NASA BATTERYMONITOR BM-1

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Q Do I need to disconnect my BM-1 when I leave the boat for long periods?

A No. The BM-1 is designed to be permanently connected to the battery. It is independently fused, and draws only 3mA from the battery. At such a low current, it would take several years to discharge a typical fully-charged marine service battery.

Q Why does my battery seem to have less capacity than it says on its label?

A The value on the manufacturer's label is seldom the value achieved in service, because of the deterioration of the cells' plates and many othe factors. If it seems to have much lower than its expected capacity, it may need replacement, or you may feel that changing the nominal capacity from the Engineering mode will suffice to let you know well enough the percentage charge remaining.

Q Why does my BM-1 show a large net charge after a day's cruising?

A You have put more charge into the battery than you have used. The amount should not exceed the total battery capacity. If it does, it may be wise to check that the charging system is working correctly and is not over-charging the battery.

Q When on heavy load, the time to run is lower than I expect. Is this correct?

A YES. When heavily loaded, a lead-acid battery delivers less energy than expected owing to electrolyte exhaustion and stagnation. When the battery is delivering heavy currents the BM-1 uses Peukert's equation to allow for these effects and so show a better estimate for the time to run.

READ THIS FIRST!

BEFORE INSTALLING THE BM-1, CAREFULLY READ THE FOLLOWING INSTRUCTIONS, ESPECIALLY THE SAFETY NOTES AND WARRANTY CONDITIONS.

INTRODUCTION

The NASA Clipper BM-1 is supplied complete with display unit, current shunt (standard 50mV), and connecting cables. It is intended for operation on 12V Lead-Acid batteries with capacities between 5 and 600 Ampere-hours (Ahr). Its own current consumption is less than 3 mA, which is about 2 Ahr per month, less than the self-discharge rate of most Lead-Acid batteries.

The NASA BM-1 monitors the battery voltage, the current into and out of the battery, the total Ahr since it was last fully charged, and predicts the time to achieve full charge (during charging) or the time to full discharge (during discharging). A visual indication of the state of the battery charge is always available, and an alarm is used as an alert when the battery voltage falls to a preset level.

INSTALLING THE DISPLAY

Safety notes - IMPORTANT

Lead-acid batteries can emit hydrogen when in operation. Hydrogen and air forms a potentially explosive mixture. Accordingly, ensure that the area around the batteries is well-ventilated, and douse all naked flames and prevent sparks.

Short-circuiting a battery with a metal tool or piece of jewellery can cause catastrophic currents to flow. Before installing any of the BM-1 units, remove all jewellery (such as rings or metal necklaces). Ensure that no metal tool can cause a short circuit.

If you are not sufficiently skilled to undertake any part of this installation safely, you must seek the assistance of a suitably qualified person.

Installation of the Display unit

The installation should be performed in the order specified in the following sections.

1 Select a convenient position for the display. Cut a hole in the panel 87mm wide and 67mm deep. The site must be flat and the cavity behind the panel must remain dry at all times. (The cable entry is deliberately not sealed to ensure adequate ventilation. This prevents misting of the display).

2 Bring the shunt cable through the hole in the panel.
3 Unscrew and remove the two wing nuts from the rear of the instrument and remove the stainless steel clamping bracket.
4 Fit the "O" ring seal into the groove in the panel-mounting face of the instrument. Ensure that it is correctly lying in its groove to provide the watertight seal for the display before fitting the instrument to the panel.

