Outback Marine Systems

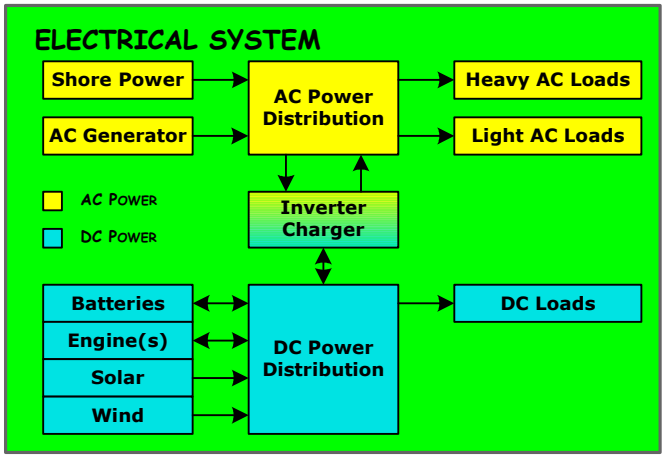
Vessel Electrical Systems

A primary objective for a vessel electrical system is to allow operation of the vessel within the parameters of safety, reliability, performance and long term total cost of ownership.

At the same time, we wish to provide support for a healthy and comfortable living environment that is akin to a modern home.

The demand on, and the dependence placed on the electrical system of a modern vessel has never been higher. The system needs to satisfy a number of driving factors:

- Operation of the system should be simple, functional, convenient and enjoyable
- The safety of the vessel and its occupants should never be compromised
- The system needs to be reliable
- Engine run time should be kept to a minimum



Functional Overview

The vessel has a DC (direct current), battery-based power system to supply all major vessel loads, which may include engine starting, anchor windlass, pumps, lighting, electronics, communications, navigation equipment, refrigeration, desalination and entertainment systems. Energy to power these systems is stored in a battery bank, which means that the DC system is capable of providing power at any time without the need to run an engine. With the right design and product selection, an engine-driven power source might only need to run for one hour each day - or significantly less if sufficient solar and/or wind power is available.

Battery System

The battery capacity is generally sized so that on a 24-hour basis, the typical discharge from the battery bank will not cause the batteries to be less than a 50% charge level. Deeper discharges are possible, however the battery life span will be shortened. It is interesting to note that battery life span may also be shortened by too-frequent shallow discharge cycles. Optimum performance is reached when the batteries are recharged after taking 40% of their capacity.

Charging System

The energy that devices take from a battery system can be replaced by:

- an engine driven alternator
- AC battery charging
- solar panels
- wind generation
- water generation

Alternators mounted on a propulsion engines converts engine power to DC energy. A battery charger converts AC (alternating current) electrical power to DC energy. Solar panels convert solar power to DC energy. Wind generators convert wind power to DC energy. Water generators convert flowing-water energy to DC energy.

Steps that can be taken for a reduction in engine run time include:

- reducing power consumption by selecting energy efficient appliances
- employing renewable energy charging devices - solar panels and wind generation
- having faster charging from the engine - large alternator, smart alternator regulation and batteries with a high charge acceptance rate

AC Power System

Certain appliances are not capable of being powering directly from the DC battery based system and require AC power. AC power can be derived from three sources:

- Shore Power Outlet
- On-board Generator
- Inverter

The shore power outlet at the marina provides utility power when the vessel is docked. An on-board generator set provides AC power when the vessel is away from dock. The inverter converts DC energy to AC power.

The inverter is a preferred choice for AC power because it does not require connection to shore power or the need to immediately run a generator set. Appliances connected to the inverter will consume battery energy as required. This energy can be replaced later, either by running an engine driven power source or by connecting to shore power at a more convenient time. Solar and/or wind power may be sufficient on certain days to maintain an energy system balance.

Practical considerations restrict the type of appliances that are suitable for inverter power. Provided that battery energy levels are maintained and that the sum of loads is kept within inverter specifications, the inverter is suitable for powering plug-in appliances such as microwave ovens, electric kettles, computer equipment, TV's, power tools, clothes washer etc.

Although some of these appliances may require a moderate power level to operate, we refer to them as light loads because their duration of operation is relatively short and the corresponding energy consumed is easily replaced. AC power for air conditioning, hot water heating and clothes drying will require a shore power connection or generator set to be run. These appliances fall within the heavy load group.

