Adventures in 6-Meter EME

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Abstract

Earth-Moon-Earth (EME) communication on the 50 MHz amateur radio band is extremely challenging. Recent software development that provides a significant improvement in weak signal detection that was unavailable just a few years ago has enhanced EME success rates. Even so, operators still face significant challenges with Faraday rotation, signal degradation, and sky temperature relative to the moon position that must be overcome by applying sound mechanical and electrical engineering practices to the station design.

Several papers and lectures have been presented on 6-meter EME at VHF conferences, national & regional club meetings via Zoom, YouTube, and websites. This paper is intended to add to the excellent material that currently exists regarding 6-meter EME and encourage radio amateurs to try 6-meter EME, even if you only have a single Yagi without elevation and moderate power.

This paper documents the work by W5ZN to establish a competitive EME system for the 50 MHz band and provide specific information that my benefit others in their EME adventure.

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1. Introduction

Earth-Moon-Earth (EME) communication has become commonplace in amateur radio today that was once enjoyed only by BIG GUN operators at stations with massive arrays and high-power RF amplifiers. Thanks to the development of digital communications software and improvements to hardware, radio amateurs with simple antenna arrays or even a single Yagi and moderate transmit power can now be successful.

Several papers and lectures have been presented on 6-meter EME at VHF conferences, national & regional club meetings via Zoom, YouTube, and websites by Lance Collister, W7GJ[1], Dave Schmocker, KJ9I[2], Tim Blank, N0TB[3], and others dedicated to 6-meter EME. This paper is not intended to usurp those, by any means, but rather document the experience at W5ZN and provide details on my adventure in this area. The purpose is to hopefully encourage you to try 6-meter EME even if you only have a single Yagi, without elevation, and moderate power.

2. W5ZN EME History

I became active in EME in the early 1990's on 144 MHz. Cushcraft had just introduced their new 17B2 antenna that touted impressive gain so four antennas were purchased and erected at my station (WB5IGF at the time). Of course, during those days the effective mode for EME, in fact the only mode, was CW. After a few years I was able to work 48 DX Century Club (DXCC) countries, complete my Worked All States (WAS) award as I only lacked Alaska and Hawaii, and add new grids to my VHF/UHF Century Club (VUCC) total. EME also provided some much-needed grid multipliers during the VHF contests! Around 1995, I had worked everything possible at that time with only four Yagi's so I disassembled the array and moved up to 432 MHz.

The 432 MHz system was larger in comparison to 144 MHz. Clyde "Scotty" Scott, KD4LT (SK) had just constructed a 28 ft parabolic dish and was selling the 16 FO-22 antennas he had used on 432 MHz. My son and I saddled up and headed down to Moltrie, Georgia and loaded them in the truck. I erected the 16 antennas and was off to a great start. The FO-22's were mounted horizontally so I could not rotate polarity and often became a victim of Faraday rotation, more so than on 2-meters. Still, I was able to work 21 DXCC countries, bring my WAS total to 38 states, and increase my VUCC grid total. Once again, during that time in the evolution of EME, I maxed out on available stations I could work even though I had a relatively large array. In 1999 I removed and sold the antennas to focus on a terrestrial VHF/UHF antenna system through 24 GHz although a brief stint on 5.7 GHz EME with a 3-meter parabolic prime focus dish occurred.

My love of EME never faded and during the time I was absent significant developments occurred, not only with digital mode software for EME use, but hardware as well. In 2012 I had to get back into the EME action so I reinstalled the four 17B2's that had been in dry storage in my shop for several years. In 2018 I completed 144 MHz DXCC.

In late 2020 and early 2021 increased focus on 222 MHz WAS developed[4]. I had 40 states confirmed on the band and within reach of completing WAS. Interest was further heightened with planned portable operations by Gene Shea, KB7Q in the west for MT, NV and WY, and Peter Van Horne, KA6U in the northeast for MA, NH, RI and VT. I installed two FO-16 antennas, later upgrading to four FO-16's, and completed 222 MHz WAS #11 on December 28, 2021.

After completing 222 MHz WAS it was time to focus on 432 MHz again so an array of eight FO-25 antennas was installed. WAS #40 on 432 MHz was completed on October 4, 2024.

