Centroid Snet 2
Battery Management Software
User Manual V1.1
## Contents

1. **Centroid Viewer Overview** ........................................................................................................... 4  
   1.1 System Requirements .............................................................................................................. 4  

2. **Installation** .................................................................................................................................... 5  
   2.1 Installation Steps ..................................................................................................................... 5  
   2.2 Start Centroid Snet 2 Service .................................................................................................. 6  
   2.3 Updating Centroid Viewer ........................................................................................................ 7  

3. **Getting Started** ............................................................................................................................. 9  

4. **System Management** .................................................................................................................. 10  
   4.1 System Management Overview ............................................................................................. 10  
   4.2 Creating a Site ....................................................................................................................... 11  
   4.3 Registering Systems into Centroid Viewer ............................................................................. 11  
   4.4 Configuring Email Alerts ........................................................................................................ 16  
   4.5 Temperature Unit Setting ....................................................................................................... 18  

5. **Battery Monitoring** ........................................................................................................................ 19  
   5.1 Local Server ........................................................................................................................... 19  
      5.1.1 Discharge Log ................................................................................................................. 20  
   5.2 System Dashboard Interface ................................................................................................. 22  
      5.2.1 Summary View ................................................................................................................ 23  
      5.2.2 Overall View Tab ............................................................................................................. 24  
      5.2.3 Chart View Tab ................................................................................................................ 25  
      5.2.4 List View Tab ................................................................................................................... 27  
   5.3 History View ........................................................................................................................... 28  
      5.3.1 String History View .......................................................................................................... 29  
      5.3.2 Cell/Unit History View ...................................................................................................... 30  
      5.3.3 Cell/Unit Trending ............................................................................................................ 31  

6. **Battery Alarms** ............................................................................................................................ 33  
   6.1 Local Server Alarm View ........................................................................................................ 33  
   6.2 System Alarm View ................................................................................................................ 34  
      6.2.1 Alarm History ................................................................................................................... 35  

**Appendix A – Alarm Values** ............................................................................................................. 36  
1. String Alarm Points .................................................................................................................. 36  
2. Cell/Unit Alarm Points ............................................................................................................. 37  

**Appendix B – Sample Reports** ....................................................................................................... 39
1. Centroid Viewer Overview

Centroid Viewer, Eagle Eye’s proprietary battery management software, is included with most BQMS, iPQMS, BDS-Pro, and BMS-icom battery monitoring solutions. An exception to this is if any of these systems are ordered to communicate via Modbus only.

The purpose of Centroid Viewer is to provide an easy to use graphical user interface to manage battery measurement data. The software provides complete data analysis, including real-time viewing of parameters as well as trending on a string and cell/unit level. Measured data can be exported to PDF or Excel.

It is possible for Centroid Viewer to manage all battery systems installed on a company network, this could include hundreds of systems installed over a large geographic location. Alternatively, standalone installations can be installed per battery system, which allows Modbus out directly from a dedicated PC; this is the only solution which allows the software and Modbus to be used simultaneously.

The software can be installed as the Server or Client. The Server aspect handles all communication between the battery monitoring systems and Clients. The Clients are basically instances of Centroid Viewer installed on other PC’s on the same network; these installations point to the IP address of the Server PC.

1.1 System Requirements

Listed below are the recommended system requirements for Centroid Viewer based on the two most common methods of installation:

General requirements:
- 64-bit Windows based operating system (Windows 7, 8, 8.1, 10)
- .NET-Framework 4.5 or higher
- Active Internet connection for email alerts

Installation for management of a single battery system on a dedicated PC:
- CPU-Type: Intel® Core™ i3 Processor 3.1 GHz
- Memory: 4 GB
- Display Resolution: 1280 x 1024
- Disk Space: 500 GB

**NOTE:** The above requirements are for monitoring no more than one battery system registered in the software.

Installation for management of multiple systems on a dedicated PC:
- CPU-Type: Intel® Core™ i7 Processor
- Memory: 8 GB
- Display Resolution: 1280 x 1024
- Disk Space: 2 TB
2. Installation

Centroid Viewer has two components which have separate executable files. Both need to be installed on a dedicated PC which will act as the “Server PC”; this PC will be responsible for communication with all BMS systems installed in the field. The two components are explained below.

- **Centroid Viewer**: The main user interface, all interaction occurs within this program.
- **Centroid Snet 2**: A Windows service that runs in the background on the Server PC. This service manages the measurement data from the BMS systems via a proprietary protocol. The service must be running at all times in order for measurement data to populate in Centroid Viewer.

