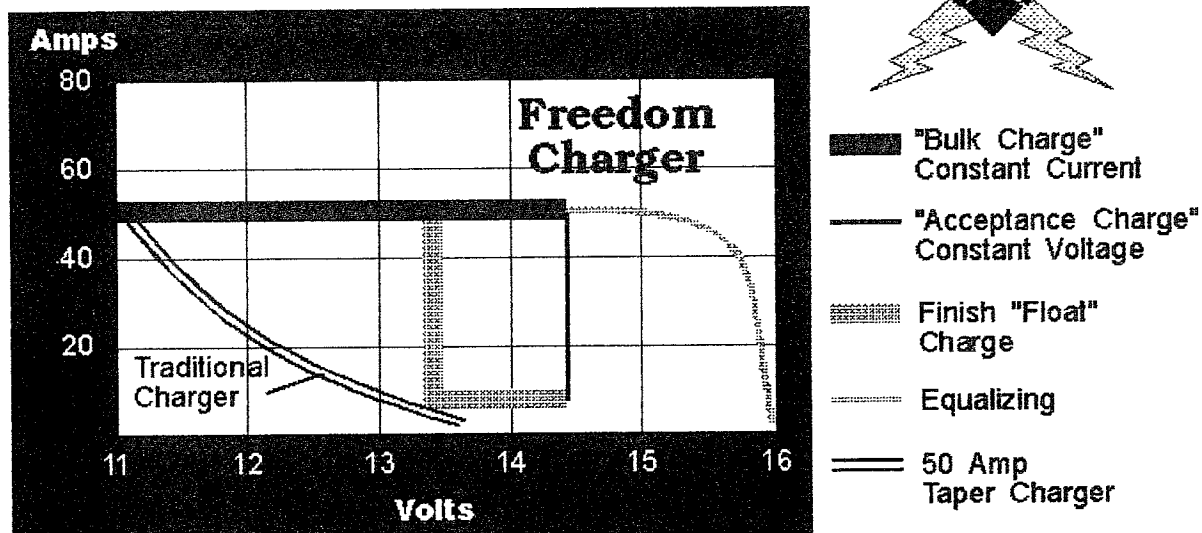
There are two problems with this. First, since the battery voltage does not reach the gassing point, sulfate is left on the plates. Second, 13.8 volts is close enough to the gassing point that some gas will escape, and the battery will need to be frequently topped up with distilled water.

Conventional battery chargers also suffer from another inherent characteristic of their design, which is a tapering output. While they will deliver their rated current into a deeply discharged battery, as the battery becomes charged and the voltage rises, the output current of the charger tapers down. This taper continues as the battery is charged, taking a very long time to reach an acceptable recharge.

## The Freedom Battery Charger

**The Freedom battery chargers are designed to overcome the limitations of conventional chargers by utilizing 3 distinct stages, each designed for optimal recharging of both wet cell and gel cell deep-cycle batteries.**

### The benefits of the Freedom Charger vs. the traditional taper charger.



Quicker more complete recharging, safe long term charging and battery rejuvenation through an equalizing charge.

(12 volt Freedom 10 charge curve shown)

**NOTE:** The Freedom 20 Battery Charger is on whenever there is AC power connected to the charger input, regardless of the condition of the on/off switch. This feature can be disabled by setting the dip switch #4 (back of remote) to "on" so that the charger will respond to the on/off switch.

Each time the battery charger is engaged, the 3 stages proceed automatically, resulting in an efficient, complete recharge and safe battery maintenance. In addition, use of the

remote control provides the ability to periodically apply an 8 hour timed equalizing charge.

#### The battery charger stages are:

**Stage 1- Bulk Charge:** During the bulk charge stage most of the charge current is delivered to the battery bank. This phase is engaged as soon as the battery charger is activated. Full rated charger current is delivered to the battery bank until the bulk charge voltage limit is reached. This results in a relatively rapid recharge.

