NIGHTSHIFT SURVEILLANCE

HYBRIDLIGHT SOLUTIONS LLC.

Troubleshooting Guide Revision __

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Required Tools

- Laptop with Software (APECS, OrionBMS, Axis Camera Software)
- Serial Cable (RS232)
- USB to RS232 Adapter if Required
- Ethernet Cord and Adapter if Required
- Multimeter
- Basic tools

HYBRIDLIGHT SOLUTIONS LLC.

NIGHTSHIFT SURVEILLANCE

Outline

BMS FAULTS

01

DTC SPN = 1370 FMI = 0 Internal Communication Fault

FAULT DESCRIPTION

This error indicates that the Orion BMS has encountered an error trying to communicate with the isolated circuitry that measure cell tap voltages. This error can be caused by external electrical noise if the BMS is not properly grounded or by an internal hardware failure.

Fault Code	Fault Description	Possible Trouble Area
P0A1F	An internal communication fault (cell voltage measurement) was detected.	• Battery Management System

FAULT BEHAVIOR

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

DTC SPN = 1370 FMI = 0 Internal Communication Fault (Cont. 1)

DIAGNOSTIC STEPS

1.	**Ensure that the BMS case is properly grounded.** Almost all cases of this error are caused by grounding issues. In most cases, the enclosure should be grounded to the chassis and the chassis would also be connected to the 12/24v ground, however is some applications without a grounded chassis, it may be necessary to ground the BMS enclosure to the negative wire on the 12/24v power supply or another ground. Please refer to the wiring manual for more information.
2.	**Remove all sources of noise and determine if the error returns.** Sources of noise include battery chargers, inverters, DC:DC converters and power supplies for the 12v power source. Additionally, some Earth ground connections may also conduct significant electrical noise. If the error persists even when all devices generating noise are disconnected and turned off, the BMS should be tested by an authorized dealer or the factory to determine if the BMS unit is working properly.
3.	**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. <u>Additionally this freeze frame data may be requested by Technical Support if further assistance is required.</u> **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.
4.	**Contact technical support.**

DTC SPN = 1370 FMI = 2 Weak Cell Fault

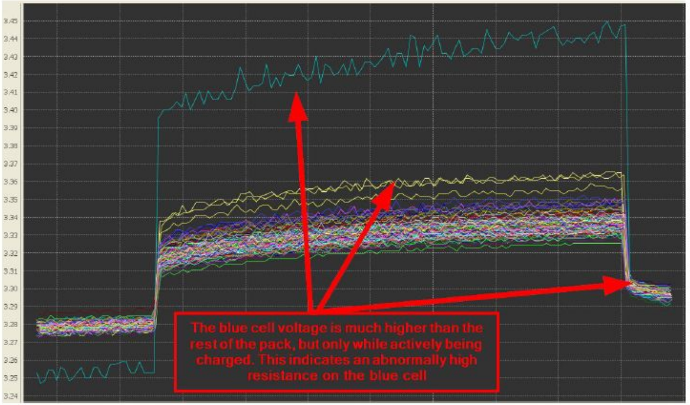
FAULT DESCRIPTION

This fault is triggered based on thresholds programmed into the BMS profile that indicate when a cell is "weak". While this error code is designed to indicate a cell is weak, **this error is triggered when certain pre-programmed conditions are met and does not necessarily indicate a dead cell because it can also be triggered by loose busbars, other wiring issues or incorrect error threshold settings in the profile.**

While this error code will not impact the operation of the BMS, this error message likely indicates a problem exists and the actual problem itself (not this error code) may cause the BMS to limit charge or discharge current (as would be the case with a high resistance cell). If the charge and discharge limits are both zero, look for other fault codes, specifically open wire faults or total pack voltage fault codes to begin addressing the issue.

The "weak" cell fault can be triggered as the result of the following 3 conditions:

1. **High measured cell resistance** – The Orion BMS measures each cell's internal resistance and compares the measured resistance against the nominal resistance specified in the profile in the "temperature compensation" section. The current temperature is used to select the nominal resistance value to compare against. If the measured resistance is higher than the nominal resistance by the amount specified in the profile (General Settings -> Maximum Resistance [%]), a fault code will be triggered. For example, if the nominal resistance is 1 mOhm at 20 degrees Celsius and the BMS is programmed with a maximum resistance threshold of 2 mOhm at 20 degrees Celsius, an error code will be triggered if the cell resistance is measured at more than 2 mOhm resistance at 20 degrees Celsius. An increase in the cell resistance will result in an increase in the voltage drop / voltage rise while under load / charge respectively.

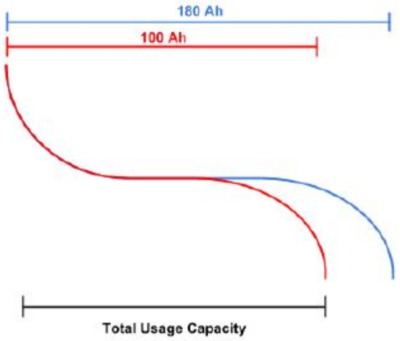


An example of a high resistance cell

Most often this condition is the result of a loose busbar or a problem with a cell interconnect cable. Because the BMS measures cell voltages by measuring the voltage between each of the cell voltage tap connections, the BMS also "sees" the resistance of the busbar or cable connecting the cell with the adjacent cell. Because of this, the busbar resistance is included in the measured cell resistance. If a busbar, cable or battery terminal is loose, corroded or oxidized, this can cause the measured resistance to rise and trigger the error.

DTC SPN = 1370 FMI = 2 Weak Cell Fault (Cont. 1)

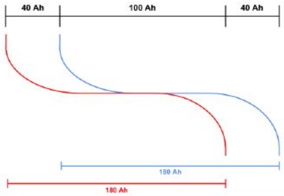
2. **Difference in open (sitting) cell voltage between one cell and the rest of the pack** – In addition to measuring the resistance of the cell, the BMS also looks for significant differences between the open cell voltage of a cell and the rest of the pack. The BMS calculates the open circuit voltage of each cell (this is the voltage as if the cell were setting at rest (no load) even when a load is applied to the cell). The BMS compares each cell's open circuit voltage to the pack average open circuit voltage and if they differ more than the preset value in the profile, a weak cell fault is triggered. The setting is under the "Fault Settings" tab -> "Weak Cell Settings". This can be caused by a cell that has deteriorated disproportionately to the rest of the battery pack or by a cell balance issue.

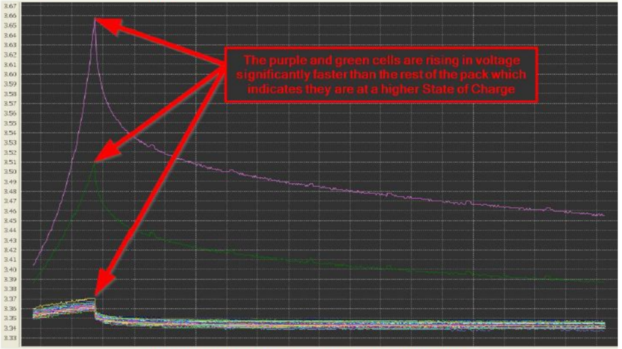


A cell with a significantly lower capacity than the rest of the pack will likely cause a large difference in open cell voltages at lower states of charge. Additionally, the internal resistance of cells typically goes up when they are at very low and high states of charge. A lower capacity cell may also trigger a weak pack error code.

DTC SPN = 1370 FMI = 2 Weak Cell Fault (Cont. 2)

3. **Cell being out of balance with the rest of the pack** – A cell that is significantly out of balance with the rest of the pack can trigger this error message for the same reason as above. For balance issues, the issue can easily be resolved by simply balancing the pack.





An example of two cells being out of balance with the rest of the pack.

FAULT THRESHOLDS

Fault will trigger when **ANY** of the following conditions are satisfied	(a) **OR** (b) **OR** (c)
(a) High battery cell resistance beyond programmed maximum cell resistance threshold at current battery temperature.	Monitored battery cell is showing abnormally high voltage drop (high cell resistance). This is determined based on the thresholds set on the "Cell Settings" tab -> "Cell Resistance" in the BMS Utility Profile settings. This threshold will change based on the battery pack temperature.
(b) Low battery cell capacity (manifesting in a significantly different sitting voltage than the rest of the battery pack).	Monitored battery cell is demonstrating lower energy capacity than expected (higher voltage than the rest of the pack at full charge and lower voltage than the rest of the pack at low charge).
(c) Battery cell out of balance with the rest of the battery pack.	Monitored battery cell is out of balance with the rest of the battery pack (cell is constantly registering lower voltage than the rest of cells or higher voltage than the rest of cells).

Orion BMS

DTC SPN = 1370 FMI = 3 Low Cell Voltage Fault

DIAGNOSTIC STEPS

1.	**Determine which cells are flagged as weak by the BMS.** 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 "Weak Cell" 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. A freeze frame may also be available which will give much more detailed information about the conditions when the fault occurred. Only one freeze frame will be stored, so if multiple cells are "weak", detailed information will only be available for the first cell that was flagged as weak (chronologically).
2.	**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.
3.	**Determine if fault was set due to high resistance or open voltage.** This can be determined by looking at the freeze frame data and looking at the cell resistances and the open cell voltages and comparing them to the values programmed into the BMS profile. For example, if the affected cell's open circuit voltage is 0.5V lower than most of the other cells and the trigger threshold is 0.5V, that is likely the cause. Likewise, if the cell resistance is greater than 4.0 mOhm and the maximum resistance threshold is also 4.0 mOhm with the nominal resistance of 1 mOhm for this specific temperature, that is likely the cause. Go to the next step based on whether the issue is high resistance or open cell voltage difference.

DTC SPN = 1370 FMI = 3 Low Cell Voltage Fault (Cont. 1)

4. **High Resistance:**

Step 1. Check if there is additional resistance from long cables, busbars, fuses, and particularly loose terminals.

This can be done by inspecting the battery pack. If a longer cable or longer busbar is used to connect the cell in question to the next cell, "busbar compensation" or re-wiring may be required to compensate for the additional resistance. Please see the wiring manual for more information on high resistance cables. Special rules apply to the placement of fuses and if a fuse is directly adjacent to a "weak cell", please review the wiring manual to ensure proper placement.

Step 2. Check to see if the high resistance can be explained by difference in temperature.

Low temperatures can cause dramatic increases in resistance for some cells. If the cell is a significantly lower temperature than the rest of the pack such as when a pack is split into multiple locations, it may be necessary to add (or move) a thermistor to this cell so the BMS can monitor the temperature better or ideally, alter the thermal management to keep all cells roughly the same temperature.

Step 3. Determine if the high resistance can be explained by the state of charge.

The internal resistance of most Lithium-ion cells will spike significantly at very high and low states of charge such as the top 2% and bottom 2%. Look at the actual cell voltage under no load (open cell voltage) for clues if the cell is fully charged or fully discharged.

Step 4. Check the nominal resistance in the BMS profile to ensure it is proper for the type of cell selected at the temperature where the error code was triggered.

The nominal resistance table can be found in the BMS utility under thermal compensation. The Orion BMS may incorrectly set an error if the nominal resistances in this table are wrong.

Step 5. Manually measure the resistance of the cell at the actual cell terminals.

At this step, it is now likely that either the cell or the busbars connecting the cell to the next cell actually has a high resistance. Cell resistance can be measured by applying a known load (or source) to the battery pack and measuring the voltage drop at the cell. Care must be taken to ensure that the known load or source will not over-charge or over-discharge any cell in the pack as this can cause damage and a serious safety hazard. This can be done by using a multimeter with the leads on ***the actual cell terminals*** (not the screws, ring terminals, etc). With the leads on the terminals, note the cell voltage with no load (or source). Then apply the known source and measure the cell's voltage again at the terminal after the load has been on 10 seconds. Calculate the cell's DC resistance with the following calculation: DC resistance = (Voltage_before_load – Voltage_after_load) / known_amperage. If the cell is high resistance, replace the cell.

Step 6. If cell resistance is good, look specifically for loose terminals, oxidized terminals, or bad crimps.

The resistance of the busbars and connections will increase dangerously if terminals are loose, oxidized, etc. Busbars and terminals can oxidize or corrode in ways that are not visible or obvious. If there is a question, remove, clean and reseat the busbar or terminal (always disconnect all cell voltage tap and pack voltage connectors from the BMS first!) The resistance of the busbars can be measured by applying a known load (or source) to the battery pack and measuring the voltage drop on the busbar and therefore calculating the resistance. Care must be taken to ensure that the known load or source will not over-charge or over-discharge any cell in the pack as this can cause damage and a serious safety hazard. Using a multimeter capable of measuring voltages in millivolts, measure the voltage between the actual cell terminal of the suspect cell and the actual cell terminal of the next adjacent cell connected to the same busbar. The measurement should read 0.000v (or almost that) with no load. When a known load is applied, make note of the voltage. Typically the voltage drop should only be a few millivolts, but the actual value will vary depending on the amperage used to test and based on the thickness of the busbars and terminals. Because of this, it may be useful to measure the resistance of surrounding busbars for comparison. The resistance of the busbar can be calculated with the following formula: busbar_resistance (in ohms) = Voltage_measured / amperage.

DTC SPN = 1370 FMI = 3 Low Cell Voltage Fault (Cont. 2)

5.	**Difference in Open Circuit Voltage:** **Step 1. Check the cell voltages when the battery pack is fully charged.** Carefully monitoring the battery for unsafe conditions such as high temperature and over-voltage, charge the battery pack up to full charge (use the BMS to control the charger ensuring that no cells get over-charged). When at a full state of charge, compare all cell voltages using the Orion BMS utility or a multimeter. For iron-phosphate cells, the voltage should be compared immediately after the charge termination since the voltages will quickly fall back into the 3.35 volt range and will mask the difference in balance. If the cell in question has a noticeably different voltage than the rest of the pack, the difference in open circuit voltage is likely due to a difference in balance. If the open circuit voltage is identical to the rest of the pack at full state of charge, the issue is likely that the cell has a deteriorated capacity. To confirm deteriorated capacity, cell voltages can be graphed using the data logging and graphing capabilities in the Orion BMS utility and the shape of the discharge curves can be analyzed.
6.	**If the problem persists, contact technical support.** If all above steps fail to determine the cause of the fault then additional support is needed. **Please contact the company or reseller that the BMS was originally purchased from for additional questions, warranty claims, repair requests and technical support.**

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault

FAULT DESCRIPTION

This fault is a serious code that effectively disables the BMS and often causes many 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 and as a result, it has determined that it cannot accurately measure cell voltages. Wiring faults can be caused by improperly wired cell taps, loose cell tap connection, 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.