3. The Spark That Ignited the 6-meter EME Adventure

My first taste of EME on 50 MHz began sometime around 2010. Dave "Jacques" Olean, K1WHS traveled to one of those very rare grids in northeast Maine next to the Canadian border and was planning to also utilize EME to help W7GJ and others in the far western USA work and confirm the grid for the Fred Fish Memorial Award (FFMA)[5]. I needed the grid as well and thought I would enlist a spare M^2 6M9KHW for EME in addition to my terrestrial option. The makeshift EME arrangement used a rope and a pulley on one of my towers to elevate the front of the antenna with a saw horse propping up the rear. I manually elevated and rotated the antenna.

I did not copy K1WHS that evening but no one else did either. I did, however work S59A and decoded W7GJ!

As time progressed more stations were trying EME on 6-meters and a few major DXpeditions included 6-meter EME capability. Additionally, W7GJ began traveling to remote DXCC countries focusing on 6-meter EME. As an avid DX'er I wanted to apply EME to increase my 6-meter standings as well as my DXCC Challenge count. In October, 2021 W7GJ planned a DXpedition as FO/W7GJ to French Polynesia and TX7MB to Marquesas Island. I needed both of these DXCC countries on 6-meters so it was time for action using the 6M9KHW in my terrestrial system during my moonset. I was able to complete with FO/W7GJ but initial attempts with TX7MB on my moonset during the first couple of days failed! This was an unacceptable result, I had to take further action! I had a spare M^2 6M7JHV available so I replaced one of the lower 17B2 antennas in my 2-meter EME array with the 6M7JHV so I could elevate the antenna. On the last day of the TX7MB operation I was able to decode Lance, and he decoded me, but not in sync to complete and I ran out of moon. A lost effort!

4. The Adventure Begins

The failure to complete with TX7MB did not set well with me and it was due solely to the deficiency of my station. While extremely effective for terrestrial work it was not at a level to support reliable EME performance on 50 MHz. It was time for a change!

Having completed my 222 MHz WAS in December 2021 I decided to relocate the 144 and 222 MHz antennas that were on the same tower/rotor/elevation system and install a four-antenna array for 6-meter EME. I had four M^2 6M7JHV's that would work well but

the 144/222 array was supported by a short Rohn 25 tower and elevated with an M^2 MT-1000 rotor. I would need a more robust tower and elevation mechanism for four large 6-meter Yagi's. The Orion 2800 azimuth rotor would be retained for use with the new 50 MHz system.

The plan was to remove the Rohn 25 tower and its concrete base and replace it with Rohn 55. As shown in Figure 1, removal of the old base is a simple process with the right equipment. Once the tower is removed a hole is dug on one side of the old base of sufficient size and depth to contain old base.

Figure 1: Hole dug to contain the old concrete base.

In Figure 2, the old base is then pulled over into the new hole and Figure 3 shows the base hole where the Rohn 25 was located is now ready for the new Rohn 55 base section thanks to backhoe support from Roger & Dawn Gray, N5QS & N5QT !!

Figure 2: Old base is pulled into new hole

Figure 3: Old base hole is now ready for new Rohn 55 tower base

With the new tower base installed, tower erected, and the Orion 2800 azimuth rotor installed it was time to complete the design of the H-frame and decide what elevation mechanism to employ. About this time an M^2 MT-3000 elevation rotor and H-frame from the estate of Richard King, K5NA, became available that I was able to purchase. The H-frame, designed by Dick Hanson, K5AND, was of superior quality. The horizontal H-frame boom design is shown in Figure 4 and the vertical boom in Figure 5.

