Automating dome rotation for a ProDome

Gregg Ruppel
www.greggsastronomy.com

Technical Innovations ProDome (10)

I purchased my ProDome 10 back in 1998 and installed it on a pad in my backyard. For the past 13 years I have been content to operate the dome manually. However, because the telescope, camera, mount, and focuser are all automated I was able to take long imaging sequences, limited only by the need to move the dome slot every hour or so. I decided to automate the rotation of the dome to allow long unattended imaging sequences. I opted to automate rotation first, and later decided to automate the shutter. I can easily prepare for imaging in just a few minutes.

My set up

In my ProDome 10 I have an ASA 10" f/3.7 Newtonian astrograph that is mounted on an AP900 GTO. An SBIG STL11000 CCD camera with internal filter wheel is the main imaging device. I also use an external guide head with a 50mm MiniBorg guide scope. By luck more than planning, the scope with a dew shield can point to any position in the sky even with the dome closed. I have a PC in the observatory which controls all functions via ASCOM drivers. The PC is hard wired to my home network and I am able to control everything remotely from inside the house about 150 feet from the observatory. I also use RealVNC to control operations wirelessly using an iPad.

TI Rotation Motors

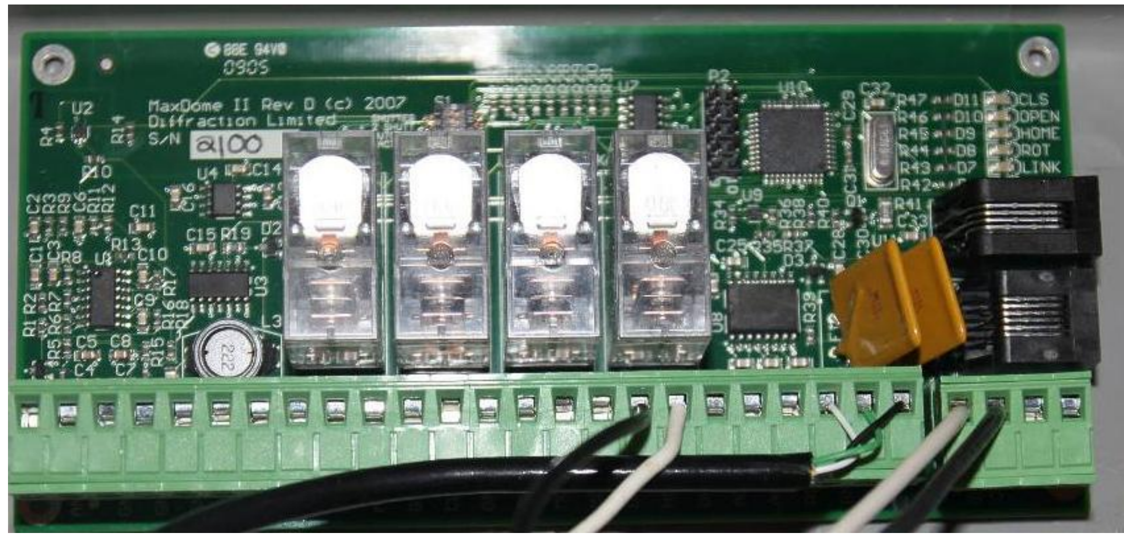
Technical Innovations supplies two matching motors which are mounted on opposite sides of the dome. Each unit mounts to the dome wall below the Dome Support Ring (DSR). A plate carrying the motor/gear assembly attaches to a rotating arm that is spring loaded to keep the driving wheels in contact with the base of the dome. The wheels contact the dome through an opening in the DSR. The motors are heavy duty wind-shield wiper motors with gearing that drives a toothed belt around the two drive wheels. The spring allows the tension to be adjusted so that the wheel and belt assembly can drive the dome without slipping. Because the TI motor frames are tied to one side of the motor coil, care should be taken to keep the TI motors from being grounded to, or even touching , any electrical system in the observatory .

