RADIO MAGiC

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FM Voice and Data and the ISS: Part 2

Introduction

The International Space Station (ISS) is a very easy to work, two-way FM voice and data repeater/digital repeater (digipeater) because of its low Earth orbit (LEO) and 10 watts nominal transmitter power, which is by far more than most other Amateur Radio CubeSats (or "birds") normally use. They usually transmit at one-half watts or less because of their limited onboard solar/battery electrical power resources especially when in eclipse (shadow). I was rather fortunate to write my part 1 article when the ISS' FM voice repeater (VHF up/UHF down, V/u or mode J) was active so I could test and try different antenna designs. It was switched over to an FM APRS/packet digipeater in October 2020, and I reran the same antenna tests using APRS. Then it was switched back to a FM voice repeater in November until late December 2021 when four days of SSTV images were transmitted commemorating 60 years of historic space achievements, and then switched back to APRS/packet. This mode switching seems be the regular pattern adopted for the new Kenwood voice/data radio system installed in spring 2020, except when it's shutdown for operational reasons: space walks and resupply/crew exchange rockets docking and undocking, or when used for scheduled voice/video ISS contacts with schools (1200+ in 20+ years). The cool thing is that you can run your ISS receiving station in fully automatic mode to capture APRS/SSTV and FM voice transmissions alongside a digital audio recorder to replay them back for class and/or group demonstrations.

Educators can also participate in the ARISS program to arrange on air video/voice contacts with schools. See https://www.ariss.org. And there's the Sally Ride EarthCam, which allows teachers to create an ARISS account then students can request targeted digital photographs to be taken by the astronauts and downloaded to their ARISS account for viewing, study and discussion. See https://www.earthkam.org.

ISS Easy Build Antennas

Because I don't have very good mechanical or carpentry skills, anything that relates to building antennas has to be easy to make using only basic household tools and also parts that you can easily scrounge or source on a frugal budget. If the darn thing actually works after I'm done (it usually doesn't look "pretty"), well, that's a bonus! The one thing that you can't make are the coaxial (coax) feed line and connectors so I use the easy to locally obtain and inexpensive RG6 quad-shield 75-ohm coax with compression type F-connectors (they are waterproof) and keep runs under 20 metres to minimize signal losses. The 75 to 50-ohm impedance mismatch adds to the overall antenna system loss at UHF but not so much for VHF frequencies. While the ISS antenna designs I'm presenting are for casual ISS use, they can also be used with other Amateur Radio satellites ("birds") such as the telemetry transmitting birds FUNcube-1 (AO-73) and Nayif-1 (EO-88). See https://tinyurl.com/wftu5fua. While you won't be able to compete head-to-head against the "big-gun" Amateur Radio satellite stations with thousands of dollars invested in computerized satellite tracking rotators, high-gain beams plus high end multimode transceivers, etc., you can still have just as much fun for less money, IMHO. The FM capture effect is the only real "enemy" because the strongest terrestrial transmitted FM signal always blocks out the weaker ones so there's an understanding to not dominate the entire satellite pass.

<Insert Figures 1, 2A, 2B, 3A, 3B & 4>

1. The stock (comes with) quarter-wave antenna on your dual-band handie-talkie (HT) with added "tiger tail" radial. See my "Antenna Tales, *TCA* Sep-Oct 2021. It works well for close in, very high (> 50 degrees) passes using only 5 watts for quick FM voice or APRS packet radio contacts/posits. Not ideal for inside-the-shack transmit operation but you'll still be able to here signals on the downlink frequency.

2. A repurposed quarter-wave mobile magnetic mount (magmount) with 5 m of RG58 coax, stuck on a pizza pie pan attached to four quarter-wave insulated radials (Figure 1). The radials are #12 insulated solid copper wires with curled ends (prevents injury and blood loss!). They hold their shape very well in free space but fold/unfold for portability, and ring terminals attach them to the pizza pie pan with wing nuts and bolts. The antenna also receives the ISS' UHF downlink frequency because it works as a 3/2 wavelength UHF antenna so you can work UHF up/VHF down, U/v mode B, too with the short feed line (to minimize UHF signal losses). RG58 coax fits nicely under outer storm/screen doors so even in cold temperatures, rain or snow I can place it outside and comfortably sit and operate from my living room or kitchen. *Note: If you want a more backpack portability, cake ring pans have a smaller diameter detachable bottom that works just as well because it's the radial wires that do all the work, even when sitting on wooden picnic tables!*

Figure 1: Pizza Pan Ground Plane Antenna
The radials are must to ensure a low transmit VSWR (VHF and UHF). Insulated solid copper wire (#12) has enough tensile strength to hold its shape and position but flexible enough to give way.