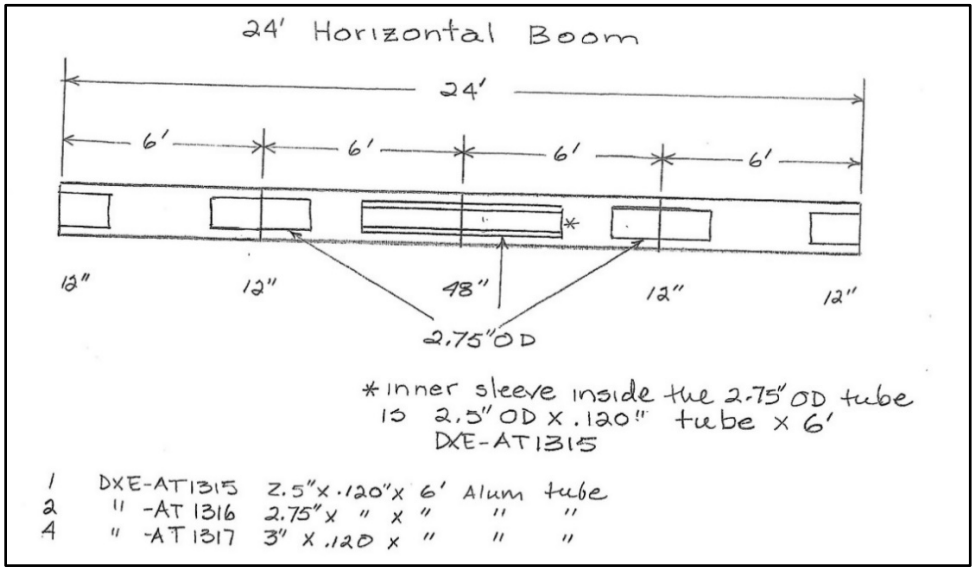

Figure 4: K5AND design for H-frame horizontal boom

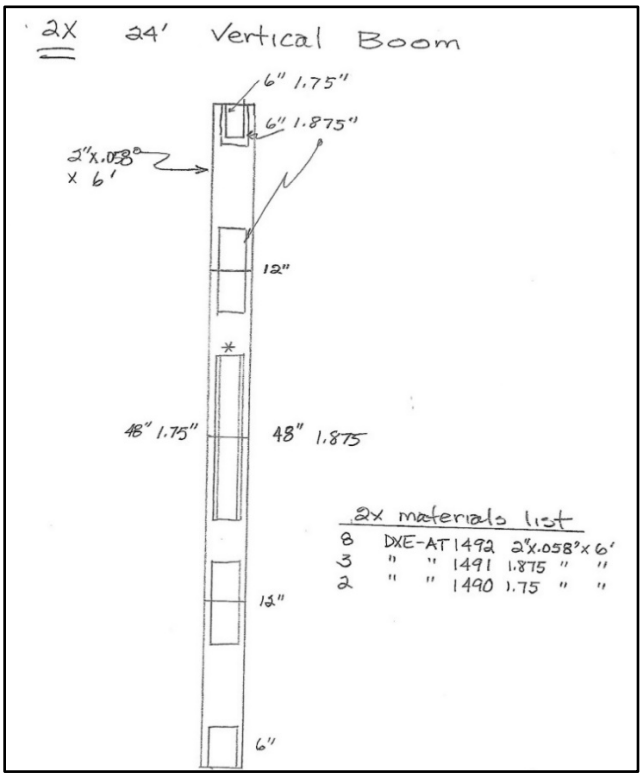

Figure 5: K5AND design for H-frame vertical boom

The Austin, Texas trip to pick up the H-frame and MT-3000 was arranged to coincide with the 2023 Six Meter BBQ hosted by Jimmy, W6JKV and Dick, K5AND. Sadly this was the last of those amazing BBQ's hosted by two great 6-meter ops and DXpeditioners! Many thanks to Jimmy, Drew, Dick, and Kathy for hosting these and providing many years of fond memories!

The H-frame had been removed from the K5NA tower but was still assembled and laying on the ground. With able body assistance from my buddy Tom Whitted, N7GP (x-WA8WZG) we had the H-frame disassembled and loaded in the truck.

Once back home in Arkansas the H-frame reassembly was quick and easy. The MT-3000 elevation rotor was raised and mounted on the mast, then the H-frame was raised and attached to the MT-3000. Figure 6 and Figure 7 shows the Orion 2800 azimuth and MT-3000 elevation rotors and Figure 8 shows the mounted H-frame horizontal boom, without the vertical booms attached, at 27 ft above ground.

Figure 6 – M^2 MT-3000 elevation rotor

M^2 Orion 2800 azimuth rotor

Figure 8: Installed H-frame without vertical booms

5. The Great Antenna Debate!

As noted earlier, I had four M^2 6M7JHV antennas I planned to use for the array. Although some radio amateurs have noted increased SWR during wet weather conditions and bandwidth issues with this antenna, I experienced none of these in 20 years of use.

Over the past few years, the loop fed array (LFA) antenna designed by Justin Johnson, G0KSC, has become quite popular. The direct 50-ohm impedance of the loop driven element and broad bandwidth provide stellar results. Once the LFA 6-meter crowd learned I would be using my M^2 antennas I was almost shunned from 6-meter EME before I even got started with the new array. So, I broke down and purchased four new 7 element LFA2-HD Yagi's from Justin. At the time of this purchase the LFA's were only available through WiMo in Germany[6]. DX Engineering now stocks the Innovantenna LFA's[7]. Once the M^2 6-meter EME crowd heard I had purchased LFA's, they shamed me and insisted I had wasted my money and thrown it away! Having already purchased the LFA's I put my M^2 antennas up for sale. Guess who bought all four? THE LFA CROWD!!!!! 😊

Not to be deterred, I moved forward with the attitude I would be very pleased with either antenna. It does warrant, though, a thorough review of the simulation results from the antenna model for each design and not rely on emotional opinions from radio amateurs.

