● Monitoring, individual charging/discharging & alarm system for batteries
● Avoid unnoticed or unexpected battery failures, extending the battery lifespan and preserving the reliability of the complete system

The patented BACS „Battery Analysis & Conditioning System“ now the 3rd generation is the most advanced product on the market today providing an Ethernet-network integrated battery monitoring and management system. Using web-management technology it checks the internal resistance, the temperature and the voltage of every single Battery sequentially.

Through our patented CONDITIONING process it corrects the charging voltage of each Battery individually. The Battery are kept in the optimal voltage operating range.

The constant monitoring and controlling of the individual charging voltages for each Battery guarantees the availability of the battery at all times – making the Achilles Heel of a UPS systems (or any other battery powered device) a thing of the past!

In addition, it can manage environmental measurements (temperature, humidity, acid fill level, hydrogen gas concentration, etc.) and appliances (UPS, inverters and other devices).

BACS is the ideal system for all lead-acid based Battery (open/wet cells, maintenance free, gel, AGM), etc.

Charging process of Battery with BACS® patented Conditioning – the charging of battery 3 is capped to prevent overcharging that could cause 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.

Discharge process displayed via the BACS VIEWER software shows the voltage drop of several batteries during a discharge, unnoticed by the UPS. In a later stage these Battery would make the complete system collapse.

BACS® web server displays here the battery status of 140 accumulators. Any change in impedance, temperature and voltage is displayed and stored. Status LEDs show a change of color if any Battery drifts beyond thresholds.
every battery in the string. Oscilloscope graph of battery voltages at an Equalizing process: The voltages of the 3 batteries behave different because of the regulating influence of the BACS modules. The ideal harmonic charging curve will be archived for every battery in the string.

- **Avoid undercharging:** Through the CONDITIONING process, the unnoticed undercharging of individual batteries (sulphation, loss of capacity) is prevented.

- **Indicator of battery problems:** Typical battery problems like sulphation, corrosion, gassing, dry-out, thermal runaway etc. are visible through a rise of Impedance and temperature.

- **Avoid sulphation:** Sulfation is a typical problem for UPS batteries because they are consistently held at a float charge level for a long time. Its not guaranteed that ALL Battery have really been fully charged when the UPS charge switches from boost charging to float charging. The result maybe that some Battery are overcharged, while others have never been fully charged. CONDITIONING avoids sulphation through the process of bringing the overcharged and undercharged Battery to a balanced voltage level.

- **Show stratification:** BACS warns through increasing impedance and drifting Voltages of a possible stratification of the electrolyte. The acid-gel-water mix requires from time to time a discharge process to reverse the stratification of these parts due to gravity. Through the discharge process the stratification can be removed and the BACS shows this effect through a lower impedance and improved equalizing.

- **Protection of neighbour batteries:** BACS avoids damages on neighbouring Battery through the Conditioning process in balancing all individual voltages of the accumulators.

- **Battery alert system:** Through monitoring of key parameters of the Battery and measuring against set thresholds, the system is able to give you pre-warnings via audible, visible and network messages that attention is required.

- **Battery breaker switching at thermal runaways:** Through the embedded dry contact output the BACS system may trip the battery breaker in case of high battery temperature. A stringwise battery disconnection is possible.

The GX_R_AUX Module provides 4 relay contacts plus 4 digital inputs. One of the standard functions is the control of a battery breaker to avoid a thermal runaway. The digital inputs read eg. The battery breaker status and display this in the BACS Webinterface. Any other alarm device may be connected to the outputs (eg. Alarm buzzer, breaker etc.) or digital inputs of the GX_CON_R and the device itself can be placed anywhere within the BACS bus system – ideally close to the alarm devices which makes the installation easy.

- **Increase battery capacity:** BACS® guarantees, through CONDITIONING, a full charge level and the optimal capacity of a battery system.

