



APPLICATION NOTE

A Guide To Battery Charging

A GUIDE TO BATTERY CHARGING

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1. Charging a Battery

There are many types of battery but batteries on boats are nearly always LEAD-ACID types - similar to car batteries but heavier duty.

A BATTERY is made up of a number of CELLS.

A LEAD-ACID CELL generates around 2 volts. Small batteries contain 6 cells in a container, which add together to give 12 volts at the terminals. Larger cells are quite heavy and individual CELLS are connected together 'in series' to make batteries of either 12 volt (6 cells) or 24 volt (12 cells).

Although a battery is called a '12 volt' battery, its voltage varies from about 12.6 volts down to 10 volts when it is discharging and can rise to 15 or 16 volts during charging. It is very important, however, to limit the maximum battery voltage during charging otherwise the battery will be damaged. The battery voltage should not exceed 13.8 volts for long periods and 14.4 volts for short periods (8 hours maximum).

MORVEN chargers automatically control the battery voltage at a very precise, safe level.

2. 3-Stage Charging

There are two basic types of lead-acid battery charger: FLOAT chargers and 3-STAGE CHARGERS. Float chargers also come in two versions - good ones and bad ones!

A good FLOAT charger charges the battery at a constant current until the 'FLOAT' voltage (13.8V or 27.6V) is reached, then it progressively reduces the current to maintain that voltage.

This gets about 75% capacity back into the battery quickly but then takes a long time to restore the other 25%.

A bad FLOAT charger commences charging at the rated current but as the battery takes the charge, its voltage rises and the current drops off long before the float voltage is reached.

Thus, even 75% capacity takes a long time to restore and full charge takes forever.

By far the best type of charger is the 3-STAGE CHARGER. This starts charging like a good float charger but continues charging at constant current until the 'BOOST VOLTAGE' (14.4V or 28.8V) is reached. Then, the current is progressively reduced until it drops to one quarter of its maximum. This corresponds to 90% capacity in the battery. The charger voltage now changes automatically to the float voltage where it then remains, slowly restoring the last 10% capacity. Thus almost full charge is restored quickly and safely.

MORVEN chargers are all 3-stage chargers and they also have an additional safety feature - an electronic timer ensures that the battery will not remain at the 'BOOST' voltage (called the 'EQUALISE' mode) for more than a preset time, after which time the charger is forced into 'FLOAT' mode regardless of charging current. MORVEN chargers re-charge batteries as quickly and safely as possible - there is no better way of charging lead-acid batteries.

3. Types of Charger

There are several types of electronic circuitry used within battery chargers for the marine market

3.1 FERRO-RESONANT (or CVT)

These use a low-frequency MAGNETIC control system, which makes them very HEAVY, very BULKY and are also only available with a poor FLOAT charge characteristic, therefore very SLOW recharging. They can also generate a large



magnetic field, which can upset other equipment on board. On the plus side, they are CHEAP and RELIABLE due to the low number of components used and they tend to appeal to boat-builders who put price at the top of their list of priorities.

3.2 LINEAR CHARGERS

These also use a low-frequency transformer to reduce the input voltage to a lower level, but they then use transistors to control the current and voltage fed to the battery. This technique can be used for either FLOAT or 3-STAGE chargers but is very IN EFFICIENT and therefore HOT, HEAVY and BULKY. The biggest drawback is a LIMITED INPUT VOLTAGE range – not ideal for running from a generator or some marina supplies.

3.3 SWITCHED MODE CHARGERS

These are more complicated than the previous two types and use the techniques perfected for and now universally used in computers and televisions. The AC input is first turned into high-voltage DC. It is then turned into high-frequency AC using special types of transistor and a high-frequency transformer (one thirtieth the weight of a low-frequency transformer!) reduces the voltage to the exact level needed to charge the battery. A sophisticated control circuit produces an overall design with HIGH-EFFICIENCY, SMALL SIZE and LIGHT WEIGHT. The extra complexity adds to the initial cost but results in lower running costs and the ability to run from a SMALLER (and cheaper) GENERATOR if required. Switched mode chargers can be either FLOAT or 3-STAGE types.

All MORVEN chargers are SWITCHED MODE 3-STAGE types. They are designed by specialists in switched mode techniques with over 50 years design experience in this field between them.

4. Protection

Battery chargers should be designed to survive a number of fault conditions that can occur during or after installation

4.1 SHORT-CIRCUIT OUTPUT can cause instant destruction or the charger may survive for a few minutes or it may survive forever - it depends on how it was designed.