Figures 9 and 10 displays the azimuth pattern from modelling and simulation for each antenna, Figures 11 and 12 displays the elevation simulation, and Table 1 tabulates the statistical results.

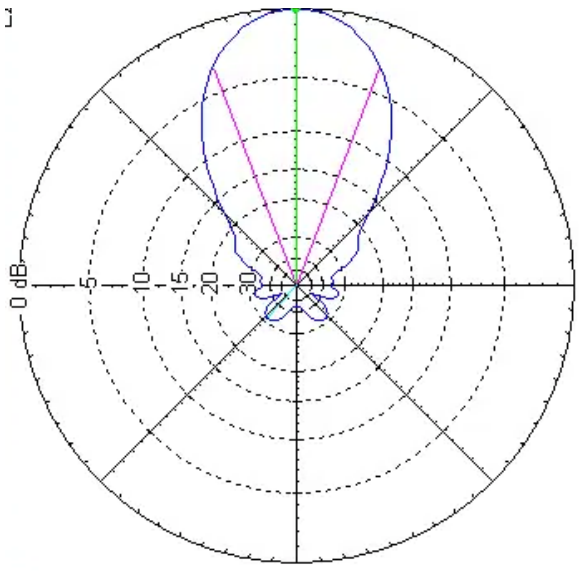

Figure 9: Azimuth plot for LFA2-HD

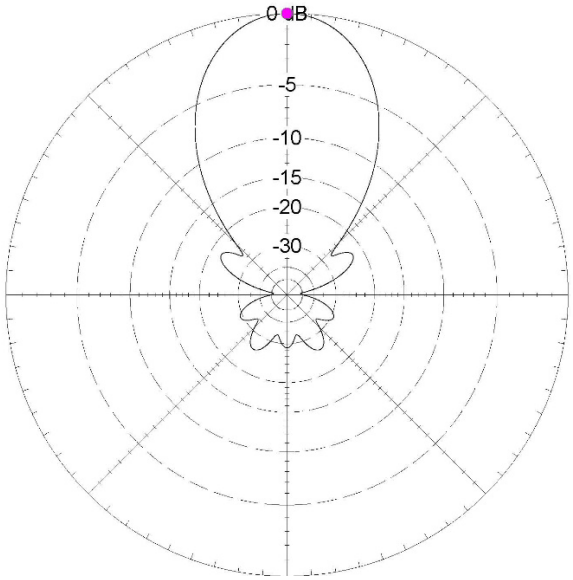

Figure 10: Azimuth plot for 6M7JHV

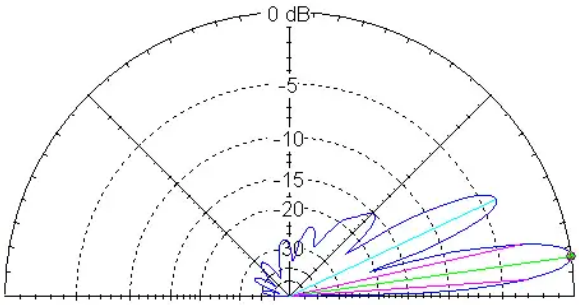

Figure 11: Elevation plot for LFA2-HD

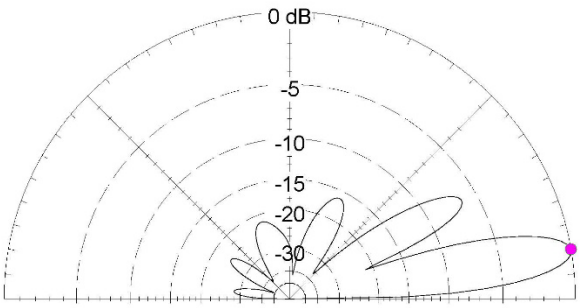

Figure 12: Elevation plot for 6M7JHV

Table 1 – Statistical Results for Each Antenna

Model	LFA2-HD	6M7JHV
Gain	12.81 dBi	13.0 dBi
Front to Back	30 dB Typical	25 dB Typical
Beamwidth	E=42° H=46°	E=40° H=42°
Boom Length	29.2’	30’8”
Stacking Distance	22.3’	25’ High 27’ Wide

M^2 does not publish simulation pattern results for the 6M7JHV, or at least I could not find the information on their website or in any of my instruction manuals or documentation. The modeling and simulation results above for the 6M7JHV are my own generated in EZNEC but they agree with the M^2 published specifications.

