

# Moon Bounce For QRPerS



Making contacts via the moon with a modest amateur 2 meter station

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# EME (Earth-Moon-Earth)



EME involves transmitting a signal towards the moon and receiving the reflected wave. This allows worldwide contacts on frequencies where contacts are normally line of sight only.

# EME Factoids

- Average distance to moon ~240,000 miles
- 2.4 second radio signal round trip
- Moon apparent size  $\sim 0.5^\circ$
- Moon reflects only  $\sim 7\%$  of signal
- Average 144 MHz path loss:  $\sim 250$  dB

# What is 250 dB?

- Ratio of 10,000,000,000,000,000,000,000,000 : 1
- Difference between 1KW and 0.1 $\mu$ W is only 100dB, 2KW and 0.1 $\mu$ W is 103 dB
- You could make a 250 dB attenuator for 2M with 3.14 miles of LMR 400 Coax
- If US power grid had these losses, you would have to multiply the total generating capacity by 10 Billion to get one watt out

# Complicating Factors

- Moon moves
  - Formerly needed AZ/EL system to track Moon
  - Doppler shift in frequency
- Apogee/Perigee variations add losses
- Ionospheric absorption can add more loss
- Faraday rotation skews polarization
- Cosmic & solar noise interferes with signal
- Libation fading, Declination, Others

**EME may be the biggest technical challenge in Ham Radio!**

# Overcoming the Obstacles

- Myths to Debunk – important!
- High power
- Big antennas
- Low loss coax, good connectors, etc.
- Low noise receivers & pre-amps
- Special techniques

# System Loss Calculations

## GAIN

- Power out
- Transmit antenna
- Receive antenna
- Receiver gain

## LOSS

- Transmitter feed line loss
- Path loss
- Receiver feed line loss

$$\Sigma(\text{gains}) - \Sigma(\text{losses}) > \text{Noise}$$

# EME Bands

- 6M - Once thought to be impossible because of antenna size, but gaining popularity
- 2M - Most popular band mostly because of availability of equipment
- 432 & 1296 MHz - Most popular after 2M. Lower noise levels but not much commercial equipment available.
- Higher microwave bands are for the really dedicated EMEers.

