Automating Shutter Operation for a ProDome

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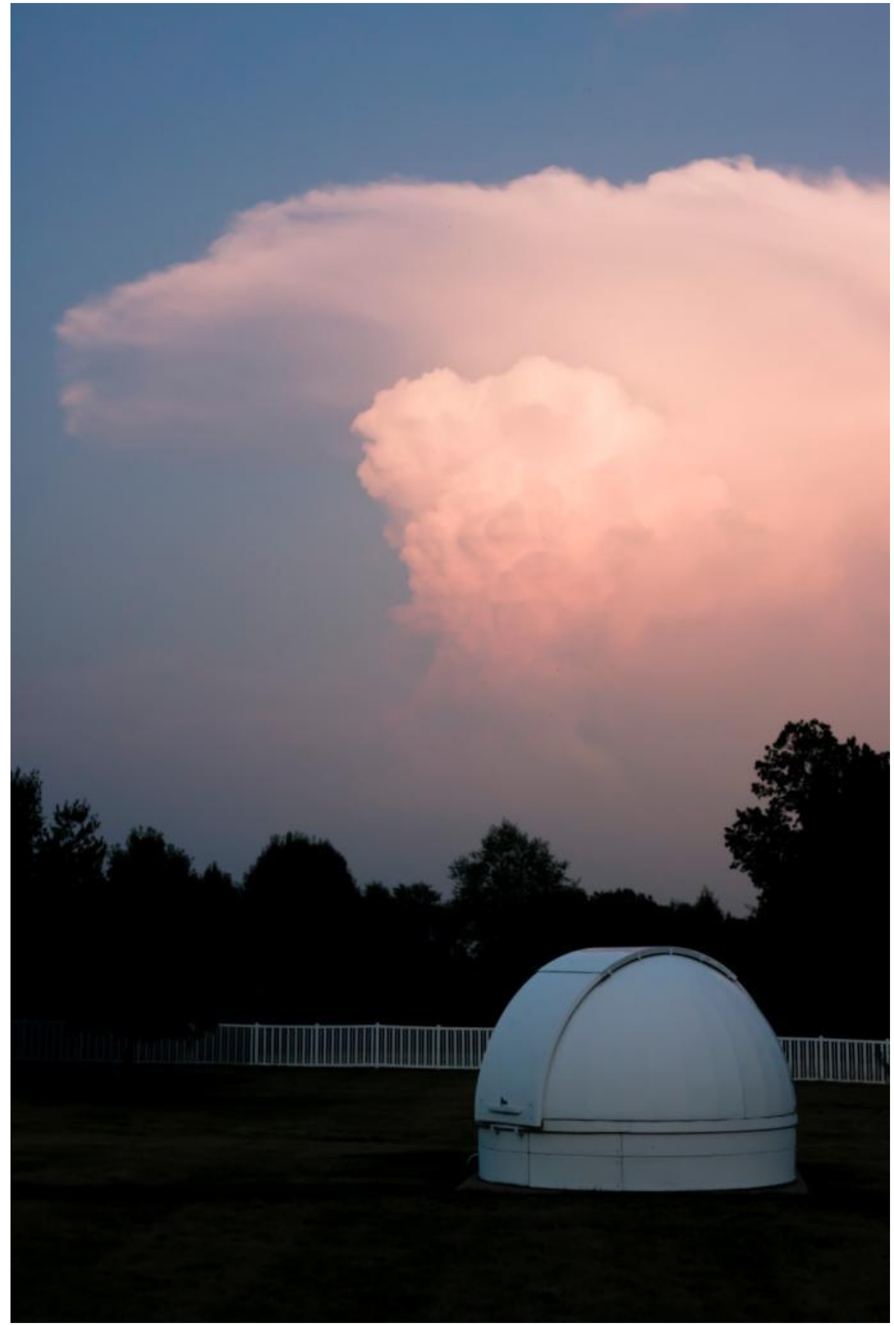
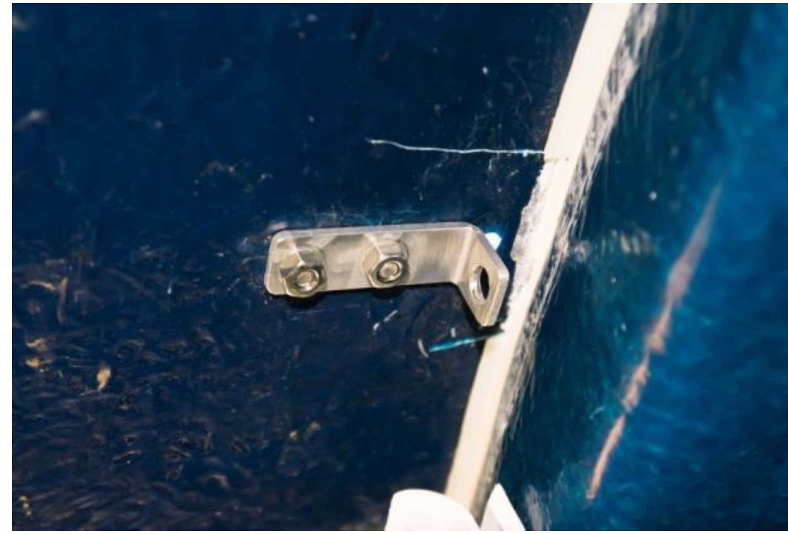
I purchased my ProDome 10 in 1998 and used it in the 'manual' mode for many years. In 2011 I decided to automate the rotation of the dome (See Dome Rotation Automation II), but opted not to do the same for the shutter. After about a year of reliable automated rotation, I made the decision to work on automating the shutter as well.