Power supply

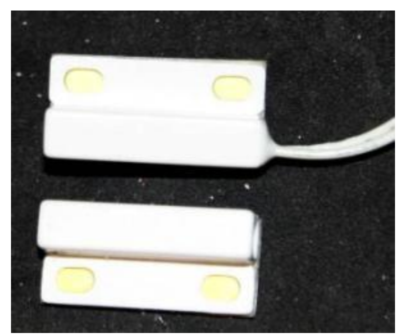
TI also sells a power supply for the dual motor setup for the 10’ dome. This supply provides a 16 VDC output rated at 12 Amps. It includes a key lock switch along with toggle switches for manual control of rotation and the shutter. I installed the power supply and wired the motors according to the instructions provided by TI to make sure that the mechanical aspects of rotating the dome operated properly before undertaking automation. The power supply activated the dome quickly with minimal slippage. Unfortunately the PS was an unregulated and unfiltered supply which would cause some serious limitations when I attempted to interface it with a dome automation system. I have since replaced it with a 12V deep-cycle marine battery.

MaxDome II card

I purchased a MaxDome II interface card from Cyanogen. I chose this interface because of it's simplicity, ASCOM compatibility, and support from the same company that sells MaximDL which I use for control of the rest of my system. The MaxDome card accepts a 12VDC input and controls output to the drive motors via a series of 12V relays. The card receives information about dome movement and location from external sensors, and communicates with a PC by means of an RS-232 telephone style cable. The "home" sensor is a simple magnetic switch as might be used in a home security system. Dome rotation is recorded by an optical sensor that relies on seeing alternating black and white signals. The dome rotation sensor has to be adapted to each individual dome installation.



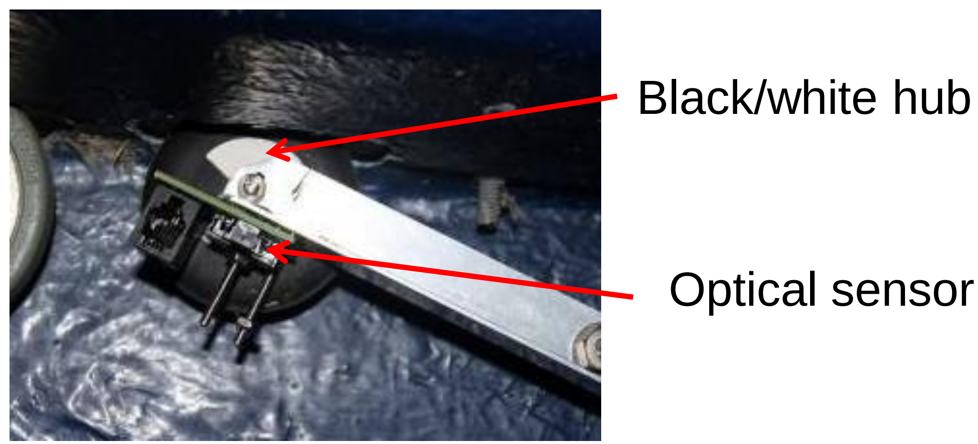
MaxDome card



Magnetic home sensor

Rotation sensor

I had to design my own rotation sensor. I settled on using a rotating wheel that would allow the optical sensor provided with the MaxDome card to detect alternating black and white colors. I used a 1.75" model aircraft wheel with a rubber tire and a white hub. The white hub was painted half black (see lower image). The wheel was then mounted on a piece of aluminum angle that allowed the optical sensor to be place at a right angle to the rotating wheel and detect two 'tics' each rotation (i.e. black-white). The entire assembly was mounted as a spring loaded arm to ride against the base of the dome through a slot in the DSR. This allows the wheel to remain in contact as the dome shifts during rotation. A 4-wire telephone style cable connects the optical sensor to the MaxDome card (not shown in the photo).



