Load Controller Maintenance Manual:

The purpose of the load controller is to control the last switches before the high voltage lines reach the load. It is in charge of monitoring the high voltage and detecting any ground faults. Under system tests we have seen little issues with the use of the load controller and ideally, the box will never have to be opened up to fix problems. However, there are some foreseeable issues that may arise and their fixing would require the load controller to be opened up. For all of the listed issues please make sure that the system is safely shut down before operating on any of the load controller internals. Additionally, at the end of this document is a list of errata or things that should be changed when the box is redesigned to be put onto the car. These are merely suggestions that we did not have the time to implement this semester. For reference, a picture of the inside of the box is included.

Foreseeable Problems:

1. Connector falls into the Box:

   While creating the load controller, one of the front pin connection holes, the one for SCADA communication, was made slightly too wide. This issue was rectified by using plastic to push the pin connector’s snapping parts out wider. However, it is still feasible that this connector or any of the other ones could get pushed into the box if too much force is used. Follow this procedure to rectify the problem:
   i. Unscrew the box top and take it off
   ii. Identify the connector that was pushed into the box and snap it back into place. Test the mechanical connection.
   iii. If the connector falls back into the box during the test trying wedging a piece of plastic into the sides of the connector. Test the mechanical connection
   iv. If it still does not work see the procedure for “Broken Connector”
   v. Repeat steps two and three until the connector is mechanically sound
   vi. Screw the lid back onto the box.

2. Broken Connector:

   There are a number of ways in which a connector might need to be replaced. One of them is the previously mentioned issue where the connector itself might fall into the box. Another is that the pins inside the connector may fall out or become misaligned such that a solid electrical connection is no longer possible. To fix this issue do the following:
   i. Unscrew the box top and take it off.
   ii. Identify the connector that needs replacement.
   iii. Use the ICD and Load Controller design to determine the type of connector and the type of pins that are needed
   iv. Unscrew the wires from the DIN terminal in the load controller that the connector uses and discard the broken connector.
v. Crimp new wires into the pins and place the new wires into the new connector. It is extremely important to use the ICD for this step, so that all of the pins are in the right place.
vi. Snap the connector into place and make sure the connection is secure.

vii. Using the load controller design pages and the DIN terminal key in the box itself, screw in the replaced wires to their proper DIN blocks.
viii. Run relevant QA tests for the connector that was replaced.
ix. Screw the lid back onto the box.

3. IR1 and IR2 LEDs Mismatch:
The two isolation relays within the load controller are controlled by the same signal. It is a 24V signal that comes from the SCADA when the drive button is selected. When this signal is high it should close the relays and subsequently turn on both LEDs. If these LEDs ever mismatch (one on, one off), then something is wrong.

Follow this procedure to fix the problem:

i. Unscrew the box top and take it off.
ii. Use the provided SCADA connector that has wires stripped to provide 24V across the black and red wires. This is in effect closing the relays. You should hear a popping sound for each relay.
iii. Use an ohm meter to test the resistance across the in and out terminals of each isolation relay. There should be very little resistance (almost 0 ohms).
iv. If one of the isolation relays has a notable (non-zero) resistance than either the connection to the LED is broken or the isolation relay itself is broken.
v. Look at the DIN terminal blocks involved and make sure that there are no loose wires. If there are, screw them into their proper place and repeat step ii.
vi. If the Din terminal blocks are not the issue, unscrew the LED wires from the Din Rail.
vii. Apply 24V across the LED terminals (it matters which side is plus and which is minus). If the light does not turn on, you will need to replace the LED. The load controller design and bill of materials has the information you need to do this. You will have to resolder and shrink wrap the relay wires to the new LED.
viii. If the light does turn on, then the issue lies with the isolation relay. To replace the relay look at the ICD and load controller design for the necessary part. Then read the instructions for “Plate Removal”.
ix. Once the plate is returned to its position properly, make sure that it is wired correctly.
x. Repeat step ii.
xii. Screw the lid back onto the box.
4. Plate Removal:
   Removing the aluminum plate that sits inside the box is probably the biggest hassle to have in terms of maintenance for the load controller. However, it is a necessary step if components that are screwed into it (TSAL PCB, isolation relays, IMD, DIN Block) need to be replaced. Follow these procedures in order to take the box apart.
   i. Unscrew the box top and take it off.
   ii. Cut any of the zip ties that hold wires to the box (TSMP wires).
   iii. Remove all of the ring terminal connections made by the isolation relays (all HV wires and fused wires).
   iv. Unscrew the front panel of the box from the rest of the box. You may have to cut some front zip ties but there should be enough slack so that the front panel can lie face down.
   v. Unscrew the four corners of the aluminum plate.
   vi. Lift the aluminum plate up and over the rest of the box (it comes out easier lifting than sliding).
   vii. Disconnect any of the wires from the part that needs replacement. This may involving unscrewing wires from the DIN Rail such as the isolation relays. It could also involve crimping and making new connectors such as with the IMD.
   viii. Unscrew the part from the bottom of the plate and replace it with the new part. Screw the new part in.
   ix. Place the aluminum plate back into the box and screw it in.
   x. Screw the front panel back on to the box.
   xi. Rewire any connections needed by the replaced part.
   xii. Follow instructions for “Smoke Detected” to reattach high voltage cables and fused ring terminals properly.
   xiii. Do any relevant QA testing on the replaced part.
   xiv. Screw the lid back onto the box.