- **Early warning to replace batteries:** Through impedance trending you can see in the early stage that some Battery are damaged or simply weaker than others. The earlier Battery are replaced the better for an increased lifetime of the complete battery system!

- **Extension of service life up to 30%:** The service life of all Battery in a string depends on the weakest member, the weakest battery. Typically the service life of Battery in a UPS are around 50-60% of the manufacturer design life. By Equalizing all batteries are kept constantly in their ideal voltage window so that all negative influences of wrong charging voltages and currents within the string are eliminated. Through this constant „care“ process through Equalizing, it is possible to increase the service life up to 30%, probably more. At ideal operating conditions it is possible to keep batteries in a string operating until the design life, and beyond. From scientific researches it has been proofed that Equalizing increases the service life for at least 10%. From our testresults we can proof today that more than 30% service life has been reached. We hope to be able to show that with Equalizing even more than the design life of 5 years is possible. (2 BACS systems running since 2004 with Panasonic 5 year design life batteries, already 2 years longer in operation than the manufacturer design life and still performing.)
- **Power & Environmental alert system**: The BACS system monitors environmental parameters (temperature, humidity, hydrogen gas concentration, acid fill level, DC current, etc.) and UPS system data. This information including alarm alerts is available via a mix of multiple communication systems.

- **Maintenance**: A BACS system improves the service quality by providing remote monitoring through Internet, VPN or other network for downloading real time data and battery history for analysis. Single, individual battery tests are now possible without the effort to disconnect batteries from the group. Maintenance and battery testing are able to take place at time, under real operating conditions, without downtime of the system!

- **UPS SNMP & MODBUS manager**: A BACS system includes a full qualified UPS/SNMP and MODBUS manager - compatible to any UPS vendor in the market! A unique function in the market of BMS system.

- **MODBUS/PROFIBUS/LONBUS/SNMP**: A BACS system allows MODBUS clients to read the data of the BACS system through IP and RS232 (optional through RS485) and through SNMP. Through optional converters a conversion to PROFBIS and LONBUS is possible. From 2013 a BACnet converter will be available.

- **Free BACS VIEWER analysis software**: Provides graphical BACS data analysis and reports!

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The free BACS VIEWER software shows the CONDITIONING of a battery within a string or 32 batteries (shown as bold violet line) during a discharge/recharging process.

BACS CONDITIONING avoids that this violet Battery gets overcharged, while other Battery still require further charging.

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

<table>
<thead>
<tr>
<th>Number of BACS modules</th>
<th>Logging time range (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>1200</td>
</tr>
<tr>
<td>60</td>
<td>1000</td>
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<tr>
<td>80</td>
<td>800</td>
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<tr>
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</tr>
<tr>
<td>140</td>
<td>200</td>
</tr>
<tr>
<td>160</td>
<td>0</td>
</tr>
</tbody>
</table>

This table shows the capacity of the BACS WEBMANAGER flashrom for the BACS data during float charging operation. (Autosave of battery data every 20 minutes). At a discharge or any other alarm, the autosave interval is drastically reduced which increases the data to save on the flash rom to provide very precise data for the analysis through the BACS VIEWER. The number of BACS modules and the number of discharges determines the available capacity. The table above shows the storage of battery history in days on the flashrom, assuming that there is no discharge and the system operates normally. This amount of data is available for the transfer to other storages in the network. Older files get overwritten and only the latest battery data is kept on the flashrom. We recommend to use the BACS VIEWER software for regular downloads of battery history and storage on a remote computers harddisk.
BACS Description

The reliability of a Battery-based power supply can only be guaranteed when the availability of each Battery is at 100% capacity all of the time!

The BACS® battery modules have instruments for taking exact measurements of the internal resistance, temperature, and voltage which are valuable for making a precise analysis of each battery. The data is transferred through a bus system to the BACS WEBMANAGER which is at the same time the manager for UPS, inverters, environmental sensors and other devices.

