

# Moonbounce for the Masses

By:

Bob DeVarney W1ICW

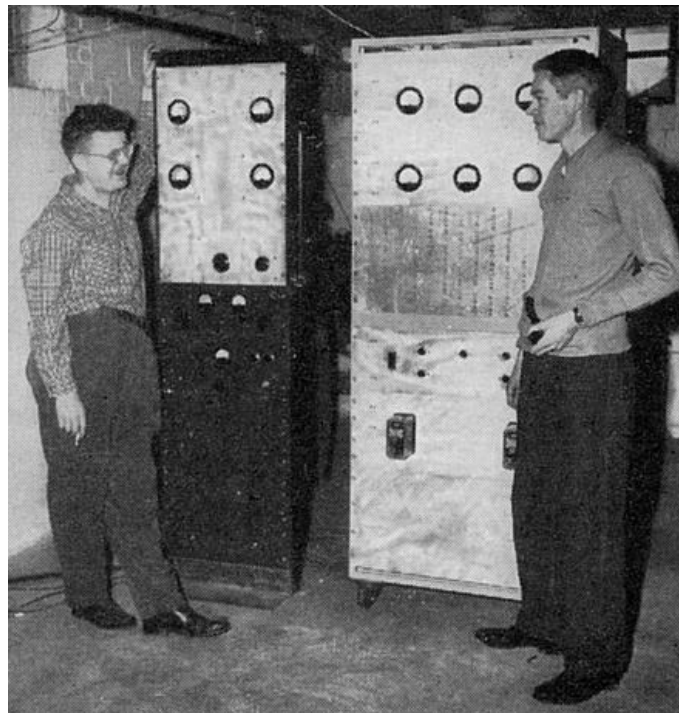
# History of Moonbounce

- Project Diana, US Army FT Monmouth, NJ in 1946
- 3000 watts
- 24 dB collinear



# First Amateur EME

- January 1950 between W4AO and W3GKP
- 2 meters, 32 element array
- 1 kw output power
- Echoes only
- First 2-way in 1960



## EME in Vermont

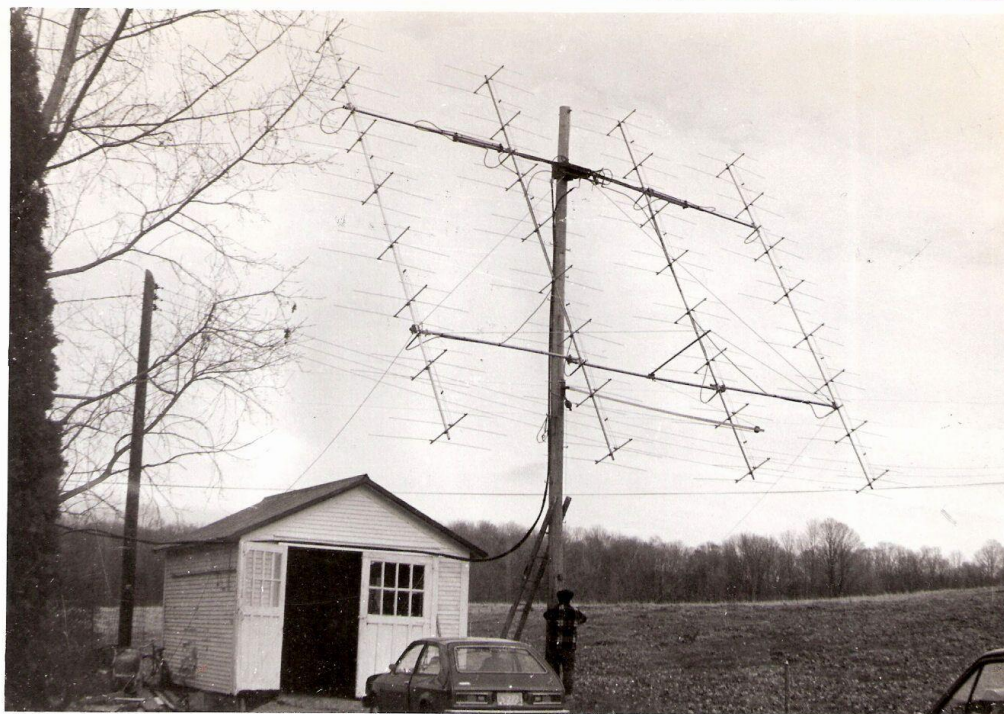
- Al Parrish K1KKP made two 60 foot helix antennas in 1965 and worked moonbounce from Peru, VT for Vermont's first EME effort.