## BATTERY CHARGING

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It is generally agreed that a wet cell battery bank should not be charged up to the gassing point at a rate which exceeds 25% of its capacity. In other words, a 12 volt battery bank of 400 amp hours should not be charged at over 100 amps.

Gel cell batteries can accept a higher rate of charge, consult the manufacturer for details.

**Stage 2- Acceptance Charge:** The acceptance stage immediately follows the bulk charge stage. During this stage the battery voltage is held constant at the bulk charge voltage limit and the current gradually ramps down. During this stage the battery is accepting its final amount of charge current and the last of the sulfate on the plates is removed.

The acceptance stage lasts until the charge current reaches about 6-7 (3-4\*) amps. A timer will terminate the acceptance stage if this current level is not reached. This timer is set automatically when the dip switches for battery type are set. Maximum acceptance time is 1 hr. for wet cells and 3 hrs. for gel cells. Gel cell acceptance time can be increased because the battery is not gassing. Expect wet cell batteries to gas somewhat during acceptance, this is a necessary part of the charging process.

\* 24 volt model

**Stage 3- Float Charge:** When the acceptance stage is terminated, either because the charge current ramped down to 6-7 (3-4\*) amps or the timer engaged, battery charger current will shut off and the unit monitors the battery voltage while it drifts down from the bulk charge voltage limit. When it reaches the float voltage set point, the float charge stage is engaged.

The float charge stage holds the battery voltage at a lower level, where it is safe for long term battery maintenance. During the float charge stage the full output current of the battery charger is available to operate any DC appliances that may be on the system, while constantly maintaining the float charge voltage.

The battery charger remains in the float charge stage indefinitely until the charger is disconnected from incoming AC power.

**Stage 4- Equalizing Charge:** This is the only battery charger stage which is not engaged automatically. It must be manually initiated each time using a dip switch on the rear of the remote control. Applying an equalizing charge is not possible without the use of a remote.

Periodic equalizing is recommended by most wet cell deep-cycle

battery manufacturers. There are no firm rules for how often an equalizing charge should be applied, but once a month is a good rule of thumb for batteries which are regularly cycled, less often for systems in only occasional use.

The equalizing charge is a timed 8 hour cycle. If desired, it can be ended by interrupting the AC power to the charger at any time during the cycle. Equalizing should be engaged after the batteries have been fully charged by a normal battery charging cycle. The battery voltage will increase to 16.3 (32.6\*) using the cool temperature wet cell setting. This will cause the battery bank to gas profusely and will accomplish the following:

### **1. Removal of residual sulfate.**

Each time a battery is cycled (discharged and recharged), a small amount of sulfate is left on the plates. Over time, this gradual buildup of sulfate will compromise the performance of the battery. By applying an equalizing charge, this sulfate is returned back to the electrolyte, raising the specific gravity and fully exposing the active material of the plates.

### **2. Bring all cells to the same potential.**

All lead-acid batteries are made up of individual 2 volt cells. As

the battery bank is cycled, slight

\* 24 volt model

HI3273CE 3/99  
HP 90-0103-02

differences in the cells results in different cell voltages, affecting the overall charge effectiveness. Equalizing will serve to bring all cells up to the same voltage and the electrolyte in each cell to the same specific gravity.

### **3. Mixing up of the electrolyte.**

There is a tendency in the cell of a battery for the electrolyte to separate into layers of acid and water. The vigorous boiling action of the battery during equalizing serves to physically mix the electrolyte.

Equalizing is not required on gel cell batteries. You will note that if the dip switches are set in one of the two gel cell positions, the equalizing charge voltage is the same as the bulk charge voltage, therefore equalizing is equivalent to an 8 hour acceptance stage and is not harmful.

Equalize charging is current limited to 16 amps DC. Remove all AC loads from the output of the inverter/charger.