In order to detect this condition, the BMS will periodically place a very small pulse of current on the tap wire and measuring the voltage drop of the wire. 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 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.

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault (Cont. 1)

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.

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault (Cont. 2)

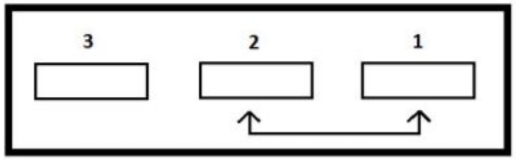
DIAGNOSTIC STEPS

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

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault (Cont. 3)

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 or with the unit itself.

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault (Cont. 4)



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 problem most likely is a blown internal fuse on the BMS. Internal fuses require servicing of the unit to repair.

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault (Cont. 5)

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 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 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.

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault (Cont. 6)

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.

DTC SPN = 1370 FMI = 4 Open Cell Voltage Fault (Cont. 1)

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

DTC SPN = 1370 FMI = 5 Current Sensor Fault

FAULT DESCRIPTION

The Orion BMS uses an external current sensor to measure and track the amount of current (amperage) going into and out of the battery pack. This allows the BMS to accurately track State of Charge, Cell Resistances (impedance), calculate current limits and observe the overall pack health.

There are two different types of current sensors used by our products: Hall Effect and Shunt Sensors:

- Hall effect sensors work by measuring the magnetic field generated by current as it travels through the power cables and are fully passive (they go around the power cables and thus are non-invasive). This value is converted by the sensor to a linear 0-5v analog signal that is measured by the BMS.
- Shunt sensors are technically large resistors that intentionally cause a predictable voltage drop across them when current is run through, allowing the BMS to determine the overall amount of current flowing through based on how much voltage drop is present across the sensor. Because this voltage drop is extremely small (+/-50mV for the full range of the sensor) it can be very difficult to observe this without high precision equipment.

Because this sensor is very important to the overall product operation, the BMS will monitor the behavior of it continuously. There are a number of abnormal conditions that will trigger this fault.

DTC SPN = 1370 FMI = 5 Current Sensor Fault (Cont. 1)

Fault Description	Possible Trouble Area
The BMS has determined that the current sensor is either unplugged (disconnected) or that the current being run through the sensor is exceeding the maximum ratings for the sensor (maxing out the sensor by over saturation).	• Current Sensor • Current Sensor Wire Assembly • Application Drawing Too Much Current
The polarity (directionality) of the current sensor appears to be reversed or installed backwards.	• Configuration Settings (Current Sensor Polarity)

DTC SPN = 1370 FMI = 5 Current Sensor Fault (Cont. 2)

FAULT BEHAVIOR

This fault will trigger **Current Sensor Failsafe Mode** which will inhibit the BMS from using the values from the current sensor in calculations.

This impacts the following calculations:

- State of Charge (coulomb counting is disabled)
- Cell Internal Resistances (resistance calculation is disabled)
- Current Limits (limit determination accuracy is severely reduced)

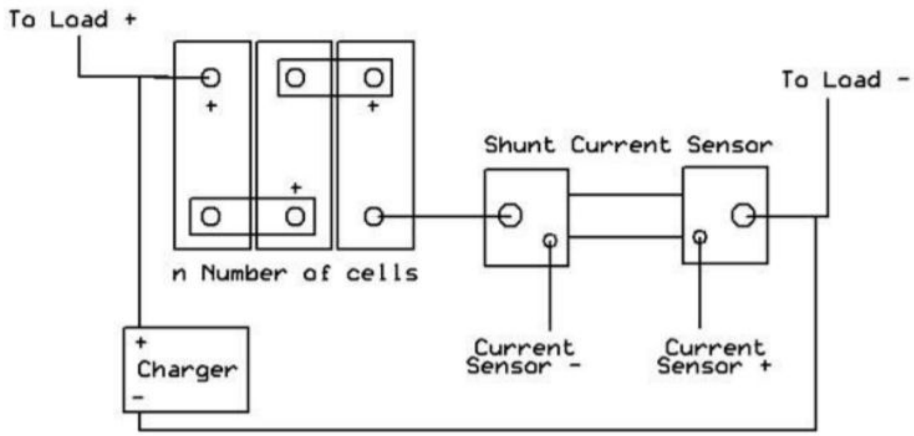
DTC SPN = 1370 FMI = 5 Current Sensor Fault (Cont. 3)

FAULT THRESHOLDS

Fault will trigger when **ANY** of the following conditions are satisfied	(a) **OR** (b)
(a) Current sensor maximum range exceeded	Measured value from current sensor exceeds the maximum range ratings for the sensor itself (or the sensor is reading as disconnected)
(b) Current appears to be measured backwards	The current sensed appears to be backwards or inverted (eg: discharging the pack results in higher pack voltage)

DTC SPN = 1370 FMI = 5 Current Sensor Fault (Cont. 4)

Shunt Style



Schematic showing the current sensor wiring for a **Shunt style** sensor

DTC SPN = 1370 FMI = 5 Current Sensor Fault (Cont. 5)

1.	**Verify that the current sensor is correctly wired and plugged in.** If the current sensor is miswired or disconnected this will result in a fault being set. Carefully inspect the wiring harness going from the BMS to the current sensor to ensure that it is both wired properly and free from defect or damage (a damaged or cut wire would also result in a fault). If the current sensor is intentionally disconnected or not used (for applications opting to forego the sensor entirely), the current sensor itself must be disabled on the "General Settings" tab in the BMS utility (by selecting "None" in the "Selected Current Sensor" field). **For Shunt style sensors (this does not apply to hall effect style sensors), make sure the current sensor is installed right before the NEGATIVE side of the battery pack, just before cell 1 negative. The sensor should be installed as close to the battery pack negative terminal as possible.**

DTC SPN = 1370 FMI = 5 Current Sensor Fault (Cont. 6)

2.	**Attempt to replace the suspected components.** If possible, try using a known good current sensor or wiring harness assembly to rule out components.
3.	**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.

DTC SPN = 1370 FMI = 5 Current Sensor Fault (Cont. 7)

If the problem persists, contact technical support.

If all above steps fail to determine the cause of the fault then additional support is needed.

DTC SPN = 1370 FMI = 6 Pack Voltage Sensor Fault

This fault code is set if the total pack voltage sensor reads zero volts. This error will also cause a voltage redundancy fault code. This fault code may be the result of the voltage tap connection not being connected when the BMS was turned on, a wiring error on the total pack voltage sensor, a voltage tap that is wired to the wrong location or an internal BMS error.

If this error is triggered, the BMS will assume that it cannot accurately measure the voltage of the battery pack and will go into a voltage failsafe mode. The voltage failsafe mode is the most critical condition and ***the BMS will not allow charge or discharge when this error is present.***

DTC SPN = 1370 FMI = 6 Pack Voltage Sensor Fault (Cont. 1)

Resolving this error code:

Step 1. Check to insure the total pack voltage sensor is properly connected to the Orion BMS and that the full pack voltage is present at the connector.

It may be possible that pack voltage is interrupted by a safety disconnect or blown fuse in the battery pack if those are included in the battery pack design.

Step 2. If the BMS unit was powered before the total pack voltage sensor connector was connected, this error code may simply be caused by the BMS not seeing voltage when it was first powered up.

If this was the case, attempt to clear this error code and monitor to see if the error code comes back. To clear codes on Revision A – C units, either remove all power from the unit for >30 seconds or use the utility to clear the codes. For Revision D and newer units, the best approach is to use the utility to clear the error code. If the Revision D or newer unit is setup not to store error codes over power failures, power all power can be removed from the unit for >45 seconds to clear the error codes. Clearing error codes will delete freeze frame data that may be useful for diagnostics. If other errors are present, review the freeze frame data before clearing.

Step 3. Using the BMS utility, download the freeze frame data for this error code by clicking on the error code.

See the software manual for more information on downloading the freeze frame data. The text will show the total pack voltage when this error was triggered. Review the data for clues about why the voltage was not measured (for example, if the runtime counter is zero, it may be helpful to know the error happened when the BMS unit was powered on). The real-time total pack voltage sensor value can be seen on the “Live Text Data” screen and may be useful for diagnosing loose or intermittent connections.

DTC SPN = 1371 FMI = 2 Thermistor Fault

For thermistor faults on the main BMS unit, inspect the thermistor wiring.

Carefully inspect the wiring for the identified thermistor.

1. Inspect the entire length of cable for the thermistor (both leads) for any signs of breakage, cuts or shorts. Also look for slits in the insulation covering. If either of the thermistor leads are shorting together or potentially shorting to anything else (such as ground) that can completely distort the thermistor value being read.
2. Wiggle the thermistor wiring to see if the problem changes. This can help identify loose or intermittent connections.
3. Verify that the thermistor leads go to the correct thermistor inputs on the BMS itself.

DTC SPN = 1371 FMI = 2 Thermistor Fault (Cont. 1)

4. Using the Orion BMS utility, go to "Live Text Data" and select "Temperature Parameters" from the drop-down menu at the bottom to see the individual thermistor values reported by the BMS. The displayed temperature value for the faulted thermistor may help diagnose problems further.
    - A value of -41C likely indicates either an open (break) in the line or that it is shorted to the BMS power supply input voltage.
    - A value of 85C or higher likely indicates that the thermistor lead is likely shorted to ground (the wire could be punctured or pinched by something that is grounded).
5. Using a multimeter, measure the resistance across the thermistor at the connector to the BMS. It should read approximately 10K Ohms at 25 degrees Celsius. A significantly different reading at 25 degrees Celsius could indicate a failure of the thermistor itself or help diagnose a wiring problem.

DTC SPN = 1371 FMI = 3 Cell Voltage Over 5V

FAULT DESCRIPTION

IMPORTANT WARNING: The cell tap harness should be immediately disconnected from the BMS if this fault code is set. Leaving the harness connected to the BMS is likely to cause damage to the BMS and may indicate that a cell is severely overcharged. Incorrect wiring may pose a fire and/or personal safety hazard or may lead to cell damage. Never continue to use a damaged BMS unit!

This fault code is triggered if the voltage of an individual cell (as measured by the BMS) exceeds 5.0 volts. This fault code will only trigger after a number of samplings to prevent false positives. If this fault triggers, it will cause the BMS to enter into a voltage failsafe condition disabling all charge and discharge.

This fault can be caused by incorrect cell tap wiring, a loose or disconnected cell tap, a blown fuse inside the BMS, a high resistance or loose busbar, a cell which is actually over 5 volts, or from internal damage to the BMS unit due to previous wiring faults. This fault code should always be immediately investigated as the BMS can be damaged by cell voltage readings above 5.0v and as there may be other dangerous conditions such as over-charged cells.

The Status LED on the BMS will rapidly flash red when this fault code is present to alert the operator to disconnect the BMS immediately.

SAFETY WARNING: Cells which have been over-charged or over-discharged may not be safe to use even after bringing the voltage into a correct range. A cell which has previously been over-charged or over-discharged at any time may develop internal damage, compromising the safety of the cell. Always consult the cell manufacturer for advice on whether a cell can be safely used after an over-charge or over-discharge event.

DTC SPN = 1371 FMI = 3 Cell Voltage Over 5V (Cont. 1)

DIAGNOSTIC STEPS

1.	**Immediately disconnect the cell tap wiring harness(es) from the BMS.** **Always unplug the cell tap harnesses from the BMS immediately when this fault occurs.**
2.	**Immediately disconnect any battery chargers or loads from the pack.** If a charger is malfunctioning or failing to turn off it may be severely over-charging the battery pack. Make sure no charging sources of any kind are connected to the battery pack.

DTC SPN = 1371 FMI = 3 Cell Voltage Over 5V (Cont. 2)

3.	**Verify that the cell tap harnesses are properly wired.**

If the cell taps are not wired properly (eg: a reversed wire or tap, or if more than 1 cell in series is being measured by a single cell tap) could cause the BMS to see more than 5v on a particular input. **This can quickly damage the BMS as the inputs on the BMS are only designed to measure up to 5vDC.**

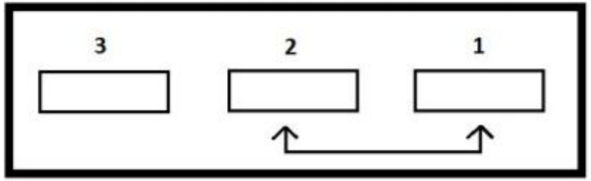
Correct any wiring issues found.

Once the cell wiring is verified then proceed to the next step.

DTC SPN = 1371 FMI = 3 Cell Voltage Over 5V (Cont. 3)

4.	**Clear the fault codes on the BMS.** The fault codes on the BMS will need to be cleared through the BMS utility before proceeding. This can be done on the "Diagnostic Trouble Codes" tab in the utility.
5.	**Attempt to reconnect the cell tap harnesses.** Once the cell wiring is verified to be correct, attempt to reinsert the cell tap harnesses into the BMS. If the fault immediately returns the BMS may be damaged. Verify the accuracy of all reported cell voltages manually to ensure the readings are correct.
6.	**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 or with the unit itself.

DTC SPN = 1371 FMI = 3 Cell Voltage Over 5V (Cont. 4)



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 internal to the BMS and may require servicing.

DTC SPN = 1371 FMI = 4 Charge-Enable Relay Fault

Fault Description: This will be shown when there is current going to the pack when there should not be. Please note that current going into the pack is shown as a negative number.

1. Solar controller needs to be adjusted. It is letting in current when the pack is showing no need for power or full SOC
2. System is running in manual mode and the gen is charging even when it is not supposed to.
3. Current sensor needs to be zeroed.
4. Contact Technical Support

DTC SPN = 1371 FMI = 5 Discharge-Enable Relay Fault

Fault Description: This is shown when pack SOC is 10% or below.

1. Verify 200 amp Charge circuit breaker is in the closed position
2. Verify Gen Output for Voltage (no load) and current (load).
3. Verify charge contactor is closing when machine is calling for charge.
4. If 1-3 check out hold in reset button until soc is to 11-12%. Then machine should operate normally.
5. Contact Technical Support

DTC SPN = 1372 FMI = 0 Internal Thermistor Fault

FAULT DESCRIPTION

This error code indicates that the Orion BMS has determined that an internal hardware fault has occurred with the internal thermistors that monitor the unit temperature. If this error message occurs, please download the associated freeze frame data and contact the factory or authorized dealer for assistance. Please save the freeze frame data and send it along with any other relevant information to the factory as it may be crucial for appropriately repairing the unit.

