Diagnosing Incorrect Cell Voltage Readings

This document is intended to assist in diagnosing voltage readings that are incorrect while the battery pack is at rest (no current entering or leaving the battery pack) only. If the voltage inaccuracies only show up when the battery pack is in use this may be the result of a high resistance link rather than a wiring issue. Please see the "Cell voltages appear incorrect (under load)" document for more details.

Incorrect cell voltage readings while at rest can be caused by the following:

1. Disconnected, intermittently disconnected, loose or high resistance cell tap wire or corroded connector / ring terminal.
2. Incorrect cell tap wiring, particularly if more than 2 cells are showing an incorrect voltage
3. Blown fuse inside the BMS from previous wiring fault, altering cell wiring while the BMS was connected or a cell voltage outside of the nominal maximum range or other damage or faults.

Note: A disconnected, loose or intermittent cell tap connection will result in ***undefined*** voltage readings for the cell tap in question and *often results in undefined voltage reading for at least one other adjacent cell.* Due to protection diodes inside the BMS unit, an undefined cell voltage reading may appear correct at times even though the tap wire is disconnected. All 3 of the above conditions can cause multiple voltage readings to become inaccurate and it is common for a single bad cell tap wire to cause one voltage reading to be high and an adjacent reading to be low.

Most cases of a cell voltage showing incorrectly when the pack is not under load or charge are a result of wiring an loose or disconnected cell tap wire or a result of damage to the BMS unit from altering battery pack wiring while the BMS is connected. This damage most commonly occurs if wiring, including terminals, busbars, etc inside the battery pack have been altered in any way while the BMS is connected to the battery pack. Always ensure that the BMS connectors are **unplugged** from the BMS unit before making any changes to the battery pack since this can damage the BMS unit. If the wiring harness appears to check out, connectors can be swapped around on the BMS to give an indication if the problem is located inside the BMS (i.e. previous damage) or a problem with the wiring.

Note: If the voltage is correct while at rest and only becomes incorrect while the pack is being charged or discharged, the issue may be related to cell or terminal resistance and not from the causes listed in this document.

Important Note: Never leave a damaged BMS unit connected to a battery pack.

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173

Steps To Resolve

Step 1. Using a multi-meter, manually check the voltage of the actual cells.

First, check the voltage of the cell in question as well as the voltage of the surrounding cells to ensure the cell in question is actually a different voltage. Also, using the multi-meter, check to ensure that the sum of the voltage of all the cells in the particular cell group is at least 11 volts. Keep in mind that the accuracy of a mutli-meter may be lower than the accuracy of the BMS, so the readings may differ slightly in normal circumstances. Additionally, the accuracy of some multi-meters will change when the meter's battery is low. Verify the correct operation of the multi-meter by verifying the voltage of a known voltage.

Step 2. If the cell voltage is reading 0 volts, ensure that the BMS is properly configured to monitor this cell.

Unpopulated cells are ignored by the BMS and show up as zero volts (or a voltage near zero some cases.) The population settings can be seen and modified in the BMS utility on the Battery Profile tab under Cell Settings -> Cell Population Settings. Verify the population table is correct and that the settings have been properly uploaded to the BMS. For more information on cell population settings, please refer to the software manual.

Step 3. Verify the cell tap wiring is correct.

A. **Verify correct order of cell taps.** Verify the correct order of the cell taps using a tap validation tool or multimeter. Adjacent cell taps cannot be more than 5V or less than 0V. If cell taps are in an incorrect order, damage to the BMS can occur and can cause fuses inside the BMS to blow. If a fuse inside the BMS has blown, the voltages may actually appear correct even if there are cell taps in an incorrect order. Checking the correct order of wires is critical to ensure that the BMS will not get damaged.

   Note: The tap validation tool is designed to detect the correct order of cell tap wires. It is not designed to or able to detect intermittent connections or high resistance cell tap wires such as can occur from corroded connectors, broken but intermittently connecting wires, etc.

B. **Check to ensure that enough cells are wired into the affected cell group and that the voltage of the cell group is sufficient.** Each cell group on the BMS must have a minimum of 11v on the group to maintain accurate readings. If the total voltage of all the cells in any group drop below 11v, accuracy of the cell voltage measurements in that group will be decreased. At a low enough voltage, no cell voltages from that group will appear. In most cases, this means at least 4 cells must be wired on the cell group (assuming a minimum cell voltage of 2.8v or higher, for cells with a lower minimum voltage, the minimum number of cells may be higher.) If less than 4 cells are wired to the cell group, re-arrange the cell groups to allow for the minimum number of cells.