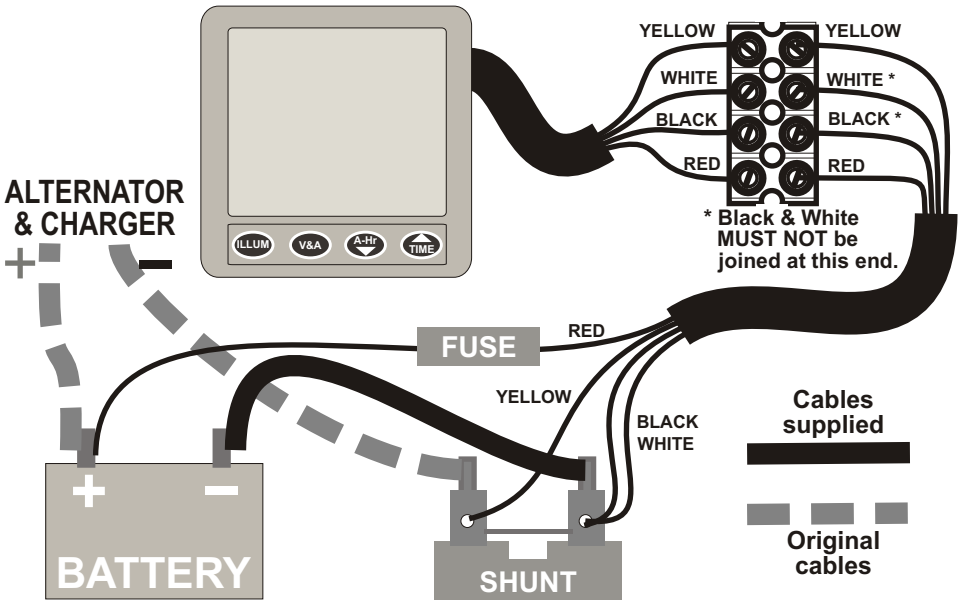

Figure 1 - Wiring Installation

5 Connect the shunt cable to the display unit as shown on Figure 1, below, using the terminal block supplied. Be careful to connect the wires exactly as shown, noting that the black and white wires are joined at the shunt connection, and are connected separately at the instrument end of the cable.
6 Fit the instrument into the panel, fit the stainless clamp over the studs, fit and tighten the two wing nuts finger tight only. It is important that the O-ring rubber seal makes good contact with the panel to prevent water getting behind the unit and entering the cavity behind the panel.
7 It is good practice to run the cables vertically downwards from the unit, even if they later have to rise to connect to the vessel's supplies. Doing so prevents any water that might get onto the cables from running back along the cables and into the unit.
8 Ensure that all loads are switched off
9 Disconnect the NEGATIVE terminal from the battery and connect to the shunt as shown on Figure 1. Ensure it is positioned where it

With no current flowing into or out of the battery, press **V&A** until the residual current is shown. Now press the TIME key or the A-Hr key to bring the value to zero. (Note: eight presses of the key alter the setting by 0.1A). The desired setting is stored when the **V&A** key is pressed to move to the other setting again, or the **ILLUM** key is pressed to exit Engineering.

QUESTIONS AND ANSWERS

Q Why is the screen of my BM-1 blank?
A Check the wiring is correct and securely terminated. Check the fuse, and check that the battery is not completely flat.

Q Why does my BM-1 show that the number of hours remaining is high or low when a constant discharge current is flowing?.
A The actual battery capacity is different from the value you have entered in Engineering. The reasons for this difference have been discussed above. Adjust the battery capacity in Engineering to match the battery.

Q My battery is made up of a bank of several batteries. Is that a problem?
A Not as long as the combination produces a nominal 12 volts, and all the current drawn from the bank passes through the shunt.

Q Can the BM-1 monitor my engine starting battery as well as my service battery?
A No, it cannot. The service battery is in continuous use, and so needs continuous monitoring. The starter battery, however, is subject only to periodic heavy loads followed by float charging, and so does not need to be monitored.
Q I have another voltmeter on my boat which shows a different value to the BM-1 indication.
A The BM-1 very accurately measures the voltage directly across the battery terminals. Other voltmeters may read differently owing to volt drops in the boat's wiring.

Q Why does my BM-1 show a higher capacity immediately after charging than it does after a few minutes' discharging?
A This is an unavoidable feature of battery chemistry, which varies from battery to battery, and the charging regime used.

Showing the time to go.

Press the TIME key to show the percentage remaining battery capacity (%C), and the up-to-date estimate of how long it will take to charge or discharge the battery fully. As the load changes, the estimate of the time updates continuously, reflecting the best estimate of time to fully charged or fully discharged (0% remaining charge). Values in excess of 199 hours are shown as 199 hr.

If the BM-1 is left for long periods registering little or no charge or discharge current, the estimate of capacity may become unreliable. It is important to switch some load onto the battery for a few minutes so a reliable estimate can be calculated, and its value settles, before starting charging.