DTC SPN = 1372 FMI = 0 Internal Thermistor Fault (Cont.1)

DIAGNOSTIC STEPS

1.	**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.
2.	**Contact technical support.** **Please contact the company or reseller that the BMS was originally purchased from for additional questions, warranty claims, repair requests and technical support.**

DTC SPN = 1372 FMI = 1 Internal Logic Fault

FAULT DESCRIPTION

This error code indicates that the Orion BMS has determined that an internal software fault has occurred. If this error message occurs, please download the associated freeze frame data and contact the factory or authorized dealer for assistance. Please save the freeze frame data and send it along with any other relevant information to the factor as it may be crucial for appropriately repairing the unit.

DTC SPN = 1372 FMI = 1 Internal Logic Fault (Cont.1)

DIAGNOSTIC STEPS

1.	**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. <u>Additionally this freeze frame data may be requested by Technical Support if further assistance is required.</u> **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.

DTC SPN = 1372 FMI = 2 ERROR (MIL) Output

Fault Description:

This fault is displayed anytime the battery management system sees a fault.
Not all BMS faults are displayed.

DTC SPN = 1372 FMI = 2 ERROR (MIL) Output

Diagnostic Steps:

1. Open panel verify color (Green/red) on the led light located on the BMS.
2. If light is red, push reset button located inside of panel.
3. If step 2 is unsuccessful, plug into bms with laptop.
4. Open bms utility software.
5. Call HLS tech support once connected to BMS.

APECS (ECU) FAULTS

02

General System Troubleshooting Guide

The table below describes issues that may be encountered in the system but are not diagnosed with fault flags.

Issue	Possible Cause	Suggested Actions
Service Tool not communicating – establishing connection on Com x' status indicated	Power not applied to the controller	Check controller's power supply.
	Wiring fault	Check the wiring of power supply and RS232.
	Incorrect cable used	Check that the interconnect cable is selected in accordance to wiring diagram (straight-through).
	The wrong communications port has been selected	Verify the port setting.
Service Tool not communicating – displays message "Unable to locate the correct SID file for device application..."	Improper tool version is being used	Obtain the newest version of APECS 4800 Service Tool from Woodward website. If the problem persists, contact Woodward for support.
Engine speed not sensed properly	MPU sensor or wiring issue	Check MPU wiring; check or replace the sensor.
	MPU voltage too low	Verify that MPU voltage is within spec. The voltage is lowest at low speed.
Desired speed always zero, engine shuts down after cranking	Autocrank configuration	If autocrank relay or dependent glowplug is configured, ASE switch must be active to allow engine starting.
Engine unstable	Improperly tuned speed or position PID gains	Recalibrate the position control and then the speed control.
	Intermittent or incorrect speed signal	Check/replace the speed signal wiring and the MPU sensor.

DTC SPN = 638 FMI = 5 Actuator - Open Circuit

Fault Code	Fault Name	Possible Cause	Action
DTC SPN = 638 FMI = 5:	Actuator - Open Circuit	Shutdown Relay	relay coil properly wired/failed
		Wire Unconnected	Check Actuator and shut down relay contact wiring

DTC SPN = 638 FMI = 6 Actuator - Over Current

Fault Code	Fault Name	Possible Cause	Action
DTC SPN = 638 FMI = 6:	Actuator - Over Current	Wire short circuit	Check for actuator power supply line short to ground
		Short Circuit inside the actuator	Power the controller off and replace the actuator

DTC SPN = 3671 FMI = 0 Auto Crank

Fault Code	Fault Name	Possible Cause	Action
DTC SPN = 3671 FMI = 0	Auto Crank	Unable to start the engine	Verify Fuel level
			Verify that crank actuator position allows enough fuel for the engine to start

DTC SPN = 3509 FMI = 4 APS Power Supply (5V-1)

Fault Code	Fault Name	Possible Cause	Action
DTC SPN = 3509 FMI = 4	APS Power Supply	Wire short to ground	Check the APS +5 (J2-B1) Wiring

DTC SPN = 639 FMI = 2 CAN Communication

Fault Code	Fault Name	Possible Cause	Action
DTC SPN = 639 FMI = 2	Can Communication	Can Wiring Issue	Check CAN wiring- Contact technical support

DTC SPN = 168 FMI = 1 CPU Power Supply (5V-3)

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =168 FMI = 1	CPU Power Supply (5v-3)	Excessive Battery Voltage Drop	Verify that 12v battery power does not fall below specification (11.5VDC)

DTC SPN = 629 FMI = 12 CPU Failure

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =629 FMI = 12	CPU Failure	Controller Defective	Contact Technical Support

DTC SPN = 110 FMI = 3 ECT Sensor High

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =110 FMI = 3	ECT Sensor High	Wiring Issue	Check ECT analog input wiring
		Temperature sensor defective	Check/Replace the coolant Temp. Sensor

DTC SPN = 110 FMI = 4 ECT Sensor Low

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =110 FMI = 4	ECT Sensor Low	Wiring Issue	Check ECT analog input wiring
		Temperature sensor defective	Check/Replace the coolant Temp. Sensor

DTC SPN = 630 FMI = 12 EEPROM RW Failure

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =630 FMI =12	ECT Sensor High	Controller Defective	Replace Controller
			Call Technical Support

DTC SPN = 168 FMI = 0 High Battery Voltage

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =168 FMI =0	High Battery Voltage	Configuration	Verify Battery Voltage Supply and Configuration
		Wiring Issue	Verify voltage at controller supply pins

DTC SPN = 190 FMI = 8 Loss of Speed

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =190 FMI =8	Loss of speed	No Fuel	Verify machine has fuel
		MPU wiring issue	Check/Replace MPU wire
		MPU damaged	Check/Replace MPU sensor
		Autocrate issue- controller unable to enable starter motor	Check the auto crank relay wiring.
			Check /Replace starter motor
		Autostart enable switch issue	Verify the engine speed is sensed when ASE input is active

DTC SPN = 102 FMI = 3 MAP Sensor High

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =102 FMI =3	Map Sensor High	Wiring Issue	Check the analog input wiring
		Map sensor defective	Check/replace the MAP sensor

DTC SPN = 1210 FMI = 4 MAP Sensor Low

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =102 FMI =4	Map Sensor low	Wiring Issue	Check the analog input wiring
		Map sensor defective	Check/replace the MAP sensor

DTC SPN = 3510 FMI = 4 MAP Power Supply (5V-2)

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =35010 FMI =4	MAP power supply	Wire short to ground	Check the MAP +5V (J2-H1) wiring
		Map sensor current draw excessive	Verify the MAP sensor supply current doesnt exceed 15 mA

DTC SPN = 190 FMI = 0 Overspeed

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =190 FMI =0	Overspeed	Actuator not capable of closing the fuel throttle	Check the force needed to close the fuel against the actuator force
		Speed control gains not calibrated properly	Calibrate (Increase) gains for better handling of load rejection
		Overspeed Value set too low	Check the overspeed configuration

DTC SPN = 110 FMI = 0 Over Temperature

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =110 FMI =0	Over Temperature	Engine coolant temperature exceeded	Verify the engine coolant temperature
		Coolant Temperature sensor defective	Verify the temperature sending unit signal against measured engine coolant temperature

DTC SPN = 1210 FMI = 3 Position Sensor High

Fault Code	Fault Name	Possible Cause	Action
DTC SPN =1210 FMI =3	Position Sensor High	Wiring Issue	Measure the position sensor signal against the actuator position
		Position Sensor Defective	Replace the actuator if needed.

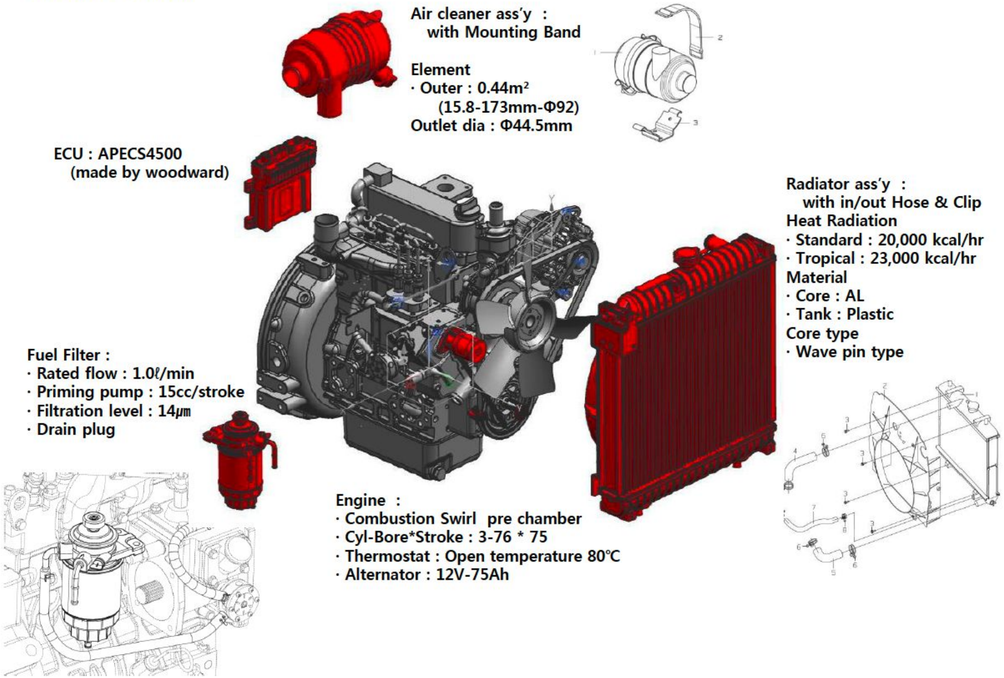
DTC SPN = 1210 FMI = 4 Position Sensor Low

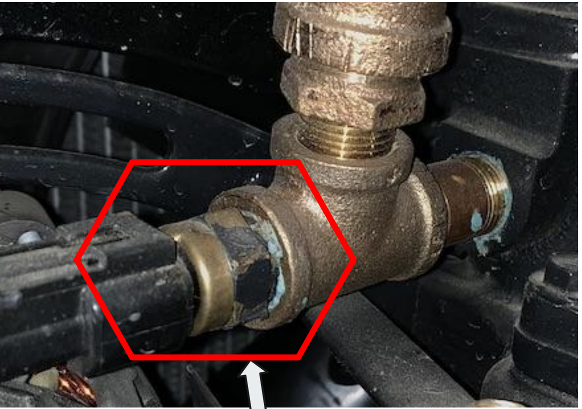
Fault Code	Fault Name	Possible Cause	Action
DTC SPN =1210 FMI =4	Position Sensor Low	Wiring Issue	Measure the position sensor signal against the actuator position
		Position Sensor Defective	Replace the actuator if needed.

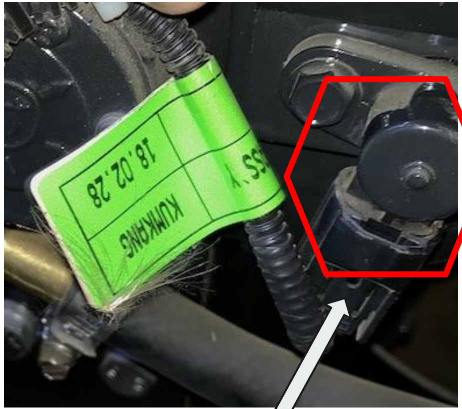
Engine
03

Tier4 Engine Introduction

SP103NH & SP103NI







Coolant Sensor

Speed Sensor

Fuel Rack Actuator

Oil Pressure Sensor

◎ LUBRICATION SYSTEM

Force-feed lubrication by gear pump	
► Lub. Method	Fully forced pressure feed type
► Oil pump	Gear type driven by crank-shaft gear
► Oil filter	Full flow, cartridge type
► Oil capacity	Max. 3.8 liters
► Lub oil pressure	Governed Speed : Min 220kPa
► Maximum oil temperature	121℃
► Angularity limit	Front down 30 deg , Front up 30 deg Side to side 30 deg
► Lubrication oil	SAE 10W-30 or SAE 15W-40(Above -10℃)

◎ FUEL SYSTEM

Bosch type in-line pump	
► Injection pump	K-type mini pump
► Governor	Mechanical centrifugal + Woodward Apecs 4500
► Speed drop	G2 Class(ISO 8528)
► Feed pump	Diaphragm type pump
► Injection nozzle	Throttle type
► Opening pressure	14.7 ~ 15.7Mpa
► Fuel filter	Full flow, cartridge type
► Maximum fuel inlet restriction	-

This is normally attained after a running period of about 100 hours and Image shown may not be actual engine.

◎ COOLING SYSTEM

Water circulation by centrifugal pump on engine.	
► Cooling method	Fresh water forced circulation
► Coolant capacity (Engine Only)	1.6 liters
► Coolant flow rate	liters / min
► Pressure Cap	90kPa
► Water Temperature	
-. Maximum for standby and Prime	110℃
-. Before start of full load	40℃
► Water pump	Centrifugal type driven by belt
► Thermostat Type and Range	Wax – pellet type Opening temp. 82°C , Full open temp. 95°C
► Cooling fan	Blower type, Polypropylene, Dia : Ø315mm, 6 blade
► Max. external coolant system restriction	Not Available

◎ VALVE SYSTEM

► Type	Overhead valve type	
► Number of valve	Intake 1, exhaust 1 per cylinder	
► Valve lashes at cold	Intake 0.15mm , Exhaust 0.15mm	
► Valve timing	Open	Close
-. Intake valve	8 deg. BTDC	38 deg. ABDC
-. Exhaust valve	44 deg. BBDC	8 deg. ATDC

MEASUREMENT	ACTION
Battery Voltage	Attach multimeter leads to battery terminals/wires on controller. Set Fluke 83/87 for volts DC (second position). This permits monitoring battery voltage into APECS controller. You can record minimum battery voltage during cranking using the min/max feature. Voltage should be > 9 Vdc when cranking; > or = 12 VDC for 12-volt system when running; > or = 24 VDC for 24-volt system when running.
Actuator Output (PWM duty cycle display)	Attach red lead to actuator positive terminal/wire and black lead to actuator negative terminal/wire. (If you do it backwards, you will read 100 duty cycle.) Set the Fluke 83/87 dial for volts AC (first position above Off). If you press the button labeled “Hz” once, you should read 400. This is the normal PWM frequency for APECS 2000. The APECS 3000 and APECS 4000 are factory set to 100 Hz but can be changed by user. If you press the “Hz” button once more, you will read percent duty cycle. When the engine is running, duty cycle should be somewhere around 50-70% and should increase with engine load. If you run much above 85-90% for very long, the actuator may be working a little too hard (or you don't have enough travel in the linkage, or the engine is exceeding its rated load).
Actuator Resistance	Model 0175: 2.80 ohms (12 V), 10.63 ohms (24 V); Model 0250: 1.76 ohms (12 V), 6.84 ohms (24 V); Model 0300: 1.72 ohms (12 V), 6.57 ohms (24 V). You can also check the resistance between the coil and the steel case of the actuator. (Resistance should be infinity.)
Speed Sensor Output	Attach the multimeter leads to speed signal terminals/wires. Set the Fluke 83/87 for volts AC. Monitoring volts AC during cranking is helpful for determining if the speed sensor voltage is adequate during cranking. It should be a minimum of 2 Vac, preferably higher. Voltage will increase as engine speed rises. Pressing the “Hz” button once to display sensor frequency can be helpful for determining if the appropriate frequency has been set. On generator applications, you can experimentally determine the number of gear teeth by running first on the mechanical governor. Measuring the frequency of the generator output voltage and comparing it to the frequency of the speed sensor can allow you to determine the number of gear teeth—though you may need to know the number of generator poles (normally 4 poles, though large generators may be more and small generators may be 2).

