Battery Beak User Manual

Revision 1.1

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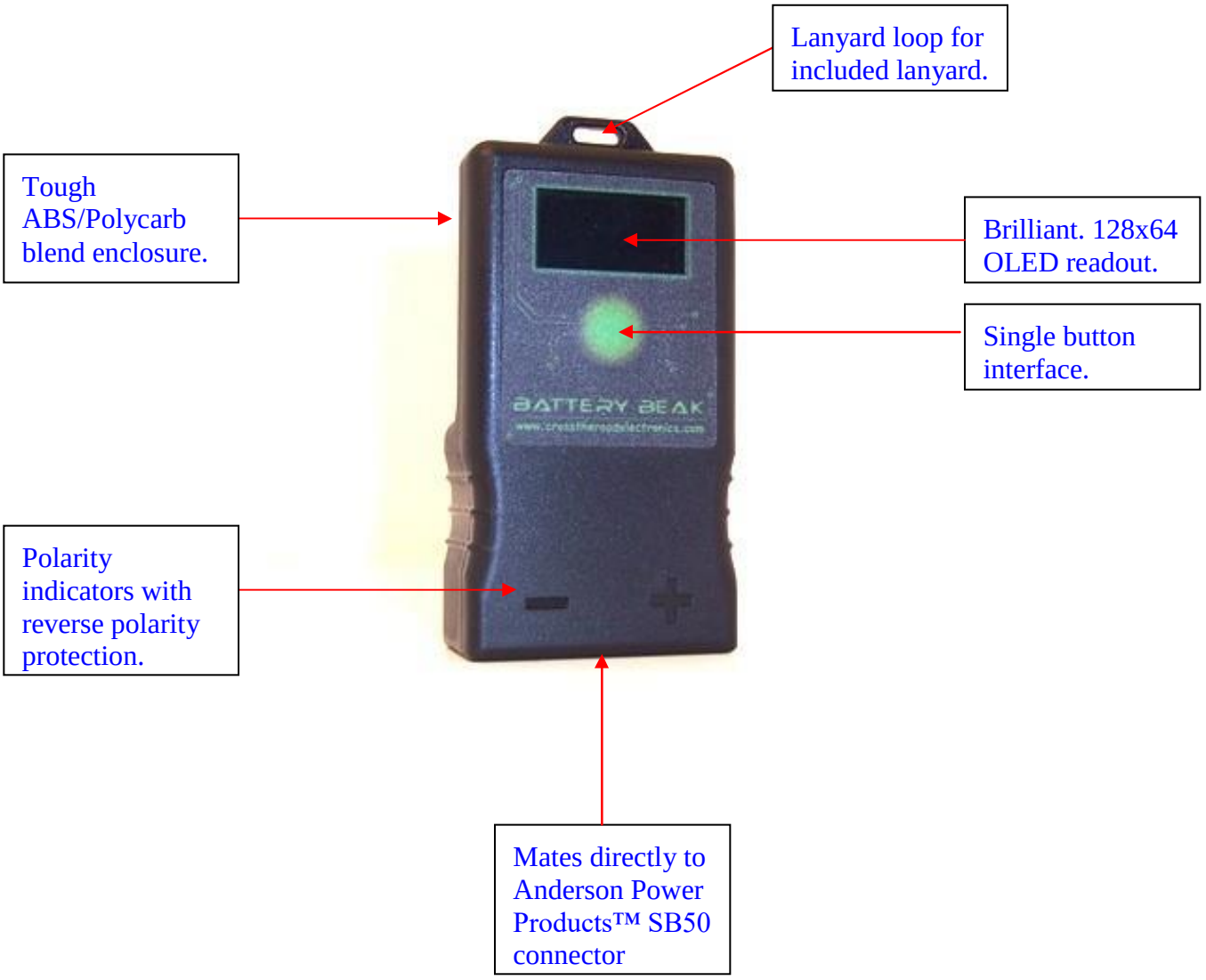
Device Overview



1) What is a Battery Beak?

A Battery Beak is a battery load tester that can be used to determine state of charge, battery internal resistance, and overall battery quality of both NIMH and Lead Acid type batteries. The Beak may also be used to measure circuit impedance and help find poor connections in high power DC applications.

