

# ASPIRO & GUARDIAN BATTERY MANAGEMENT WITH ACX ADVANCED CONTROLLER

## DESCRIPTION

Battery management is implemented in the Aspiro and Guardian DC Power Systems using the ACX Advanced controller.

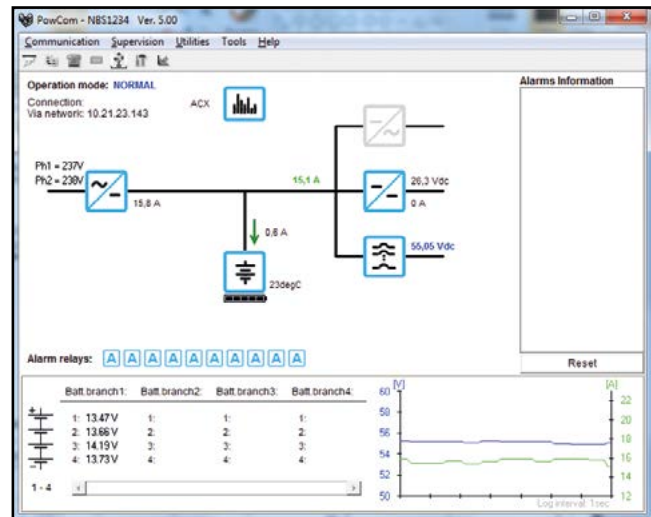
The main benefit of integrating battery management into the controller and its associated interconnection boards is that it does not require any additional hardware other than associate wiring.

## MONITORING FUNCTIONALITY

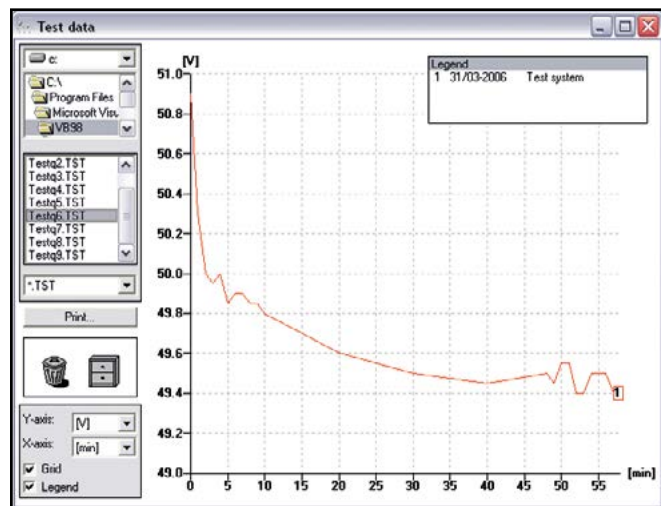
- ◆ Know the Health of your system 24/7.
- ◆ Real time cell voltages are displayed or cell voltages from a previous discharge.
- ◆ User can remotely monitor and store battery telemetry data reducing trips to site and increasing uptime.
- ◆ Automatic or on-demand battery testing (over the internet) ensures batteries are functioning properly and provides battery health statistics back to a NOC without affecting the existing system loads.

## INTELLIGENT MANAGEMENT

- ◆ Battery Disconnection
- ◆ Boost Charging
- ◆ Battery Testing
- ◆ Temperature Compensation Charging
- ◆ Battery Current Limiting
- ◆ Enhanced Monitoring and Data Logging
- ◆ Symmetry Measurement
- ◆ Load Shedding



