Uniblitz optical shutter driver

1. Introduction

Optical shutters manufactured by Uniblitz (http://www.uniblitz.com/) are commonly used in a range of optoelectronic applications. The claasical shutter designs are available in a range of optical diameters and are characterised by fast and reliable operation, with switching speeds of a few milliseconds, and in some cases very much less. We have used the classical Uniblitz 25 mm optical beam diameter shutters for several years and with a variety of drive systems. Our experience has shown that when these devices are operated at the fastest possible transition speeds (3 ms) that reliability is somewhat impaired and that small silicone rubber pads used to damp the blades' motion at the extremes of the open and closed positions had a tendency to fail after many thousands of operations, as shown in Figure 1. On the other hand, when opening speeds were slightly restricted, to around 10 ms or so, still fast enough for many applications, no such failures occurred. We thus designed several years ago a drive circuit which ensures reliable shutter operation and found it useful where access to the shutter is restricted. The principle application described here is associated with the use of such shutters for controlling fluorescence excitation light in widefield microscopes. The operation speed penalty is considered to be negligible since excitation periods much below 30-100 ms are rarely used with commonly used cooled CCD cameras as used in microscopy.

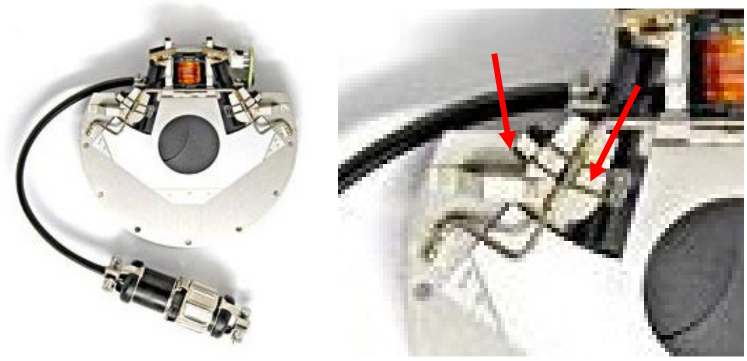


Figure 1. TheVS25 series of Uniblitz shutters (left, image from (Vincent Associates) and failure points (right) with arrows indicating positions of small silicone rubber pads used to damp the open and closed shutter positions.

The VS25 series of shutters are available in a cased version and this is by far the most convenient package for general purpose use. We use the VS25S2ZM1 model, which is capable of handling 10Wmm^{-2} on the blades. In order to increase versatility, we arrange the cased shutter to be mounted on Thorlabs (http://www.thorlabs.com/) cage system plates. This can be achieved as shown in Figure 2, where the cased shutter is sandwiched between customized LCP03 and LCP02 plates.

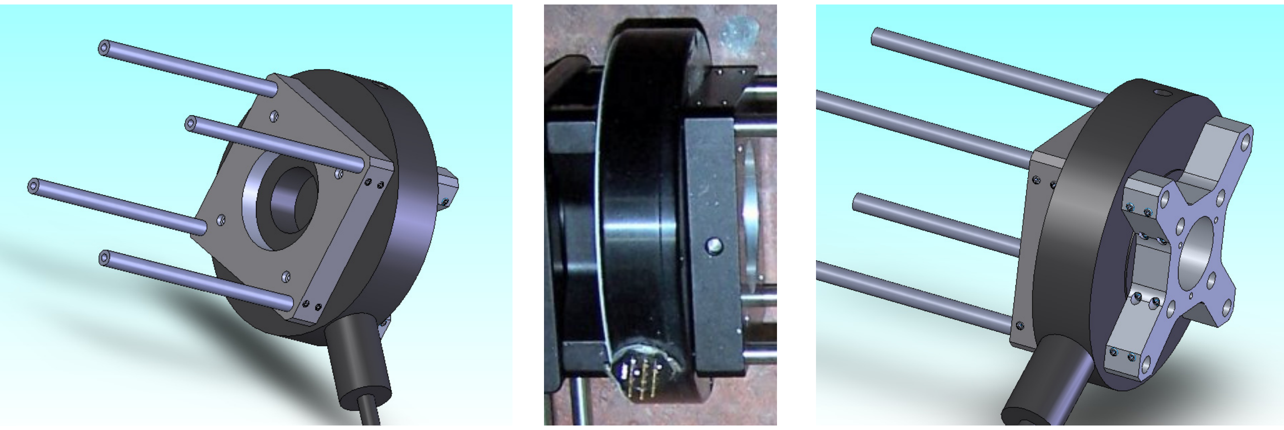


Figure 2. Mounting of the VS25 series of Uniblitz shutters between Thorlabs LCP)2 and LCP03 cage plates. Four holes are tapped into the shutter case and corresponding holes in the LCP02, as well as a central hole are made. Three holes to match existing shutter holes are also made in the LCP03 plate.

