10 GHz Antenna Range Setup

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The 2025 Southeastern VHF Society Conference marks the first time I can recall us doing 10 GHz antenna range testing. Some new goals in our setup involve trying to not need 110VAC. That has often been a challenge at previous conferences. You might find outdoor outlets only to have them not be powered up.

Plus faster setup and takedown was needed since the antenna range time was after the last presentation and before the banquet on Saturday.

How Big Does a Range Need to Be?

The goal is to be far enough to be in the antenna’s Far Field. This is defined by keeping the phase error across the aperture of the receive antenna flat basically planar waves as much as possible.

Fraunhofer Distance $df = (2(D)^2)/\lambda$

Wavelength Lambda λ at 10.368 GHz = 3 cm

D = diameter of the largest dish to be testable 18” = 45.72cm

$Df = (2(45.72)^2)/3 = 2(2090)/3 = 1393.5$ cm = 549 inches = 45.72 feet

For a 1m dish $Df = (2(100cm)^2)/3 = 20000/3 = 6666$ cm = 2625” = 219 feet

For a 3.7m dish $Df = (2(370)^2)/3 = 91{,}266$cm =3000 feet = 0.567 miles

You can see this quickly gets out of hand. Looking at available space around the hotel we are hoping to get mostly 18” and smaller dishes requiring a 45.72 foot range

Path Loss

Using a path loss calculator

https://www.pasternack.com/t-calculator-fspl.aspx?srsltid=AfmBOorxdUxfSUGvemCkHD0AXewlALvmTUyfLaWJ2TEC8d8VbvgkrD-b we find the free space path loss to be:

20’ = 68.45 dB	50’ = 76.4 dB	80’ = 80.5 dB
30’ = 72 dB	60’ = 78 dB	90’ = 81.52 dB
40’ = 74.5 dB	70’ = 79.34 dB	100’ = 82.43 dB

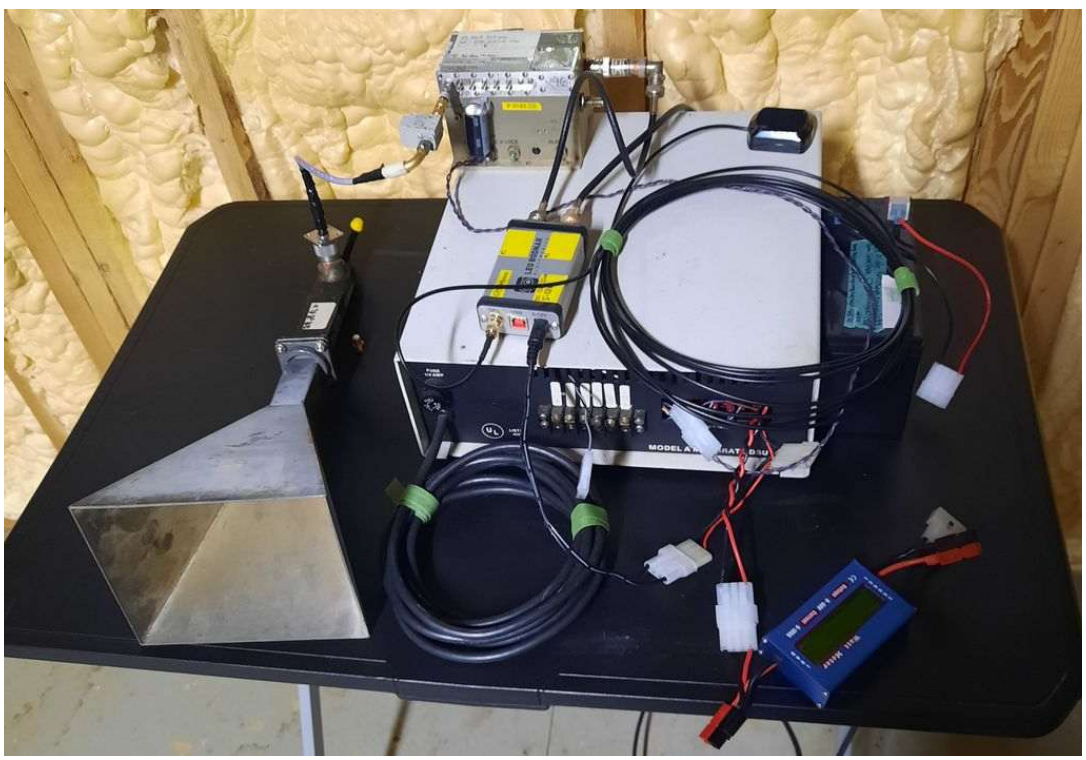
The Source End

The antenna range will use a 25 dBi gain horn fed from a x96 Phase Locked Multiplier "brick" producing +9 dBm at 10.368 GHz. A 6dB attenuator and isolator helps ensure the PLO stays locked by maintaining low reflected power back into the source. We have just above 0 dBm into the horn after a short test cable.