2.1 Installation Steps

The software is provided on a USB Drive that is included with the system. A download link can also be obtained by contacting Eagle Eye directly.

*Click this link for a video tutorial on installing the software*

1. Right click Centroid Snet2 vX.X.X.X.exe and select **Run as administrator**.

2. After the program installs, ensure “Run Centroid Snet 2 X.X.X.X” is checked then click **Finish** as shown below.
3. A command prompt-style window will appear to finish the installation. When completed the window should appear and will automatically close after a few seconds.

**Note:** If it says “Centroid Snet2 has stopped working…” simply close the dialogue box, the installation is not affected by this message.

4. Right click CentroidViewer vX.X.X.X.exe and select *Run as administrator.*

5. After the installation has completed, you can choose to run the program, however it is not required.

### 2.2 Start Centroid Snet 2 Service

After the software installation, the Snet 2 Service needs to be started in order for the program to operate correctly.

1. Open the *Run* command (Win key + R) and type “services.msc” as shown below.

2. With the Services window open, select *CentroidSnet 2* and then click *Start* on the left as shown below.
3. After starting the service, it should display as “Started” or “Running” under the status column.

2.3 Updating Centroid Viewer

This section will outline the steps to update Centroid Viewer to the latest version.

Click this link for a video tutorial on updating the software

1. Close Centroid Viewer. Open the Run command (Win key + R) and type “services.msc”.

2. In Services, select CentroidSnet 2 and then click Stop on the left.

3. Navigate to the installation directory of Centroid Snet2 which is typically: C:\Program Files (x86)\Waton\Centroid Snet2

4. From this directory, copy the data folder. (This folder contains all of the test data and system information and will need to be restored after installing the updated version.)
5. Paste the data folder in a location it can be readily copied from.

**Warning:** Be sure to paste the folder in a safe location, such as the desktop. Losing this folder means losing all measurement data and system information.

6. Open **Programs and Features** from the **Control Panel** and uninstall Centroid Snet2 vX.X.X.X and CentroidViewer X.X.X.X

7. Install the new version of both Centroid Snet 2 and Centroid Viewer following the same steps from **Section 2.1**.

8. After the installation of both components is complete, copy the data folder to the Centroid Snet2 directory (typically - C:\Program Files (x86)\Waton\Centroid Snet2).

9. Start the Centroid Snet 2 service following the same steps from **Section 2.2**.

10. Run Centroid Viewer and ensure all systems are present and monitoring.
3. Getting Started

Upon starting Centroid Viewer, you will be presented with three main areas:

- **Battery Monitoring**: Displays measured values, recorded discharge logs, and bank history.
- **Battery Alarms**: Displays all active alarms for any given system.
- **System Management**: Displays registered and unregistered BMS systems.

**Menu**: The Menu button is present at all times and displays the three areas of the software: Battery Monitoring, Battery Alarms, and System Management.
4. System Management

The System Management section of the software is used for the following purposes which will be covered step-by-step in this section:

- Registering new BMS systems into the software.
- Adding new sites to the software.
- Confirming the IP address of the Server PC (for client installations).

**Click this link for a video tutorial on registering new systems in the software**

4.1 System Management Overview

![Image of Centroid Viewer interface]

1. **Local Server**: The name of the network in which the systems are installed on. All Sites and Systems will appear under the Local Server.

2. **Network**: IP address of the Server PC that is running the Snet 2 Service.

3. **Email**: Configuration for setting up email alerts.

4. **List of Registered Devices**: List of all systems currently registered in the software.

5. **List of Unregistered Devices**: List of systems which the software recognizes (by IP) but have not been registered.

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(4) **List of Registered Devices**: List of all systems currently registered in the software.

(5) **List of Unregistered Devices**: List of systems which the software recognizes (by IP) but have not been registered.
4.2 Creating a Site

A site is a location under the Local Server which can have systems added to it. The term “Site” can refer to a physical location such as a battery room, plant, substation, building, etc. Sites must be made before adding systems to them.

1. Right click Local Server and select New Site.

2. Enter a name for the site and click Save to create the site.

3. The new site will appear under the Local Server.

4.3 Registering Systems into Centroid Viewer

All battery monitoring systems installed in the field must be registered in the software. Unregistered systems will appear under the list of unregistered devices as an IP address.

