OUTBACK MARINE
AUSTRALIA PTY LTD

Smart Energy Solutions

Energy Systems for Cruising Vessels

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Introduction to Vessel Energy Systems

For a “cruising” vessel, the energy system must support the vessel and its occupants independent of whether the vessel is at a dock, making way under sail/power or at anchor in a remote location for an indefinite period of time. The system is engineered with a view to safety, reliability, efficiency, ease of operation, minimal weight, environmental friendliness and people comfort. Engine run-time is kept to an absolute minimum and the vessel tends to be self sufficient.

A “day” vessel would share all of the same objectives except that the systems to support living away from the dock might only cater for a single day or maybe a couple of evenings away. Fresh water, ice, food, fuel and services are readily obtainable back at the dock. Energy generation will primarily come from the propulsion engine or a generator set and many hours of engine run-time per day may be required to support the vessel and occupants. For one or two days, the run-time might be tolerable.

The cross-over point between the two vessel configurations is difficult to objectively define. Only the vessel owner/operator can decide where to draw the line - where operation of the day vessel becomes impossible, impractical or onerous at best. Too often the systems offered as standard on so called cruising vessels barely pass muster for a well engineered day boat. Although a day vessel would certainly benefit by the systems described here, this discussion is primarily aimed at the needs of the cruising vessel.

A cruising sail vessel is primarily powered by renewable energy for propulsion (the wind) and electrical energy generation (wind and solar). A modern cruising power vessel only differs from sail in that engines are always used for propulsion.

Energy Storage

Because energy is not available from generation sources on a 24-hour per day basis, a means of storing energy is required. A house battery bank is used to store energy for supply-on-demand to all electrical devices - most of which operate directly on 12-volt[a] or 24-volt DC (Direct Current).

The house battery is a bank of energy. Whenever energy generation exceeds demand, charge is placed into the battery bank. When demand exceeds supply, charge is taken out. Charge is the currency of the house battery bank and is measured in amp-hours.

A reserve battery with engine cranking capability provides an emergency backup facility. Energy required for 240-volt[b] AC (Alternating Current) appliances is also sourced from the battery system by utilizing a sine wave inverter - a device that converts DC energy into AC energy.

Energy Consumption

Every amp-hour of consumed energy has to be replaced. A balanced system will lessen the demand placed on generation equipment (with associated cost) by keeping electrical loads to a minimum. Home comforts are very attainable by utilizing energy efficient devices and practising prudent power management.

Refrigeration equipment in particular requires careful attention. The main factor for the reduction in energy consumption is to minimize the transfer of heat energy from the warmer air outside of the box to the colder air inside. The main work load of the refrigeration plant is to counter this heat loss - the area (box size), thickness and thermal properties of the insulation is a major factor.

In the past, desalination equipment needed an AC generator set or direct mechanical drive from an engine. A new generation of desalination equipment can now produce ample quantities of water approaching 35 liters per hour - using 12-volts DC at only .25 amp-hours per liter (1 amp-hour per US gallon). Other models produce 55 litres per hour at 19-amps. Once a desalinator has been installed, expect to use around 30-litres per day per person.

Energy Generation

A solar panel array can provide the bulk of energy generation - a surplus can be expected whilst at anchor on a good sunny day. Whilst passaging, solar performance is typically reduced due to sail shadow. Unfortunately at the same time, energy consumption under passage is much greater due to the autopilot, instrumentation and navigation light usage. None-the-less, solar energy is the first choice for renewable energy generation.

A wind generator can have a significant impact to the passaging deficit provided that the apparent wind is substantial. At anchor, the wind generator is less effective as the anchoring location is often selected to be in the lee of an island or peninsular. It’s a case of balancing the considerable noise factor of wind generation against the benefit of more renewable energy.

In practice, while living aboard or passaging, an engine driven charge source will be run once per day to bring the batteries up to a near-full charge level - at the same time, waste engine heat is used for hot water heating. The amount of time required to run the engine depends on the energy deficit. Deep-cycle batteries which exhibit a high charge

a. Discussions on the energy system will refer to 12-volt systems. Vessels fitted with 24-volt engine cranking are best to employ a 24-volt house bank as well. The temptation to split system voltages should be avoided.
b. 110-volt, 60Hz for North America

acceptance rate in combination with a properly regulated high output alternator significantly reduce engine run time. The resulting higher load placed on a diesel engine will also counter bore glazing.

Monitoring and Control

With so many parameters affecting the overall operation and performance of the system, a monitoring system that goes beyond the familiar volt and amp meter is employed. The system continually computes the house bank state-of-charge to indicate when and for how long an engine driven source should be run. It will also raise an alarm if a critical condition on either the house bank or reserve battery requires attention.

All battery charging equipment is properly regulated according to manufacturers specifications. Temperature compensation is recommended.

Safety and Reliability

A vessel is a very hostile environment from an electrical engineering point of view. Power distribution - wiring, switching and protection - is of prime importance.

With the exception of the actual battery terminals, every electrical circuit/contact is protected by either a fuse or circuit breaker. Battery terminals must have a physical barrier to prevent short circuits. The purpose of the protection is to prevent cable heating and subsequent fire risk. A short circuit must activate a protection device which isolates the fault without affecting other branch circuits. All steps are taken to minimize corrosion and protect against vibration.

Conventional flooded-cell batteries and salt water are not friendly. The battery electrolyte and salt water chemically react to produce chlorine gas. When charged, flooded batteries produce explosive hydrogen and oxygen due to electrolysis. Toxic gasses are also generated by flooded deep-cycle batteries. Only fully sealed, valve regulated AGM (absorbed glass mat) or gel-cell batteries are used.

The modern cruising vessel has become more dependent on the use of electronic navigation equipment and life support systems. Desalination equipment has paved the way for equatorial cruising where fresh water is virtually unattainable. Even in remote island locations, water may be scarce. The capability of remote living and travel brings a dependence on self sufficiency. Safe, reliable equipment and owner serviceability has a new meaning when equipment service or replacement may be weeks or months away. A good head start is a well engineered system using top quality components.

Energy System Architecture

The "System Block Diagram shows the component layout of a DC-based energy system for a "cruising" vessel with two propulsion engines. Single engine vessels are identical in layout - just delete one engine/alternator. The arrows shown on interconnections indicate the functional flow of energy.

The design shown does not include an AC generator set - unless the vessel specifically needs one for operation of a high-powered appliance such as an electric cooking range, air conditioning or an AC dive compressor - it's not required. If a generator set is called for, the only functional change would be the allocation of a higher output battery charger and/or the inclusion of an additional high output alternator on the generator set engine.

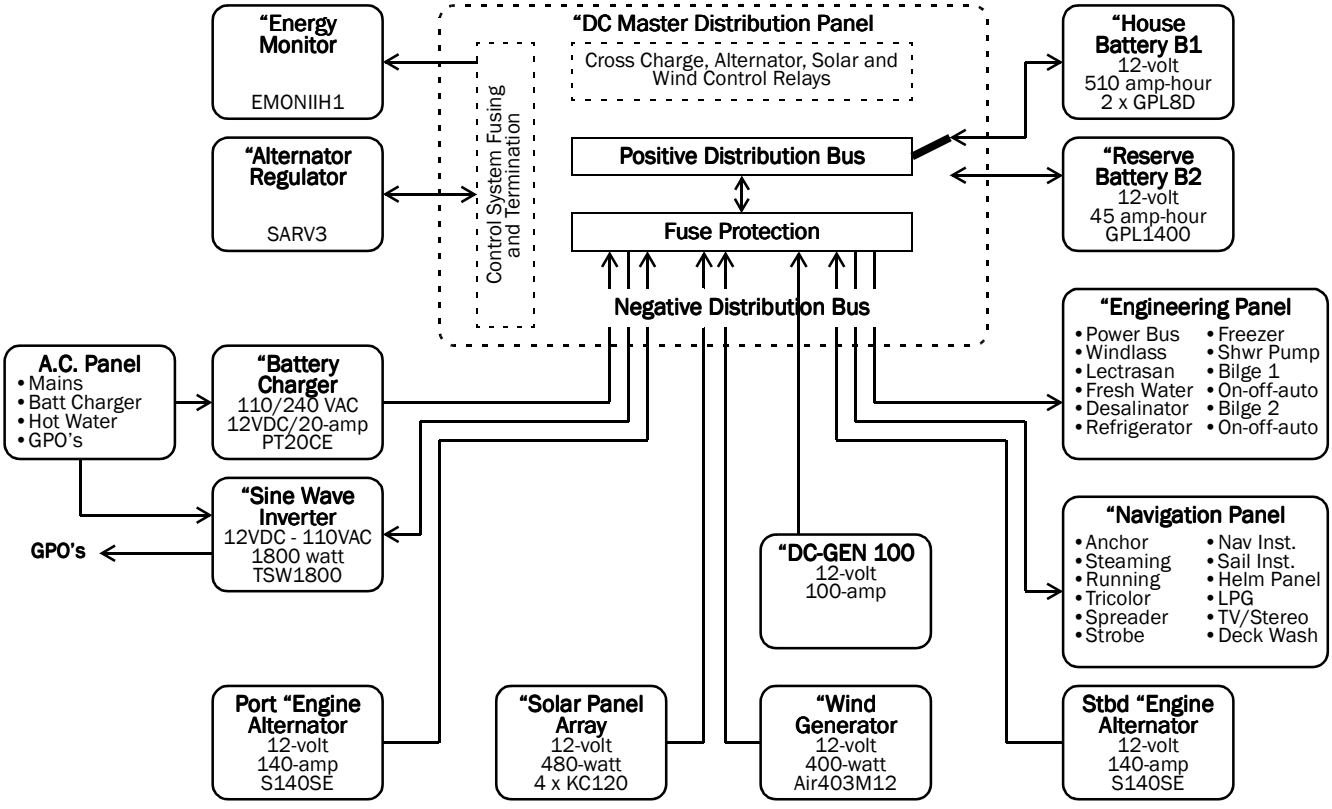
The inverter is still used to conveniently provide AC power to appliances for shorter periods of time without the need to start a generator. The task of secondary battery charging at anchor will most likely be transferred from the propulsion engines to the generator. Solar and wind generation sources might be traded off against generator set run time.

For vessels with larger diesel propulsion engines that are not suited for running alternators at anchor under relatively light load conditions, a small light weight DC generator may be employed. This option is only considered necessary when the ratio of alternator power to available engine power may risk bore glazing. For most diesel engines under 2-liter capacity, this is rarely an issue when fitted with high-output alternators. The engine manufacturer should be consulted.

Irrespective of the vessel being power or sail, AC generator set or not, an inherent strength of a well engineered DC-based system lies in it's ability to supply energy to all equipment and appliances without the need to start an engine at the time of intended or required use.

For a discussion on sizing and trade-off of the various components, see section on sizing. This discussion will focus on the purpose and operation of each element and will highlight features of the employed technology.

Figure 1: System Block Diagram



House Battery B1

The house battery bank is the primary source of stored energy in the vessel. All charging sources and load devices are normally connected to the house battery - including engine cranking[1], anchor windlass and bow thruster if fitted. A battery selector switch (see "DC Master Distribution Panel" on page 4) provides the facility to completely isolate the house bank or to switch to the reserve battery in case the house bank is inadvertently flattened. In normal day to day operation, the battery selector is left in the "B1" position.

Energy System Architecture

The house battery bank uses Lifeline AGM deep-cycle batteries. They are fully sealed, maintenance free and exhibit a very high charge acceptance rate. Under normal operating conditions they will never out gas. A condition that would possibly cause out-gassing would be an abnormally high charging voltage due to a charge source regulation failure - in which case, the Energy Monitor would raise an alarm before explosive levels of gas accumulate.

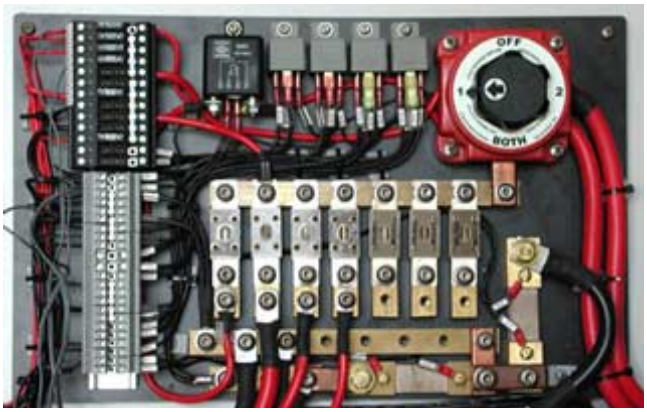
A small computer-type fan provides positive ventilation to keep the battery compartment cool during charging - battery life is inversely proportional to temperature. As the batteries are fully sealed and do not require access for periodic maintenance, greater flexibility is offered as to location. Even if the battery case is punctured, no acid will escape - so it is not necessary to provide a "spill-proof enclosure". The batteries are appropriately covered to prevent accidental short-circuits across the terminals. The utmost care must be taken when working around exposed terminals.

Reserve Battery B2

The reserve battery provides an emergency backup in case the house bank is inadvertently flattened. The reserve battery is a Lifeline AGM-type cranking battery. It exhibits all of the same qualities as Lifeline deep-cycle AGM batteries described above, however it is optimized for high current output in a small package suitable for engine cranking. The reserve battery is located adjacent to the house bank. Reserve battery voltage is continually monitored by the Energy Monitor.

Connection to the reserve battery can be made by moving the battery selector switch to position "B2". After engine starting, the switch can be returned to "B1". Under normal operation, no load is connected to the reserve battery. Charge is maintained by a "cross charge relay" controlled by the SARV3 Alternator Regulator - irrespective of charge source. It is recommended that the reserve battery system is periodically tested by performing a reserve battery engine start.

DC Master Distribution Panel



This section is at the core of the overall DC distribution system yet is an area of attention most often neglected on too many vessels. The panel brings together all high current charge sources, load devices, monitoring and regulation control circuits with the correct fuse protection.

Battery Selector Switch

Provides the facility to completely isolate the batteries or to switch to the reserve battery in case the house bank is inadvertently flattened.

- "B1" position - house bank is connected to positive distribution. Normal operation.
- "B2" position - reserve battery is connected to positive distribution. Emergency operation.
- "Both" position - Both House and Reserve batteries connected to positive distribution. Not required.
- "Off" position - Total isolation[1] of both batteries for electrical system maintenance or electrical fire procedure.

In normal day-to-day operation, the battery selector is left in the "B1" position.

Positive Distribution Bus

This is a bus bar that connects to the common terminal of the battery selector switch. Attached to positive distribution are all primary fuses.

Fuse Protection

The positive leg of each power circuit has a dedicated ANL[2] type fuse. Fuse sizes vary from 50-amps to 500-amps depending on load or source characteristics. The fuses protect the cable from short circuit conditions and must never exceed the cable ampacity rating[3].

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1. Engine cranking can be implemented by a dedicated cranking battery if required for special circumstances in which case the dedicated cranking battery is treated like the reserve battery. Additional wiring and complexity is an issue and in our experience is not required.
1. Some circuits (for example the Energy Monitor) are permanently connected to the batteries by dedicated fuses which must be separately pulled for any required maintenance.
2. A special high-power fuse with sufficient interrupt rating to safely break the high power source from batteries.
3. Cable ampacity is a rating placed on the cable that specifies the maximum current allowed in a cable at a specific operating temperature and bundle configuration.

Negative Distribution Bus

The negative legs of each power circuit connect to this bus bar which in turn connects to house and reserve battery negative posts via a current shunt[1]. The shunt is used by the energy monitor to observe the total current flowing into or out of the house battery bank.

The negative distribution is also the single point to which any vessel bonding circuits and AC grounds are connected.

Cross Charge Relay

The contacts of the cross charge relay join the positive distribution bus to the reserve battery whenever an engine alternator is running or whenever any charge source is detected. The relay is controlled by the SARV3 regulator. In this way, the reserve battery is maintained in a fully charged state irrespective of house bank state of charge.

Alternator Field Control Relays

When alternators on independent engines are running, the field control relays steer the regulator field current to an active alternator. The relay coils are activated by oil pressure switches on corresponding engines. An AFD switch on the battery selector switch protects alternator diodes from damaging open circuit conditions if the selector switch is rotated while an engine is running.

Solar Panel Control Relay

This relay switches the solar panel array on or off. It is controlled by the energy monitor to maintain correct solar panel regulation. If outboard engines were used for propulsion, an additional relay would provide regulation for the outrboard charge source.

Wind Generator Control Relay

This is a relay that provides a control mechanism to stop the wind generator from turning whenever noise levels are considered too high or when wind conditions are excessive. It is manually activated by an external switch.

Control System Fusing and Termination

This facility provides convenient fusing and termination for circuits connecting to the energy monitor, alternator regulator and other system components. Spare fused circuits from the house battery bank allow devices such as bilge pumps, alarm systems and radios to operate independent of the battery selector switch position if required.

Energy Monitor

The Energy Monitor ("Ample Power - Energy Monitor) is a multi-function device that primarily connects to the batteries through the DC Master Distribution Panel. It is responsible to:

- Monitor house bank voltage, current and temperature and provide an alarm for conditions that are outside of programmed limits
- Monitor reserve battery voltage and provide an alarm if for a condition that is outside of programmed limits
- Independently monitor a separate charge or discharge shunt. Typically configured to accumulate amp-hours generated by solar panels but might be configured to monitor parameters such as total refrigeration amp-hours consumed.
- Calculate house bank state-of-charge condition and provide an alarm if state-of-charge is outside of programmed limits. This is a key parameter to determine when to start and stop engine driven charge sources. An option is available to automatically start or stop an engine driven charge source.
- Drive the Solar Panel Control Relay according to programmed parameters to maintain solar panel regulation
- Facilitate an external alarm such as a sonalert.
- Provide an RS-232 interface for computer monitoring of all energy system parameters

Alternator Regulator

The alternator regulator ("Ample Power SARV3 Regulator) continuously monitors the voltage on the positive distribution bus and house bank temperature to perform it's tasks: It connects directly to the DC Master Distribution Panel

- Regulate the output of one or more alternators by controlling their field current. The SARV3 employs a three-stage charging algorithm to minimize battery charge time in a safe manner by adjusting voltage output according to battery temperature.
- Limit the output of relatively large alternators on smaller engines to avoid "over-propped" running conditions when the engines are used for propulsion.
- Provide a mechanism for equalization charging of the house battery bank.