ENGINEERING

Engineering is the mode for setting the nominal battery capacity, the battery temperature, and the zero-current. Engineering is accessed by keeping **ILLUM** pressed until ENG is displayed to show that Engineering settings are now available. The first value when **ILLUM** is released is the stored nominal battery capacity in Ampere-hours. Then press the **V&A** key to move between capacity, battery temperature, and zero-current settings. In any of these modes, the TIME and A-Hr keys alter the chosen setting. All settings are saved by pressing the **ILLUM** key to exit Engineering.

Setting the battery's nominal capacity

Press **V&A** until the stored capacity appears in the upper numerals, and the Ahr symbols are showing (the factory default is 100 Ahr). Now press the TIME key to increase the value, and the A-Hr key to reduce the value. Keep the key pressed for repeating adjustments.

The maximum capacity is 600 A-hr, and the minimum is 5 A-hr. When the correct value has been selected, press the **V&A** key to finish adjustment, store the new value in memory and to move to temperature setting, or press the **ILLUM** key to exit Engineering.

Setting the Estimated Battery Temperature

Press **V&A** until the battery temperature appears and the symbols °C are shown. The factory preset value is 20 °C which is the value used by battery manufacturers to define their products' capacity. Now, if desired, press the TIME key to increase the value, and the A-Hr key to reduce the value, which changes by 10 °C for each press. The values are limited to the range -20 °C to +40 °C.

Setting the zero-current

If no current is flowing into or out of the battery and a residual current is shown on the display, the reading can be adjusted to zero.

cannot come into electrical contact with other parts, and ensure it will remain dry and free from contaminants. Also note that the shunt can get warm when heavy currents flow, so ensure it is secured in a position where its heat cannot affect other parts. TAKE CARE TO AVOID OVER-TIGHTENING THE CONNECTION TO THE SHUNT.

10 Connect the Black and White wires and Yellow wire to the shunt as shown on Figure 1.
11 Connect short link cable to the shunt and then to the negative terminal of the battery.
12 Finally, connect the red wire to the POSITIVE terminal of the battery to complete the electrical installation. The BM-1 will now begin assessing the battery state, using its factory default values. The default values must be set to the values appropriate to the new installation as follows.
13 Press, and keep pressed, the **ILLUM** key until the word "Eng" is shown on the display. Release the **ILLUM** key and adjust the capacity shown using the TIME and A-Hr keys to match the value shown on your battery (see the Engineering section below for more details).
14 Press the **V&A** key to change to adjusting the battery temperature, and adjust it using the TIME and A-Hr keys to match the estimated average battery temperature within 10°C.
15 Press **ILLUM** to finish Engineering settings.
16 Do NOT put the battery on charge immediately.
17 Apply a load to the battery by switching on lights or instruments and wait for a few minutes for the BM-1 to "learn" the battery's characteristics and to show a steady reading before starting charging.

BATTERY MANAGEMENT BASICS

After Voltage and Current, the most useful measurement available from a battery condition monitor is the sate of charge of the battery. However. estimation of the state of charge of lead-acid batteries is never exact. The problem of making accurate estimates results from the characteristics of the cells, the electrolyte, and the history of currents drawn from (discharge) and supplied to (charge) the battery.

The basis for the best capacity estimates is that the starting condition is known. The only well-established "known" state of a battery is when it is fully charged after a long period of trickle or float charging, usually on a shore or regulated alternator-driven charging system. Discharging a fully-charged new battery at a current 1/20 of the manufacturer's stated capacity will discharge it fully in 20 hours. This current is known as the "20-hour rate".

So, for example, if a battery has a stated capacity of 100 Ahr, then the 20-hour rate for that battery is 5 Amps (because 100/20 = 5). Likewise, a 40 Ahr battery would have a 20-hour rate of 2 Amps (because 40/20 = 2).

If higher currents than the 20-hour rate are drawn from the battery, the available capacity is reduced. For example, if it is steadily discharged at 10 times the 20-hour rate (50 Amps from a 100Ahr battery), the available capacity falls to about half of the stated capacity. The battery will be flat after about 1 hour instead of the expected 2 hours. (However, if the battery is left to recover with the heavy load removed, most of its remaining capacity will return after perhaps 20 hours' resting or at a discharge rate close to the 20-hour rate.) The NASA BM-1 makes due allowance for these effects when estimating the battery's state of charge and the expected time to discharge the battery fully.

