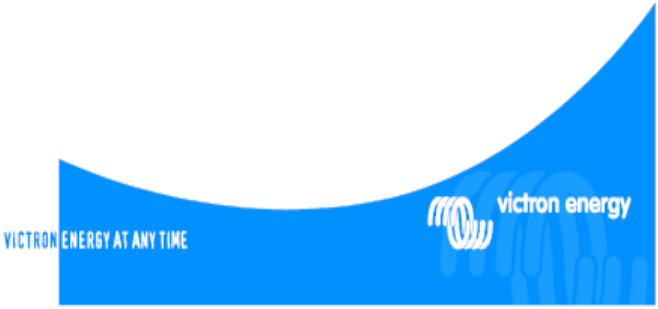
Precision Battery Monitor BMV-600

USER MANUAL
INSTALLATION MANUAL



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1 INTRODUCTION

Victron Energy has established an international reputation as a leading designer and manufacturer of energy systems. Our R&D department is the driving force behind this reputation. It is continually seeking new ways of incorporating the latest technology in our products. Each step forward results in value-added technical and economical features.

1.1 Victron Energy battery monitor basics

The Precision Battery Monitor BMV-600 is a device that monitors your battery status. It constantly measures the battery voltage, and battery current, and uses this information to calculate the actual state of charge of your battery.

The BMV-600 is supplied with a shunt that delivers a –50 to 50mV voltage at a current rating of 500A.

The BMV-600 is also equipped with a potential free contact. This can be used to automatically start and stop a generator, or signal alarm conditions.

1.2 Why should I monitor my battery?

Batteries are used in a wide variety of applications, mostly to store energy for later use. But how do you know how much energy is stored in your battery? No one can tell by just looking at it.

Battery technology is often oversimplified, but some basic battery knowledge and good monitoring is essential if you want to enjoy maximum life from your expensive batteries. The life time of batteries depends on many factors. Battery life reduces by under-charging, over-charging, excessively deep discharge, too fast a discharge and too high an ambient temperature. By monitoring your battery with an advanced battery monitor like the BMV-600, important feedback is given to the user so that remedial measures can be taken when necessary. This way, by extending battery life, the BMV-600 will quickly pay for itself.

1.3 How does the BMV-600 work?

The capacity of a battery is rated in Amphours (Ah). For example, a battery that can deliver a current of 5Amps for a period of 20hours is rated at 100Ah (5 * 20 = 100). The BMV-600 continuously measures the nett current flow in or out of the battery so it can calculate the amount of energy removed from or added to the battery. But since battery age, discharge current and temperature all influence the battery's capacity, you can't rely simply on an Amp-hours reading. When the same 100Ah battery is discharged completely in two hours, it will give you only 56Ah (because of the higher rate of discharge).
As you can see the battery's capacity is almost halved. This phenomenon is called Peukert efficiency (see also chapter 2.2). Also, when the temperature of the battery is low, its capacity is decreased even more. This is why simple Amphour counters or Voltmeters give you far from an accurate state-of-charge indication.

The BMV-600 can display both Amphours removed (not compensated) and actual state-of-charge (compensated by Peukert efficiency and charge efficiency). Reading state-of-charge is the best way to read your battery. This parameter is given in percent, where 100.0% represents a fully charged battery and 0.0% a completely flat battery. You can compare this with a fuel-gauge in a car.

The BMV-600 also makes an estimation of the time the battery can support the present load (time-to-go readout). This is actually the time left till the battery needs to be charged again. If the battery load is fluctuating heavily it is best not to rely on this reading too much since it is a momentary readout and must be used as a guide only. We always encourage the use of the state-of-charge readout for accurate battery monitoring.

Besides the main function of the BMV-600, displaying the actual battery status, this monitor offers many other features. The readout of actual battery voltage and current, the ability to store historic data, the PC computer-link and the voltage of the start battery are just a few features of the BMV-600. These features are more specifically explained in the corresponding chapters of this manual.

1.4 Safety Precautions!

1. Working in vicinity of a lead acid battery is dangerous. Batteries can generate explosive gases during operation. Never smoke or allow a spark or flame in the vicinity of a battery. Provide sufficient ventilation around the battery.

2. Wear eye and clothing protection. Avoid touching eyes while working near batteries. Wash your hands when done.

3. If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters eye, immediately flood eye with running cold water for at least 15 minutes and get medical attention immediately.

4. Be careful when using metal tools in vicinity of batteries. Dropping a metal tool onto a battery might cause a short-circuit battery and, possibly an explosion.

5. Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a battery. A battery can produce a short-circuit current high enough to melt a ring or the like to metal, causing severe burns.

Included:
- BMV-600 battery monitor
- Safety and Regulatory information
- 500A/50mV current shunt
- This user and installation manual
- Quick install guide
- Front mounting kit incl 4 screws

2 SETTING UP THE BMV-600

Before proceeding with this chapter, please make sure your BMV-600 is fully installed in accordance with to the enclosed installation guide.

When your BMV-600 is installed it is time to adjust the battery monitor to your battery system. But before discussing the functions in the setup menu, four important items are explained first in the following chapters. It is important that as a user of the BMV-600 you have some insight into these four items. The actual setup menu functions are explained in chapter 2.5 'Function overview'.

2.1 Charge Efficiency Factor (CEF)

Not all energy transferred into the battery during battery charging, is available during discharge of the battery. The charge efficiency of a brand new battery is approximately 90%, meaning that 10Ah must be transferred to the battery to get 9Ah actually stored in the battery. This efficiency figure is called Charge-Efficiency-Factor (CEF) and will decrease with battery age. The BMV-600 can automatically calculate the CEF of the battery.

2.2 Peukert's exponent

As mentioned earlier in chapter 1.3 the Peukert efficiency describes how, when you discharge a battery faster than the 20hr rating, its Amphour capacity decreases. The amount of battery capacity reduction is called 'Peukert exponent' and can be adjusted from *1.00* to *1.50*. The higher the Peukert exponent the faster the battery size shrinks with increasing discharge rate. An ideal (theoretical) battery has a Peukert Exponent of 1.00 and doesn't care how big the discharge current is. Of course such batteries do not exist, and a setting of *1.00* is only implemented to bypass Peukert compensation in the BMV-600. The default setting for the Peukert exponent is 1.25, and is an acceptable average value for most lead acid type of batteries. However for precise battery monitoring, entering the right Peukert exponent is essential. If the Peukert exponent is not provided with your battery, you can calculate it by using other specifications which must be provided with your battery.

The Peukert equation is stated below:

$$Cp = I^n \cdot t \quad \text{where Peukert exponent 'n'} = \frac{\log t2 - \log t1}{\log I1 - \log I2}$$

The battery specifications needed for calculation of the Peukert exponent, are the rated battery capacity (usually the 20hr discharge rate[1]) and for example a 5hr discharge rate[2]. See the calculation example below to define the Peukert exponent using these two specifications:

5hr rating, C5 = 75Ah
–> t1 = 5hr
–> I1 = 75Ah/5hr = 15A

20hr rating, C20 = 100Ah (rated capacity)
–> t2 = 20hr
–> I2 = 100Ah/20hr = 5A

$$\text{Peukert exponent n} = \frac{\log 20 - \log 5}{\log 15 - \log 5} = \underline{\mathbf{1,26}}$$

When no ratings are given at all, you can measure your battery using a 'constant load bank'. In this way a second rating can be obtained, besides the 20hr rating which represents the rated battery capacity in most cases. This second rating can be defined by discharging a fully charged battery with a constant current; until the battery reaches 1.75V per cell (is 10.5V for a 12V battery or 21V for a 24V battery). A calculation example is shown below:

[1] Please note that the rated battery capacity can also be defined as the 10hr or even 5hr discharge rate.
[2] The 5hr discharge rate in this example is just arbitrary. Make sure that besides the C20 rating (low discharge current) you choose a second rating with a substantially higher discharge current.

A 200Ah battery is discharged with a constant current of 20A and after 8.5 hours 1.75V/cell is reached.

So, –> t1 = 8.5hr
–> I1 = 20A

20hr rating, C20 = 200Ah
–> t2 = 20hr
–> I2 = 200Ah/20hr = 10A

$$\text{Peukert exponent } n = \frac{\log 20 - \log 8.5}{\log 20 - \log 10} = \underline{1.23}$$

To calculate the Peukert exponent with the specifications above, you can also use the Peukert calculator which can be downloaded from our website at www.victronenergy.com.

2.3 Charged-parameters

Based on increasing charge voltage and decreasing charge current, a decision can be made whether the battery is fully charged or not. When the battery voltage is above a certain level during a predefined period while the charge current is below a certain level for the same period, the battery can be considered fully charged. These voltage and current levels, as well as the predefined period are called 'charged-parameters'. In general for a 12V lead acid battery, the voltage-charged-parameter is 13.2V and the current-charged-parameter is 2.0% of the total battery capacity (e.g. 4A with a 200Ah battery). A charged-parameter-time of 4 minutes is sufficient for most battery systems. Please note that these parameters are very important for correct operation of your BMV-600, and must be set appropriately in the corresponding menu items.