MEASUREMENT	ACTION
Magnetic Pickup Resistance	Coil resistance ohms @ 78° F (25.6° C): SA-2170 / 144 to 230; SA-2171A / 144 to 198; SA-4423 / 360 to 540; SA-4424 / 40 to 85
Steady State Stability	To monitor steady state stability of the governor, you can use the min/max feature. Attach the leads to either speed signal terminals/wires, or to the genset output voltage. Monitor volts AC. Press the "Hz" button once to display frequency. Press the "Min Max" button. The meter will begin tracking minimum, maximum and average frequency. By repeatedly pressing the "Min Max" button, you can check the minimum, maximum, average, and current frequencies. If you press and hold the "Min Max" button for several seconds, it will turn off the min/max feature and return to normal operation. This feature can also be used to capture overshoot/undershoot on load transients. It doesn't work as well as a strip chart recorder, as the Fluke 83/87 will not sense rapid changes in frequency.

PH3 POWERHALT
AIR INTAKE EMERGENCY SHUT-OFF VALVES by PACBRAKE

TROUBLESHOOTING GUIDE • PH3 AIR INTAKE EMERGENCY SHUT-OFF VALVE L6455

IMPORTANT: Prior to proceeding:

- Ensure all wiring harness connections are securely latched to their mates.
- Inspect all wiring for signs of damage or wear that could cause electrical shorts or discontinuities.
- Ensure valve is re-calibrated (See PowerGuard Programming Manual [L6452]) if individual system components are replaced.

WARNING:

- **Do NOT cycle power to the system until instructed to do so. In certain cases, cycling the power can cause the system to fail. Cycling power will clear an error code but should only be done once the issue has been remedied.**
- **Do NOT attempt to operate the engine with any of the harness connections disconnected. Doing so is dangerous and could cause system components to fail and trip the valve.**
- **Unnecessary connection and disconnection of harness connections wears out the plating on the electrical contacts and will affect continuity.**

Error Code 1-2

Cause	Solution
The valve failed to close (1) or open (2) – the motor position is not reading.	• Inspect the valve for any obstructions and remove if possible. • Perform Calibration to re-calibrate the valve. Refer to PowerGuard Programming Manual for more information • Ensure all connectors are fully installed and latched. • Ensure continuity from the valve connector to the controller. • Cycle power to the system.

Error Code 3-4

Cause	Solution
The valve opens (3) or closes (4) too slowly or not all the way.	• Inspect the valve for any obstructions and remove if possible. • Attempt to manually press the flap closed/open while feeling for any binding.

Error Code 5

Cause	Solution
The valve is drawing too much current.	• Ensure continuity from the valve connector to the controller and to the power wires. • Check all wiring for damage that could cause a short and replace if necessary. • Replace controller if necessary.

Error Code 6-9

Cause	Solution
Internal controller error.	• Replace controller.

Error Code 10

Cause	Solution
Motor position sensor reading is out of range, disconnected, or failed.	• Ensure all connectors are fully installed and latched. • Ensure continuity from the valve connector to the controller. • Cycle power to the system.

Error Code 11

Cause	Solution
Electrical motor is receiving no power or a low voltage.	• Ensure all connectors are fully installed and latched. • Check battery voltage and replace/charge if necessary. • Check for damage to wiring causing discontinuity and replace if necessary.

Error Code 12

Cause	Solution
Electrical motor failed to rotate in the correct direction and may be miswired.	• Replace wiring harness.

Error Code 13

Cause	Solution
High position deviation from calibrated range.	• Visually check for mechanical integrity of the valve. • Cycle power to the system and recalibrate the valve.

Error Code 14-18

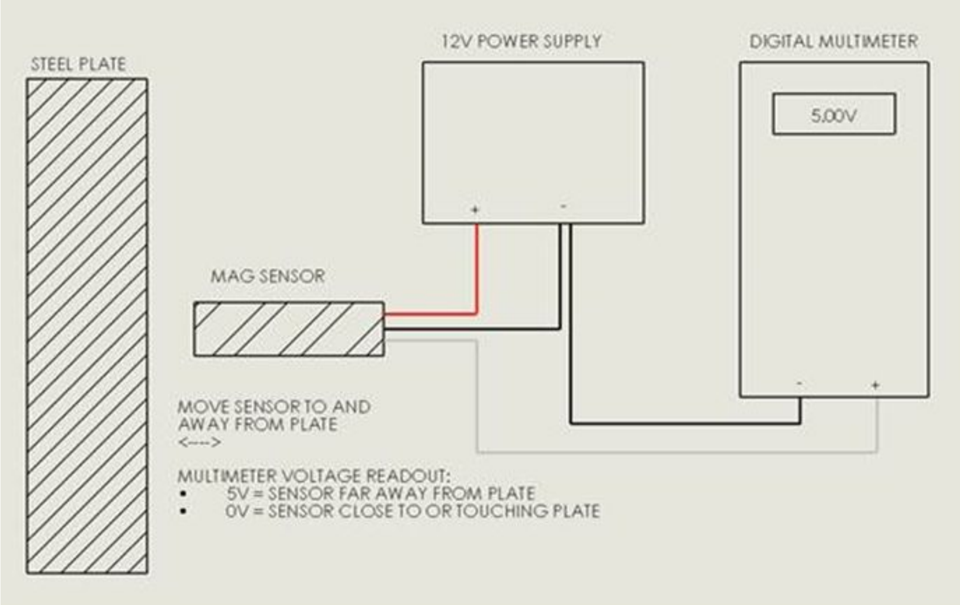
Cause	Solution
Internal controller error.	• Inspect all wiring for signs of damage and replace if necessary. • Ensure battery voltage is not less than 10V and replace/charge battery if necessary. • Replace controller.

Error Code 19

Cause	Solution
The valve has seized and is stuck in position or is moving too slowly.	• Perform Calibration to re-calibrate the valve. Refer to PowerGuard Programming Manual for more information • Ensure all connectors are fully installed and latched. • Ensure continuity from the valve connector to the controller. • Inspect the valve for any obstructions and remove if possible. • Attempt to manually press the flap closed/open while feeling for any binding. • Cycle power to the system.

False Trip: System has automatically shut down the engine without a runaway condition

Cause	Solution
PowerGuard Controller is not programmed for the correct trip speed.	• Use TEST Mode to ensure the controller was programmed correctly. Refer to PowerGuard Programming Manual for more information.
Speed sensor is not correctly sensing the engine speed.	• See Speed Sensor troubleshooting below.
Secondary RPM Set-Point is enabled/disabled and is causing the system to trip at the incorrect speed.	• Depending on your application, ensure that the Secondary Set-Point is correctly enabled/disabled.
Wiring harness is loose.	• Ensure all connectors are fully installed and latched.
Wiring harness is damaged.	• Inspect all wiring for signs of damage and replace if necessary.



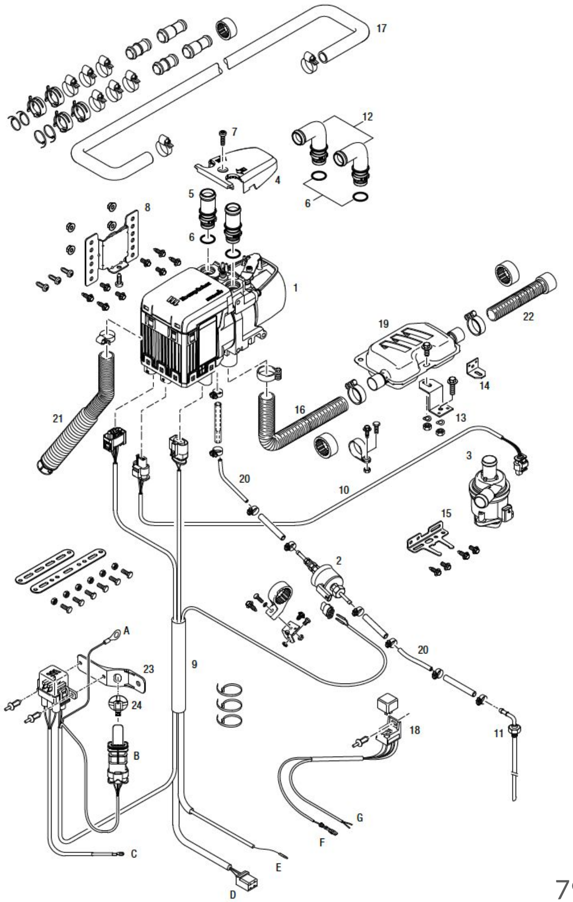
6.1 Troubleshooting

If faults occur, check the following items first:

- If the heater does not start after being switched on:
  - Switch the heater off and on again.
- If the heater still does not start, check whether:
  - Fuel in the tank?
  - The fuses are ok?
  - The electrical cables, connections, terminals, are ok?
  - Is the combustion air system or exhaust system blocked?

Note

Always ensure that there is sufficient fuel in the tank, as the heater switches to fault and locks if operated without fuel.



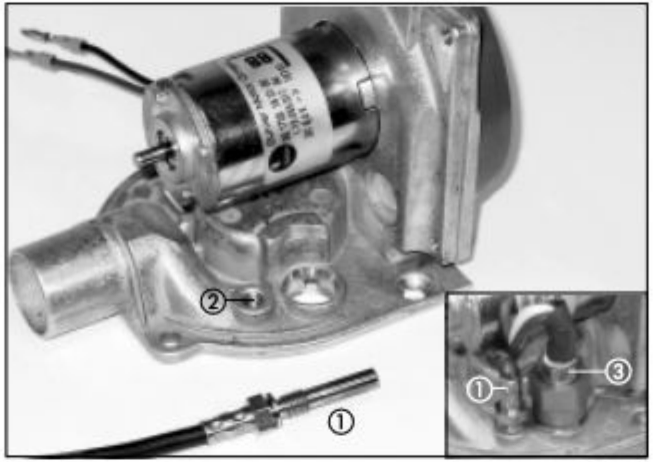


Fig. 5a: *HYDRONIC* B 4 W SC / B 5 W SC / D 4 W SC / D 5 W SC

① Flame sensor
② Flame sensor bracket
③ Glow plug

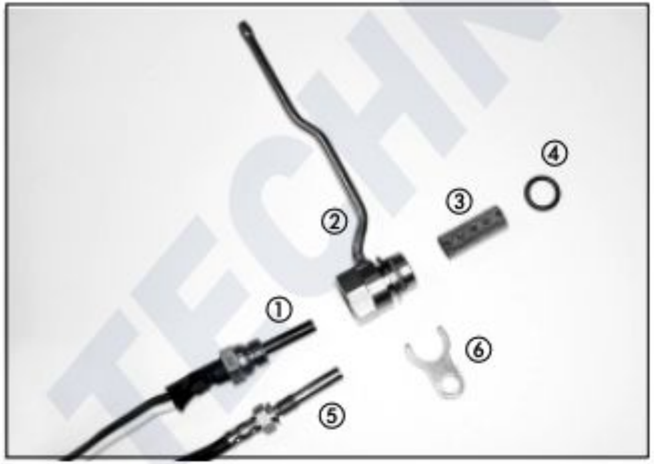


Fig. 5b: *HYDRONIC* B 4 W SC / B 5 W SC / D 4 W SC / D 5 W SC

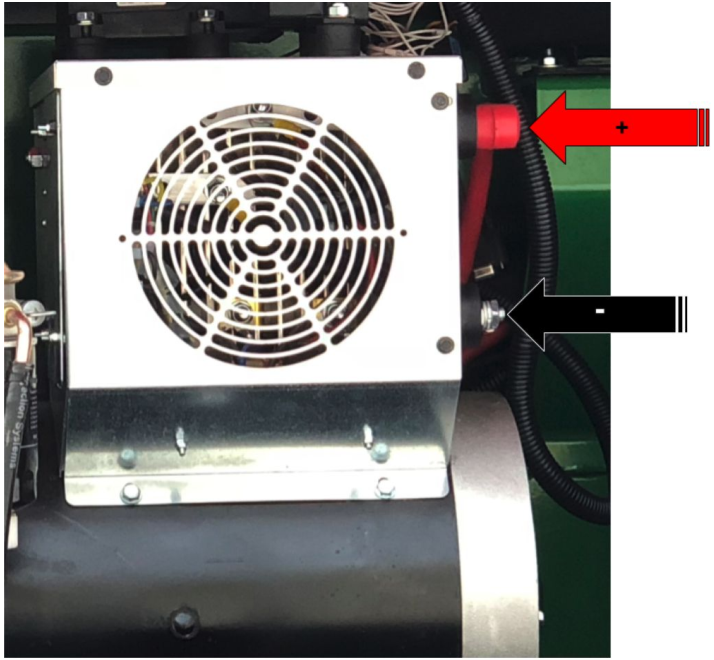
① Glow plug
② Socket
③ Plug filter
④ O-ring
⑤ Flame sensor
⑥ Bracket

