BACS®

BACS® - Battery Analysis & Care System

3rd Generation Battery Management System

- BACS is a monitoring, balancing & alarm system for batteries
- BACS allows the user to prevent unnoticed or unexpected battery failures
- BACS extends battery life and helps to preserve the reliability of UPS systems

GENEREX's 3rd generation BACS® (**B**attery **A**nalysis & **C**are **S**ystem) is the most advanced product of its kind on the market today. An ethernet integrated battery monitoring and management system, BACS® uses web management technology to monitor the temperature, internal resistance, and voltage of every single battery in a given system.
Through our patented balancing process—called **Equalization**[1] in Europe and **Balancing** elsewhere—BACS® calibrates the charging voltage of all batteries with the charger's target value, keeping all batteries within optimal voltage operating range.

The constant monitoring and harmonization of the individual charging voltages of batteries helps to guarantee the availability of the battery at all times, making the Achilles' heel of any UPS system—or any other battery powered device—a thing of the past!

What's more, BACS® has the capacity to manage environmental measurements (temperature, humidity, acid fill level, hydrogen gas concentration, etc.) and appliances (UPS, inverters, transfer switches, generators, dry contacts, air conditioning systems, etc.).

BACS® is the ideal system for lead-acid batteries (open/wet cell, maintenance free, gel, AGM, etc.), as well as NiCad, NIMH and most types of Li-Ion batteries.

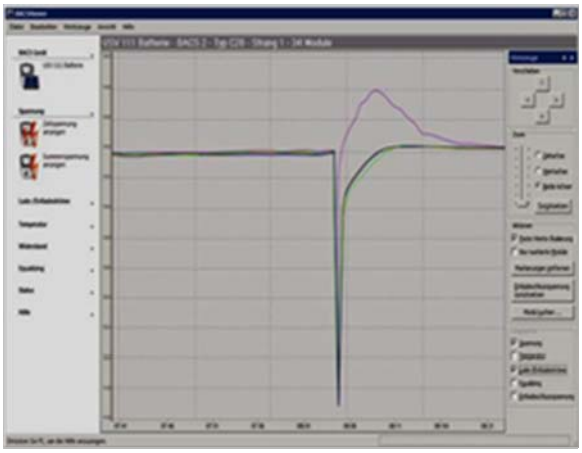
1—Note: The term GENEREX uses in Europe (equalizing) should not be confused with the process of overcharging from wet-cells. As pertains to BACS, the term 'Equalizing' (like the term 'Balancing') refers to the process of harmonizing the voltages of cells with the charger's target voltage.

TEL +49(40)22692910 - EMAIL generex@generex.de - WEB www.generex.de (This and all other product datasheets are available for download.)

BACS features at a glance

- **REGULATE CHARGING**

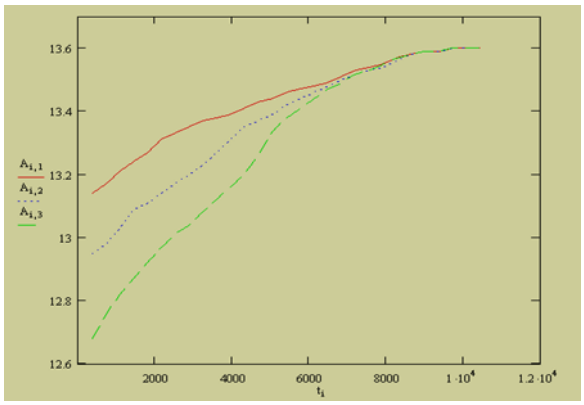
BACS® is designed to monitor and optimize lead-acid and other battery types in a given battery sytem.



Free BACS® viewer software shows the Equalization (Balancing) of a battery (the bold violet line in the graphic) within a string of 32 batteries during a discharge/recharging process. BACS® Equalization (Balancing) prevents the overcharging of the violet battery, while the batteries around it continue to charge.

- **INDIVIDUAL VOLTAGE REGULATION**

By means of a patented process called **Equalization** (or **Balancing**), BACS® regulates the voltage supply from the charger or UPS for every battery. This process serves to calibrate the batteries and results optimal capacity and improved lifespan.