1. A shunt is a precision high-current device that develops a small voltage drop proportional to current flow. The shunt used with the EMONIIH1 is factory calibrated to 8-amps per millivolt. In this way, the monitoring device can be remotely located away from the high current circuit.

- Control the Cross Charge Relay whenever any charge source is detected to be active. This relay is used to maintain the reserve battery in a full charged condition.

Engine Alternator

The standard engine alternators may be converted for external regulation to be controlled by the SARV3 regulator. In this case, the SARV3 is set up to limit output power to protect the alternators from overload conditions. Around 45-amps of charge current can be expected.

A much higher charge current with a corresponding reduction in engine run-time is achieved by fitting the AmpTech S140SE heavy duty alternators. Around 90-amps can be expected at 1400 engine R.P.M. with alternators rated for full power output on a continuous basis.

In either case, the correct charge profile is achieved by the SARV3 regulator.

DC-GEN 100

A dedicated DC generator set is ideal when the main propulsion engine is not suitable for continuous battery charging. This is normally the case when the power required to drive the engine mounted alternator is too small for a larger propulsion diesel. In addition, the per hour running costs of a small diesel is much less than the larger propulsion diesels.

Based on a 4 horsepower horizontal Kubota diesel engine, the DC-GEN 100 produces 100-amps of 12-volt battery charging capacity (50-amps @ 24-volt) in a small and light weight package. With the optional hot-water heat exchanger system, all of a vessels energy needs and hot water heating can be met in a couple of hours of run-time per day.

Solar Panel Array

Solar panels can provide the bulk of charge source. They rely on direct sunlight without shadows for maximum output. The output will also vary according to the season and declination of the sun. Care must be taken to properly factor realistic output according to mounting position, weather conditions, latitude, time of year and rigging obstructions.

Kyocera solar panels provide a higher output proportional to panel area. In contrast, Unisolar panels have less output for panel area but exhibit a higher tolerance to partial shading. Available area for installing the recommended number of panels is a common issue - particularly on mono hull vessels.

Solar panel regulation is fully from the Energy Monitor and is normally set to the battery float voltage.

Wind Generator

Provided there is enough apparent wind, the wind generator will usually cover the deficit of energy usually experienced while passaging under sail.

A valid concern of wind generators is the noise factor in stronger wind conditions. The AirMarine 403 has a facility to be turned off by shorting it's electrical output if noise becomes a factor or if the house bank is at a fully charged level. This relay is located on the DC Master Distribution Panel and controlled by an external switch. on the Navigation Panel.

Regulation on the Air MArine 400 is internal to the generator and is normally set to the battery float voltage.

Battery Charger

The battery charger is used as a secondary energy source at a dock to avoid running an engine. The Newmar PT20CE has a 20-amp output - over 400 amp-hours per day will easily cover vessel requirements. It has a switch to select from either 110 or 240 mains input voltage for international capability. An external switch can invoke an equalization charge voltage for periodic battery equalization.

Sine Wave Inverter

The inverter converts DC energy from the batteries to AC energy that is compatible with common household appliances. Lower performance inverters have a modified square wave output waveform. Although these inverters work fine for resistive loads, the harmonics of the square wave can present many problems for inductive loads and sensitive electronic equipment. Many small appliance battery chargers may self destruct with this type of inverter. A better approach is a sine wave inverter. It's output wave form is nearly identical to utility supply and presents none of the problems encountered by modified square wave product.

A common problem with combined inverter/battery chargers is their incompatibility with international voltage and frequency. By separating the two functions, all appliances run from the inverter at their native voltage and frequency. The Statpower

TSW Series sine wave inverterter is connected to all GPO's on the vessel. It has a remote control panel for monitoring inverter parameters and controlling it's operation. A separate battery charger with international capability handles dock side charging.

Engineering Panel

This panel controls the power distribution of all devices that are normally enabled for longer periods of time. It is mounted close to and powered from a dedicated fuse on the DC Master Distribution Panel. This is to avoid unnecessary voltage drops and to shorten cable runs. Magnetic type circuit breakers up to 300-amp capacity can be accomodated. Functions included at the Engineering Panel include:

- Power Bus - A circuit breaker that provides the main power feed to all low amperage non-essential vessel services. On/off control of individual devices is handled by a switch at the device or a control relay.
- Anchor Windlass - A circuit breaker that provides a dedicated power feed to the windlass - control is provided by a foot switch mounted adjacent to the windlass.
- Lectrasan - A circuit breaker that provides a dedicated power feed to the Lectrasan unit - a local control is provided in the head.
- Freshwater Pump - a switch that enables the pump via a local relay
- Desalination - a switch that enables the disseminator via a local relay
- Refrigeration - A circuit breaker that provides a dedicated power feed to the refrigerator and freezer. Local control is provided by the local thermostats.
- Shower Pump - a switch that enables the pump via a local relay
- Bilge 1 - A circuit breaker that provides a dedicated power feed to the port bilge pump. Control is via a local relay, float switch and the following panel control
- On-off-auto - control for Bilge 1
- Bilge 1 - A circuit breaker that provides a dedicated power feed to the starboard bilge pump. Control is via a local relay, float switch and the following panel control
- On-off-auto - control for Bilge 2

Navigation Panel

The Navigation Panel is reserved for devices that are frequently turned on or off during the day to day operation of the vessel. The panel is powered from a dedicated fuse on the DC Master Distribution Panel. As all high power devices are powered from the Engineering Panel, switching transient noise is minimal. Panel functions include:

- Anchor - A circuit breaker that provides a dedicated power feed to the "anchor" navigation light
- Steaming - A circuit breaker that provides a dedicated power feed to the "steaming" navigation light
- Running - A circuit breaker that provides a dedicated power feed to the "running" navigation light
- Tricolor - A circuit breaker that provides a dedicated power feed to the "tricolor" navigation light
- Strobe - A circuit breaker that provides a dedicated power feed to the "strobe" navigation light
- Helm - A circuit breaker that provides a dedicated power feed to the Helm Panel. This is a waterproof switch panel that controls the spreader lights, cockpit lights and horn warning device
- Nav Instruments - A circuit breaker that provides a dedicated power feed to the navigation instruments. A local fuse panel provides the individual power feed to each instrument. The instruments are turned on or off by their individual front panel controls.
- Sail Instruments - A circuit breaker that provides a dedicated power feed to sailing instruments. A local fuse panel provides the individual power feed to each instrument. The instruments are turned on or off by their individual front panel controls.
- Deck Wash - A switch that enables the saltwater deck-wash pump via a local relay.
- Stereo - A switch that enables the stereo/entertainment equipment via a local relay. Individual components have local fuse protection.
- LPG - A circuit breaker that provides a dedicated power feed to the LPG gas solenoid

Inboard Diesel Sailing Configuration

See Table 1 on page 8 for the equipment configuration of both catamaran and monohull sailing vessels fitted with inboard diesel propulsion.

A catamaran will most likely have more space available for solar panels and therefore will require less engine run-time.

Table 1: Inboard Diesel Sailing Vessel Configuration

System Item	Day Configuration		Cruise Configuration	
	Qty	Device	Qty	Device
Reserve Battery	1	LIF#GPL1400 AGM Cranking Battery 12-volt, 45 amp-hour capacity for reserve communication and emergency engine cranking.	1	LIF#GPL1400 AGM Cranking Battery 12-volt, 45 amp-hour capacity for reserve communications and emergency engine cranking.
House Battery Bank	1	LIF#GPL8D AGM Deep-cycle Battery 12-volt, 255 amp-hour house battery sized to handle vessel loads for day sailing and overnight anchorage. Space is allocated for upgrade to cruising configuration.	2	LIF#GPL8D AGM Deep-cycle Battery 12-volt, 510 amp-hour house battery bank sized to handle vessel loads for 24-hour passage making and prolonged anchorage.
Energy Monitor	1	CRU#EMETER Monitors house-bank voltage, amps and amp-hours.	1	AMP#EMONIIH1 Monitors house-bank voltage, amps, amp-hours and temperature. Monitors reserve battery voltage. Has programmable alarms for all critical parameters. Controls solar panel regulation.
Engine Alternators	2	OEM Alternator Modified for external regulation. Output power is derated to avoid alternator over-heating when charging deep cycle batteries. Expect around 50-amps charging @ 1400 engine RPM.	2	REV#S140 Heavy duty hot-rated 12-volt alternator. Expect around 90-amps charging @ 1400 engine RPM.
Alternator Regulator	1	AMP#SARV3 Regulator Provides a temperature compensated charge profile for deep-cycle batteries. Output power can be set for alternator derating. One regulator drives multiple engine alternators. Controls cross-charge of reserve battery.	1	AMP#SARV3 Regulator Provides a temperature compensated charge profile for deep-cycle batteries. One regulator drives multiple engine alternators. Controls cross-charge of reserve battery.
Battery Charger	1	STA#TC2020 Three-stage battery charger with sufficient capacity (10-amps) to handle all dockside loads.	1	NEW#PT20CE Three-stage battery charger with sufficient capacity (20-amps) to handle all dockside loads. Includes international voltage range adjustable with slide switch.
Solar Panels	-	Optional - wiring and control relay installed.	4	KYO#KC120 360-watt 12-volt solar panel array. Regulation is controlled by Energy Monitor.
Wind Generator	-	Optional - wiring and control relay installed.	1	AIR#403M 400-watt, 12-volt wind generator. Regulation is internally adjustable. Control relay mounted on Master DC distribution.
Inverter	-	Optional - Fuse location reserved	1	STA#TSW1800 1000-watt, Sine Wave Inverter. 1800-watt optional.

Table 1: Inboard Diesel Sailing Vessel Configuration

System Item	Day Configuration		Cruise Configuration	
	Qty	Device	Qty	Device
AC Electrical Panel	1	BSS#8x43 Mains input breaker with reverse polarity indication, 3 x load breakers and AC voltmeter	1	BSS#8x43 Mains input breaker with reverse polarity indication, 3 x load breakers and AC voltmeter
DC Battery Distribution	1	OMA#DCDIST1 DC distribution board servicing interconnections of batteries and all high power loads and charge sources. Prewired for optional solar panels, wind generator and inverter.	1	OMA#DCDIST1 DC distribution board servicing interconnections of batteries and all high power loads and charge sources.
DC Engineering Panel	1	BSS#8083 Master battery switch, anchor windlass breaker, and 8 DC breaker positons (5 installed).	1	BSS#8083 Master battery switch, anchor windlass breaker, and 8 DC breaker positons (5 installed).
DC Navigation Panel	1	BSS#8x68 13 DC breaker positions (10 installed), volt meter and amp meter	1	BSS#8x68 13 DC breaker positions (10 installed), volt meter and amp meter
Helm Panel	1	BSS#8262 4 position waterproof switch panel	1	BSS#8262 4 position waterproof switch panel
Desalination	-	Optional - circuit breaker position allocated	1	SPE#200C 12-volt, 35 LPH desalination system with 20-micron pre-filter and manual backflush options.
Refrigerator	1	OMA#REF200A 200 litre air-cooled DC refrigerator with dedicated condensor set. Optional keel-cooled condensor available.	1	OMA#REF200A 95 litre freezer with dedicated air-cooled DC condensor set. Optional keel-cooled condensor available.
Freezer	1	OMA#FRZ95A 95 litre air-cooled DC freezer with dedicated condensor set. Optional keel-cooled condensor available.	1	OMA#FRZ95A 95 litre freezer with dedicated air-cooled DC condensor set. Optional keel-cooled condensor available.
Hot Water	1	OMA#HW20L 240-volt AC 20 litre storage hot water system fitted with engine heat exchanger.	1	OMA#HW20L 240-volt AC 20 litre storage hot water system fitted with engine heat exchanger.

Outboard Powered Sailing Configuration

See Table 2 on page 10 for the equipment configuration of both catamaran and monohull sailing vessels fitted with outboard petrol propulsion. A catamaran will most likely have more space available for solar panels and therefore will require less engine run-time.

Because outboards have a limited charging capacity, a secondary generator set/battery charger combination will be required for a cruising vessel. Solar and wind generating capacity will be increased as well.

Table 2: Outboard Powered Sailing Vessel Configuration

System Item	Day Configuration		Cruise Configuration	
	Qty	Device	Qty	Device
Reserve Battery	1	LIF#GPL1400 AGM Cranking Battery 12-volt, 45 amp-hour capacity for reserve communication and emergency engine cranking.	1	LIF#GPL1400 AGM Cranking Battery 12-volt, 45 amp-hour capacity for reserve communications and emergency engine cranking.
House Battery Bank	1	LIF#GPL8D AGM Deep-cycle Battery 12-volt, 255 amp-hour house battery sized to handle vessel loads for day sailing and overnight anchorage. Space is allocated for upgrade to cruising configuration.	2	LIF#GPL8D AGM Deep-cycle Battery 12-volt, 510 amp-hour house battery bank sized to handle vessel loads for 24-hour passage making and prolonged anchorage.
Energy Monitor	1	CRU#EMeter Monitors house-bank voltage, amps and amp-hours.	1	AMP#EMONIIH1 Monitors house-bank voltage, amps, amp-hours and temperature. Monitors reserve battery voltage. Has programmable alarms for all critical parameters. Controls solar panel regulation.
Outboard Charging	2	Outboard Charging Standard outboard charging system. Requires external “solar” regulator for correct charge profile.	2	Outboard Charging Standard outboard charging system. Regulation incorporated in Energy Monitor and Master DC Panel.
Outboard Regulator	1	PLA#PL40 or PLA#PL20 12-volt 40-amp (20-amp) solar regulator used to regulate outboard charging system	1	Included on Master DC Panel Relay controlled by Energy Monitor
Battery Charger	1	STA#TC2012 Three-stage battery charger with sufficient capacity (10-amps) to handle all dockside loads.	1	STA#TC4012 Three-stage battery charger with sufficient capacity to handle all dockside loads. Output of 40-amps sized to match 900-watt AC generator
Generator Set	-	-	1	HON#EU10i 900-watt continuous rated petrol generator sized to match 40-amp battery charger.
Solar Panels	-	Optional - wiring and control relay installed. Dedicated solar regulator will be required unless AMP#EMONII is fitted instead of CRU#EMeter	4	KYO#KC120 360-watt 12-volt solar panel array. Regulation is controlled by Energy Monitor.
Wind Generator	-	Optional - wiring and control relay installed.	1	AIR#403M 400-watt, 12-volt wind generator. Regulation is internally adjustable. Control relay mounted on Master DC distribution.

Table 2: Outboard Powered Sailing Vessel Configuration

System Item	Day Configuration		Cruise Configuration	
	Qty	Device	Qty	Device
Inverter	-	Optional - Fuse location reserved	1	STA#TSW1800 1000-watt, Sine Wave Inverter. 1800-watt optional.
AC Electrical Panel	1	BSS#8x43 Mains input breaker with reverse polarity indication, 3 x load breakers and AC voltmeter	1	BSS#8x43 Mains input breaker with reverse polarity indication, 3 x load breakers and AC voltmeter
DC Master Distribution	1	OMA#DCDIST2 DC distribution board servicing interconnections of batteries and all high power loads and charge sources. Prewired for optional solar panels, wind generator and inverter.	1	OMA#DCDIST2 DC distribution board servicing interconnections of batteries and all high power loads and charge sources.
DC Engineering Panel	1	BSS#8083 Master battery switch, anchor windlass breaker, and 8 DC breaker positons (5 installed).	1	BSS#8083 Master battery switch, anchor windlass breaker, and 8 DC breaker positons (5 installed).
DC Navigation Panel	1	BSS#8x68 13 DC breaker positions (10 installed), volt meter and amp meter	1	BSS#8x68 13 DC breaker positions (10 installed), volt meter and amp meter
Helm Panel	1	BSS#8262 4 position waterproof switch panel	1	BSS#8262 4 position waterproof switch panel
Desalination	-	Optional - circuit breaker position allocated	1	SPE#200C 12-volt, 35 LPH desalination system with 20-micron pre-filter and manual backflush options.
Refrigerator	1	OMA#REF200A 200 litre air-cooled DC refrigerator with dedicated condensor set. Optional keel-cooled condensor available.	1	OMA#REF200A 95 litre freezer with dedicated air-cooled DC condensor set. Optional keel-cooled condensor available.
Freezer	1	OMA#FRZ95A 95 litre air-cooled DC freezer with dedicated condensor set. Optional keel-cooled condensor available.	1	OMA#FRZ95A 95 litre freezer with dedicated air-cooled DC condensor set. Optional keel-cooled condensor available.
Hot Water	1	OMA#HW20L 240-volt AC 20 litre storage hot water system fitted with engine heat exchanger.	1	OMA#HW20L 240-volt AC 20 litre storage hot water system fitted with engine heat exchanger.

Inboard Diesel Power Configuration

See Table 3 on page 12 for the equipment configuration of both catamaran and monohull power vessels. Fundamentally, the only difference to a sailing vessel is that energy generation while passaging is easily covered by the engine alternators. A wind generator will most likely not be required.

A dedicated AC or DC generator set might be an option for the cruising configuration if the propulsion engines are greater than 2-litre displacement - sufficient load is needed to counter bore glazing.

