DTC P0A04 - Open Wiring Fault

Product Family	Fault Supported
Orion BMS [Original] (24 - 180 Cell)	**YES**
Orion BMS 2 (24 - 180 Cell)	**YES**
Orion JR [Original] (16 Cell)	**YES**
Orion JR 2 (16 Cell)	**YES**

FAULT DESCRIPTION

This fault is a serious error that effectively disables the battery pack and often causes other fault codes to occur. When diagnosing errors, this error code should be corrected first.

This error code indicates that the BMS has determined that a cell tap wire is either weakly connected or not connected at all (open) and as a result, it has determined that it cannot accurately measure cell voltages. Open wiring faults can be caused by improperly wired cell taps, loose cell tap connection, corrosion build-up on cell terminals, damaged busbars, cell taps that are not connected to the battery, internal fuses blown inside the BMS or other internal damage to the BMS from previous improper wiring.

To detect this condition, the BMS will periodically place a small internal current load (approximately 100 micro-amps) on each cell tap input very briefly and observe the amount of voltage drop this load creates. This allows for the BMS to gauge the rough resistance (impedance) of the wire connections to look for abnormalities. On Orion 2 and Orion JR 2, the BMS will also apply a small charge (also approximately 100 micro-amps) to check for voltage deviations in both directions which improves accuracy. This is an important test for the BMS to perform regularly as the protection diodes inside the BMS may cause the cell voltages to appear roughly normal when a cell tap wire may in fact be open or disconnected. **When voltages are inaccurate due to an open wire, one cell voltage**

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usually rises while the adjacent cell voltage drops. One cell voltage reading high while the adjacent cell reads low is a typical sign of an open wire fault.

For more information on what causes fuses within the BMS to be damaged, please see Why Orion BMS Internal Fuses Blow.

Warning: Never continue to use a damaged unit. Damaged units must be immediately disconnected from all wiring harnesses and power sources including cell taps and Main I/O. Please contact contact the factory or an authorized reseller for evaluation and repair options. There are no user serviceable parts inside the unit and opening the enclosure will void the warranty. Due to hazardous voltages and risks posed by improper repairs, users should never attempt to repair a damaged BMS unit. Ewert Energy is not liable for damage caused by user attempted repairs or continued use of a damaged BMS unit.

Note: The Orion BMS scans for this fault condition at set intervals and it may take several minutes for this error to show up depending on the severity of the fault condition. This is especially true if a wire has a high impedance connection or is intermittently failing. Certain intermittent wiring errors may not trigger this error message since the error must be present for a minimum amount of time to trigger.

Note: It is possible for a “non-populated” cell to appear under the “open wire” list on the diagnostic trouble code tab even if they are wired properly. Even though a cell marked as unpopulated may be listed, it will not set an error code.

Note: The BMS may still read a roughly correct voltage on a cell flagged as “open wire”. This does not necessarily mean that the BMS is functioning correctly or that the fault code was set incorrectly. Due to the way that the BMS voltage sensing circuitry works it’s possible for the BMS to read approximately correct voltages on a cell that is completely disconnected under certain circumstances. The problem arises when the cell voltages start to change under load or charge (the “open wire” fault detection circuitry is able to look for these conditions even when the battery pack is at rest).

Fault Code	Fault Description	Possible Trouble Area
P0A04	An open or high resistance connection was detected by the BMS on one or more cell tap wires.	• Battery Pack Assembly • Battery Wiring Harness • Internal BMS Fault

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FAULT BEHAVIOR

This fault will trigger **Voltage Failsafe Mode** which will inhibit the BMS from allowing charging or discharging of the battery pack.

IMPORTANT NOTE:
A single open wire (wiring fault) in a cell group may cause cell voltages in the rest of the cell group to be incorrectly measured. Cell voltages may read artificially higher or lower due to the effects of the protection diodes contained within the Orion BMS and cannot be trusted when this error message is present which is why such drastic steps are taken.

FAULT THRESHOLDS

Fault will trigger when **ANY** of the following conditions are satisfied	(a)
(a) An open wire fault is consistently detected by the BMS.	A fully open or high resistance link between the BMS and one or more cell terminals is detected. The BMS requires multiple positive triggers on a specific cell before the fault is actually set. The tests are performed once every 15 seconds during normal operation. At least 3 triggers on the same cell must be detected before a fault is set. This count is decremented once every minute to provide longer term hysteresis.