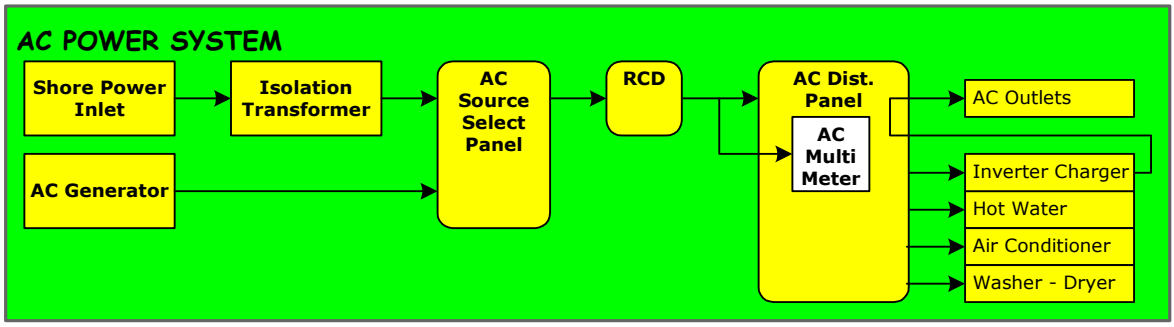
Design and Implementation

A healthy respect of AC power systems from a lethal voltage point of view is almost general knowledge - yet the risks associated with DC power systems are not so evident.

A professional design and implementation will consider all factors including AC grounding, earth bonding, earth leakage, over-current, lighting, corrosion, wire size, environment stress, RF interference and so on.

Always consult a suitably qualified marine electrical professional for design and maintenance of the system.

AC Power System



The AC power system provides power to AC appliances and the inverter/battery charger via the AC distribution panel. AC power is available from either shore power, the generator set or an inverter. In this discussion certain values are vessel specific.

Shore Power Inlet

The Shore Power Inlet is used to connect the vessel to dockside power and is rated at 15-amps (3600 VA). The sum of AC loads on the system should not exceed this rating when connected to shore power.

Isolation Transformer

The isolation transformer circumvents the need to connect the shore power ground to the vessel ground, which avoids the possibility of dockside related electrolysis.

Generator Set

The Generator Set is rated at 32-amps (7600 VA). Care must be taken not to exceed generator set capacity when connecting additional loads in parallel and load start-up restrictions may also apply. An AC Multi-meter is fitted to the main AC panel to monitor generator and shore power sourced loads.

AC Source Select Panel

The AC Source Select panel incorporates an interlocking double pole circuit breaker to select either the generator or shore power for connection to the electrical system. The shore-power select circuit breaker must be in the off position before connecting the shore power cord to the dockside power outlet. A reverse polarity indicator is provided – shore power must not be switched on if a reverse polarity condition is present.

The AC Source select panel:

- provides reverse polarity indication to guard against an incorrectly wired shore power system
- ensures that only the generator or shore power source can be selected at any one time
- switches both line and neutral to ensure that MEN integrity is maintained
- provides separate circuit-overload protection

Residual Current Device (RCD)

A safety RCD provides a level of protection against electrical shock when the vessel is powered from either shore power or generator set.

AC Distribution Panel

The AC Distribution Panel has separate circuit breakers for the supply of power to the Hot Water System, the Air Conditioners and the Inverter/Battery Charger. Note that these circuits are powered when the generator set or shore power source is available – the system is not configured to run any of these loads from the inverter. An AC Multi-Meter is provided to show the exact load parameters to avoid unwanted circuit breaker trips at the marina or overload conditions on the generator set. It can indicate AC volts, amps, frequency and watts.

The output from the inverter charger returns to the AC Distribution Panel through an isolation breaker to feed the power outlets to service appliances that can be powered from the inverter, shore power or generator. An automatic transfer function of the inverter/charger will source shore power or generator power if available, otherwise the inverter will take energy from the battery system to deliver AC power.

Inverter / Battery Charger

The battery charger output of 100-amps allows around 90 amp-hours of battery capacity to be replaced for each hour of operation. The inverter has a continuous rating of 2500 watts. This is sufficient power for a 2000-watt electric kettle – it characteristically takes only 4.5 amp-hours of energy to bring 1 litre of water from room temperature to the boil in less than 3 minutes. Later on, only 4 minutes of incremental generator run-time would be required to replace the energy used – on your time table.

A remote panel provides full control over inverter/charger functions including variable battery charger load rating and remote on/off control.