Table 3: Inboard Diesel Power Vessel

System Item	Day Configuration		Cruise Configuration	
	Qty	Device	Qty	Device
Reserve Battery	1	LIF#GPL1400 AGM Cranking Battery 12-volt, 45 amp-hour capacity for reserve communication and emergency engine cranking.	1	LIF#GPL1400 AGM Cranking Battery 12-volt, 45 amp-hour capacity for reserve communications and emergency engine cranking.
House Battery Bank	1	LIF#GPL8D AGM Deep-cycle Battery 12-volt, 255 amp-hour house battery sized to handle vessel loads for day sailing and overnight anchorage. Space is allocated for upgrade to cruising configuration.	2	LIF#GPL8D AGM Deep-cycle Battery 12-volt, 510 amp-hour house battery bank sized to handle vessel loads for 24-hour passage making and prolonged anchorage.
Energy Monitor	1	CRU#EMETER Monitors house-bank voltage, amps and amp-hours.	1	AMP#EMONIIH1 Monitors house-bank voltage, amps, amp-hours and temperature. Monitors reserve battery voltage. Has programmable alarms for all critical parameters. Controls solar panel regulation.
Engine Alternators	2	OEM Alternator Modified for external regulation. Output power is derated to avoid alternator over-heating when charging deep cycle batteries. Expect around 50-amps charging @ 1400 engine RPM.	2	REV#S140 Heavy duty hot-rated 12-volt alternator. Expect around 90-amps charging @ 1400 engine RPM. Alternator capacity might be upgraded to 300-amps for larger displacement engines.
Alternator Regulator	1	AMP#SARV3 Regulator Provides a temperature compensated charge profile for deep-cycle batteries. Output power can be set for alternator derating. One regulator drives multiple engine alternators. Controls cross-charge of reserve battery.	1	AMP#SARV3 Regulator Provides a temperature compensated charge profile for deep-cycle batteries. One regulator drives multiple engine alternators. Controls cross-charge of reserve battery.
Battery Charger	1	STA#TC2020 Three-stage battery charger with sufficient capacity (10-amps) to handle all dockside loads.	1	NEW#PT20CE Three-stage battery charger with sufficient capacity (20-amps) to handle all dockside loads. Includes international voltage range adjustable with slide switch.
Inverter	-	Optional - Fuse location reserved	1	STA#TSW1800 1000-watt, Sine Wave Inverter. 1800-watt optional.
Inverter/ Charger	-	Optional - Fuse location reserved	1	TRA#SW2600 Only considered if an AC Generator set is used for secondary battery charging in which case, the seperate battery charger and inverter would be deleted.

Table 3: Inboard Diesel Power Vessel

System Item	Day Configuration		Cruise Configuration	
	Qty	Device	Qty	Device
Solar Panels	-	Optional - wiring and control relay installed.	4	KYO#KC120 360-watt 12-volt solar panel array. Regulation is controlled by Energy Monitor.
AC Electrical Panel	1	BSS#8x43 Mains input breaker with reverse polarity indication, 3 x load breakers and AC voltmeter	1	BSS#8x43 Mains input breaker with reverse polarity indication, 3 x load breakers and AC voltmeter
DC Battery Distribution	1	OMA#DCDIST1 DC distribution board servicing interconnections of batteries and all high power loads and charge sources. Prewired for optional solar panels, wind generator and inverter.	1	OMA#DCDIST1 DC distribution board servicing interconnections of batteries and all high power loads and charge sources.
DC Engineering Panel	1	BSS#8083 Master battery switch, anchor windlass breaker, and 8 DC breaker positons (5 installed).	1	BSS#8083 Master battery switch, anchor windlass breaker, and 8 DC breaker positons (5 installed).
DC Navigation Panel	1	BSS#8x68 13 DC breaker positions (10 installed), volt meter and amp meter	1	BSS#8x68 13 DC breaker positions (10 installed), volt meter and amp meter
Helm Panel	1	BSS#8262 4 position waterproof switch panel	1	BSS#8262 4 position waterproof switch panel
Desalination	-	Optional - circuit breaker position allocated	1	SPE#200C 12-volt, 35 LPH desalination system with 20-micron pre-filter and manual backflush options.
Refrigerator	1	OMA#REF200A 200 litre air-cooled DC refrigerator with dedicated condensor set. Optional keel-cooled condensor available.	1	OMA#REF200A 95 litre freezer with dedicated air-cooled DC condensor set. Optional keel-cooled condensor available.
Freezer	1	OMA#FRZ95A 95 litre air-cooled DC freezer with dedicated condensor set. Optional keel-cooled condensor available.	1	OMA#FRZ95A 95 litre freezer with dedicated air-cooled DC condensor set. Optional keel-cooled condensor available.
Hot Water	1	OMA#HW20L 240-volt AC 20 litre storage hot water system fitted with engine heat exchanger.	1	OMA#HW20L 240-volt AC 20 litre storage hot water system fitted with engine heat exchanger.

System Analysis

Design Objectives and Methodology

The previous section discussed the need to provide a system:.

- that is safe in terms of vessel operation and fire risk
- that is robust, easy to operate and requires little if any maintenance
- that minimizes engine run-time in support of energy generation
- that offers a high level of comfort in support of living aboard
- that economizes on weight

In order to select the equipment to support the objectives and balance expectations to budget, an analysis is required of operation parameters:

1. Determine the energy budget of the vessel for all operation modes.
2. Factor typical (good) and poor case renewable energy generation. The resulting surplus/deficit will determine the demand placed on engine based charging.
3. Size the house battery bank amp-hour capacity to at least twice the daily amp-hour consumption. This will ensure that over a 24-hour period, the target battery depth of discharge is no more than 50%. To reduce weight, battery capacity may be less at the expense of lifetime amp-hours/dollar.
4. Size the engine charge source to the desired engine run-time per day.
5. Fine tune each step to meet expectations.

Energy Budget

Energy consumption is considered for three cases:

a **Ashore** - the lightest load. Defined by the vessel at anchor with no person living aboard. The system is sustaining the load of an anchor light and refrigeration equipment. The objective is to meet this load indefinitely from the solar panels.

a **Anchor** - Defined as the loads for “Ashore” plus loads associated by general living aboard. The objective is to have an energy surplus from solar panels operating in good sunshine conditions. Occasional engine run-time can be expected when conditions are not optimum.

a **Passaging** - this is the highest consumption case. The system has to support all loads applicable for “Anchor” plus loads associated with running the vessel under way. An engine will most likely need to be run on a daily basis to supplement the shortfall in solar generation. A wind generator may be to advantage in this case. For power vessels, alternator output will easily cover energy consumption.

The following table provides a summary of anticipated daily amp-hour consumption for the three cases listed above.

See “Detail Energy Budget” on page 16.for calculation data.

Table 4: Energy Budget Summary

DC Loads	Ashore	Anchor	Passaging
Load AH (24-hr):	72.0	135.3	202.6

Renewable Energy Generation.

Table 5: Solar (320-watt)[a]

Solar	Ashore	Anchor	Passaging
Typical AH (24 hr)	94	94	56
Poor AH (24 hr)	28	28	19

a. 4 x Kyocera 80-watt panels

Solar panel output varies by the declination of the sun, cloud conditions and obstructive shadows. For calculation, 1 amp of charge current corresponds to about 17-watts of solar panel running at full output. To calculate daily solar output, estimate the number of hours that the panels are running at an effective 50% power level. For sailing vessels, output may be considerably less while passaging due to sail shadow. See “Renewable Energy Estimates” on page 16. for calculation data.

Table 6: Solar (320-watt) + Wind[a]

Solar+Wind	Ashore	Anchor	Passaging
Typical AH (24 hr)	94	94	200
Poor AH (24 hr)	28	28	67

a. Air Marine 400

Wind generator output is proportional to wind speed. The start-up wind speed is 10 knots for which we allow 2-amps. Add 1-amp per knot up to a maximum of 20 knots. We suggest that typical wind conditions at anchor are less than 10 knots when in the lee of an island or headland.

Table 7: Energy Surplus/Deficit

Surplus (Deficit)	Ashore	Anchor	Passaging
Solar Only			
Load AH (24-hr):	72	135	203
Typical AH (24 hr)	22	-41	-146
Poor AH (24 hr)	-44	-107	-184
Solar + Wind			
Load AH (24-hr):	72	135	203
Typical AH (24 hr)	22	-41	-2
Poor AH (24 hr)	-44	-107	-136

The table above shows the energy surplus or deficit for each operational case over a 24-hour period.

Any energy deficit will need to be made up by running a generator set or engine alternator.

House Battery Bank Capacity

Table 8: Battery Capacity[a]

Battery Capacity (AH)	Charge %		
420	Ashore	Anchor	Passaging
Solar Only			
Load AH (24-hr):	72	135	203
Typical Charge % (24 hr)	105%	-10%	-35%
Poor Charge % (24 hr)	-10%	-26%	-44%
Solar + Wind			
Load AH (24-hr):	72	135	203
Typical Charge % (24 hr)	105%	-10%	0%
Poor Charge % (24 hr)	-10%	-26%	-32%

a. 2 x Lifeline GPL-4D 210AH AGM batteries

The house bank capacity should be at least twice the daily energy consumption in order to avoid battery discharge below 50%. The upper limit is determined by targeting the number of days desired to support the system without running a genset or engine alternator. The table above shows the daily surplus or deficit (including renewable energy) as a percentage of house battery bank capacity.

Engine Charging

The standard automotive type alternators fitted to the Yanmar diesels will charge at about a 50-amp rate (1400 engine RPM). A 140 amp-hour energy deficit will require about 4-hours of engine run-time. Fitted with 140-amp alternators, we can expect around 90-amps of charge current resulting in less than 2-hours of run-time per day. Average run-times will be much less if good solar conditions prevail.

Energy Monitoring

Proper management of battery state of charge is crucial to the operation of the system. The energy monitor will monitor all battery parameters, calculate the house bank state of charge and give an alarm if any system parameter is beyond a programmed limit.

Recommendations

Referring to “Energy Surplus/Deficit” on page 14, there is a significant shortfall of renewable energy for both passaging and poor case anchor conditions. We would recommend that:

1. The standard engine alternators are upgraded to high output units to reduce engine run-time and to improve reliability.
2. Add an additional 160 watts of solar. Given that there is physical space to fit, the addition would lesson the need to run engines while at anchor.
3. Increasing battery capacity to 510 amp-hours will allow more surplus energy, particularly at “anchor” on good days to be banked to fill in for poorer days.
4. A wind generator is recommended to further reduce engine run-time when passaging. We do not expect the wind generator to have any substantial impact to “anchor” numbers.

Table 9 lists the energy system devices intended for the vessel.

Table 9: Primary Equipment

Device	Objective
Auxiliary Engines	2 x Yanmar 2GM diesels used to supplement solar panel power generation. See “Recommendations” on page 15 for upgrade to high output alternators.
Generator Set	Not required - AC power is provided by a sine-wave inverter when away from dock
Solar Panels	12-volt solar array to provide primary energy generation.
Wind Generator	Not specified - wiring and control is included to facilitate easy addition at a later date. See “Recommendations” on page 15 for inclusion of a wind generator
Battery Charger	12-volt, three-stage charger with international input voltage and frequency capability. Provides vessel power at a dock.
Sine-Wave Inverter	110-volt, 60-cycle, AC power source. Sine wave output is compatible with computers and portable appliance battery chargers.
House Battery Bank	12-volt deep cycle, house bank. Capacity sized to at least twice daily energy consumption. Batteries are fully sealed and maintenance free.
Reserve Battery	Reserve cranking battery with cranking capacity sufficient to start diesel engines. Battery is fully sealed and maintenance free.
Alternator Regulator	Controls port and starboard engine alternators. Provides the correct temperature compensated charge profile to match the deep-cycle house battery bank. Controls cross charge of reserve battery from any charge source.

System Analysis

Table 9: Primary Equipment

Device	Objective
Energy Monitor	Monitors house-bank volts, amps, amp-hours and temperature. Monitors reserve battery voltage. Has programmable alarms for all key battery parameters. Controls solar panel regulation.
Desalination	9 gallon per hour capacity at 1 amp-hour per gallon
Refrigerator	Refrigerator of 200 litre capacity
Freezer	Freezer of 95 litre capacity
Protection and Wiring	All circuits protected by fuses and circuit breakers. Wire is UL approved tinned copper. Wiring system conforms to ABYC standards.

Calculation Data

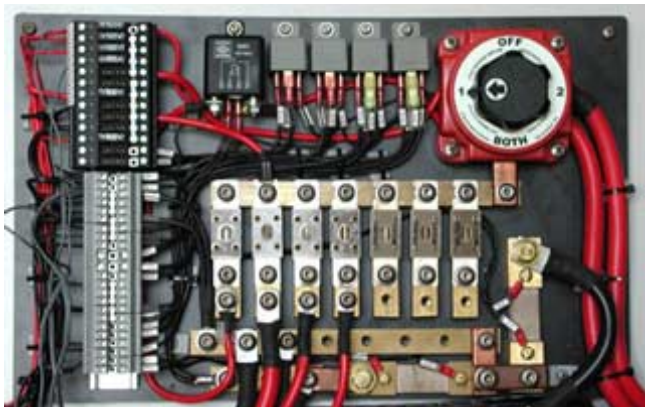
Table 10: Detail Energy Budget

Direct DC Loads	Amps	Ashore		Ancor		Passaging	
		Hrs/Day	AH/Day	Hrs/Day	AH/Day	Hrs/Day	AH/Day
Coms - HF	2	0.0	0.0	0.5	1.0	1.0	2.0
Coms - VHF	0.25	0.0	0.0	8.0	2.0	24.0	6.0
Ent - DC TV/Stereo	2	0.0	0.0	4.0	8.0	3.0	6.0
Fridge	4	6.0	24.0	8.0	32.0	8.0	32.0
Freezer	4	6.0	24.0	8.0	32.0	8.0	32.0
Lights - Ancor	1	24.0	24.0	8.0	8.0	0.0	0.0
Lights - Cabin	2	0.0	0.0	4.0	8.0	2.0	4.0
Lights - Spreader	20	0.0	0.0	0.0	0.0	0.2	4.0
Lights - Nav	2	0.0	0.0	0.0	0.0	8.0	16.0
Nav - Auto Pilot	1.5	0.0	0.0	0.0	0.0	24.0	36.0
Nav - GPS/Plotter	0.5	0.0	0.0	0.0	0.0	24.0	12.0
Nav - Instruments	0.75	0.0	0.0	0.0	0.0	24.0	18.0
Nav - Radar	2.5	0.0	0.0	0.0	0.0	2.0	5.0
Pump - FW	8	0.0	0.0	0.5	4.0	0.5	4.0
Pump - SW	8	0.0	0.0	0.1	0.8	0.1	0.8
Water Maker	9	0.0	0.0	2.0	18.0	2.0	18.0
Winch - Ancor	80	0.0	0.0	0.1	8.0	0.0	0.0
Inverter Loads	**Watts**						
Breadmaker	500	0.0	0.0	0.0	0.0	0.0	0.0
Microwave	1000	0.0	0.0	0.0	0.0	0.0	0.0
Computer	40	0.0	0.0	4.0	13.5	2.0	6.8
TV/Stereo	100	0.0	0.0	0.0	0.0	0.0	0.0
Total AH (24 hrs)		**72.0**		**135.3**		**202.6**	

Table 11: Renewable Energy Estimates

Renewable Source	Watts	Ashore AH/Day		Ancor AH/Day		Passaging AH/Day	
		Poor	Typical	Poor	Typical	Poor	Typical
Solar Panels	320	28	94	28	94	19	56
Effective Hrs @ 50% output:		3	10	3	10	2	6
Wind Gen.	400	0	0	0	0	48	144
Average Wind Speed:		3	6	3	6	10	14
Total AH (24 hrs)		**28**	**94**	**28**	**94**	**67**	**200**

Master DC Distribution Panel



Features

- Battery isolation and change-over switch. Location can be either on or off panel.
- ANL-type fuse protection (50 to 500 amps) for all distribution circuits.
- Cross-charge relay for reserve battery charging.
- Field relays to support multiple engine alternator charging (alternator regulator separately supplied).
- Solar panel regulation relay (controlled by separately supplied Energy Monitor).
- Wind generator start/stop relay (controlled by separately supplied switch).
- DIN-rail type ATO fuse blocks for monitoring and control circuits protection.
- DIN-rail terminals for monitoring and control circuit connections.
- Supplied pre-wired with schematic diagram
- All wires are labeled with cable markers.

Description

The panel simplifies the design and wiring of a vessel energy system. All power circuits are protected by fuses and wiring distances are kept to a minimum. Connections to external circuits are clearly identified on terminal blocks and internal wires are identified with cable markers that share the same name as the schematic diagram. The system is designed for direct connection to the an Energy Monitor and SARV3 alternator regulator.

The "System Block Diagram below shows the distribution panel in a typical vessel configuration. See "Terminal Connections" on page 19. for termination list.