## EME in Vermont

Warren, K1BKK was Vermont's second EME op circa 1975 with a 160 element collinear array running 1 kw from a pair

of 4CX250Bs in a K2RIW-design amplifier from his home in Charlotte, VT



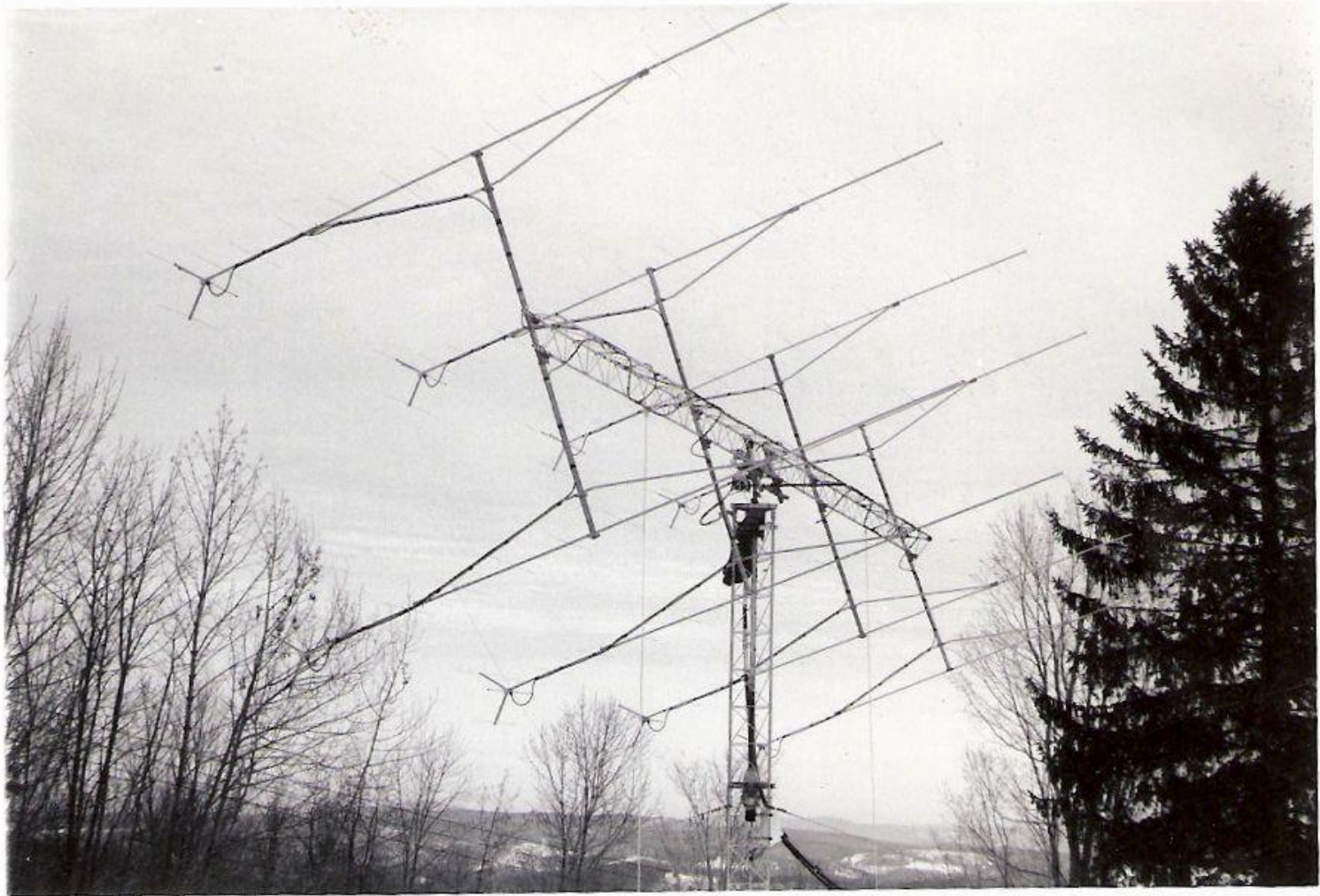
160-el Cushcraft collinear

K1BKK 2M EME

1975



Lance, WA1JXN, ( now W7GJ ) was third from Bridgewater VT  
Now, from Montana, he is the undisputed 6 meter EME king.



# Fast forward to 2010



# Design Considerations:

- Antennas small enough to use standard rotors; large enough to get the job done
