

VHF/UHF weak signal equipment and operations

1. Overview of Antennas, Preamps, Amplifiers
2. Range Improvement through Gain/Power
3. Advantage of Narrowband Modes (CW, SSB, FT8)
4. External Noise Effects
5. Useful VHF/UHF Propagation Effects
6. Amateur Radio Satellites: LEO, MEO, & GEO
7. VHF/UHF Equipment, Nets and Resources

Jim Eagleson , WB6JNN
jeagleson945@gmail.com
youtube/jimeagle1
(see Radio Electronics Stuff)



VHF/UHF weak signal equipment and operations

1. Extend VHF/UHF Point-to-Point Range Using Higher Antenna Gain

This applies to *any* antenna and *any* mode

RX Sensitivity Improvement is $10^{((-Gain \text{ in dBi})/20)} \times \text{Original Sensitivity}$

(Note: I use a negative sign in front of the antenna gain in the formula to get the proper multiplier.)

Example: If Sensitivity is 0.25uV using a 0dBi gain antenna, use of a 2.15dBi antenna (a dipole) provides the same Signal to Noise Ratio (SNR) with a lower incoming signal

$$\text{New Sensitivity} = 10^{(-2.15 / 20)} \times 0.25\text{uV} = 0.78 \times 0.25 = \underline{0.195\text{uV}}$$

Some Calculated values for other antenna gains:

$$3\text{dBi} = 0.707 \times 0.25 = 0.177 \text{ uV}$$

$$6\text{dBi} = 0.501 \times 0.25 = 0.125 \text{ uV}$$

$$9\text{dBi} = 0.355 \times 0.25 = 0.089 \text{ uV}$$

$$12\text{dBi} = 0.251 \times 0.25 = 0.062 \text{ uV}$$

BUT....

OMNI-DIRECTIONAL ANTENNA GAIN DOES NOT ALWAYS IMPROVE RECEIVER PERFORMANCE IN THE PRESENCE OF NOISE, INTERFERENCE OR MULTI-PATH.

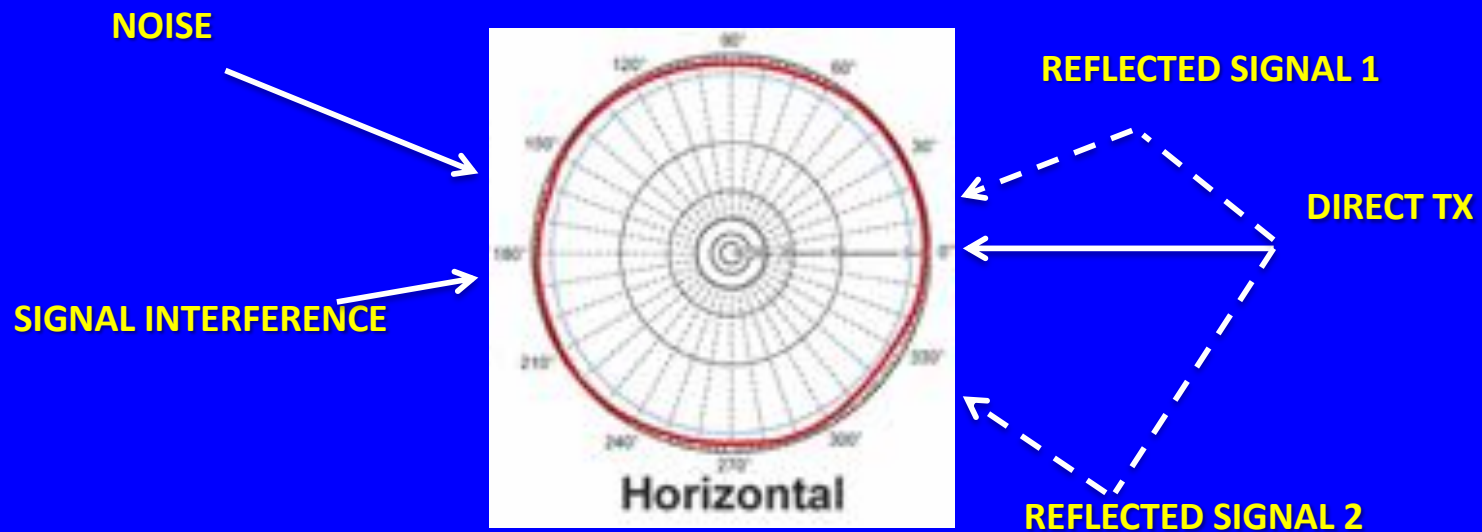


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An Omni doesn't eliminate noise, unwanted signals, or multipath reflections.

1. *Noise Sources* surrounding your location will be picked up with the same gain as the desired signal. Thus no improvement in Signal-to-External Noise.
2. *Interference Sources* surrounding your location will be picked up with the same gain as the desired signal. Signal-to-Interference will not improve.
3. *Reflected Signals* surrounding your location will be picked up with the same gain as the desired signal. Signal-to-Multipath will not improve.