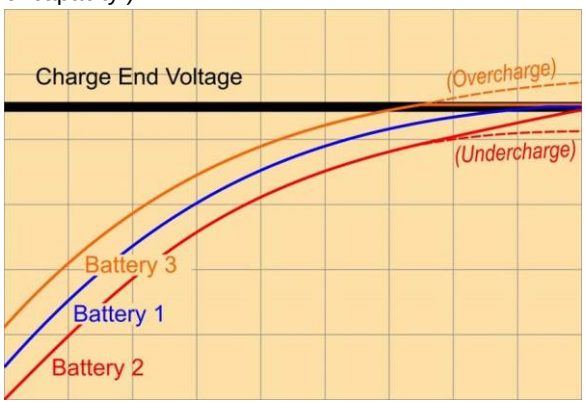
Oscilloscope graph of battery voltages during the Equalizing (Balancing) process: The voltages of the 3 batteries behave differently given the regulating influence of the BACS® modules. The ideal harmonic charging curve will be achieved for every battery in the string.

- **AVOID OVERCHARGING**

The Equalization (Balancing) process prevents the unintended overcharging of batteries. (By preventing overcharging, BACS® helps to limit gassing, dry-out, and thermal runaway.)

- **AVOID UNDERCHARGING**

The Equalization (Balancing) process also prevents unintended undercharging. (By preventing undercharging, BACS® helps to limit sulfation and loss of capacity.)



The charging of accumulators according to BACS® patented equalization process. The charging of Battery 3 is capped to prevent overcharging and gassing. Supply of charging energy to Battery 2 is continued and boosted until the target charging voltage is obtained. Battery 1 performs ideally and is not regulated.

- **DETECT IMMINENT BATTERY ISSUES**

Typical battery problems like sulfation, corrosion, gassing, dry-out, thermal runaway are detectable given proper monitoring. (Changes in impedance and temperature— which are monitored by BACS®—tend to indicate the onset of such issues.)

- **AVOID SULFATION**

Sulfation is often a problem for UPS batteries given that they are consistently held at a float charge level or subject to a charging principle that leaves them uncharged for long periods of time. Without proper regulation, there is no guaranteeing that all batteries have been fully charged when the UPS charge switches from boost to float charging. Often enough, when this takes place, some batteries are overcharged, while others remain incompletely charged. The Equalization (Balancing) process retards sulfation by maintaining ALL batteries at a balanced voltage level and keep them at the ideal SOC— and, thus, in the ideal SOH (State of Health).

- **DETECT STRATIFICATION**

By catching increases in impedance and drifting voltages, BACS® allows the user to detect battery stratification. From time to time, in order to reverse stratification, a battery's acid-gel-water mix requires rectification. It is by rectifying the mix that the ill-effects of stratification are managed. By verifying lower impedance and improved Equalizing (Balancing) performance, BACS® confirms for the user the benefits of the rectifying process.

- **PROTECT BATTERIES**

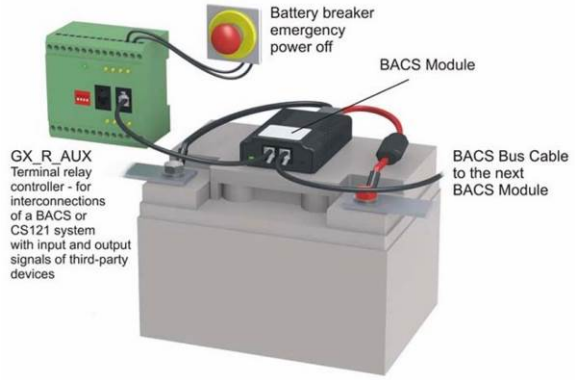
By balancing the voltages of a system's batteries, BACS® prevents damage caused to batteries by neighbors in the system. Thus, a new battery can be swapped into a string of older ones without risk of overcharge, making full swaps unnecessary.

- **ADVANCE WARNING SYSTEM**

Because it monitors key battery parameters and set thresholds, BACS® is able to provide advance warning—via audio, video, and network messages—of system events that require attention.