The first step was to purchase the Technical Innovations hardware to allow mechanical operation of the shutter. This consists of a windlass with a following nut that controls a set of cables and pulleys. The pulleys attach to the slot opening and to the front shutter. The windlass is powered by a reversible 12VDC motor.



One of the first problems I encountered was that some of the original hardware, such as the guides for the shutter locking mechanism (top, right) were not compatible with placement of the pulleys on the shutter. TI supplied a newer version of this hardware so that the existing holes in the shutter could be used.



A second issue arose with placement of the pulleys mounted on the dome slot inside face. Because this surface is not perfectly flat (in fact somewhat curved), the pulleys when mounted near the bottom of the slot face did not lie flat against the surface. This was problematic because as the shutter moved from open to closed, the pulleys on the shutter are supposed to lay the steel cable down into the pulley mounted on the slot. With as much as a ¼ inch space (lower, right) the cable would not fall into the pulley as the shutter was closing.

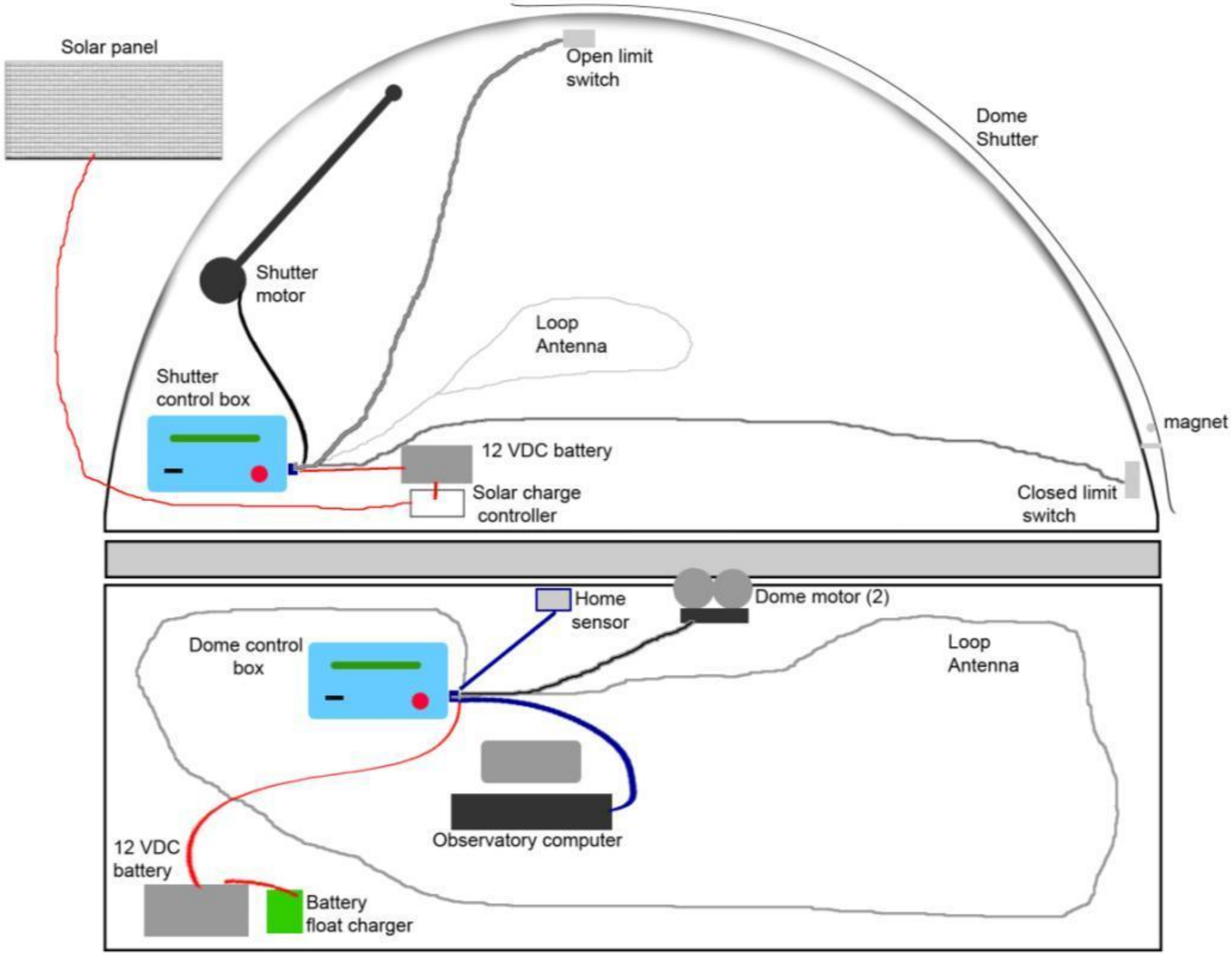
The supplied pulleys for the shutter extended too close to the face of the slot and further complicated the movement of the steel cable during opening and closing. This was corrected by fabricating a new bracket for the pulleys (see below).