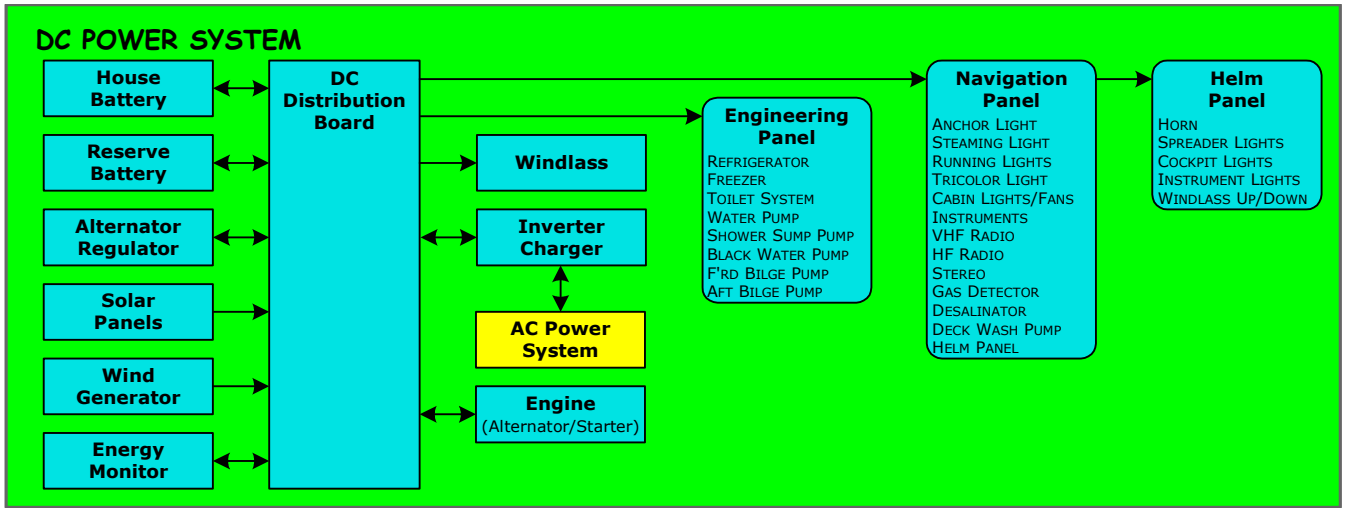
AC Outlets

The AC outlets (GPO's) feed all devices that can be powered from the inverter. When generator or shore power is available, the inverter system transfers this power direct to the outlets; otherwise the inverter generates the power from the DC system. The first GPO in the outlet chain is fitted with an RCD safety device which protects all outlets in the chain irrespective of power source.

AC Source Select Panel

AC Distribution Panel

DC Power System



DC Distribution Board

At the core of the DC power system is a DC Distribution Board; a specialty design that ties together all of the heavy power devices on the vessel. It includes:

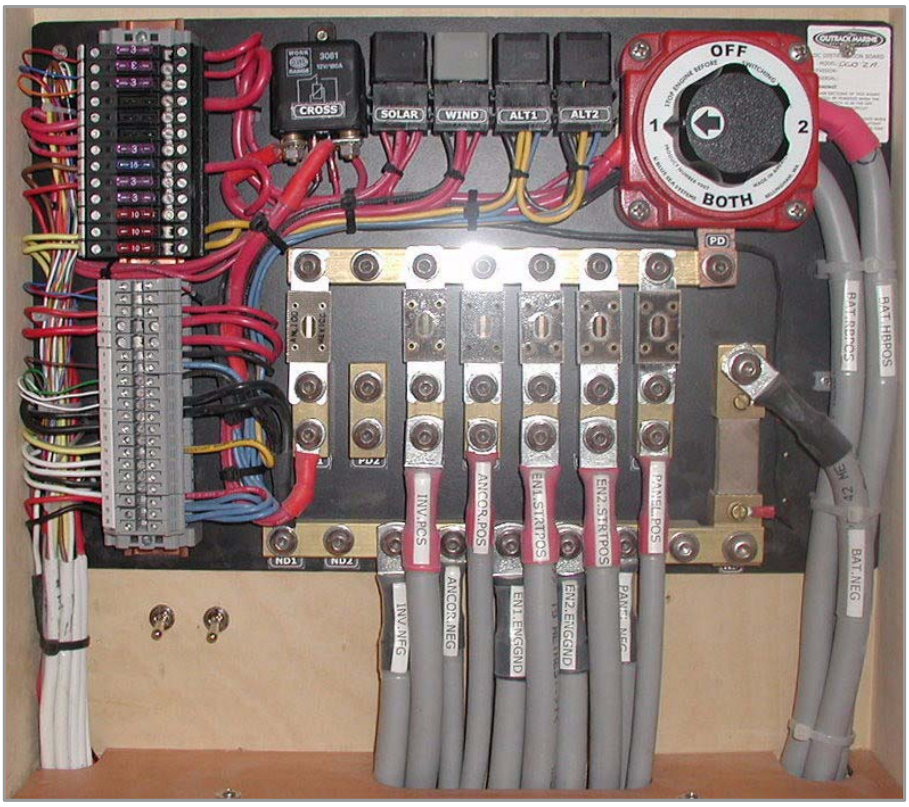
- A simple change-over/isolation switch to select either house battery, reserve battery or full isolation
- A single positive and negative distribution bus point for the vessel
- Individually fused terminals for all heavy power devices including the engines, generator set, windlass, inverter/charger and electrical panels
- Automatic cross-charging of the reserve battery from any source – controlled by the Smart Alternator Regulator
- Direct fused connections and terminals for the Energy Monitor and Alternator Regulator
- Field switching to enable one alternator regulator to drive multiple alternators
- An alternator field disconnect to protect the alternators when the battery switch is operated while the engines are running
- Auxiliary fused outputs from the house battery for security and car radio memory; which remain powered when the battery selector switch is off
- A solar panel relay that is controlled by the Energy Monitor for solar panel regulation
- A stop relay facility for remote on/off control of a wind generator