3. A "reactive" turnstile eliminates the usually used quarter-wave, quadrature (90 degree) phase shift coax (Figure 2). See *Modern Antenna Design,* 2nd ed., © 2005 Thomas A. Milligan, https://tinyurl.com/3da6ajy5 (pgs. 231-234). Mine is made with aluminum arrow shafts, #8-32 hardware and 12.5 mm (half-inch) schedule 40 polyvinyl chloride (PVC) pipe/fittings. It's very easy to break down and transport. It also receives the ISS' UHF downlink frequency and you can transmit mode B with minimal losses by using a short feed line (< 5 m). I also built a receive-only version with a feed point 2 metre preamplifier using a 20 metre run of RG6 back to the shack for receiving the AO-73 and EO-88 telemetry birds and streaming their data to the AMSAT warehouse along with receiving the 137 MHz APT NOAA weather satellites. See https://tinyurl.com/r6hh72w7. My VHF satellite receiving station (ISS, APT and AO-73/EO-88) runs autonomously 24/7, using inexpensive distribution VHF/UHF TV amplifier connected to my reactive turnstile antenna and VHF low-noise preamplifier (LNA) that feeds four computers (XP to W10) and four receivers.

Figure 2: Reactive Turnstile
One crossed dipole is cut slightly shorter and one cut slightly longer than resonance. No phasing harness is required using this method. An optional mirror image radial screen is placed 3/8 wavelength below but isn't electrically connected to the crossed dipoles above. The screen forces more radio wave energy skywards and also minimizes out-of-phase ground reflections from interfering with incoming signals from above.

4. The now famous tape measure Yagi-Uda VHF beam; a 3-element lightweight handheld beam invented by Joe Leggio, WB2HOL (SK) in the early 1990’s. See https://tinyurl.com/49smfhp9 and https://tinyurl.com/2p8rjfpv. It can also receive the ISS UHF downlink frequency. See Figure 3.