Here's how I solved the problem with the poorly fitting pulleys. The guides on the pulleys are PVC and will tolerate a bit of heating to reshape them. I used a hobby style heat gun to gently warm the PVC.

Then using a wood block I pressed the guide to match the shape of the shutter flange and held until the PVC cooled. If done carefully this makes each pulley have a custom fit and does not interfere with the movement of the pulley. The same technique can be used on the curved guides to form them to allow the shutter mechanisms to clear.

The image at the left shows the replacement pulley assembly mounted in place at the correct distance from the shutter flange. The guide for the shutter locking mechanism is installed on top of the pulley assembly.

The image at the right shows the replacement pulley assembly with the locking rod inserted into the guide. I found that the locking mechanism was not absolutely necessary when the cable system was installed, and would prevent remote operation of the shutter any way. I left it in place in the 'open' position (as seen here) and adjusted the length of the rods on either side so that they just clear the flange. This allows the locking mechanism to act as a guide and keep the front shutter centered on the slot opening.

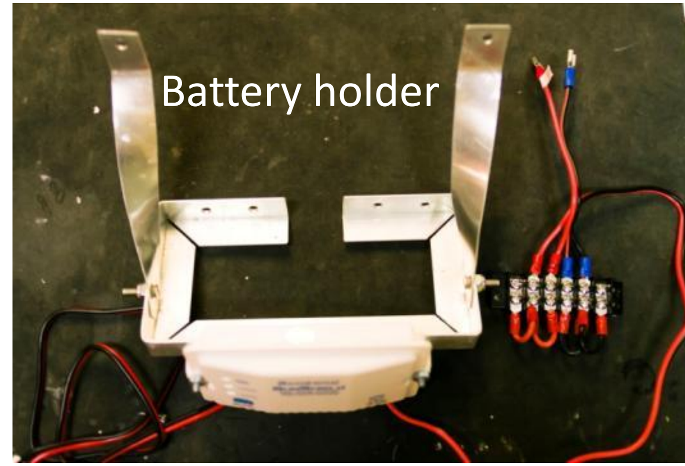


An interface box riding on the dome holds the MaxDome II card that controls the reversible shutter motor. It is powered by a small 12vdc battery which is continually recharged by a solar panel. Open & closed limit switches keep track of where the shutter is. A magnetic inductance loop antenna communicates with a larger loop antenna connected to the dome controller. The dome controller also has a MaxDome II card that controls rotation and receives commands from the observatory PC.

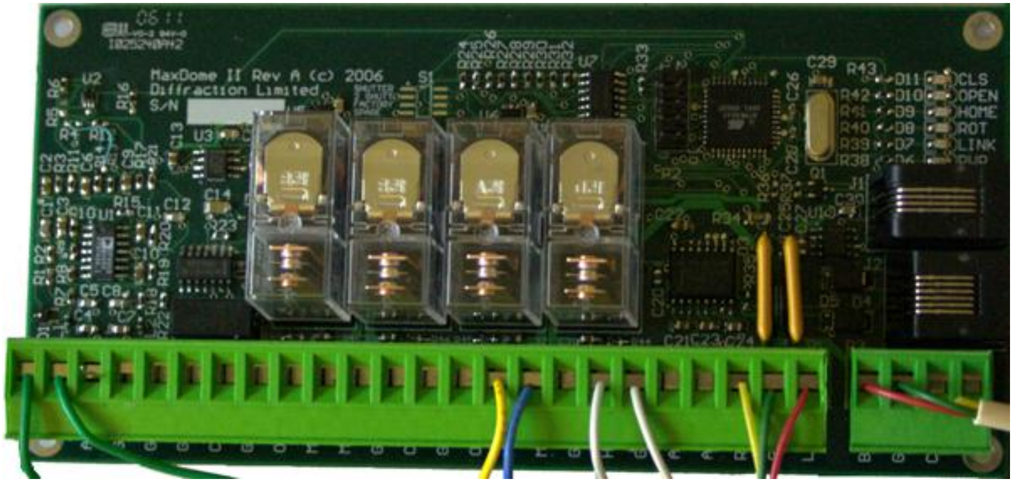
The 12VDC battery used to power the shutter windlass is kept charged by a solar panel (20 watt). Since my shutter faces north-south when closed I needed to devise a means of mounting the solar panel to face south at the appropriate angle. This was accomplished using aluminum channels attached to the dome by means of stainless steel eye-bolts. This arrangement allows the shutter to open and close sliding beneath the panel while providing a very light weight but sturdy mounting.

In order to maximize the amount of sun light hitting the panel during the winter I adjusted the tilt of the solar panel to about 90 - Local-Latitude - 23.5, pointintg due South. For my latitude this worked out to 90 - 38.6 - 23.5 = 28 degrees.

