

Li510 LITHIUM-ION BATTERIES SERVICE MANUAL



Previously LiFT FORCE LPX 2.0

WARNINGS AND GENERAL INFORMATION



Observe these Instructions and keep them located near the battery for future reference. Work on the battery should only be carried out by qualified personnel.



While working on batteries wear protective eye-glasses and clothing.



Caution – parts of the battery may carry dangerous voltages. Be careful when handling cables.



Keep battery dry.



DO NOT smoke.
DO NOT dispose of the batteries in a fire.
DO NOT dispose of the battery in normal waste.
DO NOT include battery with lead acid battery recycling.



Explosion and fire hazard. Avoid short circuits. Avoid electrostatic charges and discharges/sparks.



Keep children away from batteries.



DO NOT pressure wash.



- Lithium Batteries are heavy. Make sure they are installed securely.
- Handle with care, avoid mechanical shock.
- Do not lift or pull up on power or communication cables.
- Avoid wearing any loose metallic items such as jewelry, watches, or bracelets
- Corrosive contents! Do not open. Avoid contact with contents of a damaged battery.
- To avoid the release of harmful gases, avoid deeply discharging, charging when damaged, and improperly charging the battery.
- Use certified insulated safety tools for installation. Any work procedures and tools used should be in compliance to EN 60900 or similar standard.



Battery may require recycling in accordance with local laws. Contact Stryten Energy or regulatory authorities for further information. DO NOT include battery with lead acid battery recycling.



Tray lifting at this area.



Before working on any battery, a Stryten Energy ServiceMAX ticket must be created! Contact Stryten Energy customer service if you need assistance creating a ServiceMAX ticket.



Do not break the warranty seals of any battery without authorization from Stryten Energy Service! Breaking a warranty seal without authorization from Stryten Service will void the warranty.

Stryten Energy Motive Power Service 1-866-462-2288 strytenncc@stryten.com

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MAJOR COMPONENTS

Components used by Operators, most commonly serviced:

Charger Connector – Delivers power from charger. DIN320 or DIN640, per current requirements. Uses aux pins for communications with charger

Forklift cable and connector – Delivers power to forklift, connector type per customer specification

Power Button and Buzzer – Activates battery, alert operator of warnings as needed

Opus Display – Provides battery information to Operator such as State of Charge (SOC) and other status information

Components interior to the battery, not typically serviced:

Power Modules – Configured in series and/or parallel to achieve battery voltage and capacity per customer requirements

BMS – Controls System operation, Monitors Power Modules

Power Contactors – Controlled by BMS. Used to Isolate truck while charging and as needed for system safety events

Charger and Forklift Fuses – Protect against system overcurrent

Battery Tray – Protects components and provides ballast for forklift

Power Bus – Power distribution to and from individual Power Modules

CANbus and Safety Line – Between BMS and all modules.

IDENTIFYING Li510 BATTERY INFORMATION

Every Li510 battery has a label plate on the lid of the battery which identifies the following battery information:

- Nominal Voltage
- Max Charge Voltage
- Capacity in Ahrs
- Energy in kWh

- Weight, in kg and lbs
- Model number
- Serial Number

Before servicing a Li510 battery, make sure to note the model and serial number of the battery, in the event that this information needs to be provided to Stryten Energy Service. (See below)



OPUS BATTERY DATA DISPLAY

The Opus Display shows State of Charge (SOC), battery temperature, voltage and current. The display is used primarily by the Operator to monitor SOC in between charging breaks. (See below)



If the BMS detects a warning or alarm condition, it will show the warning or alarm on the display. (See below) For warnings, the buzzer will beep once per second. Otherwise, the battery operates as normal. For alarm conditions, the buzzer beeps 3 times per second for 15 seconds, to alert the operator that the battery will shut off and forklift operation will be disabled in 15 seconds.

Once the alarm condition is removed, the battery can be restarted with the power/reset button. **When troubleshooting a Li510 battery, be sure to note the values displayed on the Opus screen before, during and after battery problems occur.**



The following Warnings, Alarms and Alerts may be displayed on the Opus during normal operation:

Low SOC Warning – typically the most common warning, indicating that the battery needs to be charged soon

Low SOC Alert – If the Battery reaches 0% SOC, the battery will shut itself off in order to protect itself. The buzzer beeps 3 times per second for 15 seconds, to alert the operator that the battery will shut off and forklift operation will be disabled in 15 seconds. If a battery shuts off with a low SOC Alert, it can be reset one time, after which the forklift must immediately return to the charging area so that the battery can be charged

Low Voltage Alarm – If following a Low SOC Alert, the battery is not immediately charged and continues to be used, the battery will further protect itself with a Low Voltage Alarm. After the Low Voltage Alarm occurs, the battery cannot be reset and the forklift must be towed back to the charging area

Low Voltage Warning – If the battery is at low SOC and the forklift is performing work that puts a heavy power load on the battery, a Low Voltage Warning may occur. This is another indication that the battery needs to be charged.

