Another autonomous cover design for solar trackers

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Introduction

This cover is designed to match the NIWA360 solar trackers, but the basic concepts could be adapted for other tracker designs.

Our solar trackers are completely autonomous and rotate continuously in azimuth. They are generally left to run 24/7/365. A matching cover also needs to be autonomous, rotate continuously in azimuth and protect the tracker inside from adverse weather conditions. The cover can be mechanically isolated from the tracker – decoupling any wind vibrations from the tracker inside.

Features

- Weatherproof
- Low maintenance
- Solar powered with battery – no moving cables or contacts
- Rain sensing – closes when wet
- Wind sensing – shut if excessively windy
- Continuous rotation in either direction, matching tracker inside
- Low Profile

Figure 1. Cover in use at Lauder

Turntable drive mechanics

The key component for the cover is the large ball bearing race upon which the whole cover turntable rotates. The 800mm diameter "Lazy Susan" aluminium bearing is rated at 380kg. It is also surprisingly affordable (~$US300 from vxb.com).

The bearing outer is stationary (and fixed to the roof), while the inner is attached to the tracker cover. A toothed rubber belt attaches to the fixed outer, and pulls the inner around using a robust, low-geared, DC motor. The motor has a custom toothed-sprocket but the bearing is driven purely on friction. The motor is mounted so that belt tension can be easily adjusted to achieve the required amount of drive friction.

Two identical plastic rings sandwich the bearing, forming the chassis. One ring connects to the inner bearing, allowing plenty of real-estate to mount motor, electronics, battery, and the cover itself. The second ring attaches to the outer bearing and mounts to the roof. The rings are made from Uniboard – a recycled plastic marine plywood replacement material that is light and strong.

Figure 2. Bearing, drive motor and belt

Tracking the tracker inside

Two optical switches sense a metal flag attached to the tracker inside. Initially the cover will rotate at high(er) speed until the first switch is triggered, then slow, and finally stop when both switches activate. This prevents over-shooting. As the tracker inside creeps around in azimuth, eventually one switch will open, triggering a brief, slow pulse of drive to move the cover once more. The switches and flags are arranged so the cover moves a short distance every 5 minutes or so, and so the hatch never obscures the tracker mirrors inside.

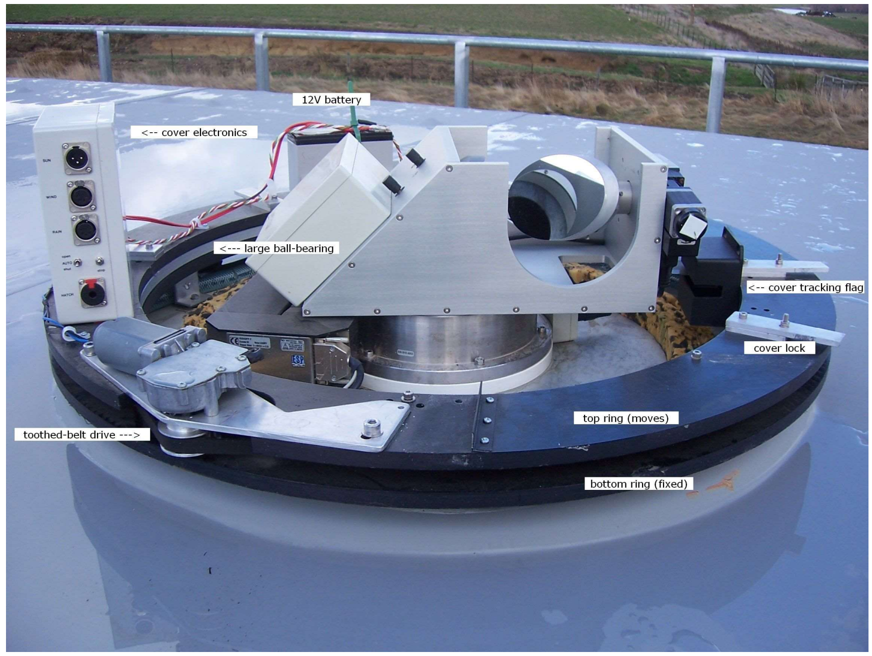

Figure 3. View with cover removed, showing the NIWA360 solar tracker inside

Remote and manual control

Remote control (via serial Bluetooth dongle) is optional. This is useful for initial testing, development, and to set parameters such as rain, wind and light thresholds. The dongle was later removed to save power and use elsewhere. A standard serial cable could also be used for initial setup.