DIAGNOSTIC STEPS

1.	**Determine which cells are flagged as open by the BMS.**

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	The BMS will categorize which cells (by cell ID number) are registering this fault code. Steps to view the list of Open Wiring Fault IDs: 1) Connect to the BMS using the Orion BMS utility. 2) Click the "Diagnostic Trouble Codes" tab at the top. 3) View the "Open Faults" section on the far right hand side of the window. Please note that these are the tap positions on the BMS itself and do not necessarily correspond to the actual cell numbers. Inspect the wiring harness for obvious issues such as disconnected wires or obviously loose wires. Terminal oxidation, loose terminals and bad crimps can all cause issues and may not be visually obvious. If external fuses are used, verify they are both good and sufficiently low resistance.
2.	**Test the wiring harness with the Orion BMS tap validation tool.** The tap validation tool is designed to check the voltage of each cell tap and indicate when wiring errors are found. The tap validation tool can locate completely disconnected wires and wires that are very high resistance. It is possible that if wires are intermittently loose or only moderately high impedance, that the tool may not find them. If a tap validation tool is not available this testing can be performed with a hand-held multi-meter (see wiring manual for details). **NOTE:** Please review the product wiring & installation manual to ensure that all minimum requirements are met for the product being installed. Some products require a certain amount of cells to be loaded to function correctly.
3.	**Determine if cell tap wiring was previously incorrect.** If the BMS has been previously wired incorrectly, it is possible internal damage to the BMS can cause this fault condition. Each cell tap has an internal fuse in series with the tap in order to protect the BMS from significant damage and to protect the wiring harnesses in the event current is forced through the cell taps. The fuses can withstand many common wiring mistakes and will usually "reset" after the wiring error is fixed without blowing the internal fuse, but wiring errors which expose two adjacent cell taps to more than +/- 24v may cause internal fuses to blow. If fuses have blown, the BMS unit must be returned for service.
4.	**If possible, attempt swapping the order of the cell tap connectors.** On BMS units that support multiple cell tap harness connectors (standard Orion BMS units over 36 cells), swapping the connector locations on the BMS around is a very useful test that can help identify if the problem is located in the wiring harness (external) or with the unit itself (internal).

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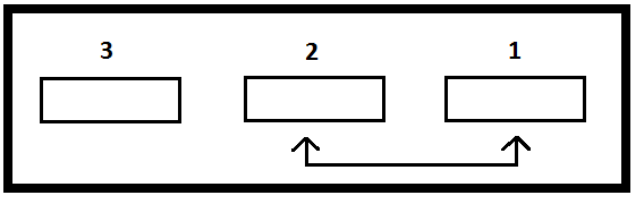

Example of swapping connectors #1 and #2 to test the wiring harness.

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.

If the problem follows the harness (ie: the issue moves from cell 5 to cell 41) then the problem is with the wiring itself. If the problem remains on the same cell despite swapping the affected connector, the problem most likely is a blown internal fuse on the BMS. Internal fuses require servicing of the unit to repair.

5. **Inspect the cell voltage 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 contribute to the problem. Note that an intermittent or high resistance cell tap connection may measure fine with a multi-meter or the tap validation tool, yet still ultimately be problematic.

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 open 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 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.

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	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. **Friction fit connections to cell terminals are strongly discouraged, as they are highly vulnerable to vibration.** 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) Corrosion, either at a battery terminal, ring terminal, intermediary connector or BMS connector. 6) Improperly terminated cell groups. If a cell group is used on the BMS, any unused cells on that group must be terminated to the most positive cell in that group. For example, on a standard Orion BMS, if cell taps 1 thru 8 are connected to cells, cell taps 9 thru 12 must be tied to cell 8 positive to complete the circuit. 7) Insufficient stack voltage on a cell group. On the Orion standard BMS products, each group of 12 cells must be at least 12vDC nominal for proper operation (this typically equates to 4 cells in series or more for most lithium chemistries). If the group is below 10vDC it can reduce the accuracy of the cell sensing circuitry, and in some cases can result in an open wire fault if the voltage is significantly low.
6.	**Download the freeze frame for the fault code using the BMS Utility.** The BMS will normally produce a freeze frame on the "Diagnostic Trouble Codes" screen in the BMS Utility when this fault code occurs that contains a comprehensive list of BMS data parameters at the time the fault occurred. **It is strongly recommended that the freeze frame be downloaded from the BMS and saved to disk before the fault is cleared again** as this data may assist in the future if further diagnostics are required. Additionally this freeze frame data may be requested by Technical Support if further assistance is required. **NOTE:** Only Fault Codes with a (F) next to them have freeze frame data available for download. If there is no (F) next to the fault, there is no stored freeze frame available and this step can be skipped. Steps to download the Freeze Frame: 1) Connect to the BMS using the Orion BMS utility. 2) Click the "Diagnostic Trouble Codes" tab at the top. 3) Select the correct fault code by clicking on the ID on the left side of the screen to initiate the Freeze Frame retrieval. 4) Once the retrieval process is complete, click the "Export (CSV)" button to save the freeze frame data to the computer disk.
7.	**Contact technical support.**

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	Please contact the company or reseller that the BMS was originally purchased from for additional questions, warranty claims, repair requests and technical support.

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