High or Low Temperature Warning – If the battery gets within 5C of its high or low temperature limits, a warning will be displayed on the Opus

High or Low Temperature Alarm – If the battery exceeds its high or low temperature limits, an alarm will be displayed on the Opus. The buzzer will beep rapidly for 15 seconds, after which the battery will shut down for protection.

The following Warnings, Alarms and Alerts may be displayed on the Opus during error conditions:

Please Check CAN Communication – If this alarm occurs during charging, it is typically indicative of a communication error between the charger and battery. This alarm is usually resolved by servicing of the AUX pins on the charger connector on the battery and / or the Aux pins on the charger's output connector. If this error occurs during forklift operation, with no charger present, it may indicate a CAN communication error inside

the battery, in which case contact Stryten Energy Service to arrange for factory repair.

Over Current CHG Alert – This Alert is typically indicative of a loose current shunt in one of the power modules. It typically occurs when the forklift is operating, and results in the battery powering down after issuing an alarm beep for 15 seconds. In some cases the problem may stop after the battery is reset, however this issue, once presented, usually reoccurs with increasing frequency. If this message occurs, contact Stryten Energy Service to arrange for factory repair.

Plug Removed DIS Alert – This Alert is typically indicative of a loose current shunt in one of the power modules. It typically occurs when the battery is put on charge, and results in the battery powering down after issuing an alarm beep for 15 seconds. In some cases the problem may stop after the battery is reset, however this issue, once presented, usually reoccurs with increasing frequency. If this message occurs, contact Stryten Energy Service to arrange for factory repair.

Safety line Alert – This Alert indicates that either one of the Power Modules has detected a problem or that one of the internal CAN communication lines is loose. If this message occurs, contact Stryten Energy Service to arrange for factory repair.

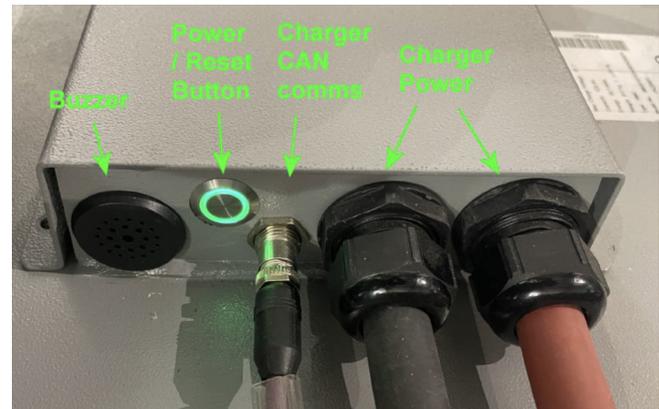
Plausibility Error – The BMS has detected inconsistent readings between Power Modules in the battery. This may indicate that a module has a blown fuse, a low

voltage cell block, or some other unusual condition. If this message occurs, contact Stryten Energy Service to arrange for factory repair.

BATTERY POWER SWITCH LEDs

The Li510 Battery power/reset switch has two LEDs that are also used to indicate status of the battery. The power / reset switch is located on the gland pod, on top of the battery, on the same side of the gland pod as the buzzer.

To power the battery on, press and hold the Power/Reset button until it turns green (approx 1s). To power the battery off, press and hold the Power/Reset button until it turns red (approx 5s). When troubleshooting a battery, make sure to note the status of the switch LEDs (See below)



On / Off button	LED Green	LED Red
System in Standby mode	Off	Off
System active, no alarm or warning detected	Once per second	Off
Warning	Off	Once per second
Alarms	Off	Three per second
Button pressed for less than 5s to Reset Warnings / Alarms	On as long as button is pressed	Off
Button pressed for more than 5s to move from active to Standby mode	Off	On as long as button is pressed
Button is pressed in standby mode and the system is moved into active mode	On as long as button is pressed	Off

PERIODIC MAINTENANCE

Fully charging the battery

In order to keep all the cells in the battery balanced, it should be fully charged to 100% State of Charge (SOC) at least once per week and ideally once per day, as shown on the M-Series X-3 and X-7 charger screen below.



In order to make sure that the battery is fully charged, plug the battery into the charger and do not disconnect the battery until the “Complete” status is shown on the charger. Make sure that the weekly charging schedule allows adequate time for the battery to get a full charge once per week and ideally once per day.

Keeping power and aux contacts on charger connector clean

Make sure that the blue coding key is installed properly and that the interior mating surfaces of the 2 power pins and 4 aux pins on the charger connector are clean. Clean the interior of the pins with either 95% ethanol or 91% isopropyl alcohol and swabs. This should be done at least every six months in a clean facility and more often for facilities with large amounts of airborne material.



REMA640 Charger connector contacts



REMA320 Charger connector contacts

When the blue coding key is inserted properly, the battery voltage will be visible through the hole in the top of the connector. See the section on servicing the charger connector if the coding key is not installed properly.