2) Features

- User selectable Chemistry, Voltage and Ampere-hour settings
- Powered from test battery power so no need for additional batteries
- Low current consumption (< 25mA) with auto disconnect feature.
- Applies up to an 18 Ampere load.
- Provides open load voltage, load voltages, state of charge, and internal resistance in seconds.
- Crisp organic LED display.
- Rugged ABS/polycarbonate blend enclosure.
- +-15 mV and +-1 mΩ resolution.
- Tests Batteries up to 15 volts DC

3) How does the battery Beak work?

SOC -The Battery Beak calculates battery State of Charge, or SOC, based on the no-load voltage of the battery in test. This voltage is measured at the beginning of every test prior to applying any load and is expressed in percentage. The SOC value is capped at 130%.

Internal Resistance - Internal resistance (Rint) is calculated using the $\Delta V/\Delta I$ method. Two different loads are applied depending on battery chemistry selected, the voltages are measured at each load. Rint is calculated by dividing the difference in voltage by the difference in current.

Status - The battery status is calculated using the results from the Rint calculation. A set of predefined ranges are used to determine if the battery is “Good”, “Fair”, or “Bad”. The predefined ranges are dependent on battery Chemistry, Voltage and Ah rating.

Auto Disconnect Feature – While the Battery Beak is powered it draws very little current (<25 mA). However, a feature has been added that powers down the device and removes it from the battery 1 minute after the last button press. This feature allows the Beak to be left connected to a battery for long periods of time without discharging it.

4) How to use the Battery Beak

To use the Beak, you must know some information regarding your battery, the three things you must know are; Chemistry, Voltage and Amp hour rating. The Beak comes preconfigured with the following settings.

Chemistry: Lead Acid
Voltage: 12 Volt
Amp-hour: 17 Ah

Table 1 shows the possible settings for Voltage and Amp Hour for each supported Chemistry.

Chemistry	7.2 Volts	9.6 Volts	12 Volts	2 Ah	3 Ah	5 Ah	10 Ah	17 Ah
Lead Acid			X	X		X	X	X
NIMH	X	X	X	X	X			

Table 1.
*X = supported

Connecting the Beak

Once you know your batteries values you will next need to ensure that your battery is equipped with an Anderson SB50 connector or you have an appropriate adaptor to connect the Beak to your battery. The Battery Beak is protected against reverse polarity so if you choose to make your own adaptor and the Beak will not power-up check to ensure the polarity is correct.

Powering the Beak

Once the battery is connected the Beak must be powered, do this by pressing the green button located just below the display window. Once the Beak is powered a splash screen will appear as shown below.

Once the screen appears the button should be released. The Beak is now powered and ready to be configured for testing. If you are testing 12-volt lead acid batteries that have an Amp hour rating of 17 – 20 Ah, there is no need to enter the “BATTERY TYPE MENU”, simply press and release the button and the test will begin with test results appearing within 1 second.

Using the Battery Type Menu

The battery type menu is used to configure the Beak to accurately determine SOC and battery status for any supported battery type. Settings are categorized based on chemistry, that is the Ah and voltage values are specific to each chemistry. Changing the value for

'Amp Hour' for NIMH will not affect the 'Amp Hour' setting for Lead Acid.

The Battery Type Menu can only be entered from the splash screen. To enter the Menu from the splash screen simply press and hold the button for three seconds. Once the menu has been entered the screen should appear as shown below. Note the values shown for CHEMISTRY, VOLTAGE, and AMPHOUR may be different than shown below.

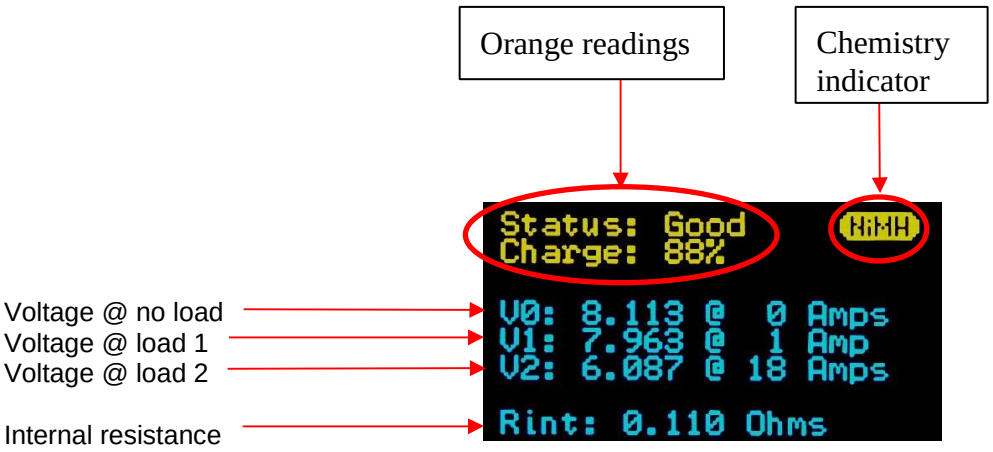
To scroll through the menu options simply press and release the button to advance the cursor down. To select an option, move the cursor to the desired setting then press and hold the button for one second and a submenu will be entered. IMPORTANT – settings are saved upon exit of the 'Battery Type Menu'. To exit, move the cursor to 'EXIT' then press and hold for 1 second. Exiting from a submenu will take you to back to the 'Battery Type Menu'. Exiting from the 'Battery Type Menu' will return to the Splash Screen. All settings are retained after saving even after a power down or removal of the device.

