Driver for an Electromechanical Laser Shutter

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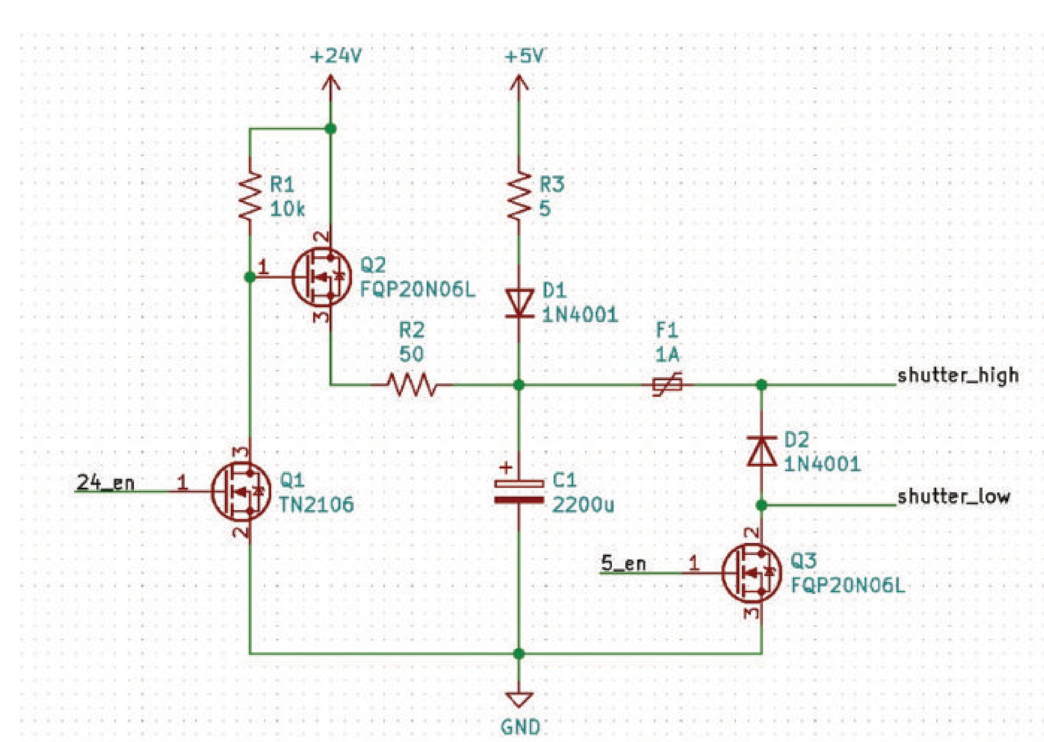
Electromagnetic shutters such as the one shown here are frequently used in science labs of all sorts. They can quickly and reliably block or unblock a laser beam to all or part of an experiment without causing the disruption and warm-up issues that can result from shutting down the laser. They can also be controlled electronically, rather than by manually moving a mechanical shutter.