Checking cable from battery to Forklift

Check the connector to the forklift to make sure that it is inserted tightly. Also check the exit point of the battery compartment to make sure that the power cables to the forklift are not rubbing on any metal surface where they could be abraded.



General operational considerations

Make sure that the battery is kept clean and dry

- Never clean the system or system parts using a vapor jet or spray water.
- Dirt and water may enter the system and cause major damage.
- Use only a moist and clean cotton cloth for cleaning.
- Avoid chlorine-based disinfectant wipe-downs.

Do not let the battery sit for long periods of time at low state of charge.

Before being placed in storage the battery should be charged to 50 % SOC, powered off, and disconnected

from both the vehicle and the charger.

The Li510 Lithium Material Handling Battery system has a very low self-discharge and can be put into storage for up to 12 months. It must then be recharged

If batteries are taken out of service, they should be stored in a dry and frost free room.

TROUBLESHOOTING ISSUES DURING BATTERY OPERATION

SOC on Opus display does not match Forklift BDI display

The Li510 batteries use NMC chemistry. If the Forklift Battery Discharge Indicator (BDI) is configured for lead acid or some other type of lithium chemistry, the SOC displayed by the Opus may not match the SOC displayed by the forklift BDI. For example, in the images below, the Opus display on the top is showing 100% SOC and the forklift BDI on the bottom is showing 90% SOC.



The discrepancy on the previous page in displayed SOC values is normal when the truck BDI is configured for lead acid or some other lithium chemistry. Check with the forklift dealer and/or forklift technical support to configure the truck BDI for NMC lithium. If this is not possible, use the SOC displayed by the Opus to gauge the battery SOC and ignore the SOC displayed on the forklift BDI. The following table should be used when setting up a Forklift BDI to be used with Li510 batteries.

Nominal Voltage	0% SOC	100% SOC	Undervoltage alarm	Overvoltage alarm
24V	22.4 V	28.8 V	20.3 V	29.8 V
36V	32.0 V	41.2 V	29.0 V	42.5 V
48V	44.8 V	57.7 V	40.6 V	59.5 V
72V	64.0 V	82.4 V	58.0 V	85.0 V
80V	67.2 V	86.5 V	60.9 V	89.3 V
96V	89.6 V	115.4 V	81.2 V	119.0 V

Forklift goes into “turtle” mode at high or low SOC

If the Forklift BDI is configured for lead acid or some other type of lithium chemistry, the Forklift BDI may limit the operation at either the high voltage or low limit of the battery. In this case, it will be necessary to work the forklift dealer and/or forklift technical support to configure the truck BDI for NMC lithium. Use the table on the previous page to verify that the working voltage range of the battery is supported by the Forklift’s drive electronics and set the Forklift’s BDI accordingly.

Battery quickly drops to low state of charge after charging

If the battery quickly drops to a low state of charge after charging, this may be a sign of a loose current



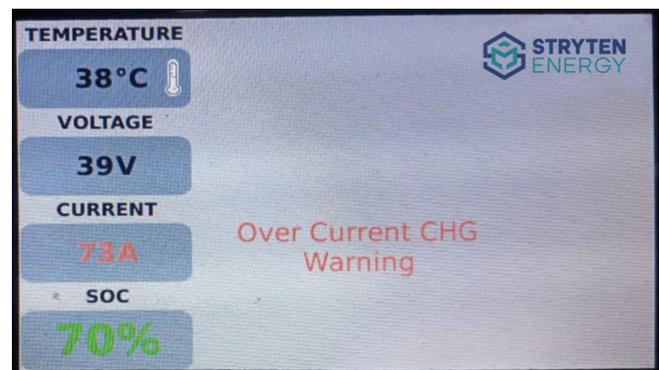
sensor inside the battery. Indications that the Low SOC Warning is likely due to a loose current shunt are:

1. Typically the voltage reading will be higher than normal for a low SOC battery. For a 36v battery, the voltage that corresponds to 6% SOC is approximately 34V. If the battery voltage shown at low SOC is significantly higher than this, it could indicate a loose current sensor.
2. If a current shunt is loose, typically there will be a current of ~-65A displayed, even if the forklift is stationary and not moving.

While the forklift can be operated safely at a false low SOC, the warning beeping from the battery may be objectionable to operators. If this error occurs, please take a picture of the Opus display and battery serial number, and contact Stryten Energy Customer service, as this is not a field repairable issue.