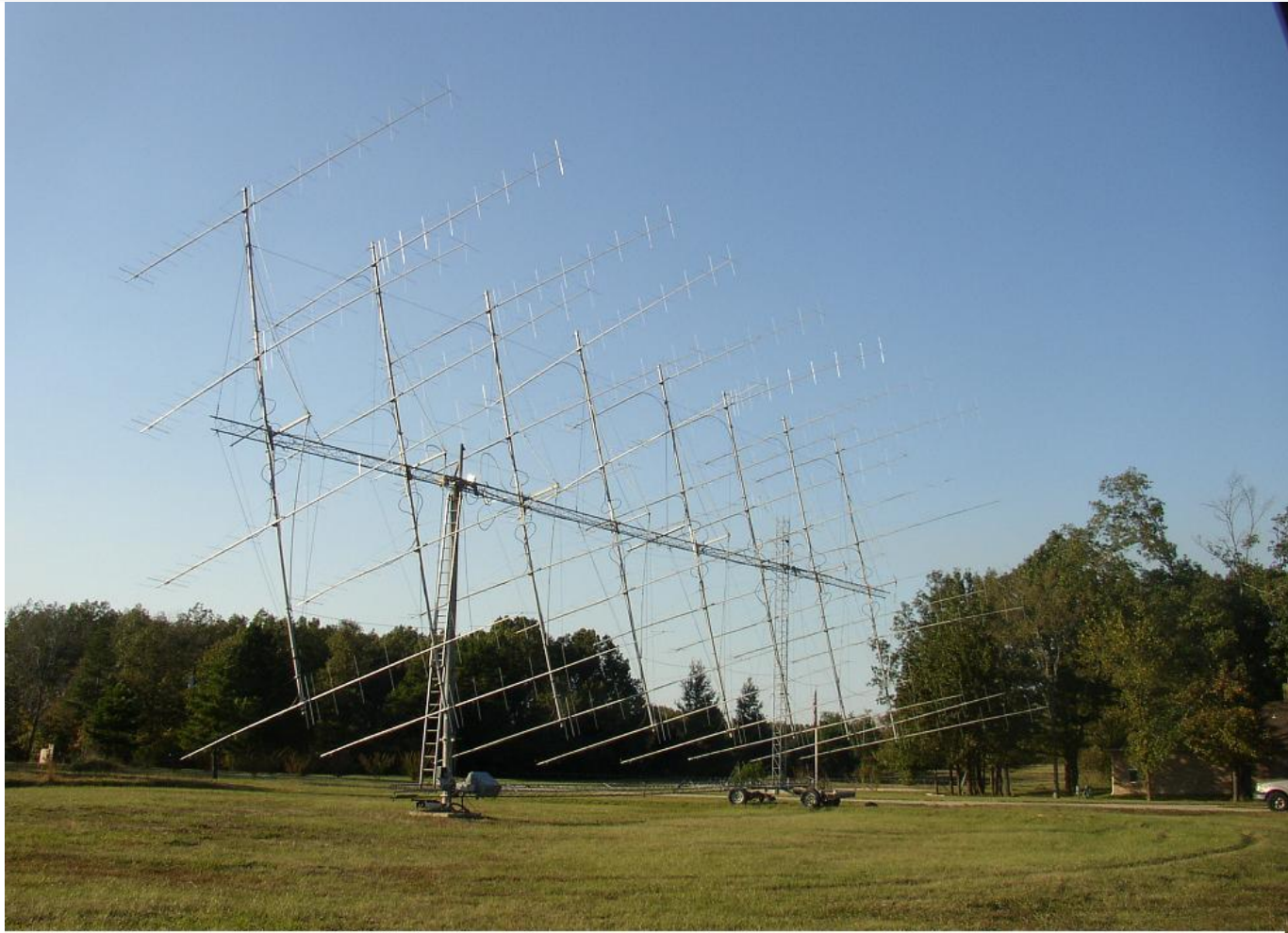


# Entry Level EME Antenna



Tuesday, April 16, 13

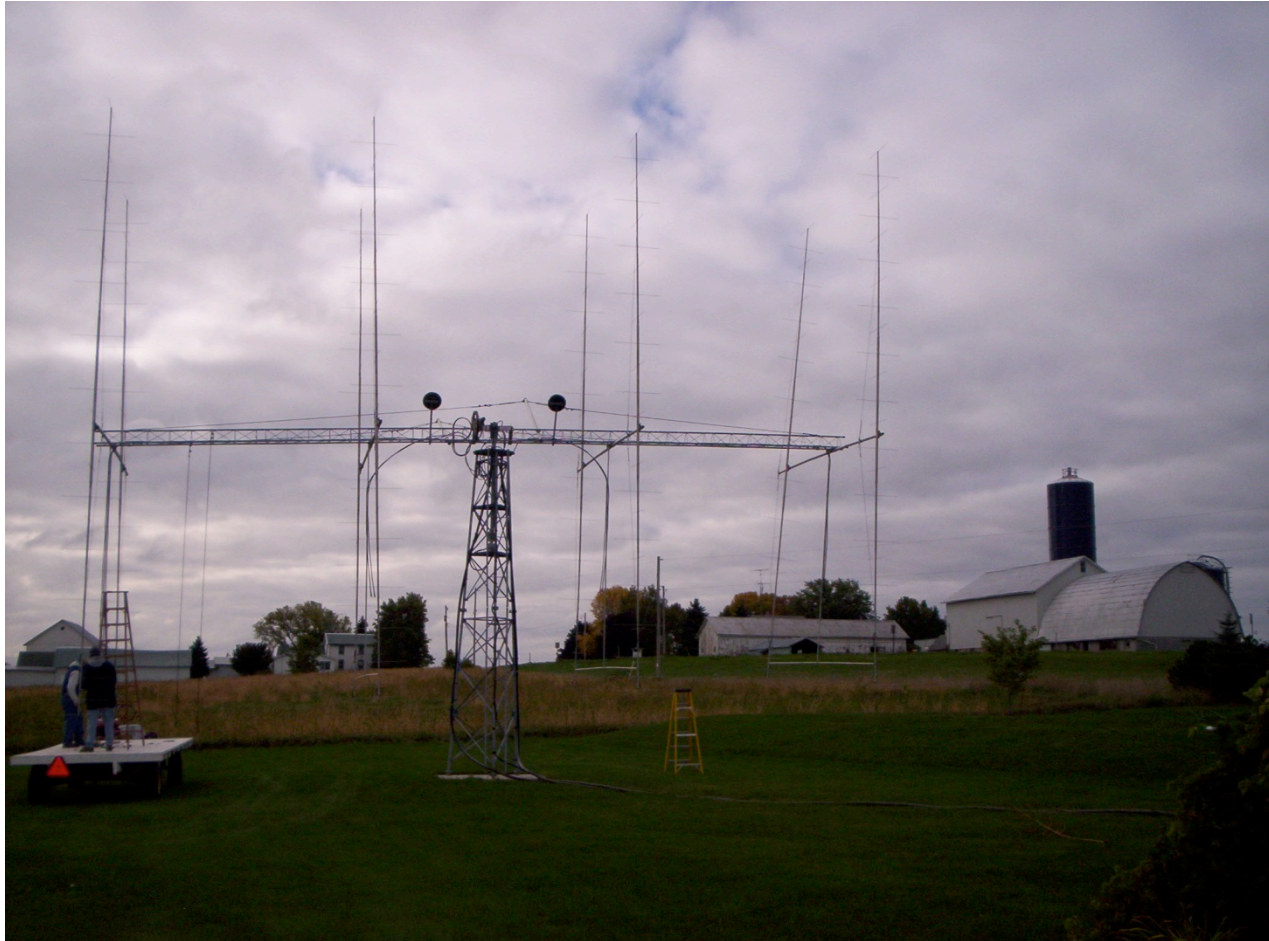
# W5UN



W5UN EME Array with 32 2M5WL horizontal antennas, and 32 front mounted ten element vertical antennas

Photo courtesy of Dave Blaschke, W5UN

# KJ9I



**W9GA Photo**

# W7IUV



Left: 8 X 8 Element, 2M

Right: 7' dish, 1296 MHz



Photos courtesy of Larry Molitor, W7IUV

# K1JT's WSJT Program

- WSJT – “Weak Signal Joe Taylor”
- Free PC Program Suite
- Uses special DSP techniques
- Modulation optimized for weak signal modes
- Dig out signals deep in noise
- JT-65 optimized for EME
  - Low data rates
  - Single tone per character
  - Narrow bandwidth
  - Decode calls to about -28dB, reports to about -30dB