When the battery is being charged, the voltage is no longer a reliable estimate of the state of charge, and so the BM-1 integrates the Ampere hours added to the last known capacity to estimate the battery's state of charge on a continuous basis. Allowance for charge efficiency (not all charging current results in useful charge in the battery) is also computed.

Available battery capacity is significantly reduced at temperatures significantly below 20C. The value quoted by the manufacturers is valid at 20C. However, at 0C the capacity may be only 90%, and at -20C may be only 70% of the 20C value. A small increase in capacity is achieved at battery tempeartures above 20C, rising to about 105% of the nominal value at 40C.

The effects of cell deterioration on the available capacity are significant. If the battery is charged for long periods, gassing takes place. The gases are Hydrogen and Oxygen, derived from the water in the battery acid. Loss of this water needs to be made up by topping up the cells if possible, or by avoiding lengthy overcharges in sealed cells.

Other irretrievable effects include sulphation (encouraged by leaving the battery flat for long periods), and deterioration of the cells' plates. If the battery voltage falls below 10.7 Volts (for a nominally 12 Volt battery), and charging is not started, sulphation of the plates can begin. The NASA BM-1 has an alarm which flashes the bell symbol when the voltage falls below 10.7 Volts. If the alarm is triggered, it is important to reduce the current being drawn immediately, and if possible place the battery on charge, to avoid permanent damage to the cells. If the alarm is ignored, the total number of charge/discharge cycles which the battery will survive before it loses a substantial fraction of its nominal capacity may be substantially reduced.

All of these (and other effects) reduce the available charge after fully charging the battery. If the effects are ignored, the NASA BM-1 will incorrectly estimate that more capacity is available at any state of discharge than is actually the case. If so, it is wise to alter the nominal capacity stored in the unit to match the reality of the battery's condition.

NORMAL OPERATION

The NASA BM-1 offers three normal modes of operation:

- Volts and Amps;
- Ampere-hours;
- Time to go.

In all these normal modes, the battery charge state is also displayed on the scale on the right of the display. Also, if the battery voltage falls below the preset alarm level representing dangerous discharge, the alarm bell symbol is flashed.

The three normal modes, and the keys which activate them, are shown in Figure 2, below.

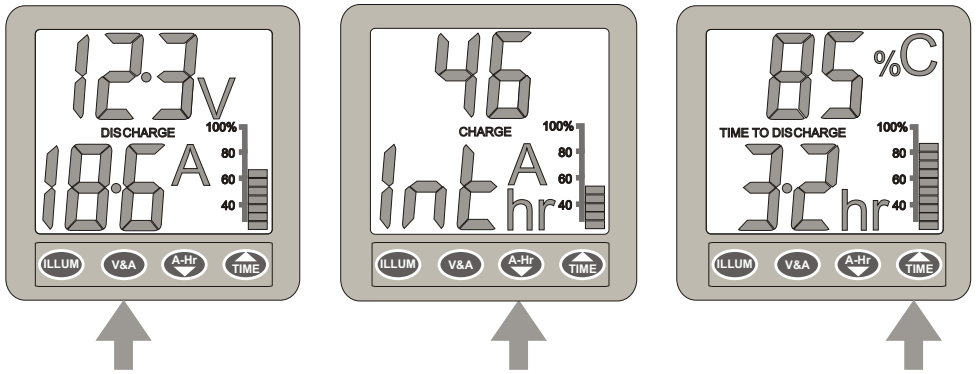

Figure 2 - Operating modes

Switching the backlight

Press the **ILLUM** key to switch the backlighting on or off.

Showing the Voltage and Current

Press **V&A** key to show the present battery voltage and the present battery current, as well as the estimate of the state of the battery's charge on the scale. The maximum current measurement is 102 Amps.

Showing the Ampere-hours total.

Press the A-Hr key to show the total Ampere-hours since the totals were last reset. Int is shown, and all the uncorrected normal total Ampere-hours are shown in the upper numerals. They show the net charge or discharge in Ampere-hours since the unit's counters were last reset. (A new, ex-factory, instrument shows zero.) To reset the Ampere-hours integrator, press the A-Hr key and keep it pressed until 0 is shown.