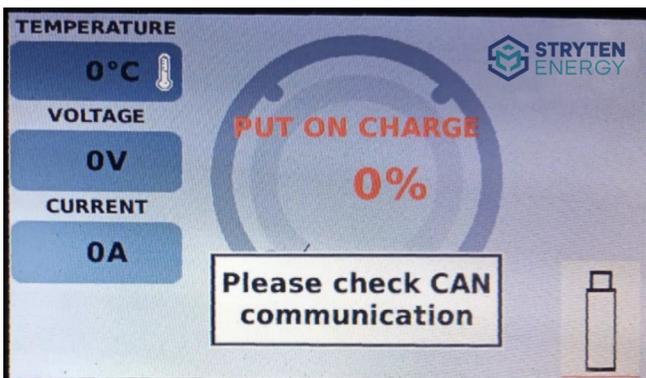
Battery beeps for 15 seconds and stops with Over Current CHG warning

This error indicates a faulty current sensor internal to the battery. Typically a current of ~70A is displayed, even though the battery is not on charge. If this error occurs, please take a picture of the Opus display and battery serial number, and contact Stryten Energy Customer service, as this is not a field repairable issue.



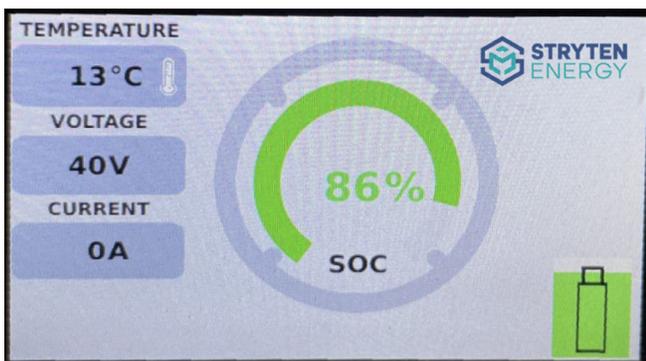
Forklift will not operate – All zeros displayed on Opus display

This indicates that there is an internal CAN communication problem within the battery. If this error occurs, please take a picture of the Opus display and battery serial number, and contact Stryten Energy Customer service, as this is generally not a field repairable issue.



Forklift will not operate – All values displayed on Opus display are normal

If the forklift does not operate and the Opus display does not indicate any problems, the first thing to check is to confirm that the forklift cable from the battery is mated properly to the connector on the forklift.



If there are no obvious problems with the connection from the battery to the forklift, disconnect the battery from the forklift and measure the voltage on the battery terminals. If the battery is in normal operating mode (LED on the power switch is slowly flashing green) and the battery is not being charged, the battery voltage should be present at the output terminals of the battery. If battery voltage is present,

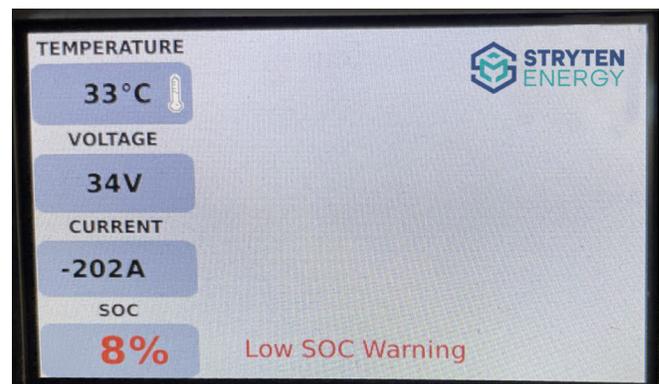
the problem is likely with the forklift. Contact the forklift dealer and/or forklift technical service for further support.

If there is no voltage on the battery’s output cable when the battery is powered on, not charging and disconnected from the forklift, it will be necessary to open the battery for further troubleshooting. Contact Stryten Energy Customer service to open a ServiceMAX ticket before proceeding. Make sure to provide pictures of the Opus display and battery serial number, voltage readings and any pertinent information about how and when the forklift stopped working.

The forklift output cables are fused, so the next step after receiving authorization from Stryten Energy is to check the continuity of the fuse on the forklift cable. If the fuse is not open, the next thing to check is the contactor for the forklift cable. All batteries have a contactor on the positive cable and some modules have a contactor on the negative cable as well. Contact Stryten Energy customer service for assistance troubleshooting the contactors if the problem appears to be with the contactors.

Forklift will not operate – Low SOC Alert

If the SOC of the battery drops below 10%, the battery will beep once per second and a low voltage warning will be shown on the Opus display



If the SOC drops to 0%, the battery will beep rapidly for 15 seconds and turn off. The reset button can be pressed once to get the vehicle to the charger. After that, the battery remains turned off in order to avoid further damage. The vehicle now has to be towed to the charge with auxiliary means.



TROUBLESHOOTING ISSUES DURING BATTERY CHARGING

Opus displays High temperature warning during charge

If a battery is being charged at close to its temperature limits, the battery will display a warning. The warning occurs when charging temperature reaches 45C or drops to 5C.

The M-Series X-3 and X-7 chargers will never charge a Li510 battery above or below its allowable charge temperature limits. When the battery reaches 45C, the M-Series X-3 and X-7 chargers will reduce its output current to slow the rate of heating. If the battery ever reaches 50C, the M-Series X-3 and X-7 chargers will stop charging and wait for the battery to cool before resuming charging.



