HYBRIDLIGHT
SOLUTIONS LLC.

Installation and User Instructions

MODEL 200 HYBRID TOWER

Lighting, Surveillance and Communications Tower

2018-12-V1

October 2017
Version 1.05

DISCLAIMER

Hybrid Light Solutions LLC. makes no representations or warranties with respect to this manual and, to the maximum extent permitted by law, expressly limits its liability for breach of any warranty that may be implied to the replacement of this manual with another. Furthermore, Hybrid Light Solutions LLC. reserves the right to revise this publication at any time without incurring an obligation to notify any person of the revision.

The information provided in this documentation contains general descriptions and/or technical characteristics of the performance of the products contained herein. This documentation is not intended as a substitute for and is not to be used for determining suitability or reliability of these products for specific user applications. It is the duty of any such user or integrator to perform the appropriate and complete risk analysis, evaluation and testing of the products with respect to the relevant specific application or use thereof. Neither Hybrid Light Solutions LLC. nor any of its affiliates or subsidiaries shall be responsible or liable for misuse of the information that is contained herein. If you have any suggestions for improvements or amendments or have found errors in this publication, please notify us.

All pertinent state, regional, and local safety regulations must be observed when installing and using this product.

When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

Failure to observe this information can result in injury or equipment damage.

Hybrid Light Solutions LLC

4604 Morehouse Drive, Pequot Lakes, MN, 56472

1-218-568-1188

TRADEMARKS

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General Notice: Some product names used in this manual are used for identification purposes only and may be the trademarks of their respective companies.

Product Modifications

Year	Type	Modifications
2019	1	2019 Model 200
2022	3	2022 Model 230

Document Revisions

Date	Version Number	Document Changes
14-07-2017	1.0	Initial Draft
17-07-2019	2.0	Version Two
01-01-2022	3.0	Version Three

Table of Contents

1. PREFACE

1.1 Description of the User

This manual is intended to support end users of the Hybrid Light Solutions Model 200 mobile tower. Our products are designed and intended to provide site support solutions for lighting on a variety of applications including: construction job site, oil and gas job sites, pipelines, events, security and government or military operations.

The user will deploy and setup the Model 200, and should be qualified and follow all instructions contained in this operating manual.

1.2 Conventions Used in This Manual

The following style conventions are used in this document:

Bold
Names of product elements, commands, options, programs, processes, services, and utilities Names of interface elements (such windows, dialog boxes, buttons, fields, and menus)
Interface elements the user selects, clicks, presses, or types

Italic
Publication titles referenced in text
Emphasis (for example a new term)
Variables

`Courier`
System output, such as an error message or script
URLs, complete paths, filenames, prompts, and syntax

User input variables
< > Angle brackets surround user-supplied values
[ ] Square brackets surround optional items
| Vertical bar indicates alternate selections - the bar means “or”

1.3 Explanation of Safety Warnings

⚠DANGER

Danger indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury

⚠WARNING

Warning indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.

⚠CAUTION

Caution indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.

NOTICE

Indicates information considered important, but not hazard-related.

1.4 Retaining Instructions

Read and understand this manual and its safety instructions before using this product. Failure to do so can result in serious injury or death.

Follow all the instructions. This will avoid fire, explosions, electric shocks or other hazards that may result in damage to property and/or severe or fatal injuries.

The product shall only be used by persons who have fully read and understand the contents of this user manual and understand safe operation of the machine.

Ensure that each person who uses the product has read these warnings and instructions and follows them.

Keep all safety information and instructions for future reference and pass them on to subsequent users of the product.

The manufacturer is not liable for cases of material damage or personal injury caused by incorrect handling or non-compliance with the safety instructions. In such cases, the warranty will be voided.

1.5 Obtaining Documentation and Information

1.5.1 Internet

The latest version of the documentation is available at the following address:
http://www.hybridlightsolutions.com

1.5.2 Ordering Documentation

Documentation, user instructions and technical information can be ordered by calling Hybrid Light Solutions LLC. at 1-218-568-1188

1.5.3 Other languages

This is the English user manual. Manuals in other languages are available upon request. Not all languages are covered.

1.5.4 Documentation Feedback

If you are reading Hybrid Light Solutions LLC. product documentation on the internet, any comments can be submitted on the support website. Comments can also be sent to: joe@hybridlightsolutions.com

We appreciate your comments.

1.5.5 Support and service

For information about special tools and materials please contact:

Hybrid Light Solutions, LLC.

Address: 4604 Morehouse Drive, Pequot Lakes, MN 56472

Phone: 1-612-961-9115

Web: www.hybridlightsolutions.com

For other questions, information, technical assistance, ordering user instructions, and service related information please contact the manufacturer:

Hybrid Light Solutions, LLC.

Address: 4604 Morehouse Drive, Pequot Lakes, MN 56472

Phone: 1-612-961-9115

Web: www.hybridlightsolutions.com

2 Description of the product

2.1 Intended Use and Reasonably Foreseeable Misuse

The machine is a mobile, trailer-mounted light tower. The Hybrid Light Solutions Light Tower consists of a trailer with a diesel generator, a fuel tank, a control panel, and a hydraulic power system with a telescoping tower with four lights. An hydraulic cylinder raises and lowers the telescoping tower. As the engine runs, the generator converts mechanical energy into electric power. The LED lights run off this power.

This machine has been designed and built strictly for the intended use described above. Using the machine for any other purpose could permanently damage the machine or seriously injure the operator or other persons in the area. Machine damage caused by misuse is not covered under warranty.

The following are some examples of misuse:

Operating the machine in a manner that is inconsistent with all federal, provincial and local codes and regulations

Using the machine as a hoist or hanging items from the tower

Operating the machine outside of factory specifications

Operating the machine in a manner inconsistent with all warnings found on the machine and in the Operator's Manual

This machine has been designed and built in accordance with the latest safety standards. It has been engineered to eliminate hazards as far as practicable and to increase operator safety through protective guards and labeling. However, some risks may remain even after protective measures have been taken. They are called residual risks. On this machine, they may include exposure to:

