Roving with Large (1m) Dishes

Stephen Hicks, N5AC and Jim Reese, WD5IYT

About two years ago several of us were discussing antenna systems for portable 10GHz operation. Currently in use were converted 18" DSS dishes, small horns and a few smaller prime-focus dishes. Al Ward, W5LUA, made the suggestion that someone should try a larger dish at some point, specifically a one meter dish and an offset-fed one at that. Not realizing how unwieldy one of these really is, one of us (N5AC) got excited about the possibility of record-setting QSOs on 10 and even 24GHz with such a dish. Hunting on the Internet yielded Winegard's website. Winegard makes a number of antennas, preamps and such primarily for the recreational vehicle and home satellite markets (they are also makers of the infamous Winegard UHF beacon also, but that's another story).

After some searching, a local satellite TV warehouse was located that would order 10 of these for our group at $85 each. Not exactly surplus pricing, but they would be new-in-box and have all the hardware. I ordered ten of these, passed them out to the group and for the most part, we set them in our garages (and Craig, KA5BOU's barn) to age before being committed to a project.

Craig, KA5BOU, has a workshop full of mills, saws, welders, etc. and he had an idea for a mount that would go in a standard 2" receiver hitch on the back of a vehicle, but would swing out to the side of the vehicle for operation. After a prototype that didn't have enough travel, Craig constructed a mount that would hold the dish and would swing 180-degrees so that the dish was pointed the same direction as the vehicle.

Figure 1: KA5BOU's hitch receiver mount

To understand why this was so important to operation for us, I need to explain a little about our overall rover operation.

When we rove, we use custom software that Joe, K5FOG and one of us (N5AC) wrote that uses the grid square of the remote station and our position to show a pointer that indicates which direction we should turn to line up with the remote station. The antennas themselves do not turn so this is really necessary to get lined-up on the remote station. We have been using this successfully for several years and it works very well provided there's room to maneuver the truck. So by having a dish that would exactly line-up with the direction of the truck buys us some instant alignment without having to hunt all over the place for the remote station or use a compass.

Armed with the dish on the mount, we went out to try the dish a few contests ago. At this point, we had done no work on 10GHz to use this antenna and we were unsure of how well the station worked. We had only the Armstrong pointing method at the ready and due to our mounting arrangement, the feed was inverted (on top of the dish) which made pointing somewhat confusing. We were largely unsuccessful and most of the guys that saw what we had would scratch their heads and suggest that the dish was just too big to point. It would not be a stretch to say that we were ridiculed by some for our attempt. We must admit that we were also concerned that we might have bitten off more than we could chew...

One of us (WD5IYT) had significant experience pointing large commercial microwave dishes for a living some 15 years earlier. Jim believed it should be challenging to point, but that we should be able to do it. The numbers on the dish said that we had about a 2-degree 3dB beamwidth and while small, we still believed it would be possible to accurately point.

At an antenna gain measurement affair at WA5VJB's house the measured gain with a W1GHZ dual 10/24 feed at 38dB on 10GHz so we felt that our basic apparatus was sound.

IDEAS AND REFINEMENTS

Both of us began thinking of ways to combat our difficulty pointing the dish. You will no doubt remember the expression that when you have a hammer in your hand, every problem looks like a nail. As a microprocessor person at heart, Steve felt a good solution would be to build an apparatus to automatically steer the antenna based on data collected from positional sensors. Jim agreed this was a viable idea and agreed to undertake the mechanical design of an Az-El mount for the dish and the associated system to move it.

After several "back of the napkin" designs, Jim finally settled on linear 12VDC screw-drive actuators to move the dish. Finding a source of these turned out to be a challenge, but after a little Googling, Jim purchased two from E-Motion LLC[1]. The mechanical design is an Az-El mount based around a shaft mounted in bearings for Azimuth, and an actuator pushing the bottom of the dish up and down for elevation. The original Winegard fixed dish mount was modified to form a pivot point for the elevation axis.

Video of the dish mount being tested can be found on WD5IYT's YouTube Channel[2].

Figure 2: Completed mount ready for testing

Figure 3: Dish Mount During Final Assembly

In January, we tested the completed dish and mechanical drive system in front of Greg, WD0ACD's house using a signal generator. Running the actuators at full speed, the dish would pass by a signal that was only a few dB out of the noise in about one second. In other words, from AOS-LOS, we had to notice the signal and stop the dish in about a second. This sounds short, but it was fairly easy to reverse the direction of the dish and go back and reacquire the signal. We also noticed a number of side-lobes, as we expected, but there was a clear difference in signal quality of the main vs. side lobes.