- **PREVENT THERMAL RUNAWAYS**

By means of an embedded dry contact output, the BACS® system is capable of tripping the battery breaker in the event of thermal runaway. Automatic stringwise battery disconnection is possible, given the presence of a GX_R_AUX relay, which trips the battery breaker when user defined parameters are met.



The GX_R_AUX module provides 4 relay contacts and 4 digital inputs. It controls up to 4 breakers. The digital inputs read the battery breaker status and display it in the BACS® web interface. Other alarm devices (for example, audio alarms) may be connected to the outputs or digital inputs of the GX_R_AUX.

- **INCREASE BATTERY CAPACITY**

BACS® guarantees, through Equalization (Balancing), a full charge level and the optimal functioning of the battery system.

- **BATTERY REPLACEMENT NEEDED**

By monitoring impedance trends, BACS® allows the user to detect weak or damaged batteries in early stages of deterioration. Timely replacement of bad batteries is vital to improving the lifespan of the battery system as a whole.

- **EXTENSION OF SERVICE LIFE BY > 30%**

The service life of a string of batteries depends on the weakest cell of the weakest battery in the string. Typically, in a UPS, the service life of such a string is 50-60% of what is called for by manufacturing designs. By virtue of the Equalizing (Balancing) process, each of the batteries within the string is maintained at optimal voltage levels, eliminating the ill-effects of improper charging. **The constant care provided for by the Equalizing (Balancing) process has been shown to increase service life of batteries by more than 30%!** And, given the virtues of the Equalizing (Balancing) process, we aspire to improve on this. (Test results from 2004 have demonstrated that an increase of 50% in not unrealistic. Two BACS® regulated systems in our labs have been running on the same batteries for 10 years—two years longer than the time frame stipulated by manufacturing specs. These systems are still running.) BACS® proves it is possible to meet—and even greatly exceed—service lives called for by manufacturers.

- **ALERT SYSTEM**

BACS® monitors UPS system data and environmental parameters (temperature, humidity, hydrogen gas concentration, acid fill level, DC current, dry contacts, etc.). Alerts can be set up, and this information can be accessed via multiple communication systems.

Here, a BACS® web server displays the battery status of 140 batteries. Actual impedance, temperature, and voltage of every cell is displayed and stored. Status LEDs show a change of color if any battery drifts beyond thresholds.

- **MAINTENANCE**

BACS® improves the service quality by providing remote monitoring through Internet, VPN, or any network that allows for the downloading of real time data and battery history. It is now possible to test batteries without going to the trouble of disconnecting them from the system. Maintenance and testing take place under real operating conditions and require no downtime!

- **UPS/SNMP & MODBUS MANAGER**

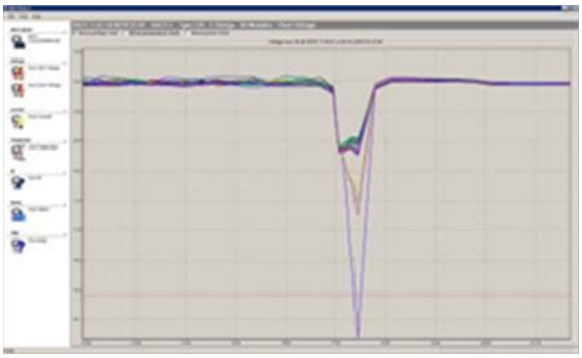
BACS® includes a full qualified UPS/SNMP and MODBUS manager, one that is compatible with any UPS presently on the market! Among BMS systems on the market, this function is unique.

- **MODBUS/PROFIBUS/LONBUS/SNMP**

BACS® allows MODBUS clients to read the system data through IP and RS232 (and optionally RS485), as well as through SNMP. Conversion to PROFBIS and LONBUS is possible through optional converters.