Typical hazards related to towing a trailer on roads and highways

Over speed transportation around corners or rough terrain

Heat, noise, exhaust, and carbon monoxide from the engine

Multiple heat sources: lights, engine, hydraulics

Ultraviolet radiation from the lights

Overhead hazards presented by items on location

Fire hazards from improper refueling techniques

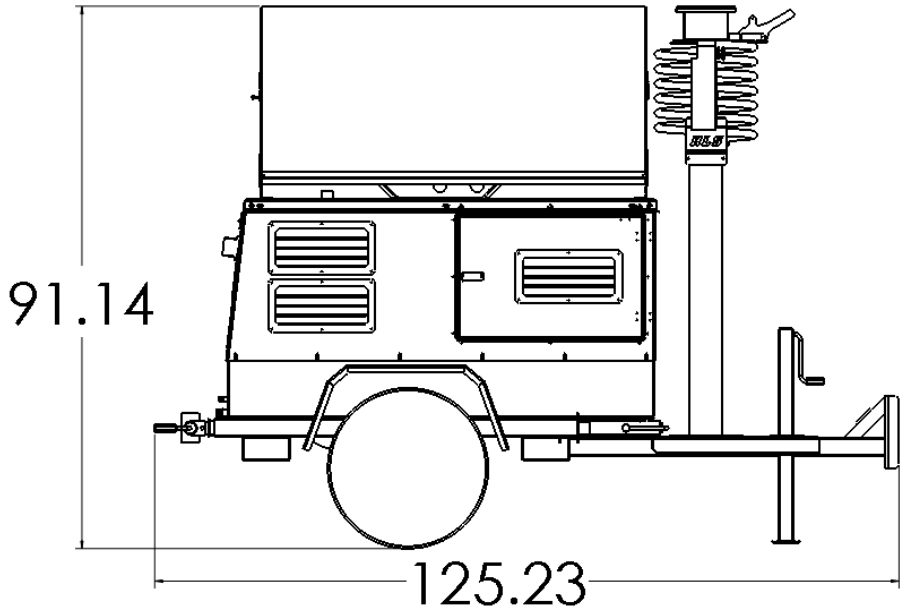
Electric shock and arc flash

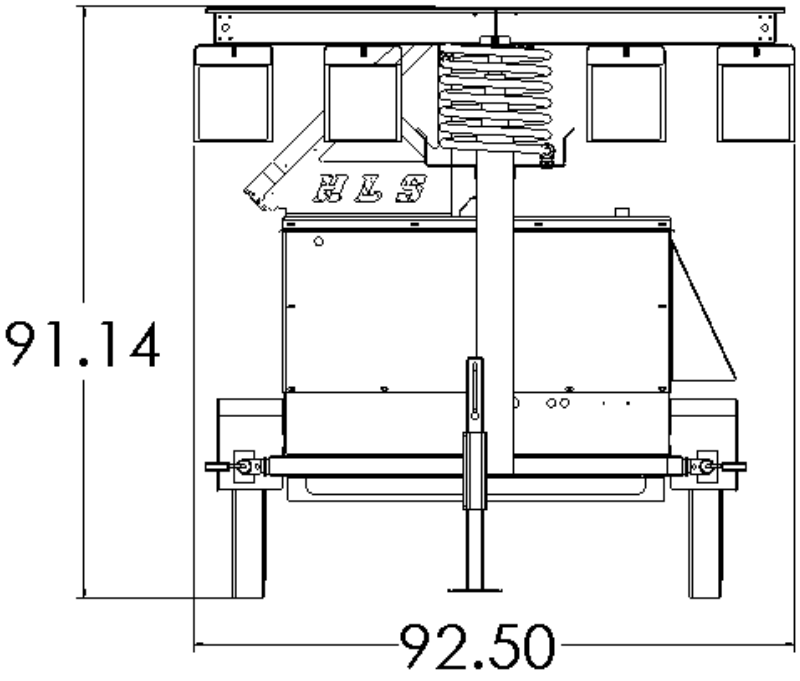
Diesel Fuel and its fumes

Glare from lights (lights may blind drivers of nearby motor vehicles if the lights are incorrectly positioned)

To protect yourself and others, make sure you thoroughly read and understand the safety information presented in this manual before operating the machine

2.2 Product Dimensions





Trailer	Unit
Gross Vehicle Weight (Fueled)	3712 lbs / 1687 kgs
Max Axle Capacity	2272 kg/ 5000 lbs. per axle
Wheels	6 on 6.5
Tires	ST235/80R16
Tire Pressure	60 PSI
Brakes	Electric, Forward Self Adjust
Hubs	6 on 6.5, ⅝” Studs, Grease or Oil

Parameter	Unit
Device name	HLS
Designation	230D
Type	Mobile Tower
Technical life span	5,000 Engine Hours, 2000 charges
Capacity	60 US Gallons / 226.8 Litres
Energy consumption	0.75 GPH / 2.8 LPH
Weight	3712 lbs / 1687 kgs
Battery chemical composition	AGM and Lithium Ion LIPO4
Performance data	11.7 kWh Battery Bank
Fuel Type	No.2 Ultra Low Sulfur Diesel Only
Sound Pressure	68 dBA @ 7m
Gross Engine Power	17.9 kW @ 3000 RPM

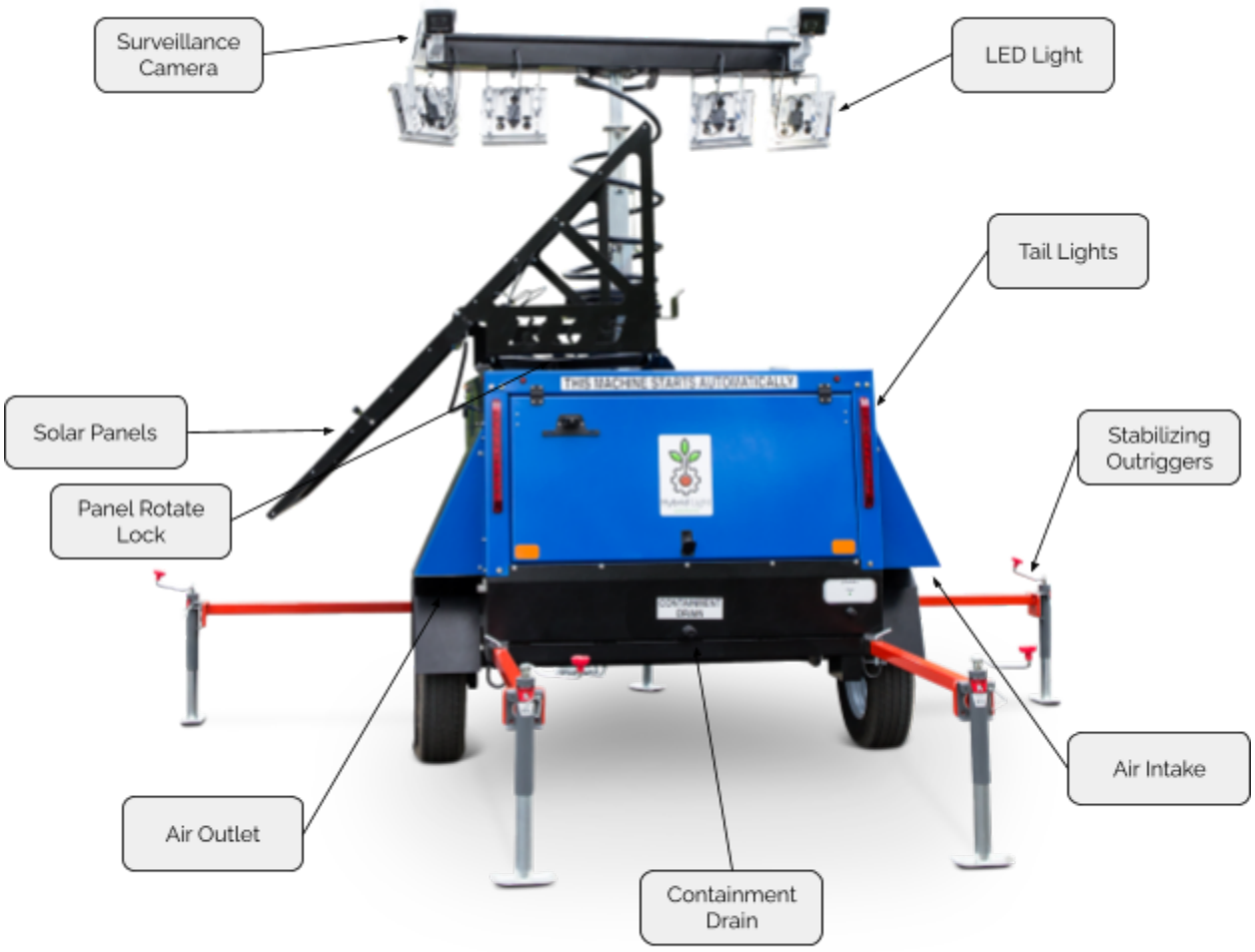
Lighting	Unit
Fixture Type	4 x 200W LED
Nominal Voltage	48 VDC
Ballast	Integrated Intro Fixture
Control Strategy	GPS Automatic or Manual Control
IP Class	65