To minimise voltage drop and cable weight, the major power devices; DC Distribution Board, batteries and inverter/charger; are physically grouped in one local area. For hierarchical protection, individual fuses and power feeds to each power device ensures that an overload condition on one circuit does not disable other circuits; and that interactive voltage drops are minimized.

Batteries

DC power for the entire vessel (including engine cranking and windlass operation) is sourced from a single *House Battery Bank*. The consolidation of all vessel loads and the charging system to a single house battery bank gives the best utilization of battery capacity; increases the effective life of the batteries; simplifies energy monitoring and management; and results in the fastest possible charge.

In case the house battery becomes



DC DISTRIBUTION BOARD

BATTERIES

ENERGY MONITOR

totally discharged, a *Reserve Battery* provides power for priority vessel functions including engine cranking, windlass, communications and bilge pumps. Before switching to the reserve battery, switch off all nonessential loads. Once the engine is started and the alternator is charging, the battery select switch can be restored to the house battery bank position.

Operationally, the battery switch is simply left on "Position 1". No power is drawn from the reserve battery and it is always kept topped-up. "Position 2" is available for reserve. "Off" is used for service or emergency disconnect. As a last resort, the "Both" position will join the house and reserve batteries.

Energy Monitor

The Energy Monitor provides complete management of battery state-of-charge; accurately indicates battery voltage and current; controls battery charging from solar panels and other unregulated sources; and keeps a watchful eye on vital battery parameters including over voltage and temperature. An alarm is generated if any parameter is outside of specification - an indication to "fix-it" before serious damage results.

SMART ALTERNATOR REGULATOR

The energy monitor gives a direct indication of energy consumed and energy remaining from the house battery – this is an essential tool for battery management and is especially useful to indicate when to start and stop battery charging from the main engine or generator set.

Inverter/Battery Charger

The Inverter/Battery Charger builds two functions into the same package.

The battery charger has three-stage regulation to ensure a fast and full charge. Charging voltage is varied according to battery temperature; essential to prevent thermal runaway and consequent explosive risk.

Engine Alternators

The Engine Alternators charge the house battery and are controlled by a *Smart Alternator Regulator*. They each have an isolated ground with a dedicated ground return to the DC distribution board. The engine blocks have a separate ground return to ensure that both are at a common potential – particularly important when only one engine is being run; this arrangement is necessary to avoid electrolysis.

Smart Alternator Regulator

The Smart Alternator Regulator (SAR) utilizes 3-step regulation with battery temperature compensation to ensure safe, accurate and fast charging. The SAR also monitors the voltage on the positive distribution bus to detect any active charging source; if present, it drives a cross-charge relay to keep the reserve battery in a fully charged condition. The cross-charge relay isolates the reserve battery when no charging source is present. A single SAR is used to drive multiple alternators

Solar Panels

The Solar Panels charge the batteries during the day. The amount of energy replaced by the solar panels depends on the capacity of panels fitted and solar conditions. A greater investment in solar energy will result in less engine run time. The Energy Monitor controls solar panel regulation by means of a relay fitted to the DC Distribution Board. Solar charging parameters are fully programmable.

