Moon Bounce For QRPers

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

Owen Wormser, K3OB

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 ~0.5°
- Moon reflects only ~7% of signal
- Average 144 MHz path loss: ~250 dB

What is 250 dB?

- Ratio of 10,000,000,000,000,000,000,000,000 : 1
- Difference between1KW and 0.1µW is only 100dB, 2KW and 0.1µW 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

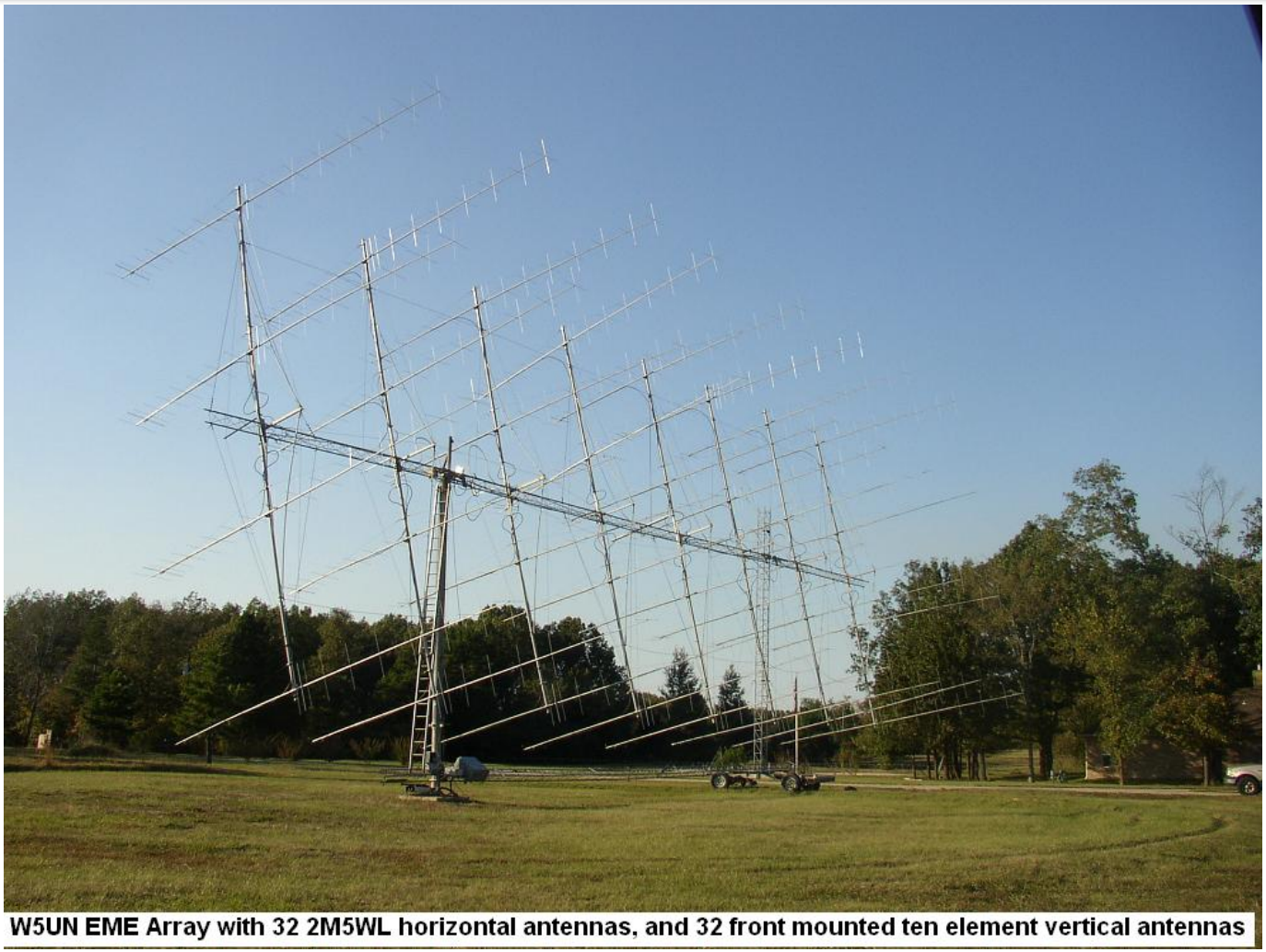
Σ(gains) – Σ(losses) > Noise

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

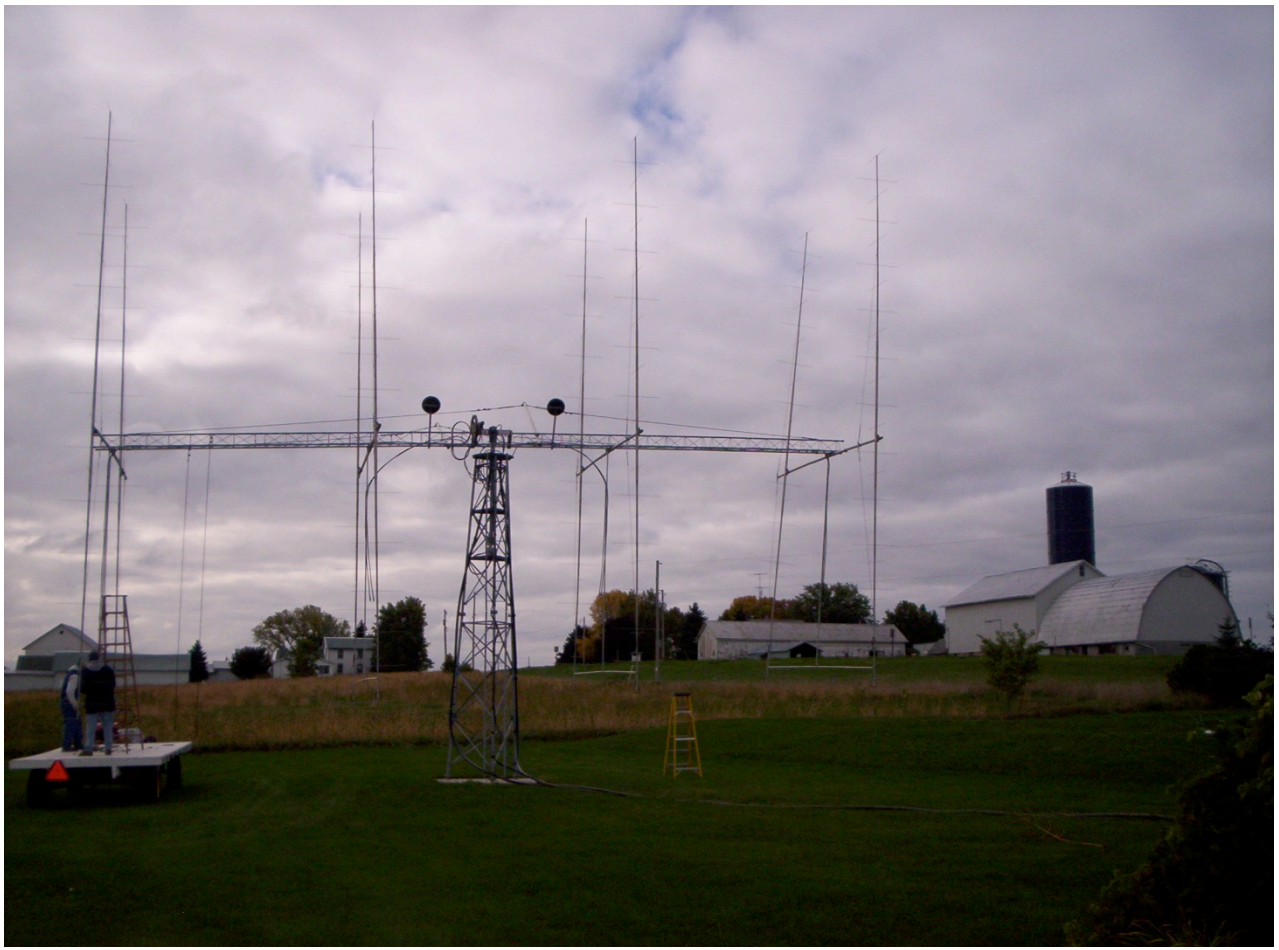
W5UN