2. Shutter drive circuit

A simplified drive circuit of the shutter is presented in Figure 3. It has been adapted form one of our past notes (“Useful circuits”, 2005). The idea is to use an isolated DC-DC converter to produce about 35V and to charge up, through D2, a 470 µF storage capacitor. An FET (MOSFET#1) switch energises the shutter coil and discharges this storage capacitor. The shutter coil is maintained in an energised condition by D1, fed from the +5V supply. When the shutter is energised, the DC-DC converter is switched off through MOSFET#2. When MOSFET#1 turns off, i.e. when the shutter is to be closed, MOSFET#2 is enabled and the storage capacitor is recharged. The shutter position is monitored through the shutter’s optical feedback arrangement and the signal from this is buffered and used as part of a latch formed with the aid of other inverters in the circuit; this latch can be set or reset using push-button switches. This arrangement has been found to be extremely versatile and efficient.

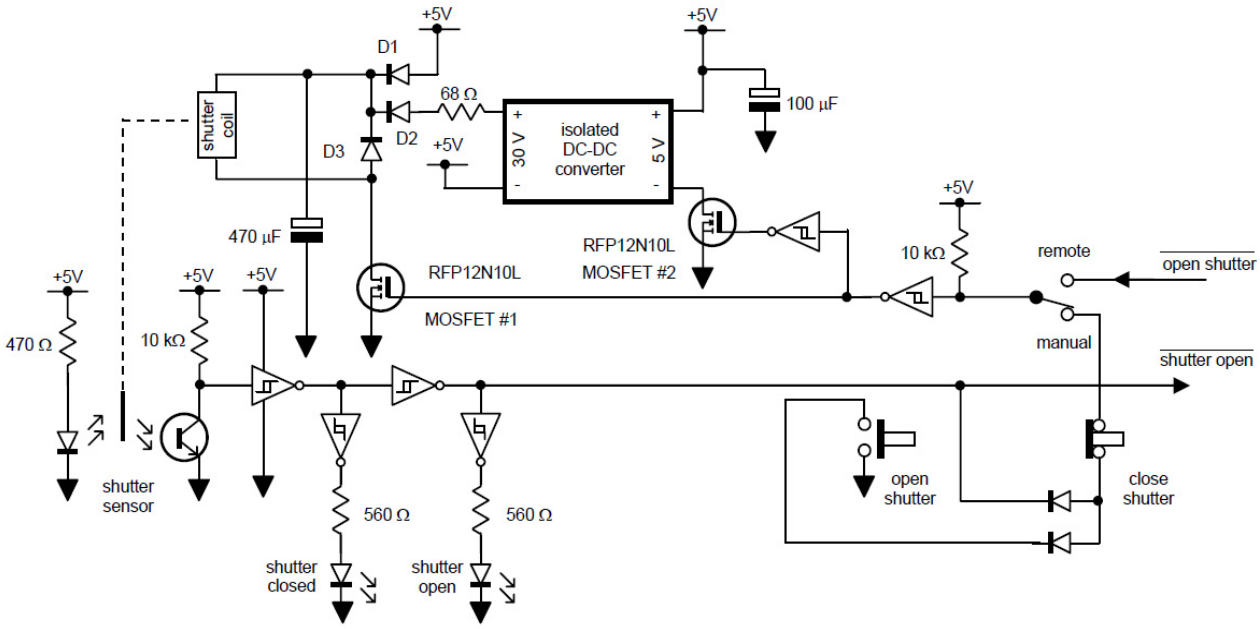


Figure 3. Simplified circuit diagram of the shutter driver. Please see text for details operation.

The actual circuit of the driver appears to be somewhat more complex, but this is largely so as it reflects details to increase the versatility and make it possible to increase the versatility of the arrangement. This circuit is shown in Figure 4. The first enhancement is to make switching between digital control and push-button switches (remote/manual switch in Figure 3) programmable, using a section of a HCT4053 one pole two way switch. A second feature allows direct drive of the switch to be made possible. Finally, we arrange simple RC ntetworks to mimic the delay in the shutter operation and to allow both the latch and the output circuits to operate without feedback circuitry, allowing legacy shutters without photo-interrupter feedback to be used. Finally, two other features enhance the versatility. We provide a trigger pulse to any camera that may be used with this device. This is normally provided by the feedback circuit, allowing camera trigger only after the shutter is fully open. However, there are instances when the camera is to be operated without energising the shutter (e.g. when acquiring a black level image) and for those circumstances, we provide a dummy trigger pulse. These various features can be enabled or disabled with the aid of jumpers on the circuit board. In addition we can synchronise shutter operation with a vertical sync signal from a camera. Furthermore, the way that the circuit is constructed also allows a degree of versatility. We chose to separate the sections dealing with shutter coil switching from those dealing with control and with capacitor charging. In this way we eliminate high currents from flowing in any backplane wiring and allow potential choice of charging voltage, should a shorter operation time be required (by changing the DC-DC converter to a higher voltage unit).