Figure 2: System Block Diagram

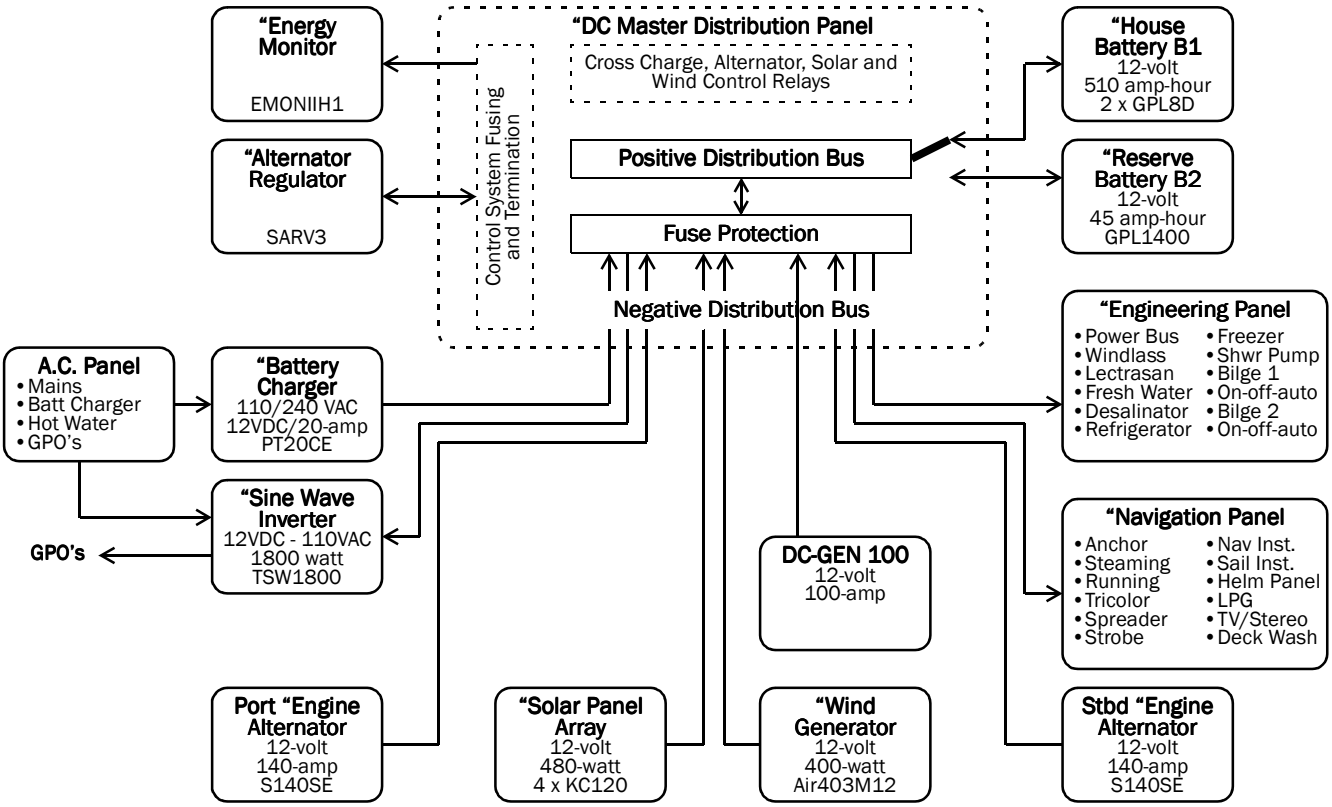


Table 12: Terminal Connections[a]

Term #	Fuse[b] (amps)	Wire Label	Signal	Connects to:
F1	1	RBREF	Reserve Battery Reference	Energy Monitor - B2 Volts Navigation Panel - B2 Volts
F2	1	HBREF1	House Battery Reference	Energy Monitor - Power
F3	1	HBREF2		Energy Monitor - B1 Volts Navigation Panel - B1 Volts
F4	1	HBAUX1		Auxilliary control circuits
F5	10	HBAUX2		Spare (House Bank positive)
F6	1	REGSEN+	Positive Distribution	SARV3 - Voltage Sense
F7	15	REGB+		SARV3 - Power
F8	1	POS3		Reserved - Solar and Wind relay coils
F9	15	POS4		Spare (Positive Distribution)
F10	20	SLRPOS		Solar Panel - Positive
F11	30	WINDPOS		Wind Generator - Positive
T1	-	SH1-	Shunt 1 negative	Energy Monitor - Shunt Negative
T2	-	SH1+	Shunt 1 positive	Energy Monitor - Shunt Positive
T3	-	REFGND1	Reference Ground	Energy Monitor - Ground
T4	-	REFGND2		Energy Monitor - Ground
T5	-	REFGND3		Energy Monitor - Shield
T6	-	REGGND	Ground	SARV3 - Ground
T7	-	NEG3		Spare
T8	-	NEG4		Spare
T9[c]	-	SLRON	Solar Panel Control	Energy Monitor - SLR
T10	-	SLRNEG	Solar Panel Negative	Solar Panel - Negative
T11	-	WINDNEG	Wind Generator Negative	Wind Generator - Negative
T12	-	WINDON	Wind Generator Control	Wind Generator Control Switch
T13	-	FLD1NEG	Alternator 1 Field Negative	Alternator 1 - Field Negative
T14	-	FLD2NEG	Alternator 2 Field Negative	Alternator 2 - Field Negative
T15	-	FLDNEG	Regulator Field Return	SARV3 - Alternator Negative
T16	-	FLDPOS	Regulator Field Positive	SARV3 - Field
T17	-	OIL1	Alternator 1 Field Control	Engine 1 - Oil Pressure Switch
T18	-	OIL2	Alternator 2 Field Control	Engine 2 - Oil Pressure Switch
T19	-	REGON	Regulator On Control	SARV3 - Regulator On
T20	-	PARALLEL	Cross Charge Control	SARV3 - Parallel
T21	-	SH2-	Shunt 2 Negative	Energy Monitor - Aux Shunt Negative
T22	-	SH2+	Shunt 2 Positive	Energy Monitor - Aux Shunt Positive
AF1	50	POS1	Panel 1 Positive	Engineering Panel - Positive Bus
ND1	-	NEG1	Panel 1 Negative	Engineering Panel - Negative Bus
AF2	50	POS2	Panel 2 Positive	Navigation Panel - Positive Bus
ND2	-	NEG2	Panel 2 Negative	Navigation Panel - Negative Bus
AF3	50	BCPOS	Battery Charger Positive	Battery Charger - Positive
ND3	-	BCNEG	Battery Charger Negative	Battery Charger - Negative
AF4	200	INVPOS	Inverter Positive	Inverter - Positive
ND4	-	INVNEG	Inverter Negative	Inverter - Negative
AF5	150	ALT1POS	Engine 1 Positive	Engine 1 - Alternator/Starter Positive
ND5	-	ALT1NEG	Engine 1 Negative	Engine 1 - Alternator/Starter Negative
AF6	150	ALT2POS	Engine 2 Positive	Engine 2 - Alternator/Starter Positive
ND6	-	ALT2NEG	Engine 2 Negative	Engine 2 - Alternator/Starter Negative
AF7	100	CCPOS	Cross Charge Positive	Cross Charge Relay - Contact 87
PD[d]	-	PD	Positive Distribution	Internal connection to battery switch common
SWB1	-	HBPOS	House Battery Positive	House Bank - Positive
SWB2	-	RBPOS	Reserve Battery Positive	Reserve Battery - Positive
SH1-1[e]	-	BATNEG	Battery Negative	Battery Bank - Negative
SH2-1	-	AUXNEG	Auxilliary Source Negative	Internal - Wind and Solar control relays

a. Subject to change without notice
b. ATO fuses from 1 to 40 amps. ANL fuses from 50 to 500 amps.
c. Energy Monitor (EMONIIH1) or external solar panel controller required.
d. Connects externally if battery switch is not installed on panel.
e. Auxilliary shunt is an option for Energy Monitor EMONIIH1.

Lifeline AGM Batteries

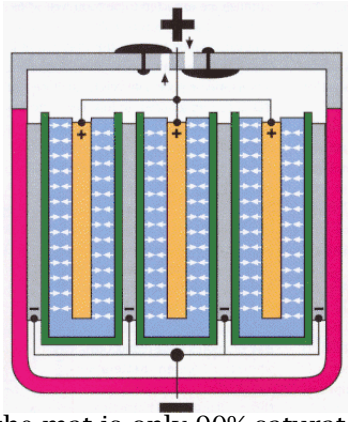
Lifeline AGM Technology Batteries are the culmination of continual improvements since the introduction of this technology in 1985.

Dedicated research and development motivated by the desire to engineer an improved sealed battery without compromising safety, Lifeline has refined this new technology to its current state. With proven reliability and safety, the Lifeline AGM Technology Batteries have received great acceptance in military sea, air and land applications and commercial deep cycle, starting, and standby/back-up (UPS & Photovoltaic) applications.

How They Work

Unlike gel batteries, AGM recombination takes place within the separator in a molecular state, therefore, the Lifeline sealed batteries are safe for Marine/RV, UPS and Photovoltaic applications. The cells are sealed and relief valves provide a safe positive pressure during charging. A fiber floss glass mat with wicking characteristics is sandwiched between the plates for retention of electrolyte. The electrolyte is absorbed and held in place by the capillary action of this glass mat.

Figure 3: Lifeline Gas Recombination

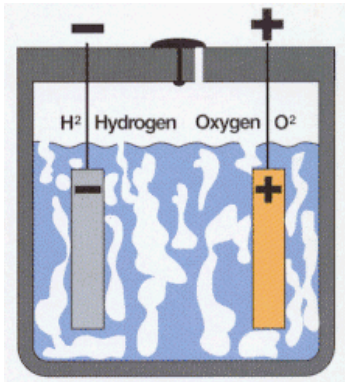


By design, the mat is only 90% saturated with electrolyte allowing a portion of the mat to be filled with gas. These gas spaces provide the channels by which the freshly generated gasses, which are in their atomic state and very reactive, are allowed to recombine rapidly and safely. Due to this engineered reaction, and coupled with the purity of the plate material and grid material, Lifeline Batteries have much lower internal resistance and thus can provide higher rates of discharge and quicker rates of recharge. Additionally, this glass mat provides a higher degree of support against shock and vibration than other types of batteries.

Not a Gelled Electrolyte

In contrast to the Lifeline AGM design, gelled electrolyte batteries are manufactured using a silica gel and acid mixture. As a semi solid, voids develop between the gel matrix and plate to allow passage of gases. This renders that area of the cell inert thus reducing the capacity of the gel battery. In addition, recombination takes place in a compressed gas state in the space between the plates and the battery lid

Figure 4: Gel Electrolyte Voids

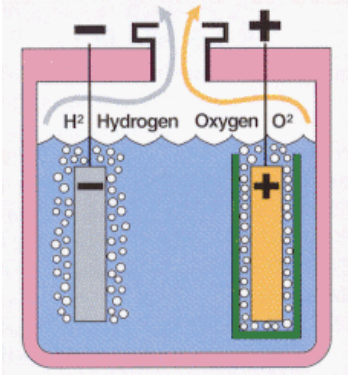


FLOODED CELL BATTERY COMPARISON

Some of the main differences between vented lead acid batteries and the LIFELIINE AGM valve regulated sealed lead acid batteries are:

The electrolyte is absorbed in a glass mat (AGM) separator in the LIFELINE and it is spillable in the flooded or vented type.

Figure 5: Flooded Electrolyte Loss



The cells have pressure relief valves in the LIFELINE that are designed to keep positive pressure in each cell. The older vented or flooded type battery

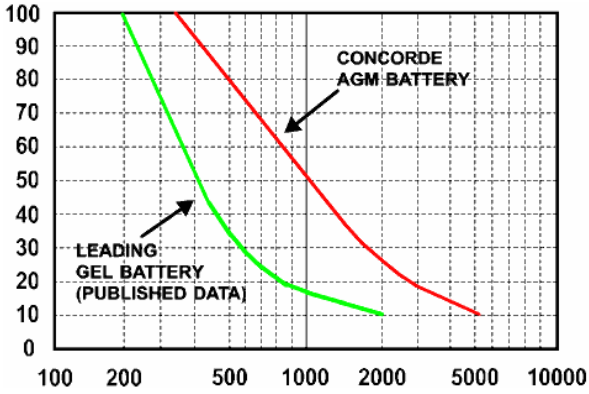
cells are open to atmosphere through the vent cap holes (should the vented battery be tilted or inverted, the result can be electrolyte (sulphuric acid/water mixture) spilled all over your equipment, a highly corrosive and potentially dangerous condition).

The cell groups in the old vented type batteries are loosely packed and thus have high plate separation. In contract, the LIFELINE AGM marine battery has every square inch of positive and negative plate material tightly packed and compressed with the AGM and supported by the walls of each cell.

Increased Capacities

Unlike other sealed battery technologies, the AGM battery technology allows for more positive plate material in its cell construction. Therefore, there is an increase in Amp Hours, Reserve Capacity, depth of cycle, cycle life and a reduction of internal self-discharge over other sealed batteries. They do weigh a little more but compare amp-hour capacity - it's greater for a given case size.

Figure 6: Discharge vs. Life Cycles



New Starting Batteries

Purpose built for starting applications, the new GPL-1300 and GPL-1400 batteries are lighter than conventional batteries. With a peak power current of 1300 and 1400 amps respectively, and a power rating current of 600 and 1000 amps, these batteries are ideal for fast cranking engines.

Feature Summary

- Lower internal resistance for high charge efficiency and cranking power
- Withstand shock and vibration much better than standard flooded or gelled electrolyte designs. Aircraft class cell construction:
- Superior discharge cycles
- Faster recharge; no current limitations with voltage regulated recharging.
- Much better charge retention than low cost, flooded cell types, even at high ambient temperatures.
- Full recharge after 30 days storage in a full discharge condition (77 degree F rating).
- Less than 3% per month self discharge at 77 degree F (25 degree C); less at lower temperatures.
- Sealed construction with absorbed electrolyte-no shipment restrictions; submersible without damage; install in any position; no need for watering, cell safety vent valves
- Safety--even during severe overcharge the LIFELINE AGM battery produces less than 2% hydrogen gas (4.1% is required for flammability in air).
- Properly supported, LIFELINE AGM batteries with absorbed electrolyte can be installed and operated on their side.

Table 13: Lifeline Battery Specifications[a]

Battery	Amp Hours	Volts	CCA	Reserve Capacity	Dimensions (cm)			Weight (kg)
					L	W	H	
GPL-1300	17.6	12	265	32	13.3	11.5	14.7	7
GPCL-U1	33	12	325	50	19.6	13.2	18.3	10.4
GPL-1400	45	12	550	90	25	13.1	17.5	15
GPL 24	80	12	550	149	27.7	16.8	25.4	24.1
GPL 27	95	12	575	176	32.0	16.8	25.4	28.6
GPL 31	105	12	600	190	32.8	17.0	25.1	30.9
GPL-2C	180	6	760	317	26.4	18.0	29.5	25.0
GPL 4D	210	12	1100	380	52.6	22.1	26.2	59.0
GPL 8D	255	12	1350	461	52.3	27.9	25.9	71.7

a. Specifications subject to change without notice

Ample Power - Energy Monitor

The EMON II is designed to completely monitor one or two battery banks. It provides the resolution and accuracy necessary to eliminate battery discharge problems and its selectable alarms will keep you informed of overcharges before they become dangerous. Solar and wind generator control with load disconnect make the EMONII the most sophisticated energy controller in existence. With English language messages like 7/8 FULL, even electrical novices are battery experts with the EMON II.

Dual Battery Monitoring

The EMONII monitors a single house bank and a starter bank. It measures voltage, current and temperature for the house bank, voltage for a starter bank, and has an optional auxiliary input for charge current or alternator current. The auxiliary shunt can be used in the negative lead of solar panels and wind generators to measure their current and accumulate the Amp-hours returned by those charge sources. Alternatively, the channel might monitor loads such as refrigeration to determine exact amp-hours of consumption over a period of time.

Solar and Alternator Regulator Control

The EMONII provides an output signal that is used to control a solar panel disconnect relay, and to lock the Next Step or SAR Alternator Regulator into the absorption mode until the batteries are full. To control a solar panel, an optional EM-RELAY is required. This assembly is a Form-C relay capable of 30 Amps. Relay actuation is based on programmable set points.

Generator and Load Disconnect

The EMONII has an output signal that can be used as generator start/stop, or as a load disconnect signal. Actuation is based on programmable set points. The signal is programmable to operate the generator at specific capacities, for instance "on" at 50% capacity and "off" at 90% capacity. The signal can also be used as a load disconnect output by programming the on and off capacities as desired. An optional Load Disconnect Relay is required to disconnect loads.

Computations

The EMONII computes Amp-hours consumed and remaining, percent state of charge, and displays state of charge as a fractional value, i.e. 7/8 FULL.

- Amp-Hour Capacity for the house bank from 50 to 3267 AH
- Amp-Hours Consumed and Remaining for th house bank.
- Uses Peukert's Exponential Equation to Compute Amp-Hours Remaining thus Accounting for Rate of Discharge
- Interval `Trip' Amp-Hours on the house bank.
- Accumulated Lifetime Amp-Hours of the house bank.
- Accumulated Lifetime Amp-Hours Recharge from the Auxiliary channel
- Displays Battery Charge Efficiency
- Automatically computes Battery Charge Efficiency or Allows Manual Override

Alarms

The EMON II contains alarms for two battery banks Alarms can be individually enabled or disabled. Alarm setpoints are programmable and all programmed data is saved in non-volatile memory in the event of power failure.

- Depth of Discharge Alarms for the house bank; 50% and 80%
- High Voltage Alarms for both banks
- Low Voltage Alarms for both banks
- High Temperature Alarms for the house bank
- Voltage and Temperature Alarm Setpoints are User Programmable
- All Alarms can be Individually Enabled or Disabled

Non-Volatile Memory

The EMONII also protects your time spent setting up the instrument. All programmed data is protected in non-volatile memory ... you don't have to reprogram just because the unit was inadvertently turned off.

Universal 12/24V Operation

Either 12 or 24 Volts may be supplied as power to the EMON II, and the measurement channels can be a mixture of the two. Full scale voltage is 39.99 Volts with resolution of 0.01 Volts.

- Operation from any Mix of 12 or 24 Volts

- High Resolution Analog to Digital Conversions with 12 Bits for Voltage and Temperature and 13 Bits for Current
- Voltage for Two Battery Banks to 39.99 Volts with Programmable Alarms

CURRENT MEASUREMENTS

Full scale battery current is 399.9 Amps with a displayed resolution of 0.1 Amps. Battery current is measured with 13 bit precision (including sign). Auxiliary current is measured in the charge direction only, (positive), with full scale of 200 Amps and a resolution of 0.05 Amps.

- Battery Amps to 400 Amps Full Scale and Resolution of 0.1 Amps
- Auxiliary Amps to 200 Amps Full Scale and Resolution of 0.05 Amps

TEMPERATURE MEASUREMENTS

Battery temperature is measured to accurately calculate Amp-hours remaining using Peukert's equation. Temperature compensation is also used for controlling solar panels as well as the SAR and Next Step Regulators, when interfaced.

- Display in Fahrenheit or Centigrade.

COMPUTER INTERFACE

Computer interface hardware is standard inside the EMON II and optional software is available that allows full screen displays of electrical system parameters. Data may also be logged to the disk.

Computer software is user friendly, using a menu hierarchy. Panels of information may be named, saved on exit, and read at startup. View any named panel quickly. Disk logs are done in an analogous fashion.

ERGONOMIC, WATERTIGHT PACKAGING

The Energy Monitor II is packaged in a hardened and watertight housing. Signals exit the chassis via a waterproof cable and terminate on a free standing terminal block.

- Rugged Aluminum Water Resistant Package
- High Reliability Package with Sealed Membrane Keypad and no Internal or External Ribbon Cables which Experience Failure in the Marine Environment
- Large Alphameric Menu-Driven Display with Variable Intensity Backlighting
- Membrane Keypad with Variable Intensity Backlighting
- English Language Messages like B1 VOLTS and 5/8 FULL

KEYPAD CALIBRATION:

While not normally necessary, all measurement channels can be calibrated in the program mode. At least a 4-1/2 digit multimeter is required.