It is always advisable to consult reliable third-party evaluations. Sometimes “marketing department simulation” is applied to a published design. I’m not suggesting this occurred with either of these two Yagi’s, but let’s check in with the “Master of VHF EME Antenna Analysis” Lionel Edwards, VE7BQH. Lionel has applied his decades of antenna and EME experience to evaluating almost every VHF Yagi antenna available[8]. Table 2 displays the result of Lionel’s evaluation for each antenna individually and Table 3 contains information for a 4-antenna array with optimal spacing. The data indicates both antennas are very similar, such that your ability to identify any differences between the two on-the-air will most likely not exist.

One thing that is obvious from the simulation is the LFA2-HD has a much cleaner rear pattern and reduced side and rear lobes. This is important, and under marginal conditions or a local noise environment should have an advantage over the 6M7JHV.

My good friend Mike Greenway, K4PI in Douglasville, GA has four 6M7JHV’s on EME. Since the LFA2-HD and the 6M7JHV are comparable based on the simulation and VE7BQH’s results, Mike is an excellent person to conduct on-the-air comparisons with. Does my array outperform Mike’s? Not with any consistency. In comparing recent 6-

meter DXpeditions, I was able to work the DX station first on some occasions and Mike beat me in the log on others. The variables you encounter on 6-meter EME, including Faraday rotation, atmospheric conditions, terrestrial propagation occurrences, and many other factors during an EME attempt all impact the real-world comparison of antennas when separated by geographical distance.

Table 2 – VE7BQH Data for a Single 6M7JHV and LFA2-HD Yagi

1 Ant				
		<	H Plane	>
TYPE OF ANTENNA	GAIN (dBi)	F/R (dB)	1st SL (dB)	2nd SL (dB)
M² 6M7JHV	13.11	20.5	15.2	20.5
InnoV LFA2	12.92	24.4	20.3	none

Table 3 – VE7BQH Data for Four 6M7JHV and LFA2-HD Yagi's

				DL6WU Optimal Stacking				
		Spacing		4 Antennas				
TYPE OF ANTENNA	Length m	E (m)	H (m)	G_A (dBi)	T_A (K)	Tloss (K)	G/T (dB/K)	S/N (dB)
M² 6M7JHV	9.33	8.53	7.56	19.06	11122.81	5.6	-21.34	-26.72
InnoV LFA2	9.54	8.23	7.15	18.83	9417.32	4.7	-20.86	-26.25

My LFA2-HD antennas arrived from WiMo Germany in excellent condition and the assembly was easy and straight forward. Compared to the 6M7JHV, it is a more robust and structurally solid antenna and each LFA2-HD had as near perfect 50-ohm match as practically achievable. The bandwidth is quite impressive.

Phasing the antennas is straight forward with a simple 4-port power divider. Included with the materials from the K5NA estate was the power divider Richard used with his system and is shown in Figure 13. I later built a new power divider to a more efficient design and it is described in a subsequent section of this paper.