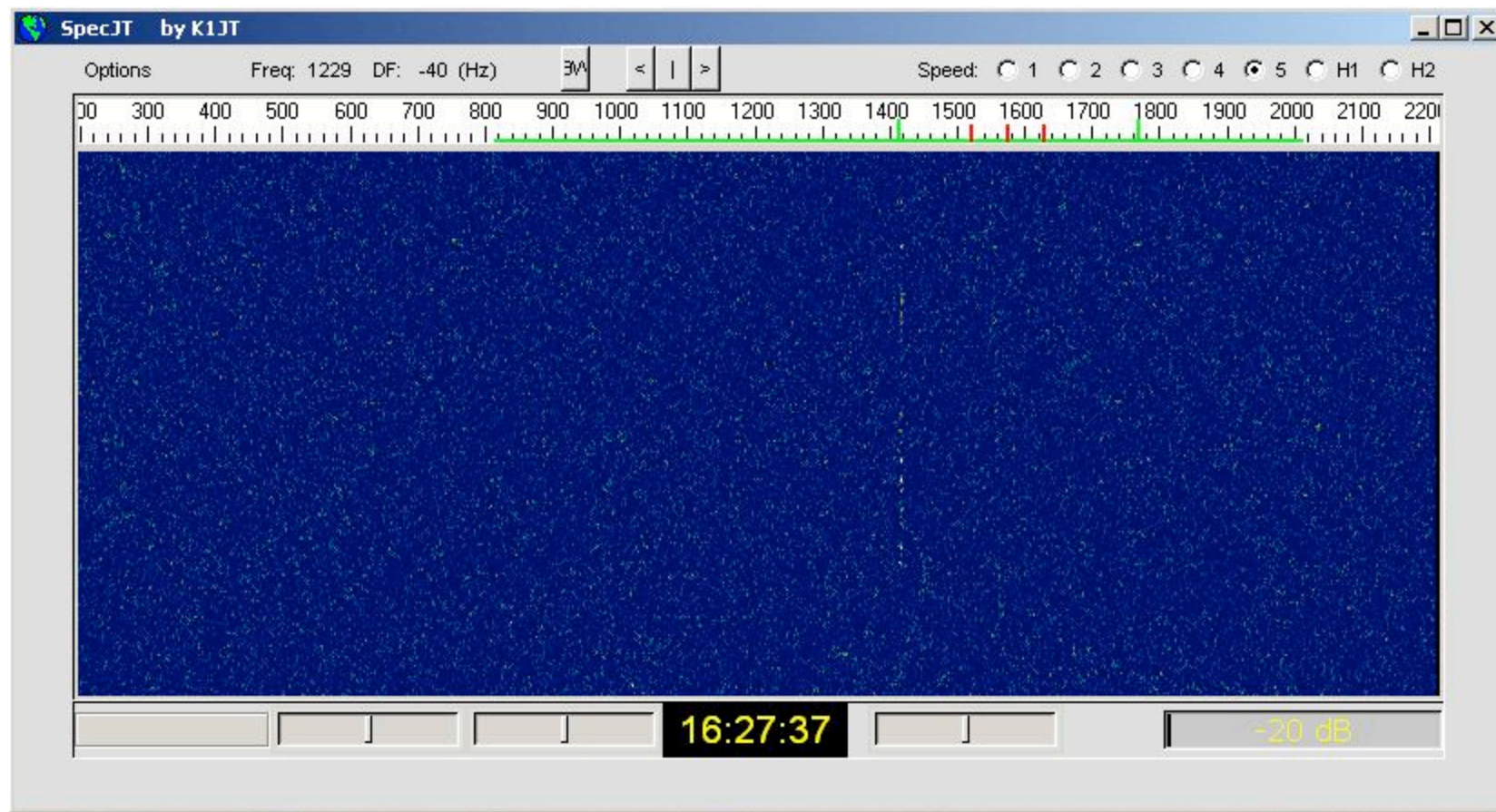
# K1JT WSJT – JT65 Mode

The screenshot displays the WSJT 7 software interface. At the top, the title bar reads "WSJT 7 by K1JT". The menu bar includes "File", "Setup", "View", "Mode", "Decode", "Save", "Band", and "Help".

The main window is divided into several sections:

- Spectrum Plot:** A green line graph showing signal strength over time. A red vertical line indicates a signal at 3.7 seconds. The plot is labeled "DK1CO\_100124\_214800".
- Moon Data:** A cyan box on the right displays moon position data:  
Moon  
Az: 104.89  
El: -20.67  
Dop: 58  
Dgrd: -5.9
- Log Table:** A table with columns: FileID, Sync, dB, DT, DF, W. The first entry is: 214800, 6, -23, 2.3, 118, 3 \* W9XT DK1CO J063 1 10. The second entry is: 214800, 1, 1/1, W9XT DK1CO J063 1 0.
- Control Panels:**
  - To radio:** DK1CO (Lookup), Grid: J063sx (Add), Az: 41, 4307 mi.
  - Sync:** Sync 1, Clip 0, Tol 400, Dsec 0.0, Shift 0.0.
  - Options:** Tx First (unchecked), Rpt (26), Sh Msg (checked), TxDF = 0, GenStdMsgs, Auto is Off.
  - Message List:** DK1CO W9XT EN53 (Tx1), DK1CO W9XT EN53 000 (Tx2), RO (Tx3), RRR (Tx4), 73 (Tx5), CQ W9XT EN53 (Tx6).
- Status Bar:** 1.0000 1.0001, JT65B, Freeze DF: 0, Rx noise: 0 dB, TR Period: 60 s, Receiving.

# SpecJT Waterfall Screen Shot



Signal Received: DL5BBW ES3RF KO29 OOO  
Signal -22dB – A strong one!

# JT65 EME QSO Sequence

**Stations alternate 1 minute transmissions:**

**Station 1 Transmission**

CQ W9XT EN53

DX1XX W9XT OOO

RRR

**Station 2 Transmission**

W9XT DX1XX ZZ99

RO

73

Each station transmits the current sequence until it receives the full response.