Powcom™ Battery Symmetry Screen



Powcom™ Test Data Screen

## Available Functions

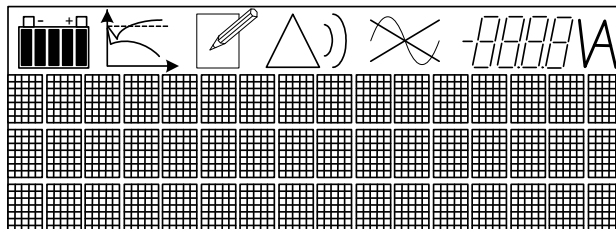
Battery Disconnection	Allows voltage controlled disconnection of batteries.
Boost Charging	Manual time controlled or automatic boost charging with adjustable time and voltage levels.
Battery Tests	Automatic or manual testing of batteries up to six times per year with a 10 test memory. Variables include test duration and end voltage. Battery discontinuance test to ensure battery connection.
Temperature Compensation Charging	Allows continuous adjustment of output voltage according to battery temperature. Features include adjustable compensation factor and separate thresholds for high temperature alarms.
Battery Current Limiting	Limits the maximum current flowing into the batteries during charging.
Enhanced Battery Monitoring	Monthly logging of essential battery parameters including temperature, temperature hours, current, charging voltage and symmetry voltage, Data logged for 5 years. Battery alarms are also logged.
Symmetry Measurement	Optional tool that measures batteries for early detection of thermal runaway.
Load Shedding (PLD)	Optional feature that allows voltage or time controlled disconnection of non-essential load.

Each Aspiro and Guardian system supports batteries as follow:

- ◆ Aspiro 1U: 1 string
- ◆ Aspiro 2U: 2 strings
- ◆ Guardian 2U: 2 strings
- ◆ Guardian 3U: 3 strings
- ◆ Guardian 5/6U: 6 strings
- ◆ Guardian Central: Varies according to the number of cabinets deployed.

## ACX Advanced Front Panel Display Icons

The controller displays several icons at the top of LCD screen two of which are specifically related to the batteries, the “Battery” icon at the top left and the “Graph” icon at second left.



## Battery Icon

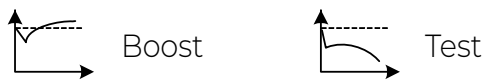


The battery icon displays the battery charge status in 20% increments. To predict the remaining capacity, immediate load current and voltage are also taken into account.

During battery charging the icon pulses. Once the battery is fully charged only the rightmost segment blinks.

When starting the system for the first time it takes some time before the battery icon is fully operational and displays correctly. The battery capacity must be set correctly (Adjust Limits → Battery settings → Battery Capacity). If the Battery capacity is set to 0 (zero) the icon is not shown.

## Graph Icon



The graph icons indicate charging mode as either Boost or Test. The graph showing an up-going curve is the Boost icon, while Test is indicated with a down-going curve on the graph.

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## Battery Disconnection

The battery disconnection function disconnects the battery from the load at the end of the discharge cycle and before any damage to the batteries can occur. This is achieved by the controller monitoring the bus voltage when the system is running on batteries and opening the Low Voltage Disconnect contactor at a predefined voltage according to the battery manufacturer's recommendations.

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## Boost Charging

The boost charging function defines the parameters that are to be used during a boost charging cycle. The following parameters can be set:

- Boost time (Hours)
- Boost interval (Weeks)
- Boost factor (-)
- Boost t1 (V)
- Boost t2 (V)
- Autoboot Enable (On/Off)

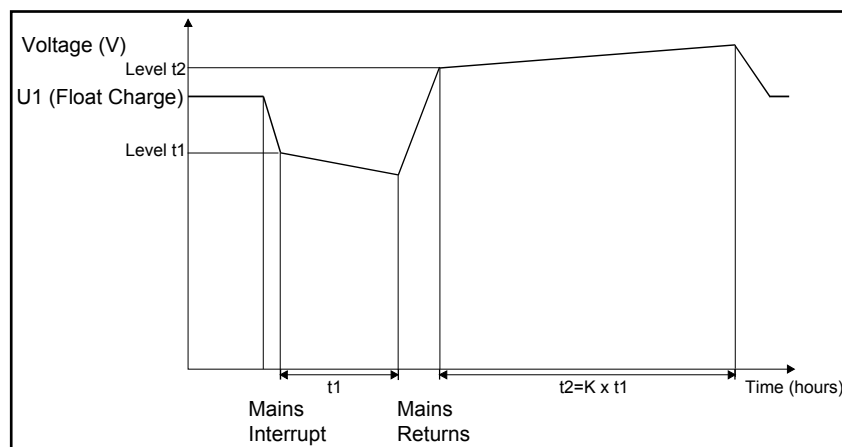
Boost charging can be activated by three methods:

1. **Manual boost charging** - can be activated manually by selecting U2, boost charger voltage setting, via the controller front panel, WEB interface (Select/Adjust U1-U4 ® Reference ® U2) or via PowCom™ software (Adjust limits window).