MORVEN chargers can survive continuous short-circuit output without damage

4.2 REVERSE BATTERY CONNECTION can be disastrous if suitable protection is not fitted.

A fuse is the simplest method. A relay is good at low output currents but is unreliable at higher currents. Electronic methods are uneconomic at high currents.

All MORVEN chargers have output fuses fitted. The fuse of BCH and BCO chargers are mounted with bolts, all others are soldered into the printed circuit board.

4.3 OVER-TEMPERATURE PROTECTION is needed in case either the engine room temperature exceeds the rated level or the ventilation of the charger is obstructed (air-flow through a charger is essential to keep the electronic components cool).

All MORVEN chargers incorporate a thermal trip, which automatically resets when the temperature drops to a safe level.

4.4 OUTPUT OVER-VOLTAGE protection should be present in case of a fault in the charger control circuit. Well-designed electronic circuits are very reliable but components can still occasionally fail on a random basis. If this happens, a second circuit should prevent the battery from receiving continuous over-charging.

All MORVEN chargers have independent over-voltage protection circuits built-in.

5. Remote Sensing

5.1 TEMPERATURE SENSING

The FLOAT voltage of 13.8V/27.6V mentioned earlier is the ideal voltage at a battery temperature of 25C. At higher temperatures this voltage should be progressively reduced by a small amount. This is not much of a problem in the U.K. but in the Mediterranean, for example, engine rooms can reach 40-45C and a charger for use at high temperatures should have a remote temperature sensing facility. This consists of a small sensing block, which is affixed to the battery and a cable connecting it to the battery charger.



Large MORVEN chargers have remote temperature sensing inputs but the temperature sensor is an optional extra. Fitting is very simple. The smaller BCM chargers can have temperature sensing fitted but this is a factory fitted option.

5.2 VOLTAGE SENSING

The thickness of cables joining a charger to a battery should be chosen to keep the voltage drop on the cable very low. However, any drop in the cable will increase the re-charging time to some extent. For the ultimate performance, the charger should control the voltage at the battery not at the charger. This is achieved by taking a thin cable from the battery positive terminal to a remote voltage sense terminal on the charger. Some chargers have this feature, others do not. It becomes increasingly important at higher currents.

MORVEN BCH and BCO chargers have remote voltage sense terminals as standard; BCM chargers can have this as a factory-fitted option.

6. Power Factor Correction (PFC)

Although the AC mains voltage is a smoothly changing waveform called a SINE-WAVE, the current taken from the mains by most battery chargers, TV's and computers consists of narrow peaks of current. This is inefficient for the power generating companies and, with the proliferation of TV's and computers in particular, the EC have considered enforcing the addition of an extra circuit called a POWER FACTOR CORRECTION circuit to smooth out the peaks. The date for introduction of this has already been postponed twice but it will eventually become compulsory. In the meantime, PFC is beneficial on a boat because it uses the mains power very efficiently and will therefore run from a smaller generator or poor marina supplies which non-PFC chargers might struggle with.

MORVEN BCH and BCO chargers have power factor correction. The BCH chargers will also work on any input voltage from 270 volts right down to just 90 volts making them useable worldwide without any adjustment.

7. Volts, Amps and Watts

WATTS are the units of POWER. A hairdryer full on might be 500 WATTS; on the low-power setting it might be 200 WATTS.

The higher the POWER the bigger the charger.

VOLTAGE must be matched to the equipment in use and will be either 12 VOLTS or 24 VOLTS in a boat.

CURRENT indicates the flow of energy from the battery and is measured in AMPERES (or AMPS). Zero current and the battery is not discharging. The higher the current the faster the battery will discharge.

A battery is rated in AMPERE-HOURS (abbreviated Ah) and this is called the BATTERY CAPACITY. For example, a small boat might have a 12-volt 100Ah battery. This battery will provide 100 AMPERE-HOURS before needing to be re-charged. This may be taken from the battery as:

- 1 AMP for 100 hours
- 2 AMPS for 50 hours
- 10 AMPS for 10 hours etc.

WATTS are VOLTAGE multiplied by CURRENT, so taking the above example with the 12 volt battery

- 1 AMP x 12 VOLTS = 12 WATTS for 100 hours
- 2 AMPS x 12 VOLTS = 24 WATTS for 50 hours
- 10 AMPS x 12 VOLTS = 120 WATTS for 10 hours

Re-charging a battery follows the same principle. The requirement is usually to re-charge the battery over-night - say in 10 hours.