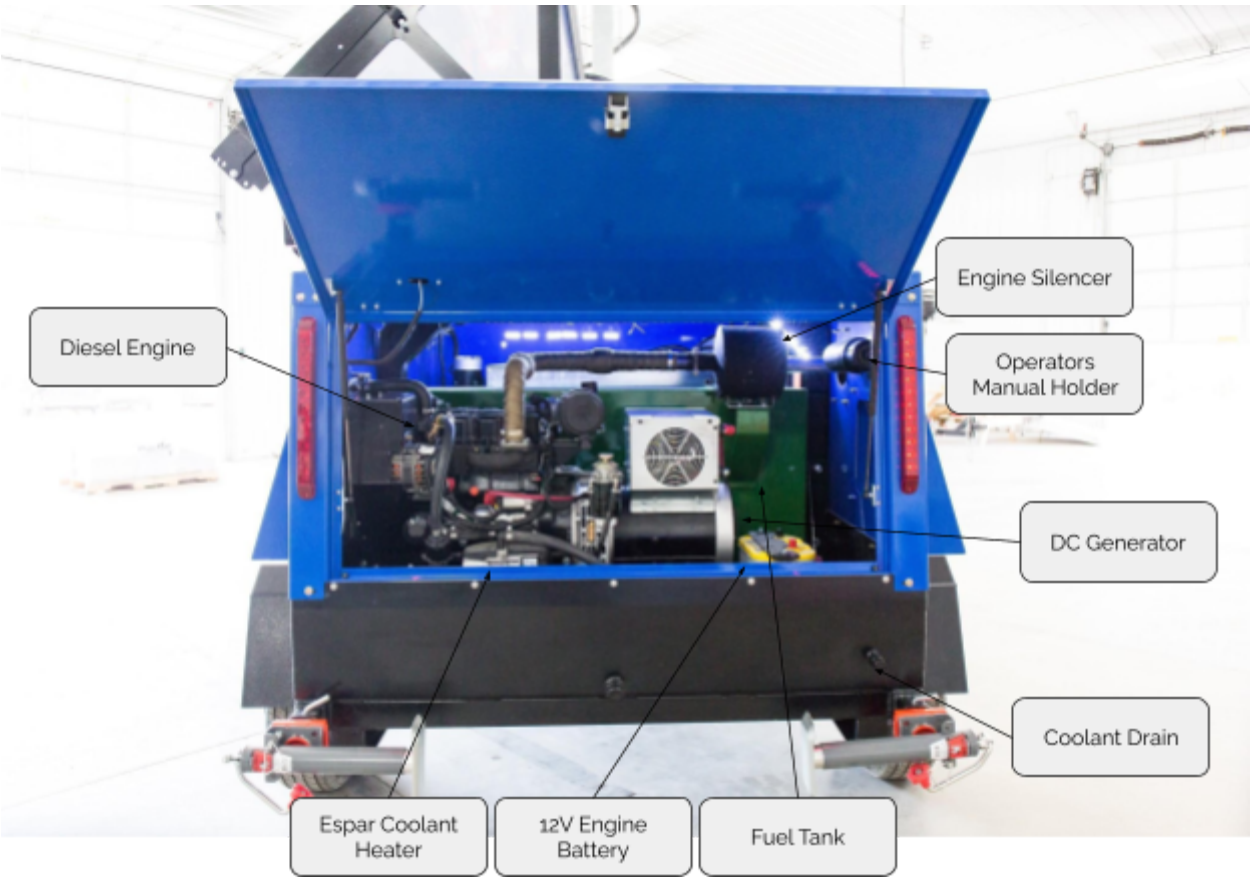
Housing Material	Aluminum / Plastic

Engine Generator	Unit
Engine Make/Model	Doosan D10
Voltage	48VDC Nominal
Main Circuit Breaker	200 Amps
Prime Power	12.4 kW @ 3000 RPM
Fuel Consumption	0.75 GPH
Oil Capacity	4 litres
Oil Type	15W-40 Diesel Summer, 5W-40 Diesel Winter
Oil Change Interval	250 hours (recommended full synthetic)

Mast	Unit
Max Wind Speed Full Height	104 kph (50 mph)

2.3 Product elements




Diesel Engine
Engine Silencer
Operators Manual Holder
DC Generator
Coolant Drain
Espar Coolant Heater
12V Engine Battery
Fuel Tank


Light Tilt Pin
Mast Rotation Pin
Mast Electrical Feed
2-5/16" Ball
Safety Chains
Mast Hydraulic Lift
Hydraulic Pump Access

2.4 Understanding the user interface and control panel

The main user interface is within the main control panel door. The control panel consists of a series of toggle switches and a graphical user interface to provide control of all operating system - and provide the user with operating parameters.

2.5 Setup Process

The setup and deployment process involved for the Model 200 Model 200 Tower involves locating the machine on level, suitable terrain, deploying outriggers, and raising the mast.

Before using the unit, be sure to read and understand all of the instructions. This equipment was designed for specific applications; DO NOT modify or use this equipment for any application other than which it was designed for. Equipment operated improperly or by untrained personnel can be dangerous.

Before starting to visually inspect the Model 200 Light Tower for leaks or damage. A full walk-around visual inspection of all mast pivot points, hydraulic system, and LED lights and light distribution panel.

Quick Setup Guide:

1. Read and understand ALL safety sections at the beginning of this manual
2. Ensure all maintenance procedures are up to date
3. Ensure the unit is set up on firm and level ground
4. Extend all four outriggers and level the trailer with jacks, ensure outrigger jacks are in firm contact with the ground, it is not required or recommended to lift the wheels off the ground
5. Ground unit in accordance with local grounding requirements through ground lug connection
6. Direct as required for surveillance area, ensuring to inspect all camera connections, pin placements, and secondary retention systems (if equipped), it is important to visually inspect and review all cameras before deployment on location
7. Turn disconnects to the off position (12V and 48V)
8. Aim solar panels to be at the optimal angle toward the sun, in most of the US and Canada, this is pointing south
9. Inspect all electrical cords; repair or replace any that are cut, worn, or bare.
10. Ensure all mast cables are in good condition and centred on each sheave. Do not use if cables are kinked or beginning to unravel
11. Ensure battery connections are secure.
12. Remove cameras from the storage container, installed on the mast cross member, ensure to plug in all connections securely and utilize secondary retention cables in conjunctions with cam lock system
13. Turn ON battery disconnect switches (12V and 48V)
14. Turn ON System On switch
15. Direct lights to desired location
16. Raise mast using mast up switch
17. Engine will start and charge batteries to full

WARNING:

It is the operator's responsibility to ensure that the light tower trailer is properly and safely positioned at the lighting location.

DANGER:

Check for overhead power lines and obstructions before raising. Raising the light tower without properly positioning the outriggers and lowering jacks could cause machine rollover resulting in death or serious injury.

DANGER:

Entering electrical compartment while equipment is in operation can result in death or serious injury.

WARNING:

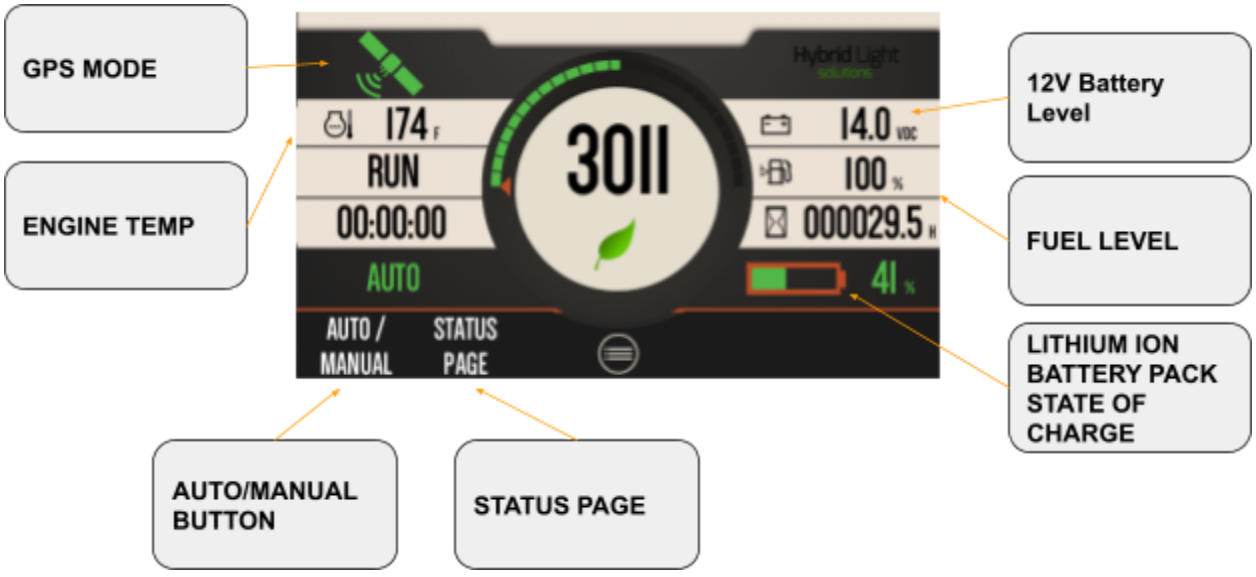
ALWAYS lower the mast when not in use, or if high winds or electrical storms are expected in the area.