The BACS WEBMANAGER acts as the central control unit by gathering, evaluating and storing all information on its internal flash MEMORY. A display shows the actual status of the accumulators, a 2nd display shows the actual UPS data and a 3rd display shows environmental data and alarm contacts status. The web browser interface of the system is designed for easy configuration, displaying all system values and events, a flexible EVENT MANAGER is the programming interface for automatic reactions in case of alarms.

The BACS WEBMANAGER compares constantly the individual Battery voltage in relation to the current voltage level of the overall system. This value is sent to every BACS® module which starts counter steering. This process is called “CONDITIONING” and ensures that the voltages of all Battery are balanced.

The BACS® system limits the charge to the overcharged Battery to avoid gassing and the drying out that would occur from this action. Each individual Battery receives an optimal charging voltage through this CONDITIONING process.

Limiting the charging voltages of the Battery increases the durability and reliability of the whole system considerably.

Rising internal resistance of an Battery due to corrosion or sulphate deposits will trigger an alarm.

Alarm values can be configured to match the type of battery. This „early warning system“ makes it possible to warn users (by email, email-to-SMS, network message, SNMP, RCCMD, MODBUS, PROFIBUS, LONBUS etc.) far in advance about battery weaknesses before it is too late. For instance, should sulfation increase internal resistance, the user can reverse this process with a series of discharging and charging cycles. The effect of such „battery training“ on the internal resistance can be read immediately!

In addition to internal resistance, the values for voltage, temperature, regulating activities, and the number of charging / discharging cycles are constantly monitored and compared with preset thresholds. When any of the threshold values are exceeded, corresponding alarms will be communicated using the network connection, modem (optional), email, SMS, SNMP, RCCMD, MODBUS and (optional) PROFIBUS or LONBUS.

At the BACS-Manager an alarm buzzer acoustically warns the users. An alarm LED on the module and on the BACS-Manager shows the alarm optically.

The BACS WEBMANAGER is equipped with a large flash MEMORY or SD memory cards that can log all system data for a duration of at least 6 months and up to 3 years dependent of the size of the system. All data can be downloaded and archived over the network in order to free-up storage capacity for further data logging and for analysis using the BACS VIEWER software or other graphical tools.

The alarms for other devices connected to the BACS WEBMANAGER (e.g. UPS) are also logged in separate files with a date and time stamp and shown in the web interface. The BACS WEBMANAGER is equipped with a real-time clock for precise data/time stamps in the log files, additionally the system time is automatically synchronized with a network time server (SNTP).

BACS Viewer shows the individual battery voltage of all Battery at the end of a discharge. The red dotted line shows the voltages when power has returned. In the lower bar graph is shown which Battery have collapsed earlier than others and have been discharged to a very low level. These Battery are a risk to the complete system.
Battery in UPS applications

In a typical UPS battery installation there could be many Battery (singles cells, multiple cells like 6Volt 12Volt accumulators) that are connected in series to archive a very high voltage in the string. Modern UPS with IGBT Rectifiers are working very efficiently, but require a high string voltage, compared to the string voltages of older type Transformer UPS systems. This increase in string voltage has in turn increased the number of Battery required within a string. It is not unusual to have 800 Volts or more within a string of Battery – with the equivalent number of batteries/cells. Modern UPS tend to have to use many more Battery per string, but smaller capacities to avoid more space in the server rooms.

Short battery life in UPS usage: The more Battery that are in a string, the more cables, connectors, distances are involved which leads to higher and lower potential within the battery string. The more resistive materials Battery placement, length of cabling etc. the more differ the impedances within the Battery of this string and the more the charging levels are different. This effect gets over the time so dramatic that it is even visible from the different voltage levels of the Battery withing the string. The differences will in the beginning be the 10th's of a volt but over time an Battery that is at the stated float of 13.60 Volt will drop incrementally as other Battery rise as the current will flow elsewhere.

