Abstract

This memo analyzes our system within relation to general requirements GPR05.9, GPR05.10 and GPR05.11, as well as competition requirements EV5.1.1, EV5.1.3, EV5.1.7, EV5.2.2, and EV3.4.3. It shows how our safety circuits ensure the safe operation of the LFEV-ESCM.
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Executive Summary

Introduction
The general requirements require that the project activities must adhere to the general Lafayette College safety policy, possibly augmented by any ECE Department or ECE Laboratory safety rules. In order to ensure that this is the case, a safety plan has been written up and posted to the team’s website. A talk was given to all members of the team about the contents of the safety plan and all members signed a document acknowledging that they would abide by those rules.

The Safety Plan has been approved by the ECE Director of Laboratories, and Jack Fedak is the designated Safety Officer. All safety procedures are approved by the ECE Director of Laboratories and the Safety Plan outlines the responsibilities of the Safety Officer as per requirement GPR05.10. With regard to requirement GPR05.11, the hazard that comes with this system is its use of high amperage. As specified in the safety plan, all high amperage testing must have an associated test procedure.

In order to address the competition requirements EV5.1.1, EV5.1.3, EV5.1.7 and EV5.2.2, the shutdown circuit, known in our system as the safety loop, must be fully analyzed.
Safety Loop

Figure 1 gives an overview of the safety wiring of the ESCM system. The safety wiring centers around a safety loop that runs from and then back to the safety controller going through all of the subsystems, as well as the power for the AIRs (located in the PACK). From this diagram it is clear that the current going to the relays is directly powered by LOOPIN, which is only powered if the shutdown circuit has no faults, as per requirement EV5.1.1. In the diagram this connection occurs in the Safety Controller, directly to the left of P1. The GLV switch (the first switch on the left side of the diagram) turns off all of the current from the battery as per requirement EV5.2.2. The Bill of Materials confirms that this is a red, rotary-type key. It has been installed so that the “on” position is in the horizontal position.
Emergency Buttons

The wiring of the emergency buttons is simple and involves no use of any logic. As shown in Figure 1, if an emergency button opens, the current going from \texttt{LOOPOUT} to \texttt{LOOPIN} is cut, which opens the safety loop as per requirement EV5.3.3. In the diagram the connection from the \texttt{LOOPOUT} to the \texttt{LOOPIN} is in the safety cap on the very far right.

Accumulator Isolation Relays (AIRs)

Table 1 gives the specifications of the GIGAVAC GX14CAB high-voltage contacts that will be used in this system as the AIRS. This table gives the release time that the GIGAVAC will take to cut the HV power, which is a max of 12 milliseconds. This is well under the 5 seconds necessary per requirement EV5.1.3.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|}
\hline
\textbf{Specifications} & \textbf{Units} & \textbf{Data} \\
\hline
Contact Arrangement & Form X & SPSTNO \\
Auxiliary (2A, 24VDC) & Form A or B & SPSTNO or SPSTNC \\
Mechanical Life & Cycles & 1,000,000 \\
Contact Resistance & mohms & 0.4 \\
 & Typical & 0.15 to 0.3 \\
Operate Time & ms & 20 \\
 & Typical & 13 \\
Release Time, Max & ms & 12 \\
Insulation Resistance & Mohms & 100 \\
Dielectric At Sea Level (Leakage - 1mA) & VRMS & 2,200 \\
Shock, 1/2 Sine, 11ms & G peak & 20 \\
Vibration, Sinusoidal (500-2000 Hz Peak) & G & 15 \\
Ambient Temp Range & & \\
Operating & °C & -55 to +85 \\
Storage & °C & -70 to +150 \\
Weight, Typical & Kg (lb) & 0.5 (1.1) \\
Environmental Seal & & Exceeds IP67 & IP69K \\
Salt Fog & & MIL-STD-810 \\
\hline
\end{tabular}
\caption{GIGAVAC GX14CAB Specifications}
\end{table}
Shutdown Circuit

The circuits that are part of the shutdown circuit are referenced in Figure 2. There are two 24V relays in the box, one is shown in the figure and another is in the IMD circuit. The wiring of the circuit requires that the Tractive 24+ power line go through both relays using the normally open connections and then to the LOOPOUT. As described earlier, this line ultimately carries the current to the relays, so if the power is cut to the relays, the current going to the AIRs will be shutoff as per requirement EV5.1.7.

Surface Envelope

The last requirement to be addressed is EV3.4.3 that requires the accumulator container to lie inside the surface envelope of the vehicle. As the vehicle has not been built, here the distance will be calculated for the next team. The current three-cell pack (accumulator) length is 31 inches. Adding four more cells would increase the length by 20 inches. So, in total, the surface envelope of the vehicle must be at least 51 inches.
Appendix A: References

LFEV-ESCM 2013 Bill of Materials: http://sites.lafayette.edu/ece492-sp13/deliverables/final-presentation-and-demo#bom