REALIZATION A FAST OPTICAL SHUTTER

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Abstract. The precision in time of light exposure requires the optical shutter in an optical system to work with high-speed response and rapid change between close/open state, however, a motor-driven system cannot attain perfect accuracy due to the system response. This is the unsolvable problem that comes when designing an optical shutter; and with different methods to approach the problem, many types of shutter with various parameters have been built. The most popular optical shutters now in the market are made by Thorlabs with acceptable responses to the controller but they are very expensive. In this paper we have developed an optical shutter system using Arduino software and hard disk drive base, which is superior to some characteristic of Thorlabs' shutter (e.g transfer initialize, transfer open, minimum open pulse), but also much cheaper and can be widely manufactured.

Key word: *optical shutter, Arduino, light exposure, laser shutter*

I. INTRODUCTION

A laser shutter is one of the vital types of equipment in an optical system. It serves the purpose of controlling the duration of light exposure to an optical lens or a lens system by allowing or blocking the laser using a shutter. By using this apparatus, we can achieve an outgoing laser source that strictly follows our time requirements for system operation, and is also easily modified and maintained for the repeated process. Not only for adjusting the time interval set for the laser, but the optical shutter also protects human eyes from the laser. The visible and near-infrared wavelength in the laser can dramatically harm the retina because the cornea and lens in the eye allow these radiations to go through. Therefore, the studies of the optical shutter are widely be developed and carried out. The shutter can be adjusted manually or automatically by motor, yet the automatic way is undoubtedly preferable since the stability and accuracy of the shutter will be much greater than the manual.

The time responses of the system for an optical shutter are the vital specifications, show the rapid change between the close/open state of the shutter and also present the adaptability of the system to the user's purpose. Facing the questions of designing a fast response system for an optical shutter, many different methods have been researched all over the world, both for software improvement and mechanical design [1,2,3]. In the market, there are many shutters with various specifications, including the shutter of Thorlabs [4] with a good time response

but also a high price. In this paper, we propose an optical shutter using a hard disk drive base and controlled by Arduino, which shows some better specifications compared with Thorlabs' product.

II. COMPONENTS CONFIGURATION AND SETUP

1. Shutter design

The shutter for this sytem makes use of a hard disk drive base. This base includes a stepper motor and a read/write head to read/write the data from the hard disk. The movement of the read/write head can be controlled by two methods: a) use a coil to move the head by magnetic force, or b) use a stepper motor driver. Figure 1 shows the configuration of the former method, which we chose to design our shutter: the coil is placed between two permanent magnets and in the magnetic field between the two magnets. When the electric current flows in the coil, the coil is under magnetic force, therefore it causes the movement of the arm and the read/write head by the pivot.

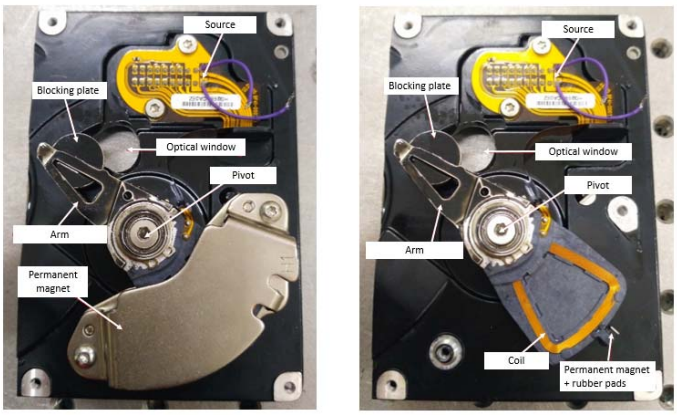

Figure 1. *Configuration of the shutter made from the hard disk drive.*

On the outside of the shutter, two optical windows is created with the diameter of 1cm, in order to let the laser goes through. A blocking plate made of 2-milimeter-thick aluminum is stick on the tip of the arm (drive bar) to block the laser via the controller program. This design allows the system to work with various types of laser.