## BATTERY CHARGING

### WARNINGS

- 1. Do not equalize gel cell batteries with the remote programmed for wet cells.**
- 2. Always monitor the equalize charge.** Provide proper ventilation for battery fumes. Do not allow any sparks during equalizing. If one or more cells begin to overflow, terminate the equalize cycle.
- 3. Check and top off the battery electrolyte both before and after the equalizing charge.** Do not expose the battery plates to air. Leave the battery caps on while equalizing.
- 4. Remove all loads from the DC system before equalizing.** Some DC loads may not tolerate the high charge voltage.
- 5. Do not leave the equalize dip switch in the ON position.** It must be cycled OFF and left in the OFF position. If left ON, the unit will engage the equalizing cycle every time the battery charger is engaged.

### Charging Over-Discharged Batteries

Charging into a battery bank with a terminal voltage of less than 8 (16\*) volts presents a special problem for the Freedom 20.

If this situation arises, the unit will attempt to charge for 1 minute. If the inverter senses excessive ripple voltage, it will shut down to protect itself.

**To successfully charge an over-discharged battery, you must remove as much DC load as possible.** Then, set dip switches 7 and 8 to the ON position to limit the amount of charge current and the resulting ripple voltage. After the battery voltage has reached 10 (20\*) volts, these switches can be set to their previous positions.

Please note that if a continuous DC load in excess of 100 (50\*) amps is placed on the battery bank, eventually the battery voltage will drop below 8 (16\*) volts and the battery charger will shut off. This load must be significantly reduced and the power to the charger cycled to resume charging.

Blinking of the BATTERY LED on the remote control while charging is a warning that an over-discharge is imminent and that the DC load should be reduced.

\* 24 volt model

# TROUBLESHOOTING

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## Using the remote control DC AMPS LED bar graph

(LEDs are numbered by counting up from the bottom)

LED Number	Indication
LED 1	Illuminates if the unit shuts down for any reason.
LED 2	Over-temperature. Allow to cool.
LED 3	The unit detected a failure. Call Heart Interface Technical Support.
LED 4	Inverter overload caused by too large a load or short circuit. Reset by cycling power switch or plugging in incoming AC power.
LED 5	Battery overload caused by excessively discharged batteries. Refer to page 22.
LED 6	Incoming AC backfeed. Potentially damaging to the unit. Disconnect incoming AC power and correct the situation.
LED 7	Triac thermal run away. Turn OFF and allow to cool down.
LED 8	High battery voltage shutdown during charge mode. Check all charging sources for proper voltage. Reset by cycling the power switch.
LED 9-10	Not used for troubleshooting.

## TROUBLESHOOTING

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Problem	Things to Check
No Inverter Output	<ol style="list-style-type: none"> <li>1. Battery voltage under load.</li> <li>2. Battery connections and DC fuse.</li> <li>3. Circuit breaker on front panel.</li> <li>4. Thermal condition, high powered loads or inadequate ventilation may cause overheating.</li> <li>5. Overloads or short circuit, check for excessive loads or bad wiring connections.</li> </ol>
Low Inverter Output Voltage	<p>Confirm that your volt meter is a true RMS meter. Standard volt meters will not accurately read the waveform of the inverter and may read anywhere from 180 VAC - 240 VAC. If a true RMS meter is not available, check the brightness of an incandescent light bulb - if it appears normal, the output voltage is properly regulated.</p>
Little or No Output from Battery Charger	<ol style="list-style-type: none"> <li>1. Wiring connections - check both the AC and DC connections.</li> <li>2. AC input voltage - low voltage input will result in low DC output current. Expect reduced charger output from generators under 6,500 watts.</li> </ol>
Microwave Oven Cooking Slow	<p>1. Microwave ovens will normally cook slow on inverters due to a slightly low peak AC voltage. 2. Cooking speed will be determined by battery voltage. Low voltage results in increased cooking time. Support the battery bank with an alternator or other charging source for quicker cooking.</p>



# GLOSSARY

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**Alternating Current (AC)** Also referred to as shore power, utility power, inverter output power, generator power or household current.