5. Smoke Detected:
   If smoke is ever detected coming out of the load controller. There could be a possible short somewhere, but the most likely scenario is that the connection between the high voltage wires and the isolation relays are not electrically sound. We saw this occur when attempting to charge a battery at about 30A. Follow these instructions to fix the problem:
   i. Unscrew the box top and take it off.
   ii. Remove the nuts, washers, and wires from each of the isolation relays’ interfaces.
   iii. Smear conductive grease on the isolation relay terminals, the bolts, the nuts, the washers, and the ring terminals. There should be an even and thin layer.
   iv. Reattach the wires to their proper places using the load controller design pages. The high voltage ring terminals should be on the bottom of each
relay terminal, followed by the fused ring terminal (not for HV side),
followed by the washer, and finally the nut.
v. Use a wrench to screw on the nut as tight as possible.
vi. Screw the lid back onto the box.

6. IMD Malfunction:
If the safety loop is not closing this could be a result of the IMD always detecting a
ground fault error. Conversely, a simple test of connection TSMP- with GLV GMP
could prove that the IMD is not detecting any ground faults. These could be issues
with the system in general (perhaps there is actually a ground fault in other box).
i. Use an ohmmeter or multimeter to determine if any other part of the
system has a ground fault.
ii. Redo the QA test with Safety Loop for the isolation monitoring device.
   Determine whether the device lies within these two systems and if further
   analysis is needed.
iii. Disconnect the Safety Controller In wire. Connect the safety controller in
     connector that has wires stripped.
iv. Attach a multimeter to the plus and minus terminals of this connector. In
    addition, connect a 2.2K Ohm resistor between the plus and minus signals of
    this connector.
v. Using the IMD datasheet, determine if the output is proper. Without a fault,
   the multimeter should read 24V. With a fault, it should read 0V.
vi. If the output is incorrect look further into IMD interfaces. Unscrew the box
    top and take it off to see if those connections are secure. If they are not,
    replace them.
    
   vii. If all else has been tried, perhaps the fault is with the IMD. If this is the case,
       use the ICD and load controller design pages to replace the part. Follow the
       directions for “Plate Removal”.
   viii. Do any relevant QA testing for the IMD.
   ix. Screw the lid back onto the box.

7. TSAL Malfunction:
The TSAL has to monitor whether the tractive system is active. It should turn
whenever, either the safety loop is closed, or if there is over 5V present on the
tractive system. (Note that the TSAL only gets power when the GLV tractive control
power switch is closed. If the tractive system is off but there is more than 5V
present at the accumulator, the TSAL will not turn on). If the TSAL behavior has
become improper, follow these steps to correct for it.
   i. Unscrew the box top and take it off.
ii. Look at the DIN terminal blocks and the TSAL connections to see if perhaps any of the wires have become loose. Reconnect them if so.

iii. Perform QA test for the TSAL and note its performance.

iv. Test any of the ICs for replacement (LM324, Optoisolator). If any of them need replacement, replace them.

v. If it’s determined that the TSAL needs replacement follow the instructions for "Plate Removal".

vi. Use the DX Designer files, and PADS Layout Files to purchase a new TSAL PCB. Please refer to the TSAL design, and LC BOM for part information. Also make sure to look at the TSAL errata page for improvements that could be made.

vii. Perform QA test for the TSAL and note its performance.

viii. Screw the lid back onto the box.

Errata:

1. General Size:
   Laying out the mechanical design of the load controller, was a significantly difficult task. It is required that you keep high voltage and low voltage lands separate, but there are a lot of components and a lot of them exist in both lands. Ideally, this part would be a lot smaller, however I had trouble fitting everything into the space that I had.

2. Load Side TSAL:
   The TSAL reads the voltage coming into the isolation relays. The IR closed LEDs indicate whether each isolation relay is closed, however nothing measures the voltage across the load directly. It would be nice to have something almost exactly like the TSAL except that reads voltage on the other side of the isolation relay.

3. Plastic Divider:
   Going along with a different layout idea and the idea of keeping high voltage and low voltage lands separate comes the idea of the plastic divider. My voltage lands are designated by black electrical tape, but ideally this would be replaced with an electrically insolated divider. This way a wire could not become loose and cross lands.

4. Pilot Light:
   It would be nice if there was a light to indicate whether the load controller was turned on or not. Now it’s open to interpretation of what “On” means in this case, but I would advise simply connecting an LED to the tractive power that comes into the system from the GLV box.
5. **High Voltage Connectors:**

The current set up for the high voltage wires makes them extremely difficult to disconnect from the load controller. You would need to take off the lid in order to do this. This was done because it’s very difficult to work with such thick and high amperage wires in such a confined case. However, it would be nice to disconnect these wires through something like a power lock. This would require coming up with a method to transfer the high voltage wires from the isolation relay terminals to the power lock connectors in a safe and manageable way.

**Load Controller Interior:**