- Small ( less than 500 watt ) amplifier to start
- Build as much as possible to save \$\$\$
- Zero dollar investment. Sell off surplus gear to fund the project
- First 10 QSOs made using existing gear to test the concept



# First EME QSOs from W1ICW

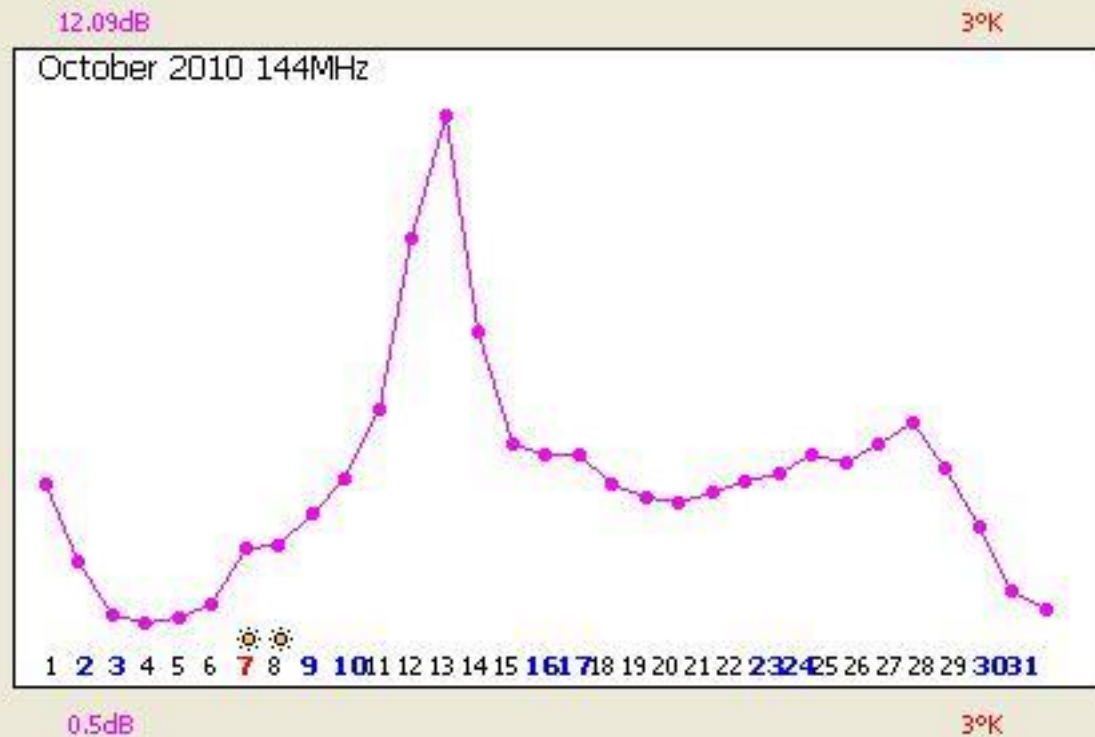
- Used existing satellite antenna ( M2 2MCP14 ) and existing radio ( Kenwood TS-2000X ) running 100 watts/ SSB mast mount preamp
- First QSO on January 31 2010 with RK3FG ( degrade 0.2 dB )
- Second QSO February 3 with Gary, KB8RQ ( degrade 2.5 dB )
- Third QSO I2FAK Feb 21 ( degrade 3.7 dB )