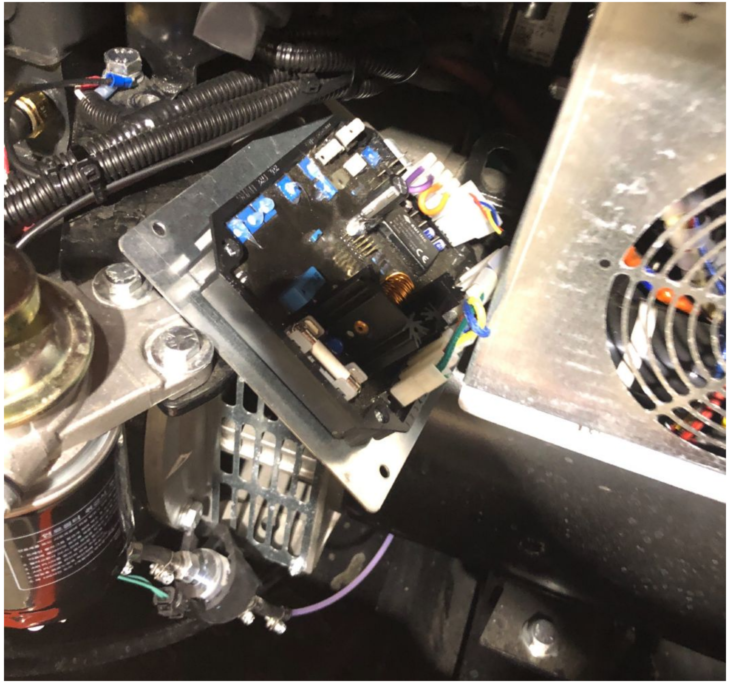
Service Interval

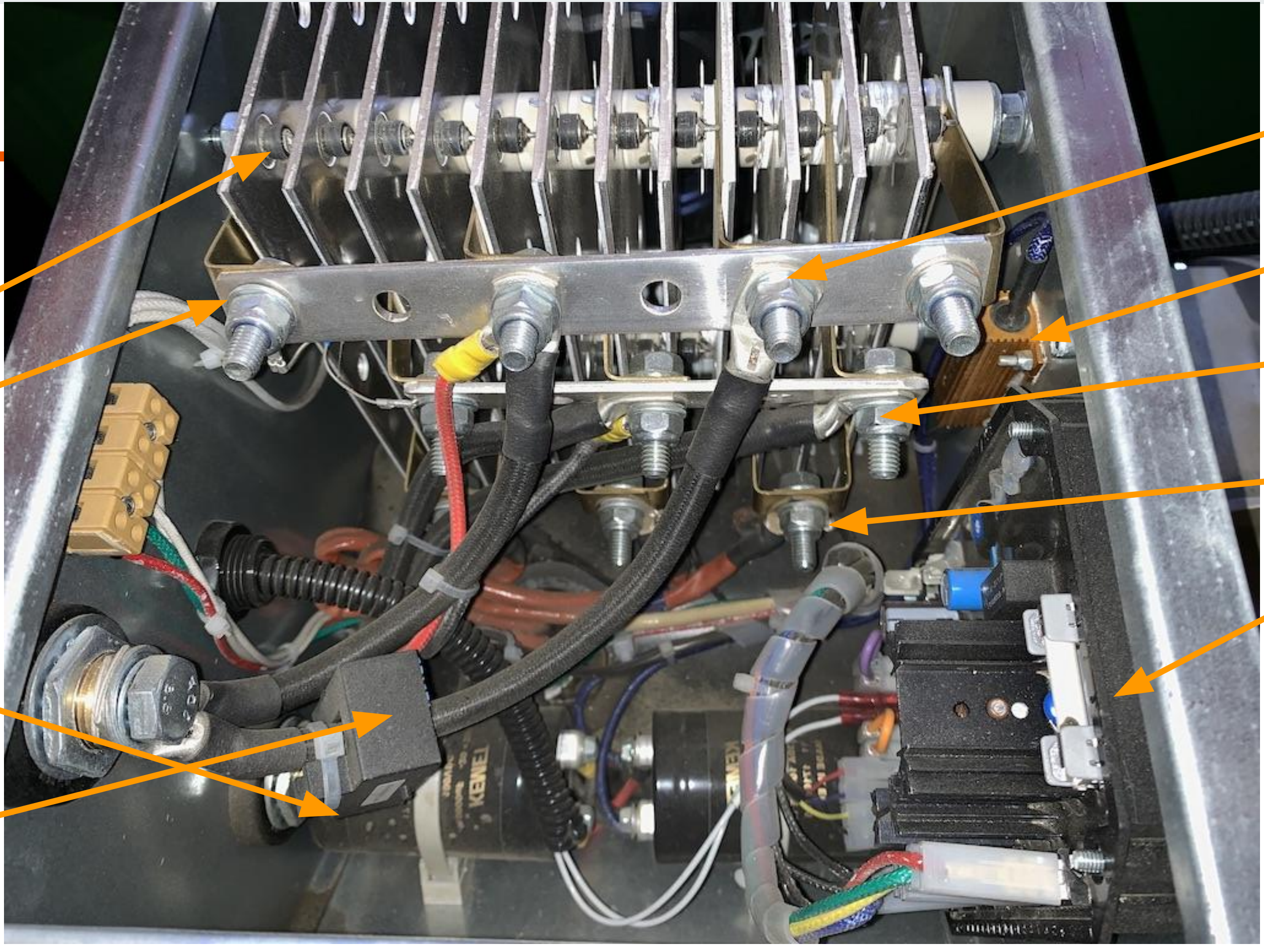
Maintenance	Oil Filter Chance	500hr
	Fuel Filter Change	500hr
	Valve Adjustment	1000hr

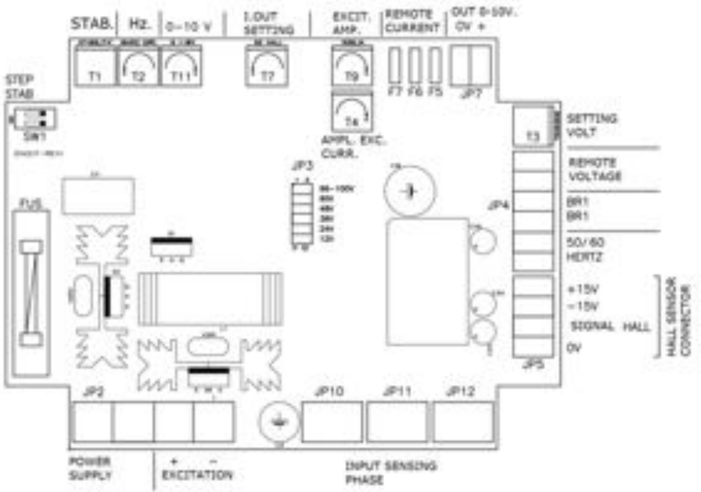
Gen End

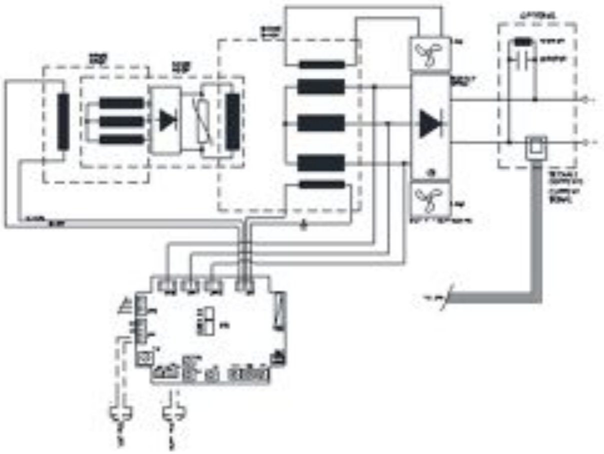
04



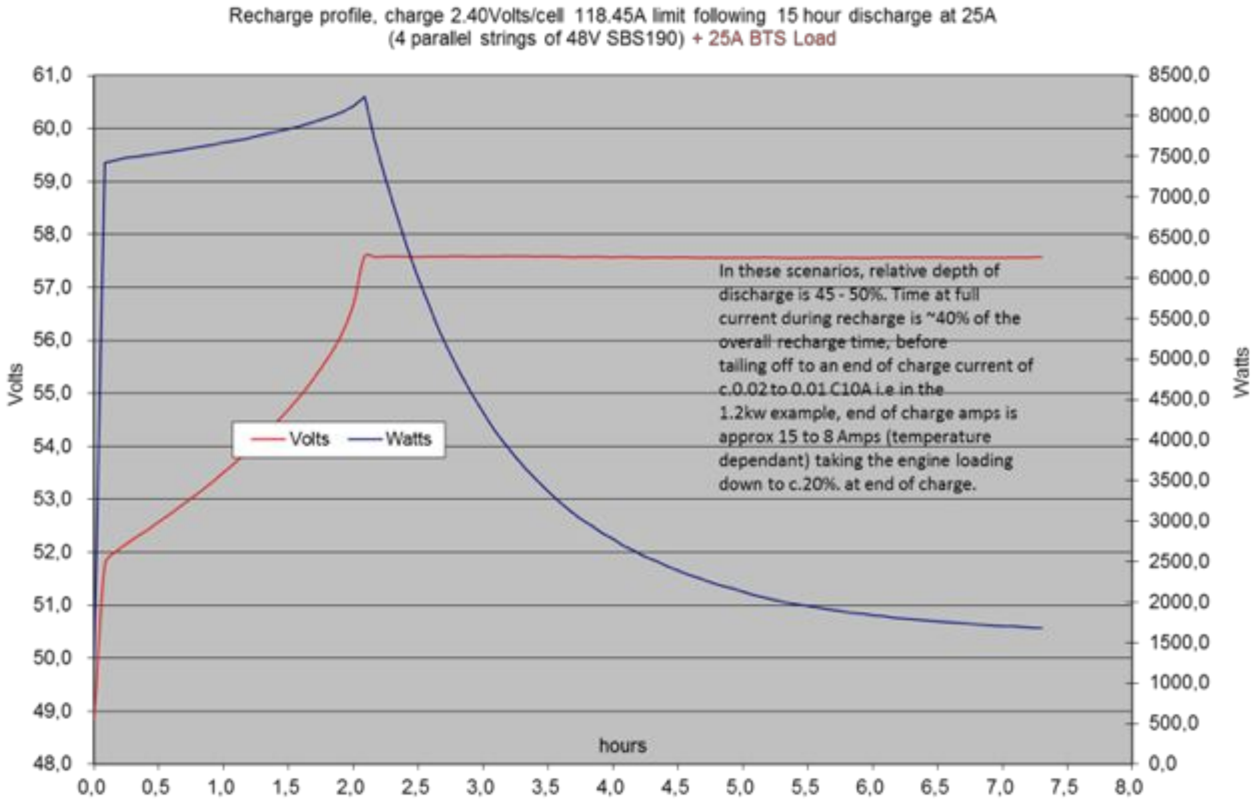



Diodes
Rectifier
Capacitor
CT
DC +
Thermal Sensor
DC -
AC
DVR



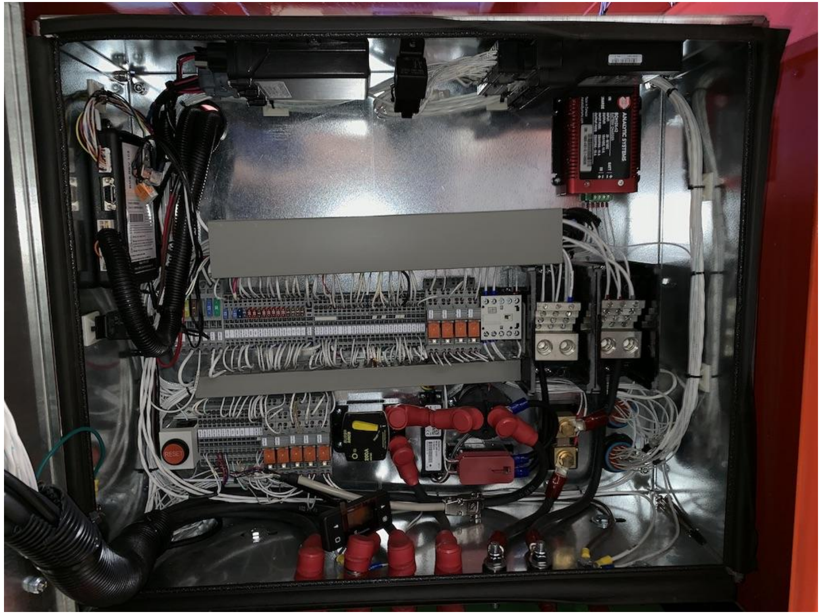


-T1= Stability trimmer usually from 4-5 tag.
-SW1= usually we set this switch both in number side write in component "off side" this switch extend the range of setting to T1.
-T2= under speed protection (for 1800-3600rpm remove bridge 50/60hz in JP4)
-T3= output voltage setting
-T4= amplification of T9 function, is made for extend the range of current setting by T9
-T9= trimmer for setting the maximum limit for exciter current output, this value must remain above this limit for 5 seconds (this for have the start-up capability).
-T7= output current limit setting the max. power output current (see from the hall sensor).
-The F5-6-7 (attached the revision of manual) is the remote for max. limit current : the same function of T7 but remote by potentiometer.(the trimmer T7 have no effect when external potentiometer is connected.)