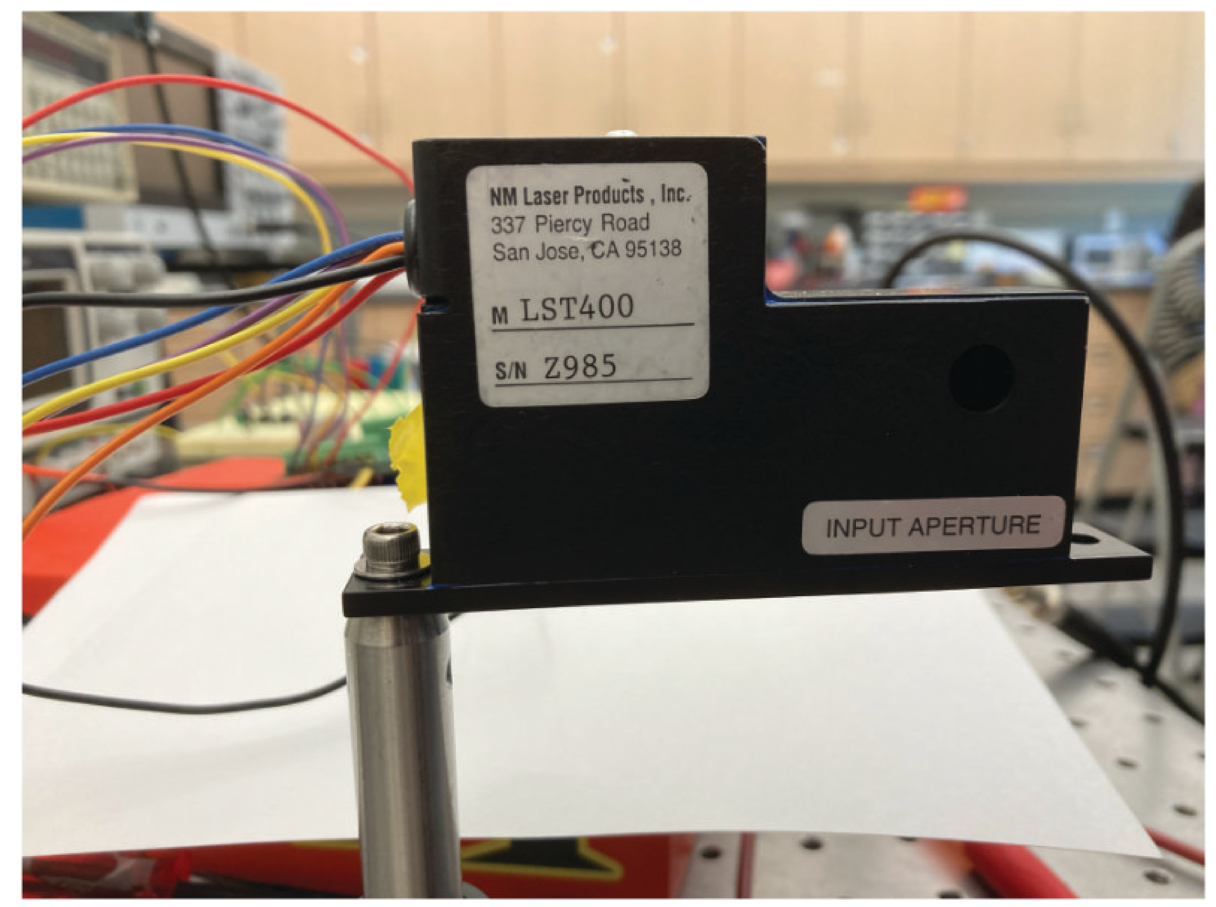
The disadvantage to these devices is that they require a specific sequence of voltages to operate. The one shown, for example, needs a 24V pulse for 50 ms to open the shutter, followed by a steady 5V to hold the shutter open.

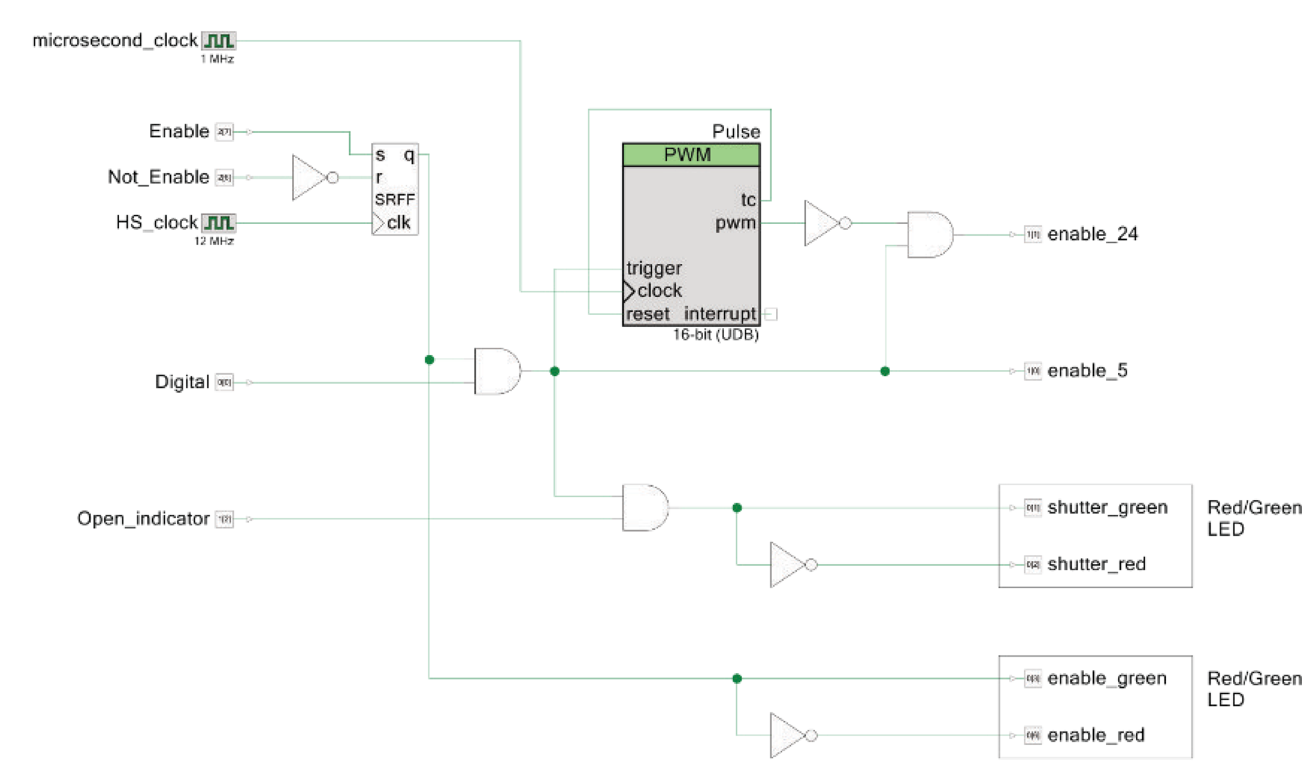
The shutter manufacturers offer dedicated controllers for the shutters, but they're proprietary and expensive. We have developed a low-cost alternative using a Programmable System on Chip (PSoC) to provide the timed voltages necessary to operate the shutter. As an added bonus, the PSoC provides an easy means of adding other features such as safety-interlock compatibility.