DIMENSIONS AND MOUNTING:

The EMON II front panel is 5.5 inches, (139.7 mm), wide by 4.5 inches, (114.3 mm), high. Allow 4.5 inches, (114.3 mm), depth to permit cable access. Unit requires a rectangular cutout of 5 inches, (127 mm), wide by 4 inches, (101.6 mm), high. A backup ``squeeze'' plate is supplied which has outside dimensions of 6 inches, (152.4 mm), wide by 5 inches, (127 mm), high. The squeeze plate eliminates need for screws in the mounting surface and may also be used for cutout template.

ORDERING INFORMATION:

Energy Monitor II, H1 #EMONII-H1

Auxilary Shunt #1011

Control Relay, 12V #EM-RELAY-12

Control Relay, 24V #EM-RELAY-24

Alternator Current Sensor, 12V #ALTCS-12

Alternator Current Sensor, 24V #ALTCS-24

PC Software, H1 #EMONII-PCH1

Ample Power SARV3 Regulator

The New Standard for Alternator Regulators

We hate to disappoint the thousands of users who think the Ample Power Smart Alternator Regulator, V2, is the best way to charge batteries, however, there is now a better way ...the V3. Combining the best features of the V2, with the best features of the Next Step Regulator, and adding a few new wrinkles to the art of battery charging, the V3 is the culmination of years of engineering. Using a microcomputer with twice the memory of the V2 and the Next Step, the V3 is packed with features you'd expect from Ample Power. You certainly don't want to try this with the competition, but you can short the field output of the V3 and it will live to tell you about it ...even if you forgot to fuse the B+ line! In fact it tells you immediately by flashing its red LED 3 seconds on, and 6 seconds off.

What's New?

The SAR-V3 has all the features that have made the SAR-V2 so popular, and incorporates the following new features.

Much improved field short circuit protection ...no more worries about losing the regulator when the alternator brushes short.

Dual alternator current limit inputs permit throttling the horsepower drawn by the alternator. This feature lets even small engines use a large alternator, by reducing alternator output when watermaker pumps or other loads are run. Dual current limit is standard on the V3 ...it was optional on the V2. The Next Step has no current limit capability.

Battery equalization can be enabled and will be automatically terminated at the appropriate voltage or time.

No adjustments required ...set the dip-switches for your battery type and you're done!

Both error and status signals are now available for use with remote indicators or audible alarms.

A new yellow LED shows when the parallel solenoid is actuated.

The regulator stays partially active all the time and will open and close the parallel solenoid as appropriate to maintain a second battery. With the V3 there's no need to purchase another product to keep the starter battery charged when a battery charger or solar panels are being used instead of the engine.

Even without the engine running, the SAR-V3 will flash the red LED should too high a voltage be applied to the battery.A pluggable terminal block permits wiring the harness prior to mounting the SAR.

Smart Discharge Detection

What if the regulator is in float, and the alternator can't keep up with demand? The SAR-V3 is smart enough to sense this condition and go into the absorption state so that a full charge will be returned when the load demand lessens and the alternator can once again continue charging.

Charge State Indicator

An LED keeps the user informed about the progress of charging. The green LED flashes on/off codes indicating the charge step at the moment. A terminal is provided that can drive a remote indicator.

Error Indicator

A red LED only flashes when faults are detected, such as loss of sense input, or over-voltage on the battery. Other faults such as shorted field driver or shorted field are reported. Errors are identified by the duration of on and off times for the red LED. This mechanism permits rapid troubleshooting of the charging system.

Easy to Adjust

The SAR-V3 has no set-point adjustments ...just choose your battery type on the dip-switches. There are two current limit potentiometers corresponding to two input signals that activate current limiting.

Performance Enhancements

The SAR-V3 improves on earlier design performance with these important additions:

- an output to drive a parallel solenoid which connects the house and starter batteries during charge
- an input signal to limit the absorption voltage when halogen lights are on

- an input signal that holds the regulator at the absorption set-point (compatible with Energy Monitor II)
- two alternator drive capability.

PARALLEL SOLENOID SIGNAL

The SAR-V3 has also been designed to provide a new level of system integration. The unit drives a parallel solenoid to simplify charging a starter battery at the same time a house battery is charged. This parallel signal is active even when the engine isn't running.

With the parallel solenoid driver, the SAR-V3 is ideal for motorhomes and fifth-wheel homes. The loads which are normally drawn from the starter battery can stay connected as wired ...the standard solenoid will supply 85 Amps continuously, (400 A intermittent). The same parallel solenoid can even be used with a manual parallel switch to connect the house and starter batteries.

TEMPERATURE SENSING

To provide an ideal charge regimen, the SAR-V3 senses battery temperature and compensates the various set-points. Temperature compensation corrects the output voltages from -4 to 140 Fahrenheit (-20 to 60 C). Above 140 F, the regulator cuts off completely to prevent thermal runaway. The SAR-V3 continues to operate below -4 F, but does not continue to increase battery voltage. Depending on the battery type, the battery voltage can range from 15.9 Volts on an extremely cold battery to 13.5 Volts on an extremely hot battery. Charge profiles follow time-proven regimens customized for each battery type.

ABSORPTION HOLD

The SAR-V3 interfaces to the Energy Monitor II and will stay in the absorption voltage until the Monitor releases it to float. The interface can also be used with a switch to hold the regulator in the absorption state or force it into the float state.

HALOGEN LAMP PROTECTION

While batteries need a voltage higher than 13.8 to charge fully, the higher voltage will take its toll on halogen lights, reducing their life considerably. The SAR-V3 includes an input that locks the set-point to 13.8 Volts when desired. This naturally slows the charge process but the locking feature can be used when long hours of motoring at night are expected. On motorhomes, the LOCK input can be connected to the headlights so that the regulator is locked out of high voltages whenever the headlights are on.

DUAL ALTERNATOR RATED

The SAR-V3 Regulator is rated to drive the fields of two alternators or more in parallel. No additional circuitry is required if both alternators are mounted on the same engine. When the alternators are mounted on separate engines, a diode and relay, (DUAL), kit is available which permits either or both engines to be run without applying field power to an alternator that isn't rotating.

FEATURES AT A GLANCE

- Fast, Full, Multi-Step Charging
- Automatic Compensation for Battery Temperature
- Adjustable Dual Current Limits
- Automatic Equalization Termination
- `Smart' Error Lamp Output Identifies Problems
- `Smart' Status Lamp Indicates Charge State
- Dip-switches select Charge Set-points
- Compatible with all Battery types
- Synchronizes operation with Energy Monitor II, H1 unit
- Lockable at 13.8 (27.6) Volts
- Easy Installation with pluggable terminal block
- Precision Reference Control Over Time and Temperature
- Field Driver is Short Proof
- Signals available for remote error and status indicators
- Voltage runaway indication even without engine running
- Operates parallel solenoid for cross charging house and starter battery for any charge source, (battery combining function).

DIMENSIONS AND MOUNTING

The SAR-V3 Regulator is 5.8 inches, (148 mm) long by 6.7 inches, (171 mm) wide. It stands 1.65 inches, (42 mm) off its mounting surface. It can be mounted in any orientation. The housing is marine grade aluminum which has been clear anodized.

Ordering Information:

SAR-V3, 12-Volt, P-type #SAR-V3-12P
SAR-V3, 24-Volt, P-type #SAR-V3-24P
Parallel Solenoid, 12-Volt, 100A #SOL12-100
Parallel Solenoid, 12-Volt, 200A #SOL12-200
Parallel Solenoid, 24-Volt, 100A #SOL24-100
Dual Alternator Relay Kit, 12 Volt #DUAL-12
Dual Alternator Relay Kit, 24 Volt #DUAL-24

Product Brief

AmpTech High Output Alternators

AmpTech High Output Alternators

'S' Series Small Frame Alternators

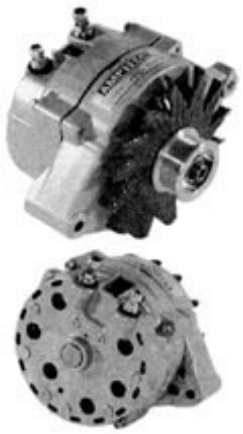
Direct mount replacement[1] for most engines

- 3 mounting foot configurations
- 125-amp and 140-amp 12-volt models
- 75-amp 24-volt models
- SAE continuous rated output for high temperature bulk charging applications
- Marine certified - complies with Coast Guard and BIA standard, Title 33 CFR, Part 183, Sub part 1, section 183-410 (Ignition protected)
- Isolated ground to protect against electrolysis
- 6 x 50-amp high voltage diodes
- 14-guage hand wound stator
- Precision balanced rotor
- Extended life copper composite brushes
- Heavy duty bearings with high temperature grease
- 2 x 5/16" cable posts
- Hand crafted in U.S.A

'L'Series Large Frame Alternators

Larger frame model has increased cooling. In most cases will require custom mounting.

- 163 to-203 amp 12-volt models
- 135-amp 24-volt models
- Direct mount replacement on some larger engines
- SAE continuous rated output for high temperature bulk charging applications
- Marine certified - complies with Coast Guard and BIA standard, Title 33 CFR, Part 183, Sub part 1, section 183-410 (Ignition protected)
- Isolated ground to protect against electrolysis
- 12 x 50-amp high voltage diodes mounted on "Cool Flow" precision cast heat sink
- 12-guage hand wound stator (14 guage on 24-volt model)
- Precision balanced rotor
- Extended life copper composite brushes
- Heavy duty bearings with high temperature grease
- 2 x 5/16" cable posts
- Hand crafted in U.S.A.



'Code 3' J180 Case Alternators

Code 3 model has highest output. In most cases will require custom mounting.

- 203 to-311 amp 12-volt models
- 163-amp 24-volt model
- Industry standard J180 case for direct OEM replacement
- SAE continuous rated output for high temperature bulk charging applications
- Maximum 8000RPM operating speed
- Marine certified - complies with Coast Guard and BIA standard, Title 33 CFR, Part 183, Sub part 1, section 183-410 (Ignition protected)
- Isolated ground to protect against electrolysis
- 24 x 50-amp high voltage diodes
- Massive 11-guage hand wound stator for coolest operation at maximum output
- Precision dynamically balanced high-amp rotor
- Enclosed long-life copper composite brushes
- Heavy duty bearings with high temperature grease
- 2 pair of 5/16" output posts for low loss connection (minimum 4# cable required)
- Hand crafted in U.S.A

1. Some minor modifications to adjustmentarm may be required

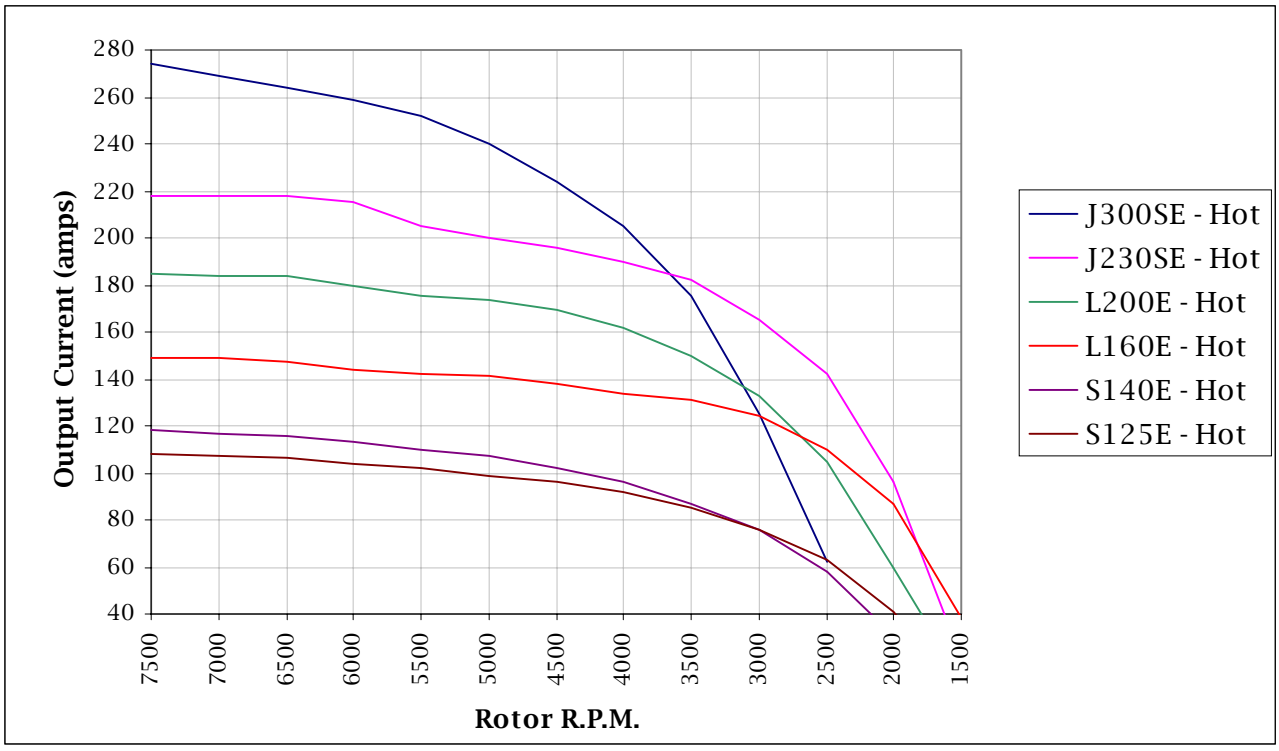
.

Table 14: Alternator Output Characteristics[1]

ALT RPM	J180 LARGE CASE CLASSIFICATION								LARGE CASE CLASSIFICATION								SMALL CASE CLASSIFICATION					
	J200SE		J230SE		J270SE		J300SE		L200E		L175E		L160E		L135/24E		S75/24E		S140E		S125E	
[2]	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot
7500	203	177	235	218	270	241	311	274	203	185	178	163	163	149	138	125	75	65	140	118	127	108
7000	202	176	235	218	266	241	308	269	202	184	177	162	162	149	137	123	75	65	138	117	126	107
6500	200	173	235	218	260	238	300	264	199	184	177	161	160	147	135	120	75	65	136	116	124	106
6000	198	171	232	215	255	236	295	259	197	180	176	160	159	144	130	119	74	64	134	113	123	104
5500	193	168	227	205	250	230	284	252	194	175	174	158	158	142	128	117	73	62	131	110	121	102
5000	190	166	222	200	243	226	272	240	189	174	171	155	156	141	126	114	70	60	127	107	118	99
4500	187	163	215	196	234	218	252	224	184	169	166	152	154	138	123	111	66	56	123	102	114	96
4000	182	160	207	190	223	208	232	205	176	162	162	148	150	134	119	107	64	52	117	96	108	92
3500	174	158	195	182	208	130	204	175	165	150	155	141	144	131	113	99	55	45	107	87	102	85
3000	165	148	178	165	184	166	160	125	146	133	143	130	134	124	100	86	47	37	93	76	92	76
2500	147	133	150	142	141	125	89	62	114	105	122	111	122	110	80	67	32	22	73	58	78	63
2000	124	106	110	96	78	55	8		65	60	88	77	94	87	35	33	8	4	42	31	54	41
1900	113	85	98	83	58	33			55	49	78	69	86	76	31	29	6	3	37	27	47	35
1800	105	86	85	69	40	18			45	40	70	58	77	69	26	24	4		31	21	40	29
1700	94	76	71	49	13	8			36	31	58	46	67	58	22	20			26	17	33	22
1600	82	66	51	35	8				25	21	45	35	56	47	18	17			21	12	24	15
1500	67	48	35	21					16	12	34	26	46	38	12	11			16	8	16	8
1400	48	33	28																			
1300	30	21																				
1200	12	8																				

1. Specifications subject to change without notice
2. Cold rating is 75 degrees farenheight, Hot rating is 200 degrees farenheight

Figure 7: Output Current Chart



Solar Panels

APPLICATIONS

- Sailboat and motorhome charging systems
- Microwave/Radio repeater stations
- Electrification of villages in remote areas
- Medical facilities in rural areas
- Power source for summer vacation homes
- Emergency communication systems
- Water quality and environmental data monitoring systems ·
- Navigation lighthouses, and ocean buoys
- Pumping systems for irrigation, rural water supplies and livestock watering
- Cathodic protection systems
- Desalination Systems

Kyocera Solar

Kyocera's advanced cell processing technology and automated production facilities have produced a highly efficient multi-crystal photovoltaic module. The conversion efficiency of the Kyocera solar cell is over 14%.

These cells are encapsulated between a tempered glass cover and an EVA pottant with PVF back sheet to provide maximum protection from the severe environmental conditions.

The entire laminate is installed in an anodized aluminum frame to provide structural strength and ease of installation.

Kyocera panels have a high power to area ratio. Like most solar panels, output will

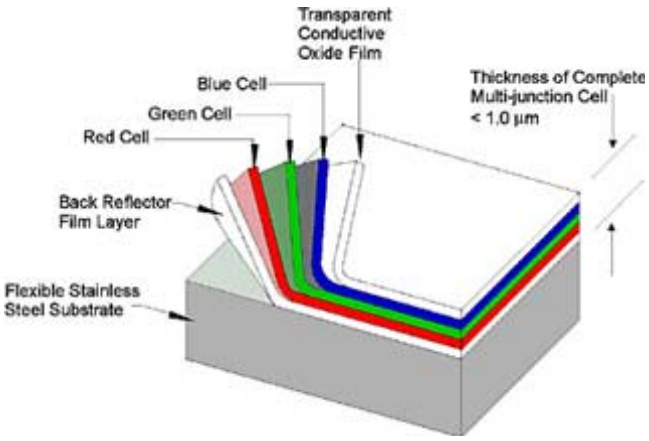
QUALITY ASSURANCE

Kyocera multi-crystal photovoltaic modules exceed government specifications tor the following tests.