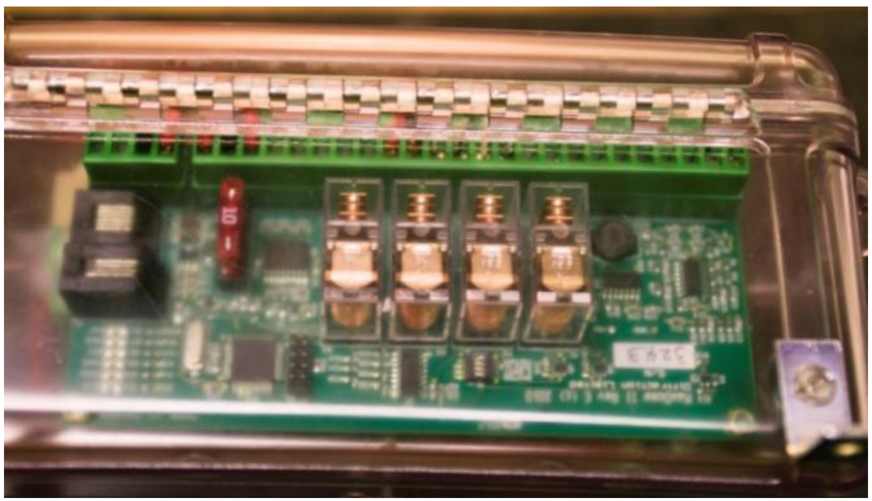
The 12VDC 5Ah sealed battery is supported by an aluminum frame which mounts on the inside of the rear shutter panel. All of the components are mounted using flat-headed stainless steel screws counter-sunk in the fiberglass dome to prevent any obstruction to the upper and front shutters as they open or close.



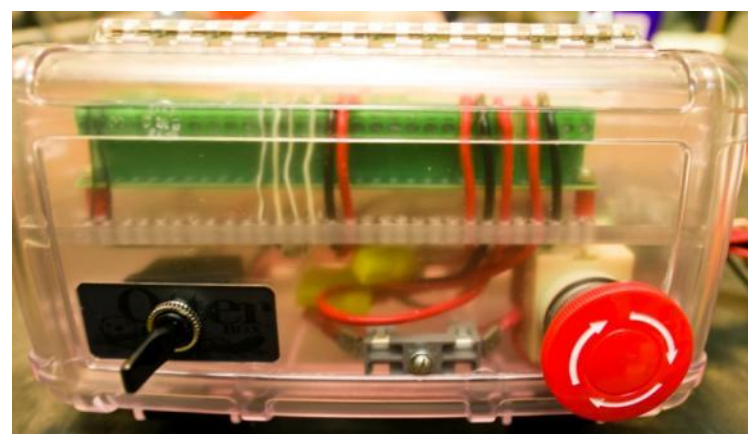
The image at the right shows the battery mounted in the holder with a junction block attached above. Mounted to the front of the holder is the charge controller for the solar panel. Colored lights show when the panel is generating a voltage and whether the battery is charging or fully charged.

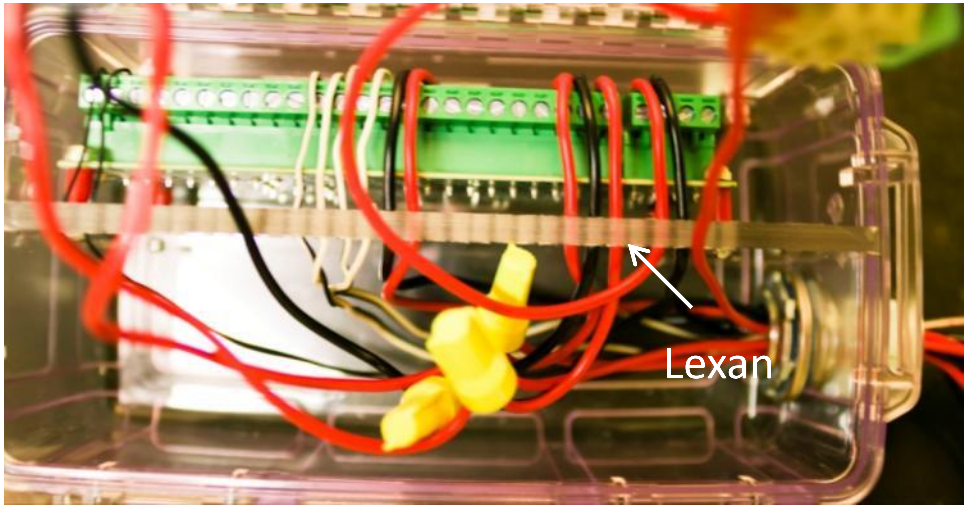


For control of the shutter I used the MaxDome II interface cared from Cyanogen. This is the same card used for controlling rotation of the dome, but configured to operate the shutter. It consists of a series of relays along with connections for open and closed switches, a manual operation switch, and a magnetic inductance antenna for communication with the rotation controller.