A LeoBodner programmable GPSDO makes 108.000 MHz at +10 dBm to act as the PLO reference. This is attenuated by a 10 dB attenuator to feed into the brick's reference input at approximately 0 dBm. This GPSDO is powered by 12vdc.

The brick is a -20vdc 500ma PLO as is very common. But this presents a problem of risky + and - grounds. A DC-DC converter helps solve the problem by taking in 9~18vdc and putting out regulated -20vdc. It allows me to use a 7AH 12VDC gel cell battery. The battery voltage itself powers the LeoBodner GPSDO. This allows cordless operation of the source end of the range for several hours.

The antenna for the source end is a Diamond Antenna and Microwave Company Model 849 25 dBi gain WR90 horn. 6" x 5" aperture and 6" taper length. Using Kent Britain WA5VJB's proven technique of placing the horn on the ground angled slightly up to eliminate ground reflection unknowns helps keep the range reflections reduced. We may even use some microwave absorber on the ground in front to further reduce the reflection potential.



The Receiver

By using a DEMI transverter we are able to do most of the interference rejection and gain in that unit automatically. Things are frequency stable. And all the power readings are taken at 144 MHz. There is of course the potential for interference from handhelds. But with most members no longer carrying anything but a cellphone the interference potential is greatly reduced.

The DEMI feeds a Millivac MV-828a analog Power Meter. This unit has good dynamic range to account for down conversion gain. But primarily we want to insure that we are always operating in a linear range.

The Measurement Process

Two items are fundamental to getting actual dBi gain numbers: A known gain Standard Gain Horn (SGH) and a few known attenuators. The attenuators are used after the Unit Under Test (UUT) to reduce its gain to where we are close to the same power level into the downconverter and power meter.

Our Standard Gain Horn (SGH) is a Narda Model #640 2.75” x 2” x 4.75” deep WR90 8.2 ~ 12.4 GHz unit. The dBi gain graph is taped to the top of the horn for reference. Horns of this type have proven to be very predictable in pattern and absolute gain across the frequency range they are designed for. Sidelobe performance is excellent.

In a typical case we are dealing with an 18” dish with roughly 34.2 dBi gain. The SGH is 16.2 dBi gain. That’s 18 dB more power received by the dish than the horn. By following the dish output with a 20 dB attenuator the power received into the DEMI downconverter is 2 dB lower than it was for the horn and no attenuator.

The process is really not that dependent on the downconverter as long as the gain isn’t radically different from a typical 26 dB gain DEMI. So even a participant’s downconverter could be used. The goal is simply to switch from the SGH to UUT and compare the received power. Using the attenuator to keep the power similar on the power meter helps alleviate any accuracy difference in the meter ideally keeping it from switching ranges.

The analog meter is used to enhance or speed up the peaking process. We will try to place it where the antenna owner can see it easily to manipulate their tripod and dish mount for best signal.

One group of antennas is a bit more challenging to get accurate results on. Omni waveguide beacon antennas can be a bit of a challenge because they have a much greater field of view making it hard to not pickup reflections from transfer trucks, fences, air conditioners, cars, billboards, street signs. Anything that can inadvertently become part of the antenna test is reduces the accuracy. And with people milling around watching they too can become part of the test, reducing signals from transient reflections. Omni antennas typically read higher in gain than they should because of all these added signals effectively producing a larger effective aperture than we can control.

Another feature we would like to add eventually is a tone which varies in proportion to the received signal power. Many of you have no doubt used this to peak a Dish Network or DirecTV dish onto the desired satellite.

Not as likely at 10 GHz is interference on frequency. But at lower frequencies a trick for discriminating out desired versus interference is by modulating the source signal with audio and using a power sensor which only sees the signals with that modulation. That was a common trick years ago. But the compatible vintage power meters are aging out.

We do have a potential way to expand the signal source to 24 GHz antenna tests using the same 108 MHz frequency reference to drive a x128 brick. 108 x 128 = 13.824 GHz. Mixing this with the 10.368 GHz test signal gives 10.368 + 13.824 = 24.192 GHz. Though it may be just as easy to put someone’s 24 GHz transverter driven from an rfZero at 144 MHz on the source end. Tests will continue for next year. We do have a Narda SGH for 24 GHz as well.

5760 MHz is also a possibility. I have a Narda SGH for that frequency. Will have to look at interest. With the proliferation of Icom IC905 units it may be time to think about doing 5760 MHz on the range. Contact Kent KA2KQM or Charles K4CSO with your interest in testing at these other frequencies so we know if it’s worth the effort.