2.4 Synchronizing the BMV-600

For a reliable readout of the state of charge of the battery, the battery monitor has to be synchronized regularly with battery and charger. This is accomplished by fully charging the battery. When the charger is operating in the 'float' stage, the charger considers the battery full. At this moment the BMV-600 must determine that the battery as full too, so that the Amphour count can be reset to zero and the state-of-charge reading set to *100.0%*. By precisely adjusting the charged-parameters in the BMV-600, the battery monitor can automatically synchronize with the charger when the 'float' stage is reached. The range of the chargedparameters is wide enough to adjust the BMV-600 to most battery charging methods.

When the supply voltage to the BMV-600 has been interrupted, the battery monitor must always be synchronized in order to operate correctly. When power is first applied the monitor is always preset in setup mode, this is the mode to set the parameters.

Please note that regularly (at least once per month) fully charging your battery not only keeps it in sync with the BMV-600, but it also prevents substantial capacity loss of your battery that limits it's life time.

2.5 Function overview

The BMV-600 factory settings are suitable for an average 12V/24V lead acid battery system of 200Ah. So in most cases when monitoring a 12V/24V system, the only menu item which possibly needs to be changed is the battery capacity (CB). When using other types of batteries please ensure that all the relevant specifications are known to properly setup the BMV-600 parameters.
Users can fully adjust their BMV-600 with the help of 28 different settings, called 'Parameters'.

There are four buttons to control the BMV-600:

Name	Function
Setup	-Enter/exit setup mode by pressing this button for 3 seconds. -Confirm change. When a parameter is changed and this button is pressed, it will be checked for validity. If the value is valid it is stored. If the value is invalid, the display blinks rapidly 10 times and the nearest valid value is displayed but not stored. The value can be corrected if need, and then stored by pressing this button again.
Select	-Select a digit. The cursor is moved one digit to the right (or to the far left if it was already on the far right) so the next digit can be changed. The number of selectable digits depends on the setting (some have only one, so this button will do nothing). -Switch between display mode and historic mode.
Up	-Change digit. The selected digit will be increased (after 9 it is set to 0). Some digits are not decimal (like the sign and the 'x'). These digits just switch between the available values. -Select displayed item. The previous enabled item is displayed.
Down	-Change digit. The selected digit will be decreased (after 0 it is set to 9). Some digits are not decimal (like the sign and the 'x'). These digits just switch between the available values. -Select displayed item. The next enabled item is displayed.
10 sec. Up/Down	-In setup mode: When these buttons are pressed together for more than 10 seconds all parameters will be set to the default values. -In historic mode: When these buttons are pressed together for more than 10 seconds all historic values will be cleared.

In setup mode the following parameters can be set:

Name	Description	Min.	Max.	Default	Resolution	Unit
Cb	Battery capacity	20	9999	200	1	Ah
Vc	Charged voltage	0.0	150.0	13.2	0.1	V
It	Tail current	0.5	10.0	2.0	0.1	%
Tcd	Charged detection time	1	4	3	1	min.
CEF	Charge efficiency factor	50	99	90	1	%
PC	Peukert exponent	0.00	1.50	1.25	0.01	
Ith	Current threshold	0.00	2.00	0.01	0.01	A
Tdt	Time To Go Δt	0	12	3	1	min.
DF	Discharge floor (SOC relay)	0.0	99.0	50.0	0.1	%
CIS	Clear SOC relay	0.0	99.0	90.0	0.1	%
Al	Alarm low voltage (buzzer)	0.0	99.0	0.0	0,1	V
Alc	Clear low voltage alarm	0.0	99.0	0.0	0,1	V
Ah	Alarm high voltage (buzzer)	0.0	99.0	0.0	0,1	V
Ahc	Clear high voltage alarm	0.0	99.0	0.0	0,1	V
AS	Alarm low SOC (buzzer)	0.0	99.0	0.0	0.1	%
ASc	Clear low SOC alarm	0.0	99.0	0.0	0.1	%
Rl	Relay low voltage	0.0	99.0	0.0	0.1	V
Rlc	Clear relay low voltage	0.0	99.0	0.0	0.1	V
Rh	Relay high voltage	0.0	99.0	0.0	0.1	V
Rhc	Clear relay high voltage	0.0	99.0	0.0	0.1	V
BLI	Backlight intensity	0	9	5	1	
D V	The quantity with an 'x' can be selected in display mode. When they are all clear, the SOC is displayed	no	Yes	yes	n.a.	
D I		no	Yes	yes	n.a.	
D CE		no	Yes	yes	n.a.	
D SOC		no	Yes	yes	n.a.	
D TTG		no	Yes	yes	n.a.	
Lock	Setup lock	no	Yes	no	n.a.	
SW	Firmware version (cannot be altered)	x.xx	x.xx	x.xx	n.a	