# Ping Jockey

**JT65 EME - 1.**

<a href="#">PingJockey Central</a>	<a href="#">JT65 Terrestrial</a>	<a href="#">JT65 EME - 2</a>	<a href="#">CW EME</a>	<a href="#">Who's Earwigging?</a>	
<a href="#">Distance/Bearing Locator</a>	<a href="#">Refresh</a>	<a href="#">Look back</a>	<a href="#">Update User details</a>	Gary, W9XT/2X13V/150 EN53uh	Refreshed 10/13 00:15

Exchanging any contact details on here before you're complete, invalidates the contact, and, if it's not JT65 via Moonbounce it doesn't belong here!

Enter your message here

MM/DD UTC  
10/12 23:28 stop cq ([WA3QPX/4MXP28KW](#) Paul DE FM29di 72.45.31.28)  
10/12 23:17 CQ144.144 2nd 10 min now v-pol ([WA3QPX/4MXP28KW](#) Paul DE FM29di 72.45.31.28)  
10/12 23:08 good echos with wsgt-9 in echo mode ([WA3QPX/4MXP28KW](#) Paul DE FM29di 72.45.31.28)  
10/12 23:05 Cq 144.144 H-pol 5 min 2nd ([WA3QPX/4MXP28KW](#) Paul DE FM29di 72.45.31.28)  
10/12 23:04 Rolf tnx fer info will look for you Friday, maybe condx better then. Have been looking past few days. 73 ([WA3QPX/4MXP28KW](#) Paul DE FM29di 72.45.31.28)  
10/12 22:56 auch = euch ([CT1HZE](#) Joe CT IM57nh 85.245.8.134)  
10/12 22:56 73 Rolf - muss leider am 22.10. zurueck nach DL und werde auch aus CE2 verpassen.... viel erfolg noch! ([CT1HZE](#) Joe CT IM57nh 85.245.8.134)  
10/12 22:50 das ist einer der im hintergrund die ohren spitzt... + (CE0Y/DK2ZF Rolf xx DG52hu 200.29.179.221)  
10/12 22:50 CQ CQ from Easter Island - EME ops will start again friday Rolf + (CE0Y/DK2ZF Rolf xx DG52hu 200.29.179.221)  
10/12 22:17 stop cq ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 22:11 no signal at all, thanks for trying ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)  
10/12 22:05 I have it throttled back to ~1200 W ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 22:04 what is your output power on 432 ? ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)  
10/12 22:02 Iexpect that my coaxial relays will arrive, than I'll have 800w ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)  
10/12 22:00 \*CQ\* \*CQ\* \*CQ\* //// 144.108 2nd \\\ \*CQ\* \*CQ\* \*CQ\* ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:59 by the weekend it will be better. when are you grv? ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:57 nope, not even a scratch ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)  
10/12 21:57 rrr david, anything felix??? ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:56 Sorry Tom, have to leave soon, was just seeing what was going on. ([AD4TJ4X15H4X11V](#) David VA FM08le 71.62.252.94)  
10/12 21:51 David, interested in 2m try??? ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:50 Hans, I would like to know that, too! ([AD4TJ4X15H4X11V](#) David VA FM08le 71.62.252.94)  
10/12 21:49 no clue hans ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:47 I am a new user, 2m Moonbounce ready. What means Earwigging ? ([HB9XJ](#) Hans xx JN47g7 84.74.103.146)  
10/12 21:47 ok ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)  
10/12 21:46 432.060 ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:46 felx, making noise on 432..2nd ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:42 stop cq... warming up the 432 amp ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:41 yes big noise , my station is modest too, 4 x18el ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)  
10/12 21:37 felx, we could try, but with the high sky noise, it might be a waste of time. ([KD9NH/4X17/ORO](#) Tom WI EN44wv 71.87.25.83)  
10/12 21:36 RX on 432.060 ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)  
10/12 21:34 I just installed a LNA, still waiting for the relays, I'm wondering if I could copy you ([VA3GMT](#) Felix ON FN03iv 99.247.18.46)