DANGER MAX WIND SPEEDS:

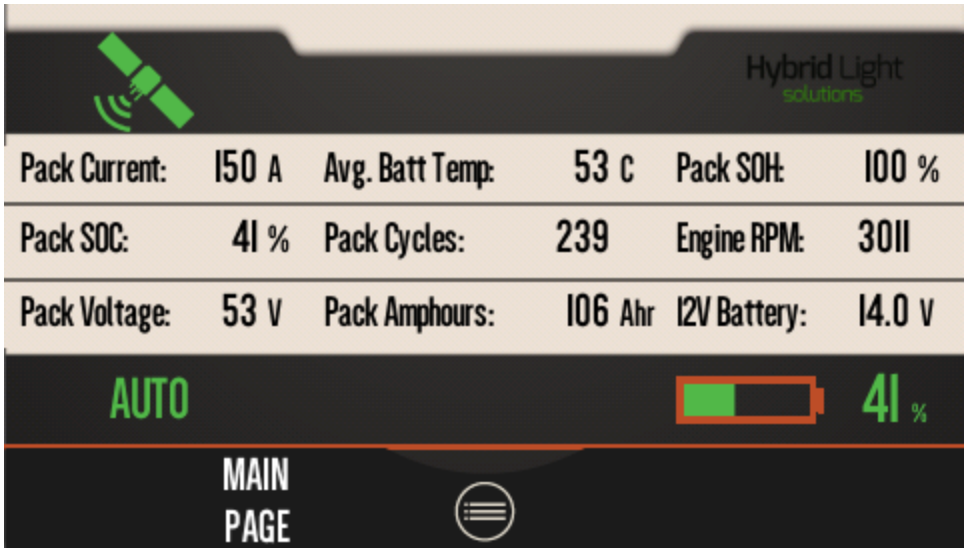
Never operate the tower in high wind speeds:

80 kph (50 mph) @ Mast @ Max Height

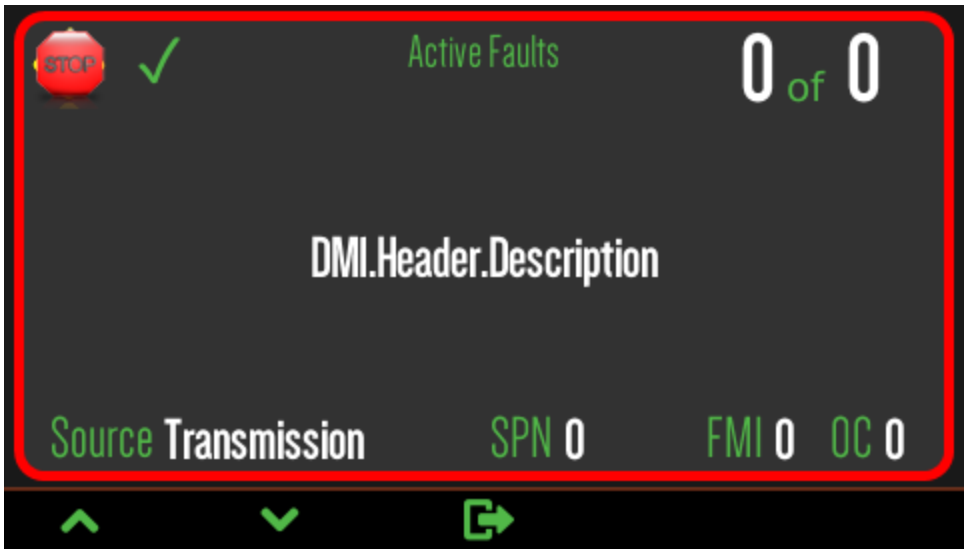
Main Operating Page:



Status Page:



Active Fault Page:



Safety Instructions

⚠WARNING

Read and understand this manual and its safety instructions before using this product. Failure to do so can result in serious injury or death.

2.6 How to Use the Product Safely

2.6.1 Safety information

- Electrocution Hazard: Always check for overhead power lines and wires before deploying mast, allow for a minimum of 50 feet of clearance from all overhead power lines
- High voltage is present in the system while on, never attempt to service the electrical system while the engine is on, or the system is on - qualified technicians only
- Do not operate the light tower if there are signs of wear or damage
- Never permit anyone to operate the machine without proper training
- Never modify equipment without the written consent of Hybrid Light Solutions
- Do not raise, lower, use the mobile tower without deploying all outriggers and jacks, on firm ground suitable for the weight of the Model 200 tower
- Never transport or move the tower without lower mast to transport position
- Explosion Hazard: Flammable diesel fuel and combustible gases can be present in mobile tower
- Never charge a frozen 12V or 48V battery

2.6.2 Technical life span

- Diesel Engine: 5,000+ hours
- Frame and Assembly 5+ Years
- Hybrid Light Solutions recommends that our customers implement an annual inspection process, utilizing proven non destructive testing inspections on critical overhead components

2.6.3 Personal protective Equipment

- Always wear personal protective equipment, including appropriate head protection, clothing, gloves, steel toed boots, eye and hearing protection as required by the task at hand when operating the HLS-200-D

2.7 How to Tow the Product

⚠WARNING

HLS-200-D towers are large mobile piece of equipment designed to be portable, these machines are large and heavy by design to tolerate higher wind load conditions. Appropriate care must be placed on transporting this product safley: take turns and unlevel ground conditions with care and low speeds.

Preparing for Towing or Lifting

2.8 How to connect the trailer

Make sure the doors are properly latched.

Return the outriggers to their travel position. Check that the outrigger bars and jacks are locked in place.

Note: Prior to connecting the vehicle confirm that the towing devices are properly rated for the GVWR of the trailer fully fuelled.

Use the tongue jack to raise the trailer tongue up and then lower it over hitch on towing vehicle. Lock the hitch to the coupling, raise tongue jack completely, pull the spring loaded pin on the tongue jack to completely collapse jack, and attach the safety chains. Note: Ensure your ball hitch is properly secured and that the coupling is pinned correctly, the factory adapter is a 2-5/16” ball

Connect the trailer wiring to the towing vehicle. Check the brake, turn, and tail lights for proper operation. The unit is equipped with self-adjusting electric brakes, ensure you set the brake controller appropriately for the load.

Position the light fixtures down. For rough, off-road transportation remove lamps from fixtures to avoid damage.

Check the tire inflation @ tire manufacturer rated pressure found on the sidewall of the tire

NOTICE: Maximum recommended speed for highway towing is 72 km/hour (45 MPH). Recommended off-road towing speed is not to exceed 16 km/hour (10 MPH) or less depending on terrain. Model 200 tower design can be dependably transported in most conditions. However, we advise drivers to take extra caution during turns or uneven ground conditions, use appropriate caution during cornering maneuvers as the mast is mounted in a top heavy position during transportation and a high level of caution should be used. Note: Stability of trailer is within Transport Canada regulations.