Jim thought it would be harder to find a weaker signal, and that slowing the dish movement would make this easier. With the January VHF contest fast approaching, and no control system yet built, WD0ACD suggested a simple PWM drive using an H-Bridge. For those not familiar with the H-Bridge, it is essentially four electronic switches configured in an "H" shape. By turning on switches 1&4 the motor will move forward since the motor is forward biased (+12V). By closing switches 2&3, the polarity of the DC is reversed and -12V is applied to the actuator making it travel in the opposite direction. It is driven with a low current pulse train. H-Bridges are very common in robotics and there is a wealth of information about their use on the internet.

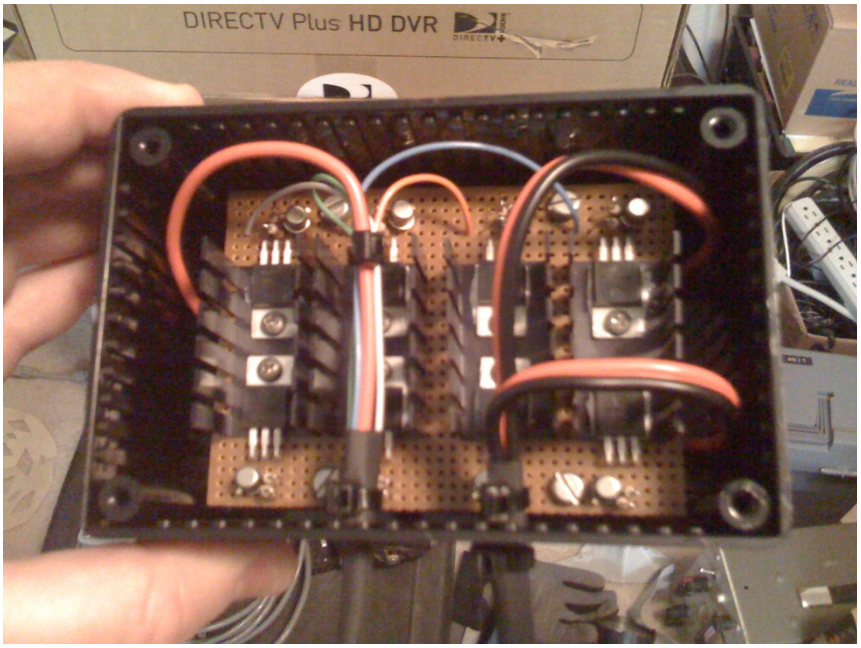


Figure 4: Completed dual H-Bridge motor driver

Jim breadboarded the first control system using Darlington transistors for the high-current portion and a simple NE555 pulse generator to drive it. It is a very simple design that allows for two speeds of dish motion. The slow speed is about one-half full speed, and the fast speed is about three-quarters full speed. Toggle switches control left-right and up-down motion by feeding the pulse train to the appropriate input of the H-Bridge.

FIELD TESTING

After the initial control system was built, testing commenced in the ARRL January 2009 VHF Sweepstakes. With Steve's 10GHz rig and a borrowed 24GHz rig from Al Ward, W5LUA, numerous contacts on 10GHz and a few on 24GHz were made. In all cases on 10GHz, when we packed the truck and swung out the dish, we heard the far end station sending dashes when they transmitted first. This is a huge improvement from even our luck with an 18" dish or horn on a tripod which always required some hunting. We attribute this to the ability to get the vehicle pointed with software and GPS and then knowing that the dish is aligned with the truck. Video from some of the contacts from the contest can also be found on WD5IYT's YouTube page.

On Sunday, February 1st, 2009, Steve scheduled a drive from Dallas to Austin to commute for his job. Both of us decided to make a day of the drive, meeting in Hico, TX near the intersection of grids EM01, EM02, EM12 and EM11 and attempt to work some 10/24GHz contacts with W5LUA and AA5C. Over the course of the we travelled through several grids (EM01, EM02, EM11, EM12, EM10). We found that we could set up, point the vehicle, swing the dish and immediately hear W5LUA's dashes on 10GHz. Peaking up required less than a couple of degrees movement and signals were >10dB out of the noise in virtually every spot on 10GHz (Al runs 100W and we had 8W and a 1.5dB NF preamp). We also discovered that the vertical and horizontal patterns of the dish are different. In the horizontal direction, a couple of degrees significantly altered the received signal level whereas the vertical direction required 2-3 times more movement for the same difference in signal. We are not sure of the reason for this difference.