1. There are two ways to add a new system:

   • If the system is already connected to the network, it must be registered from the List of Unregistered Devices. Identify the IP address of the system you want to register and click the Reg. String button.

   • If the system is not yet connected to the network, it can still be added given that the IP address of the system is known. To add a system before it is connected to the network, click the Add New String button.
2. Regardless of how the system will be added, the **System Configuration Wizard** will appear. This allows parameters for the system to be configured.

(1) **Device Type**: Select the MPU type (BQMS, iPQMS, BDS-Pro, or BMS-icom)

(2) **Network Info**: Confirm the IP address of the MPU.

(3) **No. of Units**: Value varies depending on the MPU type:
   - **BQMS**: Enter the number of Modules installed on the system.
   - **iPQMS**: Enter the number of Relaying Units installed on the system. If only 1, then leave as 0.
   - **BDS-Pro**: Always leave as 0.
   - **BMS-icom**: Always leave as 0.

(4) **Measuring Interval**: Time in minutes between measurement cycles (can be changed at any time.)
3. Click the **Next** button to progress to the next window.

4. Enter the battery system information on the next window.

![System Configuration Wizard](image)

(1) **String Name**: Enter the name of the string / battery system being monitored.

(2) **Site**: Select the name of the site where the battery system is installed (must have been created before opening the System Configuration Wizard).

(3) **No. of Jars**: Enter the number of units (jars or cells) being monitored.

(4) **Model**: Enter the battery model number from the manufacturer.

(5) **Volt. Type**: Enter the total voltage of the battery system in V.

(6) **Capacity**: Enter the battery capacity in Ah.

(7) **Manufacturer**: Enter the name of the battery manufacturer.

(8) **Location**: Enter the address or name of place the battery system is located.

(9) **Install Date**: Enter the install date of the battery monitoring system.

(10) **Mfg. Date**: Enter the date the batteries were manufactured.
5. Click the **Next** button to continue.

6. Enter the battery system alarm information on the next window. *For further explanation on the alarm parameters, refer to Appendix A.*

![System Configuration Wizard](image)

**Note:** All alarm parameters can be changed at any time. It is not necessary to set the parameters on this screen.

7. Click the **Finish** button to add the system.
8. The system will now appear under the list of registered devices.

9. All systems which are successfully registered in Centroid Viewer will appear under the list of registered devices. This list will confirm the following details:

- Device Type
- IP Address
- Number of Units
- Number of Cells/Units
- Communication Status
4.4 Configuring Email Alerts

Centroid 2 has the option to send out email alerts to notify users of any new alarms that may be occurring on any battery system being monitored with an Eagle Eye BMS. One email address must be used as the host to send email alerts out. Additional recipients must be configured under the host email account. To send alerts to SMS, contact your mobile phone provider to determine the email to SMS address for your mobile number.

The Email Alert functionality has the following requirements:

- An active internet connection on the Server PC
- SMPT settings for the host email account

1. To configure email alerts, click Local Server then click the Email button.

2. The Email Setup Window will allow you to input the email information.

   (1) Confirm whether or not to use Email alerts (can be disabled at any time)
   (2) Enter the SMPT address
(3) Enter the SMTP port

(4) Verify whether or not to use secure connection

(5) Enter the email address of the host email account

(6) Enter the password of the host email account

(7) Enter the email address of the host account again

(8) Enter the email address of the account which will receive the email alerts (can be the same address as the host)

3. Test that the email alert settings are configured properly by clicking the **Send Test Message** button. Check the receiver email account to confirm that the test message was received.

   ![Image of a test message](image)
   
   This is the E-mail test message from Centroid Snet

4. When setup is complete, be sure to check “Send Email when outbreak Alarm” to enable the email alerts.

   **NOTE:** It is recommended to disable email alerts until all alarm settings are configured. This will prevent an excessive number of email alerts being sent out during setup.

5. Successful email alerts will display the name of the bank / string, the jar (if applicable), the alarm type, and the measured value.