3 MAINTENANCE

3.1.1 Planned maintenance of Model 200

Maintenance tasks shall be done according to the following plan:

Task	Frequency
Change Oil	Every 200 hours
Change Oil Filters	Every 200 hours
Check hydraulic system	Monthly/Weekly with Frequent Use
Inspect Mast and Tower Assembly	Daily
Be Awesome	Daily

Inspection Items / Intervals		Operating Time (hr)								Years of Operation		Reference Note	
		50	100	200	400	600	800	1,500	3,000	Every year	Every two years		
Engine oil	Replace	o	•										
Engine oil filter	Replace	o		•									
Engine starter	Inspect	•											
Battery state	Inspect		•									*3	
Air cleaner element	Clean		•									*1	#
	Replace									•		*2	
Fuel filter element	Replace			•									#
Fan belt	Adjust		•									*3	
Fuel line	Inspect		•										#
	Replace										•		
Intake air hose	Inspect			•									
	Replace										•	*3	
Engine valve clearance	Adjust						•						
Fuel injection nozzle injection pressure	Inspect							•					#
Injection pump	Inspect								•				#
Cooling system	Clean										•		
Coolant	Replace										•		
Fuel system	Inspect											*3	
Fuses	Replace											*3	

3.2 Inspection Tasks

3.2.1 Weekly inspection tasks

Task	Action
Visual inspection of mast	Utilize Murphy level gauge
Check engine oil	Ensure engine level within spec
Hydraulic System Oil and Pump	Remove and check fluids / condition

3.2.2 Annual Inspection tasks

Task	Action
Mast and Frame Weldment Inspection	NDT testing and verification
Load Test	Load Test Diesel Engine

3.3 Exporting Data Logs

3.3.1 Data Log Export

3.4 Battery Management System

3.4.1 The BMS protects and monitors a battery pack by monitoring sensors and using outputs to control charge and discharge into the battery. The BMS measures inputs from cell voltage taps, the total pack voltage tap, a shunt current sensor, thermistors, and a multi-purpose input. Using the programmed settings, the BMS then controls the flow of current into and out of the battery pack through broadcasting charge and discharge current limits via the CAN bus, analog reference voltages, or simple on/off digital signals depending on which style is appropriate for the application. The BMS relies on the user to integrate the BMS with other external devices in a manner such that the current limits set by the BMS are respected in order to protect the batteries. During and immediately after charging, the BMS will balance the cells using internal shunt resistors based on the programmed settings.

3.4.2 The BMS unit monitors the voltage of each individual cell (though the cell tap wires) to ensure cell voltages remain within a specified range. Using the collected information, which includes parameters such as minimum and maximum cell voltages, temperature, and state of charge, the BMS calculates amperage limits for both charge and discharge. These charge and discharge current limits are then transmitted to other external devices digitally via CANBUS, via 0 to 5 volt analog signals, or via on/off outputs. The BMS also calculates the state of charge of the battery pack and monitors the state of health of the individual cells and battery pack.

3.4.3 Cell Voltages - First and foremost, each cell's voltage is measured approximately every 30 mS by sensing the voltage at the cell voltage tap connector. The BMS measures the difference in voltage from one tap wire to the next to measure a cell's voltage. Unless busbar compensation has been configured, the BMS will display and use the actual measured values for cell voltages (otherwise compensated values are used). Only the cell voltages which the BMS has been programmed to monitor in the cell population table in the settings profile are monitored while the other cell voltages are ignored.

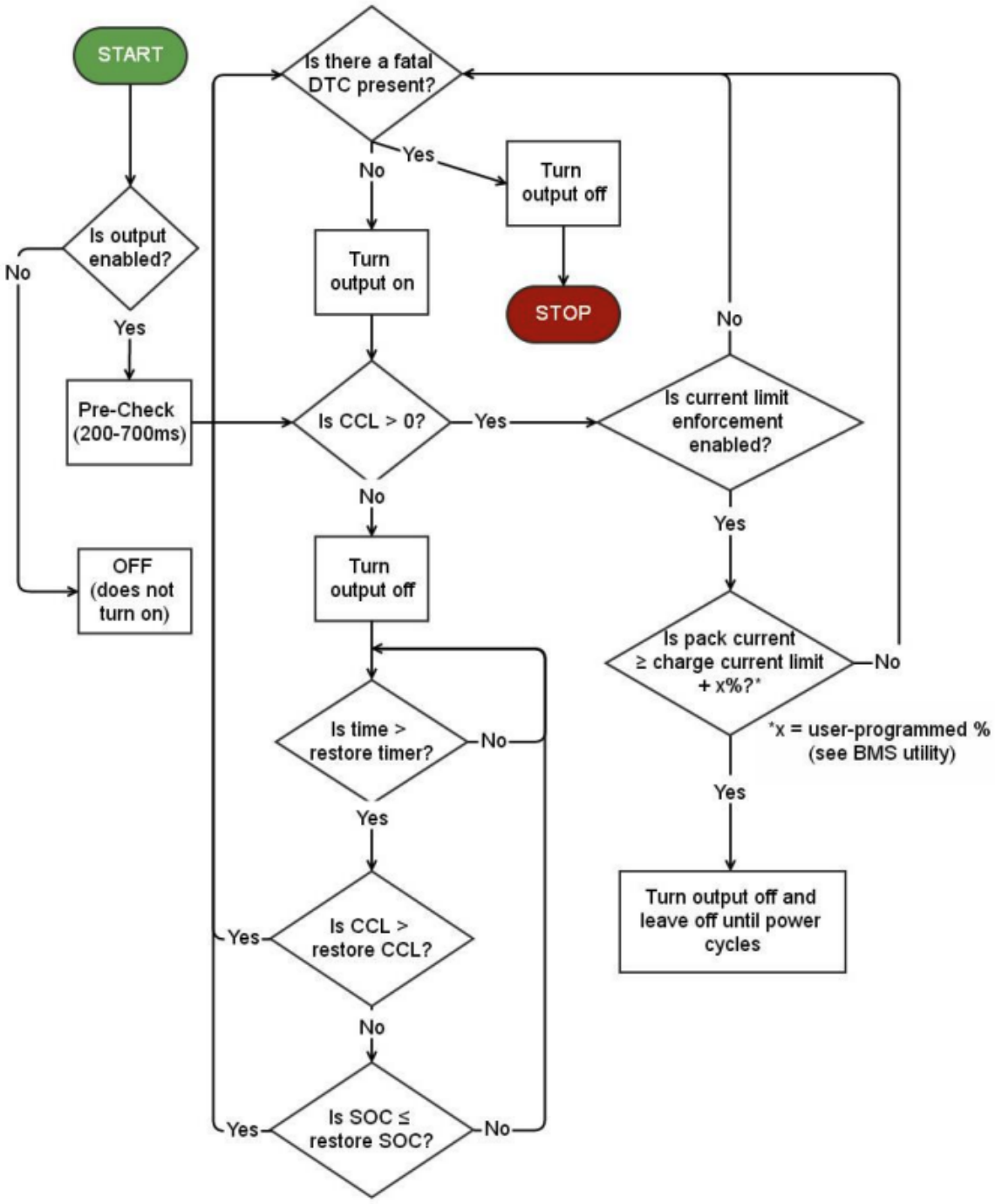
3.4.4 Current (Amperage) - The current into and out of the battery pack is measured every 8mS using the external shunt current sensor. The shunt current sensor is installed in-line with the wire carrying all current into and out of the battery pack. The current sensor must be installed immediately adjacent to the negative terminal of the battery pack and may only be installed in this location. The inline shunt msensor has a slight resistance which causes a voltage drop resulting in small analog voltage of up to +/- 50 mV. The BMS reads this small analog voltage to determine the amount of current flowing out of or into the battery pack. The smallest shunt current sensor able to measure the maximum possible peak amerpage should be used as this will improve the current sensor resolution (accuracy). Shunt current sensors up to 500A are recommended, but the BMS does support shunt current sensors up to 1000A. Sensors larger than 500A will have reduced accuracy and are not recommended unless absolutely necessary. Current sensor data is primarily used in calculating the battery pack's state of charge (via coulomb counting) and for ensuring that the attached application is staying within the correct current limits. The measured current is also used in calculating the internal resistance and health of the cells in the battery pack and various other calculations.

3.4.5 Temperatures - The BMS measures battery temperatures directly from up to 3 thermistors (2 thermistors for revisions A & B) to determine the average temperature of the battery pack. If additional temperature sensing, such as measuring the temperature of each individual cell, is required, the BMS can be connected to a thermistor expansion module which can allow measuring up to 80 thermistors. Thermistors on both the main unit and any expansion modules may be left 'unpopulated' meaning that the BMS will ignore the value of those thermistors. This allows the BMS to be configured to use as few or as many thermistors as necessary. The thermistor expansion module is connected to the BMS through two of the analog thermistor inputs on the BMS.