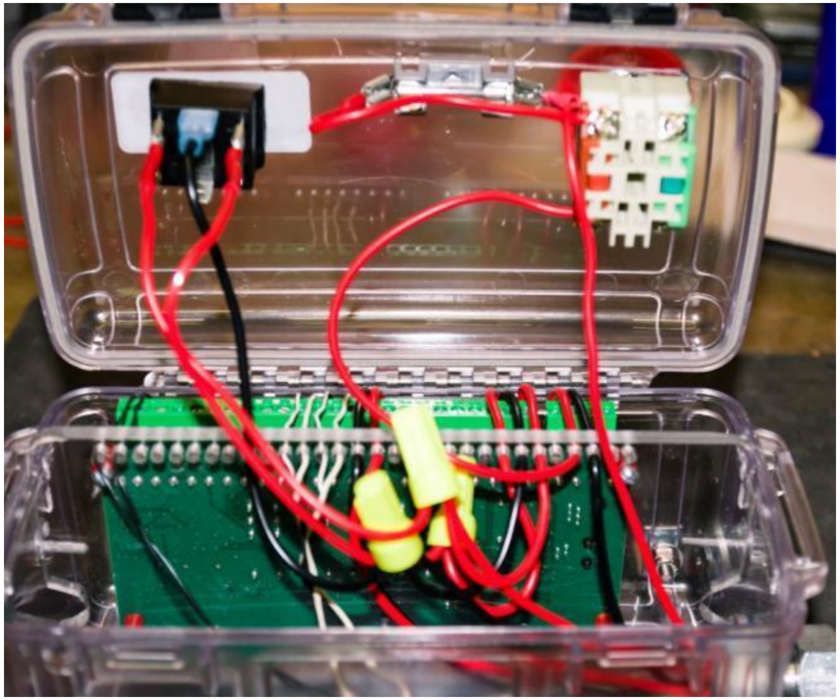


I mounted the MaxDome II card in an Otterbox 3500. This provides protection from the environment while allowing easy access to the various connections. Shown at the right is the front of the box with the manual control switch and an emergency KILL button that removes power to the interface card and shutter motor.