**Ampere (Amp, A)** The unit of measure of electron flow rate of current through a circuit.

**Ampere-hour (Amp-hr, AH)** A unit of measure for a battery's electrical storage capacity, obtained by multiplying the current in amperes by the time in hours of discharge (Example; a battery which delivers 5 amperes for 20 hours delivers 5 amperes times 20 hours, or 100 Amp-Hr. of capacity.)

**AWG** American Wire Gauge, a standard used to measure the size of wire.

**AH Capacity** The ability of a fully charged battery to deliver a specified quantity of electricity (Amp-Hr, AH) at a given rate (amp, A) over a definite period of time (Hr).

**Circuit** An electric circuit is the path of an electric current. A closed circuit has a complete path. An open circuit has a broken or disconnected path.

**Circuit (Series)** A circuit which has only one path for the current to flow. Batteries arranged in series are connected with the negative of the first to the positive of the second, negative of the second to the positive of the third, etc. If two 12 volt batteries of 50 ampere-hours capacity are connected in series, the circuit voltage is equal to the sum of the two battery voltages, or 24 volts, and the ampere-hour capacity of the combination is 50 ampere-hours.

**Circuit (Parallel)** A circuit which provides more than one path for current flow. A parallel arrangement of batteries (of like voltage and capacity) would have all positive

terminals connected to a conductor and all negative terminals connected to another conductor. If two 12 volt batteries of 50 ampere-hour capacity each are connected in parallel, the circuit voltage is 12 volts, and the ampere-hour capacity of the combination is 100 ampere-hours.

**Current** The rate of flow of electricity or the movement rate of electrons along a conductor. It is comparable to the flow of a stream of water. The unit of measure for current is the ampere.

**Current (Alternating) (AC)** A current that varies periodically in magnitude and direction. A battery does not deliver alternating current. Also referred to as shore power, utility power, inverter power, generator power, etc.

**Cycle** In a battery, one discharge plus one recharge equals one cycle.

**Dip Switch** A series of small switches used for special programming of the Freedom inverter/charger. These switches are located on the rear of the Freedom remote panel.

**Direct Current (DC)** Current that flows continuously in one direction such as that from batteries, photovoltaics, alternators, chargers and DC generators.

**Discharging (Discharge)** When a battery is delivering current it is said to be discharging.

**Equalize charge** A controlled overcharge of the batteries which brings all cells up to the same voltage potential, extends the battery life, restores capacity and mixes the electrolyte.

## GLOSSARY

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**Gel Cell Battery** A type of battery that uses a gelled electrolyte solution. These batteries are sealed and are virtually maintenance free. Not all sealed batteries are the gel cell type.

**Ground** The reference potential of a circuit. In automotive use, the result of attaching one battery cable to the body or frame which is used as a path for completing a circuit in lieu of a direct wire from a component. This method is not suitable for connecting the negative cable of the inverter to ground, instead route the cable directly to negative terminal of the battery.

**LED** (Light Emitting Diode) Indicator light.

**Negative** Designating or pertaining to electrical potential. The negative terminal is the point from which electrons flow during discharge.

**Ohm** A unit for measuring electrical resistance.

**Ohm's Law** Express the relationship between volt (V), amperes (A) in an electrical circuit with resistance (R). It can be expressed as follows:  $V = AR$  If any two of the three values are known, the third value can be calculated by using the above formula.

**Positive** Designating or pertaining to electrical potential; opposite of negative. The positive battery terminal is the point where electrons return to the battery during discharge.

**Power sharing** The ability of the charger to reduce its output when the AC power being consumed by the charger and external AC loads connected to the output of the inverter are in excess of the input breaker rating.

**RCBB** Residual Current Circuit Breaker. A protective device that deenergizes a circuit rapidly when current to ground exceeds a predetermined value.

