New CHIRON shutter

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file: prj/bme/chiron/shutter/shutter-doc.tex

1 Introduction

The CHIRON spectrograph at CTIO/SMARTS 1.5-m telescope operated with the Uniblitz TS6B bi-stable shutter and the 12 V ED12DSS driver from Uniblitz. The 5 mm shutter opening is just sufficient to transmit the sliced beam but leaves no margin and requires lateral alignment of the shutter to the beam.

The shutter failed (stayed open) and was replaced by a new one. The new shutter also failed intermittently. Hence the decision was taken to replace it with a more robust device. However, the space between slicer and lens L2 available for the shutter is very limited, requiring a miniature solution. We wanted nevertheless to increase the shutter opening to 10 mm so that the beam is transmitted securely without any fine-tuning.

We identified a tiny bi-stable rotary solenoid made by Takano.[1] The length is 10 mm, diameter 7 mm, coil resistance 9.5 Ohm, cost about 70 USD. This solenoid is specifically adapted for fast shutters. Without load, it turns by 60° in 15 ms when driven by 5 V pulses.

2 Mechanical design

The mechanics (Fig. 1) consists of 2 pieces bolted together. The solenoid is clamped in the thick piece (also providing a heat sink). The flat piece has dimensions of 40x25mm and a hole of 10 mm to transmit the beam. The blade of 16-mm radius covers the hole with a rotation (swing) of about 60°. The limiting positions are defined by two pieces of black foam, providing amortization. The blade is fixed on the solenoid axis by the M1.6 screw and stabilized by a droplet of glue. The blade is approximately balanced, so the shutter is insensitive to orientation.

The solenoid is turned in its clamp in such way that the position of its instable equilibrium (neutral) corresponds to the middle of the total swing. The blade turns by $\pm 30^\circ$ on both sides from the neutral, the un-powered solenoid provides the retaining moment in open and close positions.

The assembly has two open 3-mm holes, "fork", that fits to the existing M3 screws. By releasing those screws, we can detach the whole shutter unit without perturbing other CHIRON components.