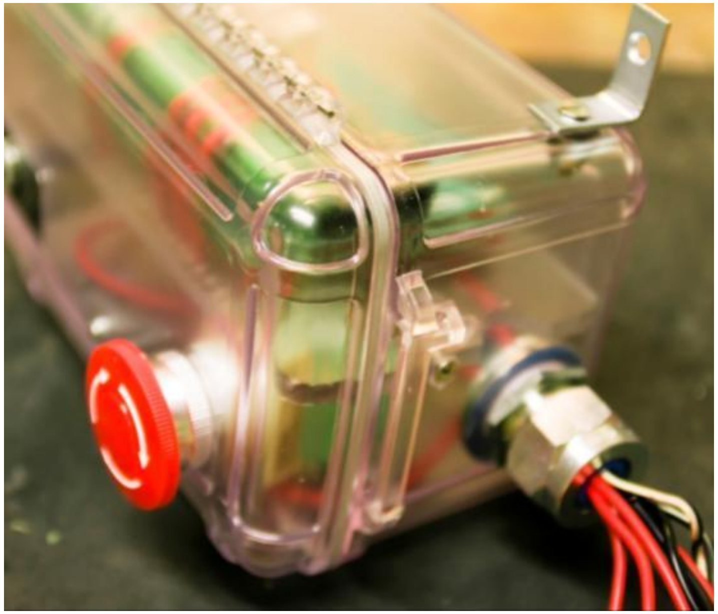




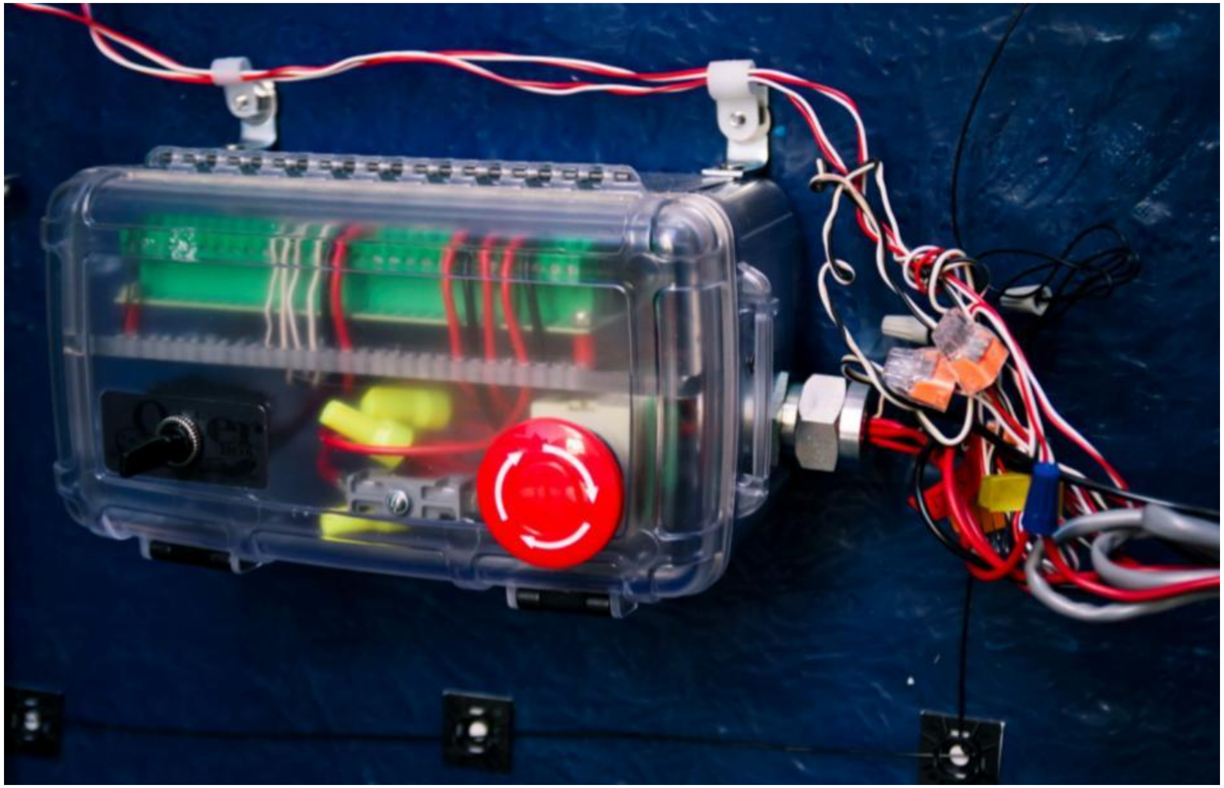
A piece of ¼ inch Lexan was cut to fit the inside of the box and serves as the mounting platform for the interface card. It is held in place with stainless steel screws on the sides and back.



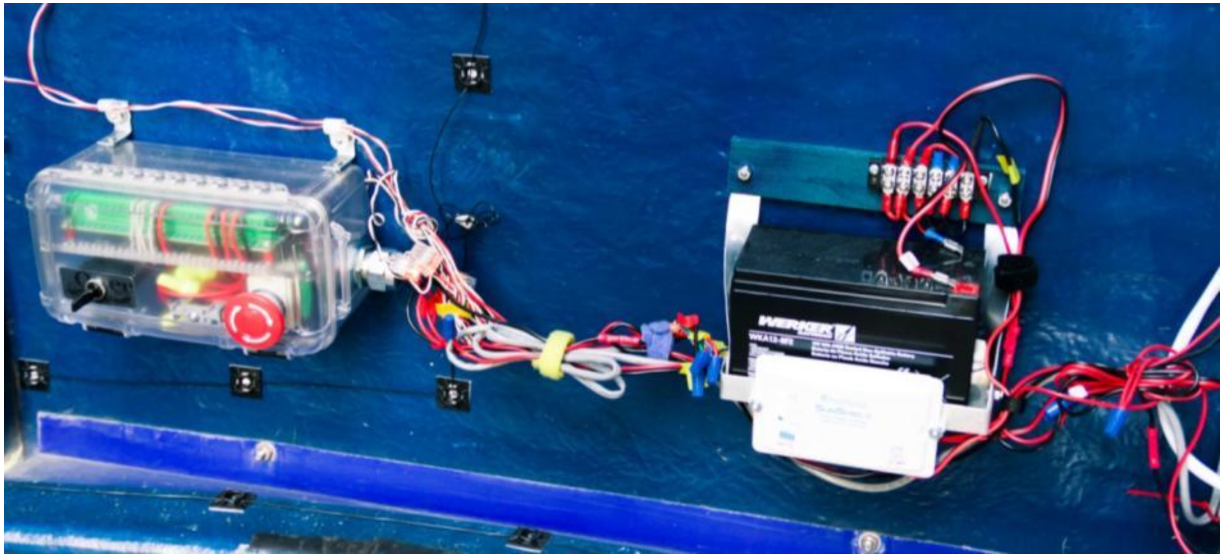
The hinged front of the box opens to allow easy access to the various connections. A series of 0.5 mm holes were drilled in the Lexan shelf to provide strain relief for the wires connected to the junction block of the MaxDome II card.