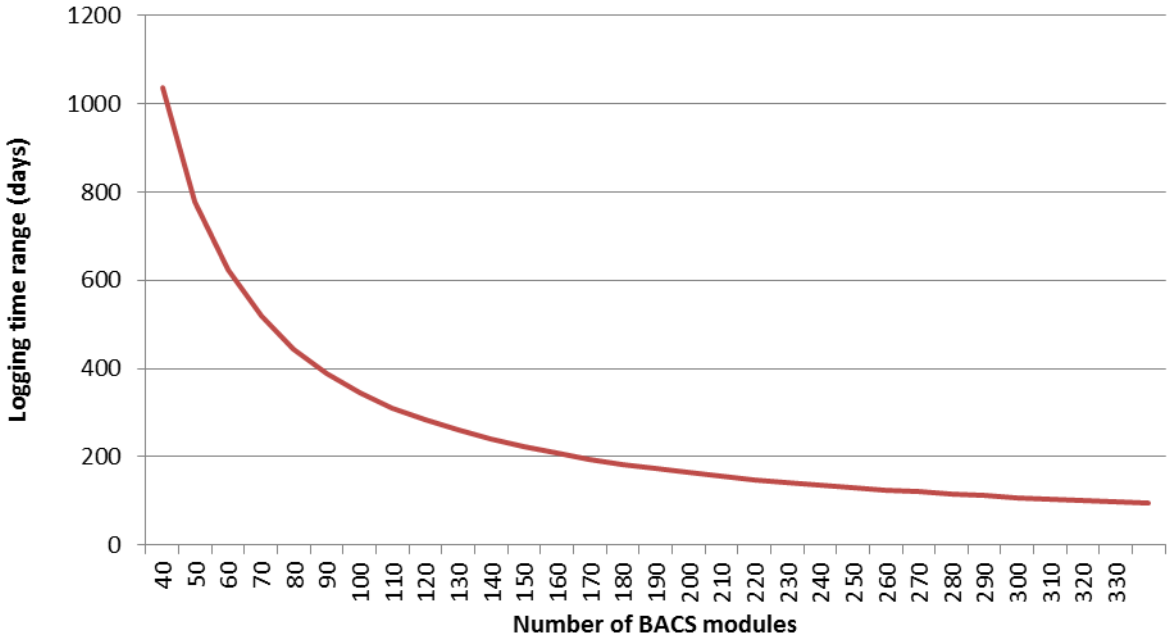
- **FREE VIEWER ANALYSIS SOFTWARE**

Provides graphical BACS® data analysis and reports!



Discharge process displayed through BACS® Viewer software shows the voltage drop of several batteries during a discharge, unnoticed by the UPS. In a later stage, these accumulators would cause the complete system to collapse! BACS® corrects this problem and attempts to fully recharge this specific battery.

Flash ROM capacity for battery history depending on no. of BACS® modules in the system



No. Of BACS Modules	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330
Log range in flash ROM (in days)	3112	1556	1037	778	622	519	445	389	346	311	283	259	239	222	207	195	183	173	164	156	148	141	135	130	124	120	115	111	107	104	100	97	94

In this graphic, we see the data capacity of the BACS® WEB-MANAGER flash rom during float charging operation. By default, battery data is autosaved every 20 minutes. After a discharge—or any other significant event—the autosave interval is greatly reduced. This increases the amount of data saved on the flash rom, but provides very precise data for analysis. (The user may access this data through the BACS® VIEWER.) The number of BACS® modules and the number of discharges determine the available capacity. The table above shows the number of days of battery history that can be stored on the flash rom during normal system operation (i.e. assuming no significant event has occurred). This data may be transferred to other storage systems on the network. Older files get overwritten once capacity is reached, and only the latest battery data is retained on the flash rom. We recommend downloading and saving battery history on a regular basis. (This also can be done via the BACS® VIEWER.)

BACS Description

The reliability of a battery based power supply can only be guaranteed if every battery in it is able to perform at an optimal level 100% of the time!

BACS® battery modules are capable of taking precise measurements of a battery's internal resistance, temperature, and voltage. These measurements are essential to making precise analyses of the batteries in any given system. BACS® transfers this data through a bus system to the BACS® WEB-MANAGER. The WEB-MANAGER handles events involving the UPS, inverters, environmental sensors, transfer switches, generators, dry contacts, and other devices.

The BACS® WEB-MANAGER acts as the battery system's central control unit. It gathers, evaluates, and (on its internal flash memory) stores all pertinent system information. The user is provided access to three web server pages. One displays the actual status of batteries; a second shows actual UPS data; the third shows environmental data and alarm contacts status. The web browser interface of the system is designed for easy configuration. It provides the user with access to all system values and events. A flexible programming interface known as the EVENT MANAGER coordinates a system response to significant events (alarms, notifications, etc.).

