Rapid Compact Optical Shutter: Using Dc Motor And 3d Modeling To Bring Affordability And Reliability To Precision Spectroscopy

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BACKGROUND

- Shutters come in diverse features and are ubiquitous in laser-based experiments.

  - Acousto-optical modulator
  - Laser Safety (Interlock) Shutter
  - Electric Fast Shutter

  - A close example is using a shutter in precision spectroscopy to improve the efficiency of ion transitions after it has been trapped.

  - Relevant features: lifespan, activation delay, switching time, and jitter.

  - Commercially available shutters are expensive and in general not the best in some combination of high vibration, low pulse rate, or large size.

  - So, experimenters frequently construct their own shutters based on desired features.

  - Goal: Design, print out, assemble, and troubleshoot the shutter driver and body to directly replace the old shutter system of the Ion lab in the CUA of MIT.

  - Long lifespan, ~1ms activation delay, ~1.5ms switching time, and no observable jitter.

METHODS

- Comprehend existing driver design
- Assemble components and build driver
- Build support circuits to assist driving and testing
- Trouble shoot and replace components as needed
- 3d design and print shutter body and blade
- Complete shutter assembly
- Test using oscilloscope
- Perform experimental test.
- Optimize

The Schematics for the circuit that drives the motor offers the bases of the PCB design.

The shutter body and blade 3D designed and printed.

RESULTS

- Current into the motor
  - The presence of the capacitor to enhance switches in directions of the blade
  - Each enhanced switch is followed by a kick by current from the capacitor as we can see the slope corresponding to charging and discharging

- Activation delay for 0.15in aperture
  - Activation delay ~2.1ms
  - Switching time is the time it takes 20% after a response to 80%.
  - Switching time ~ 0.4ms
  - No observable jitter (changes in periodic motion of shutter)

- 0.098in shutter aperture
  - Activation delay is the time difference between an initiated signal and a response.
  - The smaller the activation delay time, the preferable in precision experiments.

- Activation delay of ~2.1ms

WHAT'S NEXT: Slower Activation Delay Time

- At present, even though the shutter built is sufficient for precision spectroscopy, the activation delay limits the ability of the shutter to work with narrower pulses.

- In a long run, the activation delay needs to be reduced to at least 1ms for the shutter to be very effective in spectroscopy experiments.

- From the data of the current through the motor, the insignificant delay in kick foreshadows further research on the DC motor response time.

- A running average of the activation delay in main experimental setup-0.098in
  - Open signal delay time ~3.5ms
  - Close signal delay time ~2ms

CONCLUSIONS

- Within the parameters of the experimental test on V/h
  - The activation delay time is sufficient for the experimentation with an average value of ~2.8ms.
  - The switching time is small enough (< 1ms) to not affect the rate of cadence of the blade.
  - From video evidence, the motion of the blade experiences no observable jitter.

REFERENCES