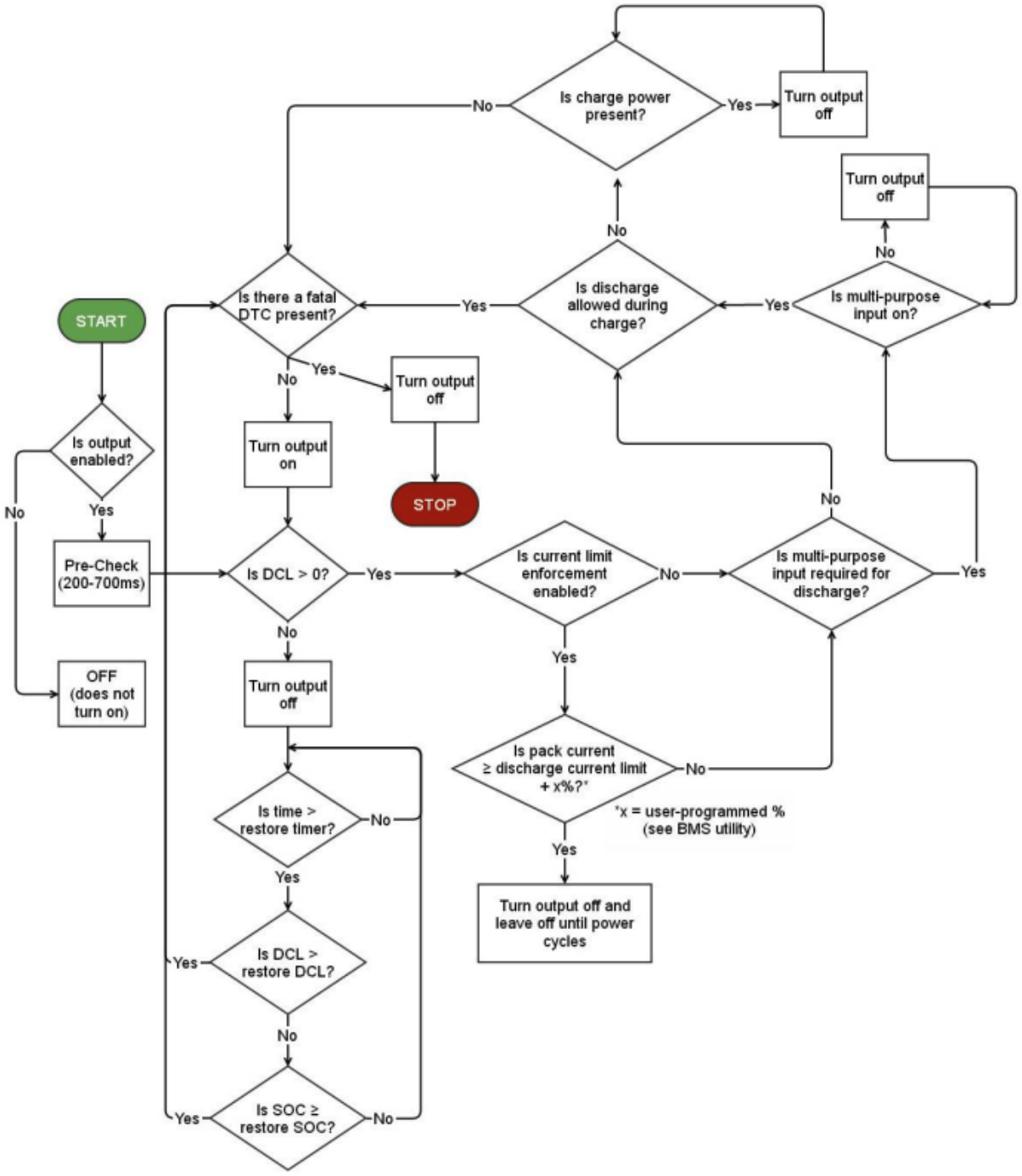
3.4.6 Total Pack Voltage - The BMS has the ability to directly measure the total pack voltage using the total pack voltage sensor on the BMS unit. The voltage from this optional sensor is internally compared to the sum of all individually measured cell voltages to verify that they are consistent with each other. If the voltages differ by more than the amount, an error code is set and the BMS goes into a fail-safe mode. This voltage measurement is intended only to measure for gross differences between the total pack voltage and the sum of all cells and is not intended to be used for accurate total pack voltage measurements.

3.4.7 State of Health Calculation The BMS determines the State of Health of the battery pack primarily by examining both the Internal Resistance and the observed capacity (measured in amp-hours) of the battery pack. As the observed capacity decreases from the nominal (starting) capacity and the internal resistance increases from the nominal capacity, the state of health will go down. This value is typically reflective of the age of the battery pack. However, defective cells or premature aging due to abuse, loose busbars or terminals, or improper wiring can also cause this calculated value to drop prematurely or incorrectly. Every application will have different requirements for what state of health is acceptable. For stationary applications such as a light mobile vehicles, a lower state of health might be acceptable. For an application such as an electric vehicle, the minimum state of health may be higher, so the pack may need replacing sooner than in other applications. A minimum state of health threshold can be programmed into the BMS. If the state of health drops below this value, a weak pack fault code will get set. This fault code is informational only to indicate that the battery pack should be inspected and will not alter the behaviour of the BMS in any way. Although the fault does not alter the behaviour in any way, a high resistance cell or a cell with a lower capacity than expected could impact operation in other ways.

3.4.8 Charge Enable Flow Chart



3.4.9 Discharge Enable Flow Chart



3.4.10 Troubleshooting Battery or BMS Issues:

3.4.11 Understanding Failure Modes

3.4.12 The Orion Jr. BMS has several failsafe software modes to ensure that the batteries are protected against internal and some external failures of the BMS. These modes are designed to place the priority on protecting the battery.

3.4.13 1. Voltage failsafe (non-operating) - This is the most serious failure mode and is triggered when the BMS has determined that it no longer has an accurate cell or total pack voltages. This can be caused by an open (disconnected) tap wire, any populated cell which is reading a voltage below 0.09 volts, total pack voltage sensor reading 0 volts, or a discrepancy between the total pack voltage sensor and the sum of all the cell voltage sensors. Because the BMS cannot protect the cells if the accuracy of the cell voltages or the total pack voltages is compromised, the BMS is forced to enter into a non-operating failsafe mode. When the BMS enters into this voltage failsafe condition, the BMS will begin to gradually de-rate the charge and discharge current limits from their last known value down to 0 to prevent charging and discharging. The amount of time to de-rate the limits is specified in the profile and is designed to provide some usable time of the battery after the failure has occurred. The gradual current limit reductions are intended to alert the operator to the fact there is a problem while providing enough power to allow the application to come to a safe stop. This is particularly useful if the application is a light mobile vehicle or application where having some available power for a short period of time may be useful. This error condition should always be investigated prior to clearing the code.

3.4.14 Current sensor failsafe mode (degraded operation) - This failsafe mode is triggered when the BMS determines that the current sensor is either unplugged or has otherwise become inaccurate and cannot be trusted or if the BMS is configured for no current sensor. In this mode, the current sensor is disabled and will measure 0 amps. The BMS will continue to operate and protect the batteries purely using voltage based conditions. However, all functions relying on the current sensor are disabled. Care should be taken to correct this issue as quickly as possible, but it is possible to continue using the battery pack in this failsafe condition. The behaviors altered while in this failsafe mode:

3.4.14.1 -Internal resistance calculations disabled (both cell and total pack)

3.4.14.2 -Open cell voltage calculations disabled for both pack and individual cell calculations. The open cell voltages will read the same as the instantaneous voltage readings. This results in highly inaccurate state of charge drifts.