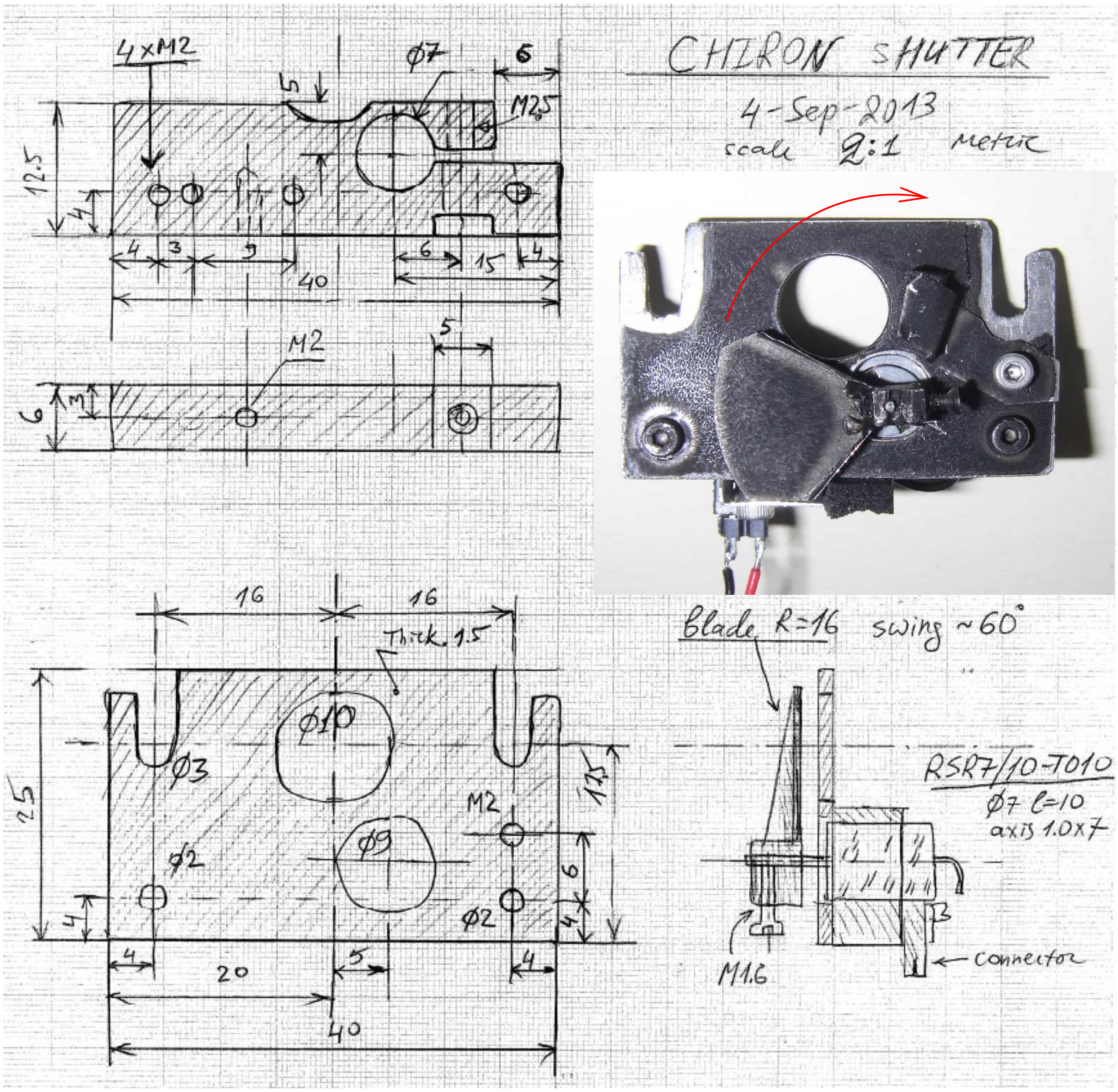

Figure 1: Mechanical dimensions of the shutter.

3 Driver

The driver was developed by P. Moore. It is powered by 5 V. The TTL input signal from the Torrent controller (opto-isolated) is pulled up to 5 V by a 680 Ohm resistor. Changes of the input TTL signal lead to the generation of logical opening or closing pulses (length ∼80 ms). They, in turn, open the transistors and create current pulses of alternating polarity in the coil of the solenoid.

The driver and prototype mechanics (solenoid with blade) were tested in the lab. The system