Explanation of terms:

Cb: Battery capacity in Amphours (Ah). This must be the capacity at a 20h discharge rate and 20 °C.

VC: Voltage-charged-parameter. The battery voltage must be above this voltage level to consider the battery as fully charged. Make sure the voltage-charged-parameter is always slightly below the voltage at which the charger finishes charging the battery (usually 0.1V or 0.2V below the 'float' stage voltage of the charger).

It: Current-charged-parameter. When the charge current value is below this percentage of the battery capacity (Cb), the battery can be considered as fully charged. Make sure the current-charged-parameter is always greater than the minimum current at which the charger maintains the battery, or stops charging.

Tcd: Detection time charged state. This is the time the charged-parameters (as described in It and Vc) must be met, in order to consider the battery as fully charged.

CEF: When a battery is being charged, energy is lost. The Charge Efficiency Factor compensates for the lost energy, where 100% is no loss. Default is 90%.

PC: Peukert exponent (discharge efficiency). When unknown it is recommended to keep this value at 1.25. A value of 1.00 disables the Peukert compensation. Contact your battery manufacturer for the correct Peukert exponent for your battery.

Ith: Current threshold. When the current measured falls below this value it will be considered as zero Amps. With this function it is possible to cancel out very small currents that can negatively affect long term state-of-charge readout in noisy environments. For example if an actual long term current is +0.05A and due to injected noise or small offsets the battery monitor measures –0.05A, on the long term the BMV-600 can incorrectly indicate that the battery needs recharging. When in this case Function 14 is set to 0.1, the BMV-600 calculates with 0.0A so that errors are eliminated. A setting of 0.0 disables this Function.

Tdt: Time-to-go averaging period. Specifies the time window in minutes that the moving averaging filter works with. Selecting the right time depends on your installation. A value of 0 disables the filter and gives you instantaneous (real-time) readout; however the displayed values may fluctuate heavily. Selecting the highest time (12 minutes) ensures that long term load fluctuations are included in the time-to-go calculations.

DF: Low-battery relay-alarm (discharge floor). When the state-of-charge percentage has fallen below this value, the alarm relay will be activated. The time-to-go calculation is also linked to this value. It is recommended to keep this value at or around 50.0%.

CIS: Clear low-battery relay-alarm. When the state-of-charge percentage has risen above this value, the alarm relay will be de-activated. This value needs to be larger then or equal to DF.

AI: Undervoltage buzzer-alarm. When the battery voltage falls below this value, after 10 seconds a bell-icon shall appear on the display, backlight flashes and the buzzer will sound. The buzzer and backlight-flashing can be turned off by pressing any key, the bell-icon will remain in the display.

Alc: Clear undervoltage buzzer-alarm. When the battery voltage rises above this value, the alarm is turned off. This value needs to be larger then or equal to AI.

Ah: Overvoltage buzzer-alarm. When the battery voltage rises above this value, after 10 seconds a bell-icon shall appear on the display, backlight flashes and the buzzer will sound. The buzzer and backlight-flashing can be turned off by pressing any key, the bell-icon will remain in the display.

Ahc: Clear overvoltage buzzer-alarm. When the battery voltage falls below this value, the alarm is turned off. This value needs to be less then or equal to Ah.

AS: Low-battery buzzer-alarm. When the state-of-charge percentage has fallen below this value, after 10 seconds a bell-icon shall appear on the display, backlight flashes and the buzzer will sound. The buzzer and backlight-flashing can be turned off by pressing any key, the bell-icon will remain in the display.

ASc: Clear low-battery buzzer-alarm. When the state-of-charge percentage has risen above this value, the alarm is turned off. This value needs to be larger then or equal to AS.

RI: Undervoltage relay-alarm. When the battery voltage falls below this value, after 10 seconds the alarm relay will be activated.