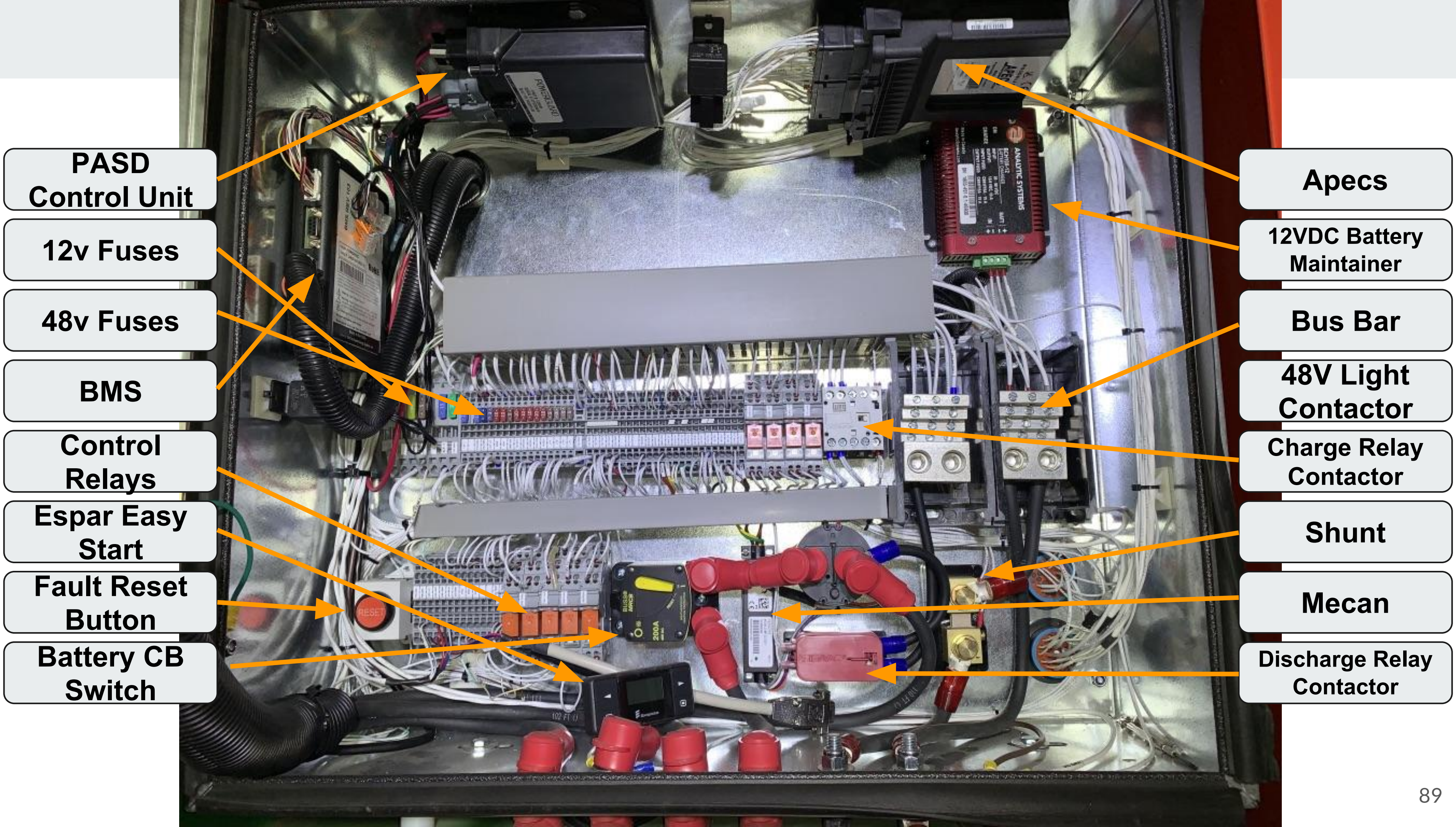

Recharge profile, charge 2.40Volts/cell 118.45A limit following 15 hour discharge at 25A
(4 parallel strings of 48V SBS190) + 25A BTS Load
Volts
Watts
hours
In these scenarios, relative depth of discharge is 45 - 50%. Time at full current during recharge is ~40% of the overall recharge time, before tailing off to an end of charge current of c.0.02 to 0.01 C10A i.e in the 1.2kw example, end of charge amps is approx 15 to 8 Amps (temperature dependant) taking the engine loading down to c.20%. at end of charge.

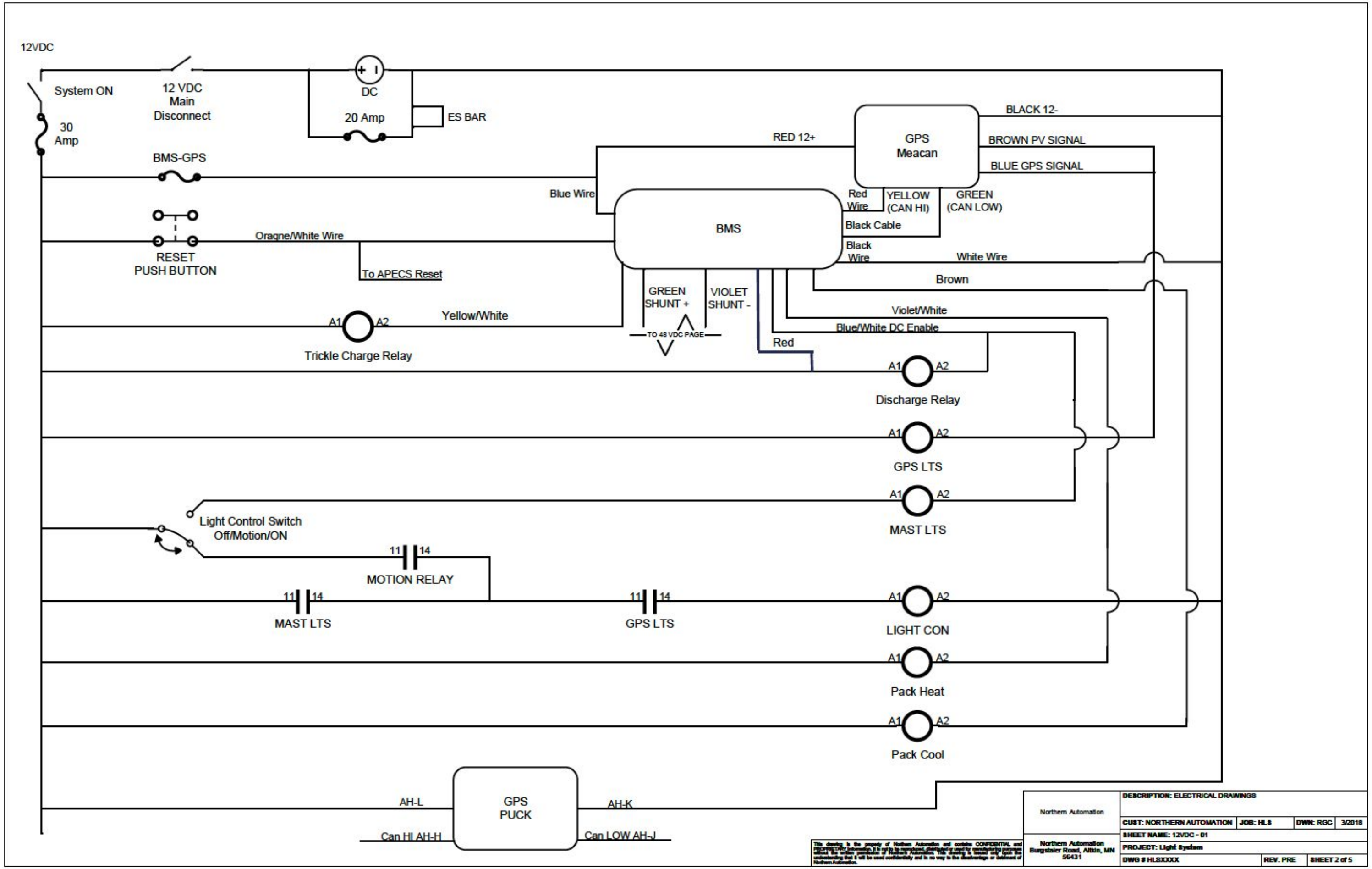
Control Panel

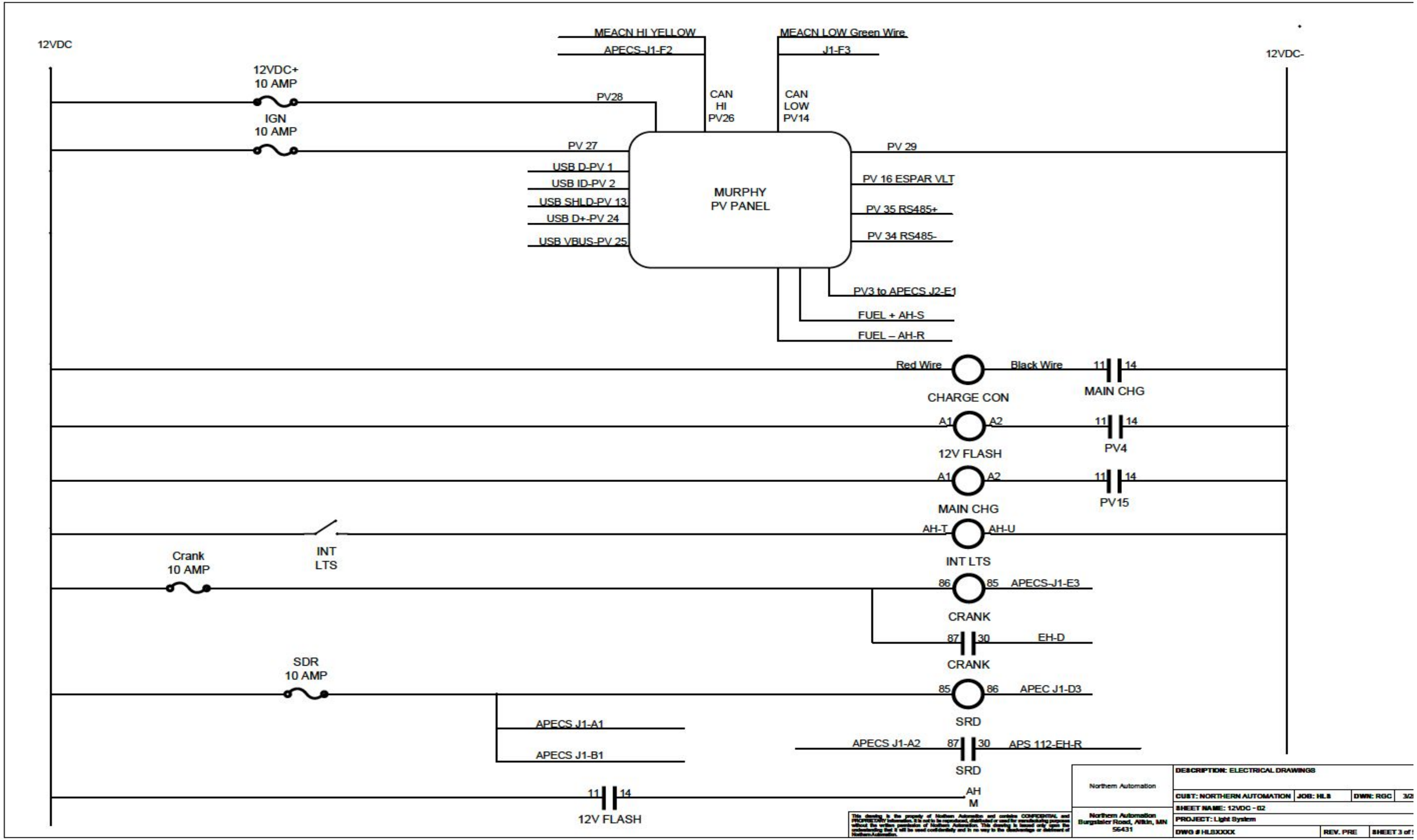
05

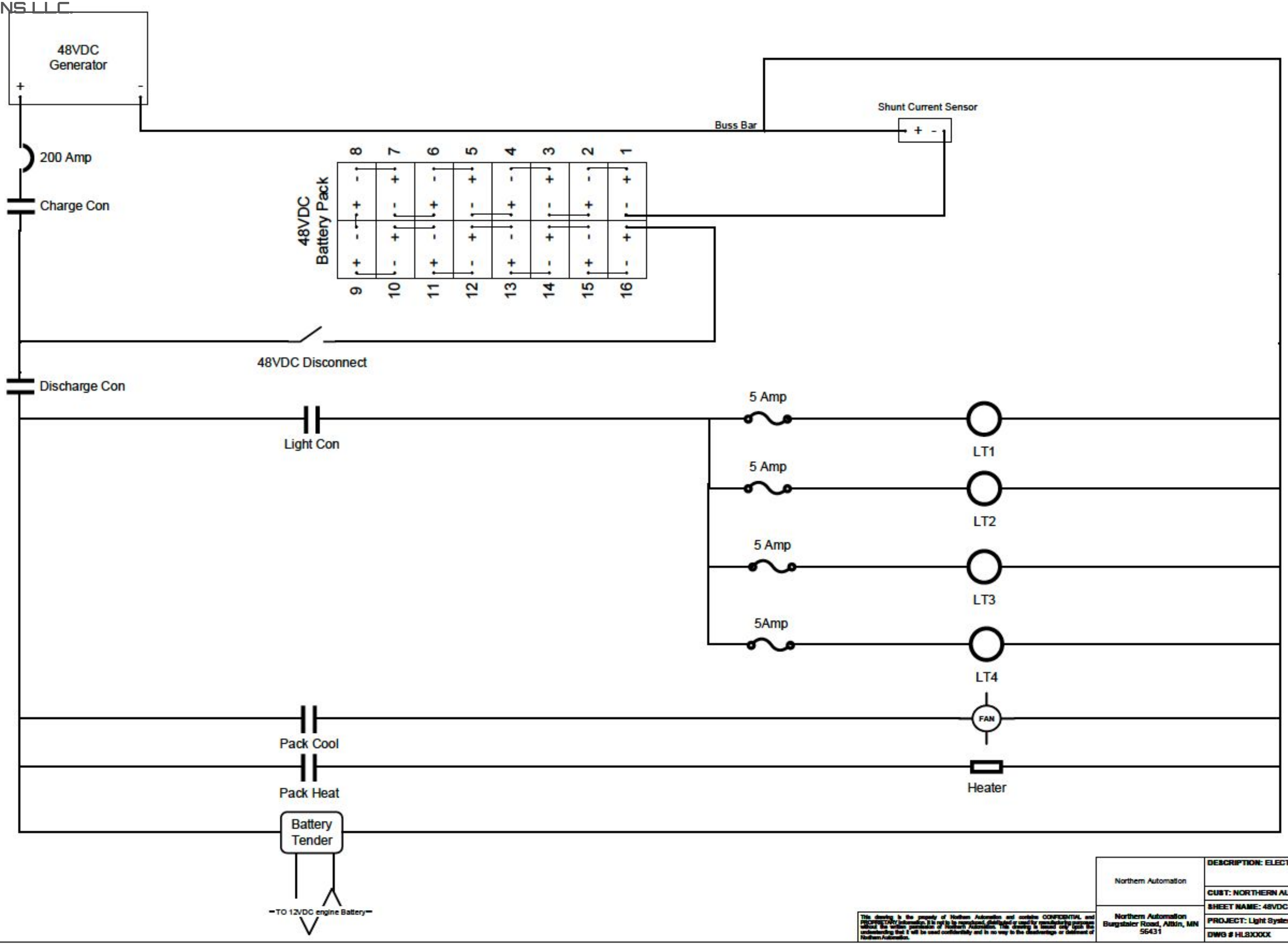



DANGER
KEEP OUT
HIGH VOLTAGE INSIDE
OVERSPEED SHUTDOWN
EMERGENCY SHUTOFF
MASTER DISCONNECTS
SYSTEM
ON
OFF
MAST LIGHTS
ON
OFF
MOTION
MAST HEIGHT
UP
OFF
DOWN
INTERIOR LIGHTS
ON
OFF
12+ VOLT DC
48+ VOLT DC