Return to float charge manually by choosing U1, float charger voltage setting, or automatically, after a pre-set time.

2. **Periodic boost charging** - after a pre-set period boost charging will be automatically activated for a pre-set time. The interval and boost time should be programmed (for example 4 hours every 3rd week).

3. **Automatic boost charging** - referring to the following graph, when the battery voltage drops below LEVEL t1 during a mains failure, timer t1 is started. When the mains is restored, timer t1 is stopped and the system starts automatic boost charging for time  $t2 = k \times t1$  (k is an adjustable constant). Timer t2 starts counting when the battery voltage reaches LEVEL t2, see Figure 11.



The following values are adjustable for boost charging:

- Boost voltage      40 - 60 V
- Boost time        0 - 200 hrs
- Boost interval    3 - 16 weeks
- Boost factor      1.0 - 16
- Boost t1          40 - 60 V
- Boost t2          40 - 60 V
- Automatic boost   Enable/Disable

Note that not all battery types support boost charging, so this facility should not be used if this is the case.

## Battery Test and Short Interval Battery Test

The following limits and parameters for Battery Test and Short Interval Battery Test can be set in the controller:

- Test end voltage (V)
- Test end Ah (Ah)
- Test duration (Min)
- Time of test (-)
- Number of tests per year (-)
- Short interval Enable (On/Off)
- Short interval period (Days)
- Short interval length (Min)
- Short interval deviation (%)

The following menu items are available:

### Battery Test

Battery test is used for checking the condition and capacity of installed batteries. The test can be activated Manually or Automatically.

#### Manual Start-up

Battery testing is activated manually by selecting U3, test voltage setting, via the controller front panel, web interface (Select/ Adjust U1-U4 ® Reference ® U3) or via PowCom™ software in the Adjust Limits window.

#### Automatic Start-up

Battery test can be also activated automatically 1-6 times a year via the controller front panel, web interface (Adjust Limits ® Battery Test ® No. of tests per Year) or via PowCom™ software in the Adjust Limits window (Auto Test). The test date is calculated from the installation date of the system defined in PowCom™ software (Supervision ® Set installation data).

The day-time (24-hour format) of the battery test is set in 'Time for Test'.

### Test Performance

Once the battery test starts, the rectifier voltage decreases to a pre-set value U3 and is stopped when the set value is reached. Reasons for the test stopping could be:

- battery voltage reaches the End voltage [V]
- battery test reaches the Test duration time [min].
- discharged capacity reaches the set Ah limit value.

Battery voltage, battery current and Ah are logged during the test. The recommended minimum duration of the test is 5 minutes.

Upon completion the test will have either PASSED or FAILED.

### PASS

The battery parameters meet requirements and the voltage reference is set back to U1 when:

- the battery voltage is higher than set End Voltage b. test [V] after expiration of Batt. test time [min].
- the battery voltage is higher than set End Voltage b. test [V] after discharged capacity reaches the set value [Ah].

### FAIL

The test is interrupted and the battery is considered as faulty when:

- the set voltage value [V] is reached before time [min].
- the set voltage value [V] is reached before "Ah limit for test" [Ah].
- the symmetry limit is exceeded. SYMMETRY FAULT alarm is activated, battery test is ended and BATTERY FAILURE alarm is generated.

The battery failure alarm is indicated and further automatically activated battery tests will not be performed while the battery failure alarm is active.

Voltage reference is set to U1 again.

### Parameter Settings

The parameter settings feature allows a partial discharge of the batteries (approximately 30-40% of their capacity) in order to test the batteries for errors. The settings should be done according to the battery manufacturer's requirements.