3.4.14.3 -State of charge. This cannot be accurately calculated and will be guessed purely on voltage and based on drift points. Drift points are based on open cell voltages, so SOC will vary considerably and should not be trusted to be totally accurate.

3.4.15 Charge and discharge current limits switch to a voltage failsafe calculation mode and may be higher or lower than they should be. However, they will rapidly adjust if voltages approach minimum or maximum levels. Cell protection based exclusively on cell voltages which may not provide full over-current protection. The BMS cannot enforce over current limit protections since current is unknown. Busbar Compensation will effectively be disabled.

3.4.16 Internal memory failsafe (non-operating mode) - In the event of an internal BMS memory failure (i.e. if the memory that stores the profile is damaged), the BMS will load the factory default battery profile with all outputs and inputs disabled to protect the battery. A diagnostic trouble code will be set to indicate this problem has occurred.

3.4.17 Diagnostic Trouble Codes

3.4.18 P0A04 – Wiring Fault Error Code (or “Open Cell Voltage Fault”) 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 Orion Jr. 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. For more information on what causes fuses within the BMS to blow, please see Why Orion Jr. BMS Internal Fuses Blow. Note: The Orion Jr. 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 the cell 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). This error indicates that the Orion Jr. BMS has encountered an error trying to communicate with the 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.

3.4.19 P0A03 – Pack Voltage Mismatch Error: This error code indicates that the voltage measured by the total pack voltage sensor did not match the sum of the individual cell voltage measurements.

This error is triggered when the difference in voltage between the two measurements exceeds the 'Pack Voltage Mismatch Threshold' setting in the BMS profile (under Pack Settings). 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. This fault code may be the result of a wiring error on the cell taps (look for "Open wire faults"), a wiring error on the total pack voltage sensor, a cell population setting error, or an internal BMS error.

3.4.20 P0AC0 – Current Sensor Fault: A current sensor fault is triggered if the analog voltages from the attached shunt current sensor stray outside of the normal range. The current sensor may be sized incorrectly, there may have been currents exceeding the maximum value of the shunt sensor, the wiring may be faulty, or the BMS or current sensor may be faulty. This error code will cause the BMS to enter a current sensor failsafe mode. With the exception of overcurrent protection, the BMS is fully able to protect the cells in this mode, and therefore the BMS will continue to operate in a voltage based mode. In this failsafe mode the BMS will continue to operate and protect the cells. However, some calculations are unavailable and many features are disabled or degraded such as state-of-charge calculation, open cell voltage calculation, and discharge and charge limit amperages are calculated using a backup algorithm. Please see the operational manual for more detailed information on what is and what is not available in this mode.

3.4.21 P0A80 – Weak Cell Fault

3.4.22 This fault is triggered based on thresholds programmed into the BMS profile that indicate when a cell is

3.4.23 "weak". While this error code is designed to indicate a cell is weak, this error is triggered when

3.4.24 certain pre-programmed conditions are met and does not necessarily indicate a dead cell

3.4.25 because it can also be triggered by loose busbars, other wiring issues or incorrect error

3.4.26 threshold settings in the profile.

3.4.27 Important Note: Weak cell faults are informational errors only and have NO DIRECT IMPACT on

3.4.28 the operation of the BMS. This error code will NOT cause the charge or discharge enable outputs to

3.4.29 turn off and will NOT cause the BMS to go into any degraded operating mode. While this error code will

3.4.30 not impact the operation of the BMS, this error message likely indicates a problem exists and the actual

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3.4.33 problem itself (not this error code) may cause the BMS to limit charge or discharge current (as would be

3.4.34 the case with a high resistance cell). If the charge and discharge limits are both zero, look for other fault

3.4.35 codes, specifically open wire faults or total pack voltage fault codes to begin addressing the issue.

3.4.36 The “weak” cell fault can be triggered as the result of the following 2 conditions:

3.4.37 1. High measured cell resistance – The Orion Jr. BMS measures each cell’s internal resistance

3.4.38 and compares the measured resistance against the nominal resistance specified in the profile in

3.4.39 the “temperature compensation” section. The current temperature is used to select the nominal

3.4.40 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

3.4.41 fault code will be triggered. For example, if the nominal resistance is 1 mOhm at 20 degrees

3.4.42 Celsius and the BMS is programmed with a 400% resistance threshold, an error code will be

3.4.43 triggered if the cell resistance is measured at more than 4 mOhm resistance at 20 degrees Celsius.

3.4.44 2. Difference in open cell voltage between a cell and the rest of the pack - In addition to

3.4.45 measuring the resistance of the cell, the BMS also looks for significant differences between the

3.4.46 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 Cell Settings tab as "Max Open Cell Variance" and is in volts. This can be caused by a cell that has deteriorated disproportionally to the rest of the battery pack or by a cell balance issue.

The above criteria are what actually trigger this error code, but the following conditions may cause one of the conditions above and therefore also trigger this error:

1. Loose busbar or interconnect cable resistance – 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 based on the threshold in #1 above.

2. Significant difference in cell capacity than other cells – 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.

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.

For information on addressing this diagnostic trouble code, please see

3.4.67 http://www.orionbms.com/troubleshooting.

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3.4.70 P0A0B – Internal Logic Fault Code

3.4.71 This error code indicates that the Orion Jr. BMS has determined that an internal hardware fault has occurred. If this error message occurs, please download the associated freeze frame data and contact the

3.4.72 factory or authorized dealer for assistance. Please save the freeze frame data and send it along with

3.4.73 any other relevant information to the factor as it may be crucial for appropriately repairing the unit.

3.4.74 P0A0A – Internal Thermistor Fault

3.4.75 This error code indicates that the Orion Jr. BMS has determined that an internal hardware fault has occurred. If this error message occurs, please download the associated freeze frame data and contact the

3.4.76 factory or authorized dealer for assistance. Please save the freeze frame data and send it along with

3.4.77 any other relevant information to the factor as it may be crucial for appropriately repairing the unit.

3.4.78 P0A09 – Internal Memory Fault

3.4.79 This error code indicates that the Orion Jr. BMS has determined that an internal hardware fault has occurred. If this error message occurs, please download the associated freeze frame data and contact the

3.4.80 factory or authorized dealer for assistance. Please save the freeze frame data and send it along with

3.4.81 any other relevant information to the factor as it may be crucial for appropriately repairing the unit.

3.4.82 P0A00 – Internal Conversion Fault

3.4.83 This error code indicates that the Orion Jr. BMS has determined that an internal hardware fault has occurred. If this error message occurs, please download the associated freeze frame data and contact the

3.4.84 factory or authorized dealer for assistance. Please save the freeze frame data and send it along with

3.4.85 any other relevant information to the factor as it may be crucial for appropriately repairing the unit.

3.4.86 P0AFA – Low Cell Voltage Fault

3.4.87 This fault code is triggered when the voltage of a cell falls below 0.09 volts (90 mV). This fault can be

3.4.88 caused by a cell that is incorrectly set in the BMS profile as a “populated” cell, a disconnected cell wiring harness, a very dead cell, or a wiring error. In a revision E unit, this fault code can also indicate two

3.4.89 or more cell voltage tap wires are backwards. If cell voltage tap wires are backwards, the cell voltage tap connectors should be immediately disconnected from the BMS unit until the issue is corrected as permanent damage may occur to the unit and may drain the attached cells damaging them.

3.4.90 For information on addressing this diagnostic trouble code, please see

3.4.91 http://www.orionbms.com/troubleshooting.

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3.4.94 P0A0D – Cell Voltage Over 5 Volts (Revision C only)

3.4.95 The cell tap harness should be immediately disconnected from the BMS if this fault code is set.

3.4.96 Leaving the harness connected to the BMS is likely to cause damage to the BMS and may

3.4.97 indicate that a cell is severely overcharged. Incorrect wiring may pose a fire and/or personal

3.4.98 safety hazard or may lead to cell damage. Never continue to use a damaged BMS unit!