# So what is degrade?

- Combination of background cosmic radiation ( sky noise ) and extra loss from elliptical orbit of moon
- Predictable and repetitive
- Can be planned for
- Sun noise also effects propagation

# Moon Graph

File Edit Window Help



## Legend

### Weekend

Sun near Moon

Tsky

DGR

Range

Declination

Year Month

2010

10

## Display

Data Points

# So what has made QRP EME possible?

- 2001 Joe Taylor releases WSJT which is a suite of soundblaster based digital modes for weak signal work.
- They rely on DSP post-processing for increasing the S/N
- Can decode as low as 30 dB BELOW the noise !
- Listen for 48 seconds, process, then tx for one minute in JT65B

# What has WSJT done for us?

- First ever single yagi to single yagi EME
- First ever 6 meter EME
- Small stations can now work EME
- 10 elements and 100 watts all you need now
- (I've actually done it with 7 elements and 100 watts )
- Revolutionized moonbounce for good and brought it to the masses



# What does it look like?

The screenshot displays a desktop environment with several windows open. On the left is a Mozilla Firefox browser window titled "JT65 EME Link by N0UK". The address bar shows "http://www.chris.org/cgi-bin/jt65eme". Below the browser is a chat window with a list of messages and a text input field. The messages include call signs like K5GMX, DL8SCQ, and DK5SO, along with technical details and casual conversation.

In the center-right is a spectrum analyzer window titled "WSJT 7 by K1JT". The top bar shows "Options Freq: 1025 DF: -244 (Hz) Speed: 1 2 3 4 5 H1 H2". The main area is a dark blue plot with a white signal trace. A prominent peak is visible at approximately 1025 Hz. Below the plot is a table of detected signals:

FileID	Sync	dB	DT	DF	W			
141300	6	-21	2.4	-336	3	*	CE0Y/DK2ZF	SP20FW
141300	7	-17	2.5	-215	3	*	CE0Y/DK2ZF	ES6RQ
141300	5	-20	2.4	-108	3	*	CE0Y/DK2ZF	PA5MS
141300	4	-15	2.3	240	3	*	CE0Y/DK2ZF	IK1UWL
141300	3	-21	2.4	450	2	*	CE0Y/DK2ZF	PA1GYS
141300	5	-22	2.3	528	3	*	CE0Y/DK2ZF	PA3FPQ

Below the table are various control buttons like "Log QSO", "Stop", "Monitor", "Save", "Decode", "Erase", "Clear Avg", "Include", "Exclude", and "TxStp". There are also input fields for "To radio:" (CE0Y/DK2Z), "Grid:" (DG52gu), and "Az: 213 5446 mi". A digital clock shows "2010 Oct 07 15:29:00".

At the bottom of the screen is a Windows taskbar with several icons, including "start", "WSJT7", "JT65 EME Link by N...", "WSJT 7 by K1JT", "SpecJT by K1JT", "Moon Track", and the system clock showing "11:29 AM".