Testing

Before performing a test make sure the battery has been fully charged and properly rested to reduce surface charge and you have the Beak configured properly. If you are only interested in the SOC or are not sure if the battery has been charged you may perform a test to determine SOC. To perform the test simply press and release the green button from the Battery Beak splash screen.

Interpreting the results

The test results page will display several readings. These readings are broken down into two colors orange and blue. The orange readings are located on the top two rows of the display and contain the 'Status:' and 'Charge:' results. The orange results are used to quickly determine the health and SOC of the battery and for users who are not concerned with the actual numbers measured. The blue text contains all the information used to determine the 'Status" and 'Charge' and may be used by more advanced users to make their own determinations about battery health or when measuring a circuits resistance. Below is a screen shot from the test view.



After the test is complete a second test may be performed after 5 seconds, this 5 second wait is to prevent the Beak's internal components from overheating. You may repeat the test as many times as desired. The Battery Beak will auto shutdown after 1 minute of inactivity. During Auto shutdown, the Battery Beak consumes no current and may be left attached to the battery.

Status

The Status field provides a value of ‘Good’, ‘Fair’, ‘Bad’ or ‘Charge Battery’ and is determined by the internal resistance measurement. The result is determined by comparing the internal resistance to a set of predefined values and is dependent upon selected Chemistry and Amp Hour rating. If the value for Charge is 10% or less the Status Field will read “Charge Battery”. Any test that results in a Status of ‘Bad’ or ‘Charge Battery” should be performed a second time after recharging the battery. If the value for ‘Status’ still reads ‘Bad’ the battery should be taken out of service. A value of ‘Fair” means that the battery’s internal resistance is higher than normal, the battery should only be used in non-critical applications such as a practice match or while testing and debugging.

Charge

The Charge field provides a value in percentage of the battery’s state of charge. The value has a range of 0 -130%. It is up to the user to determine an acceptable state of charge. It is possible to have an acceptable value for ‘Charge’ and a ‘Status’ of Bad. In general, a Charge of >= 110% for lead acid and >= 90% for NIMH is acceptable for competition use. It is important to note that good battery may have a Charge of 20% and a Status of Good. This simply means the battery needs to be charged.

5) Additional applications

Find bad connections

Testing Batteries is not the only application for the Battery Beak. The Beak can be used to measure a circuit's resistance and help find poor connections. Placing the Battery Beak in place of a motor or speed controller will measure the impedance of all connections and wires leading to your motor or motor controller. This technique can be used to find a bad crimp, solder joint or circuit breaker.

Other non-supported batteries and chemistries

Batteries that are not supported by the Status field may also be measured. If you know what the manufacturer specified internal resistance is for a battery you can use the Battery Beak to assess the health of your battery. Typically, an increase of internal resistance of 50% or higher indicates a faulty battery.

6) Why is internal resistance important?

An ideal battery has an internal resistance of zero ohms, in reality the internal resistance of a battery is never zero. The higher the internal resistance of a battery the lower the output voltage is for a given load. A batteries internal resistance is in series with any load applied to it thus limiting the current that may be supplied by the battery. As a battery ages its internal resistance typically increases, this increase leads to increased heat and power loss seen by the battery, robbing your system of performance.

Many batteries such as 12V lead acid batteries are comprised of multiple cells in series, occasionally a cell or two will fail resulting in normal output voltage under no load conditions but increased internal resistance. This change in internal resistance can be measured using the Battery Beak.

Let's use Ohms law to show an example of how internal resistance plays a role in battery performance. Ohms law; V = I*R or the voltage across a conductor is equal to the current through the conductor times the conductor's resistance.