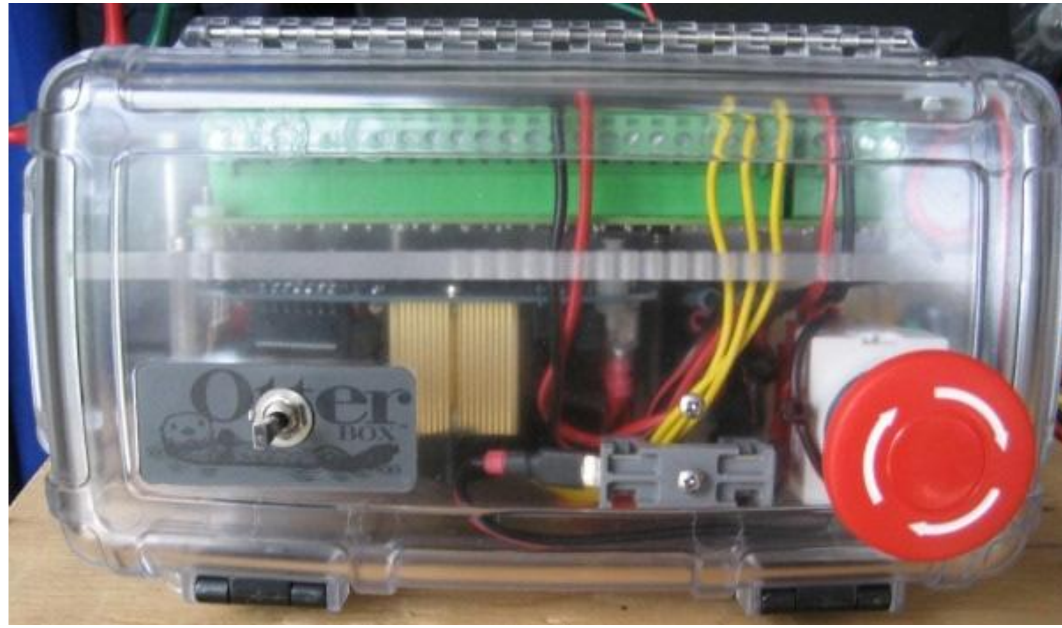
Problems

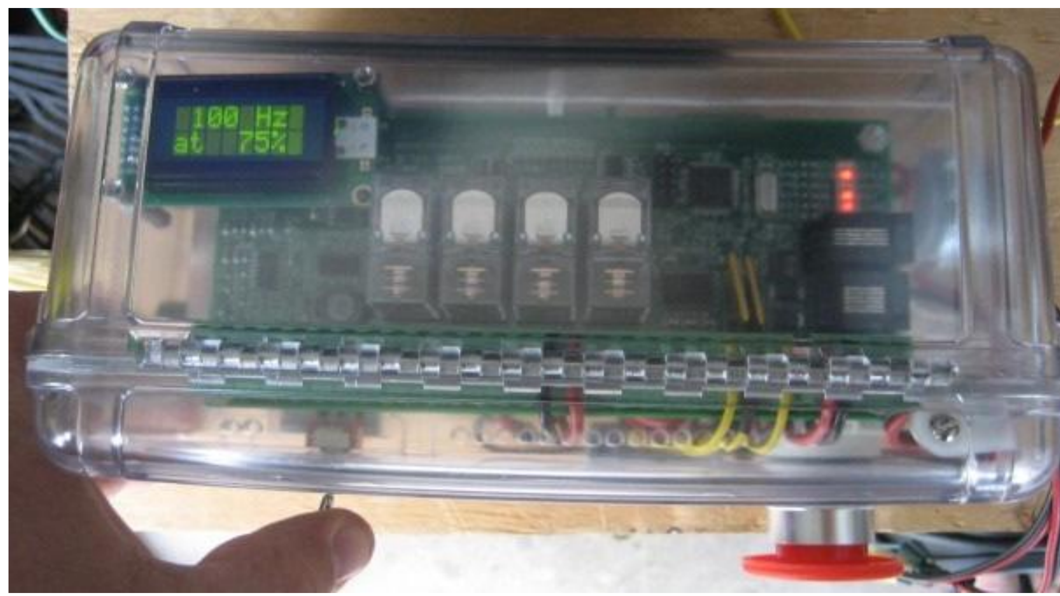
Although the MaxDome card should have handled the 16VDC output from the TI power supply, I quickly discovered that it would not. Cyanogen advised me that because the power supply was unregulated/unfiltered that it would not function with their card. Upon their advice I tried filtering by adding 1000uF 35V electrolytic capacitor to the output but that was not sufficient to allow the MaxDome card operate as designed. I also tried using a Pyramid Power Supply (12V 14A); the MaxDome card worked with this supply but it was not adequate to 'start' the two motors resulting in an overload condition. The TI motors should never be connected directly to MaxDome-II cards, due to a DC voltage ground-shorting hazard created by the nature of TI's automotive motors combined with the MaxDome-II's positive-logic relay outputs. I was fortunate not to have fried my MaxDome card as I attempted to do just this.