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

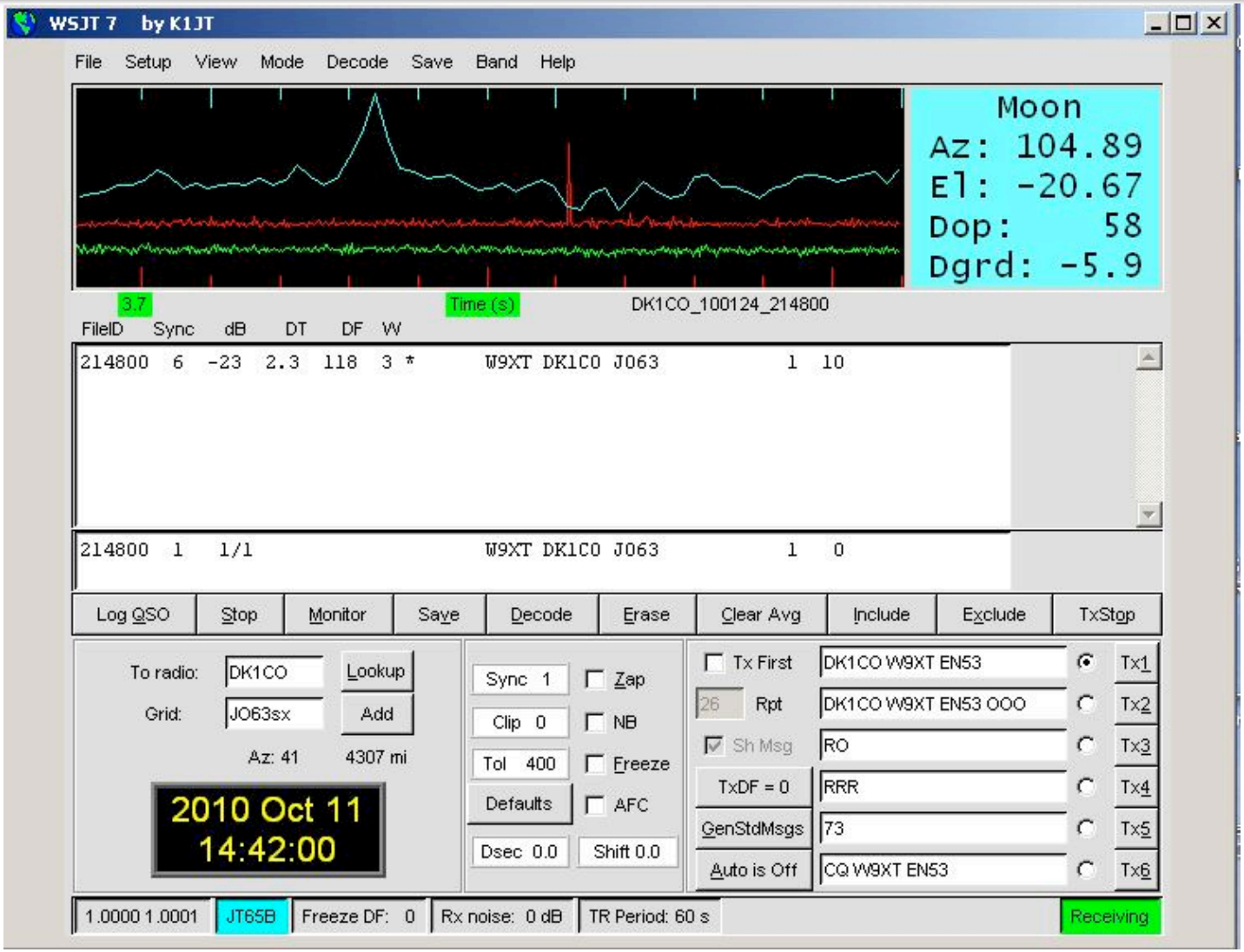
Right: 7’ dish, 1296 MHz

Photos courtesy of Larry Molitor, W7IUV

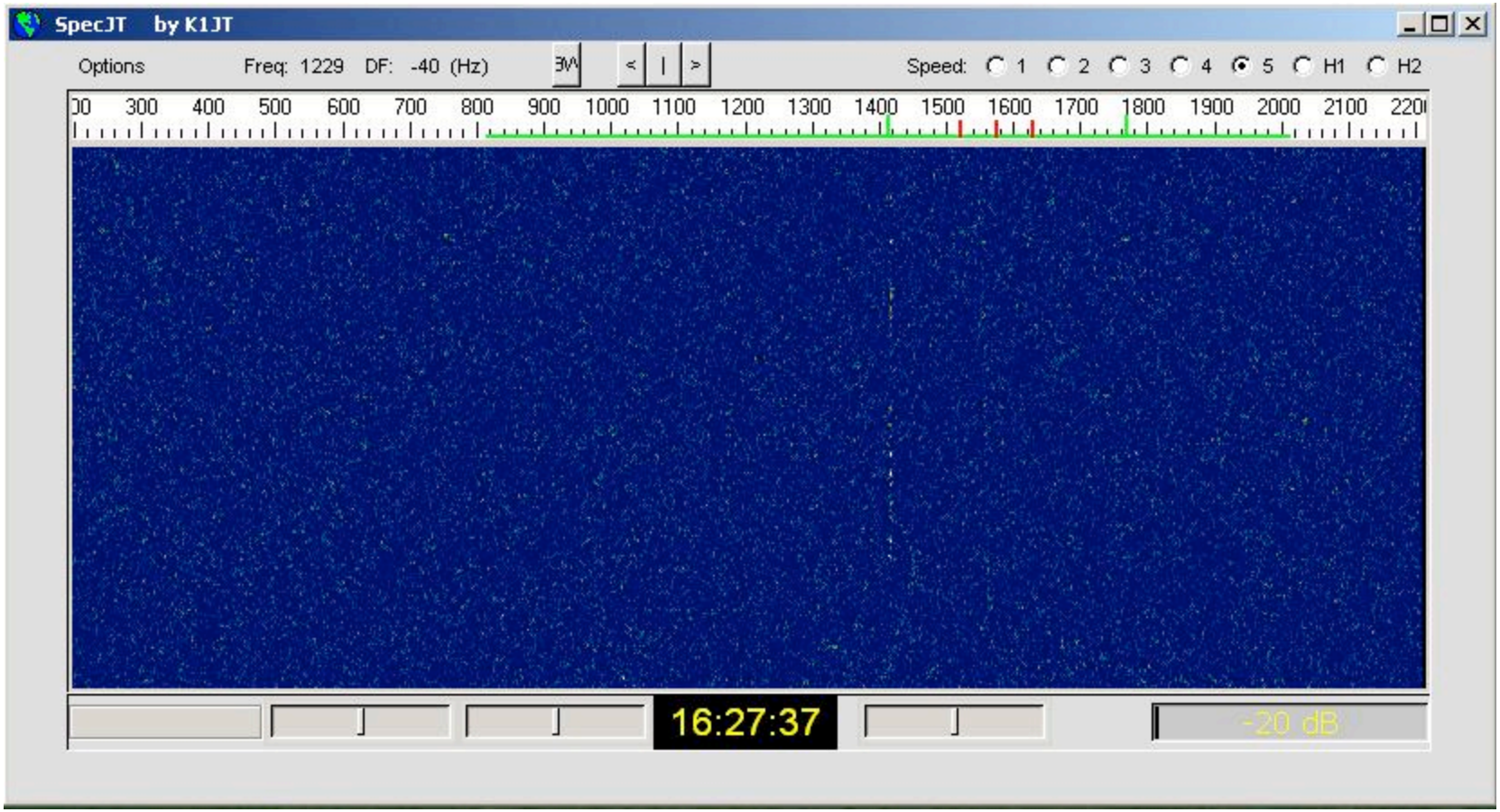
K1JT's WSJT Program

- 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