[1] http://www.takano-sanki21.com/english/product/rsr7_10-t010.html

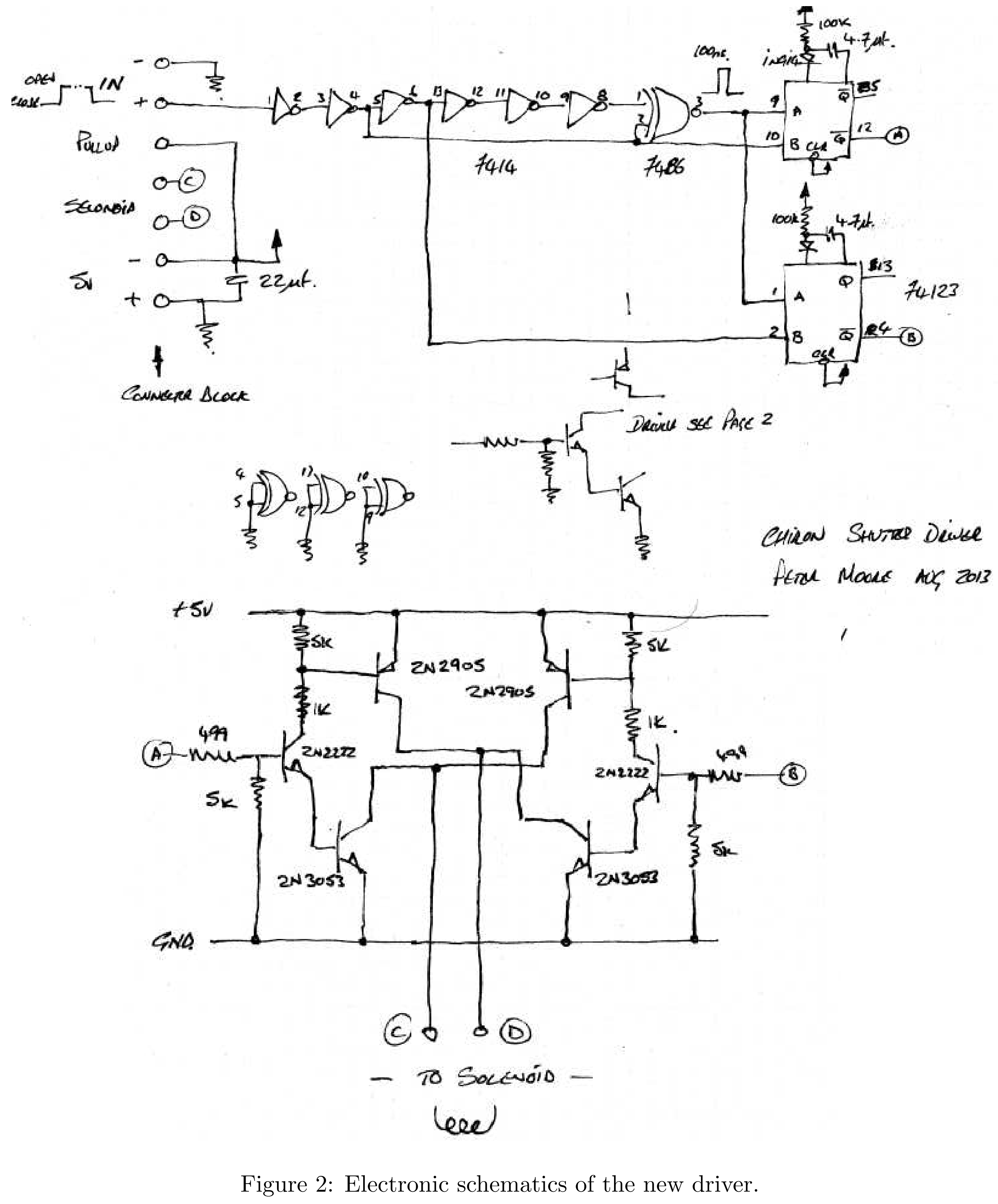

Figure 2: Electronic schematics of the new driver.

worked continuously for 2.5 days at 0.5 Hz rate (> 100 000 openings and closings). We also tested it with pulse frequency up to 5 Hz and pulse duty cycle from 0.2 to 0.5.

4 Installation and test

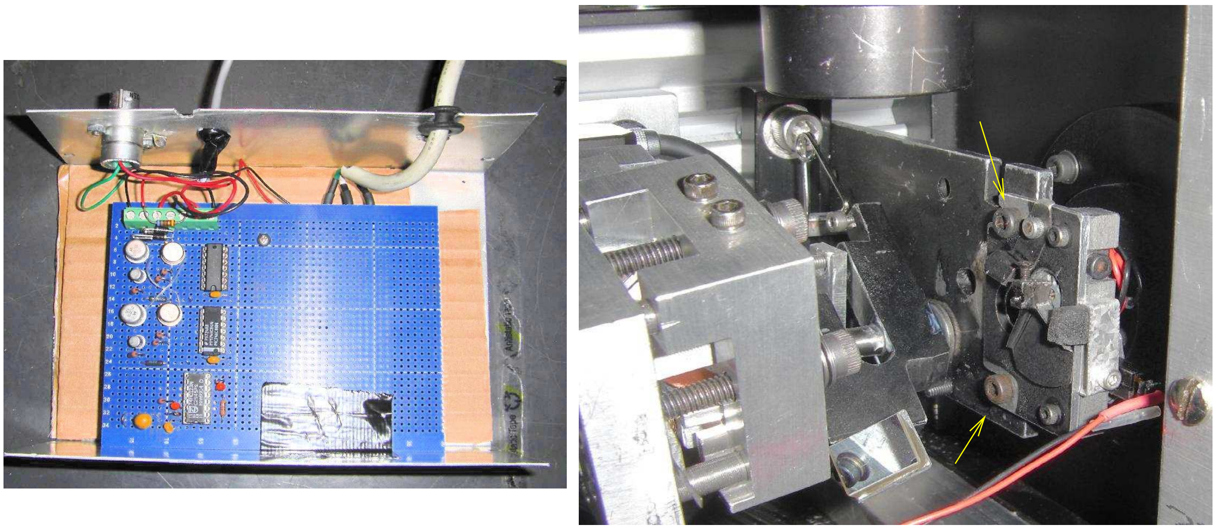

Figure 3: Left: driver in its open box. Right: shutter installed in CHIRON. Yellow arrows show the two screws used to fix the shutter.

The shutter was installed in CHIRON on September 6, 2013. The driver is mounted in the same metallic box where the old driver was (keep same cables). Figure 3 shows the driver mounted in the box and the shutter installed and connected. Spectra of ThAr lamp with exposure time of 0.05, 0.1, 0.2, and 1 s were processed by measuring the total counts in a selected bright line.. The shutter reaction remains linear down to 0.1 s (Fig. 4), but shorter exposures are not recommended (they are prolonged by the driver).

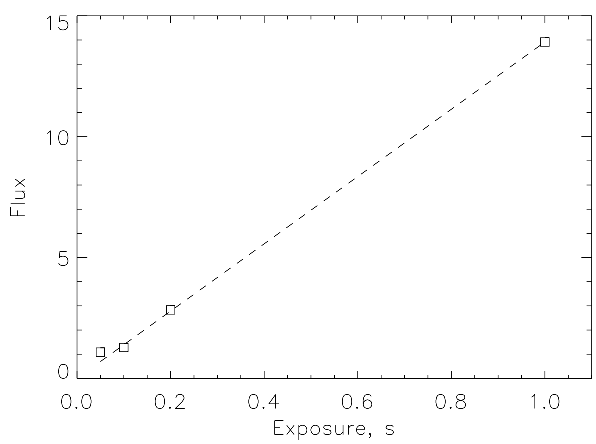

Figure 4: Flux of selected Th-Ar line vs. exposure time.