At this point I posted a request for help on the Yahoo Observatory list. Almost immediately I received a response from Chris Erickson of Summit Kinetics. Chris designs observatory control systems for applications in harsh environments, and he offered several suggestions regarding how to best solve my automation dilemma. His key recommendation was to employ separate power supplies for the card and the motors, and to have the relays on the MaxDome card drive separate relays to direct power to the motors. While two separate power supplies has reliability and functionality advantages, it is not mandatory to getting the two working together. However, after some discussion about how to best accomplish this, I opted to engage Chris to design a self contained box that would house the MaxDome card and a set of relays for the motors, along with the necessary connectors and safety electronics. Chris also suggested the addition of an electronic speed control so that the voltage applied to the motors could be tweaked. The speed controller he recommended included a ramping function so that power was applied over an interval of 1 to 1.5 seconds. This should extend the life of the motors and provide smoother starts. Chris decided to mount all of these components in an extremely weather proof case, similar what might be used for underwater applications. In about a month, I received the finished interface, along with illustrated instructions as to how to connect all of the required components. A detailed schematic was included so that I can replace components in the future should that be necessary.

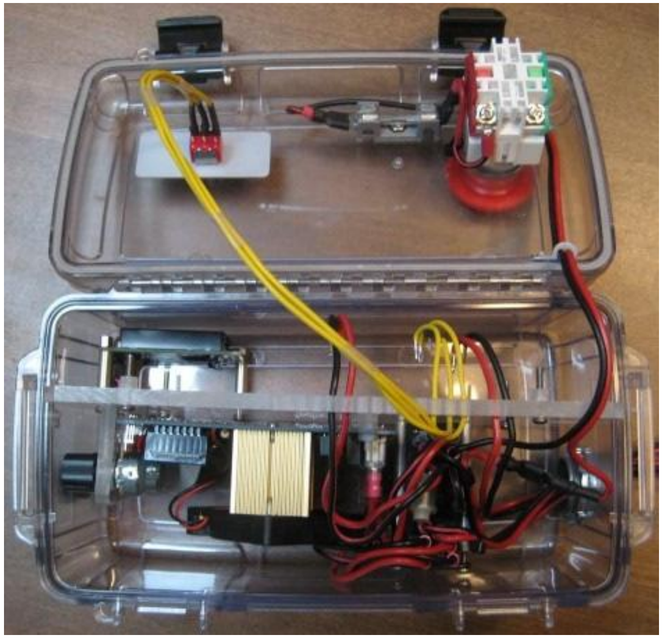
MaxDome Interface Box

The image at the right shows the completed interface box. A Plexiglas shelf provides a mounting platform for the MaxDome card (above) and the other components below. On the left side is a toggle switch that allows manual control of dome rotation. On the right is a large red 'Kill' switch that can be pressed to stop dome rotation immediately. Rotating the kill switch resets it. Because the MaxDome card has a separate power supply, it can remain in communication with the PC even when power to the motors is interrupted. The electronic speed control card is mounted below the shelf and has its own LCD display to show the adjustment of output as well as the ramping function during activation. The lower image shows a top view with the MaxDome LEDs illuminated at the right and the speed controller display at the left.