- Thermal cycling test
- Thermal shock test
- Thermal/Freezing and high humidity cycling test
- Electrical isolation test
- Hail impact test
- Mechanical, wind and twist loading test
- Salt mist test
- Light and water-exposure test
- Field exposure test

Unisolar

All United Solar products are based on a sophisticated multi-layer amorphous silicon thin-film solar cell developed originally by Energy Conversion Devices, Inc. This spectrum-splitting cell, shown schematically at the right, is constructed of three separate p-i-n type, amorphous semiconductor solar sub-cells, each with a different spectral response characteristic. In this way, the cell can convert the different visible and near infrared wavelengths of sunlight with optimal efficiency. The United Solar spectrum-splitting multijunction design now holds all the world's records for amorphous silicon solar cell efficiency, including the highest stable efficiency measured by the National Renewable Energy Laboratory (NREL) for a small-area amorphous silicon solar cell - 13 percent.



The modules are exceptionally durable. They are encapsulated in UV-stabilized polmers and framed with anodized aluminum. A Galvalume steel backing provides stiffness. The polymer encapsulation includes EVA and fluoropolymer Tefzel, a DuPont film similar to Teflon. Bypass diodes are connected across each cell, allowing the modules (excluding the US-3) to produce power even when partially shaded. US-32, US-42, and US-64 modules are equipped with weather-resistant junction boxes to accept 1/2-inch conduit.

FEATURES

- Module Ratings - 32, 42, 64 Watts
- Polymer Encapsulation
- Anodized Aluminum Frame
- Unbreakable Construction
- Limited Warranty*
- Blocking Diodes for Battery Protection

Solar Panel Specifications

Table 15: Specifications[a]

MODEL	KC120	KC80	KC60	KC40	US64	US42	US32
Manufacturer	Kyocera				Cannon/Unisolar		
Maximum Power Watts	120	80	60	40	64	42	32
Maximum Power Volts	16.9				16.5		
Maximum Power Amps	7.1	4.73	3.55	2.34	3.88	2.54	1.94
Open Circuit Voltage	21.5				27.1		
Short-Circuit Amps	7.45	4.97	3.73	2.48	4.8	3.17	2.4
Length mm	1425	976	751	526	1366	928	1366
Width mm	652				741		383
Depth mm	52				32		
Weight kg	11.9	9.6	7.8	6.0	9.17	6.27	4.8

a. Specifications subject to change without notice

Y:\Marcom\Doc\ProductSpec\KYO#KC_Spec.fm 7/20/00

Product Brief

Air Marine 403 Wind Generator

Air Marine 403 Wind Generator

The best selling wind turbine for the sailboat market has been upgraded with a more powerful alternator, new electronics and a more efficient airfoil and is yet again breaking new production records.

Used in numerous single handed B.O.C races, the AIR Marine has been installed on several vessels in the Millennium race.

AIR marine starts producing power at 6 knots and will produce over 400 watts (28 amps) in a 24-knot wind. The new AIR's output is truly impressive. In only ten knots of wind, the turbine will deliver a consistent 2-3 amps and over 8 amps in only 15 knots. Its lightweight and compact design and integrated electronics make it perfect for sailboats of all sizes.

AIR marine's cast aluminum body and corrosion-resistant powder coated finish offer the cruiser the highest possible quality and reliability in wind turbine design. When taking that next extended voyage, you can be assured the AIR marine will keep your batteries charged.

FEATURES

- Unprecedented 3 YEAR WARRANTY
- Sophisticated internal charge controller - Externally adjustable for any type of battery
- Variable pitch aerolastic carbon matrix blades - Means never having to worry about a runaway wind turbine.
- Marine quality powder coated aluminum body for maximum corrosion resistance and durability.
- Tin plated wires for maximum corrosion resistance
- Anodized hub
- Upgraded S.S. fasteners specially treated to minimize galvanic reaction
- Brush-less neodymium cubic curve alternator
- Safety protection electronics controls voltage and rotor RPM
- Operates in hurricane winds without attention
- Maintenance-free - Only two moving parts
- Auto-brake: Another exclusive feature that automatically slows the AIR to a silent spin when the batteries are charged.

SPECIFICATIONS

Rotor Diameter: 1.14 meters

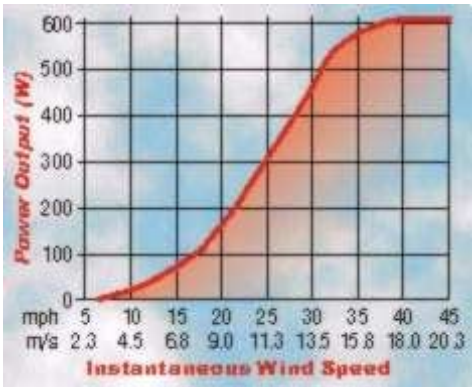
Weight: 6 kg

Mount: 1.5" (1.9" O.D.) SCD 40 pipe (47 mm O.D.)

Start up wind speed: 6 knots

Voltage: 12, 24 and 48 volts (Inquire for others.)

Output: 400 watts at 24 knots



AIR brings together advanced brush-less alternator technology, state-of the-art carbon composite rotor blades, and exclusive built-in voltage regulation all in an elegant cast aluminum body.

BLADES: The AIR's blades are made of carbon fiber reinforced composite that twists as the turbine reaches its rated output. This twisting effect changes the shape of the blade, causing it to go into stall mode. This limits the RPM of the alternator, preventing damage in high winds.

ALTERNATOR: The AIR's alternator is optimized to match as close as possible the energy available in the wind. It is constructed with Neodymium Iron Boron permanent magnets and is brush-less for superior performance and maintenance-free operation.

REGULATION & CONTROL ELECTRONICS: The electronics performs several functions to assure maximum output and safety for the user. The control electronics maintains a load on the alternator at all times to make sure that the turbine never over speeds, regardless of the condition of the battery. As the battery is charged, the sophisticated regula-

tor periodically checks the line, correcting for voltage loss and monitoring charge rate. Once the battery has reached its optimum charge level the regulator shuts the current off preventing the battery from being overcharged, then the blades slow to a silent spin, also preserving bearing life. When the batteries again need charging, the turbines electronics automatically release the brake and allow the amps to flow!

Newmar Phase III Battery Chargers

The Phase Three series represents a new dimension in charger design and performance, employing "smart" switching circuitry which puts batteries through the optimum three-step charge process, adapts for gel-cell or lead-acid/AGM batteries, features precise voltage compensation for varying battery temperature, is rated for continuous duty and is housed in a rugged stainless steel case.

Phase Three Chargers interact with batteries by regulating both voltage and amperage through each phase of the charging process, depending on battery state of charge, temperature, impedance, duration at high rate, system demand and battery type. The result is rapid battery recovery without overcharge, properly maintained and conditioned batteries, adaptability to changing charge conditions and long battery life.

Charge Characteristics

- Three stage 'smart' charging: bulk, absorption, float.
- lead-acid/gel-cell selector switch allows user to set optimum charge and float voltages based on battery type.
- Temperature compensation - automatically fine tunes output voltage based on battery temperature via remote sensor (optional).
- Internal terminals for optional equalization timer connection.
- High charge rate controlled by timer and current sensing circuit, switching to float rate even if there is a high continuous demand on any battery bank, preventing overcharge.
- Charge cycle timer is initialized each time AC power is applied.
- Charges battery and powers load simultaneously.
- Multi-battery output, charges 3 independent banks based on demand.

Circuit Characteristics

- Conservative circuit design, switching semiconductors selected to withstand over 200% of nominal power level.
- Continuous duty rated to 50˚ C, with automatic high temperature power reduction.
- Operates on 115/230 VAC 50-60 Hz. Can be used anywhere in the world. Accepts wide variation on input, produces full output even from an AC generator with a distorted sine wave output.
- Fully functional as power supply without battery connected; well regulated stand alone power source if batteries fail. (See regulation/ripple opposite page)
- Low EMI/RFI emission, compatible with on-board electronics.
- Multiple units may be wired in parallel for high power systems. (See system examples, opposite page)

Indicators/Monitors

- Ammeter displays total charge output current.
- Power "ON" L.E.D. (PT-70 + PT-24-35 only)
- Remote panel indicates output status and allows manual reset of charge phase (optional).
- Remote meter panel (optional) digitally displays battery voltage, up to 5 banks.

Protection

- Stainless steel case with optional use drip shield included.
- Current limited - won't overload when charging dead batteries.
- Variable speed thermally controlled fan with dust filter.
- Automatic high temperature power reduction above 50˚ C.
- Circuit board polyurethane conformal coated for use in marine/high humidity environments.

- Timer limits absorption charge duration, preventing overcharge when under continuous load. (settable from 5 to 13 hours)

REMOTE INDICATOR PANEL

The optional panel provides a status indication of battery charger state:

- Bulk - Batteries are accepting full charger output. Enters this state whenever power is first applied. Terminates when output voltage rises to absorption voltage
- Absorb - Batteries are held at the absorption voltage for a full charge
- Float - Charge cycle is finished. Charger maintains batteries at the float voltage.

A push button allows the charge cycle to be reinitiated.

TEMPERATURE CONPENSATION SENSOR

Optional sensor optimises charge output voltage according to battery temperature.

Table 16: Phase Three Specifications[a]

	NEW#PT20CE	NEW#PT40CE	NEW#PT70CE	NEW#PT2420	NEW#PT2435
Input Voltage	85-135 / 170-270 VAC Selectable, 47-63 Hz				
Input Amps @ full load 110/240V	4.3/2.2	8.5/4.3	16/8	8.5/4.3	16/8
Output Banks	3				
Output Volts[b]	12			24	
Output Amps[c]	20	40	70	20	35
Battery Capacity[d]	40-200	80-400	140-700	40-200	70-350
Gel Float/Absorb Volts[e]	13.6/14.0			27.2/28	
AGM/Flooded Float/Absorb Volts	13.4/14.2			26.8/28.4	
Compensation[f]	-24 mv/degree C			-48 mv/degree C	
Temperature	Derate linearly from 100% at 50 deg C to 75% at 60 deg C. Shutdown > 60 deg C				
Regulatory Approvals and other designations	Safety: UL1950, EN60950, CSA C22.2 No. 950 Conducted RF Emissions: EN 55014 Radiated RF Emissions: EN50082, IEC 801-4 Transient Voltage: EN50082-1, IEC 801-4 Flicker: EN61000-3-3 Electrostatic: EN50082-1, IEC 801-2 Ignition Protection: per USCG CFR 183.410 Carries the CE mark. Certification by NEMKO, National Testing Agency, Norway				
Height mm	386		465	386	465
Width mm	241		305	241	305
Depth mm	135		198	135	198
Weight Kg	5	5.5	10.9	5.5	10.9

a. Specifications subject to change without notice
b. Nominal voltage. Selectable by switch for battery type.
c. Continuous Rating
d. Suggested battery capacity in amp-hours. Related to charger absorption time.
e. Voltage settings shown at 22 degrees celcius.
f. Optional sensor required for temperature compensation.

Statpower Prosine Inverters

The PROsine 1000i and 1800i True Sine Wave power inverters set a new benchmark for performance and value in the inverter catagory. Based on a 'clean-sheet' design approach, the inverter breaks new ground in form and function, and distances itself from competitive products in the performance arena.

Utilizing advanced high-frequency switching technology in the power conversion process, the PROsine series incorporate some of the most advanced circuitry and components available today. Compact, light weight and bristling with a host of features, the PROsine offers a seemless, transparent delivery of AC power.

Most significantly, PROsine's True Sine Wave output allows connected loads and equipment to operate the same as they would from utility supplied power. In both features and performance, the PROsine admirably takes a significant step forward.

The PROsine power inverter draws power from a battery and delivers a true sine wave AC output that is the same as the waveform supplied by your local electric utility. In some cases, the PROsine can deliver an even better waveform than your utility-supplied power due to the extensive control circuitry incorporated in the design of the unit.

Status Monitoring And Control

The detachable LCD panel provides the user a range of mounting options and delivers important system monitoring information in the most convenient location. The LCD PANEL provides:

- DC input voltage from the battery
- DC input current (Amps) drawn from the battery
- Power scale with inverter wattage output
- Status/Error display for shutdown conditions - overload, over-temperature, over/under voltage
- Convenience - can be mounted in 4 different ways on the inverter.

Automatic Transfer Switch Option

An integral transfer relay has two functions. When utility AC power fails or is disconnected from the unit, a quick transfer takes place and the PROsine inverter begins inverting DC battery power, and delivering AC power to the loads. When utility AC becomes present again, the transfer relay switches back and utility AC power is fed through to the loads. With this option, the PROsine can be used as a standby back-up power system.

True Sine Wave output (<3%THD)

A smooth, step-free waveform delivering dependable and reliable electrical power for even the most demanding and sensitive of loads.

Detachable LCD display panel

Providing remote status monitoring of the battery, and functional control of the unit.

Built to Last

With leading edge design, microcomputer control, and stringent regulatory approvals, the PROsine is built to work hard and long, day-in and day-out.

Easy to Handle and Install:

High frequency switching technology allows for smaller internal components, and creates big savings in PROsine's overall size and weight. A slimmer profile and lighter weight - a remarkable 16.5 lbs. / 7.5 kg - make the PROsine more convenient for installation in tight spaces where competitive products just won't fit.

Connect from any angle

PROsine's DC connection terminals have been uniquely designed to accept battery cables in 180 degrees of rotation. Our design approach makes it easier to wire up the PROsine even in the most constrained areas, and lets the wires exit from the power inverter in the most convenient fashion.

PROsine Protection Features

- Over-temperature shutdown
- Auto overload protection
- Battery reverse polarity (fuse)
- Short-circuit protection
- AC Backfeed
- Over-voltage protection
- Under-voltage protection

Configuration Options

- 230V/50Hz, 110V/60Hz
- 12-volt or 24-volt DC input
- GPO Outlet
- AC hardwire terminal

· AC hardwire terminal with transfer relay

Table 17: Prosine Specifications[a]

Parameter	STA#TSW1000i	STA#TSW1800i	STA#TSW1000	STA#TSW1800
Max. Continuous Power	1000	1800 W	1000	1800 W
Surge Capability (5 seconds)	1500	2900 W	1500	2900 W
Peak Output Current	11A	20A	25A	45A
Peak Efficiency	90%		89%	90%
No Load Current Draw	<1.5 W (search mode)			
Output Frequency	50 Hz +/-0.05% (crystal controlled)		60 Hz +/-0.05% (crystal controlled)	
Output Waveform	True Sine Wave <3% THD			
Input Voltage Range	12V / 24V 10 - 16 Vdc / 20 - 32 Vdc			
Output Voltage (at no load)	230 Vac RMS +/- 3%		120Vac RMS +/- 3%	
Output Voltage (over full load & battery voltage range)	230 Vac RMS -10% /+4%		120Vac RMS -10% /+4%	
Low Battery Cut-Out	12V / 24V 10 Vdc / 20 Vdc (5 sec. time delay, 10.5 Vdc warning)			
High Battery Cut-Out	12V / 24V 16 Vdc / 32Vdc			
Protection	Automatic Overload, Short Circuit, Overtemperature, Over Voltage, Under Voltage, Reverse Polarity (fuse), AC backfeed			
Transfer Relay rating	10A (on hardwire/transfer relay models)		15A (on hardwire/transfer relay models)	
Transfer Time AC to Inverter and Inverter to AC	Max 2 cycles (typically 1 cycle), <2.5 seconds with POWERSAVE "ON"			
Regulatory Approvals and other designations	EN50091 - 1: UPS General and Safety Requirements		CSA 107.1, UL 458 and UL 1741 Designed to meet: KKK-A-1822D Fed. Spec. for Ambulance; ABYC E8, E9, A25	
EMC	EN50091 - 2: 1996 UPS EMC Requirements		FCC Class A	
Weight	7.5 kg			
Length	390 mm			
Width	280 mm			
Height	115 mm			
Operating Temperature (See power derating curves)	0 - 60 degrees C			
Storage Temperature	-30 to +70 degrees C			

a. Specifications subject to change without notice

DC-GEN 100 Diesel DC Generator

A dedicated DC generator set is ideal when the main propulsion engine is not suitable for continuous battery charging. This is normally the case when the power required to drive the engine mounted alternator is too small for a larger propulsion diesel. In addition, the per hour running costs of a small diesel is much less than the larger propulsion diesels.

Based on a 4 horsepower horizontal Kubota diesel engine, the DC-GEN 100 produces 100-amps of 12-volt battery charging capacity (50-amps @ 24-volt) in a small and light weight package. With the optional hot-water heat exchanger system, all of a vessels energy needs and hot water heating can be met in a couple of hours of run-time per day.

Direct DC Energy

Compared to a conventional AC Generator and battery charger system, the diesel powered DC generator uses reliable alternator technology to directly generate 12 or 24 volt DC power for battery charging. No AC-powered battery charger is required.

The charging output is matched to the engine to ensure an optimum engine load that results in cleaner running, longer engine life and excellent fuel consumption. At a constant 2400 RPM, fuel consumption is a miserly 0.7 litres per hour at full output.

Vessel AC power is conveniently supplied by the vessel batteries through an inverter - when you need it without starting an AC generator set. Engine run-time is consolodated into one short period each day.

Features

- Single cylinder Kubota 4 H.P. horizontal diesel
- 100-amp output at 12-volts (50-amps@24-volts)
- Electric start
- Electric fuel system
- Remote start-stop panel with hour meter
- Failsafe engine shutdown on oil pressure, engine temperature and exhaust temperature.
- Mechanical drive Johnson seawater pump
- Optional hot water system heating
- Optional SARV3 external regulator for control of alternators on propulsion engines
- Only 50 kilograms weight
- Only 500mm L x 380mm W x 500mm H

Light Weight and Small Footprint

Utilising a horizontal-format Kubota diesel with an an aluminium engine block, weight and physical size has been kept to a minimum. At only 50 kilograms, the weight is comparative to four 120-watt solar panels and at 500 mm long by 380 mm wide, minimal engine room space is required.

Solid Engineering

Designed and manufactured by On Site Power Systems, the DC-GEN 100 marinization leaves nothing to chance. The engine is fresh water cooled. A custom cupru-nickel heat exchanger assembly is used to avoid corrosion. Seawater pumping is provided by a Johnson impeller pump which is mechanically driven by a shaft incorporated into the alternator drive belt tensioning system.

A 130-amp industrial alternator has been significantly derated for higher reliability. An energy saving “HTD” section alternator drive belt provides a lifetime of service

The integrated base plate serves as an oil pan to facilitate easy oil changing without spilling oil over the engine room floor. All serviceable items are on the one side of the engine.