Wind Generator

The DC Distribution Board is prewired with terminations and a relay that can be controlled by an external switch to turn a suitable wind generator on and off. A wind generator can be most effective to replace additional energy consumed by the vessel instruments and autopilot when the vessel is sailing.

Engineering Panel

Navigation Station Panel

DC Electrical Panels

The purpose of the electrical panels is to allow switching of vessel devices and to provide overload protection of wires leading to devices. They are normally fitted with circuit breakers, which switch power to devices and will trip if the current in the circuit exceeds the circuit breaker rating. In the case of a single circuit breaker feeding multiple branch circuits, sub-fuses are used to provide over-current protection for each branch circuit. Our fuse holders incorporate an LED to indicate a blown fuse condition.

The wire connecting the circuit breaker or fuse to the load is sized according to the current required for the device and the distance to the device. The wire will have a maximum current carrying capacity – referred to as ampacity. The wire may be sized higher than the required ampacity to compensate for the voltage drop due to wire length.

The circuit breaker or fuse is always sized to be less than the cable ampacity and greater than the device load. Under no circumstances should the sum of device current in a circuit result in the circuit carrying current greater than the cable ampacity rating. Further, a circuit breaker or fuse fitted to a circuit should never have a rating which exceeds cable ampacity. Failure to observe these rules may result in fire and/or serious damage.

Navigation Station Panel

The Navigation Station Panel powers devices that are commonly switched on and off throughout the day. It is readily accessible at the navigation station fascia with functionality kept to a minimum for ease of operation. Care has been taken to avoid powering pumps and other high power devices that might subject sensitive navigation devices to voltage excursions from this panel. A dedicated circuit breaker feeds power to the Helm Panel where waterproof switches control functions applicable to the helm station.

Engineering Panel

The Engineering Panel uses circuit breakers to power devices that are less likely to be switched during the routine operation of the vessel.

To avoid inadvertent switching of vessel services (for example refrigeration) it may be advisable to recess this panel behind a door.

Vessel Wiring and Safety

All vessel wiring and power distribution components must connect power to devices in a safe and efficient manner.

The vessel environment is prone to vibration and corrosion so all wiring is multi-strand tinned copper and is regularly held in place with the use of cable tray and saddles. Heat-shrink moisture barriers further protect wiring terminations that are subject to excessive moisture ingress. Cables are selected according to loads, ampacity rules and length. Each electrical circuit is equipped with either a fuse or circuit breaker of the correct rating to protect against fire.

DC Battery systems require special care to avoid risk of fire and/or personal injury.

- The battery isolation switch should be turned to the OFF position whenever work is carried out on any part of the DC system.
- Special care is required when working in close proximity to the batteries and battery switch because these are not isolated when the switch is OFF.

AC voltages are lethal. Safety procedures must be followed for work on the AC system:

- Only a qualified electrical trade person should perform work on this system
- All AC circuit breakers must be in the off position
- Inverter DC input must be disconnected
- The shore power cord must be removed
- The generator must be disabled from starting
- Any changes of wiring or design must be documented

Your Vessel System?

All vessel electrical systems follow the same principals as discussed here. This document is an example of an electrical system specification derived for an Australian 15-metre sailing vessel. A few changes are necessary for vessels requiring survey approval or vessels destined for foreign countries.

Whether your vessel is power or sail; mono-hull, catamaran or trimaran; for leisure or commercial use; Outback Marine has the design and product solution to meet your needs.

For vessel designers and manufacturers, we develop comprehensive specifications, schematics, user manuals and operation guides; and we can assist manufacturers with marketing specifications.

Prospective vessel buyers may specify an Outback Marine system to their builder.

More than a product vendor!

At Outback Marine, we look beyond the product to a complete engineered solution. We need to meet your performance and budget expectations. We understand the importance of safety and reliability. We relate to quality products and services.

As a primary importer and distributor, our pricing is fair and reflects service support with in-depth product and application knowledge. Our system designs are fully documented to meet Australian and/or International standards. Outback Marine can help you in a number of ways:

- **Design - Supply - Install - Commission:** The design is fully documented including CAD schematics. In addition to the product manufacturer warranty, we offer a 2-year warranty on our work.
- **Design - Supply:** We can support your installation team and provide drawings for survey approval if required.
- **Supply only:** Our technical support people are ready to assist you throughout the design and install process.

Authorised dealer opportunities are available throughout Australia.

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