Because a battery is not totally efficient at converting electrical energy into chemical energy and vice-versa, re-charging a 100Ah battery requires about 120Ah to be put back into it, and this can be achieved by either:

- 120 Amp-hours / 10 hours = 12 Amps for 10 hours
- 120 Amp-hours / 15 hours = 8 Amps for 15 hours



120 Amp-hours / 24 hours = 5 Amps for 24 hours etc.

CURRENT = WATTS / VOLTS

Therefore if, say, the lights add up to 36 WATTS and the battery VOLTAGE is 12 VOLTS then the CURRENT taken from the battery will be:

36 WATTS / 12 VOLTS = 3 AMPS

If these lights are on whilst the battery is being charged, then the battery charger must also provide an extra 3 AMPS to power them.

8. Battery Charger Selection By Calculation Example

Below is a sample calculation to determine which of our products would best suit your requirements.

1. Determine the battery voltage - 12 volt or 24 volt
2. Determine how many batteries are to be charged (1,2,3 or 4)
3. What are the battery capacities (Ah, Amp-hours)?

Add them together

e.g. 2 x 60Ah, 1 x 100Ah = 220 Ah total

4. What re-charge time is required?
(6 hours minimum, usually 24 hours maximum - if not known, assume 10 hours)

5. Divide TOTAL Ah by the re-charge time to get CHARGING CURRENT

e.g. 220Ah / 10 hours = 22 AMPS.

6. ADD 20% to allow for battery in-efficiency

i.e. 22 AMPS + 20% = 26.4 AMPS

7. Is there any additional load current on the battery during re-charging? If so, add this to the CHARGING CURRENT.

e.g. 24 WATTS / 12 VOLTS = 2 AMPS

CHARGER CURRENT REQUIRED = 26.4 AMPS + 2 AMPS = 28.4 AMPS.

8. Choose the next biggest charger in the range

e.g. 12 VOLT, 30 AMP, 3 BATTERY BANKS = BCM 12/30-3

Note. Much too big a charger could damage the battery and too small will take longer to re-charge.

9. DC-DC Converters

Some equipment is only available for 12-volt operation. If the boat's main battery is 24 volt, there are three options to run 12 volt equipment on board

1. Install a separate 12-volt battery with its own 12 volt mains battery charger.
2. Use a DC-DC converter to generate 12 volts using energy from the main 24-volt battery.
3. Install a separate 12-volt battery and charge it using a DC-DC converter from the main 24-volt battery. This requires a 13.8-volt output converter designed for the purpose. For options 2 and 3 it is useful to have a remote on/off switch otherwise the DC-DC converter could drain the 24-volt battery whenever the 24-volt battery is not being charged.

The MORVEN DDH DC-DC converters are designed for battery charging. They can be set to either 12 volts or 13.8 volts output by moving a link and they have remote on/off control. Also, the input and output are completely separate, eliminating noise problems that can occur with non-isolated converters (sometimes called droppers).

The DDH chargers have two current ratings:



1. For 12 volt use as a power supply
2. For 13.8 volt use as a battery charger

This is because a battery charger operates in current limit mode but a power supply must not enter current limit or the voltage will drop below the stabilized level.

10. Battery Charger Installation

MORVEN Chargers are suitable for installation by a competent handyman but some important points of safety should be noted:

1. The INPUT to the charger is AC mains voltage and is capable of causing death. A circuit breaker of suitable rating MUST be fitted between the charger and the shore power in accordance with good marine installation practice. If the charger is replacing an existing charger, then this should already be in place.
2. The BATTERY itself stores large amounts of energy and is quite capable of causing a fire or explosion if the output terminals are shorted together. Extreme care must be taken when wiring the charger to the battery. Cables should be of suitable thickness for the current rating for the charger, cable runs should be kept as short as possible and all cables must be securely held in place with cable fixings to prevent wear to the cable insulation.
3. The charger should be securely fixed to a vertical surface using ALL mounting hole positions (3 for BCM, 4 for BCH and BCO).
4. At least 75mm clearance must be left all around the charger to allow the free flow of air over the charger. The ventilation holes or slots must not be obstructed in any way.
5. The chargers should be protected from water and spray.

MOST IMPORTANT OF ALL

IF THE PURCHASER HAS ANY DOUBT WHATSOEVER REGARDING HIS/HER ABILITY TO SAFELY INSTALL THE CHARGER, THEN A QUALIFIED MARINE INSTALLER SHOULD BE USED.