   ![Image of an alarm message](image)
   
   String [Bank 123], jar(19), Low Voltage Alarm, value 2.1

6. It is recommended to occasionally send test emails to ensure the service is operating correctly.
4.5 Temperature Unit Setting

The temperature unit in the software can be selectable between Celsius and Fahrenheit. To change the temperature unit, follow the steps below:

1. Click **Local Server** then click the **Setting** button.

![Screenshot of Local Server interface]

2. Select the unit of temperature and click the **Save** button.

![Screenshot of temperature unit selection]

3. Centroid Viewer will restart and the new temperature unit will be reflected in the measurement readings.
5. Battery Monitoring

This section provides detailed information on the Battery Monitoring area of the software which is used for managing the measurement data captured from the BMS systems installed in the field. The Battery Monitoring section provides the following functionality, each of which will be covered in detail throughout this section:

- **Local Server** to display all registered BMS systems and their current status.
  - **Discharge Log** to playback all discharge events.
- **System Dashboard** to view each system individually.
  - **Summary View** to view summary of measured parameters and alarms.
  - **Overall View** to view set alarms and system information.
  - **Chart View** to view charts and graphs for all measured data.
  - **List View** to view measured data for all cells/units
  - **Reporting** (PDF & Excel) for a specific system.
  - **System History** to view all measured data from a specific BMS system from time of installation

5.1 Local Server

The Local Server view is the default view when opening the Battery Monitoring section of the software and has the following functionality:

- View all systems registered in the software
- Sort all systems by each column displayed in the Local Server view
- View the Discharge Log

(1) All sites and systems are registered under the Local Server. Click the [+]
button next to Local Server to display all of the sites. Click the [+]
button next to each site to display each system.

(2) Click the **Local Server** name to display all of the systems registered in the software. Each system will have a row with columns showing the System Name, Communication Status, Alarm Status, Nominal System Voltage, Capacity, Measured Voltage, Measured Current, Ambient Temperature (BQMS only), BMS Model, and Measurement Interval.
(3) Click each column name to sort by that column. For example, clicking the **System Status** column will allow all Offline systems to be shown from the top. Clicking the **Status** column will sort the systems by alarm status. This can be useful for showing which systems are in alarm quickly.

(4) Click **Discharge Log** to view the Discharge Log

### 5.1.1 Discharge Log

The **Discharge Log** contains records of all recorded discharge events for all systems registered under the Local Server. To learn more about how discharge events are recorded, refer to Appendix A.

1. To open the Discharge Log, click the **Local Server** icon then click the **Discharge Log** button in the upper right.

2. The Log will display all of the recorded discharges along with: String Name, Start Time, Start Current, Start Voltage and End Time, End Current, and the End Voltage for each test.

3. Click any of the column titles to sort by that column.

4. To view a discharge, click **Replay of Discharge**.
(1) Displays the following information:
   a. Battery bank name
   b. Total number of cells/units
   c. Total time of recorded discharge
   d. Total time elapsed into the playback of the discharge
   e. Date and time the recording started
   f. Date and time the recording ended
   g. Current time displayed in the playback
   h. DC voltage and current values throughout the playback

(2) Print the discharge log to a printer or PDF file.

(3) Playback Controls (from left to right): Return to start of playback, play backwards, pause, play forward, skip to end of playback.

(4) String voltage and current graph.

(5) Cell voltage and cell resistance graph.
5.2 System Dashboard Interface

This section will explain the System Dashboard interface. To display the System Dashboard, click the System Name under Local Server > Site Name.

The System Dashboard has the following main areas:

- Summary View
- Overall View
- Chart View
- List View

The System Dashboard section of the software provides the following functionality:

- View all measured data from the BMS
- View active alarms
- View and edit all alarm parameters
- View and edit system information
- Change the operating status of the BMS
- Change the measurement interval for cell resistance (cell voltage, resistance, and temperature for iPQMS & BDS)
- Generate PDF reports
- Export measurement data to Excel
- View detailed measurement history on a string and cell level

The various sections of the Individual System View are explained below:

### 5.2.1 Summary View

The Summary View is the top section of the Individual System view.

1. **System/String/Bank Name.** Clicking the system name allows the name to be edited.
2. **String Voltage, Float/Charge/Discharge Current, & Ambient Temperature (BQMS only).** Voltage and current measurements displayed as green when not in alarm and red when in alarm.
3. **Cell/Jar Summary** displays a summary of values for the measured parameters of Cell Voltage, Cell Resistance, and Cell Temperature. The average, highest, and lowest values are displayed. The number in parenthesis refers to the actual cell for the high and low values. In the example above, cell 24 has the highest voltage of 2.303V, and cell 59 has the lowest voltage of 2.020V.
4. **Cell/Jar Alarms** displays the number of alarms for each type of cell/jar alarm. The number of active alarms for each alarm type will be displayed to the right of the alarm. In the example above, the system has (3) Warning Resistance alarms.
5. Reporting – refer to Appendix B for report examples.
6. The **History** button allows viewing of the systems measurement history. Refer to Section 5.3 for more information on viewing system history.
5.2.2 Overall View Tab

The Overall View Tab displays the set alarm parameters and system information.