Many EME QSOs are scheduled on Ping Jockey

# EME Results

## K3CB EME Results

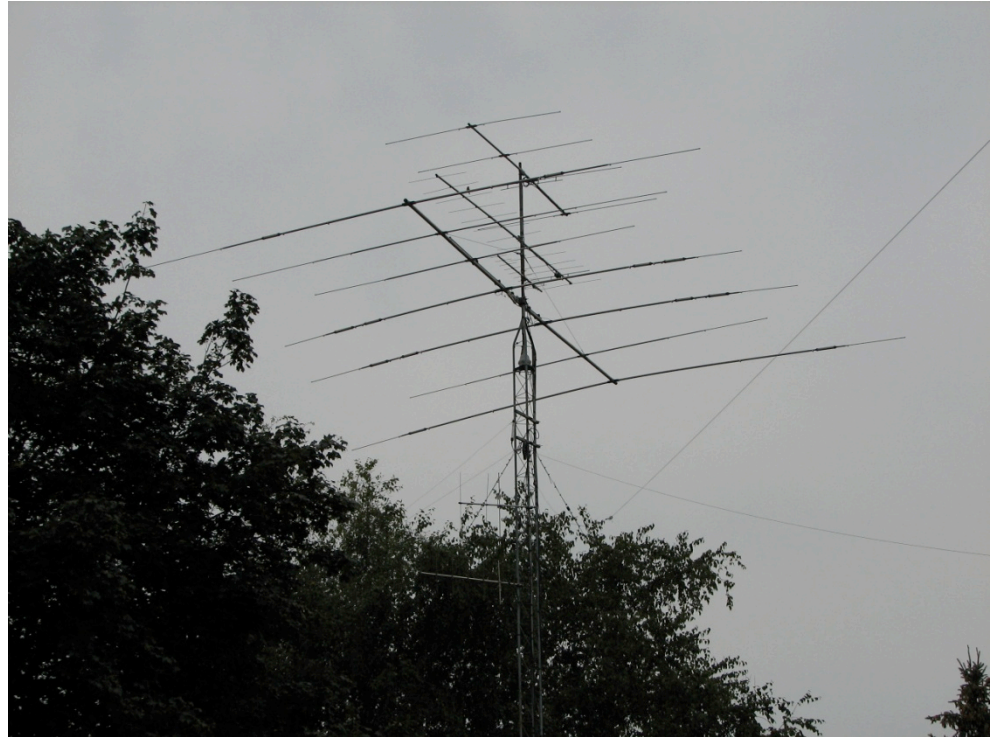
- ~ 240 QSOs
- ~36 DXCC countries
- A few new west coast states, Alaska, and Hawaii

**There are several dozen big EME stations capable of working 100 watt single Yagi stations**

**These stations are always looking for new stations to add to their “initial contact” list**

# Minimum EME Station

- Long horizontal Yagi
- SSB transceiver w/100 watts
- PC
- PC sound card interface
- WSJT Program
- Work at moon rise/set
  - Get about 6 dB ground gain
  - Don't need elevation rotor



Plus a big gun station at the other end!

Are you able to do EME with your station?

# EME Resources

- **WSJT Download:** [www.physics.princeton.edu/pulsar/K1JT/](http://www.physics.princeton.edu/pulsar/K1JT/)
- **N0UK Ping Jockey page:** [www.chris.org/cgi-bin/jt65emeA](http://www.chris.org/cgi-bin/jt65emeA)
- **Moon-Net Internet mailing list:** <http://www.nlsa.com/nets/moon-net-help.html>
- **DF2ZC 2M EME Newsletter:** [www.df2zc.de/newsletter/index.html](http://www.df2zc.de/newsletter/index.html)
  - News
  - DXpedition schedules
  - Best condition calendar
- **Unified Microsystems:** [www.unifiedmicro.com](http://www.unifiedmicro.com)
  - Inexpensive PC sound card to radio interface kit

# Not Ready for EME?

## Try Meteor Scatter!

- Bounce VHF signals off meteor trails
- Range out to about 1400 miles
- Most activity 6 and 2 Meters
- Smaller station
  - 50 watts & small Yagi
- Uses WSJT FSK441 mode
  - Optimized for short bursts (~250 msec to transmit exchange)
  - 30 second transmission sequences
- Best during meteor showers but high success rate with random meteors

# Acknowledgements

Moon and Earth Images: NASA  
Goldstone Antennas: NASA

## **Station and antenna pictures:**

Dave Blaschke, W5UN

Larry Molitor, W7IUV

Ken Boston, W9GA

Thank you for listening, there is much that can be learned about EME, no one I know of has ALL the answers, so there is no such thing as a “stupid question”. Ask away!!!