2. Controller design

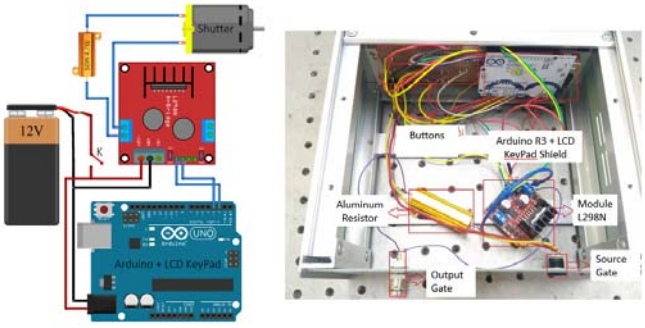

Figure 2. *Pinout and setup of the controller*

The system is controlled by Arduino software, with the setup and pinout shown in Figure 2. The circuit includes: Arduino Uno R3, source and module L298N. This circuit can control two motor for shutter simultaneously, however in this system we use only one motor. To optimize the lifespan of the shutter, we measure the minimum input voltage so that the drive bar can move stably and the shutter can work normally. After measurement, we found that the voltage input to the shutter should be in the range 6.7V to 6.9V to keep the shutter stable.

3. Experiment setup

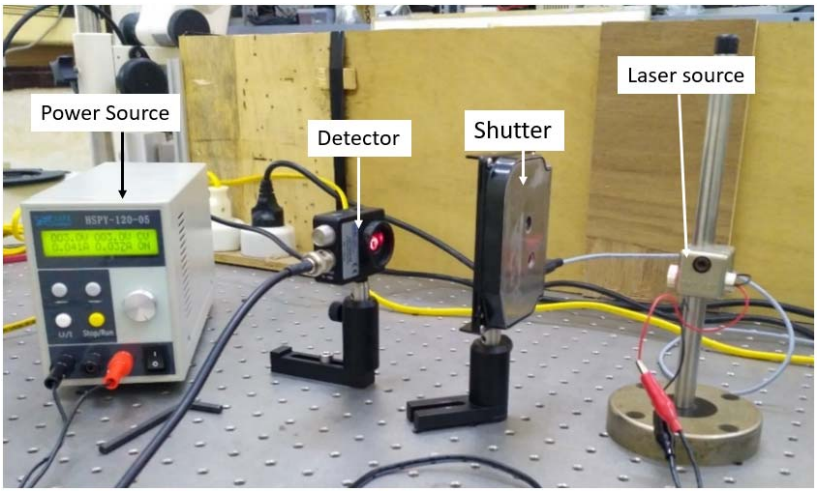

Figure 3. *Setup for the testing*

In the setup shown in figure 3, the chosen light source is a laser source with wavelength 650nm in the red wavelength and has maximum power 5mW. The light from the laser goes through the optical window of the shutter when in the "opening" state then goes to the detector. The detector is connected to an oscilloscope (not shown in the figure) thus we can observe the transition states on the screen of the oscilloscope. The value we can obtained are TI (Transfer Initialize), TO (Transfer Open), TD/R (Transfer Dwell/Release), TC (Transfer Close), MOP (Minimum Open Pulse) and MSOP (Minimum Shutter Open Time), etc. When in the "closed" state, the light is blocked by the block plate of the shutter.

III. RESULTS AND DISCUSSION

Table 1. *Comparison of specifications between Thorlabs' product [4] and the shown system*

Parameters	SC10 (Thorlabs)	KSC101 (Thorlabs)	Our product
TI	8 ms	13 ms	5 ms
TO	3 ms	1 ms	0.35 ms
TD/R	13 ms	13 ms	7 ms
TC	4.08 ms	1.2 ms	0.6 ms
MOP	10 ms	15 ms	10 ms
MSOP	27 ms	17.2 ms	15 ms

Table 2. *Overall comparison between Thorlabs' product and the shown system*

Characteristics	Thorlabs' products	Our Product
Specifications	Inferior	Superior
Stability	Superior	Inferior
Control Program	Unchangeable	Adjustable
Price	More expensive	Cheaper
Lifespan	Longer	Shorter

From the two tables, our system has shown its superior in some specifications in comparison with Thorlabs' shutter, however the tradeoffs are the stability and the lifespan of the product. Further study will be conduct to improve these two charateristics meanwhile maintain the obtained time response.

IV. CONCLUSION

A full optical shutter system is well developed and it fully performed the characteristics of such a system. Moreover, some time specification of the system are superior to some products on the market. This system also can be utilized in the laboratory for multiple purposes, including maintaining eye safety. In the future, the this shutter will be completed to adapt to the need of different laboratories and research institutes.

V. ACKNOWLEDGMENT

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