In addition to displaying a warning, batteries with BMS firmware versions prior to 2.8.7 will emit a slow warning beep (once per second) if the charging temperature exceeds 45C or drops below 5C. This beeping is intended as a warning only, as the battery is still operating within its safe limits and can still safely charge. However this beeping has caused some confusion with customers, as beeping during charging is disconcerting to operators. This has caused some operators to stop the charger at 45C when the battery starts to beep, even though the battery is still well within its allowable charge temperature.

Beginning with BMS firmware version 2.8.7, Li510 will no longer beep when they reach 45C while charging on a M-Series X-3 and X-7 charger. Because the M-Series X-3 and X-7 chargers will never allow the battery to reach 50C or drop to 0C, there is no need to warn the user as these limits are approached. Customers with BMS firmware prior to 2.8.7 may contact Stryten Energy service to schedule a firmware update if desired. Customers with older firmware should be aware that if the battery is charging at temperatures between 45C and 49C, a slow beep of once per second is normal, and not a cause for concern.

Troubleshooting M-Series X-3 and X-7 chargers communication problems:

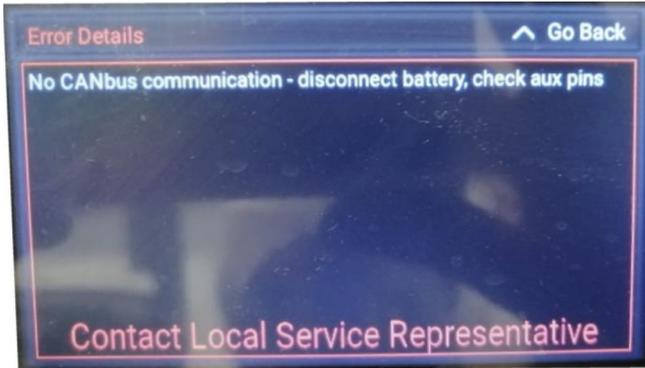
If any errors are encountered while charging a Li510 battery, the M-Series X-3 and X-7 chargers will stop and display an error message.

If an error occurs while charging, hit the down button (V) to the right of the display and check the Error Details for additional information. Take a picture of the main charger screen and Error Details screen in case assistance is needed from Stryten Energy service.

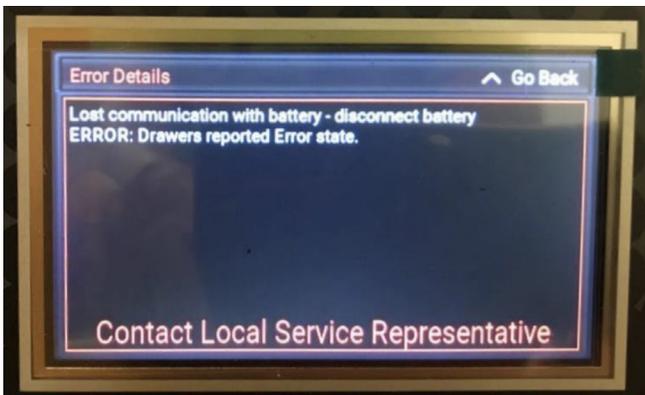


If there is a connection problem with the battery, one of several errors may be displayed.

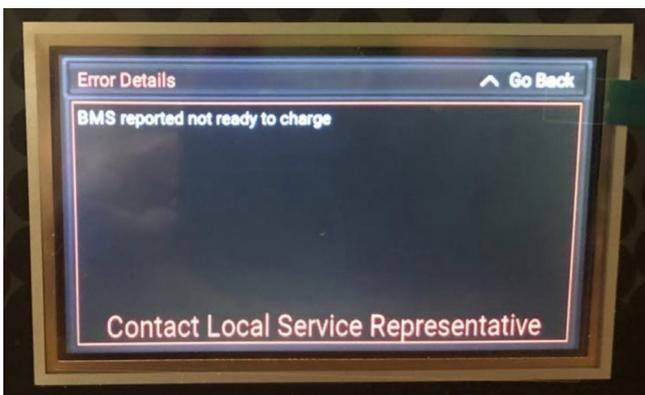
1) “No CANbus communication” Error



2) “Lost communication with battery” Error



3) “BMS reported not ready to charge” Error



Whenever an error occurs during charging, the first troubleshooting step is to determine if the problem is with the battery or charger.

a. Check the battery with other chargers i. If the battery fails on other chargers, it is a battery problem ii. If the battery works on other chargers, it is problem with the original charger.