The circuit we used to control the voltages is shown below. It uses two inputs, 24_enable and 5_enable, to control the voltages (either 24V or 5V) through the shutter coil. (The voltages are provided by an external power supply.)



Special thanks to the Pechkis Ultra-Cold Atoms Lab, without whom this project would not have been possible.





Any microcontroller could provide the signals to the voltage-control circuit. We chose to use a PSoC because it allows hardware-based digital logic for implementation of any interlock safety features that may be desired. Instead of a microcontroller program running continuously to check the state of the interlock and computer signals, the logic shown above responds almost instantly to any changes in the input.

The Set/Reset Flip-Flop (SRFF) reads the state of the safety systems. If the system is both "enabled" and not "not enabled", then activity can proceed. If not, the shutter cannot open, and is immediately closed if it's already open.

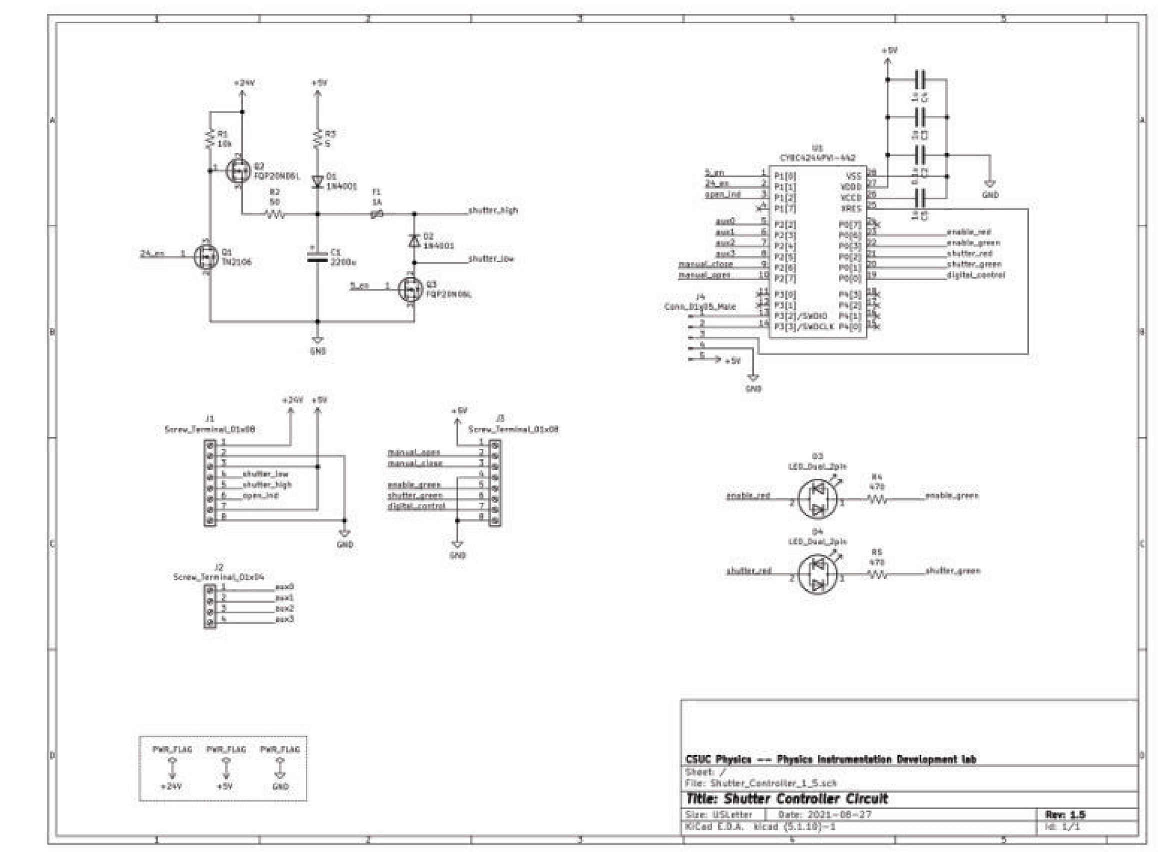
The "Digital" input is the signal from the computer (or a switch) that indicates to the controller whether the shutter should be open or closed.