# What did it all cost ?

- Yaesu rotors \$ 530.00
- 300 watt amplifier and power supply \$ 440.00
- 4 M2 2M7 antennas \$ 624.00
- DEMI preamp \$ 75.00
- Assorted hardware and cable \$ 200.00
  
- Rough total cost was \$ 2000
- Entirely funded by sale of surplus gear no longer used



# Link Budget calculation:

**VK3UM EME Performance Calculator**

Two Station EME | Receiver Performance | Source Positions | Planets | x 10 Multiplier | Note Pad | Feed Type X ref | Version History | Help | About | Exit

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### Tx A (Home Station)

Frequency: 144 MHz | Path Loss: 250.79 dB | T Sky: 195 K | Rx BW: 2500 Hz

Diam: 2.00 mm | Mesh: 9.0 mm | Sys Sensitivity: -145.4 dBm | Echo S/N: -14.8 dB

Frequency: 79 | Path Loss: 0.10 dB | T Sky: 20.0 K | Rx BW: 2500 Hz

Solar Flux: 79 | LNA Loss: 0.10 dB | LNA Nf: 0.29 dB | LNA Gain: 24.5 dB | Coax Loss: 1.0 dB | Rx Nf: 0.8 dB | Side lobes: 10 K | Back Lobe: 40 K | Sun Y: 7.1 dB

Tx A Output Power: 300 Watts | Transmission Loss: 24.77 dBW | Power at Feed: 267 Watts | Moon Y: 17,463 W EIRP

Rx T°K 27.8 °K = 0.40 dB  
Receiver Noise Temperature: 290 °K | 17 °C

Sys T°K 272.8 °K = 2.88 dB  
System Noise Temperature: 290 °K | 17 °C

Dx Station as received at Home Station ... -14.5 dB

Home Station as received at Dx Station ... -15.5 dB

Moon Distance: Perigee: 356000 kms | Apogee: 356000 kms

### Yagi Array

Number of Yagis: 4 | E: 20.3 ° | Array Gain: 18.15 dB

Single Yagi Gain in dBi: 12.45 dB | Beam Width: 20.3 °

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### Parabolic Reflector

Feed Type: W2IMU dual-mode | Efficiency: 58% | Beam Width: 17.03 ° | Gain: 9155 | Dish Gain: 19.86 dB

Diameter: 8.56 m | Size: Metric | f / D: 0.43

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### Home Station ... Y Factor Calc

Noise Source:  Sagittarius,  Cassiopeia,  Cygnus,  Taurus A,  Virgo,  Termination

Quiet Source:  Termination,  Aquarius,  Leo,  Taurus,  TSKy,  CMB (3.4°K)

Noise Flux: 290 °K | Quiet Flux: 195 °K | System Tk: 272.8 °K

Point Source Y Factor: 0.27 dB

Aperture Source Y Factor: 2.97 dB

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### Yagi Array

Number of Yagis: 2 | E: 20.0 ° | Array Gain: 18.30 dB

Single Yagi Gain in dBi: 15.45 dB | Beam Width: 20.0 °

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### Parabolic Reflector

Feed Type: VE4MA (Super) | Efficiency: 63% | Beam Width: 58.29 ° | Gain: 9155 | Dish Gain: 9.52 dB

Diameter: 2.50 m | Size: Metric | f / D: 0.43

### Tx B (Dx Station)

Frequency: 144 MHz | Path Loss: 250.79 dB | T Sky: 195 K | Rx BW: 2500 Hz

Diam: 1.00 mm | Mesh: 12.7 mm | Sys Sensitivity: -144.5 dBm | Echo S/N: -15.2 dB

Frequency: 79 | Path Loss: 0.13 dB | T Sky: 35.4 K | Rx BW: 2500 Hz

Solar Flux: 79 | LNA Loss: 0.13 dB | LNA Nf: 0.50 dB | LNA Gain: 24.0 dB | Coax Loss: 0.7 dB | Rx Nf: 1.0 dB | Side lobes: 10 K | Back Lobe: 40 K | Sun Y: 7.0 dB

Tx B Output Power: 300 Watts | Transmission Loss: 24.77 dBW | Power at Feed: 280 Watts | Moon Y: 18,929 W EIRP