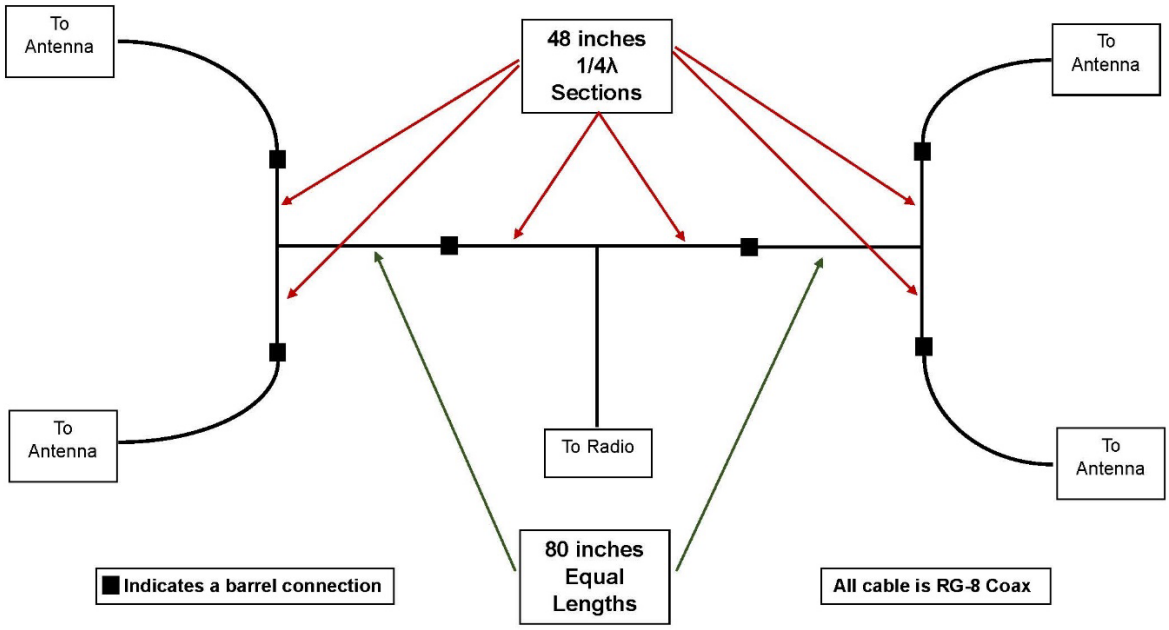

Figure 13 – Original 4-port power divider from K5NA estate

I was now on the air with four antennas for 6-meter EME! A photo of the completed array is shown in Figure 14.

Figure 14: The completed 4x7 LFA 50 MHz EME array

6. On The Air Performance

The array was completed and operational just at the start of the first weekend of the 2023 ARRL International EME Competition. First night stations worked included KJ9I, K9RX, N0TB, K5QE, S57RR, and JG1TSG. I was a member of the IARU team at WRC-23 in Dubai so I missed the second contest weekend but before I departed, I was able to add 4W8X to my 6-meter total.

I have read on-the-air claims that the LFA produces a lower noise floor than open driven element Yagi designs and theoretically it should. The documentation of band and noise floor readings at my station does not support such a conclusion. Of course, once the antenna is elevated above the horizon and away from land-based noise sources such as power lines and consumer devices, the noise floor is significantly reduced and very quiet, as would be expected.

6. How Structurally Sound is the Array?

I returned from Dubai just before Christmas, 2023. I was anxious for an activity weekend to place the array on the air once again. Just after Christmas, in January 2024, we had a massive cold front move through with snow, ice, and 50 MPH winds. The array looked like Foghorn Leghorn flopping around in the wind. My wife thought I had lost my mind, staring out the window watching the array but I couldn't help it. If it was going to come down, I wanted to watch it die in real time. Fortunately, it survived but one week later, true to Arkansas weather after the snow and ice event, thunderstorms, tornados, and 65 MPH wind gusts moved in! The array survived once again but I did lose one of the vertical boom support wires. Thankfully there was no other damage although it revealed some lose bolts that apparently were not tightened correctly during the initial installation. The size of the array is too large to work on from the center tower or from the ground, so a manlift is required to access the individual antennas and outer parts of the H-frame booms. Once the weather cleared, I rented a towable manlift and began affecting repairs to the array.

During this time, I decided to replace the original K5NA 4-port power divider constructed from RG8. I believed the design, while good, was to complicated and a more efficient, simpler approach constructed from LMR600 would provide lower loss while maintaining the correct phasing. The new design is shown in Figure 15.