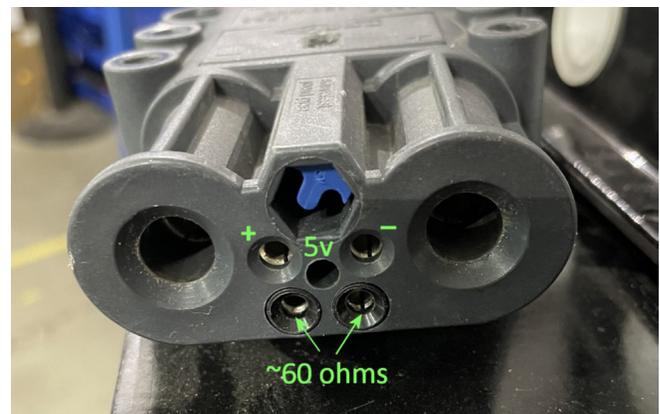
b. check the charger with other batteries i. If the charger works with other batteries, it is a battery problem ii. If the charger does not work with any batteries, it is problem with charger.

If problem is with the battery connection

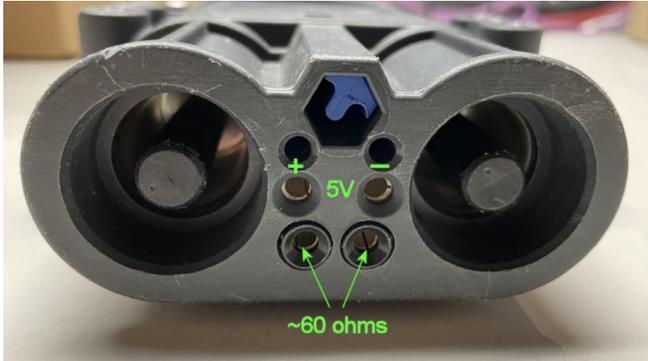
Check to make sure that the pins on the battery and charger are clean so that they will make good contact. Check to make sure that none of the pins are loose.

Next, check the Aux pins with a multimeter

The AUX pin connections for a REMA320 charger connector are shown below:



The AUX pin connections for a REMA640 charger connector are shown below:



For both REMA320 and REMA640 charger connectors, the bottom two pins on the connector are the CAN bus communications lines.

When the Opus display is attached the resistance between these two pins should read ~60 ohms. When the Opus is disconnected, they should read ~120 ohms.

For REMA320 connectors, the two top pins are the safety line pins.

For REMA640 connectors, the two middle pins are the safety line pins.

There should be 5v between the + on the left and the - on the right.

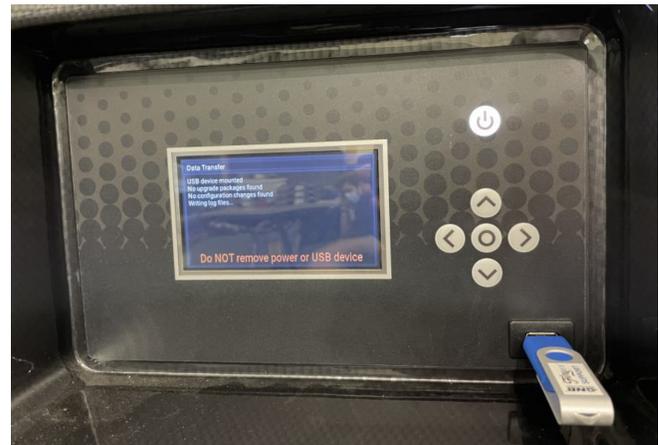
If the readings are not as shown above, the aux pins will need to be repaired.

INSTRUCTIONS FOR DOWNLOADING CHARGER RECORDS FROM STRYTEN ENERGY FURY CHARGERS

1) Obtain a Stryten Energy USB stick from your Stryten Energy Service Authorized Representative.



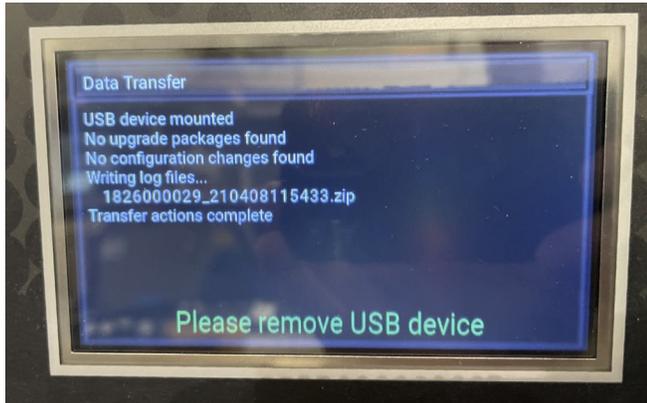
2) Insert the USB stick into the USB port of the charger.



3) While the charger is writing logs to the USB stick, a message will be displayed on the M-Series X-3 and X-7 chargers. Do not remove the USB stick while the charger is writing log files. This will take about a minute.