Rx T°K 45.8 °K = 0.64 dB  
Receiver Noise Temperature: 290 °K | 17 °C

Sys T°K 290.8 °K = 3.02 dB  
System Noise Temperature: 290 °K | 17 °C

Operating Frequency:  144 MHz |  900 MHz |  1296 MHz |  2304 MHz |  3456 MHz |  5760 MHz |  10.368 Ghz |  24.048 Ghz |  47.088 Ghz |  70 MHz |  406 MHz |  2295 MHz

Effective Aperture: 22.53 M² | Beam Width Ratio: 0.03

Moon Beam Fill Factor: 1.00 x | Sun Beam Fill Factor: 1.00 x | G/T Ratio: not known | Moon Temp @ 2.77cm Phase: 213 °K...0.2 °K

Moon Radar Eq.: 52.26 dB | Moon Flux 10°-22: 0.0010 | Moon Angular Diam: 0.559" | Actual Moon Temp: 213 °K...0.2 °K

Moon Return Loss: 250.79 dB | Moon Distance: 356400 kms | Free Space Loss at 144 MHz: 186.65 dB | Corrected sfu: 14

Note: Both Moon and Sun correction factors are applied to Home and Dx Station calculations.

Buttons: Save Data, Get Data, Default, Print, Exit

VK3UM Ver 7.04

# Bandwidth optimized for cw:

**VK3UM EME Performance Calculator**

Two Station EME | Receiver Performance | Source Positions | Planets | x 10 Multiplier | Note Pad | Feed Type X ref | Version History | Help | About | Exit

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**Tx A (Home Station)** Default

Frequency: 144 MHz | Path Loss: 250.79 dB | T Sky: 195 K | Rx BW: 50 Hz | Diam: 2.00 mm | Mesh: 9.0 mm | Sys Sensitivity: -162.4 dBm | Echo S/N: 5.8 dB

Effective ground T°K 281 °K | C/S - ground --> 0.3 dB

\* The Sun Calculation may not be accurate \*

8.8 °K | 20.0 °K | Spill: 6 °K

Solar Flux: 79 | LNA Loss: 0.10 dB | LNA Nf: 0.29 dB | LNA Gain: 24.5 dB | Coax Loss: 1.0 dB | Rx Nf: 0.8 dB | Side lobes: 10 °K | Back Lobe: 40 °K | Sun Y: 7.1 dB

Tx A Output Power: 700 Watts | Transmission Loss: 28.45 dBW | Power at Feed: 624 Watts | Moon Y: 27.95 dBW | 40,747 W EIRP

Rx T°K 27.8 °K = 0.40 dB | Receiver Noise Temperature: 290 °K | 17 °C | Sys T°K 272.8 °K = 2.88 dB | System Noise Temperature

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**Tx B (Dx Station)** Default

Frequency: 144 MHz | Path Loss: 250.79 dB | T Sky: 195 K | Rx BW: 250 Hz | Diam: 1.00 mm | Mesh: 12.7 mm | Sys Sensitivity: -161.5 dBm | Echo S/N: 1.8 dB

Effective ground T°K 281 °K | C/S - ground --> 0.0 dB

\* The Sun Calculation may not be accurate \*

8.8 °K | 35.4 °K | Spill: 0 °K

Solar Flux: 79 | LNA Loss: 0.13 dB | LNA Nf: 0.50 dB | LNA Gain: 24.5 dB | Coax Loss: 1.0 dB | Rx Nf: 0.8 dB | Side lobes: 10 °K | Back Lobe: 40 °K | Sun Y: 7.0 dB

Tx B Output Power: 300 Watts | Transmission Loss: 24.77 dBW | Power at Feed: 280 Watts | Moon Y: 24.47 dBW | 18,929 W EIRP

Rx T°K 45.8 °K = 0.64 dB | Receiver Noise Temperature: 290 °K | 17 °C | Sys T°K 290.8 °K = 3.02 dB | System Noise Temperature