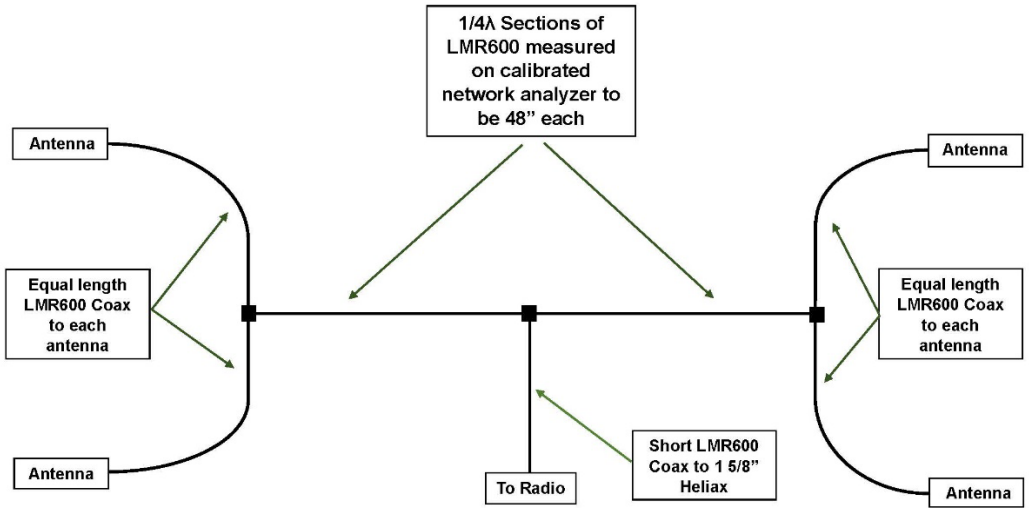

Figure 15: New 4-port power divider of LMR600

The array is now back on the air with the broken support wire repaired, all bolts properly torqued, and the new power divider installed and performing admirably. Figure 16 shows the array just after repair.

Figure 16: The 6-Meter EME array back in action.

There have only been two other issues I encountered with the array. The first was a blown preamp that occurred during the ZD9GJ DXpedition. The exact cause has not been identified however, a spare was available (if you only have one, it's the same as none!) and placed into service in time to put ZD9GJ in the log. The blown preamp was repaired and now serves as the backup.

The second occurred following an unusual 11-inch rain event over a three-day period followed by a one day, five-inch rain event one week later. During the E6RS DXpedition I encountered a high SWR on the first day. An investigation revealed water had migrated into the coax connector at the RF choke on the upper right antenna. Fortunately, this was quickly repaired the next day when I had no common moon with Niue Island and E6RS was in the log during the next moon window. The location of the water incursion into the connector could be identified but extra waterproofing measures were applied and so far, all is well.

7. Station Equipment

The array is 210 ft from the shack and fed with 1 5/8" Heliax. A 0.5 dB noise figure, 20 dB gain preamp[9] is installed at the array.

Inside I use an Icom IC-7300 transceiver and a PGXL amplifier designed and built by 4O3A. I have received a few questions regarding the use of the IC-7300. It works extremely well and I can tell no difference in performance when comparing it to my Elecraft K4D on 6-meters however, it is ***imperative*** that you understand how to properly adjust the settings of the radio. I have spent a considerable amount of time evaluating the various menu settings and parameters during operation and I'm extremely pleased with the IC-7300's performance.

I have had excellent service from the PGXL on EME. I consistently run it around 1200 watts during the 52 seconds on, 68 seconds off transmit periods at full duty cycle. You must, however, make sure the fan speed is set to "Broadcast" mode!

The software is WSJT-X running Q65-60A, usually in pileup mode. My good friend Dave Schmocker, KJ9I (I call him iDave) maintains a list of finely tuned, optimized settings for running Q65-60A on 6-meter EME and it is available to new folks (and old ones as well!) with an interest in 6-meter EME. You may contact Dave via his QRZ.com info.

At the time of this writing, the array has been in operation for one year and 8 months. There isn't daily, or even significant monthly, activity however when a new DXCC country is activated, it is exciting to see decodes like the one shown in Figure 17!

8. Stations Worked on 6-meter EME

To date I have worked over 35 stations on 6-meter EME. These include 4O6AH, 4W8X*, 7Q6M*, 7Q6UJ*, DL8YHR, E51EME*, E6RS*, FO/W7GJ*, FR4OO*, G8BCG, HA8CE, MD0CCE, OH1LEU, OH6MW, OH7KM, R6KA, S51LF, S57Q, S57RR, UR5LAK, VK3BD, YL2GD, ZD9GJ*, and ZS4TX (* single Yagi station). Upcoming DXpeditions at the time of this writing include YJ0RS, H40GJ, and more planned for the near future.