C. **If less than 12 cells are used in this cell group, ensure proper connection of the unused wires.** When less than 12 cells in a group are present, the unused wires must be connected to the positive most terminal within that group. For example, if only 8 cells are loaded, the cell tap wires for 9,10,11 and 12 must all be connected to the same location as the wire for cell tap 8.

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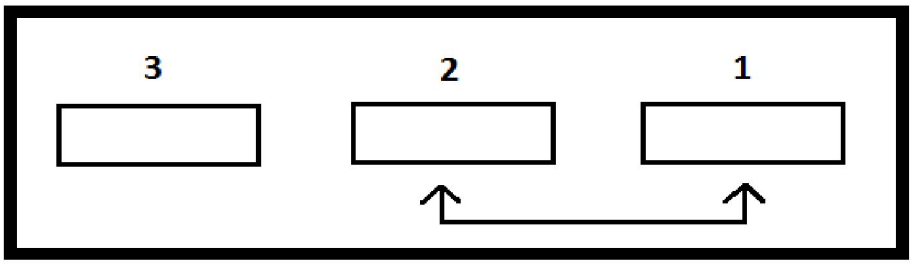
Step 4. If possible, attempt swapping the order of the cell tap connectors

Swapping the connectors on the BMS is a very useful test that can help identify if the problem is located in the wiring harness or with the unit itself. This procedure is possible since each cell tap connector on the BMS is isolated from the other cell tap connectors with 2.5kV isolation, however since the electronics inside the BMS are not populated for smaller units, it does require a minimum of a 48 - 72 cell size BMS for this to work depending on where the fault is. If it is not possible to swap the order of the connectors, it may be possible to swap out the entire BMS unit with a spare unit if one is available.



Example of swapping connectors 1 and 2 to test the wiring harness.

If the problem stays at a specific location on the BMS even though a different harness has been connected to it, the problem is likely inside the BMS unit. If the problem remains at the location on the BMS, the BMS unit will likely need to be or sent in for servicing. Contact Ewert Energy for repair options.

- otherwise -

If the problem follows the wiring harness to a new location, the problem is almost certainly with the wiring harness. Proceed below.

Step 5. Inspect the cell tap wiring.

If the problem followed the wiring harness in the step above, the issue is either in the wiring harness or with a connection to a cell. If this is the case or if the above test is not possible due to the size of the BMS, the best approach is usually to replace the cell tap wiring / connectors, etc for the cell in question plus the one directly above and below the particular cell tap as the wiring for the cell before and after may also be the problem. Note that an intermittent or high resistance cell tap connection may measure fine with a multi-meter and the tap validation tool and may still be bad.

WARNING: Always fully disconnect the cell tap connectors on the BMS before adjusting any wiring within the battery pack to prevent damage to the BMS. Ensure that all wiring is correct before connecting the BMS back up.

The most common wiring fault causes include:

1) Broken wire. Note that this can occur inside the insulation of a wire that physically appears OK on the outside the same way it can happen on a headphone connection or power cord for a laptop that works only when the cable is at a certain angle – the cable may look fine, but is not

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making a solid connection inside. If the BMS is throwing a P0A04 open wiring fault and the problem follows the harness to a new location, there is a strong possibility of this.

2) Bad crimp on a ring terminal or overcrimped wire – it is possible if a ring terminal or other terminal is crimped too hard it may break the wire inside the crimp – this is particularly possible with the portion of the crimp securing the insulation on the wire.
3) Terminals that are not properly connected such as wires simply pressed against terminals.
4) A resistor in series with a cell tap wire or fuse with too high of a resistance (note that resistors are not allowed in series with cell taps.)
5) A blown fuse.
6) Corrosion, either at a battery terminal, ring terminal, intermediary connector or BMS connector.

Additional Hints

If an "open wiring fault" (P0AO4) is present on the BMS, this indicates that the BMS tested and found that the wire was too high resistance. This test quickly places a small load on the cell tap wire to test the integrity of the wire and measures for significant voltage drop during the test.

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