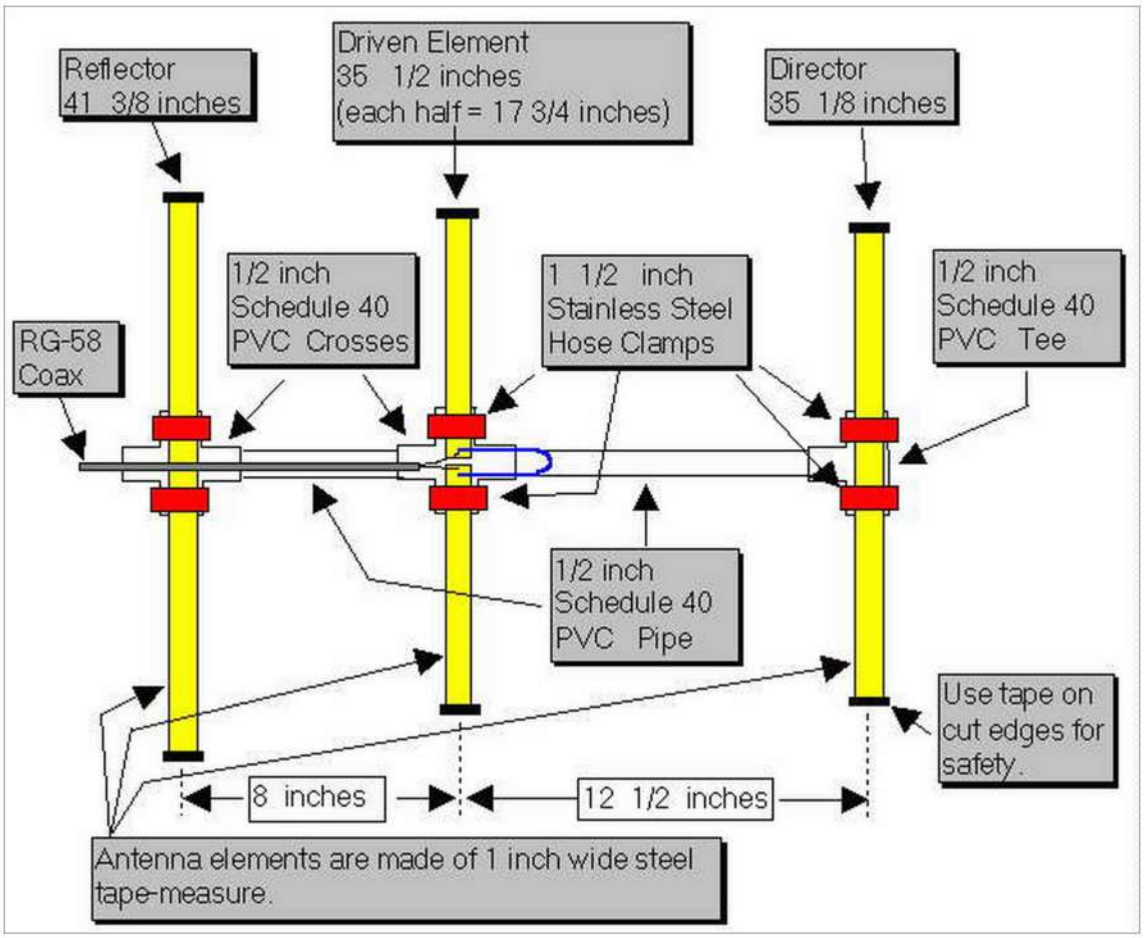

Figure 3: Tape Measure Yagi (Original)
Credit: Joe Leggio, WB2HOL (SK).

5. TV antenna rotator with dual-band Yagi-Uda beam antenna (Figure 4, next page). Now we are getting really serious! You can still use a handheld dual-band beam out in the field and wave “Hello” at passing CubeSats, but in sub-zero temps, pouring rain and other inclement weather you need an alternate way to work inside. The late Bob Bruninga, WB4APR, the “Father of APRS”, has written about the fact that if you forgo tracking in elevation, you can get by with a dual-band beam antenna tilted up at a 15 degree.

Figure 4: Fixed Elevation Beam with Azi Rotator

Mounted only 1.5 metres above ground to keep control and coax lines short (< 20 metres) and for easy servicing. Freezing rain is the enemy and small TV antenna rotators just don't have the torque needed to break off heavy layers of ice without breaking themselves (I use a heat gun as required). The antenna mast is a short length of 25 millimetre schedule 40 PVC (a thermoplastic) with a 15 degree bent "handle" to elevate the beam. Thermoplastics can be repeatedly heated and shaped.

Any inexpensive TV antenna rotator can be used to manually track satellites in azimuth with visual assistance from a satellite tracking program to help you manually aim the antenna and correct for any downlink UHF Doppler shift (stored in your transceiver's memories). For small city lots, you may need to tilt the beam higher to clear roof tops or obstructions. According to WB4APR, most LEO satellite and ISS passes are usually below 22 degrees elevation but moderate gain small beams have a wide enough beamwidth to work well even at greater tilt angles. See https://tinyurl.com/bde8pb79

The now discontinued but venerable Channel Master 9521A can be controlled by the awesome program "PstRotator" and interface "USB-UIRT" (universal infrared receiver transmitter).

I managed to snag a new-in-the-box Channel Master but other newer model TV antenna rotators, such as the RCA VH226E or F models, are readily available and also use a 3-wire control cable, however, they are not Channel Master IR code compatible as I found out many dollars later. However, if you can do the required “surgery”, PstRotator can work with these cheaper antenna rotators by using a computer serial port controlled, dual relay board connected to the rotator’s control box turn left/right buttons. Tracking is much coarser (usually in 10 degree increments) but this still works judging from my manual tracking tests with an unmodified RCA VH226E and the ISS. It’s really not an issue so long as your antenna’s beamwidth is wider than 10 degrees.

My Final

One fine and clear predawn morning, I was out stargazing when, right on time, the ISS appeared as a bright white floating “star” in the northwest sky. Its FM repeater suddenly snapped to life breaking the silence, and for a few minutes it was an ethereal experience as I watched, listened and made two quick contacts as the ISS glided literally over my head. The futurist Arthur C. Clarke wrote that “Any sufficiently advanced technology is indistinguishable from magic.” And so it was that morning!—73