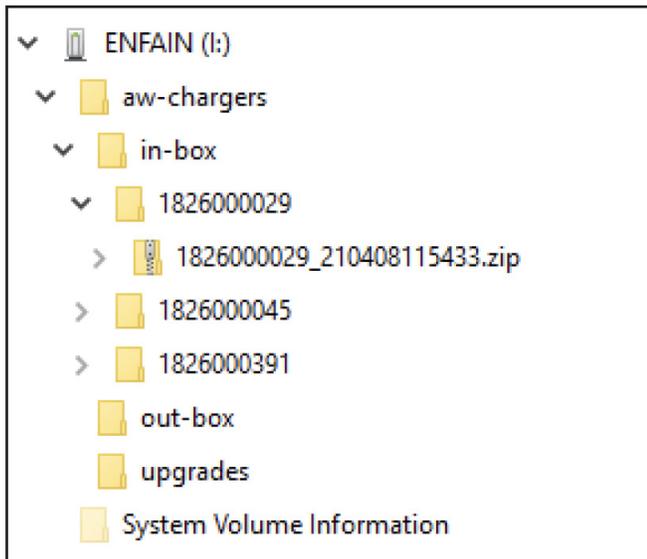


4) When the charger has finished writing its log files, it will display a message to say that it has completed the transfer and that the USB stick can now be removed.

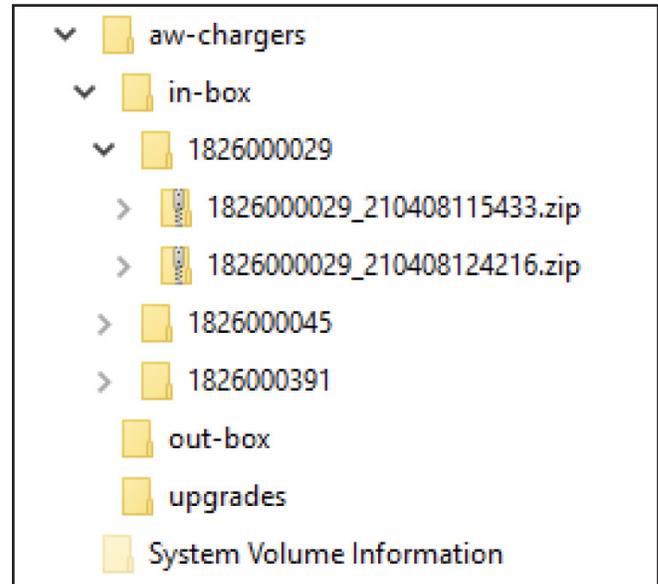


5) If you have multiple chargers, you can download charger records from all of the chargers using the same USB stick

6) Once you have downloaded all of the logs from your chargers, you can send the USB stick back to your Stryten Energy Service Authorized Representative for analysis. Or to save time, you can email the files.



In the USB stick directory, go to the aw-chargers -> in-box directory. Under that directory will be a folder for each charger, named with the serial number of the charger. In each charger folder, there will be a zip file with the logs from that charger. Email each of these zip files to your Stryten Energy Service Authorized Representative.



The USB stick can be re-used to download charger records multiple times. Each time that records are downloaded from a charger, a new zip file will be added to the folder for that charger. The number after the dash in the zip file name is the date and time that the log was created. In the example above, the logs for charger serial number 1826000029 were downloaded twice. The second zip file was downloaded on April 8, 2021 at 12:42:16, so it is the most recent of the two files. When sending files to your Stryten Energy Service Authorized Representative for analysis, you only need to send to send the most recent files.

7) Please contact your Stryten Energy Service Representative or email strytenncc@stryten.com for additional help.

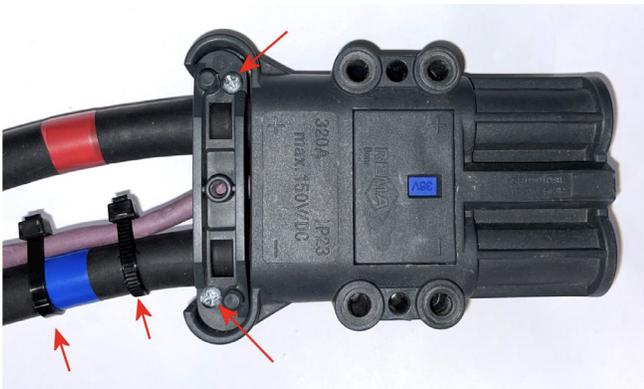
SERVICE/REPAIR OF REMA320 AND REMA640 CHARGER CONNECTORS

Note – the procedure below shows a REMA320 connector. Servicing and repair of a REMA640 charger connector is identical to the REMA320, except that there is an unused third pair of aux contacts, which is the top pair of contacts.

