Okanagan Observatory
Radio Astronomy

RAdius

April 2017

2016: "the best-laid plans of mice . . . " (apologies to Robbie Burns) and amateur radio astronomers

2016 Goals

1) fully operational 2-dish tracking interferometer: redesigned mount, cabling to Antenna 2, operational computers
2) lay the groundwork for a third antenna that is mobile, to allow eventual use for aperture synthesis observing
3) appropriate tools for controlling use of the facility, and of the generated data flows

Supreme optimism, anyone? SCORE: 0 / 3

It turns out that there is a LOT more to installing a working radio astronomy antenna than building a mount. Controlling it, telling it where to point, and how to track that point in the sky, is not a trivial exercise. Fortunately, Claude Lapointe continues to work on the control software, and has a first version capable of doing the tracking.

BUT! (there's always a huge BUT, isn't there?)
The biggest issue is not telling the motors to turn the dish; it is: HOW DO YOU KNOW WHERE IN THE SKY THE DISH IS POINTING?

It turns out the problem of knowing where an antenna is pointing is indeed HUGE - there are so many small variations, that can add up to an unacceptable error. And not only that, but the mechanical issues that arise can seem overwhelming.

This is what happened: suddenly, there was no way to be sure where the dish was pointing.
I had to find another way.

As if that was not enough, my hope to run the cables to the second tower in 2016 crashed up against the reality of MANY cables, of different types, some longer than 300 feet.

The rest of this newsletter tells the story of pointing (dishes) and pulling (cables).

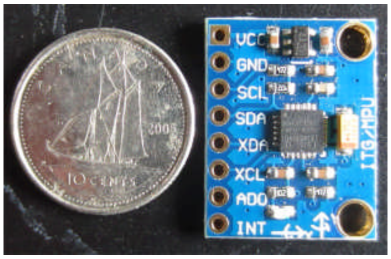
Where is that dish REALLY pointing?

My first mount was constructed with the expectation that its two shafts would have measuring devices on them, to determine the Declination and Right Ascension. The device is a shaft encoder, that translates rotation position into a value from 0 to 4095. This is precise enough to give a useful value corresponding to 0.1degree.

The mechanical construction to fasten the shaft encoders was complex, fragile, and partly open to the weather. These attributes worried me, so the search was on for another way.

One technology that has become ubiquitous in today's world is that of determining the orientation of a small computer chip. These are in everything, from smart-phones to Wii game controllers.

The fact they are produced in the millions means they are cheap, about $2.00 on a board with communication electronics. This was a good start! Let's get some accelerometer boards! (note size with dime!)



The first tests of the boards showed huge (2% or more) swings in values, even when they were held dead still.

Fortunately, part of my misspent early-adulthood gave me a working knowledge of statistics, design of experiments, and product quality testing. AVERAGING! My saving grace!

Sure enough, if the monitoring computer program averaged thousands of readings, the results hardly varied. But still, if I left the testing for a little while, when I got back to it an hour later the values had shifted. Eventually, the LED came on: the differences happened when the temperature of the board changed.

Okay, these cheap boards have a problem - the values change rapidly with different temperatures, by up to 5% from -30C to +60C, the expected range when installed at the Okanagan Observatory.

Not exactly the +/-0.03% I am looking for.

Some serious testing in the Pett Family Thermal Laboratory (Irene calls it “the freezer”), proved that yes indeed, the values from the accelerometer board changed a lot. Testing in the freezer, then watching the values change as the board warmed up outside later, meant something more was needed.

Fortunately, the changes were reasonably consistent, given the temperature on the board. Which explained why the chip manufacturer had included a temperature-measuring function RIGHT ON THE CHIP!

Now the task was to figure out how to keep the temperature constant. Or how to predict the changes from a known temperature over a range of temperatures.

Suffice it to say, that issue is under intense examination as I write this. These two approaches, control or calibration, both show some promise.

But given the fact of manufacturing variability of the chips, each one would require careful testing to build up a calibration curve. I'm basically lazy, so all that grunt work did NOT appeal to me!

On to the other approach: controlling the temperature.

In the first year of this project, the idea that thermal control might be needed arose. At the time, the simplest way to do it was to heat everything up to some temperature that would not be exceeded in operation, and hold it there. There are also devices that will cool, using electric power and no moving parts: Peltier devices.

Experiments with Peltier devices showed that they use a lot of power, for not that much cooling. They can also heat, since they are flat plates with one side hot, one cold. Controlling them is complex, and bulky.