Operation Convenience and Protection

The standard control panel includes a remote start-stop switch and an engine hour meter. A special fuel priming function allows the electric fuel pump to be run for one minute (without running the engine) for easy fuel priming in case the engine runs out of diesel.

Engine oil pressure, operating temperature and exhaust temperature are protected - the engine is automatically stopped if any parameter is outside normal operation.

Adjustable Output Voltage

The standard alternator regulator is adjustable to suit the correct absorption charge voltage for the type of batteries installed. Charging should be manually terminated when the battery charge current approaches 5% of the battery capacity. The standard system will charge at around 80 to 85 amps.

Optional SARV3 Regulation

The optional SARV3 regulator will more precisely control the charging system. The SARV3 current limit feature is set to provide the optimum output to match the available engine power. An adjustable timer on the SARV3 determines the absorption charge time. Output voltage is temperature compensated and bulk charge current output can be increased to 100-amps. A facility is provided for equalisation charging. The SARV3 can also control up to two additional alternators on separate engines.

Optional Hot Water Heating

Vessel hot water is provided by the optional hot water transfer kit. It uses a DC powered recirculating pump with thermostatic control system to heat water in a storage system. Only 20 minutes of engine run time is required to heat 20 litres of water to 80 degrees Celsius.

Table 18: Ordering Information

Item	Part #	Note	Price (including GST)
Generator Set	OMA#DC-GEN100	Includes remote control panel	$7,975.00
Hot Water Kit	OMA#DC-GEN100HW	Adds DC recirculation pump and thermostat	$450.00
External Regulator	AMP#SARV3	Includes battery temperature sensor	$795.00

Outback Marine Australia Pty. Ltd.
3/5 Ereton Drive
Labrador QLD 4215

www.outbackmarine.com.au

Ph: (07) 5563-9088
Fax: (02) 9475-0486
gary@outbackmarine.com.au

Blue Sea Systems Electrical Panels

General Features

Blue Sea Systems electrical panels are manufactured to the highest standards to withstand the marine environment.

A Superior Electrical Panel

- Countersunk mounting holes throughout
- Heavy 1/8" aluminum 5052 alloy
- MIL-C-5541C or equivalent Immersion Undercoating for lifetime corrosion resistance
- Two-part polyurethane slate finish
- Flush fitting backlightable labels (with optional backlight kit)
- Over 450 labels available worldwide
- "ON" indicating LED's
- Industry standard Circuit Breakers
- Industry standard height and width

DC Panel Features

- 100 Ampere rated tin-plated negative and grounding buses
- 100 Ampere rated tin-plated positive bus
- Heavy #10 stud terminals for feed-wire connections
- Ready for optional label backlight system
- Amber circuit "ON" indicating LED's

AC Panel Features

- Double-pole double-toggle AC rated magnetic circuit breakers break both neutral and hot AC
- 100 Ampere rated tin-plated negative and safety ground (green wire) buses
- 100 Ampere rated tin-plated positive bus
- Heavy #10 stud terminals for feed-wire connections
- Ready for optional label backlight system
- Red reverse polarity indicating LED's
- Green circuit "ON" indicating LED's

AC Auxiliary Panel Features

- 100 Ampere rated tin-plated negative and safety ground (green wire) buses
- 100 Ampere rated tin-plated positive bus
- Heavy #10 stud terminals for feed-wire connections
- Ready for optional label backlight system
- Green circuit "ON" indicating LED's

AC and DC European Panels - CE Marked

- AC and DC Panels are available for both US and Europe. European Panels are marked with the CE logo which denotes compliance with European Standards.
- The CE marked panels feature 8 Ampere B-Series Circuit Breakers for all AC branch circuits and 16 Ampere Circuit Breakers for AC main circuits. 32 Ampere B-Series
- Circuit Breakers are also available in the AC Main and AC Source Selector Panels.

The consistent height and width of Blue Sea Systems' panels allow them to be stacked together to create larger panel assemblies.

BSS#8x43 AC-Main + 3-Position CB Panel

Features
- 4 total circuit breakers
- Red reverse polarity indicating LED
- All hot, neutral and safety ground buses installed, fully pre-wired
- Includes set of 30 common AC labels, backlightable
- Ready for installation of optional 8065 Label Backlight System (1 required)

Features of 8043 Panel
- Three 15 Amp A-Series branch circuit breakers Installed
- One doubte-pole 30 Amp A-Series AC main circuit breaker
- 0-150 Volt AC voltmeter

Features of 8143 CE Marked Panel
- Three 8 Amp B-Sertes, branch circuit breakers Installed
- One double-pole 16 Amp B-Sertes AC main circuit breaker
- 0-250 Vott AC voltmeter

Application
- Main A.C. Input
- Hot Water System
- Battery Charger
- GPO Outlet

Specifications

Voltage	8043: 120 Volts AC, 8143: 230 Volts AC
Amperage	Panel Main Bus 100A
Weight	1.91U)/.87Kg
Dimensions	7.5" / 190.5mm high 5.25"/133.4mm wide

Ordering

PN	Description
BSS#8043	AC Main Panel wtth Meter, A-Series Circuit Breakers
BSS#8143	AC Main Panel wtth Meter, CE Marked, B-Series Circuit Breakers

BSS#8x68 DC 13-Position CB Panel

Ideally suited as a DC panel for placement at the navigation station.

General Features
- 13 total circuit breaker positions, 3 blank positions
- 8-16 Volt voltmeter with 3 position switch for multiple battery banks
- 0-50 Ampere ammeter with remote shunt
- All positive, ground and grounding buses Installed, fully pre-wired
- Ready for Installation of optional 8065 Label Backlight System (2 required)

Features of 8068 Panel only
- Ten 15 Amp A-Series circuit breakers Installed

Features of 8168 C 6 Marked Panel only
- Ten 15 Amp B-Series circuit breakers installed

SPECIFICATIONS

Voltage:	12 Volts DC
Amperage:	Panel Main Bus 100A
Weight:	4.06U) / 1.84Kg
Dimensions:	7.6" / 190.5mm high 10.5" / 266.8mm wide

ORDERING

PN	Description
BSS#8068	13 Position DC Panel, A-Series Circuit Breakers
BSS#8168	13 Position DC Panel, CE Marked, B-Series Circuit Breakers

BSS#8083 DC 13-Position CB Panel

FEATURES

- 100A C-Series circuit breaker provides both circuit protection and master switching for main distribution panel circuit
- 300A Continuous/400A Intermittent 4 position battery switch provides engine starting and house circuit switching
- 8 A-Series circuit breaker positions, five 15A circuit breakers installed
- 3 C-Series circuit breaker positions, one 100A circuit breaker installed
- All positive, ground and grounding buses installed, fully pre-wired
- Set of 30 common DC labels, backlightable
- Ready for installation of optional 8065 Label Backlight Svstem

SPECIFICATIONS

Voltage	32 Volts DC Maximum
Amperage	House Circuit 100A DC Engine Circuit 300A DC Continuous, 400A DC Intermittent
Dimensions	7.5" / 190.5mm high
	10.5" / 266.70mm wide

ORDERING

PN	Description	Weight Lb/Kg
8083	Circuit Breaker Panel with Battery Switch	4.06 / 1.84

Frigomatic DC Refrigeration

Manufactured to the highest standards by Veco in Italy, Frigomatic DC Refrigeration systems are expressly designed for mobile applications in boats and motor-homes.

They operate directly from 12 or 24 volts DC. There is no need to run an engine or generator set once or twice per day to maintain your refigerator or freezer. At the dock or caravan park, power is maintained on a continual basis by the vessel/vehicle battery charger. In remote locations, power comes from your house battery.

Frigomatic systems are up to three times more energy efficient than a comparitive sized AC compressor running through an inverter. A well insulated system can run on energy generated from solar panels alone.

Both air-cooled and water cooled condenser sets are offered. The water-cooled units have a 20% higher capacity than air-cooled units - at the expense of introducing contact with sea water. All units use hermetically sealed compressors that are renowned for leak-free operation.

Table 19: Performance Characteristics[a]

Model	Capacity (+45˚C[b]/-15˚C[c], BTU/hr) / Amps (@12V[d]), -25˚C /Amps vs. Compressor RPM			
RPM:	2000	2500	3000	3500
Capri	194/2.3, 104/1.7	246/3, 132/2.1	276/3.5, 144/2.5	317/4, 163/2.9
K 35F	274/2.6, 147/1.8	351/3.1, 189/2.2	414/3.9, 215/2.8	478/4.5, 248/3.2
W 35F	274/2.6, 147/1.8	351/3.1, 189/2.2	414/3.9, 215/2.8	478/4.5, 248/3.2

a. Subject to change without notice
b. Indicates condensing temperature – about 10 degrees higher than ambient
c. Indicates evaporator temperature
d. Amps should be halved for 24-volt operation

Frigomatic Evaporator Plates

- 3 models for fridge and freezer bendable to box dimensions
- Pre-charged with Veco self-sealing couplings
- Bend to minimum 25mm radius with Veco standard and professional tools
- Includes mounting standoffs

Figure 8: Frigomatic Evaporator Plate

Frigomatic Air Cooled Systems

Utilising an air-cooled condenser with special ducting to increase efficiency, Frigomatic air-cooled systems require virtually no maintenance. Without dependence on water for cooling, refrigeration is maintained even when the vessel is out of the water for maintenance. There are no water pumps or filters to maintain and no through-hulls associated with the system.

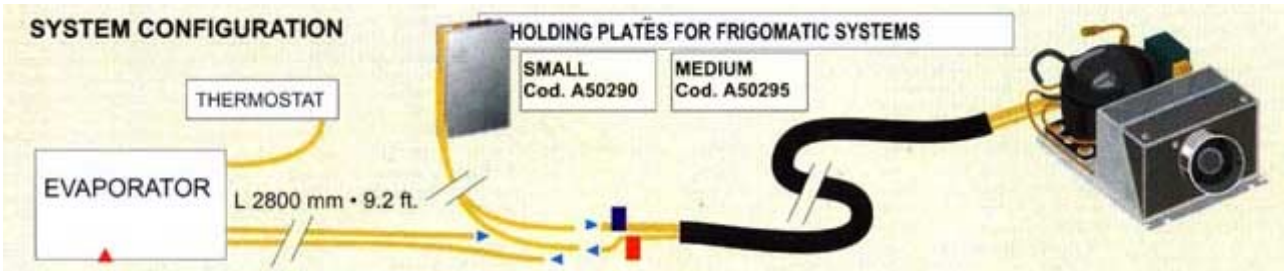
Capri 35F Air Cooled Condesnser Set

A ducted condenser fan ensures that heated air is not recirculated inside the mounting enclosure - this results in improved reliability and operating efficiency.

Eutectic holding plates or evaporator plates are used in the refrigeration/freezer enclosure. The holding plates offer slightly increased efficiency but consume enclosure volume. An evaporator plate must be used for freezer applications and costs considerably less than a holding plate.

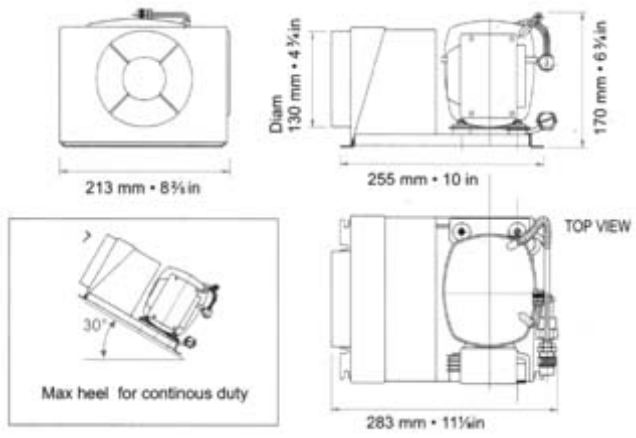
A thermostat connects to the evaporator and controls the cycling of the compressor to maintain the set temperature.

Figure 9: Capri 35F Air Cooled System



Capri 35F Features

- Latest generation Danfoss BD35F compressor automatically adjusts to 12 or 24 volt operation
- Extremely compact dimensions
- Forced air cooling equipped with ducted air housing and large fan for maximum efficiency
- Electrical consumption 25% lower compared to other compressor concepts
- System is pre-charged using Veco self-sealing couplings - no refrigeration experience is necessary for installation.
- Spring bending loops provided to prevent line kinks during installation
- Use with Frigomatic evaporator plates or capillary holding plates
- Automatic battery protection
- Light weight – only 6 kilograms



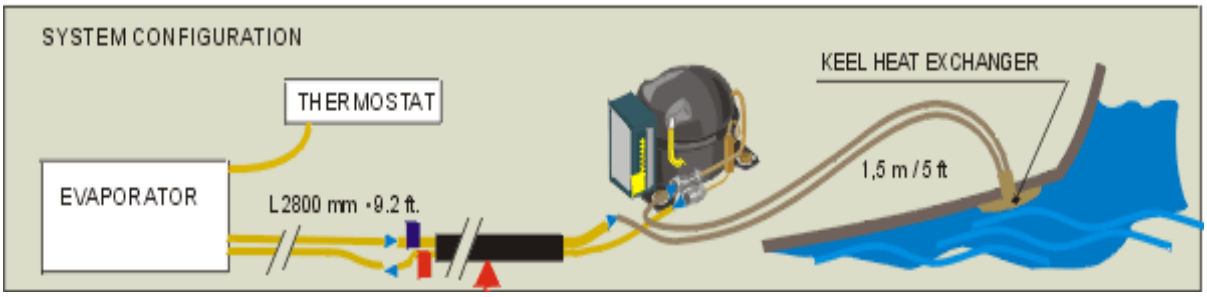
Frigomatic Water Cooled Systems

For applications requiring higher capacity, Veco offer two water cooled DC systems in the Frigomatic range. Capacities are increased by 20% compared to air cooled models.

K 35F Keel Cooled Condenser Set

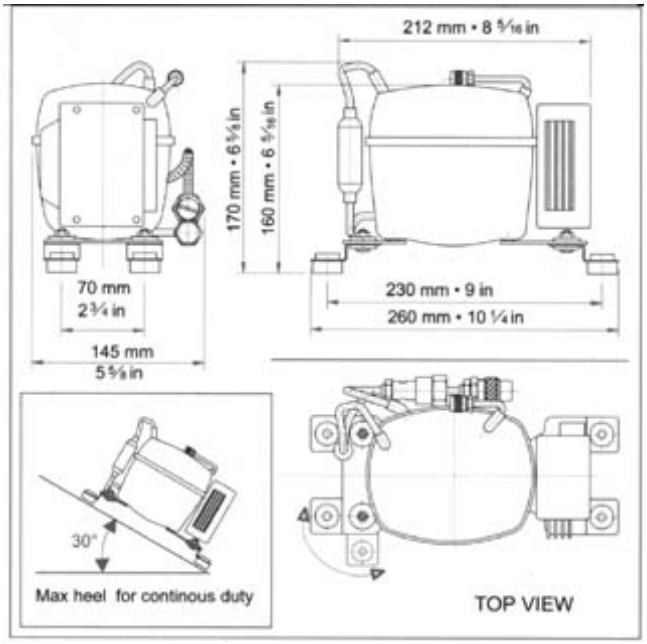
The most innovative is the “keel-cooled” unit shown in Figure 10 . Where conventional water-cooled systems incorporate a water pump to provide cooling for the condenser, Veco use an integral bronze condenser that mounts outside the hull - construction is similiar to a bronze ground plate which is not as susceptable to barnicle build-up. There are no moving parts other than the compressor. Efficiency and capacity is about 25% higher than the best air-cooled units. No maintenace is required other than routine hull anti-fouling upkeep.

Figure 10: K 35F Keel Cooled System



K35 F Features

- Water cooling with keel cooler saves more than 20% compared to air cooling.
- Keel cooler eliminates the need of independent sea water pump
- Danfoss compressor of the latest generation with electrical consumption 25% lower compared to other compressor concepts
- Extremely compact dimensions
- Precharged system equipped with Frigoboat self sealing couplings
- Configurations with evaporators for fridges up to 350 litres (12 cu.ft.) and freezers up to 80 litres (2.8 cu.ft.).
- Version with holding plate for fridges up to 160 litres.
- Automatic battery protection



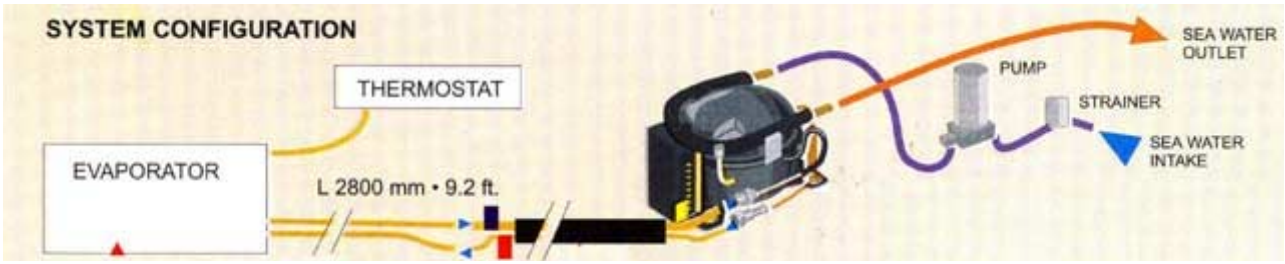
W 35F Water Cooled Condenser Set

For applications where it is impractical to use the keel-cooled unit, Veco offer a conventional type water cooled unit as shown in Figure 11 .

A water pump circulates sea water through a cupro-nickel condenser. The high condensing capacity and lower condensing temperature results in higher efficiciency and greater output compared to air-cooled systems. It is important to note that the strainer (which prevents debris from fouling the water pump) must be maintained.