Manual intervention is easy: The hatch can be forced open or shut via a 3-position switch inside the cover, accessed via a hinged panel. A manual stop switch is also present.

In practice we do force the hatch to shut occasionally, for example if we know we aren't measuring for a long period. This saves getting mirrors or the lab unnecessarily dusty. We simply pause our tracking application and the hatch shuts automatically after several minutes of inactivity.

Protection features

- A Davis wet-leaf sensor ensures that the hatch remains shut when it's raining. A Davis anemometer keeps the hatch shut in extreme winds.
- The battery voltage is monitored. A low-power mode is enabled if long periods of cloudiness prevent adequate charging. Low-power mode sleeps the electronics, briefly waking each 60 seconds to act if required. If battery voltage reaches critical the hatch is shut and tracking ceases until adequate charge is achieved.
- At night, detected by zero solar panel output, the hatch is automatically shut.
- If the tracker inside stops moving for a period (e.g. power cut) then the hatch also shuts.

Reliability and maintenance

With no cables or mechanical limit switches there is very little to fail. The belt and DC drive motor have required no maintenance. The motor may have carbon brushes, but it's duty-cycle is extremely low, and I expect it to last a long time.

The hatch actuator has potential to fail. It uses a brushed motor and has limit-sensing microswitches inside. However the duty cycle is also low. I had one example break an o-ring due to lack of lubrication, but overall these cheap units have proven reliable.

Two mechanical relays are used in the control PCB. However the motor relay almost never activates as it simply sets motor polarity. Under normal use the relay remains in the normally closed (NC) position, and the 2 levels of motor power are switched via a solid-state device. The hatch relay activates a low duty cycle (normally once per day). It also defaults to NC to shut the hatch should electronics voltage drop too low to control the whole cover. The battery is replaced every 2-3 years.

The cover shell and opening hatch

The cover shell and solar hatch are made from 2mm aluminium sheet. This is welded, smoothed and painted. The top is angled to shed water. The 5W solar panel and Davis wet leaf sensor are mounted on a hinged panel, which also provides access to the control switches and other hardware inside.

The hinged solar-viewing hatch is opened using a standard linear actuator from Hiwin, type LAS series. The actuator is rated IP54 and is further protected by a simple weather shield. The size and angle of the hatch opening is dictated by the maximum solar elevation reached at the installation latitude.

Electronics

A PIC microcontroller is programmed in C to perform all the monitoring and control functions. The PIC and associated discrete components are mounted on a custom PCB. A small solar regulator charges the 7 amp-hour, sealed lead-acid battery.

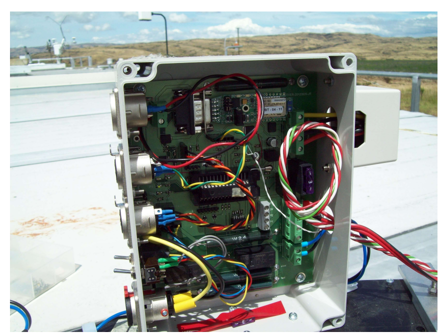

Figure 4. Inside the electronics box

Improvements?

- To avoid going into low-power mode (which is infrequent anyway), a higher capacity solar panel and battery could be used.
- The wet leaf sensor is subject to drips of condensation from actuator shield above, so it could be moved elsewhere.
- The control code could be improved a bit, especially by adding some more intelligence to the windspeed and low-power algorithms.
- A "Moon" or night over-ride switch would make lunar observations easier.