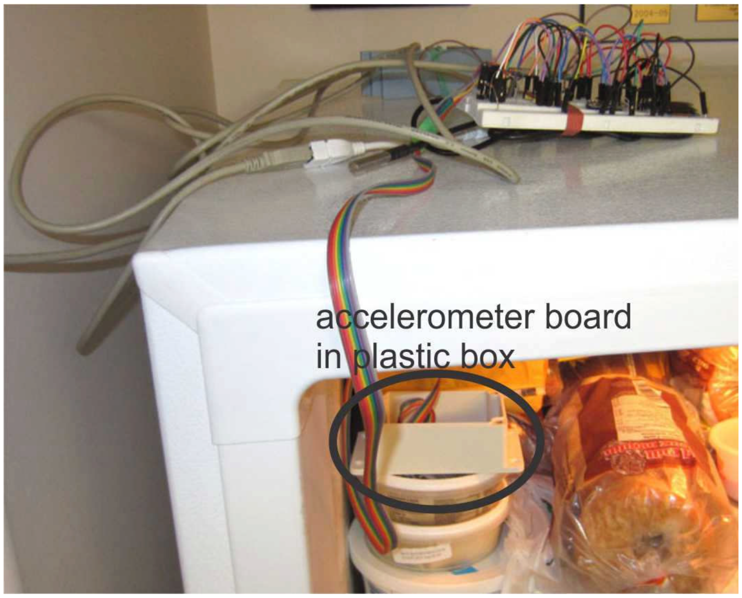
I plan to use them for cooling the sensitive receiver in the focus of the dish, the “focus box”.

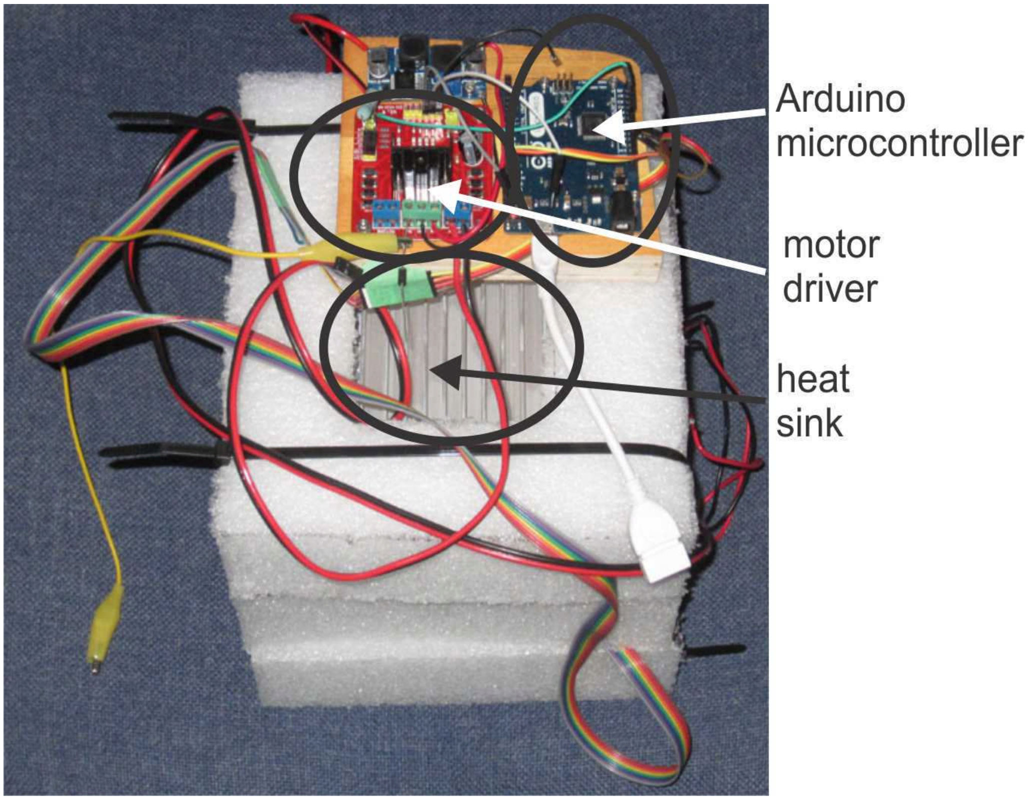
Controlling Temperatures

In photos, here is the testing arrangement to control temperatures.

This was the first round of thermal testing, just cooling off the accelerometer board in the family freezer, with a USB connection back to the computer.

This confirmed the large value changes when the temperature shifted from +22C to -18C. Oddly, one axis in particular, the Z axis pointing up from the board, changed more than the other 2 along the board.