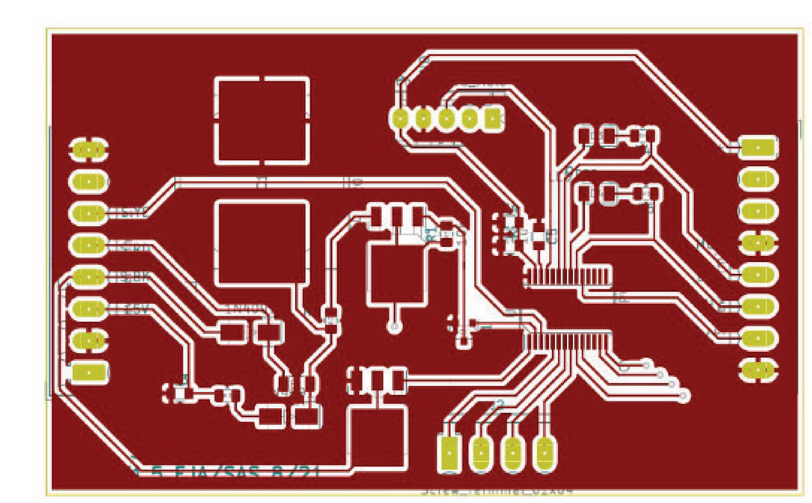
If the inputs indicate that the shutter should open, then the logic triggers the PWM block, which creates a 50-ms pulse on the enable_24 line. The same logic turns on the enable_5 line, so that when the pulse is finished the 5V 'hold' signal is already in place.

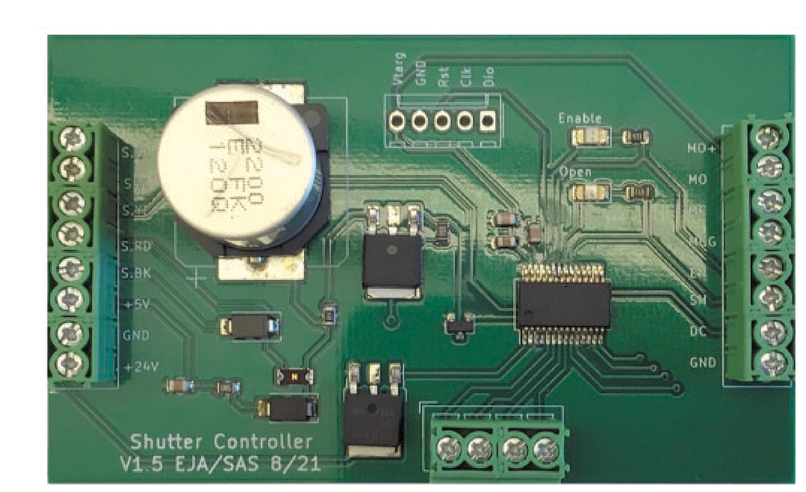
Finally, the logic also controls a pair of red/green indicator LEDs to give a visual indication of the status of the system.

This logic diagram is then compiled directly into FPGA logic on the PSoC chip.

Since we need more than one of these in the physics labs at Chico State, we decided to do them as custom boards rather than as one-off soldered-together prototypes. KiCAD makes this relatively easy.







The completed board has connections for the 24V and 5V supplies, the safety interlock(s), additional digital indicator lines for the computer controlling the experiment, and all of the shutter wiring.