Rlc: Clear undervoltage relay-alarm. When the battery voltage rises above this value, the alarm relay will be de-activated. This value needs to be larger then or equal to RI.

Rh: Overvoltage relay-alarm. When the battery voltage rises above this value, after 10 seconds the alarm relay will be activated.

Rhc: Clear overvoltage relay-alarm. When the battery voltage falls below this value, the alarm relay will be de-activated. This value needs to be less then or equal to Rh.

BLI: Backlight intensity. The intensity of the backlight, ranging from 0 (always off) to 9 (maximum intensity).

D V: Display battery voltage on/off. Determines if this value is available in display mode.

D I: Display current on/off. Determines if this value is available in display mode.

D CE: Display consumed enegy on/off. Determines if this value is available in display mode.

D SOC: Display state of charge on/off. Determines if this value is available in display mode.
D TTG: Display time to go on/off. Determines if this value is available in display mode.
Lock: When on, all settings (except this one) are locked and cannot be altered.
SW: Firmware version (cannot be altered)

When all the necessary changes are made and double checked in the setup-mode, it is time to jump back to the normal operating mode by pressing the setup key for three seconds. Your BMV-600 is now ready for use!

3 GENERAL OPERATION

In normal operating mode the BMV-600 can display the values of selected important parameters of your DC system. Use the + and - selection keys to select the desired parameter.

Battery voltage (V): This readout is useful to make a rough estimation of the battery's state-of-charge. A 12V battery is considered empty when it cannot maintain a voltage of *10.5V* under load conditions.

Current (A): represents the actual current flowing in or out of the battery. A discharge current is indicated as a negative value (current flowing out of the battery). If for example a DC to AC inverter draws 5Amps from the battery, it will be displayed as *–5.0A*.

Consumed Amphours (Ah): displays the amount of Amphours consumed from the battery. A fully charged battery sets this readout to *0.0Ah* (synchronized system). When for three hours a current of 12Amps is drawn from the battery, this readout gives *–36.0Ah*.

State-of-charge (%): This is the best way to monitor the actual state of the battery. This readout represents the current amount of energy left in the battery. A fully charged battery sets this readout to *100.0%* while a fully discharged battery is represented as *0.0%*.

Time-to-go (h): is an estimation of how long the battery can support the present load, before it needs recharging.

4 SPECIAL FEATURES

After power up, the battery monitor does a guess on the nominal voltage of the battery. Thereby the following rules are used:

1. The measured voltage will be converted to a nominal voltage with the following table:

Lower boundary(V)	Upper boundary(V) (Nom. +25%)	Nominal Battery voltage(V)	High Voltage (Nom. + 25%)	Charged Voltage (Nom. + 15%)
<<	15	12	15	13.8
15	30	24	30	27.6
30	45	36	45	41.4
45	60	48	60	55.2
60	90	72	90	82.8

2. The nominal voltage can only be increased.
3. After one hour of charging the battery monitor will stop guessing and maintain the voltage as it is at that moment.
4. If the ‘High Voltage’ or ‘Charged Voltage’ is altered by the user the battery monitor stops guessing.
5. The settings for ‘High Voltage’ en ‘Charged Voltage’ are changed according to the table.

5. TECHNICAL DATA

Supply voltage range	9 ... 95VDC
Supply current (no alarm condition)	
@Vin=24VDC without back lighting	<1 mA
@Vin=12VDC without back lighting	<1 mA
Input voltage range auxilary battery	9 ... 95VDC
Input current range	-500 ... +500A
Battery capacity range	20 ... 9999Ah
Operating temperature range	0 ... 50°C
Readout resolution:	
Voltage (0 ... 135V)	voltage dependent
Current (0 ... 10A)	± 0.1A
Current (10 ... 500A)	± 1A
Amphours (0 ... 200Ah)	± 0.1Ah
Amphours (200 ... 2000Ah)	± 1Ah
State-of-charge (0 ... 100%)	± 0.1%
Time-to-go (0 ... 100hrs)	± 1minute
Time-to-go (100 ... 240hrs)	± 1hr
Voltage measurement accuracy	± 0.3%
Current measurement accuracy	± 0.5%
Potential free alarm contact	
Mode	Normally open
Rating	60V/1A max.
Dimensions:	
Frontpanel	69 x 69mm
Body diameter	52mm
Overall depth	31mm
Net weight:	
BMV-600	70 gram
Shunt	315 gram
Material	
Body	ABS
Sticker	Polyester

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