The next step was to encase the accelerometer board inside the thermal chamber, made of blocks of polyethylene closed-cell foam (sealed bubbles, so no air infiltration).

At this point I was starting to try using Peltier devices, to see if they would cool the apparatus. The first discovery was that Peltiers absolutely REQUIRE heat sinks to operate. In theory, one side of a Peltier is cold, the other hot. In practice, the heat must be removed rapidly from the device, or it leaks back to the cold side. Of course, that means there is almost no temperature difference from one side to the other, making the device useless.

In the photo, the white foam chamber has an opening at the top, for the heat sink to radiate freely. The Arduino microcontroller (in this case, a Leonardo model), reads the accelerometer board about 1000 times a second, computing an average on each of the 3 axes. The microcontroller also reads the chip temperature, then every second sends the results to my PC which is acting as a terminal on the Arduino.

Because the Peltier devices use high currents, several Amperes, a special circuit board is required. This "motor driver" can send up to 2 Amps through the Peltier, and can also send lesser amounts as determined by the Arduino.

One Final Issue: where you think the dish is pointing, may not be correct.

No matter how carefully I calculate the “correct” shape etc. of the dish, there are always small deviations from the model, that can render results meaningless.

Ken Tapping told me about a team at DRAO that built a new design of radio astronomy antenna, and calculated how to point it. The team set it up with a receiver, pointed it at a well-studied radio source, and looked for a signal. NOTHING! They checked out their equipment, tried other sources - to no avail.

They asked Ken for suggestions.

Ken told them: calculations of where you are pointing only give you a rough starting point - you have to scan around where you think you are looking, sometimes quite widely.

(aside: those of you that have seen the movie “The Dish”, about the large radio telescope in Australia that brought the world the first video from the surface of the moon in 1969, may recall that at one point they had the dish operator search around for a signal. “The Dish” is my most-often-watched movie of all time, over 50 times and still going.)

Sure enough, by scanning around, the team found their radio sources, and were able to compute correction offsets.

This process of using real radio sources to verify pointing MUST be done for ALL radio telescopes, everywhere, no matter how much money has been spent designing and building them.

In fact, optical telescopes have similar issues, and pointing must be verified by searching out known targets.

Truth is in the sky.

Simply installing some cables becomes a major exercise in logistics

Summer 2016 was to have seen a major installation effort, to connect the second tower to the receiver in the Support Building. It is not as simple as running a coax cable from the dish to the receiver, as one might do with a small satellite-TV dish.

The antenna is an assembly of electronic and mechanical parts, which have specific and detailed requirements to control and monitor them. This requires cables with multiple wires, not carrying much current or voltage. For reasons of cost and simplicity, these will be the same type of cable that connects your computer to a router (some of you must remember doing it that way, right, before WiFi became ubiquitous?!)

As well, a fair bit of power is required to operate the electronics, the motors that move the dish, the Peltier devices. I had a long mental argument with myself at the beginning, about using ordinary house current (110VAC) to each mount, and then plugging in various wall-wart power supplies.

Finally, I decided that all primary power outside the Support Building would be based on what an ordinary car battery delivers: about 13VDC. This meant some heavy cables would be needed to carry lots of Watts long distances.

the original cables inside the Support Building

After discussions with Ken and Marcus, I decided to change the cabling method used for the second antenna. This connection to Antenna 1 is one heavy coaxial cable from the box in the tower, directly to the receiver in the Support Building, a distance of 140 feet. This is a long way for microwave-frequency signals to travel - awkward things happen to degrade them once cable runs get any much longer than that.

The cable distance from Antenna 2 to the receiver is 350 feet, much too far to use a single cable.

Fortunately, Marcus has been using inexpensive cables and cheap amplifiers to connect his antennas to receivers. These components are inexpensive because the commercial TV cable and satellite businesses use large quantities of them to bring TV into homes.

The cables weaken the signals a fair bit, hence the requirement to use amplifiers every 100 to 150 feet. This means there are several lengths of cable for one signal to travel from the dish to the receiver.

In all, there are 31 cables carrying signals. Plus 2 power cables.