SpecJT Waterfall Screen Shot



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

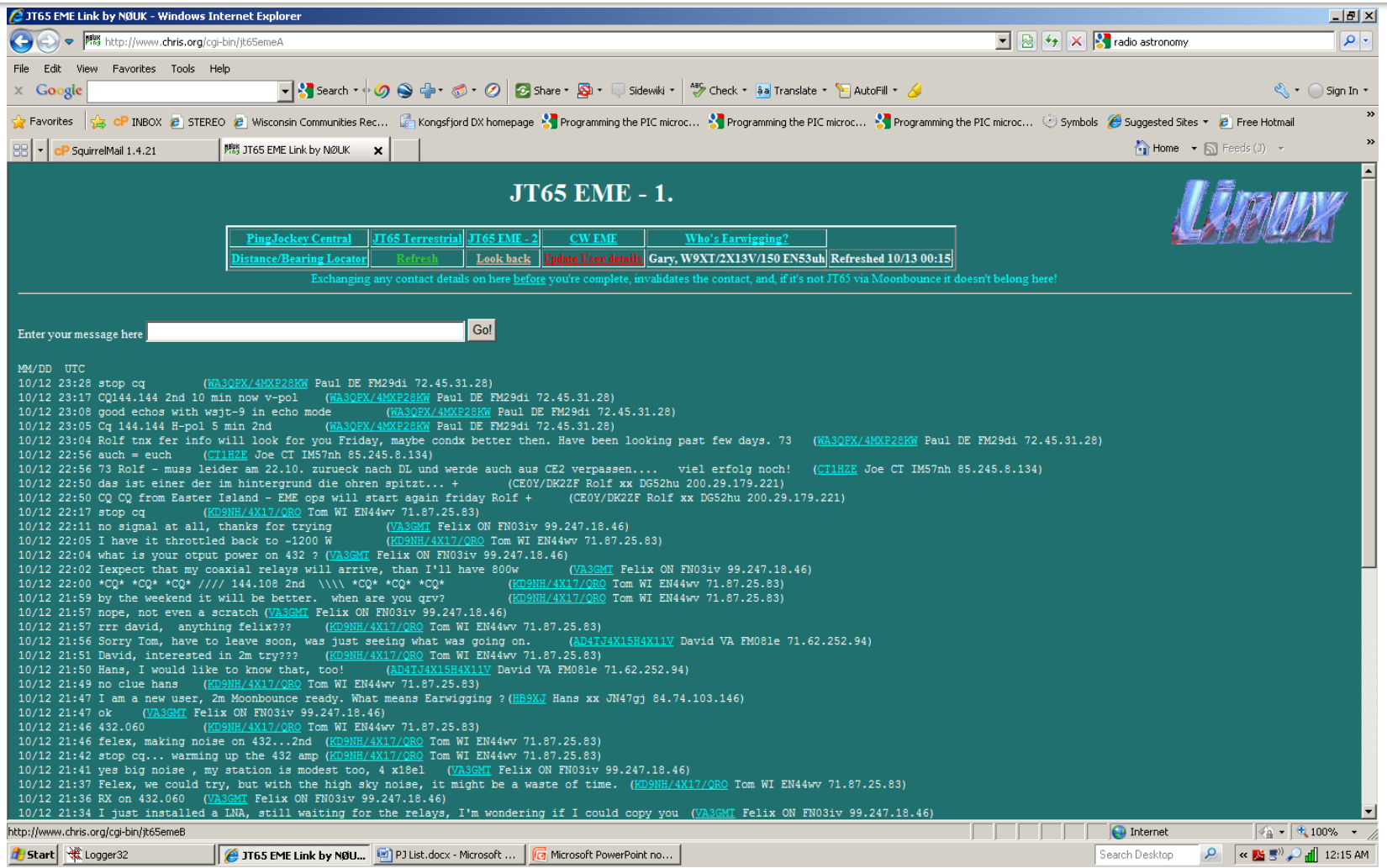
JT65 EME QSO Sequence

Stations alternate 1 minute transmissions:

Station 1 Transmission	Station 2 Transmission
CQ W9XT EN53	
	W9XT DX1XX ZZ99
DX1XX W9XT OOO	
	RO
RRR	
	73