The BACS® WEB-MANAGER reads individual battery voltages and compares them to the battery system's target voltage. The latter value (the target voltage) is sent to each BACS® module, which steers voltage levels of the batteries under its control if they happen to deviate from the target. This is the process we call equalization (or balancing). By virtue of it, the voltages of all batteries in a given system can be calibrated to within 0.01 volts of that system's target voltage.

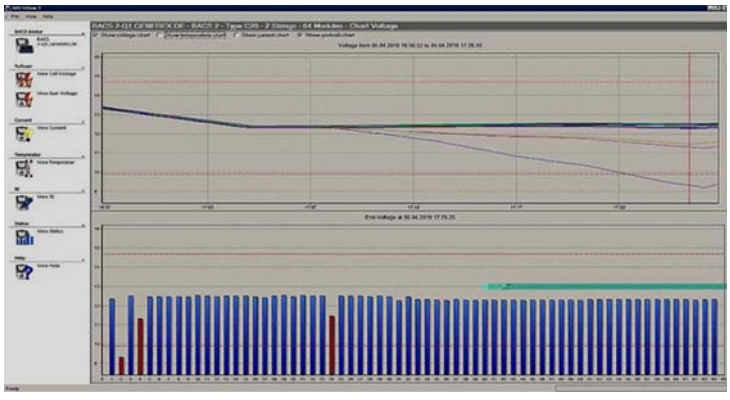
BACS® effectively mitigates the possibility of overcharging batteries. In this way, it helps to prevent gassing and drying. It also mitigates the possibility of undercharging. Thus, it helps to prevent sulfation. Through Equalization (Balancing), system batteries are kept at an optimal charging voltage, and, therefore, in an optimal SOH (State of Health).

By managing a battery system's charging voltages, BACS® vastly improves its durability and reliability.

BACS® has the ability to send out "advance warning" alarms via email, email-to-SMS, network message, SNMP, RCCMD, MODBUS, and, optionally, PROFIBUS, LONBUS, and GSM. (Alarm parameters can be configured by the user to match battery type.) For instance, discovering rising internal resistance in an battery—an indicator of corrosion or sulfation—BACS® triggers an alarm. (Sulfation, when caught in time, can be reversed by means of a series of charging and discharging cycles.) Given early warning of the issues that such a rise indicates, the user is able to investigate and take action far in advance of the consequences that can result from them. And the effects of corrective actions taken are immediately observable. In addition to internal resistance, BACS® monitors voltage, temperature, the Equalizing (Balancing) process, the system's charging/discharging cycles, and, optionally, current. When preset thresholds pertaining to any of these categories are crossed, an alarm is communicated.

In addition to sending network alarms, BACS® also warns users via acoustical and visual signals (a buzzer on the BACS® MANAGER and alarm LEDs on the module and BACS® MANAGER).

The BACS® WEB-MANAGER is equipped with flash memory or SD memory cards. Depending on the size of the battery system, it can log anywhere from 6 months' to 3 years' worth of system data. Using the BACS® VIEWER software, data can be downloaded and archived, freeing up storage capacity for further data logging. The alarms of any device connected to the BACS® WEB-MANAGER (for example, a UPS) are logged in various files on the device and at remote interfaces. The BACS® WEB-MANAGER is equipped with a real-time clock, which is automatically synchronized with a network time server (SNTP). The WEB-MANAGER applies precise data and time stamps to all log files.



BACS® VIEWER shows the individual battery voltage of all accumulators at the end of a discharge. The red dotted line shows the voltages when power has returned. The lower bar graph indicates those accumulators that have collapsed early and have been discharged to a very low level. These batteries are a risk to the entire system.