On 24GHz our luck was much different. During the daylight hours from 8AM when we started to around 7PM, no signals were heard on 24GHz. We strongly believe the equipment was working because we observed power leaving the transmitter and W5LUA was able to receive a 24GHz beacon at typical strength on his equipment. We are learning that propagation on 24GHz can be much different than 10GHz due to a number of factors including upper atmospheric stability and water vapor losses. At around 9PM, however, a storm system passed between our vehicle and Dallas where W5LUA was. This system brought cool dry air behind it and the storm center was moving through Waco, Texas near the midpoint of the path.

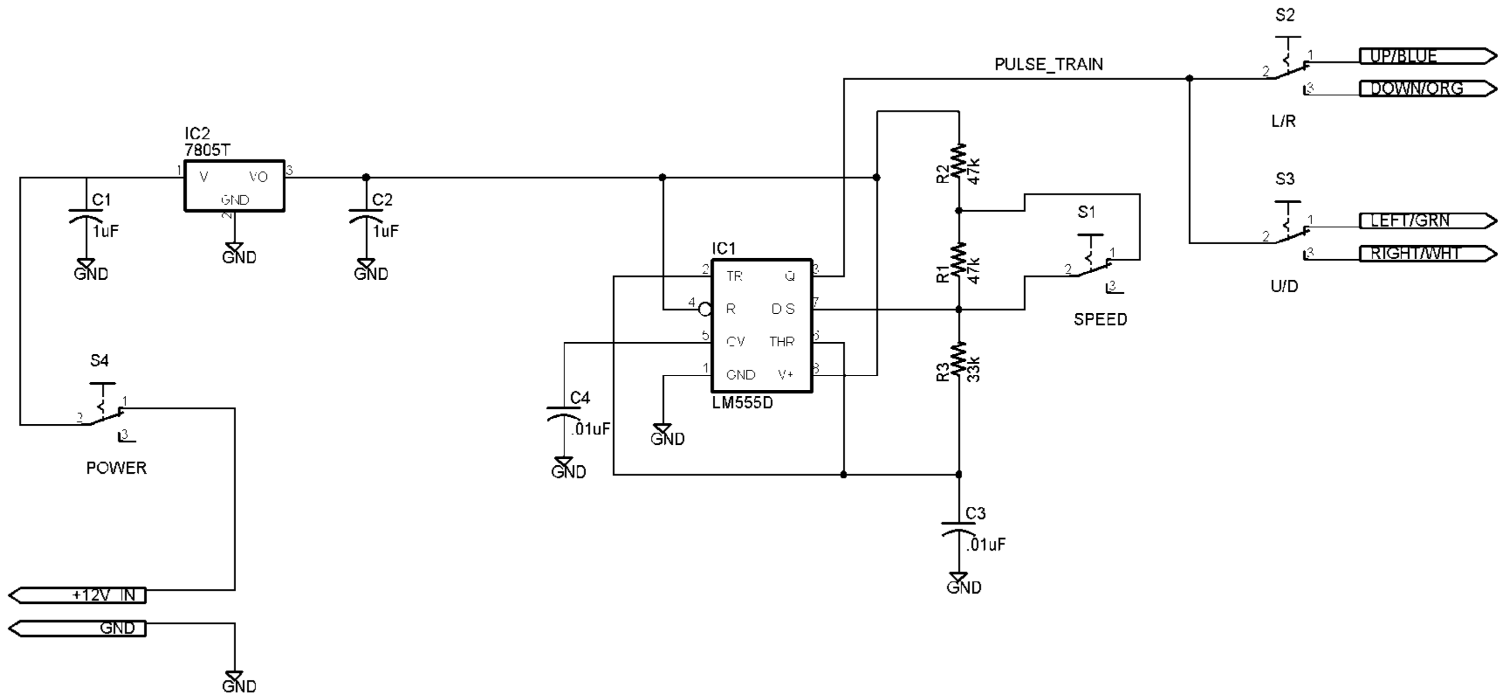
We were able to successfully work W5LUA on the 206mi path both direct and on rain scatter on 10GHz so we opted for a try on 24GHz. With our 0.75W, W5LUA was able to hear our rain scatter signal. We were unable to hear Al due to his lower power level (TWT out of service), but we feel that a rain scatter contact at this distance on 24GHz is very possible.

