EIC DIRC Laser Interlock Circuit Development

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I used Multisim to design and simulate a circuit proposed for the EIC DIRC laser test station's interlocks system.

The circuit developed uses 5-V logic gates to monitor for emergency stop button actuation or opening of the door to the laser lab while the laser is powered. If either condition is present, the circuit disables the laser's output by opening a relay contact to the laser's interlock input contacts (contacts must be shorted together for laser to operate).

For the device monitoring, the circuit was designed to expect +5 V DC when a device is in it's normal/non-interlocking state. An eight-input NAND gate was selected to allow up to eight devices (doors, emergency stop buttons, occupancy monitors, etc.) to be monitored. If any of the devices enter a tripped state, the corresponding input is toggled low, or 0 V, on the NAND gate, causing the output of the gate to be toggled high, or 5 V.

After the NAND gate, there are two NOR gates that function as a set-reset latch. When the NAND gate toggles high, it triggers the set-reset latch output to be high (latch also has an inverse output that is toggled to low). The latch circuit will hold its output high until the circuit is reset by the user via a push button.

During normal, "no interlocks preset" operation, the inverse output of the set-reset latch is used to provide voltage to an NPN transistor acting as a switch. This transistor switch then toggles a relay (to light a beacon notifying the area that the laser is enabled) and a PNP transistor switch that initiates a timer circuit that toggles the relay to enable the relay to the laser interlock after ~11 seconds (JLab's laser safety protocol requires the beacon be lit for at least 10 seconds before the laser is enabled).

- **EIC DIRC is building a laser test stand to measure the quantity of light that passes though the detectors BaBars**

- **Laser is a Class 3B laser and must have an interlock system designed to ensure laser can be quickly disabled and that the laser cannot be powered when the area is occupied**

- **For interlock circuit, Multisim was used to design and simulate a circuit that has all features required**

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During design of the circuit, Multisim's simulation capabilities were used to ensure all features operate as expected.

This allowed prototyping of the circuit without physical parts to allow quick changes without having to buy new components monitoring of voltages and currents at various points in the circuit to ensure correct operation.

One of the main benefits of using Multisim to simulate the circuit as it is being developed is that it performs error checking as it runs to ensure that there are no issues due to reverse current flow. If such issues arise, it is very easy to add diodes to the circuit to prevent the problematic reverse current flow.

The next step for this work will be to review the circuit to ensure it has all of the needed capabilities for the laser interlock system. Then, I will move on to physical prototyping to ensure that a physical circuit behaves as expected. Finally, if desired, the circuit can be converted in to a PCB design in Altium for the final laser interlock system, or the schematic created in Multisim can be used to fabricate the circuit using a proto-board and through-hole components.
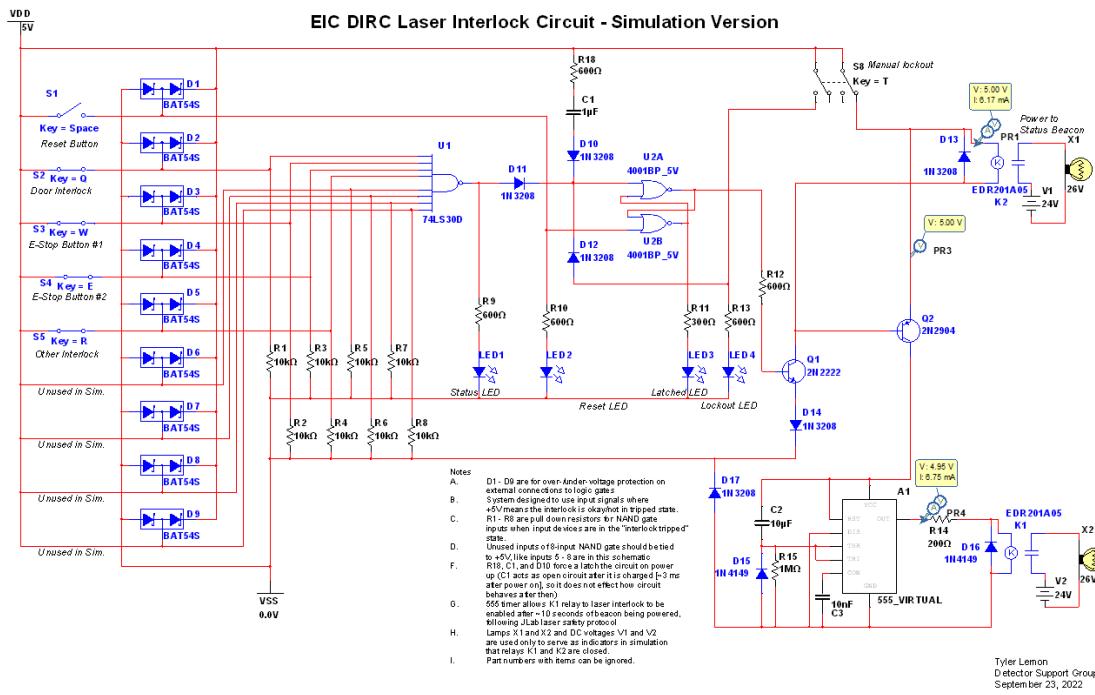

Fig. 1: Laser interlock schematic created in Multisim that the software uses for simulations.