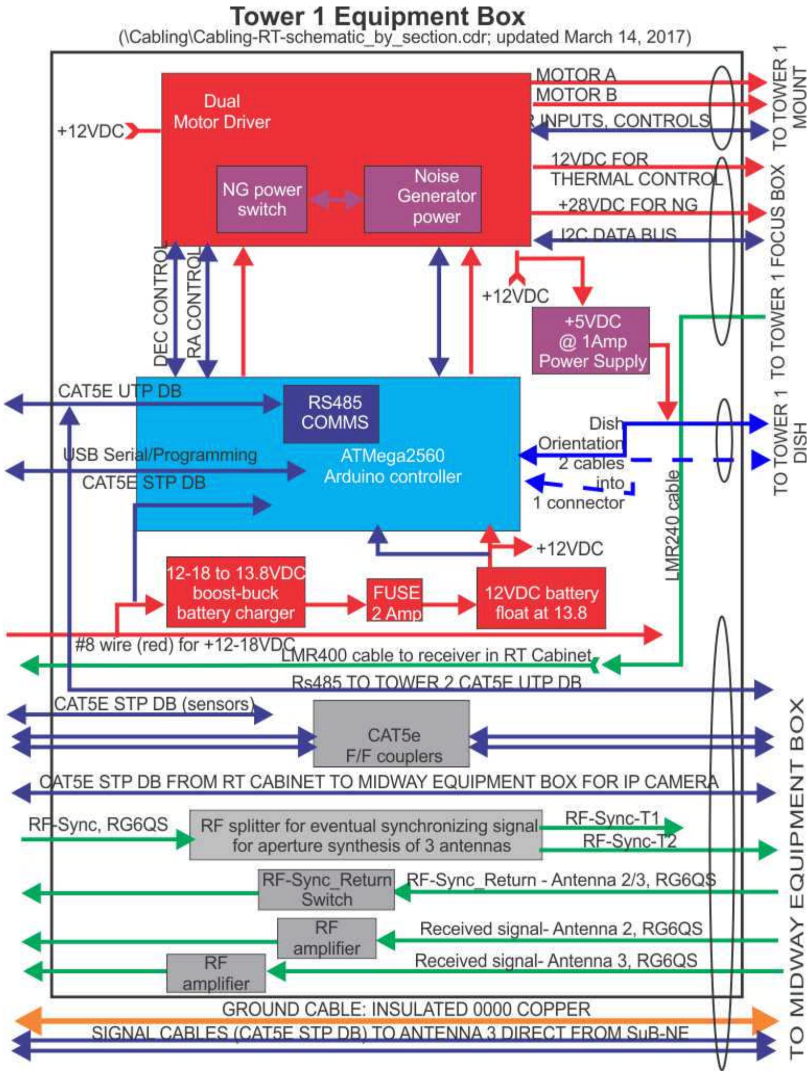
Where do the cables travel?

For the first round of cables, they went into the bottom of the 80-foot trench dug from the Support Building to the first tower. These are special cables, intended to be buried, so they should stand up well to the water and weight of material over them.

The thought of getting Serwa's large back-hoe in to dig another 270 feet did not appeal at all. The cost would be in the order of $4,000 or more, including a conduit the full length against future cabling needs.

The idea of an above-ground conduit came along, and it seemed appropriate: lower cost (less than $2,000), easier use later on (if more cables need to be run), readily accommodates the need for amplifiers for the signals from Antenna 2 (and a possible Antenna 3), can be installed with only member labour. “Work Party Time!”

Over 200 hours of designing later, I have detailed plans and layouts for the cables. Just to show an example of the complexity, here is a drawing of the cables that will go into and out of the box inside Tower 1:



You do NOT have to study this drawing, just be very impressed with my dogged determination to “DO IT RIGHT”, to “design many times, build once”. In all, the design went through more than 20 rounds, each one taking more than ten hours at the computer.

By this point it was October, and no work party would be heading to the Observatory to install cables until 2017.

At some point perhaps as early as May, I hope to organize a work session to string the numerous cables, in the right order, with the right conduit sections and couplings, on well-pounded-in support rods.

WORK PARTY NOTICE!!

If you enjoy fun physical work, getting out in the fresh air (with proper Solar protection of course!), accomplishing a worthwhile task with others -

PLEASE EMAIL ME, so that I can start a list of people to contact as the time draws near.

ONCE CABLES ARE INSTALLED

After that comes weeks of individual (mostly by me) work connecting those cables to each other, to amplifiers, to antennas, etc.

Also this year, there will be work to install the first mount on Tower 1. It sits forlornly in my garage, awaiting its grand debut!

Later on this Summer, I hope there will be work to install the mount for Tower 2, the “Mount of a Different Colour” (ie, design.)

It seems the tasks just keep rollin' along!

THIS ISSUE OF RAdius: published April 12, by Hugh Pett, hughirenep@gmail.com

If you are seeing RAdius for the first time, and would like to receive future issues, please email me and let me know where to send them.