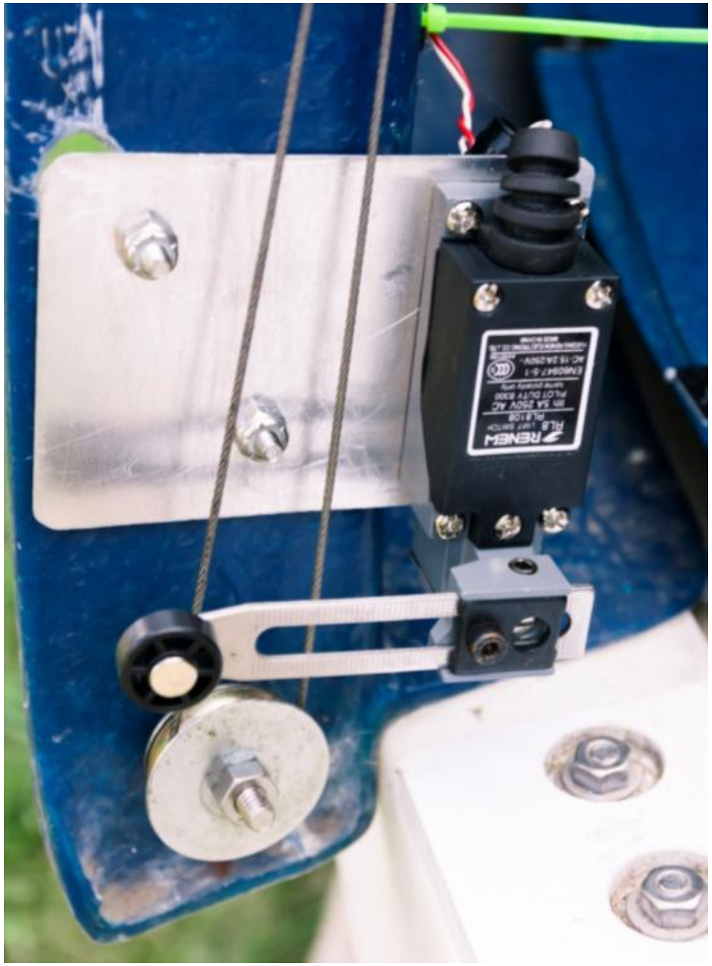
A ¾ inch lead connector with compression fitting acts as a port for the power, switch, and antenna lines that connect to the MaxDome II card. A simple right angle bracket mounts to the top of the box for attachment to the dome.



The image at the left shows the interface box with MaxDome II card mounted inside. The angle brackets at the top are used with stainless steel flat head screws to mount the box near the bottom of the rear shutter. A more sophisticated interface box with additional relays and a soft-start card for the motor (Chris Erickson, Summit Kinetics) will be installed in the future.