Batteries in UPS applications

In a typical UPS battery installation, one tends to find large numbers of batteries connected in series, this, in order to produce a high string voltage. Modern UPS systems, augmented with IGBT rectifiers, work very efficiently, but require a high string voltage compared to older systems. This increased need means an increase in the number of batteries one might find in any given string. (With larger strings, it's not unusual to see voltages of 800V or higher.) At the same time, in data centers, space is an increasingly precious commodity. Managers will often choose space saving Valve Regulate Lead Acid (VRLA) batteries over their Flooded Lead Acid (FLA) counterparts. Where VRLA batteries are smaller, they run hotter—and therefore tend to gas and dry out—often resulting in a shortened lifespan.

EARLY REPLACEMENT, REDUNDANCY…

More batteries in a string… this means higher voltage, but it also means more cables, more connectors, greater impedance, and significant voltage drop. The net effect of this is to create charging issues. (2V fluctuations from battery to battery in such a string are not unusual.) And these issues worsen over time. Over time, discrepancies of no more than a few tenths of a volt grow incrementally. It becomes increasingly difficult to maintain a float voltage of 13.6V on any given battery.

All batteries are not created equal. This is a truism. So, it stands to reason that, given a long string, providing individual batteries and cells with precisely the float voltage required to prevent charging issues is an inherently problematic task. Thus, for years, it has been commonly accepted in the UPS industry that such issues and the ill-effects they bring about (sulfation, drying out, shorter and shorter battery life, etc.) were unavoidable. Lacking a technical solution, rather than focusing on the problem, UPS makers have simply recommended replacing batteries earlier than their expected lifetime. Users wanting to avoid the risk of UPS failure have simply had to accept replacing batteries at 50-60% of the lifetimes specified by manufacturing designs.

Naturally, UPS users have never been satisfied with this solution. Changing batteries more often does not completely mitigate the risk of UPS failure. New batteries have been known to fail without warning. And no high voltage UPS can tolerate missing batteries. Entire systems may collapse given a single point of failure.

So, UPS makers have offered another solution: redundancy. Redundant UPS systems feature two or more strings of batteries. This reduces the risk of UPS failure, but has several disadvantages: increased cost, increased space requirements, increased service costs. And it is still no guarantee. The user has no idea what is going on in any given battery string at any given time. The reduction in risk accomplished by adding more strings is only theoretical.

To counteract the risk of unnoticed battery failures and loss of backup, UPS users began installing automatic transfer switches to redundant UPS systems and using emergency generators as a backup in case of power failure. This is both an extremely costly solution and one that involves a further risk. Emergency generators on standby require at least a ten second startup time—time enough to lose data in the event of battery failure. The generator's starter battery is still another risk factor. **The battery remains the Achilles' heel of any backup system known to man!**

BATTERY MANAGEMENT SYSTEMS

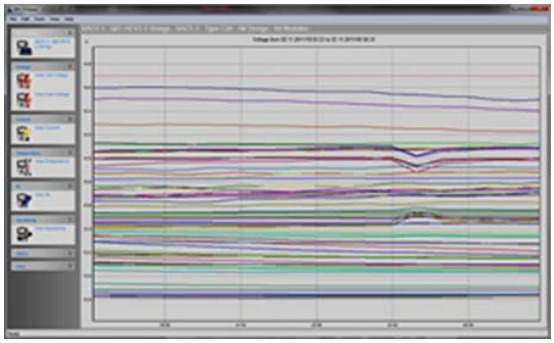
In light of this fact, the Battery Management System (BMS) has become fashionable.

It is out position a complete Battery Management System should not only detect imminent battery failure, it should 1) tell the user why batteries are failing, and 2) provide a reliable Advance Warning System, and 3) initiate actions to counteract battery issues. In a word, a good BMS should not only monitor but regulate.

By virtue of its patented Equalization (Balancing) process, BACS® is the only BMS on the market that does both: monitor and regulate!