(1) **Alarm Parameters:** All set alarm parameters for the battery system are displayed here. For further explanation on the alarm parameters, refer to Appendix A.

(2) **System Information:** Entered information about the site and battery system is displayed here.

(3) **Device Type:** Displays the type of BMS which would have been entered when the system was registered.

(4) **Network Info:** Displays the IP address of the BMS. This cannot be edited here.

(5) **Num of Units:** Value entered when BMS was registered. This cannot be edited.

(6) **Interval:** Set value for how often resistance measurements are taken (cell voltage, resistance, and temperature for iPQMS & BDS Models). Click the value to change the measurement interval.

(7) **Monitor State:** Displays whether the BMS is Online or Offline. If the BMS is Offline, it is either turned off or there is an issue with communication between the BMS and the Server.

(8) **Device State:** Displays the current state of the BMS. There are (3) possible states:
   a. **Normal:** The BMS is between measurement cycles and is operating normally.
   b. **Resistance Measurement:** The BMS is currently measuring resistance on the system.
   c. **Stop:** The BMS is stopped and will not measure cell resistance (cell voltage, resistance, and temperature for iPQMS and BDS) until the measurement cycle is manually started again.
5.2.3 Chart View Tab

The Chart View tab displays graphs for: String Voltage, String Current, Cell/Unit Voltage, Cell/Unit Resistance, and Cell/Unit Temperature. The graphs can be interacted with in the following ways:

(1) Switch between the graphs by selecting the parameter to view.
(2) View alarm threshold values on the left of the graph.
(3) Hover over any cell to view the cell # and measured value.
(4) Normal cells report in green, warning cells in yellow, and failed cells in red.
(5) Click and drag an area of the graph to zoom in.

1. String Voltage and Current Chart

2. Cell Voltage Graph
3. Cell Resistance Graph

![Cell Resistance Graph](image)

4. Cell Temperature Graph

![Cell Temperature Graph](image)
5.2.4 List View Tab

The List View tab displays a list of the following measured parameters: Cell/Unit Voltage, Cell/Unit Resistance, and Cell/Unit Temperature. Opening this tab provides a complete display of all the measured parameters from the BMS system.

1. Sort by column by clicking on the title of the column.

2. Normal values report in white, warning values in yellow, and failed values in red.

![List View Tab Example](image)
5.3 History View

Under the System Dashboard is the History View which provides the following functionality:

- View all measured for a system from the time of installation.
- View measured data between two selectable dates.
- Trend individual cells between two selectable dates for:
  - Cell/unit voltage
  - Cell/unit resistance
  - Cell/unit temperature
- Export all measured data for a system to Excel.
- Export all measured data for a specific date to Excel.

1. To open the History View window, select the bank under the Local Server to open up the System Dashboard view. Then click the History button in the upper right corner.

(1) Select the System you wish to view the history for.

(2) Click the History button to open the History View window.
5.3.1 String History View
After clicking the History button from the selected bank, the History window will open and the default view will show the String (Bank) History.

(1) Select the date range to view measurement data for.

(2) **Bank History** is displayed by default, click **Cell History** to view the history of each cell. (Section 5.3.2)

(3) The date and time of each measurement is displayed here. Select the specific date and time to view the measurement data.

(4) The cell/unit measurement data will appear for the selected date here.

(5) The graphs for each cell/unit Voltage, Resistance, and Temperature will appear here. Click the tabs to change the chart to the desired measurement value.

(6) Export the current date and time measurement data to Excel.

(7) Export all measurement data for the selected bank to Excel.
5.3.2  Cell/Unit History View

The Cell/Unit History window allows viewing of each individual cell for voltage, resistance and temperature. This section allows trending for individual cells.

(1) Select the date range to view measurement data for.

(2) Select the individual cell/unit to view measurement data for.

(3) All measurement data for selected cell will appear here. Click each column title to sort by that column.

(4) Measurement data for the selected parameter is trended here; select the parameter to display the trending graph. Each point on the graph represents a measurement date and time. Hover the mouse over each point to view the actual date, time, and measured value.

