mkove

Battery Monitor MK70

Precision Battery Monitoring System

Firmware version 162

Welcome

The Mkove Battery Monitor is a precision instrument which will allow you to monitor the state of a 12 or 24 volt lead acid battery system.

With reliable information you will be able to accurately assess your energy systems performance and take care of your battery system.

The battery monitor will show you;

• The state of charge of your battery system.
• Accurate measurements of the current flowing into and out of the system as well as the current battery voltage.
• Historical data about the utilisation and performance of the system.

This battery monitor uses a number of techniques to provide accurate information about your system.

Notes on Safety

• Please read all instructions before using this battery monitor.
• The battery monitor is designed for indoor use only. Do not expose to sources of heat, water or any other liquid. Avoid undue exposure to corrosive or salty environments.
• Do not open or disassemble the product.
• Ensure that all wiring connections are solid and secure. Do not use in systems where there is loose wiring or wiring malfunctions such as exposed, corroded or burnt wiring.
• Lead acid battery systems are sources of high energy electric current. Take every precaution to ensure that the battery terminals are not connected together, such as via tools used during installation, personal jewellery or by incorrect connections. If in doubt use a professional installer to install the system.
• Clean only with a soft dry cloth. Do not use solvents, abrasive cleaners or water.

Package Contents

Your Mkove Battery Monitor MK70 package includes the following items

- Sensor Unit
- Main Unit
- Shunt
- Terminal blocks for connection to Sensor Unit and Main Unit
- Mounting hardware (below the bottom sheet of packaging)

Important Notes on Installation

• The shunt should be installed into either the positive or negative main battery cable. The shunt carries all of the current flowing into or out of the battery - it is important that all connections and cables are appropriately sized for the loads expected.
• To install the shunt cut either of the main battery cables and then install suitable lugs to attach the shunt onto each end of the newly cut wire. Alternatively attach one battery cable to one end of the shunt and then have a short cable made up which attaches from the other end of the shunt to the original terminal on the battery.
• For the battery monitor to work as designed it must be able to measure all current flowing into or out of the battery. It is important that any loads or charge sources are connected to the shunt and not directly to the battery so that the shunt can measure all of the current flowing into or out of the system.
• The battery monitor is aware of and includes calculations of it's own current use. It should be the only item connected directly to the battery. This allows the battery monitor to show a zero reading when there are no other currents flowing into or out of the system.
• Aside from the heavy duty cables required to connect the shunt into the batteries main supply cables, all other wires carry only very small currents and can be as small as required.
• The sensor unit should be mounted reasonably closely to the battery system being monitored so that the sense wires are kept as short as possible to avoid interference.
• If the battery monitor is not installed correctly the data that it shows will be inaccurate or unusable.

Connecting the Sensor Unit

Separate instructions for installing the Sensor Unit are included below depending on whether the shunt is installed in the batteries main positive or negative cable.

All cables can be light duty as no significant current is carried on any wire.

Installing the Sensor Unit when the shunt is installed in the negative cable..

SENS+: Connect the SENS+ terminal to the more positive of the small screw terminals on the shunt. This is the end of the shunt which is furthest from the battery.

SENS-: Connect the SENS- terminal to the more negative of the small screw terminals on the shunt. This is the end of the shunt which is closest to the battery.

BATT+: Connect the BATT+ terminal directly to the positive terminal of the battery.

GND: Connect the GND terminal directly to the negative (battery ground) terminal of the battery. Also connect the GND terminal to the matching GND terminal on the Main Unit.

5V: Connect the 5V terminal to the matching 5V terminal on the Main Unit.

DATA: Connect the DATA terminal to the matching DATA terminal on the Main Unit.

Installing the Sensor Unit when the shunt is installed in the positive cable..

SENS+: Connect the SENS+ terminal to the more positive of the small screw terminals on the shunt. This is the end of the shunt which is closest to the battery.

SENS-: Connect the SENS- terminal to the more negative of the small screw terminals on the shunt. This is the end of the shunt which is furthest from the battery.

BATT+: Connect the BATT+ terminal directly to the positive terminal of the battery.

GND: Connect the GND terminal directly to the negative (battery ground) terminal of the battery. Also connect the GND terminal to the matching GND terminal on the Main Unit.

5V: Connect the 5V terminal to the matching 5V terminal on the Main Unit.

DATA: Connect the DATA terminal to the matching DATA terminal on the Main Unit.

Connecting the Main Unit

GND: Connect the GND terminal to the matching GND terminal on the Sensor Unit.

5V: Connect the 5V terminal to the matching 5V terminal on the Sensor Unit.

DATA: Connect the DATA terminal to the matching DATA terminal on the Sensor Unit.