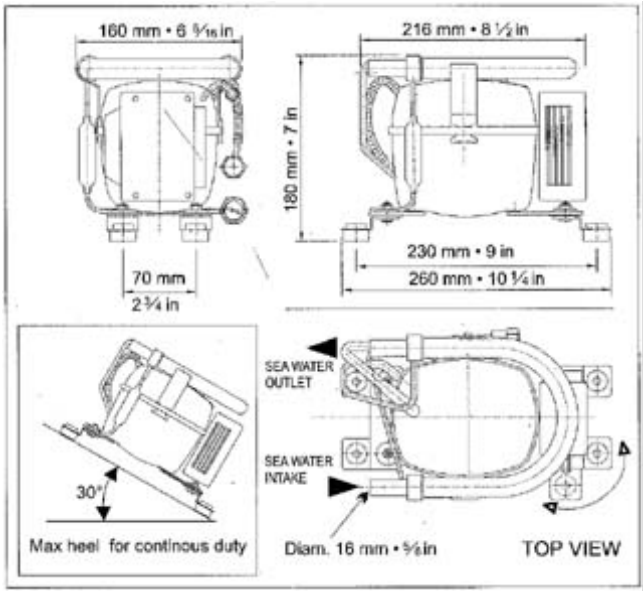
For multiple condenser set configurations, a single water pump can service up to three units with a distribution manifold.

Figure 11: W 35F Water Cooled System



W 35F Features

- Water cooling with keel cooler saves more than 20% compared to air cooling.
- Keel cooler eliminates the need of independent sea water pump
- Danfoss compressor of the latest generation with electrical consumption 25% lower compared to other compressor concepts
- Extremely compact dimensions
- Precharged system equipped with Frigoboat self sealing couplings
- Configurations with evaporators for fridges up to 350 litres (12 cu.ft.) and freezers up to 80 litres (2.8 cu.ft.).
- Version with holding plate for fridges up to 160 litres.
- Automatic battery protection



Spectra 200-C/380-C Desalinator

Modular Flexibility

The 200-C and 380-C are the most basic watermaker systems in our product line. These systems are built around the patented Clark High-Pressure Pump technology. Since its inception, Spectra has proved that efficient and reliable watermakers aboard cruising yachts can become a reality. Spectra's efficiency is unparalleled and almost three times that of our nearest competitor. Thousands of real world hours of operation in all the major oceans of the world have proven the reliability of our composite high-pressure pump.

Clark High Pressure Pump

Compared with conventional watermaker systems, the Clark High Pressure Pump technology can:

- Eliminate the Need To Adjust Pressure
- Eliminate Oil Changes
- Eliminate Heat Generation
- Reduce Power Consumption
- Eliminate Vibration
- Meet Rated Output in 50˚ F Water
- Eliminate the Need for AC Generators
- Easily Run on Alternative Energy Systems

DC Voltage versus AC Voltage Systems

Watermakers that are powered by AC or engine drives are limited just to those sources. If the genset or engine fails, so does the fresh water supply. The ship's batteries are usually charged from multiple sources. The high output, low energy DC Spectra Watermakers can take advantage of this kind of built in redundancy.

The Clark High Pressure Pump Technology

Spectra Watermakers incredible efficiency and reliability are achieved by our exclusive use of the patented Clark High Pressure Pump. The Clark High Pressure Pump technology simply combines time tested hydraulic principles in a unique way to generate high pressure without wasting energy. Its few moving parts operate in slow motion and are made of space-age plastics and composites for long life and strength in marine environments. The Clark High Pressure Pump operates on water pressure from a low voltage diaphragm pump (feed pump). It boosts the low pressure from this feed pump to the high pressure needed for reverse osmosis.

Spectra systems will operate over a wide range of water temperatures and salinity without any appreciable change in system capacity. The Spectra pumping system operates quietly and efficiently without putting a large load on the vessel's electrical system.

Spectra Modular series watermakers have been designed to install on vessels without the space to accommodate larger pre-packaged versions of our system. The system components can be built into almost any space available. The systems are sold with complete installation kits including all the plumbing, hose, and fittings required. All you have to supply is the thru-hull fittings, water tank, DC power and a cleaning bucket.

Included Components

Modular systems include: seawater strainer, prefilter housing with 5 micron element, feed pump with heat sink (380-C system has dual feed pump with heat sink and cooling fan), accumulator, composite Clark High Pressure Pump, 40 inch high rejection/ high yield spiral wound reverse osmosis membrane and Spectra free flow ultra efficient high pressure vessel assembly, mounting brackets for Clark Pump and membrane housing, instrument panel with low pressure gauge and product flow meter, 10 ft. high pressure tubing, 25 ft. product tubing, 50 ft. reinforced sea water hose, three 3-way valves for cleaning and flushing procedures, hand-held salinity monitor, all required tube fittings and hose clamps, complete installation and operation manual, warranty registration card.

We recommend adding a SPE#PRE20 20-micron prefilter to reduce the filter service interval and a SPE#CFK Charcoal Filter Kit to guard against chlorine during backflush operations.

Optional Accessories for Modular Systems

- Two 20 inch Membranes (for 200-C system only)
- Automatic Salinity Control with Remote Control Panel
- Automatic Salinity Control & Automatic Fresh Water Backflush with Remote Control Panel
- Plankton Filter with Cleanable SS Mesh Screen
- Pre-Filtration (add an additional pre-filter housing and 20 micron filter)

- Charcoal Filter Kit for Product Water (removes odor)
- UV Sterilizer for Product Water
- Bulkhead Mounting Bracket for Clark High Pressure Pump
- Overhead Mounting Bracket for Clark High Pressure Pump
- Basic Cruise Kit
- Offshore Kit
- Additional Tubing and Hose
- Additional Remote Control Panel with 25ft. Cable Harness (requires Salinity Control)

Table 20: Performance[a] Specifications[b]

200-C		10° C Sea Water				25° C Sea Water				32° C Sea Water			
DC Voltage	Feed Flow LPM	*Feed Pressure* PSI	Membrane Pressure	*Product LPH)*	Amps	*Feed Pressure* PSI	Membrane Pressure	*Product LPH*	Amps	*Feed Pressure* PSI	Membrane Pressure	*Product LPH*	Amps
Spectra 200-c													
12.5	5.7	76	650	30.0	9.0	64	550	31.4	8.0	64	530	32.2	7.9
13.8	6.0	82	685	35.2	9.6	68	570	36.0	8.5	68	550	35.9	8.4
14.4	6.4	84	700	37.8	10.0	70	580	37.8	8.8	70	560	39.0	8.9
Spectra 380-C													
12.5	7.9	104	845	53.0	20.0	92	670	56.8	18.5	92	645	57.9	18.2
13.8	9.8	110	880	56.8	21.2	98	700	62.4	19.6	98	665	64.3	19.1
14.4	10.2	112	900	57.8	21.5	102	710	64.3	20.0	100	675	66.2	19.5

a. Pressures are in PSI. Numbers based on water salinity at 35,000 parts per million TDS. Salt rejection 99.4% ~ 99.6%. Typical purity test at 400 mhos, 200 ppm, 99.4% pure. Performance Tolerance ± 10%.
b. Specifications subject to change without notice

Table 21: Weights and Dimensions

Component	Weight kg	Length cm	Height cm	Depth cm
Clark Pump	18.18	96.3	23.5	16.4
Membrane	5.91	112.5	8.9	8.9
Feed Pump (X2)	6.6	25.4	10.2	10.2
Control Panel	0.45	12.7	14.0	7.6
Strainer	0.23	8.9	12.7	7.3
Pre-Filter	1.14	11.4	30.4	4.875
Hose & Fittings	1.6	Mounted on a single bulkhead, the Spectra 200-C will require an area of around 1200 mm x 600 mm. Less space is required when split up.		
TOTAL WEIGHT	24.11			

Figure 12: Typical Bulkhead Mount

Figure 13: Plumbing Diagram

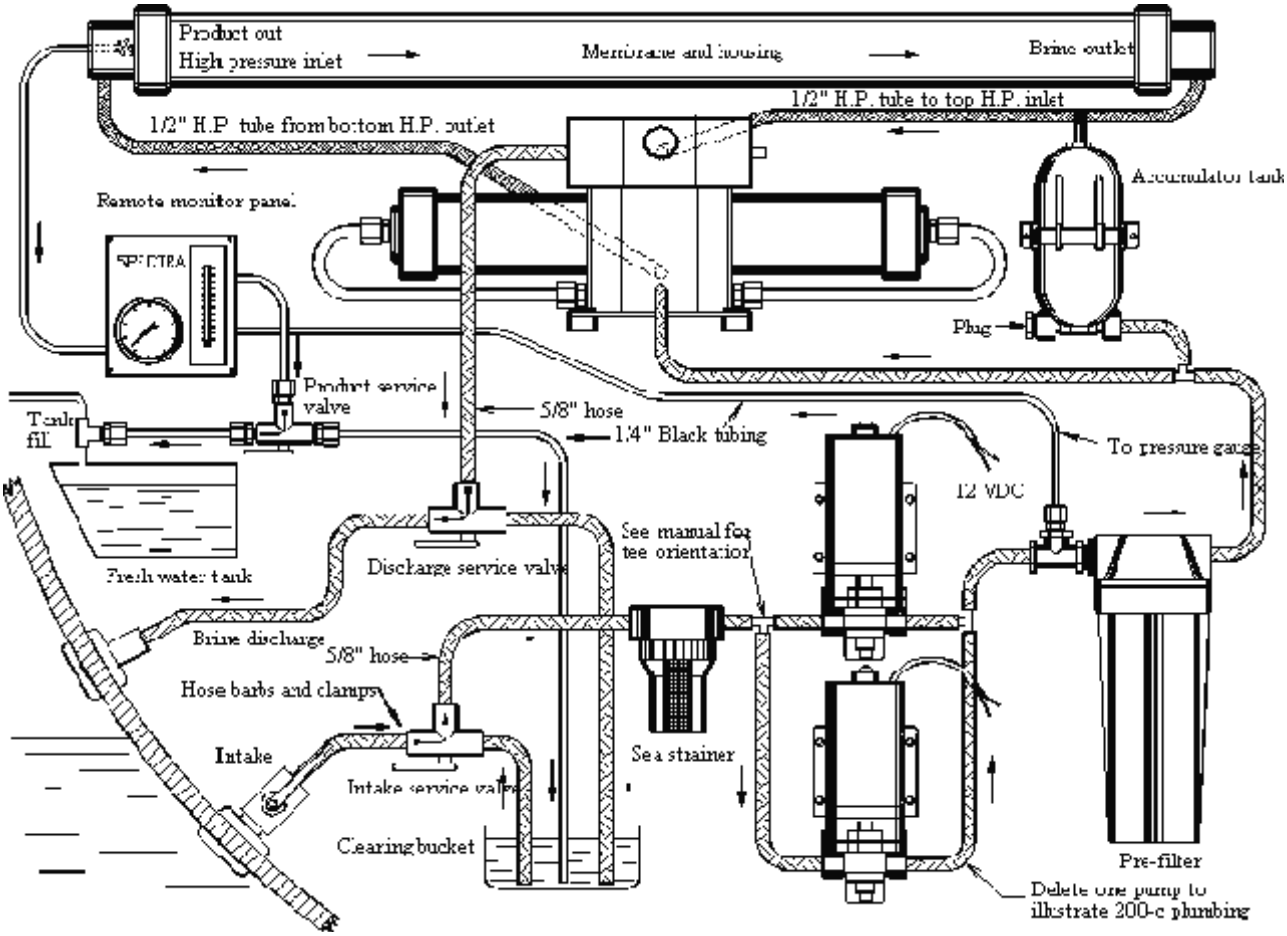


Figure 14: Spectra Modular Dimensions

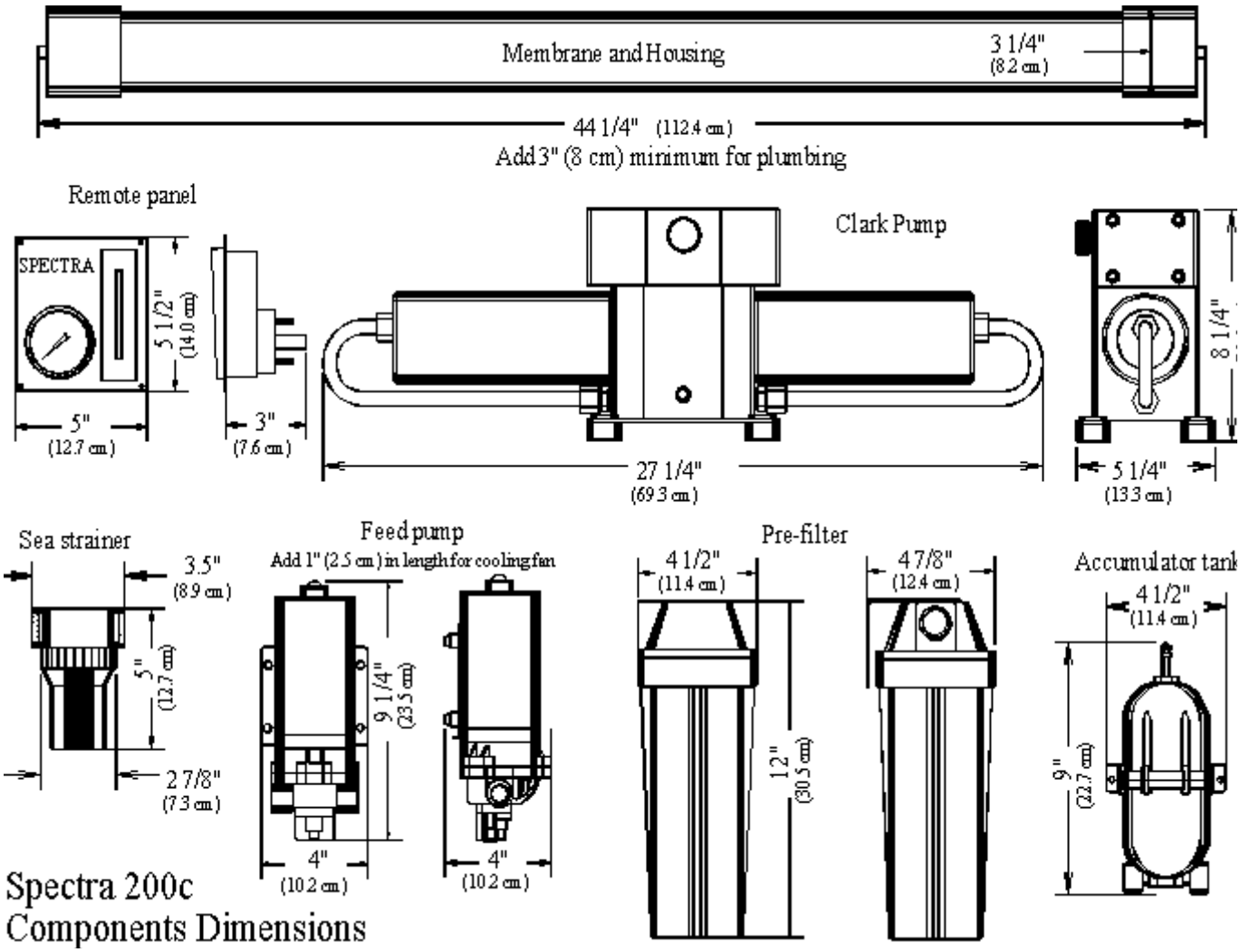
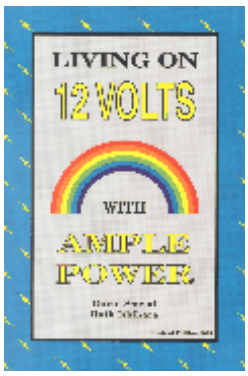


Figure 15: Spectra Gulfstream System

Electrical Reference Books

Living on 12 Volts with Ample Power



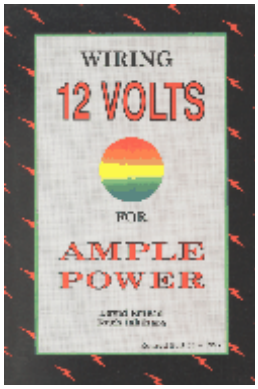
Revised, updated and expanded in 1998, Living on 12 Volts with Ample Power, has been a marine best-seller for over 10 years and is a must for anyone seriously interested in electrical and refrigeration systems. Here's what others say about Living on 12 Volts. In the April 1988 issue of National Fisherman Technical Editor John Gardner writes, “There is not a shred of technical jargon in the whole book. Elementary electrical concepts are explained for the benefit of those to whom the subject is new, as is so seldom done in technical writing."

After a thorough review of the book, Mr. Gardner concludes, “An extensive index makes reference easy and completes a book that is outstanding for systematic organization. And finally it should be said this book is a model of lucid expository style - meaning it is easy and agreeable to read."

Nigel Calder, noted marine author of three books, Refrigeration for Pleasure Boats, Marine Diesel Engines: Maintenance, Troubleshooting and Repair, and Repairs at Sea, writes about Living on 12 Volts. He says, ``a book of this kind is long overdue and should be compulsory reading for boat builders.'' We agree.

This book contains the most authoritative information about AC, DC and refrigeration systems within small energy systems. Applicable to boats, RV's and remote homes. Covers conventional lead-acid batteries as well as new sealed technology. Battery chargers explained; how they work, and why they don't. The DC alternator and proper regulation is thoroughly discussed. Essential facts regarding wind generators are presented. The workings of solar panels and how to use them effectively is explained. AC within the alternate energy system is explained with a special section devoted to electrolysis prevention aboard boats. All aspects of refrigeration are thoroughly detailed. The concept of a balanced energy system is introduced and details on how you can achieve it are presented. Special appendices are provided to allow you to design the optimum system for your needs.

Wiring 12 Volts for Ample Power



Revised, updated and expanded in 1995... now better than ever. If you plan to install your own Ample Power System, then Wiring 12 Volts for Ample Power is just the book to get you started and help you do it right the first time. Presented are general schematics, wiring details and troubleshooting information not found in other publications. Even if you don't do your own wiring, Wiring 12 Volts for Ample Power is a must book. Chapters cover the history of electrics from 600 BC to the modern age.

Covered are DC electricity, DC magnetics, AC electricity, electric loads, charge sources, batteries, wiring practices, system components, tools and troubleshooting. A chapter devoted to schematics presents many of the electrical wiring diagrams necessary in a boat of the 1990's. With thorough coverage, and easy to read style, Wiring 12 Volts for Ample Power has become another marine best-seller.

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