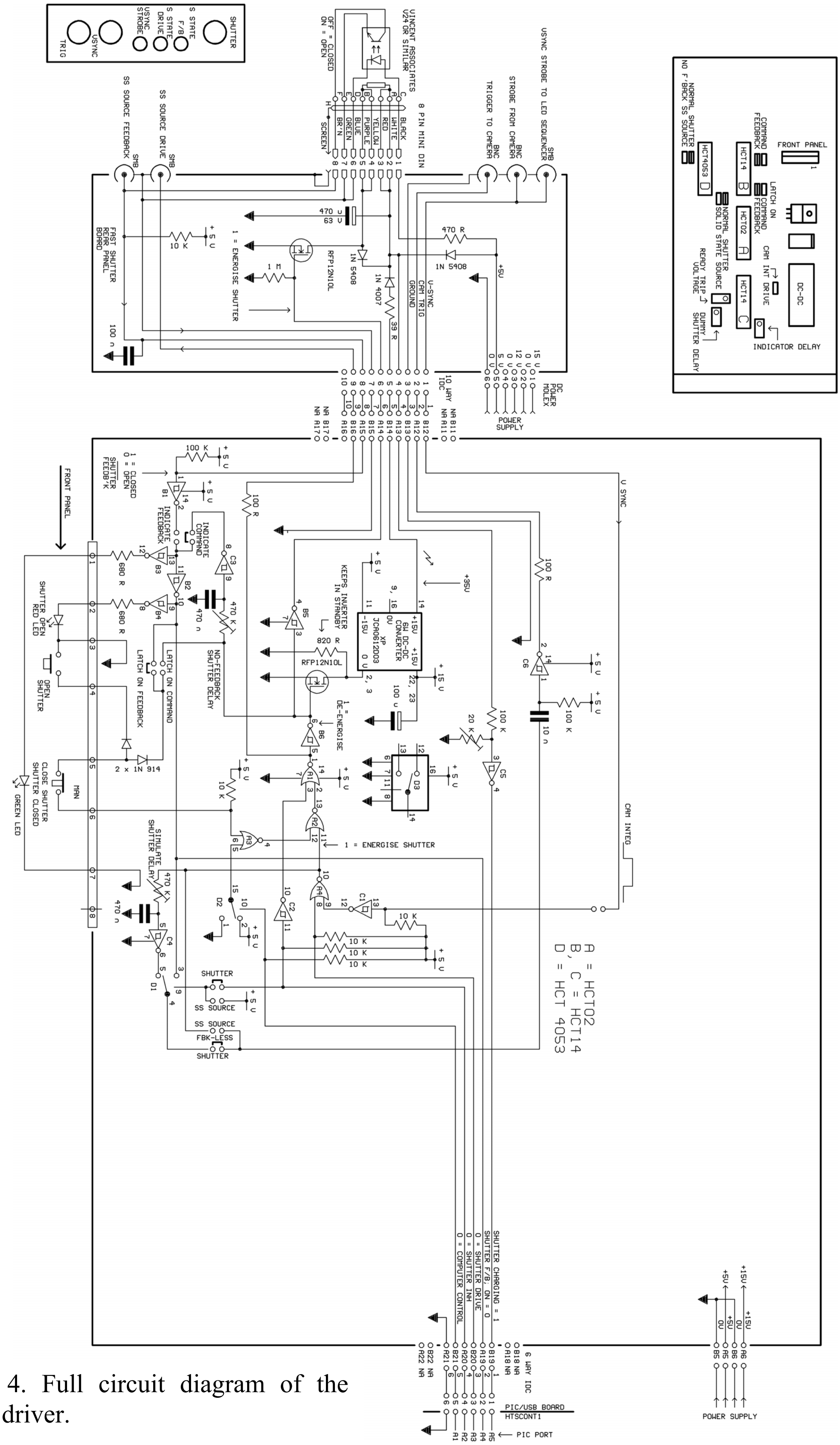


Figure 4. Full circuit diagram of the shutter driver.