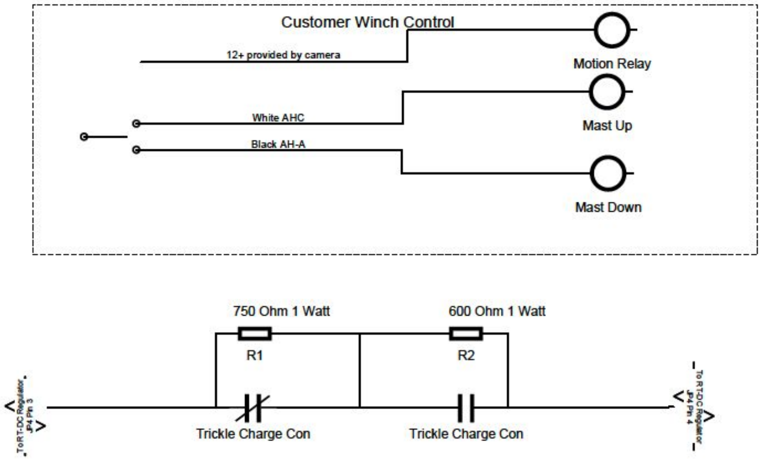

PASD Control Unit
12v Fuses
48v Fuses
BMS
Control Relays
Espar Easy Start
Fault Reset Button
Battery CB Switch
Apecs
12VDC Battery Maintainer
Bus Bar
48V Light Contactor
Charge Relay Contactor
Shunt
Mecan
Discharge Relay Contactor


12VDC
System ON
30 Amp
12 VDC Main Disconnect
DC
20 Amp
ES BAR
BMS-GPS
RESET PUSH BUTTON
Oragne/White Wire
To APECS Reset
Blue Wire
RED 12+
GPS Meacan
BLACK 12-
BROWN PV SIGNAL
BLUE GPS SIGNAL
BMS
Red Wire
YELLOW (CAN HI)
GREEN (CAN LOW)
Black Cable
Black Wire
White Wire
Brown
Violet/White
Blue/White DC Enable
Red
GREEN SHUNT +
VIOLET SHUNT -
TO 48 VDC PAGE
Yellow/White
A1
A2
Trickle Charge Relay
Discharge Relay
GPS LTS
MAST LTS
Light Control Switch Off/Motion/ON
11
14
MOTION RELAY
MAST LTS
GPS LTS
LIGHT CON
Pack Heat
Pack Cool
GPS PUCK
AH-L
AH-K
Can HI AH-H
Can LOW AH-J
Northern Automation
DESCRIPTION: ELECTRICAL DRAWINGS
CUST: NORTHERN AUTOMATION
JOB: HLS
DWN: RGC
3/2018
SHEET NAME: 12VDC - 01
PROJECT: Light System
Northern Automation Burgstaler Road, Aitkin, MN 56431
DWG # HLSXXXX
REV. PRE
SHEET 2 of 5


12VDC
12VDC+
10 AMP
PV28
IGN
10 AMP
PV 27
MEACN HI YELLOW
APECS-J1-F2
CAN
HI
PV26
MEACN LOW Green Wire
J1-F3
CAN
LOW
PV14
12VDC-
USB D-PV 1
USB ID-PV 2
USB SHLD-PV 13
USB D+-PV 24
USB VBUS-PV 25
MURPHY
PV PANEL
PV 29
PV 16 ESPAR VLT
PV 35 RS485+
PV 34 RS485-
PV3 to APECS J2-E1
FUEL + AH-S
FUEL – AH-R
Red Wire
Black Wire
11
14
CHARGE CON
MAIN CHG
A1
A2
12V FLASH
PV4
MAIN CHG
PV15
INT
LTS
AH-T
AH-U
INT LTS
Crank
10 AMP
86
85
APECS-J1-E3
CRANK
87
30
EH-D
CRANK
SDR
10 AMP
APEC J1-D3
SRD
APECS J1-A1
APECS J1-B1
APECS J1-A2
APS 112-EH-R
SRD
AH
M
12V FLASH
Northern Automation
Northern Automation
Burgstaler Road, Aitkin, MN
56431
DESCRIPTION: ELECTRICAL DRAWINGS
CUST: NORTHERN AUTOMATION
JOB: HLS
DWN: RGC
SHEET NAME: 12VDC - 02
PROJECT: Light System
DWG # HLSXXXX
REV. PRE



Northern Automation	DESCRIPTION: ELECTRICAL DRAWINGS			
	CUST: NORTHERN AUTOMATION	JOB: HLS	DWN: RGC	3/2018
Northern Automation Burgstaler Road, Aitkin, MN 56431	SHEET NAME: 48VDC - 3			
	PROJECT: Light System			
	DWG # HLSXXXX	REV. PRE	SHEET 4 of 5	



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Northern Automation	DESCRIPTION: ELECTRICAL DRAWINGS			
	CUST: NORTHERN AUTOMATION	JOB: HLS	DWN: RGC	3/2018
Northern Automation Burgstaler Road, Aitkin, MN 56431	SHEET NAME: 48VDC - 4			
	PROJECT: Light System			
	DWG # HLSXXXX	REV. PRE	SHEET 5 of 5	

HYBRIDLIGHT SOLUTIONS LLC.

NIGHTSHIFT SURVEILLANCE

Mast and Hydraulic
06

Solenoid

Pump

Flow Adjustment (Speed Up/Down)

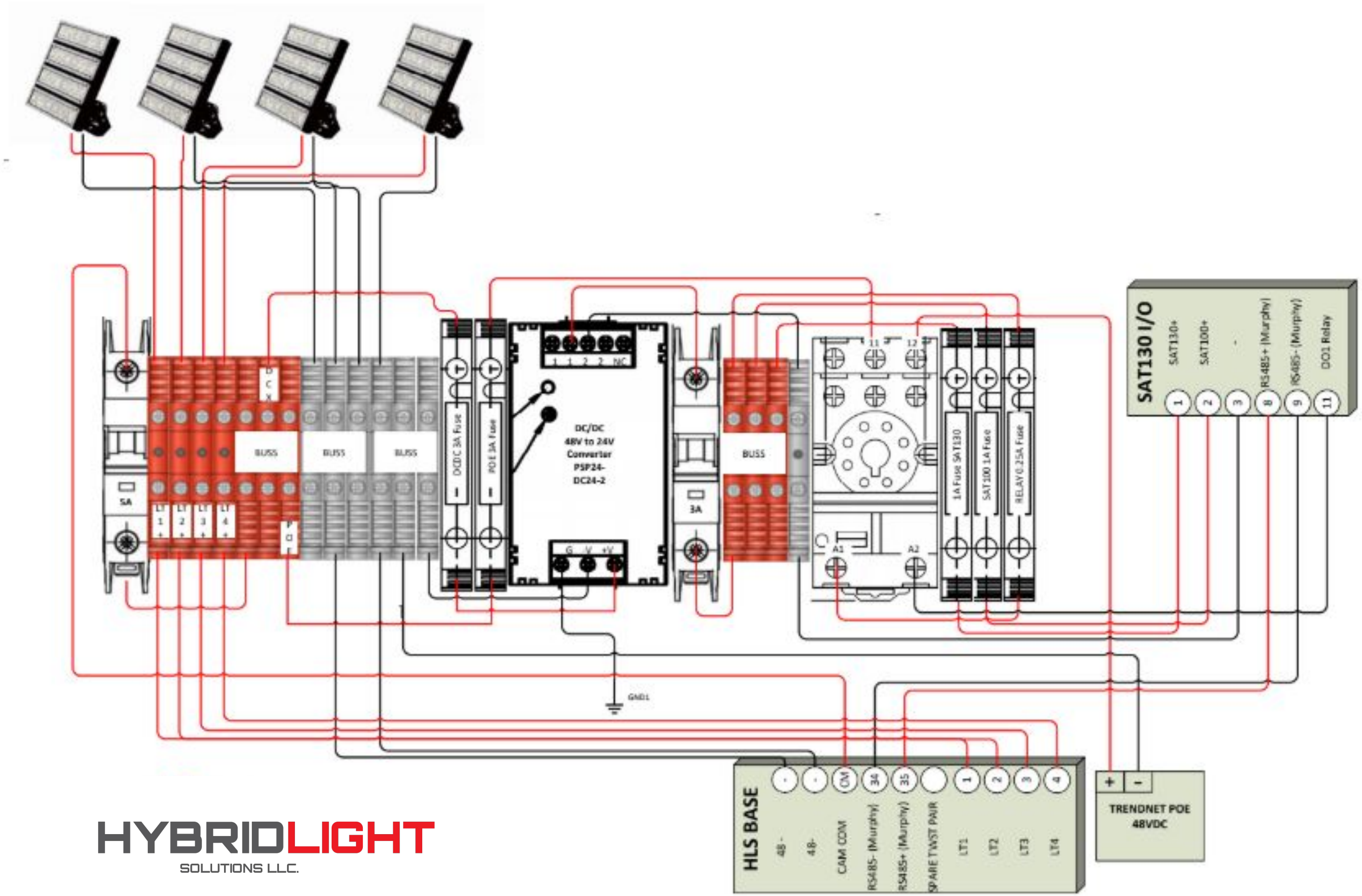
Level Indicator

Fill Cap

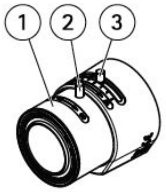
Note: Cold weather requires cold rated oil.
Recommend Petro Canada Arctic 15 or Equivalent

Camera and Modem System

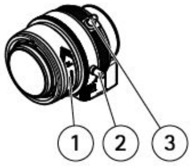
07



HYBRIDLIGHT
SOLUTIONS LLC.



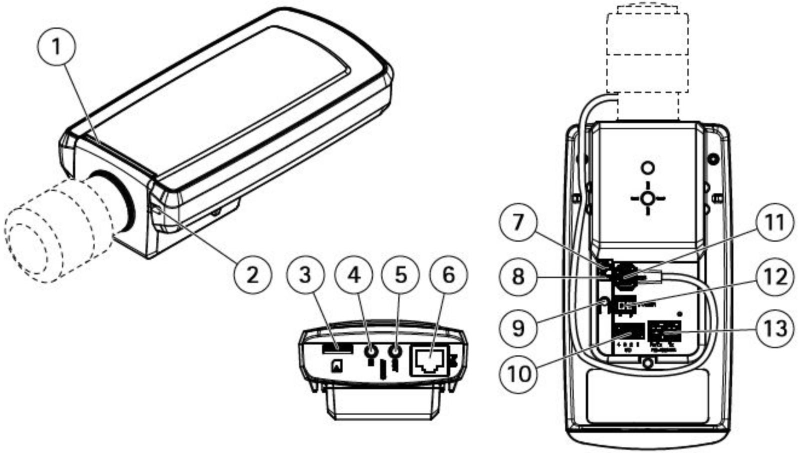
AXIS P1364



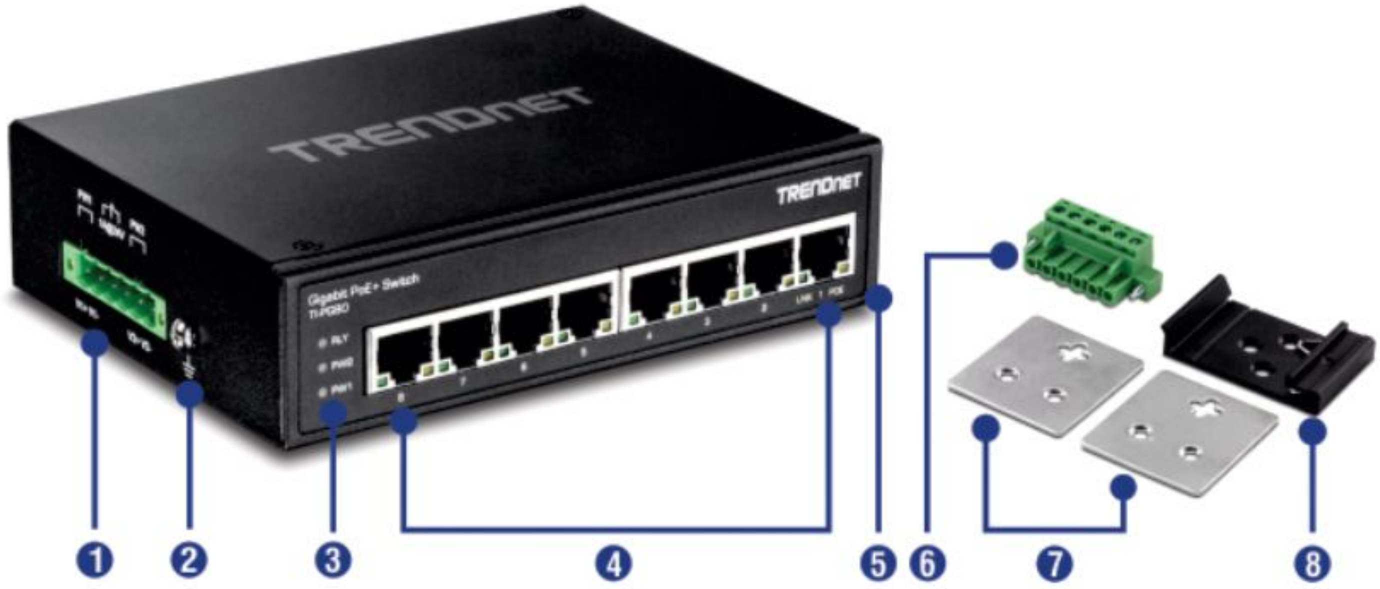
AXIS P1365 Mk II

1 *Focus ring*
2 *Lock screw for focus ring*
3 *Zoom puller*

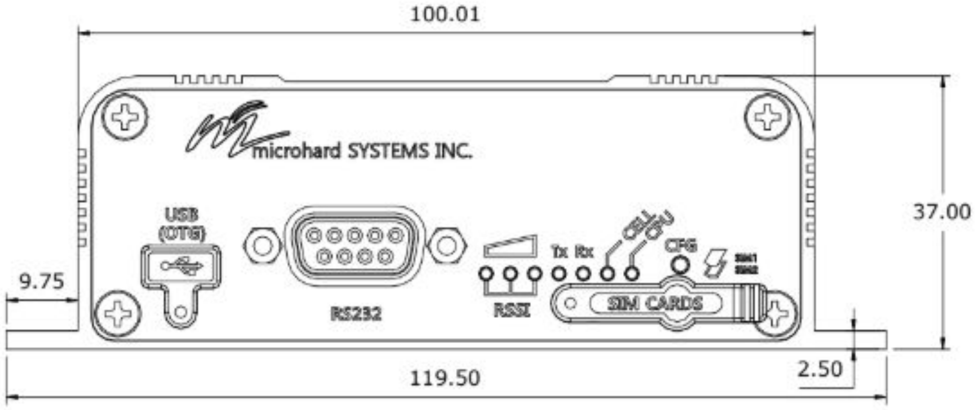
Hardware Overview



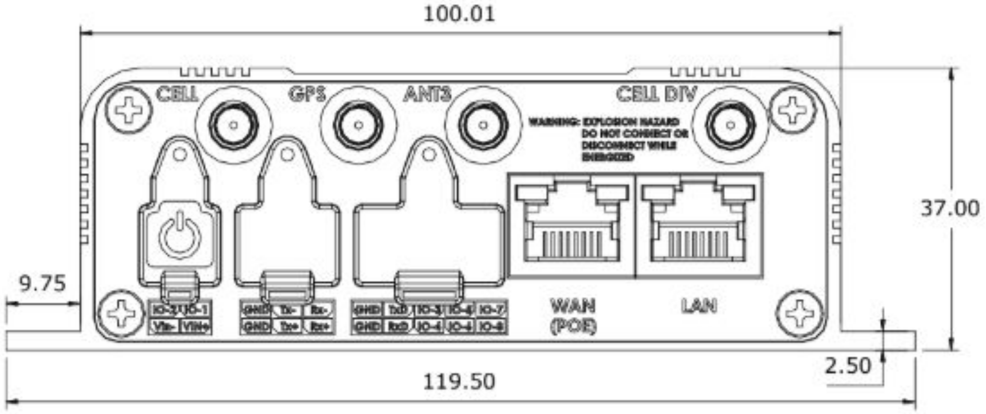
1 *Status LED*
2 *Built-in microphone*
3 *microSD card slot*
4 *Audio in*
5 *Audio out*
6 *Network connector (PoE)*
7 *Power LED*
8 *Network LED*
9 *Control button*
10 *I/O connector*
11 *Iris connector*
12 *Power connector (DC)*
13 *RS485/422 connector*