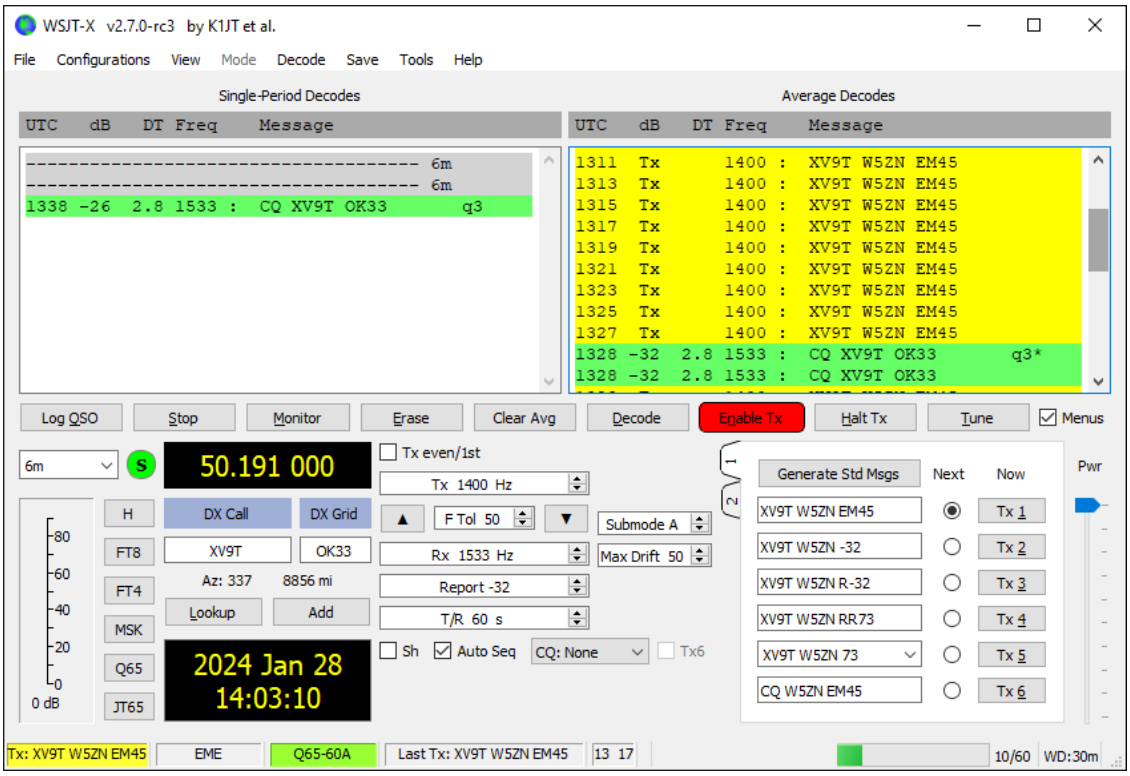

Figure 17: Eddy, XV9T, decoded via EME on 50.191 MHz

9. Conclusion

Construction of a 6-meter EME antenna system is not for the faint hearted or weak minded! This has been one of the most work intensive antenna projects I have undertaken, mostly due to the learning curve required for EME on 6-meters even though I have extensive EME experience on other bands. The work was at times frustrating however the reward has been well worth the effort. If you evaluate the amount of money invested in a 6-meter EME array and equate it to “dollars spent per QSO” you will most likely be disappointed. My advice is to not evaluate your experiences in amateur radio based on a monetary figure, rather the fulfillment received from being successful with your effort.

Good luck and best wishes if you embark on a 6-meter EME adventure!

Acknowledgements
Dave Schmocker, KJ9I has been an invaluable resource and provided extensive encouragement for me. Although a section of this paper documents the “spark” that ignited this adventure Dave provided a parallel spark and kept my interest high throughout the process. Dave has spent many hours assisting other stations to be successful on 6-meter EME and I owe my FR4OO contact to Dave for advising Paul along the way and convincing him that he could be successful on EME with his single Yagi!

Tim Blank, N0TB greatly assisted Eddy, XV9T in navigating through the maze of 6-meter EME and as a result of Tim’s effort, Eddy is in several 6 meter logs! Tim continues to be available and offer assistance to anyone desiring to learn this aspect of amateur radio.

About the Author
Joel Harrison, W5ZN was first licensed in 1972 as WN5IGF. He holds an Amateur Extra Class license and has acquired several operating awards. A passionate weak signal enthusiast, his work in this area on the bands from 1.8 MHz through 24 GHz has been documented in many publications, articles, and on-line content, some of which can be found on his website at https://www.w5zn.org. From 1988 to 2006 he served as a Director, Vice President, and First Vice President for ARRL, and as President from 2006 to 2010. He is currently Secretary for the International Amateur Radio Union. Professionally he worked for 38 years in the nuclear power industry and is regarded as a subject matter expert in ultrasound examination. Joel is currently a Research Analyst for the Pacific Northwest National Lab in the Nuclear Engineering and Analysis, National Security Directorate. He holds certification from the American Society for Nondestructive Testing as an NDE Level III and ASME qualifications from the Electric Power Research Institute for nuclear power plant inspections.

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