Example:

I = 100 amps
R = .02 ohms

*V = I*R = (100 * .02) = 2 volts*

Let's apply this to a battery's internal resistance. If a battery has an internal resistance of 20 milliohms, that 20 milliohms is in series to any load that the battery is driving. Figure 1 illustrates how battery internal resistance affects load voltage and power.

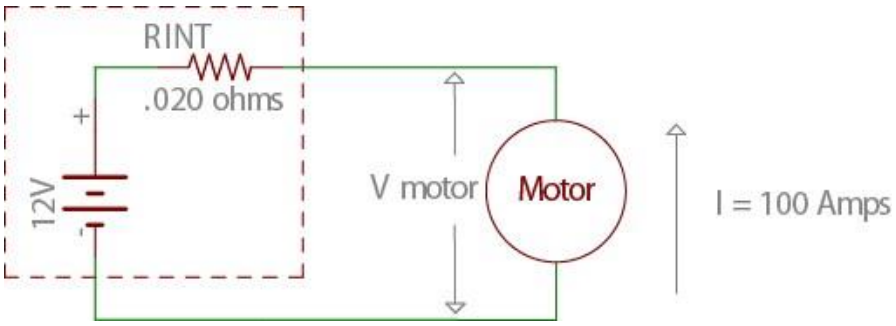


Figure 1.

Vbat	*= 12Volts*
Rint	*= .020 Ohms*
V motor	*= Vbat – (I x .Rint)*
	= 12 – (100 X .020)
	= 10 Volts

The power loss caused by the battery's internal resistance can be calculated using the equation below.

P loss = I2R
= (100 x 100).020
= 200 Watts

As you can see by the above example, as a battery's internal resistance increases so does the amount of power loss. Ever wonder why your battery gets hot after heavy sustained loads? That's why.

7) Tips for testing Batteries

Each battery Chemistries has unique attributes that can make testing them a challenge. One of those attributes is called surface charge. While surface charge is present in all battery chemistries its effects are most noticeable with lead acid types. This section is not intended to be a "White Paper" on surface charge only to inform users of behavior that can affect voltage readings. Other things that can affect test results are; poor connection or battery cabling, poor connection between the Beak and the battery being tested. Before testing always ensure that your connections are good and clean.

What is surface charge?

Surface charge is exactly what it sounds like, charge that resides on the surface of the lead plates inside of a lead acid battery. Surface charge is the result of charging the battery and is unavoidable; however, the effects of surface charge can be reduced. When a lead acid battery is charged/discharged a chemical reaction is occurring. When charging a dead battery, the plates inside contain lead sulfate that needs to be converted into lead and lead dioxide. Initially this reaction occurs at the surface of the plates, it takes time for the reaction to penetrate deep inside the plates. The rate at which you charge the battery is limited by the time needed for this chemical reaction occur. This chemical reaction continues after the battery is removed from the charger until the charge has penetrated the plates. The slower the battery is charged the less surface charge will occur.

How does this affect my readings?

Surface charge can cause a partially charged battery to measure a voltage that indicates full. Some schools of thought claim that this surface charge needs to be "bled off" before any reliable readings can be made, this is an incorrect approach since surface charge is simply charge that has not made it to the inside of the plates, bleeding it off would be wasting perfectly good charge. A simpler and more effective approach would be to allow the battery to "rest" for a period of time after charging and to charge the battery at a somewhat "slow rate". A good rule of thumb is to charge the battery at a rate ¼ of its Ah rating. So for a 20 Ah battery that would be 5 amps.

Unlike NIMH batteries lead acid batteries do not self-discharge so the drop in "State of Charge" after removing the battery from the charger is a result of surface charge working its way deeper into the plates. Even if you ignore the effects of surface charge it usually only accounts for about 10% of the actual charge of the battery.

Monitoring for change over time

Monitoring a batteries internal resistance over time is an effective method in monitoring battery aging. An initial reading should be measured when the battery is first put into service. Subsequent readings can be taken at regular intervals to look for increases in internal resistance that may indicate a weakening battery.

What does all this mean?

For the most accurate Charge readings charge your batteries slow and let them rest for about 15 minutes after charging. The effects of surface charge should have little impact on the results provided by the Battery Beak when used in FRC since the charge rate is limited to 6 amps.

8) Revision History

Revision 1.1 – Typo and grammar corrections.
Logo updated.
Bookmarks added.

Revision 1.0 – Initial Release.