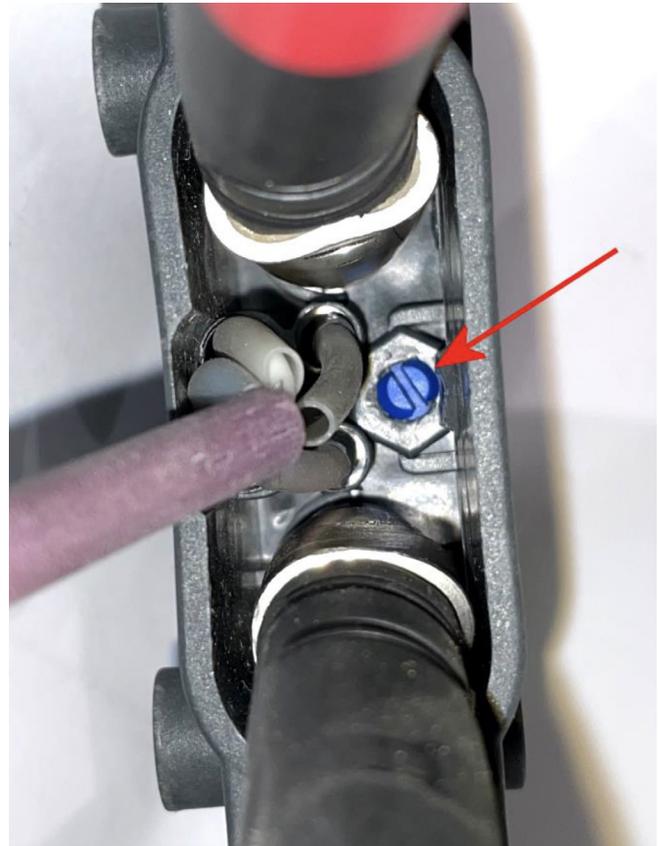
1) Check position of battery voltage key. Take picture of connector from front in order to verify that the connector is replaced in the correct position after the connector is serviced. (note – the picture below is from a 36v battery. Other voltages will have the key in a different position).



2) Remove the power cable clamp and strain relief cable ties. (See below and top right)



3) Remove the voltage key. This is done from the back of the connector. Using a needle nose pliers, gently squeeze together the clips on the end of the key that hold the key into place. Push slightly and the key will come out from the front of the connector.



4) Gently open the lid of the connector, using a small screwdriver inserted into the hole left by the voltage key to lift up the lid.

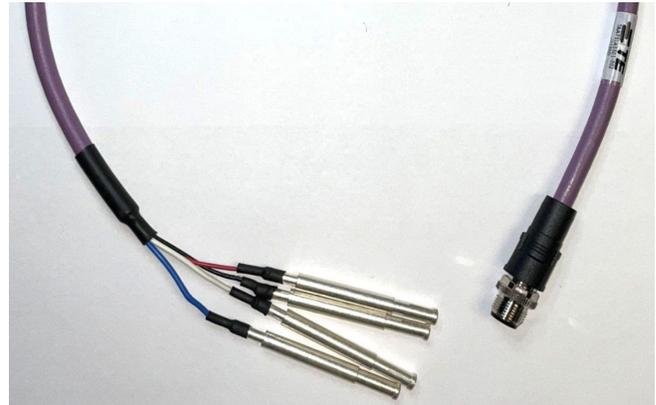


5) Back the pins out of the connector housing and service/repair/replace as needed.

If the existing pins or harness are too damaged for field repair, replacement harnesses can be ordered from Stryten Energy. The length of the harness will vary depending on the battery model. Contact your Stryten Energy service representative to determine the correct part number to order for your battery model. Make sure to give them the battery serial number and model number.

6) Replace Power and Aux pins

The positive power pin (power cable with red jacket) goes to the location marked + on the housing.



The negative power pin (power cable with black jacket) goes to the location marked – on the housing.

The safety loop 5v pin (on red aux wire) goes to the top aux pin position of the REMA320 (middle position for REMA640), on the side closest to the negative (black) power lead.

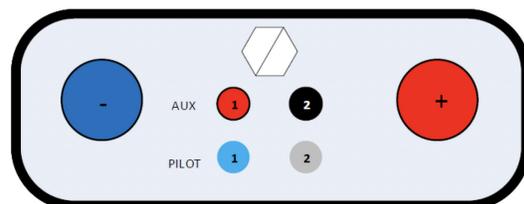
The safety loop Gnd pin (on black aux wire) goes to the top aux pin position of the REMA320 (middle position for REMA640), on the side closest to the positive (red) power lead.



Both the CAN pins (on blue and white aux wires) go into the bottom set of aux pins, using a “pilot adaptor”, which must be installed with the notch in the adaptor facing up.

CAN high pin (on white aux wire) goes on the side closest to the positive (red) power lead.

CAN low pin (on blue aux wire) goes on the side closest to the negative (black) power lead.



Battery REMA Pinout

7) Replace lid to the connector, making sure that the aux pins are all fully inserted, so that the notches in the pins all line up.



8) Before replacing the voltage key, make sure that all pins are fully inserted in the housing. If any pins are not all the way forward, repeat step 8.



9) Replace clamp to hold the power cables to the connector, making sure not to pinch the aux comm cable.



10) Use double zip ties for strain relief, so that the aux cable cannot get snagged and pulled from the connector. Make sure that there is enough play in the aux cable for the cable and connector to move from side to side without putting strain on the aux cable. Tighten the zip ties so that the cut ends are towards the interior of the cables