Taking in to play that all Battery are not created equal, it is just logic that in a string their individual accumulators/cells will never get the correct amount of charge they need to prevent sulfation and dry out as well as premature aging and failure.

For years, this was simply commonly accepted and nobody ever thought it could be a problem to have voltage difference in a battery string of 1 Volt or more. Since there was no technical solution the UPS maker did not focus on this problem and simply recommended to replace Battery far earlier than the designed lifetime to reduce the risk for battery failures. Nowadays it is commonly accepted that in a UPS application the lifetime of a 12Volt battery is just 50%-60% of the design life.

Customers who have suffered from failing UPS batteries did not feel comfortable just to change batteries more often since it would not guarantee a safe operation with the new batteries that could collapse without warning. A high string voltage UPS cannot tolerate a missing Battery and the complete system collapses at a single point of failure.

UPS makers have counteracted this issue by offering the customers redundant UPS systems with at least 2 strings of accumulators. This reduces the risk drastically, but has several disadvantages (Costs, space for installation, higher service efforts) – and still it is no guarantee – the user can not see what is going on in the battery strings and only theoretically can reduce the risk by adding as many strings as possible.

To reduce the risk of unnoticed battery failures and loss of backup, customers installed automatic transfer switches to their redundant UPS and Generators as the main backup in case of a power failure.

Also this extremely costly solution is still not safe since - all Generators need a few seconds to start, so there always will be a number of Battery between the UPS and Generator. Also the Generators starter battery is another risk factor – and the battery remains the Achilles Heel of every UPS or other battery backup system.

Knowing this, customers began to install monitoring systems “BMS” for batteries. Such systems should not only show why batteries are failing (Voltage differences, Rising impedance etc.) but also start automatic counteractions. BACS is the only system on the market which does not only “monitoring” but is regulating the system through its CONDITIONING !

The following screen shows the battery voltages of a batteries connected in a string that would be found in every UPS system today, which is not managed by BACS. The individual voltages after 5 years differ in a window of more than 1.8 Volt.

BACS VIEWER screenshot:
An UPS with 64 * 12Volt batteries after 5 years in operation shows that voltages have drifted within a large window of 1.8Volt between the lowest and the highest battery.

Voltages without the Conditioning process after 5 years in operation.
Following pictures shows the same Batteries, now with CONDITIONING
Due to individual differences in the Battery the voltages are not identical. The longer such differences have been in place and the Battery have not received a separate, balancing charge, the more the accumulators start drifting until they finally show a difference of 1 Volt or more – like in the screenshot of such 5 year batteries above.

With the introduction of the BACS patented CONDITIONING technology in 2004 the system is now able to eliminate all the voltage/charging differences in a string of accumulators. through its "CONDITIONING " process. The Conditioning process brings all Battery to 1/100th of Volt for each Battery on the string, despite its interconnections or location in that string and keeping the Battery at full charge and within the stated manufacturing float voltages.

The following screen shows the voltages of the same 5 year old Battery a few hours after BACS technology has started its Conditioning process.

BACS VIEWER screenshot:

The same 5 year old battery string above, now with BACS CONDITIONING...

Within a few hours the Conditioning brings all Battery to within 100th volt of each other and keeping the Battery at the manufacturers stated float charge.

BACS Conditioning process is correcting the negative influence that cause premature Battery failures due to voltage and impedance differences within a string.

A general description about the Conditioning principle and explanation why this extends battery life drastically and extends cycle life by about a factor of 3 is scientifically explained in the INTELEC Paper 32.1 “Life Extension through charge Conditioning of Lead-Acid...”

Based on scientific expertise and GENEREX own investigations from 2002 to 2004 the BACS patent has been established.
BACS System Components

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 NiCd, NiMH and Lithium Ion batteries with a wide range of 1.2V-3Volt.

At CONDITIONING 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 retrofitting through Velcro tapes and bus cable.