(5) Export the current date and time measurement data to Excel.
5.3.3 Cell/Unit Trending
As described in Section 5.3.4, the Cell/Unit History view allows trending of cell voltage, resistance, and temperature. These values are displayed on a color coded line-chart to easily view trending values.

1. Cell Voltage Trending
The graph below displays the internal/connection resistance of a specific cell over a 5-week period.

![Cell Voltage Trending Graph](image1)

2. Cell/Connection Resistance Trending
The line-chart below displays the internal/connection resistance of a specific cell over a 5-week period. This cell went into WARNING alarm around 3/17/16 (line-chart changes from green to yellow) and continued to rise. The graph enables us to see that the cell alarm changed to FAIL on 4/12/16 (line-chart changes from yellow to red).

![Cell/Connection Resistance Trending Graph](image2)
3. Cell Temperature Trending

The line-chart below displays the cell temperature of a specific cell over a 5-week period. In this example the BMS was testing temperature twice per day in an outdoor cabinet. The chart clearly shows the difference in temperature between early morning and early evening.

![Temperature Chart](image)

4. Identifying System Downtime

Each of the charts above shows a consistent gap where a measurement from the BMS was missed. In this example, records for the system indicate that maintenance was performed on the date the gap is present. Gaps in the cell trending charts can be used to determine certain events which occurred on specific dates such as maintenance, communication failure, outages, etc.

![Voltage Chart](image)
![Resistance Chart](image)
![Temp. Chart](image)
6. Battery Alarms

This section provides detailed information on the **Battery Alarms** area of the software. The Battery Alarms section provides the following functionality; each of which will be covered in detail throughout this section:

- **Local Server** display of all registered BMS systems with currently active alarms.
- **System View** displays all active alarms for each individual system.
  - **History View** displays all alarms that ever occurred on the system.

6.1 Local Server Alarm View

The Local Server Alarm View displays all systems registered under the Local Server. The default view has columns for the following information:

- System Name
- System Communication Status
- System Alarm Status
- No. of Cells/Units (Jars)
- String Alarms
- Voltage Alarms
- Resistance Alarms
- Temperature Alarms

The quantity of alarms per system is shown. If more than 0 alarms are present, the number is displayed in red.
6.2 System Alarm View

Clicking on an individual system under the Local Server will display the System Alarm View window. This area will display all of the active alarms on a battery system.

(1) Select an individual system to display the active alarms on that system.

(2) Active String alarms are listed here. Each alarm has the following information:

- Serial number
- Description of the type of alarm
- Date the alarm occurred
- The set alarm threshold
- The actual measured value
- The status of the alarm (all active alarms will display as “Outbreak”)

(3) Active Cell/Unit alarms are listed here.

a. The same information from the cell alarms is shown here with addition of the cell/unit (jar) number.
6.2.1 Alarm History

Under the System Alarm View, the complete history of both string and cell/unit alarms can be viewed.

1. String Alarm History

Under String Alarms click the **History** button to display the String Alarm History window.

![String Alarm History](image1)

2. Cell/Unit Alarm History

Under Cell/Unit (Jar) Alarms click the **History** button to display the Jar Alarm History window.

![Jar Alarm History](image2)
Appendix A – Alarm Values

This section explains each alarm point that can be set in Eagle Eye’s Centroid Viewer battery management software. The alarm points used are for example purposes only, Eagle Eye does not provide actual alarm point values. To best determine the alarm point values, contact the battery manufacturer or internal personnel that manage battery maintenance.

1. String Alarm Points

The following alarm points are on the string level of the battery system.

1) **String Voltage**: Alarm point for total voltage of the battery system.
   - **High** (red): Fail point for over voltage, usually due to overcharging.
   - **High** (yellow): Warning point for over voltage, usually due to overcharging.
   - **Low** (yellow): Warning point for under voltage, usually due to undercharging or failed cells.
   - **Low** (red): Fail point for under voltage, usually due to undercharging or failed cells.

2) **String Current**: Alarm point for charge & discharge current measured from the battery system.
   - **Detect**: System will record charge event when this change current value is detected.
   - **Release**: System will stop recording charge event when the charge current value drops to this value.