**Volt** The unit of measure for electric potential.

**Volt Amps (VA)** See Watt

**Watt** The unit for measuring electrical power, i.e., the rate of doing work, in moving electrons by or against an electric potential.

**Watt-Hour (WATT-HR, WH)** The unit for measuring electrical energy which equals Watts x Hours.

**Wet Cell Battery** A type of battery that uses liquid as an electrolyte. This type of battery requires periodic maintenance such as cleaning the connections and checking the electrolyte level.

## Temperature Compensated Voltage Table

This page applies to Freedom CE and Export Models above serial number 176981. **IMPORTANT NOTE FOR TC2+2 OWNERS:** Replace page 13 in your TC2+2 Owner's Manual with this page.

TEMPERATURE	WET CELL		GEL CELL	
	ACCEPTANCE	FLOAT	ACCEPTANCE	FLOAT
120 or >	12.5	12.5	13.0	13.0
110 - 119	13.6	12.7	14.0	13.4
100 - 109	13.8	12.9	14.1	13.5
90 - 99	14.0	13.1	14.2	13.6
80 - 89	14.2	13.3	14.3	13.7
70 - 79	14.4	13.5	14.4	13.8
60 - 69	14.6	13.7	14.5	13.9
50 - 59	14.8	13.9	14.6	14.0
40 - 49	15.0	14.1	14.7	14.1
< = 39	15.2	14.3	14.8	14.2

NOTE: In installations with more than one sensor, the TC2+2 will adjust the charge voltage for the sensor with the highest temperature. Example, TC2+2 is measuring 45° Fahrenheit on three sensors and the fourth sensor is measuring 115°, the charge voltage will be adjusted for the 115° setting.

NOTE: Below 20° Fahrenheit, the TC2+2 will no longer control charge voltage based on temperature. At this point, the Freedom or Fleet Power Inverter/Charger will control the charge. Voltage is based on factory settings or remote control panel settings.

# Notes

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# Specifications

Nominal Battery Voltage	12 VDC	24 VDC
Battery Voltage Range	10.0 - 15.5 VDC	20.0 - 31.0 VDC
Low Battery Cutout	10 VDC	20.0 VDC
AC Input Voltage Range	180 - 260 VAC	180 - 260 VAC
Frequency Regulation	.005% @ 50 or 60 Hz	.005% @ 50 or 60 Hz
Inverter Output Power	2000 VA	2000 VA
Inverter RMS Voltage Regulation	230 $\pm$ 10% VAC True RMS	230 $\pm$ 10% VAC True RMS
Wave Shape	Modified Sine Wave	Modified Sine Wave
Surge Power (15 seconds)	4500 VA	4500 VA
Power Factors Allowed	All	All
Full Load Efficiency	84%	84%
Peak Efficiency	93%	93%
No Load Power Current Drain	.12 amp	.06 amp
Remote Current Drain	.03 amp	.015 amp
Protection	Circuit Breaker, Electronic, Thermal, High Battery, Low Battery	Circuit Breaker, Electronic, Thermal, High Battery, Low Battery
Charging Rate	100 amps	50 amps
Bulk Charge Voltage	14.3 VDC*	28.6 VDC*
Float Charge Voltage	13.4 VDC*	26.8 VDC*
Equalizing Charge Voltage	16.3 VDC*	32.6 VDC*
Weight	52 lbs.	52 lbs.

\* indicates setting adjustable with the optional remote control

# WARRANTY



Your Heart Interface Freedom 20 is under limited warranty for a period of 12 months or 30 months 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 register your warranty.**

If the unit requires service, please contact Heart Interface by telephone. The service technician will ask you for the serial number of your Freedom 20, so please have this information ready.

## Phone numbers:

**206-872-7225**

**800-446-6180**

A return authorization number will be required on all returns. This number is issued by the service technician and should be written on the outside of the shipping box.

You must ship the unit to Heart Interface or the field service center freight prepaid.



## Heart Interface Corporation

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