The following setting can be used as an example for standard value-regulated lead batteries:

- U3 = 1.9V/cell
- End voltage = 1.94V/cell
- Time = 40% of expected backup time
- Ah = 40% of nominal battery capacity.

Parameters that can be set or adjusted in the battery test:

- Battery test voltage U3: 0-100V (Check Rectifier datasheet for min. voltage.)
- Symmetry limit: 0.0-4.0V
- Test end voltage: 0-100V
- Test duration: 0-20 hours
- Ah limit: 0-50,000Ah
- Time of test: 0-23 (0=midnight)
- No of test/year: 0-6

## Short interval battery test

This is used to test for a permanent break or interruption in the battery strings when more than one shunt with extension board is used.

Once this test is Enabled, it is performed in the time interval set in the 'Short interval period'. The system voltage is decreased to U3 for the time duration set in 'Short interval length' and the current through all used shunts is measured. If the current deviation through the shunts exceeds the value set in the 'Short interval deviation' or if one of the currents is equal to 0 (zero), a 'Battery Failure' alarm is generated.

The test can be Enabled via the controller front panel, web interface (Adjust limits ® Battery test ® Short Interval Enable ® On/Off) or in one of two ways via PowCom™ software:

1. (Supervision ® Set parameters ® Battery settings ® toggle Short interval Battery Test) or
2. (Utilities ® Config Wizard ® Battery settings window ® toggle Short interval Battery Test).

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## Temperature Compensation

Temperature compensation adjusts the float depending on battery temperature. This feature is recommended if the battery temperature is expected to vary more than  $\pm 5^{\circ}\text{C}$  from ambient temperature. The temperature coefficient for lead acid batteries is typically  $-3$  to  $-5$  millivolts/ $^{\circ}\text{C}$  per cell. Correct use of battery temperature compensation increases battery life.

Setting of the following parameters for temperature compensation is available through the front panel, web interface or via PowCom™ software:

- Enable temperature compensation (On/Off)
- Compensation factor (V/ $10^{\circ}\text{C}$ )
- Turn temperature compensation On/Off.

When the battery temperature is higher or lower than  $20^{\circ}\text{C}$ , temperature compensation regulates the set float or boost battery voltage based on battery temperature and temperature compensation factor. (This value can be changed to  $25^{\circ}\text{C}$ .)

If the temperature rises by 10 degrees, the voltage decreases according to the adjusted compensation factor, if the temperature drops the voltage is adjusted correspondingly. If the temperature changes by 1 degree, the voltage changes by 1/10 of the compensation factor.

*Example:*

*A system includes 4 x 12V battery blocks - 6 cells in each battery block.*

*The value of 1 cell defined in the battery datasheet is 2.28V/ $20^{\circ}\text{C}$ , 2.24V/ $30^{\circ}\text{C}$ .*

*The difference between values at  $20^{\circ}\text{C}$  and  $30^{\circ}\text{C}$  is 0.04V/cell.*

$6 \times 0.04V = 0.24V/10^{\circ}C$  - 6 cells in each battery block.

The compensation factor value is set for a full battery string which in this case contains 4 x 12V battery blocks. So, the correct compensation factor is:

$4 \times 0.24V = 0.96V/10^{\circ}C$ .

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## Battery Current Limit

This function limits the maximum current flowing into the batteries during charging. (It does not limit discharge current!) The minimum charging current is 5A. The maximum charging current value can be set via PowCom™ software to 1000A, via the controller front display or web interface it can be higher.

This menu allows settings for:

- Battery current limit Enable (On/Off)
- Battery current limit (A)

The charging current limit for lead-acid batteries is usually 0.1 of rated capacity. (Check the battery datasheet in case a different value is required.)

If the current limit is not required or batteries are not installed, keep the function disabled. However, non-limited charge current or improper setting may shorten battery life, so it is generally recommended to set this parameter according to the specifications of the batteries being used.

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## Enhanced Battery Monitoring

This function provides monthly logging of essential battery parameters including:

- Temperature
- Temperature hours
- Current
- Charging voltage
- Symmetry voltage

The following battery related alarms are also logged:

**Load/Battery disconnection** - This alarm is generated when the system voltage drops below a preset limit for more than 30s.