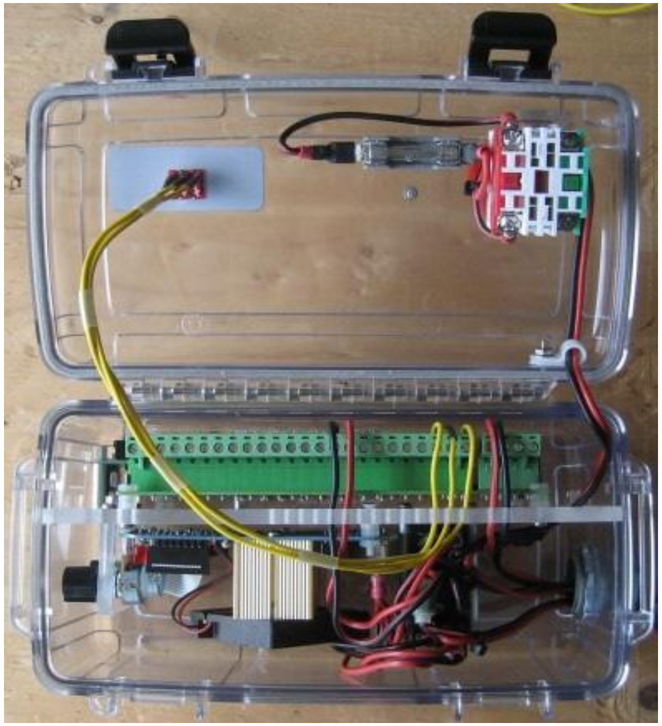




MaxDome Interface Box



The image to the right shows the interface box opened before the MaxDome card is installed. The two relays to control the motors are mounted on the right with heavy duty spade lug connectors.   The speed controller is mounted on the left with its heat sink and fan. The black control knob on the right is accessible from outside the box to adjust the output voltage. The speed controller LCD mounts over the MaxDome card. The manual toggle and kill switch along with a fuse are all mounted on the lid of the box.

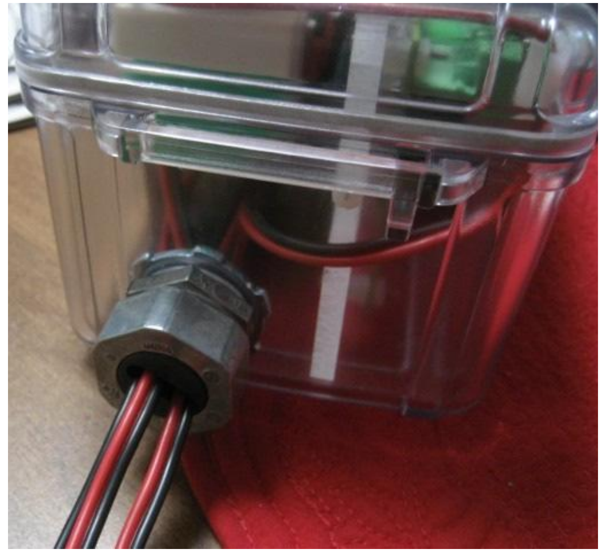


The lower image shows the box with the MaxDome card in place. Holes in the shelf provide strain relief for connections coming from the power supplies as well as the rotation and home position sensors.