SUMMARY

Our expectation at the outset was that pointing a 1m dish would be difficult but might reward us with some DX if we were very adept at pointing the dish. What we found, at least on 10GHz, is that with the proper mechanical and electrical control pieces, signal levels are significantly large and pointing significantly easy to make DX contacts on 10GHz like shooting fish in the proverbial barrel. The drive system's ease of use and the large signal levels exceeded our expectations and we are now convinced that this was the "way to go" for working DX on 10GHz.

FUTURE DIGITAL CONTROLLER

A digital controller using an LCD display and sensors to control the system was on the drawing board when these initial tests and the mechanical construction were being done. This controller and its capabilities are discussed in another paper in these proceedings.



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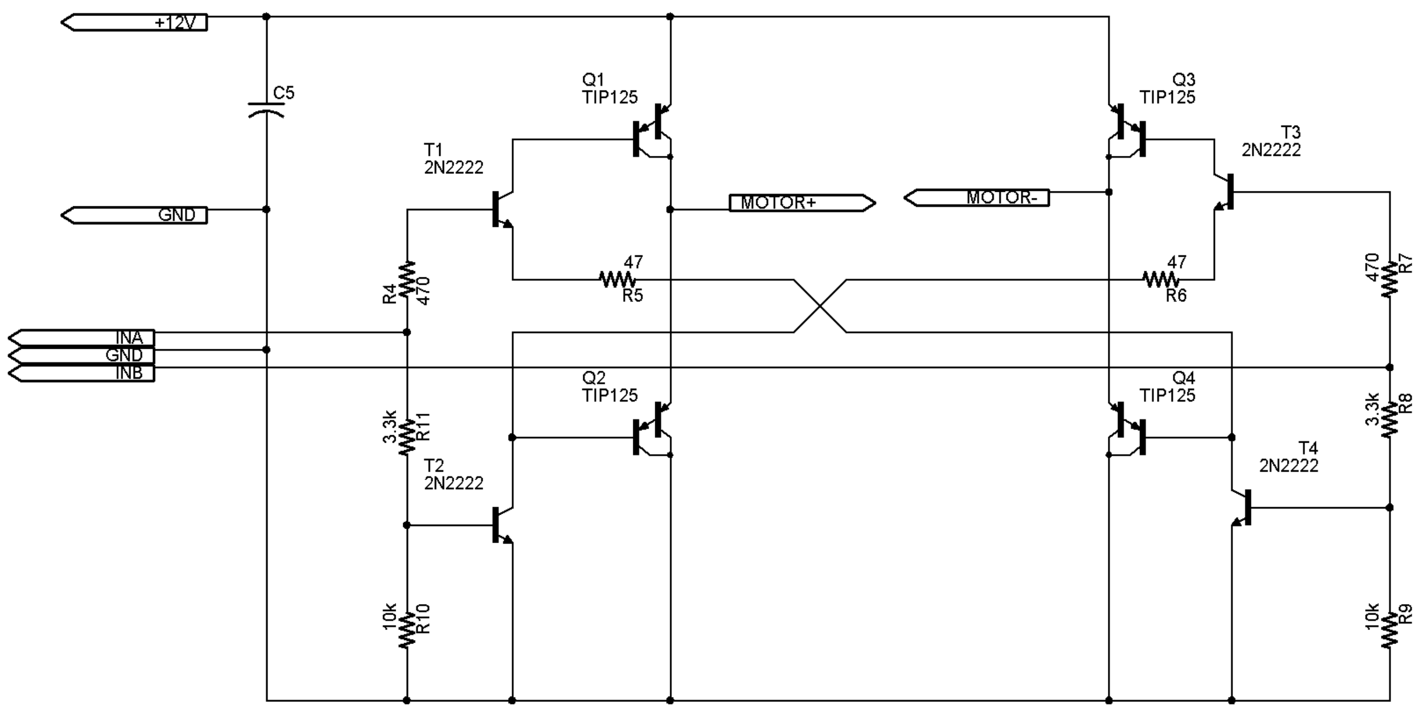

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[1] http://www.e-motionllc.com/
[2] www.youtube.com/user/wd5iyt