Mounting the Sensor Unit

Use either screws or clip ties (not included) to mount the sensor unit near to the batteries being monitored. The sensor unit should be mounted away from direct sunlight as direct sunlight will affect the ambient temperature readings which are made within the sensor unit.

Panel Mounting of the Main Unit

The main unit is designed for panel mounting. It's external dimensions are 106mm wide by 55mm high.

A hose clamp which secures the unit is included with the packaging. To protect the finish of the unit either use the neoprene spacers which are included with the package or wrap the body of the unit with electrical or other suitable tape. The hose clamp allows the unit to be securely mounted with a single screw which makes access to the unit simpler when in confined spaces.

When all wiring connections have been made connect power to the sensor and main units by connecting their matching plugs.

If the unit has not been used before or if it has been factory reset the screen will show “Battery Capacity” and a default battery capacity. Use the left and right arrow buttons, which can be held down for quick setting, to set the total combined battery capacity of the battery system being monitored. Press the Menu/OK button to enter the capacity and then press the Exit button until the main screen is shown. If required this setting can be changed at any later time via the menu system.

It is important to set the battery capacity accurately as a number of functions rely on this. Usually this is the sticker capacity in Amp Hours of the battery. If the Amp Hour capacity is not shown consult the battery supplier for the appropriate capacity in Amp Hours. Do not confuse the amp hour capacity with CCA or any other specification.

The unit should show the battery Volts in the top left corner and the Amps flowing into or out of the battery in the top right corner. It will also show the current state of charge as a percentage in the lower left corner and the current temperature measured at the Sensor unit in the lower right corner.

At this point you can press the left and right arrow buttons to cycle through all of the screens that are available. Pressing the Exit button at any time will return to the first screen. You can also press the Menu button at any time to enter the menu system.

There are a couple of things to check when first installed. The Amps reading should read 0.00A when no current is flowing into or out of the battery. If it does not show 0.00A and there are definitely no load or charge sources connected to the battery the amps reading can be zeroed from the settings menu by choosing Menu -> Settings -> Zero Amps. If you need to be absolutely certain the unit is measuring zero amps before making this setting then disconnect the SENS+ and SENS- wires from the shunt and connect them together temporarily

while making this setting.

When first connected the unit takes a snapshot of the current battery voltage to provide an initial state of charge. This will provide a rough estimation of the batteries state of charge only and assumes that the battery has been at rest for some time prior to connection. If the battery has not been at rest then this initial reading will likely be very inaccurate. The initial snapshot feature will set the state of charge to a maximum of 90 percent.

The state of charge will not be accurate when first installed. There are a few ways to bring the state of charge into line with the current battery state of charge.

If the battery is definitely full then the battery monitor can be set to the full state by choosing Menu -> Settings -> Set Full from the menus.

The battery monitor will also slowly detect and phase in the current state of charge if the battery is connected to a charging source. It can take a significant amount of time while charging for the battery monitor to align with the state of charge of the battery. During subsequent charges the battery monitor should already be closely aligned with the current SOC (state of charge) of the battery and will just apply small adjustments as required to keep the SOC reading aligned with the batteries actual SOC.

If the battery monitor detects that the battery is full at any time during the charge process then it will show 'FULL' instead of the state of charge percentage in the lower left corner. It is possible that the unit will display the SOC as 100% without the battery having been registered as FULL.

Display Screens

The unit has a number of display screens which can be cycled through by pressing the left and right arrow buttons. While cycling through the screens the Exit button can be pressed at any time to return to the first screen.

Abbreviations used on these main display screens are as follows;

V	- Volts.
A	- Amps.
C	- Temperature in degrees Celsius.
W	- Watts. This is always Volts times Amps.
%	- The current state of charge as a percentage.
FULL	- Shown in place of the state of charge when the battery monitor has detected a full state.

The last of the screens shows the state of the battery monitor and uses the following abbreviations;

Stdy	- Indicates the battery is in a steady state.
Rest	- Indicates the battery is in a resting state.
Hld High	- Indicates the battery is being held above 13.5 Volts (27 Volts for a 24 Volt system).
Chg Crct state	- Indicates that the system is Charge Correcting the state of charge during a charge cycle.

The unit also has a graph presentation on some screens which will show the current state of charge graphically on the lower half of the screen.

Menu System and Options

The menu system can be accessed at any time by pressing the Menu button. It can be exited at any time by pressing the Exit button to leave the current menu option, or to leave the menu system entirely.

All of the buttons are repeatable and will quickly cycle through options or values by holding a button down.

The menu system options are as follows;

Menu / Data: The data menu shows information about the current, last and all cycles of the battery.

Menu / Data / This Cycle: After selecting this option you can cycle through the Lowest Volts, Highest Volts and Lowest SOC.