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

Ping Jockey



Many EME QSOs are scheduled on Ping Jockey

EME Results

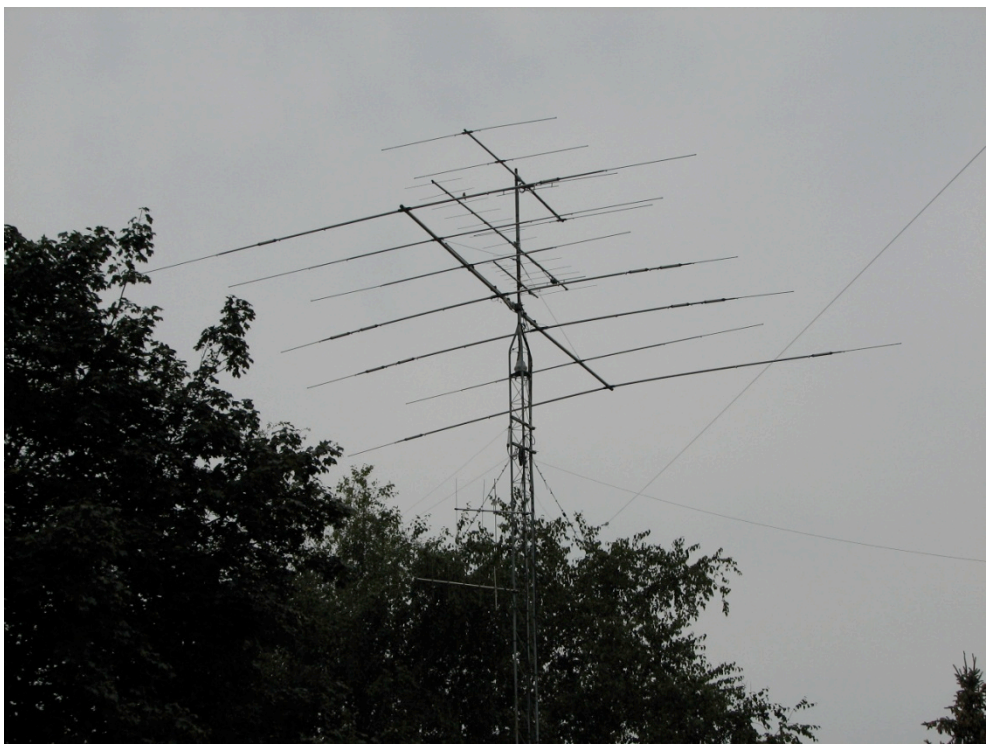
K3CB EME Results

- ~ 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/**
- **N0UK Ping Jockey page: 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**
  - **News**
  - **DXpedition schedules**
  - **Best condition calendar**
- **Unified Microsystems: 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

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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!!!