3.4.99 This fault code is triggered if the voltage of an individual cell (as measured by the BMS) exceeds 5.0

3.4.100 volts. This fault code will only trigger after a number of samplings over the period of 1 minute to

3.4.101 prevent false positives. If this fault triggers, it will cause the BMS to enter into a voltage failsafe

3.4.102 condition disabling all charge and discharge.

3.4.103 This fault can be caused by incorrect cell tap wiring, a loose or disconnected cell tap, a blown fuse

3.4.104 inside the BMS, a high resistance or loose busbar, a cell which is actually over 5 volts, or from internal

3.4.105 damage to the BMS unit due to previous wiring faults. This fault code should always be immediately

3.4.106 investigated as the BMS can be damaged by cell voltage readings above 5.0v and as there may be

3.4.107 other dangerous conditions such as over-charged cells.

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

3.4.109 disconnect the BMS immediately.

3.4.110 Note: Cells which have been over-charged or over-discharged may not be safe to use even after

3.4.111 bringing the voltage into a correct range. A cell which has previously been over-charged or overdischarged at any time may develop internal damage, compromising the safety of the cell. Always

3.4.112 consult the cell manufacturer for advice on whether a cell can be safely used after an over-charge or

3.4.113 over-discharge event.

3.4.114 P0A01 – Pack Voltage Sensor Fault

3.4.115 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

3.4.116 connected when the BMS was turned on, a wiring error on the total pack voltage sensor, a voltage tap

3.4.117 that is wired to the wrong location or an internal BMS error.

3.4.118 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.

3.4.119 For information on addressing this diagnostic trouble code, please see

3.4.120 http://www.orionbms.com/troubleshooting.

3.4.121 P0A02 – Weak Pack Fault

3.4.122 This error code is designed to alert a user to if the battery pack has degraded and is weak, this error is

3.4.123 triggered based only when pre-programmed conditions are met and does not necessarily indicate a weak is actually weak since the error threshold may be set wrong. This error may be falsely

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3.4.126 triggered by incorrect profile settings, a battery pack with an abnormally low state-of-charge or by malfunctioning thermistors which are not accurately reading the pack temperature.

3.4.127 This fault is triggered when the pack state-of-health falls below the value programmed into the BMS

3.4.128 profile that indicates when a battery pack is considered “weak”. A low state-of-health measurement is

3.4.129 calculated 50% based on pack capacity and 50% based on cell resistance. For more information on

3.4.130 how state of health is calculated, please see the operational manual.

3.4.131 Important Note: Weak pack faults are informational errors only and have NO DIRECT IMPACT on

3.4.132 the operation of the BMS. This error code will NOT cause the charge or discharge enable outputs to

3.4.133 turn off and will NOT cause the BMS to go into any degraded operating mode. While this error code will

3.4.134 not impact the operation of the BMS, this error message likely indicates a problem exists and the actual

3.4.135 problem itself (not this error code) may cause the BMS to limit charge or discharge current (as would be

3.4.136 the case with a high resistance cell). A degraded battery pack may result in degraded performance for

3.4.137 other reasons such as low capacity or high resistance.

3.4.138 For information on addressing this diagnostic trouble code, please see

3.4.139 http://www.orionbms.com/troubleshooting.

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3.4.142 P0A06 – Charge Limit Enforcement Fault

3.4.143 (Also P0A07 – Discharge Limit Enforcement Fault and P0A08 – Charger Safety Relay Fault)

3.4.144 These 3 fault codes are caused when charge or discharge current (respectively) either exceeds the limit set by the BMS or continues after the digital on/off outputs are turned off. For example, if the BMS

3.4.145 has set a discharge current limit (DCL) of 50 amps and the BMS measures 100 amps for an amount of

3.4.146 time exceeding the limit in the profile, it will set the discharge limit enforcement fault since more current

3.4.147 is being drawn than is allowed. The same fault will get set if the BMS turns off the discharge enable

3.4.148 output and any current is discharged after the set amount of time passes. Charge limit enforcement corresponds to charge current; discharge limit enforcement corresponds to discharge current. This error

3.4.149 can be falsely triggered if the current sensor polarity is backwards.

3.4.150 When this error is triggered, the BMS is put into a failsafe mode and all 3 charge / discharge / charger

3.4.151 enable outputs are turned off in the event the outputs are wired backwards. The failsafe condition will

3.4.152 reset when power is cycled.

3.4.153 For information on addressing this diagnostic trouble code, please see

3.4.154 http://www.orionbms.com/troubleshooting.

3.4.155 P0A9C – Thermistor Fault

3.4.156 A thermistor fault is triggered detected if the analog voltage measured from the thermistor is outside of

3.4.157 the normal thermal operating range. This error can be triggered if the temperature of the thermistor rises above 81C or drops lower than -41C. A shorted or open wire can result in artificially high or low

3.4.158 measurements that would result in this error code. The use of an incompatible thermistor can cause

3.4.159 inaccurate readings and trigger this error code.

3.4.160 When this error code is set, the Orion Jr. BMS will disregard the value of the affected thermistor, using

3.4.161 the values of the other thermistors and continue to operate normally.

3.4.162 For information on addressing this diagnostic trouble code, please see

3.4.163 http://www.orionbms.com/troubleshooting.

3.4.164 P0A07 – Discharge Limit Enforcement Fault

3.4.165 (Also P0A06 – Charge Limit Enforcement Fault and P0A08 – Charger Safety Relay Fault)

3.4.166 These 3 fault codes are caused when charge or discharge current (respectively) either exceeds the limit set by the BMS or continues after the digital on/off outputs are turned off. For example, if the BMS

3.4.167 has set a discharge current limit (DCL) of 50 amps and the BMS measures 100 amps for an amount of

3.4.168 time exceeding the limit in the profile, it will set the discharge limit enforcement fault since more current

3.4.169 is being drawn than is allowed. The same fault will get set if the BMS turns off the discharge enable

3.4.170 output and any current is discharged after the set amount of time passes. Charge limit enforcement corresponds to charge current; discharge limit enforcement corresponds to discharge current. This error

3.4.171 can be falsely triggered if the current sensor polarity is backwards.

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3.4.174 When this error is triggered, the BMS is put into a failsafe mode and all 3 charge / discharge / charger

3.4.175 enable outputs are turned off in the event the outputs are wired backwards. The failsafe condition will

3.4.176 reset when power is cycled.

3.4.177 This fault code may indicate a potentially dangerous condition indicating that the BMS does not have

3.4.178 control over attached loads and should be investigated immediately. Do not continue to operate the application until this fault has been investigated.

3.4.179 For information on addressing this diagnostic trouble code, please see

3.4.180 http://www.orionbms.com/troubleshooting.

3.4.181 P0A08 – Charger Safety Relay Fault

3.4.182 (Also P0A06 – Charge Limit Enforcement Fault and P0A07 – Discharge Limit Enforcement Fault)

3.4.183 These 3 fault codes are caused when charge or discharge current (respectively) either exceeds the limit set by the BMS or continues after the digital on/off outputs are turned off. For example, if the BMS

3.4.184 has set a discharge current limit (DCL) of 50 amps and the BMS measures 100 amps for an amount of

3.4.185 time exceeding the limit in the profile, it will set the discharge limit enforcement fault since more current

3.4.186 is being drawn than is allowed. The same fault will get set if the BMS turns off the discharge enable

3.4.187 output and any current is discharged after the set amount of time passes. Charge limit enforcement corresponds to charge current; discharge limit enforcement corresponds to discharge current. This error

3.4.188 can be falsely triggered if the current sensor polarity is backwards.

3.4.189 When this error is triggered, the BMS is put into a failsafe mode and all 3 charge / discharge / charger

3.4.190 enable outputs are turned off in the event the outputs are wired backwards. The failsafe condition will

3.4.191 reset when power is cycled.

3.4.192 This fault code may indicate a potentially dangerous condition indicating that the BMS does not have

3.4.193 control over attached loads and should be investigated immediately. Do not continue to operate the application until this fault has been investigated.

3.4.194 For information on addressing this diagnostic trouble code, please see

3.4.195 http://www.orionbms.com/troubleshooting.

3.4.196