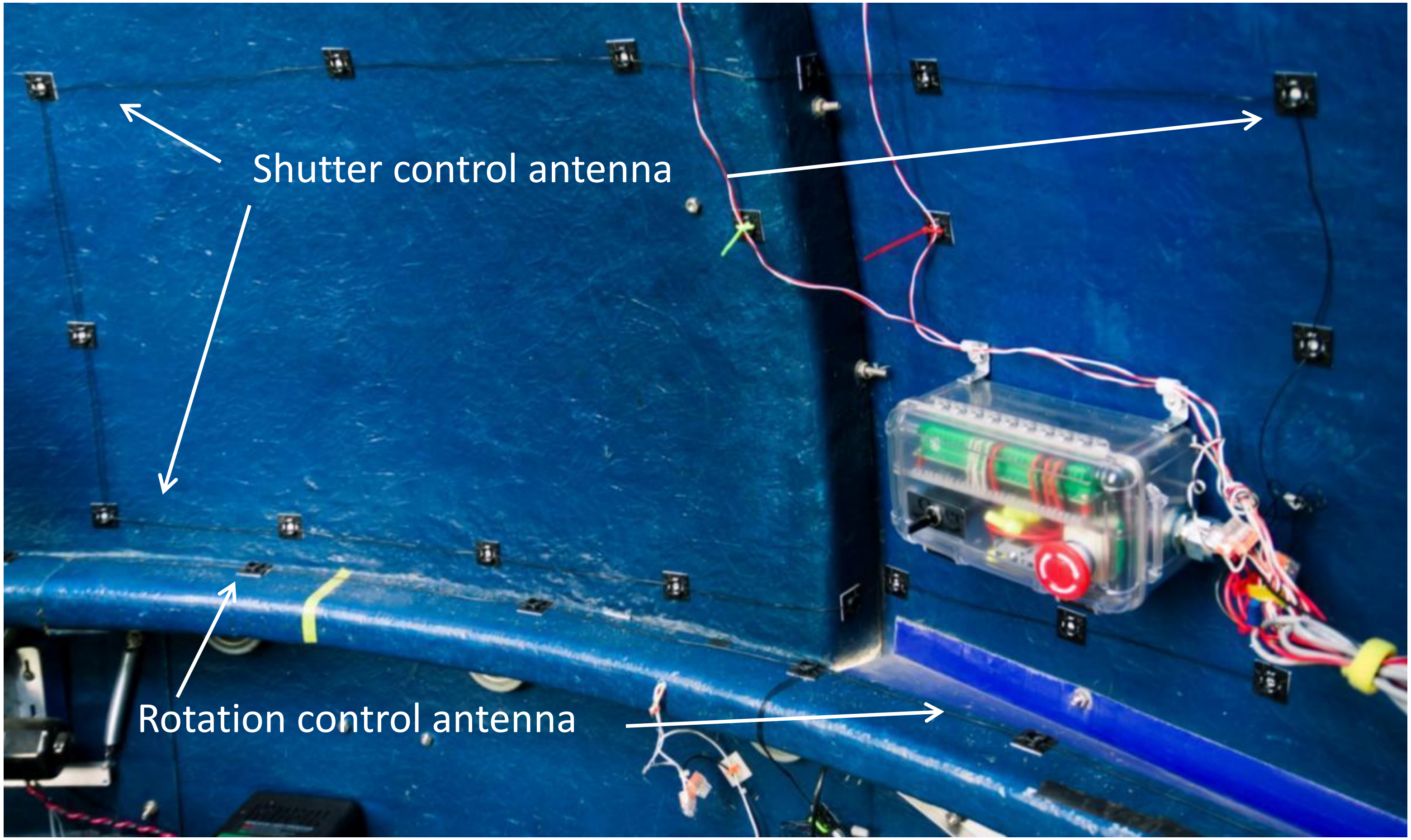


Here is the layout of the interface box and battery assembly mounted to the rear shutter. Mounting in this location prevents the box or battery from protruding excessively as the dome rotates.

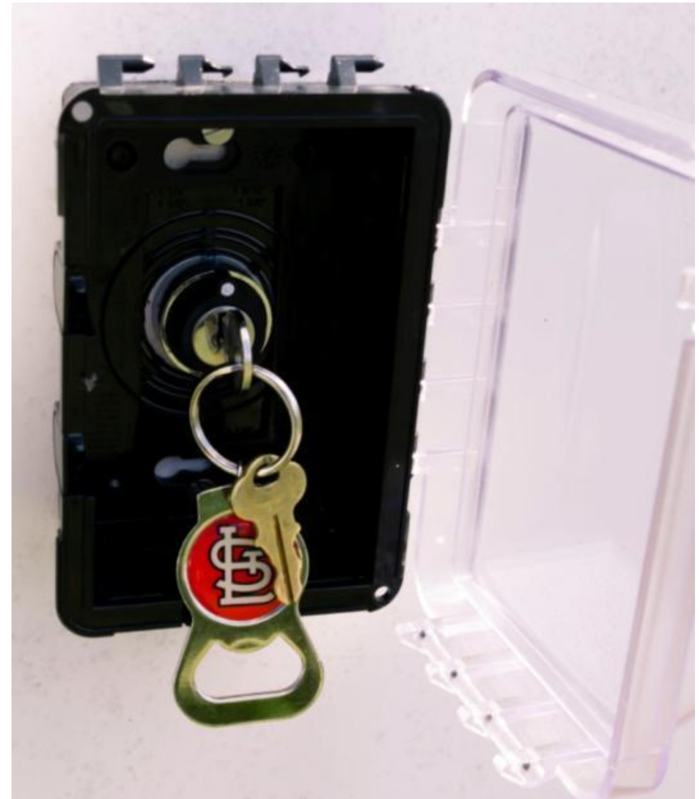


I opted to use two different types of limit switches. For the "closed" switch I used a mechanical limit switch (left) with an adjustable arm. A small piece of aluminum angle mounted on the front shutter contacts the arm as the shutter is almost closed. Because of slack in the pulley system, the shutter tends to fall about an inch when power is removed; the mechanical limit switch arm remains in contact with the shutter throughout this extra movement.

For the "open" limit switch I used a simple magnetic reed switch (right) which can be configured to 'normally open' when the magnet is present. The switch is mounted on the lip of the rear shutter and the magnet mounted on the inside of the front shutter.



The MaxDome II cards (rotation & shutter) communicate via magnetic inductance antennae. The rotation controller antenna runs all the way around the base ring of the ProDome. The shutter controller antenna forms a loop about 3 feet wide. I used a combination of outdoor tie-wrap fasteners and plastic wire loops to secure the antennae. Built into the logic of the MaxDome cards is a fail safe routine; if communication is lost between controllers, or between the rotation controller and the observatory computer, the dome will park and the shutter will close within 10 minutes.



In order to open or close the shutter manually, I installed a key-operated momentary DPDT switch. This switch is wired in parallel with the manual switch mounted on the interface box. The key switch is mounted in a convenient location next to the shutter in a weather-proof box. The key is held in the appropriate position (open or close) until the shutter reaches the end of its travel and the limit switches remove power.

One mechanical problem that I encountered was that the front shutter would sometimes not unlatch when the top shutter had been fully retracted.   This would cause the top end of the top shutter to move outward and the front shutter would not slide beneath it as it was supposed to do.   I was unable to resolve this problem despite sanding and shaping the latch holes, latches, etc. Fortunately, there was a very simple solution. I noticed that if the top shutter landed outward in the shutter catchers the front shutter would unlatch properly. I fabricated a couple of pieces of 1/8 inch aluminum with a slight angle bend and mounted them as shown at the right. Now when the top shutter reaches the full open position, the rear edge is forced outward and the front shutter unlatches and slides into place between the rear and top shutters.

The automated shutter now allows unattended imaging. I use the ASCOM dome control panel, or the dome control routines incorporated into MaximDL to open and close the shutter, and to park the dome. The dome is routinely slaved to the mount.

I would like to thank Chris Erickson (Summit Kinetics) for his assistance and advice in automating the shutter and dome rotation controllers. Gary Liming fabricated the custom pulleys for the front shutter and assisted with the construction of the shutter interface box.