1. Terminal block slot
2. Grounding point
3. LED indicators
4. Gigabit PoE+ ports
5. IP30 rated metal housing
6. Terminal block
7. Wall mounting kit
8. DIN-rail mount



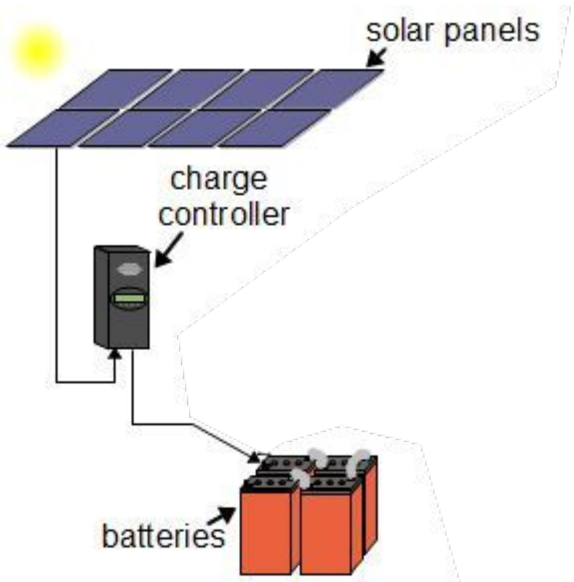
Drawing 3-2: IPnXGii Front View Dimensions

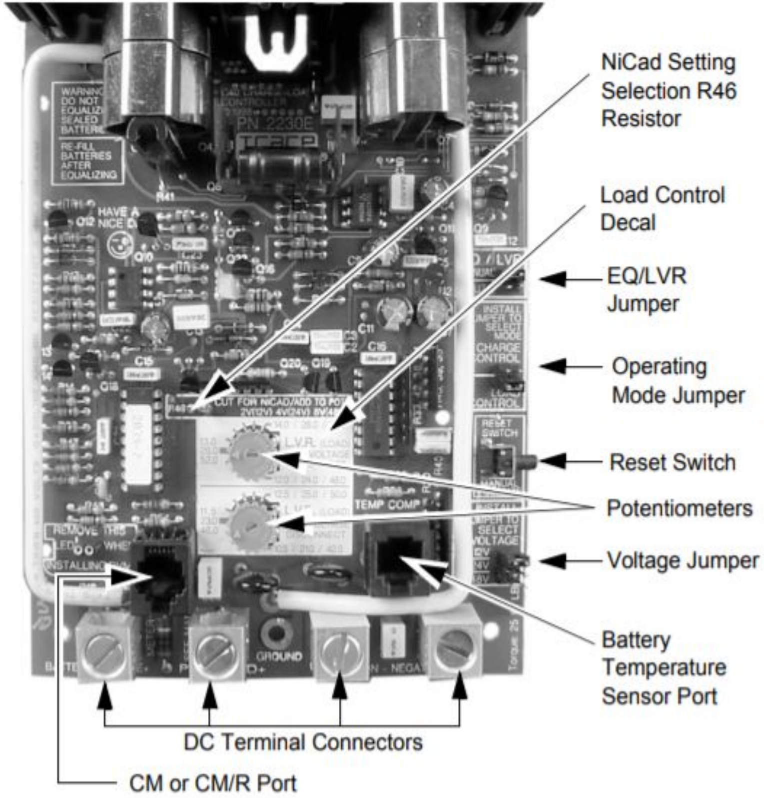


Drawing 3-3: IPnXGii Rear View Dimensions

Solar System
08

Solar Charge Controller





Battery Box

09

BEFORE YOU BEGIN

Read the provided safety sheet before you begin to set up your Orion Jr. BMS.

As you wire the various connectors, please keep them DISCONNECTED from the BMS until you are instructed to connect the BMS.

1 Determine how to control load and charger

Before you wire the BMS, it is important to figure out how you will control the load and the charger. See the "Interfacing the Load and Charger with the BMS" section of the wiring manual for assistance in how to determine this for your specific BMS application.

2 Wire Main I/O Harness

Use the provided pin-out diagram to wire the Main I/O Harness

See the wiring manual for detailed instructions on wiring this connection.

3 Wire Batteries / Voltage Taps

Read the entire "Wiring Voltage Taps" section of the wiring manual before you begin wiring your cells.

Keep the wiring harness UNPLUGGED from the BMS while you wire the batteries.

DO NOT plug the BMS into the batteries yet.

4 Verify Battery Wiring

Verify the wiring of your batteries using the tap validation tool (can be purchased or rented from Ewert Energy) or using a multimeter.

See "Verifying Cell Voltage Tap Wiring" in the wiring manual for more information.

5 Download Orion Jr. BMS Utility

Use the provided disc to download the Orion Jr. BMS Utility to your computer.

6 Connect BMS to computer and to all wiring harnesses.

7 Program BMS using the Profile Set Up Wizard

Things to know when you begin the Set Up Wizard:

- Battery configuration (chemistry, number of cells in series/parallel, location of fuses and long cables (if used))
- Size of current sensor used
- What other devices are being used (charger, motor controller, etc.)

Things to check after completing the Set Up Wizard:

- Maximum/minimum voltage settings
- Maximum current limits

Upload the settings to the BMS after making your profile. See the software manual for more information about programming your BMS.

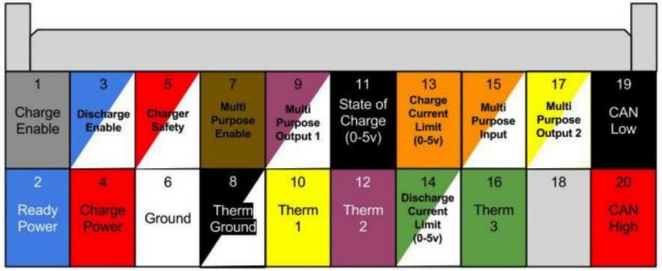
8 Test the BMS

Before putting the BMS into regular use, watch it closely for one full charge and discharge cycle to ensure that wiring and profile are correct.

Make sure the BMS correctly turns off the charger when cell voltage hits the maximum or shuts off the load when the cell voltage hits the minimum. If there are any problems, please correct before putting the BMS into regular use.

Your BMS should be ready to use. Please follow all guidelines in the safety instructions and manuals to avoid damaging the BMS or the batteries.

Main Input/Output (I/O) Connector



Looking into back of connector (wires coming toward viewer)

Signal Name	Description
1. Charge Enable Signal (Out)	An open drain digital on/off signal used to signal to a load that the load can charge the battery. This would normally be used to control regenerative breaking in a mobile application or enable a solar or wind charge in a stationary application. This signal can be used as a backup to digital CAN communication with a controller. This is a signal current level (175mA max) and should be amplified for controlling large contactors or relays (see electrical specs.)
2. READY Power Source	This power source should be connected to a 12V - 48V nominal power source whenever the BMS should be active for normal use. This input must be fused at no more than 3A. The voltage on this pin may not exceed 60V at any time.
3. Discharge Enable Signal (Out)	An open drain digital on/off signal used to signal to a load that the load can discharge the battery. This would normally be used to control a discharge contactor or to signal to a controller that discharge must be stopped if this signal is not present. This signal can be used as a backup to digital CAN communication with a controller. This is a signal current level (175mA max) and should be amplified for controlling large contactors or relays (see electrical specs.)
4. CHARGE Power Source	This power source should be connected to a 12V - 48V nominal power source whenever the BMS should be active for a defined charging period. When powered by this source, the BMS enters charging mode. If this power source is connected while the READY power source is also connected, the BMS will activate the "Charge Interlock" state. Must be fused at no more than 3A. The voltage on this pin may not exceed 60V at any time.
5. Charge Safety Signal (Out)	An open drain digital on/off signal used as a safety switch for a charger. This signal is normally connected to the charger or connected to a relay which enables AC power to the charger such that the lack of this signal will cause the charger to be inactive. This is a signal current level (175mA max) and should be amplified for controlling large contactors or relays (see electrical specs.)
6. Power Ground	This is the ground for the supply power for the BMS. Both power sources (READY and CHARGE) share this ground, and grounds for these power sources must be bonded together externally.
7. Multi Purpose Enable	An open drain digital on/off signal with configurable behavior. This is a signal current level (175mA max) and should be amplified for controlling large contactors or relays (see electrical specs.) Please see the software manual for a complete list of available functions. **This output is watchdog backed and will turn off when certain faults occur, regardless of programmed settings.**
8. Thermistor Ground	One leg of each of the two thermistors should be grounded to this ground. Both thermistors share this ground return.
9. Multi Purpose Output 1	The behavior of this multi-purpose output is configured in software for additional functionality. This output is often used to drive an LED to indicate the presence of error codes, but can also be used as a CAN controlled output as well as other functions. Please see the software manual for a complete list of available functions. This output is NOT watchdog backed and may remain on when certain faults occur.
10. Thermistor 1 12. Thermistor 2 16. Thermistor 3	One leg of each of the thermistors should be connected to the respective thermistor pin. These pins connect to 10K NTC thermistors.
Analog 5v Outputs: 11. State of Charge 13. Charge Current Limit 14. Discharge Current	0-5V analog outputs that represent charge current limit, discharge current limit, and state of charge.
15. Multi Purpose Input	This is an input signal that can have multiple different input functions such as redundant keep-awake power signals, clearing DTC fault codes and other functions. Please see the software manual for a complete list of available functions. The voltage range for this pin is 9-60V.
17, Multi Purpose Output 2	The behavior of this multi-purpose output is configured in software for additional functionality. Please see the software manual for a complete list of available functions. This output is NOT watchdog backed and may remain on when certain faults occur.
19. CAN_L 20. CAN_H	CAN interface with high and low signal lines. Only available on units ordered with CANBUS. Unless special ordered, the BMS unit has a termination resistor installed inside the unit (120 ohm).

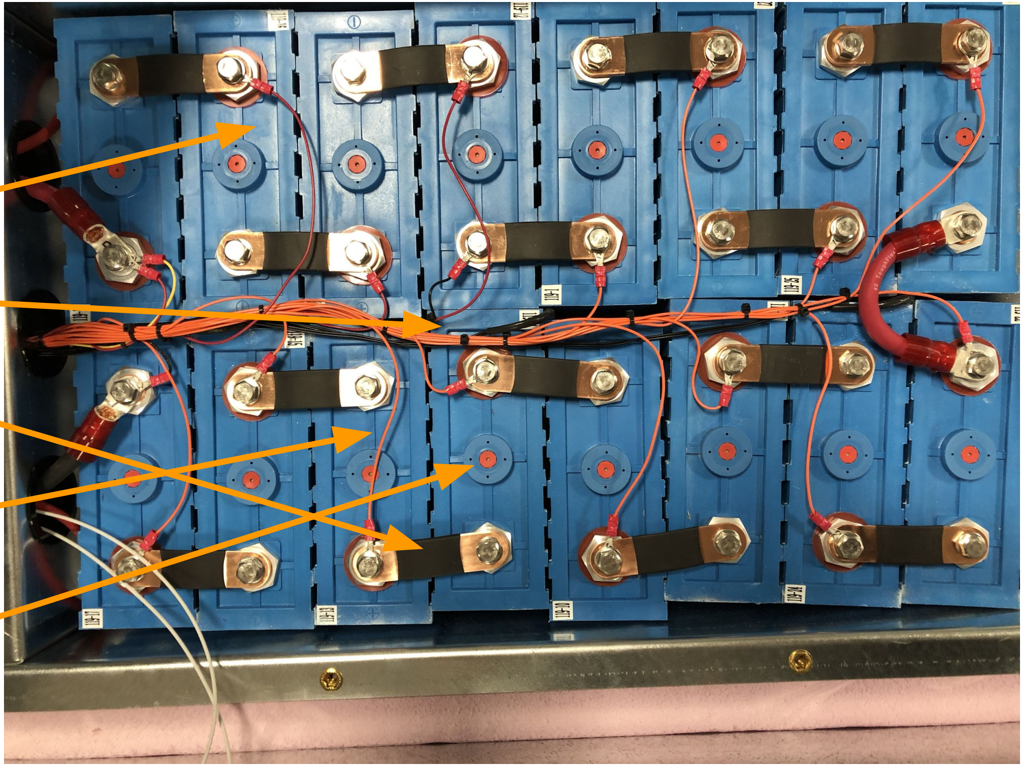
Battery Cells (16)

Thermistor (3)

Bus Bar

Voltage Sensing

Battery Safety



Nominal voltage		3.2V		
Charge	Maximum charging current	1C		
Maximum charging voltage	Maximum chargingvoltage	3.65V		
Discharge	Maximum discharging current	2C	1C	2C
	Termination voltage	2.5V		
Charging time	Standard Charge	4h		
	Fast Charge	1h		
SOC Recommended		10%~90%		
Temperature	Charge	0°C ~ 45°C		
	Discharge	-20°C ~ 55°C		
Storage temperature	short term (within one month)	-20°C ~ 45°C		
	Long-term (within a year)	-20°C~ 25°C		
Storage humidity range		<70%		

HYBRIDLIGHT SOLUTIONS LLC.

NIGHTSHIFT SURVEILLANCE

LED Lights

010

DC Driver (48v to 70v)

LED Bar