Paul Wade, W1GHZ, w1ghz@arrl.org

Small Dishes and Digital EME

Improvements in digital modes have opened EME to smaller-scale stations.

At Microwave Update 2016 in St. Louis, Al Ward, W5LUA, presented a demonstration of 10 GHz EME using a small, offset-fed dish only 1 meter in diameter (see Figure 1). There have been previous reports of small-dish 10 GHz EME, but seeing EME contacts being made by a station similar to the rover stations that many of us operate was a real eye-opener.

Small Dish Down Under

The first report of small-dish EME on 10 GHz was in March 2012 by Rex Moncur, VK7MO, who made some successful JT65 experiments with Alan Devlin, VK3XPD, using a 64-centimeter (2-foot) dish and only 8 W output power.[1] The following November (which is summer in Australia), Rex took a 0.77-meter dish on a tour of 25 grid squares across the country, working four larger stations in Australia, Europe, and the US (see Figure 2). For this trip, Rex was running relatively high power, 45 W, and tracked the Moon with a rifle scope (see Figure 3).

Another successful small-dish EME operation was an expedition to Hungary by Charlie Suckling, G3WDG. Using a 0.76-meter dish and a 50 W solid-state amplifier, he contacted several stations using JT4, as well as one station on CW.

Small-Dish EME Challenges

There are specific issues to overcome when using a small dish for EME communication. Signal strength is very weak, so digital modes are used,

Figure 1 — Al Ward, W5LUA, demonstrating 10 GHz small-dish EME at Microwave Update 2016 in St. Louis. [Paul Wade, W1GHZ, photo]

Figure 2 — Rex Moncur, VK7MO, conducting a 10 GHz small-dish EME experiment with a 77-centimeter dish. [Noel Foley, photo]

Figure 3 — VK7MO operating small-dish EME in the Australian outback. The 24 GHz station is on the tripod and the 10 GHz rig on the ground. [Rex Moncur, VK7MO, photo]

in this case JT4F, a mode developed by Joe Taylor, K1JT, with contributions from Rex, VK7MO, specifically for EME on 10 GHz and higher bands.[2] The JT4 mode uses only four tones, rather than the 65 tones used by the more common JT65, because a single tone is spread by the libration of the Moon to a wider bandwidth — at 10 GHz, it can be as much as 170 Hz wide. To compensate, the JT4 tones have more frequency separation and only four fit in a normal SSB bandwidth. During the demonstration, received tones showed clearly in the waterfall display and, at times, were faintly audible.

[Libration is the result of a "wobble" of the Moon on its axis. This wobble is too slow to be perceived when looking at the Moon, but over time, the face of the Moon swings slightly to the right and left as it orbits the Earth. This motion causes a Doppler change in radio signals striking the Moon's surface that is in addition to the Doppler frequency shift (described below) caused by the motion of the Moon in its orbit. — *Ed.*]

Another issue is that EME signals are subject to Doppler shift. As the Moon travels in its orbit, Doppler shift at 10 GHz can move the frequency by as much as 50 kHz and cause rapid changes, making manual tuning impractical. This is also overcome by the *JT4F* software. The program calculates the Doppler shift and tunes the radio to compensate. With both stations locked to GPS and one or both compensating for Doppler shift, they can stay on a common frequency and complete the contact. The latest version of *WSJT* software, *WSJT-X*, includes Doppler shift correction and the JT4 modes, as well as other modes.[3]

Lastly, an effect called spatial polarization offset (SPO) causes a change in signal polarization that is different from, and in addition to, Faraday Rotation. Looking at the Earth from the Moon's perspective, an antenna that is horizontally polarized with respect to the Earth's surface immediately below the antenna (see Figure 4) can look to an observer on the Moon like it is canted to a 45° angle, or has a vertical orientation, depending on its location on Earth. Faraday Rotation is greatest at lower frequencies and nonexistent at 10 GHz. SPO is an effect of geometry, so it is constant at all frequencies.

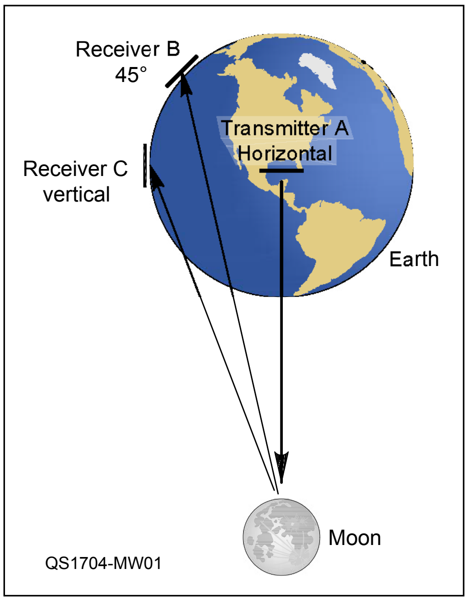

Figure 4 — Spatial polarization offset causes a change in signal polarization that is different from Faraday Rotation. When viewed from the Moon, an antenna's polarization can vary depending on its location on the Earth's surface.

For example, transmitter A sends a signal with an antenna that is horizontal with respect to the ground directly beneath it. Receiver B also has an antenna mounted horizontal to the ground, but its location on Earth causes it to appear to be at a 45° angle to the horizontal wave reflected from the Moon. Receiver C experiences the same effect as B, but its equatorial location causes its horizontal antenna to look like a vertical to the horizontal reflection off the Moon.

Using a small dish does have advantages. Tracking the Moon is easier with a small dish than with a larger one for several reasons. First, a small dish is lighter and easier to point with hand-driven or lightweight electrical drives. Additionally, a relatively small 1-meter dish has a 3 dB beamwidth of just over 2°, so you can tolerate some drift from perfect pointing and still be "on the Moon," although tracking within a smaller 1 dB beamwidth helps with the weak signals typically arriving from the Moon. With a clear, full Moon, it's possible to use the shadow of the dish's feed horn to maintain aim manually. W5LUA's demonstration showed that manual tracking is possible, with accurate azimuth readout and an inexpensive digital level for elevation.

A Challenge

There is an EME beacon, DL0SHF, on 10,368.025 MHz, maintained by Per Dudek, DK7LJ, that might be detected with a typical portable 10 GHz station, or possibly an even simpler receiver like the one I presented in "Microwavelengths" in 2014.[4] At the EME 2014 Conference in France, Hans van Alphen, PA0EHG, demonstrated reception of the beacon with a 0.5-meter (18-inch) dish.[5] So take on the challenge, get your gear together, and see if you can hear the beacon. You might be closer to an EME contact than you think.

Cheap Microwaves

I have heard lately from several hams that were put off by the challenge of getting started in microwaves, believing it requires loads of test equipment and buckets of money. I will try to address this in an upcoming "Microwavelengths."

Notes

[1] **www.vk3hz.net/microwave/10GHz-EME-Grid-Square-Tour.pdf**
[2] **www.physics.princeton.edu/pulsar/K1JT/small_station_eme.pdf**
[3] **physics.princeton.edu/pulsar/k1jt/wsjtx.html**
[4] P. Wade, W1GHZ, "Microwavelengths," *QST*, Jan. 2014, pp. 65 – 66.
[5] **www.pa0ehg.com/receiving-dl0shf.htm**