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**Receiver Bandwidth ... defaults**

- JT65
- 125 Hz
- 500 Hz
- 50 Hz
- 250 Hz
- 10 Hz

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**Yagi Array** Number of Yagis: 4 | E: 20.3 ° | Array Gain: 18.15 dBi

Single Yagi Gain in dBi: 12.45 dBi | Beam Width: 16.00 dBd

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**Parabolic Reflector** Feed Type: W2IMU dual-mode | Efficiency: 58% | Beam Width: 17.03 ° | Gain: 9155 | Dish Gain: 19.86 dBi

Diameter: 8.56 m | Size: Metric | f / D: 0.43

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**Home Station ... Y Factor Calc**

Noise Source: Sagittarius, Cassiopeia, Cygnus, Taurus A, Virgo, Termination

Quiet Source: Termination, Aquarius, Leo, Taurus, TSky, CMB (3.4°K)

Noise Flux: 290 °K | Quiet Flux: 195 °K | System Tk: 272.8 °K

Point Source Y Factor: 0.27 dB

Aperture Source Y Factor: 2.97 dB

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Diameter: 2.50 m | Size: Metric | f / D: 0.43

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Effective Aperture: 22.53 M² | Beam Width Ratio: 0.03

Moon Beam Fill Factor: 1.00 x | Sun Beam Fill Factor: 1.00 x | G/T Ratio: not known | Moon Temp @ 2.77cm Phase: 213 °K...0.2 °K

Moon Radar Eq.: 52.26 dB | Moon Flux 10°-22: 0.0010 | Moon Angular Diam: 0.559° | Actual Moon Temp: 213 °K...0.2 °K

Moon Return Loss: 250.79 dB | Moon Temp: 356400 kms | Corrected sfu: 14

Free Space Loss at 144 MHz

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Operating Frequency

- 50 MHz
- 144 MHz
- 222 MHz
- 432 MHz
- 900 MHz
- 1296 MHz
- 2304 MHz
- 3456 MHz
- 5760 MHz
- 10.368 GHz
- 24.048 GHz
- 47.088 GHz
- 70 MHz
- 406 MHz
- 2295 MHz

Free Space Loss at 144 MHz

VK3UM Ver 7.04

# So how has it worked?

- 139 QSOs since erecting new array May 15
- 120 different stations worked
- 103 grid squares worked
- 35 DXCC worked
- 18 states worked
- All worked with 4 7-element yagis, 300 watts, .3 dB NF preamp, and Elecraft K2/XV-144 transverter



# Things to consider:

- Choose best times to operate for optimal success
- Choose moonrise or moonset times to get ground gain
- 10 element yagi or better
- 100 watts or better
- Preamp as close to the antenna as possible

# Links:

WSJT Home page for WSJT software: <http://www.physics.princeton.edu/pulsar/K1JT/>

Home page for the VK3UM EME calculator software : <http://www.sm2cew.com/download.htm>

GM4JJJ MoonSked moon tracking and prediction software:  
<http://www.gm4jjj.co.uk/MoonSked/moonsked.htm>

G8KBB Noise Meter software to measure sun noise : <http://g8kbb.roberts-family-home.co.uk/NoiseMeter.zip>

Project Diana history : <http://www.k3pgp.org/1946eme.htm>

Amateur EME history : <http://www.ok2kkw.com/eme1960/eme1960eng.htm>

W7GJ web page ( lots of useful information ) : <http://www.bigskyspaces.com/w7gj/>

Moon-Net reflector signup ( to sign up for the EME reflector ) : <http://www.nlsa.com/nets/moon-net-help.html>

N0UK JT65B spotter page ( online frequency spots plus chat ) : <http://www.chris.org/cgi-bin/jt65emeA>

LiveCQ on 144 ( frequency spots from automated receivers ) : <http://www.livecq144.com/>