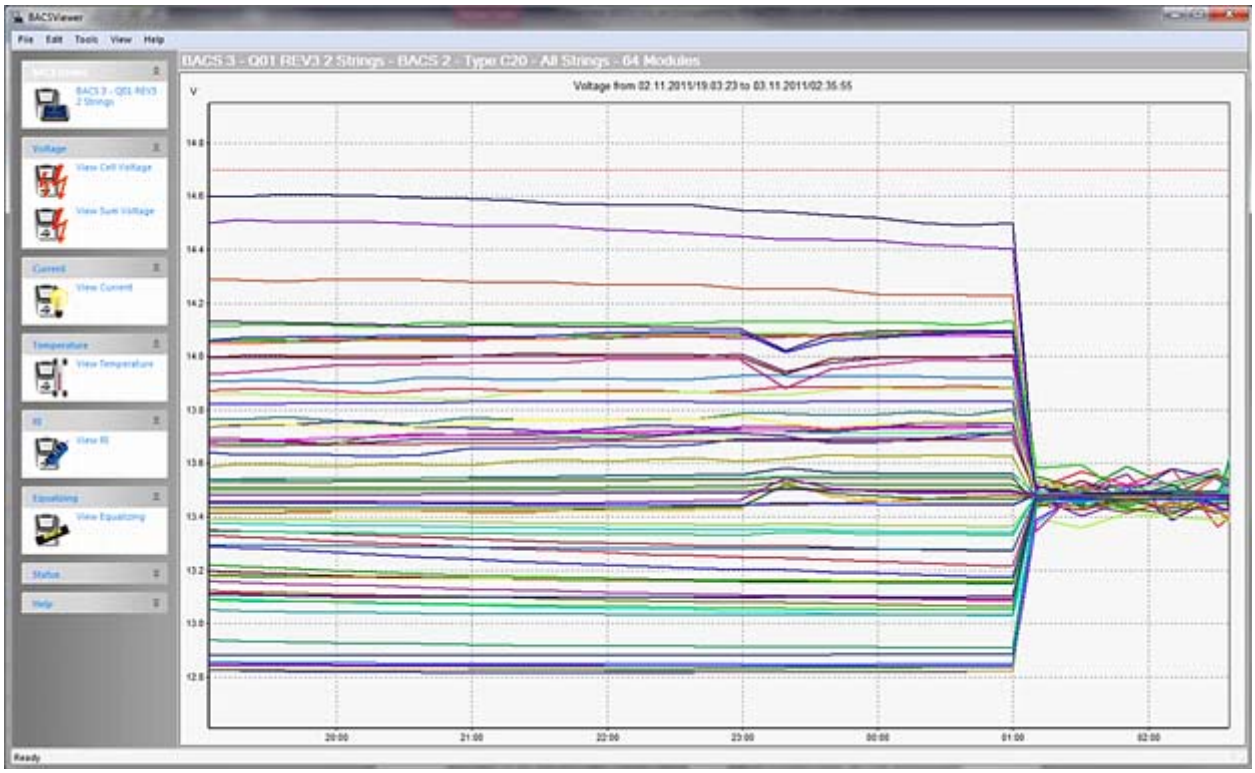
The graphic below shows the battery history in a UPS that might be found in any data center today. It is five years old; the float voltages of the batteries in the string it contains vary within a window of +/- 1.8V. (That's a large window!) During the period of time described in this readout, this UPS system was not managed by BACS®.

Typically, given the peculiarities of its batteries—without correction—the voltages in such a system will tend to be different. The longer such differences remain uncorrected, the more the voltage patterns start drifting. There comes a point at which these patterns begin to show a significant difference (1 volt or more). That is what we see in the screenshot right.



BACS® VIEWER SCREENSHOT
As seen by BACS®, after 5 years of operation, a UPS with 64 12V batteries presents voltage patterns that vary widely (a window of +/-1.8V).

