LFEV Spring 2013: Safety Loop - Description

The safety loop in the Lafayette Formula Electric Vehicle Project ensures that the high voltage electrical system is in a safe operational state and offers an easy way to shut down the system in case of an emergency or malfunction. It follows the rules outlined by the International SAE Formula Hybrid Competition as this system hopes to be integrated into a future SAE Formula Electric Vehicle. This description will outline the system, starting from the top level and working down to the wiring.

System Walkthrough

The safety loop runs through all the major electrical subsystems and is used to not only control the accumulator isolation relays (AIRs), but is also used to determine the state of the system. The safety loop starts at the safety controller, where the safety loop gets the input from the Insulation Monitor Device (IMD). The IMD constantly monitors both of the electrical systems (tractive and GLV) to ensure that they are electrically isolated. These systems are isolated to protect the GLV system from the high voltages and currents of the tractive system. From the safety controller runs a 4 wire safety loop into the rest of the subsystems.

The four wires contained in this loop are the loop-in, the loop-out, and the positive & negative power lines for the AIRs (Safety 24+/Safety 24-). The power lines are only on if the loop-in is powered. This means that if the loop is not complete, the AIR power is off. In order for a subsystem to control the loop, a switch or relay would be placed on the loop-out line. Opening this switch would remove the power from loop-in (from what the safety controller would see). If a subsystem would like to get the status of the safety loop, it could probe the power lines for the AIRs by putting a 24V relay across it or by sensing a voltage drop across the two lines.

The Safety Controller

The safety controller is the most important part of the safety loop as this is where it starts and ends. The start of the loop comes from the status output of the IMD which drives a relay powering the loop-out from the safety controller. The loop-in comes into the controller and is immediately routed back out as Safety 24+. However, inside the safety controller this signal also controls a latching relay that runs to the IMD relay. The advantage of this latching relay is that the system can’t immediately be reset if the safety loop is tripped. For instance, if an emergency button is pressed and then is reset immediately, the safety loop will maintain its open state. To reset the system, the user must use the reset button located on the controller.

The safety controller also contains important status LEDs and a test button to trip the loop. There are four status LEDs (2 green and 2 red) that indicate that the safety loop is closed or open and whether the IMD is in a fault state or not in a fault state. These LEDs are
dependent on the position of the two relays in the system. These relays are single pole double throw (SPDT) and power on either the green or red LED. If both of the green LEDs are lit, the high voltage system is energized.

There are four connectors on the safety controller. One connector is used for the power, this is a 3 wire TE connector coming from the GLV Power subsystem. The second connector attaches to the load controller to power the IMD as well as get the IMD status output. This is a 3 wire Molex connector. The third and fourth connectors are for the safety loop and are 4 wire TE connectors. One is the four wire output as describe in the previous section. The last connector is optional and could be used if there was a decision to run a 3 wire safety loop. The difference from the current 4 wire configuration is that the loop-in line would be unused and instead a separate wire would run from the end of the loop back to the safety controller. This would remove the potential of the loop-in and loop-out being shorted in the system, which in a worst case scenario, would leave the safety loop always on.

The Safety Panel

The second part of the safety loop is the safety panel. This is one of the subsystems that the safety loop will run through and is the most important to the user. This panel has four ways to shut off the safety loop. There are 3 red emergency buttons that are wired on the loop-out wire. These emergency buttons are normally closed and are also turn to reset. This means that current will run through the buttons unless they are pressed and once they are pressed, the button will stay engaged until they are turned back to their normal position. The reason there are 3 is because of the SAE rules: one is for the cockpit, one is for the left side of the car, and one is for the right side. The rules also require a brake over-travel switch, which is a simple flip switch. This is to be placed underneath the brake and is engaged if the brake goes past the mechanical system maximum allowance. Into and out of this system are the 4 pin TE safety loop connectors. Even though this subsystem is only using one of those lines, passing through the other 3 allows for the safety loop to be wired without preference to subsystem order.