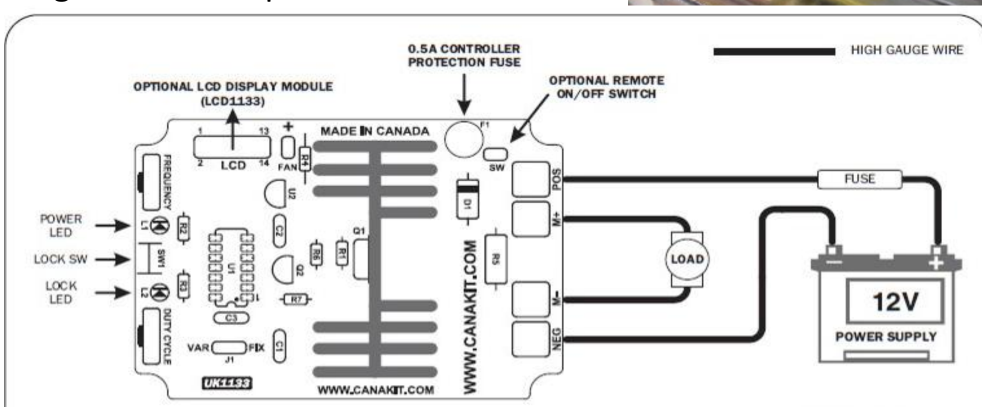
MaxDome Interface Box

Wire connections to the interface pass through a ¾ inch port on the right side (top image). A compressible rubber grommet provides an almost air-tight seal around the cables.

The lower images show the left side of the box. A black plug can be easily removed to gain access to the adjustment control for the soft start speed controller. The image on the right shows the plug removed. A separate control allows the frequency of the PWM controller to be adjusted as well but this is not used in the current application. The wiring diagram for the speed control is below.



The most significant benefit of the module is the soft start, not the PWM speed control. Soft starts prevent most startup slippage and can really extend the lives of the motorized control systems and their associated hardware when motors have to drive relatively heavy masses with lots of inertia. Soft starts can be purchased for both AC as well as DC motors and for just about any size motor. Of course the bigger the motor, the bigger and more expensive the soft start module becomes.



Wiring Diagram

Final Assembly

The image to the right shows the interface box installed in the dome. The black/white wires with orange connectors lead to the home sensor, while the black phone cable connects to the rotation sensor. The 14 gauge black/red wiring is from the power supply and to the rotation motors. I used a typical outdoor junction box to hold a barrier strip to connect the motors (lower left image). Power for the MaxDomeII card is provided by a 'wall-wart' type supply (not shown). A deep-cycle marine battery provides very clean power for the dome rotation motors. It is continually charged by a battery tender trickle charger.

Final Assembly

The image below shows the various components in my dome: one of the rotation motors, the TI power supply, the custom interface box for the MaxDome card and the junction box for the heavy gauge wires. Not shown are a separate 12V power supply for the MaxDome card itself and the observatory PC to which the card connects. I have not yet fixed the cabling in a final configuration because I wanted to make sure all components functioned correctly.

After installing the ASCOM dome drivers and setting the slaving parameters for my scope and mount, I have been able to slave the dome to the telescope successfully. The soft start speed control function ramps the voltage to the motors from 0 up to 16 V in about 1.5 seconds, providing a smooth start to rotation with very little slippage due to the inertia of the dome. If there is any slipping the soft start seems to handle it easily .

Successful Dome Slaving

Here's an image of Comet c2009 P1 Garradd made over an interval of an hour and a half during which time the dome was slaved to the telescope and dutifully moved to keep the dome slot centered on the target. Correct entry of the slaving parameters (dome radius, offset of the mount and optical axis, etc.) is necessary to keep the dome slot positioned properly.

Links for various components

Here are some links for products mentioned above. Chris Erickson can be reached through his web page below. Chris was a great resource for me; he gave me the option of purchasing just the schematics, or of having him produce a finished solution. I chose the latter which was considerably more expensive, but well worth the investment (less than the cost of the TI equipment or the MaxDome II card).

Technical Innovations (HomeDome, ProDome, dome automation accessories)

http://www.homedome.com/products.htm

Cyanogen (MaxDome II, MaximDL, other imaging products)

http://www.cyanogen.com/dome_main.php

Summit Kinetics (Christopher Erickson, observatory engineering solutions for harsh environments)

http://www.summitkinetics.com/

SparkFun Electronics (Cana Kit PWM 50A speed controller)

http://www.sparkfun.com/products/9668