Menu / Data / Last Cycle: This option shows various data from the last cycle of the battery. A cycle means going from a FULL state to less than 90% capacity and then back to a FULL state. If the battery has not gone through at least one full cycle then the data shown here will be inaccurate. Master SOC shows the master internal state of charge when the battery was detected to be in a full state at the end of the cycle. A/H Disch shows the total raw Amp Hours that were discharged during the last cycle. A/H Charge shows the total raw Amp Hours that were charge during the last cycle. Note that these are raw figures and do not include the calibration data that the unit makes internally. A/H Chg (Cal) shows the charged Amp Hours taking into account internal resistance and charge efficiency. This is largely a factor of how well the charge efficiency has been calculated from previous cycles and will improve with use.

Menu / Data / All Cycles: This option shows data from all cycles of the battery. It can be reset only by choosing Factory Reset if, for example, the battery monitor is moved to another battery. Total Cycles shows the total number of cycles applied to the battery. A cycle means going from a FULL state to less than 90% capacity and then back to a FULL state. Cycles < 75% shows the total number of cycles where the state

of charge during the cycle was less than 75%.
Cycles < 50% shows the total number of cycles where the state of charge during the cycle was less than 50%.
Cycles < 25% shows the total number of cycles where the state of charge during the cycle was less than 25%.
Chg Efficiency shows the calculated charge efficiency as calculated for all cycles of the battery. By default this value is 95% and will adjust after each valid cycle.

Menu / Settings / Brightness: Adjusts the screen brightness. For smaller battery systems please be aware that this system uses more power at higher brightness.

Menu / Settings / Contrast: Adjusts the screen contrast.

Menu / Settings / Display Timer: Options are Off, 5 Minutes, 20 Minutes or 60 Minutes. When set to Off the display will always be on, otherwise it will turn off after the specified time interval. The display timer resets whenever a button is pressed or whenever the amps into or out of the system are more than 0.5 Amps. If the display is off and the Amp reading exceeds +/-0.5 Amps the display will turn on and the display timer will be reset.

Menu / Settings / Battery Capacity: Sets the battery capacity of the system being monitored.

Menu / Settings / Set Full: Regardless of whether the system has detected a Full state this menu option will set the system to Full.

Menu / Settings / Zero Amps: This tells the system that there are zero amps flowing through the current sense shunt. It is important to be sure that this is actually the case before using this setting or the system will work incorrectly.

Menu / Settings / Shunt Calibrate: You system will have shipped with this setting correctly matching your shunt so that the Amps readings are accurate. Otherwise if a different shunt is used the Shunt Calibrate setting should be set according to the following formula: Shunt Calibrate = Millivolt rating of the shunt divided by Amps rating of the shunt

times 1000. For example for a 500 Amp 75 millivolt shunt the calculation is 75 / 500 X 1000 = 150.

Menu / Reset / Reset Data: This resets the local data held in memory by the system. It is the equivalent to powering off the unit and reconnecting it. No long term data or settings will be erased.

Menu / Reset / Factory Reset: This will reset your system to factory delivered condition. All short and long term data will be erased. The unit will restart and ask for your initial Battery Capacity.

Definitions

Full: Full is defined as the battery being held steadily at 1% of it's capacity for five minutes. During this time the battery voltage must be held at or above 13.5 Volts (27.0 Volts for a 24 Volt system).

Full can also be detected between 13.0 (26.0 for a 24 Volts system) and 13.5 (27.0) Volts if held steadily for a longer time period. At 13.0 Volts the time period required is two hours . At 13.5 Volts the time period required is five minutes and the time period is adjusted proportionally between these two voltages.

For a 100 amp hour battery this would require a steadily applied charge current of 1 amp or less.

Steady: Internally the unit requires the system to be in a steady state to make a number of it's calculations. To achieve a steady state requires that the volts and amps applied to the system are not erratic or varying greatly for at least five minutes. The amps and volts can either remain the same or they can be steadily rising or decreasing for this to be achieved. For example if the amps are decreasing steadily during the absorption stage of a normal charge the unit will consider this to be a steady state.

Resting: The system is considered to be resting if the system remains steady and the amps remain between -0.10 and 0.10 amps for a period of at least fifteen minutes.

Detecting State of Charge

Historically keeping track of the state of charge of a lead acid battery system has been an almost impossible task. Almost all other battery monitors simply monitor the current going into and out of a battery to report the current state of charge, but without any other reference they will fairly quickly go out of synch with the battery.

Generally the only reference that a battery monitor will have is to set the state of charge to 100% when the battery is charged to full and then trust that the accuracy of the system will keep the system in synch with the battery at other times. This system was specifically designed to solve this problem and to provide a much more practical and accurate monitoring system.