3) **Charge Current**: Alarm detection points for charge current in positive amps, system will record charge event when set points are detected. Recorded events can be replayed within the software.
   - **Detect**: System will record charge event when this change current value is detected.
   - **Release**: System will stop recording charge event when the charge current value drops to this value.
4) **Discharge Current**: Alarm detection points for discharge current in negative amps, system will record charge event when set points are detected. Recorded events can be replayed within the software.
   - **Detect**: System will record charge event when this discharge current value is detected.
   - **Release**: System will stop recording charge event when the discharge current value drops to this value.

5) **Equalizing Charge**: Alarm detection point for equalize charge. When cell/unit voltage of any unit falls to reference “Ref.” value, and equalizing charge alarm will activate. **NOTE**: Do not rely on this alarm only when determining whether or not to perform an equalizing charge. This alarm should only be used by those who are confident in what conditions an equalizing charge is required for the monitored battery system.
   - **Enable**: Check to enable this alarm.
   - **Ref**: Reference value for cell/unit voltage in which the alarm will activate when enabled.

### 2. Cell/Unit Alarm Points

The following alarm points are on the cell/unit level of the battery system.

1) **Cell/Unit Voltage**: Alarm point for each individual cell/unit voltage.
   - **High (red)**: Fail point for over voltage, usually due to overcharging.
   - **High (yellow)**: Warning point for over voltage, usually due to overcharging.
   - **Low (yellow)**: Warning point for under voltage, usually due to undercharging or battery state of health.
   - **Low (red)**: Fail point for under voltage, usually due to undercharging or battery state of health.

2) **Cell/Unit Temperature**: Alarm point for each individual cell/unit temperature. Only applies to units with a temperature sensor installed.
   - **High (red)**: Fail point for high temperature. Usually caused by overcharging, high internal resistance, or uncontrolled ambient temperature.
   - **High (yellow)**: Warning point for high temperature. Usually caused by overcharging, high internal resistance, or uncontrolled ambient temperature.
   - **Low (yellow)**: Warning point for low temperature.
   - **Low (red)**: Fail point for low temperature.
3) **Cell/Unit Internal Resistance**: Alarm point for each individual cell/unit internal resistance measured in milliohms (mΩ).
   - **Reference** (1): Reference value for internal cell/unit resistance, all measured values are compared to this value.
   - **Warning**: Warning point for internal resistance, set as a percent of the reference value. Does not mean the battery is bad, but indicates that the battery might be trending toward failure.
   - **Fail**: Fail point for internal resistance, set as a percent of the reference value. Typically detected on bad cells/units, the value will quickly rise to beyond 150%. It is not uncommon for cells/units around the failed unit to also be in a Warning or Fail state.

(1) **Note on Internal Resistance Reference Value**: The reference value (baseline) for cell/unit internal resistance (also referred to as impedance or ohmic value) is not always straightforward to determine. Each manufacturer of battery test equipment uses different, often proprietary technology to determine the internal resistance value of a battery. These different methods of measurement result in different battery testers measuring slightly different internal resistance values, even on the exact same battery. Because of this variation, the internal resistance value is not typically provided by battery manufacturers, so there is not typically a common or standard value for any given battery.

The internal resistance value should be treated as a trending parameter. This means that it is important to establish a baseline early on, then continue to trend against that baseline with the same equipment throughout the life of the battery. It is generally the responsibility of the user to determine the baseline, however several methods are recommended when determining the baseline of a battery:

1. Test the internal resistance value of each cell/unit approximately 6 months after the batteries have been installed and use the average as the reference value. This gives the batteries time to settle and will provide a more accurate value than at the time of installation.

2. The above method might not always be possible, especially if installing the BMS to older batteries. In this case, measure the internal resistance of each cell/unit and use the average assuming that the readings from unit to unit do have considerable deviation.

3. If the readings from unit to unit have considerable deviation, test the internal resistance value of a battery of the same make and model that is known to be in a good state of health. Alternatively, test the internal resistance of a battery that is of the same technology (VRLA, VLA, or NiCad), voltage, and capacity that is known to be in a good state of health.

When dealing with internal resistance, it is important to remember that it is not an exact science as compared to voltage and other parameters. There is room for some variation between cells/units within a battery system.
Appendix B – Sample Reports

PDF Report

Stationary Battery Check Report

Basic Information

- String Name: EE-DDS-48V
- Location: 4031 W Kiehnau Ave, Milwaukee, WI 53209
- Model: MCX-9
- Voltage: 46
- Capacity: 344
- Measured by:
- Date: 7/11/2016
- Manufacturer: GNB
- Manufacture Date: 10/15/2009
- Install Date: 6/1/2015

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