**Battery failure** - This alarm occurs when either a Battery test or a Short interval Battery Test Fails.

**High battery temperature** - This alarm occurs when the battery temperature exceeds a preset limit.



**Symmetry fault** - This alarm is generated when the voltage between battery blocks differs from a preset limit. This value is calculated from the system voltage based on the battery settings, number of batteries and battery type.

**Battery fuse failure** - This alarm occurs when a battery circuit breaker is switched Off and the system voltage is 0.65V higher than the battery voltage.

**PLD/PLD2/PLD3 Disconnection** - These alarms occur either when the system voltage drops below the associated set limits, or when the time reaches a preset value.

**Temp. probe failure** - This alarm always appears when:

- The temperature probe is disconnected and temperature compensation is enabled.
- Battery temperature is above +80°C or below -20°C, temperature compensation can be enabled or disabled. (If disabled and temperature is below -40°C the alarm does not appear.)
- Battery temperature is 10°C higher than the temperature of the controller's internal temperature sensor.
- Battery temperature is 30°C lower than the temperature of the controller's internal temperature sensor.

This alarm does not appear when:

- The temperature probe is disconnected and temperature compensation is disabled.
- Temperature compensation is disabled and the temperature drops below -40°C.

**Battery is discharging** - This alarm appears when the battery is discharging with current higher than 2% of the current rating of the shunt and the system voltage drops 1V below the voltage reference (U1 or U2).

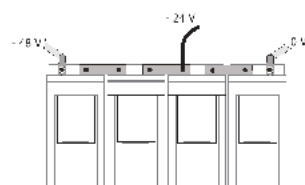
**Low battery temperature** - This alarm is activated when the battery temperature drops below a preset temperature.

Data and alarms are logged for 5 years. This function requires that a microSD data card is fitted.

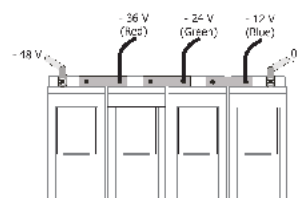
## Symmetry Measurement

Symmetry measurement is used to a battery string is faulty.

The ACX Advanced controller supports '2 block' (single wire) and '4 block' (three wire) symmetry measurement as shown below:

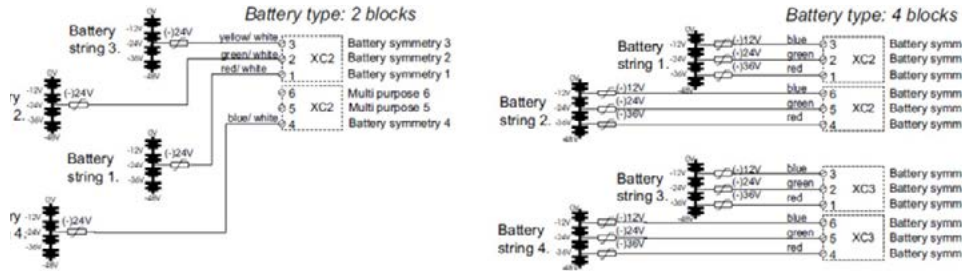


2 block measurement



4 block measurement

The total number of symmetry measurements that can be supported with the standard controller interface card is 12 (2 block measurement) or 4 (4 block measurement). The following shows how connections for up to 4 battery strings are made to the extension interface board:



Note that larger systems such as Guardian Central may have additional battery cabinets which require additional extension interface boards.

## Load Shedding

Load shedding is a method that can be used to extend system run time when operating on batteries. Systems incorporating load shedding include between one and three additional Voltage Disconnect contactors known as PLD contactors. Non-critical loads are connected through these PLD contactors so that they can be disconnected as the battery discharges at an earlier point than the battery LVD disconnects.

Note that in some system configurations load shedding is essential so as to ensure that the system bus current carrying capacity is not exceeded as current increases for a given load as the voltage drops.