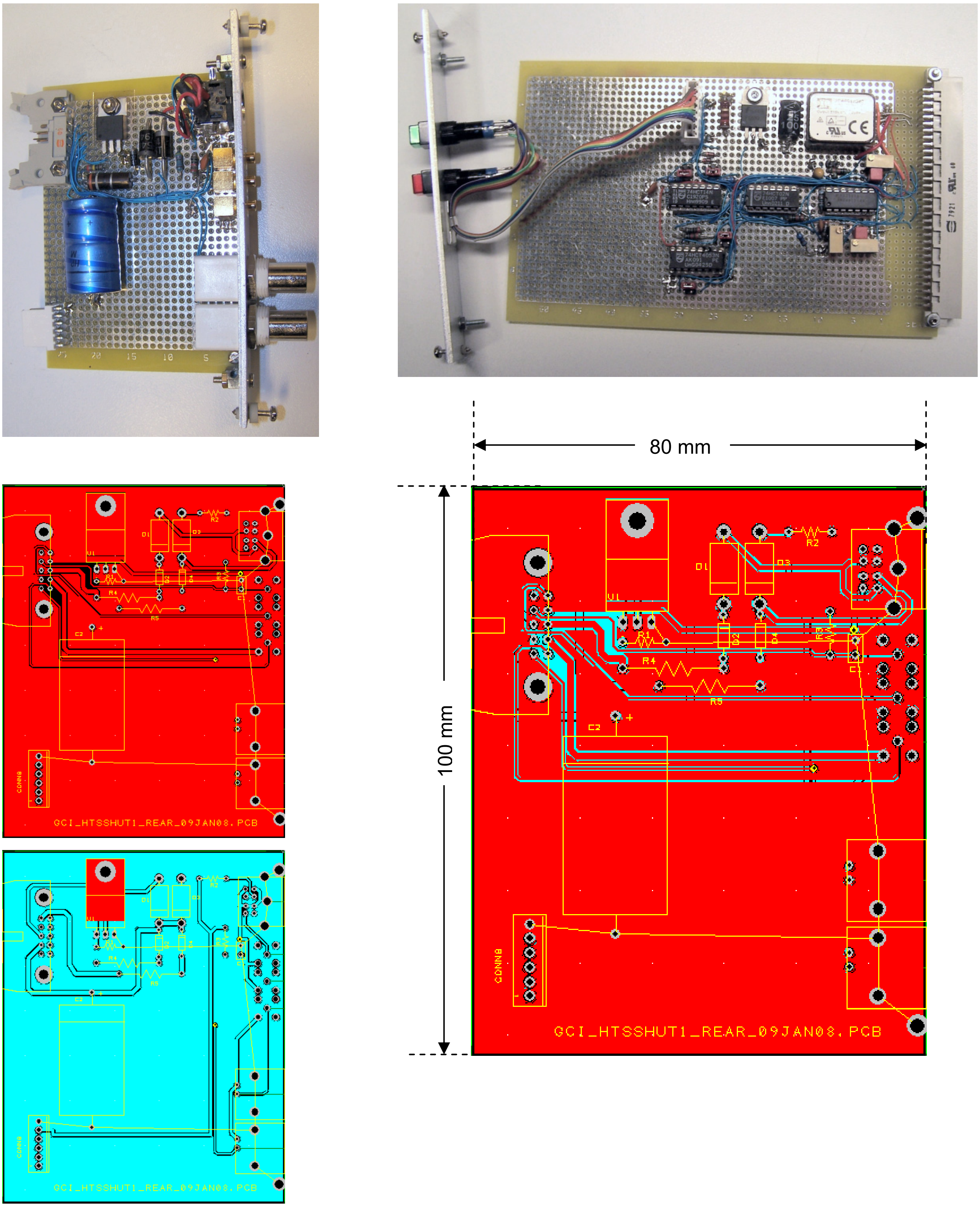


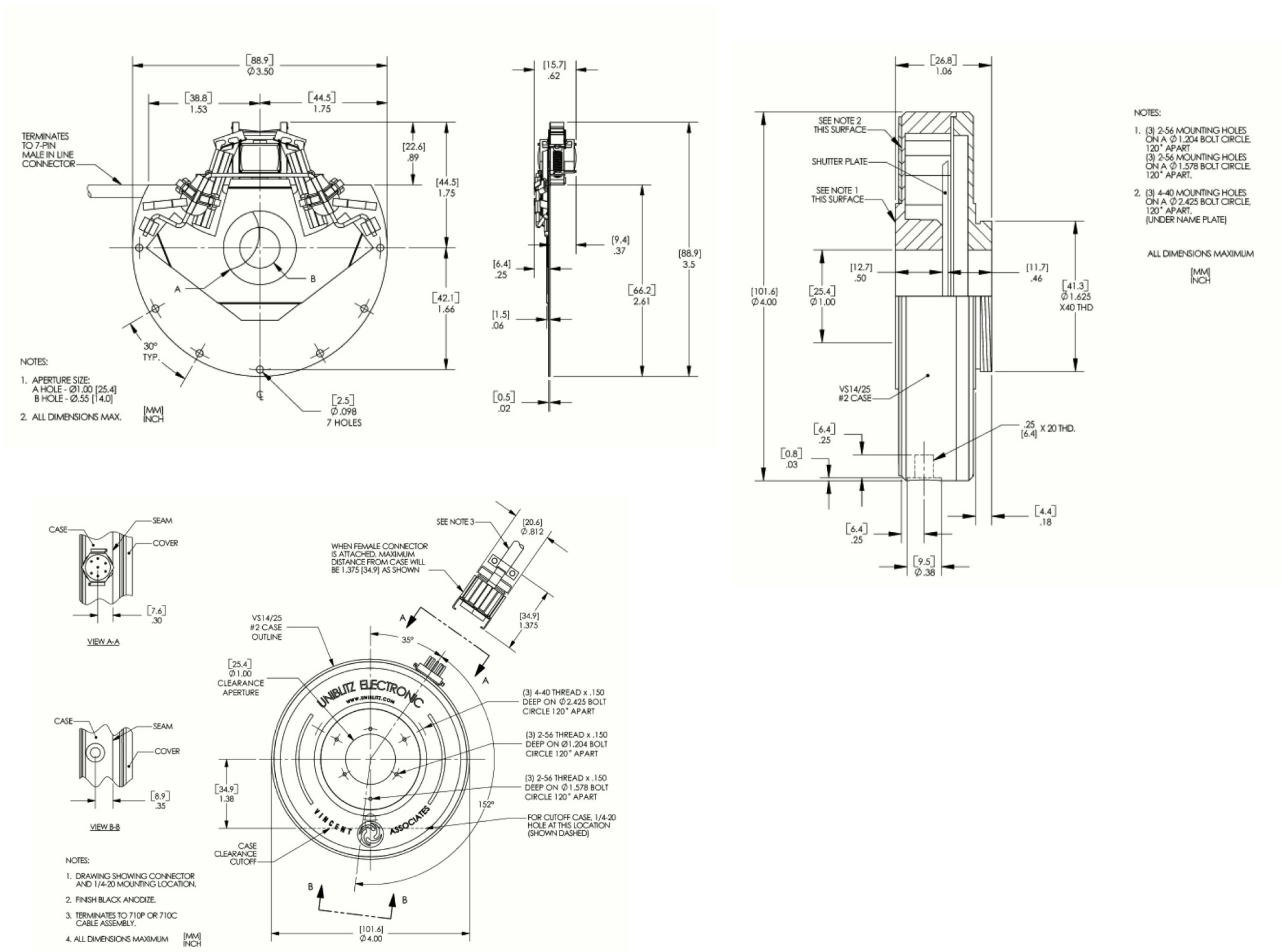
Figure 5. Construction of the shutter driver. Prototype ciccuit boards are shown above and printed circuit board layout are shown at the bottom of the figure.

3. Practical implementation

The practical implementation of the circuit is shown in Figure 5. We constructed the circuit on Eurocards, 100 mm tall, either full length (160 mm) for the control circuit or ½ full length (80 mm) for the shutter switch. A printed circuit board is available for the latter. SMB sockets are used to allow monitoring of command and feedback signals, while BNC sockets are used for the camera trigger output and the camera vertical sync input.

We note that there is a degree of latitude in component selection, though deviating from the values suggested should be done with care. If the charging voltage is increased, the charging capacitor value should be decreased. If faster turn-off is required, the back emf diode (D3 in Figure 3) could be eliminated and replaced with a zener diode to ground, allowing the MOSFFET#1's drain voltage to increase to greater level and collapsing the shutter coil's magnetic field more quickly.

For completeness, the mechanical drawings of the shutter assembly, from Uniblitz's data sheet, are presented below.



This note was prepared in July 2008 by B. Vojnovic and R.G. Newman. It was updated in August 2011. We thank J. Prentice for modifying the Thorlabs cage plates. R.G. Newman constructed the prototypes and designed the printed circuit boards.

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