On the lower picture, we see quite a different screenshot…



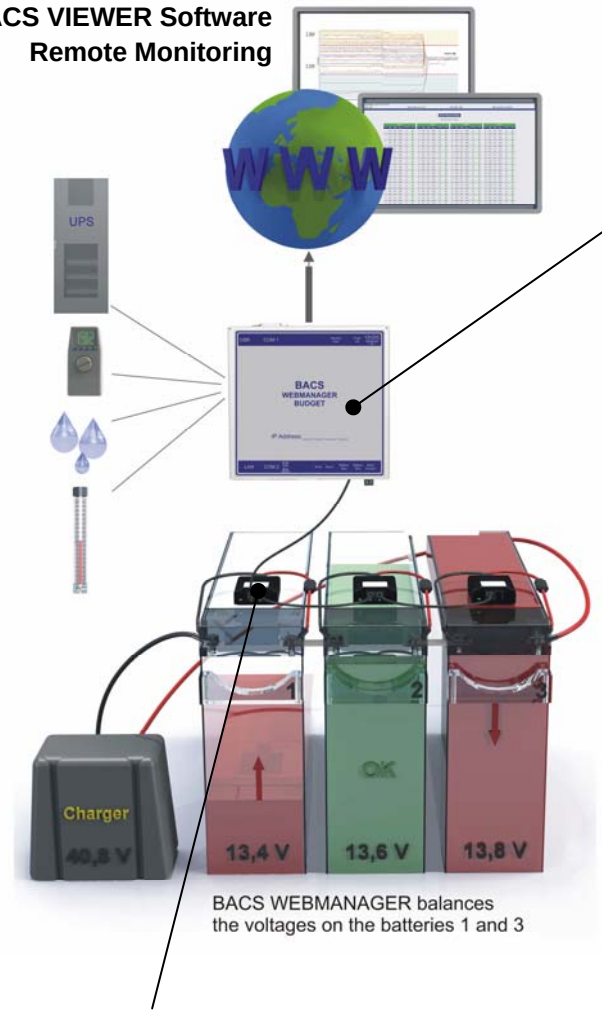
BACS® VIEWER SCREENSHOT
As seen by BACS®, **the same 5 year old system** as shown in the previous graphic, this time, after the application of the patented Equalization (Balancing) process. Within a few hours, this process brings the variance in float voltage to within 1/100th of a volt of the level recommended by the manufacturer.

Applying the patented Equalization (Balancing) process used by BACS® to this same system, note that we are able to eliminate virtually all of the variance in float voltage. The Equalization (Balancing) process brings the float voltage of **all** batteries in the string to within +/- 1/100th of a Volt, this despite such factors as connections, location within the string, and so on and so forth. BACS® **keeps** each of the batteries at full change and at the float voltage recommended by the manufacturer.

A general description about the principle of equalization and an explanation of the reasons it extends battery life drastically and extends cycle life by at least a factor of 3 is scientifically is explained in the INTELEC Paper 32.1 "Life Extension through charge Equalization of Lead-Acid Batteries" by Philip T. Krein, Member of IEEE.
The BACS® patent has been established based on scientific principles and investigations conducted by GENEREX from 2002-2004.

BACS® System Components

BACS VIEWER Software
Remote Monitoring



BACS® WEB-MANAGER

1 external and 1 UPS slot version

Management of up to 330 BACS® C modules in up to 10 parallel strings.

Includes a full qualified UPS-SNMP & MODBUS manager at COM 1 for the monitoring of a UPS/inverters/rectifiers or other devices with a serial interface.

COM 2 for optional environmental sensors (e.g. temperature, humidity, current, acid fill level, etc.).

1 programmable alarm relay output, 1 alarm-LED, 1 alarm buzzer, mute button.

Integrated web server for status display configuration of all alarm thresholds (battery impedance, voltage, temperature, UPS alarms, environmental alarms, etc. network messaging system (email, SMS, SNMP, RCCMD, MODBUS and (optional) PROFIBUS, LONBUS, BACnet.

Data logger for all measuring data, (optional) current sensors for charge- and discharge current measuring.

Compatible to UNMS monitoring software and LED matrix remote display.

Integrated DIN rail mounting on all external manager types.

BACS® C MODULE & CABLE

A diagram of a BACS® module installation:

A calibrated measuring cable with 2 high-voltage fuses connected to the positive and the negative Battery poles uses a 4-string wire for measuring the individual battery data.

The BACS® module measures through an integrated sensor the surface temperature of the accumulator, the voltage and the impedance.

The BACS® module is available in 5 different types: 16Volt, 12Volt, 6Volt, 2Volt and for NiCad, NiMH and Lithium Ion batteries with a wide range of 1.2 V-3Volt.

At Equalization (Balancing) mode, the thermal energy is transferred through the cooling fins to the environment, until the process has finished.

The status is shown at an LED on the front panel.

Simple installation or retro-fitting through Velcro tapes and bus cables.