Full state detection is normally done by sensing a specified low current being put into the battery while a high charging voltage is being held.

Detecting full is reliable in this and in other systems but it can take a very long time for a battery to reach a full state. In many cases a battery will rarely reach a full state. In a typical scenario with a modest charging system it can take only one hour for a battery to be charged from 50% to 85%. To charge from around 85% to 100% will typically require a further two hours. With a more powerful charging system the time required to charge from 50% to 85% will be less but the same time will still be required to charge from 85% to 100% as in either case the charger has to reduce it's output to allow the battery to absorb a smaller current as it approaches it's full state.

This battery monitor uses a number of techniques to keep the system closely aligned with the battery systems actual state of charge.

Accuracy

Accuracy is essential in a battery monitoring system. Most battery monitors will wander up to a third of an amp even when there is no load on the battery. They do this because of the long sense lines which are run from the battery to the display and calculation unit. This system uses a two module system to sense the voltage and current close the battery and then uses a digital signal which is immune to interference to send the data to the display unit. Using this system the data is transmitted at the full accuracy at which it is sensed. This gives you a much more accurate picture of your battery use and gives the battery monitor much more accurate data to calculate from.

The internal voltage and current sense IC is the Texas Instruments INA226, released in August 2011, and is currently the industry's most accurate current shunt monitor (ref: Texas Instruments INA226 press release Aug. 24, 2011).

Charge Correction

This battery monitor uses a system called Charge Correction which adjusts the current state of charge while the battery is being charged. It does this by making many calculations while the battery is under charge, each calculation could be inaccurate by a few percent, although they are usually very accurate, but when combined and slowly applied on a continual basis result in very accurate state of charge calculation during charging. These calculations are slowly applied to the reported state of charge to keep the monitor accurately aligned with the battery. This means that a battery can be partially charged and the system will still be able to align itself with the actual state of the battery.

State of Charge Guarding

This battery monitor uses State of Charge Guarding which monitors the battery when it is in a resting state.

After one hour in a resting state it uses a state of charge table to calculate the state of charge for the current resting voltage. It then applies an accuracy window of 40% to the current state of charge. If the state of charge does not match the voltage based SOC by more than 40% it will slowly apply a correction factor to bring the reported state of charge to within 40% of the calculated resting state of charge and keep doing this while ever the battery is resting. The accuracy window slowly reduces from 40% after one hour to 10% after 24 hours. This is because the resting voltage to state of charge calculation becomes more accurate the longer the battery has been resting. After 24 hours in a continual resting state the accuracy window will remain at 10%.

State of Charge Guarding ensures that the reported state of charge remains within voltage determined limits if the battery is left in a resting state for significant periods of time.

Peukert's Law

Peukert's Law is an old law which accurately predicts the available capacity of a battery under a constant load. However with a varying load it will not reflect the total available capacity of the battery and internal resistance is a more relevant factor to state of charge. For example if a large load is applied to a battery and Peukert's Law predicts a significant reduction in capacity, the large load can be removed, a small load applied and most of the original capacity of the battery will still be available. Peukert's Law has an immediate affect and is only used in this system to make the Capacity Floor calculation. Internal resistance however has a continual affect on the state of charge of the battery and is applied at all times during charging and discharging.

Limitations

There are some situations where this monitoring system may work less effectively. These are outlined below.

State of Charge Guarding requires the system to be in a steady resting state for at least 1 hour. If a small steady load greater than 0.1 amps is applied then the battery will not be considered to be resting and State of Charge Guarding will not be activated. If an occasional cyclic load, such as a refrigerator, draws a significant current occasionally the system will not be steady for long periods of time and State of Charge Guarding will be less effective or not operate.

During charging the Charge Correction will not be applied if the charge is not applied reasonably steadily. An example of this might be in an automotive application in city traffic where the alternator applies a lower voltage at idle. This will reduce both the voltage and the current applied and not allow the system to achieve a steady state. Other charge systems including solar panels, wind systems and battery chargers will generally apply a steady charge and will work well with this system.

This battery monitor uses figures for Peukert's, internal resistance, capacity at temperature and resting state of charge which are typical for a lead acid battery in good condition. While the effects of these are either minor or can be corrected through charge efficiency calculations, they may be inaccurate for a battery in poor condition. A battery in poor condition may be damaged, heavily sulphated, have internal shorts, have been excessively over discharged, left uncharged for a long period of time or due to age and total cycles may have a low residual capacity.

This system will not work correctly if any loads or charge sources are connected directly to the battery and not able to be measured by the battery monitor.

Support

Please contact us through our web site at http://www.mkove.com if you have any issues or need help with installing or operating this system.