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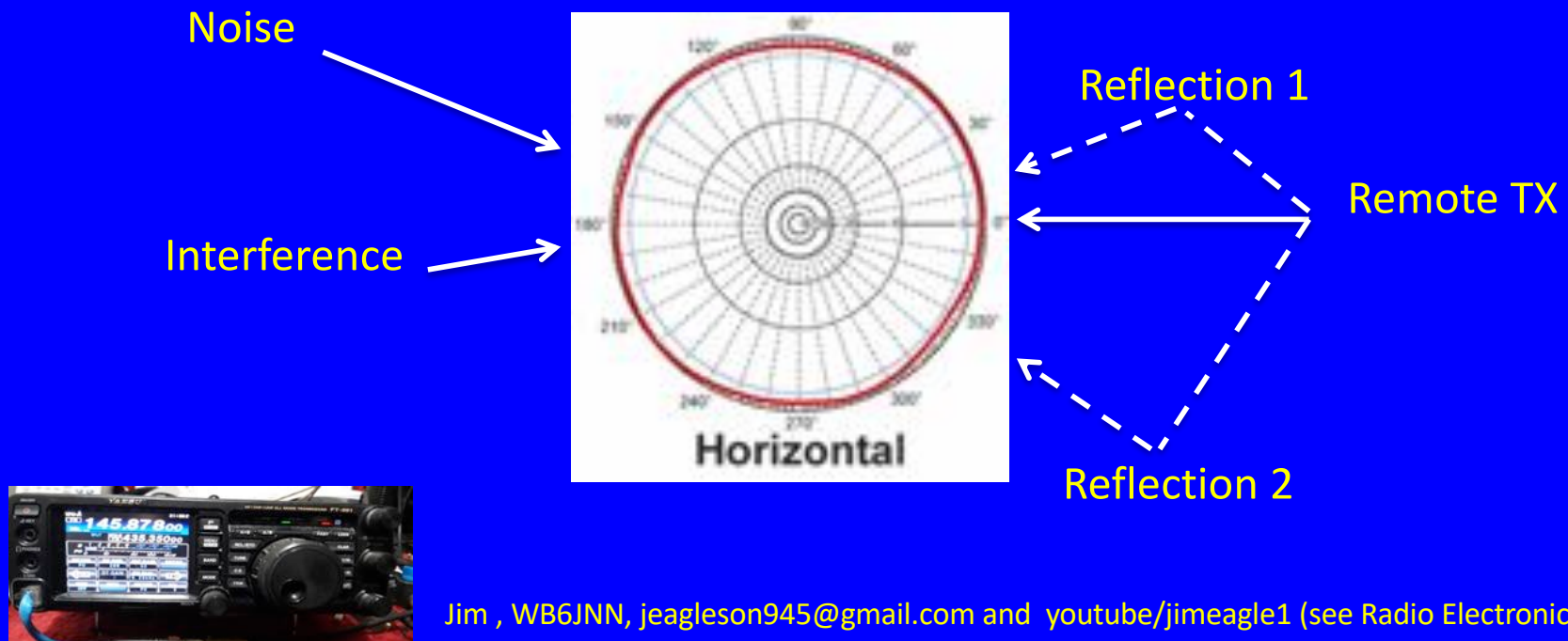
VHF/UHF weak signal equipment and operations

A Preamplifier often doesn't help with external noise, unwanted signals, or multipath reflections. It will amplify the noise, unwanted signals, or multipath signals along with the desired signal.

A preamp is most effective when long coax cable length causes significant signal loss.

A mast mounted preamp will help in *quiet* locations or when a narrow beam antenna is *aimed above the earth* at the moon or satellites.

A Power Amplifier used on the other end of the circuit *will* be effective since it raises the desired signal level at the your receiver compared to noise or interference at your location. It won't help with multipath problems, however.

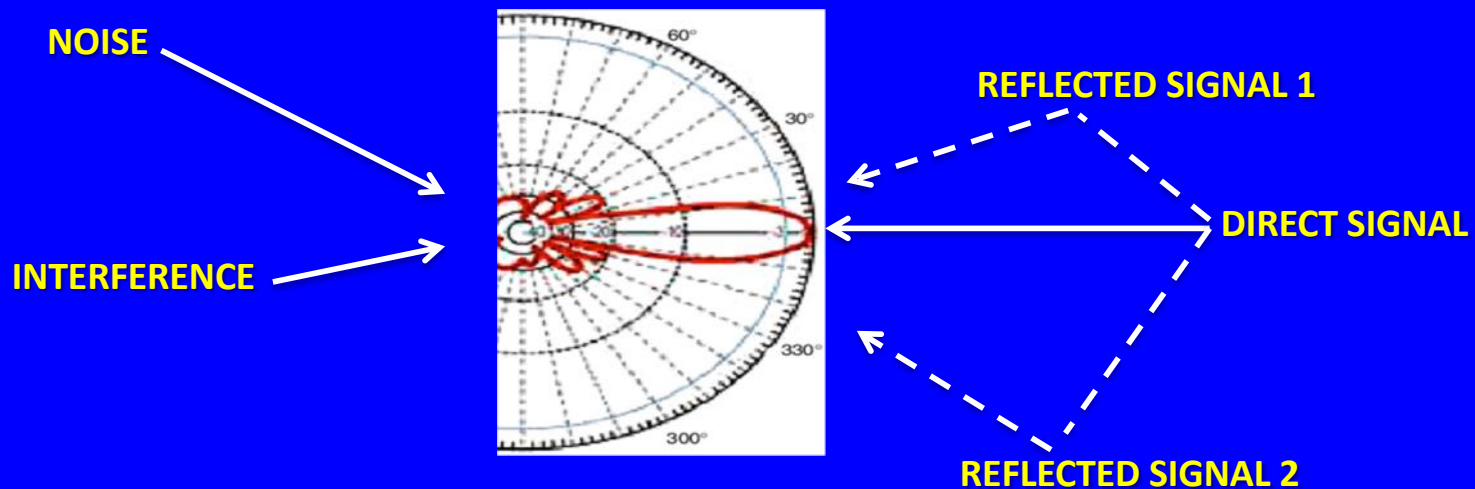


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A *Directional Antenna*, like a high gain Yagi, often *does* eliminate unwanted interference signals, external noise, or multipath reflections during reception.

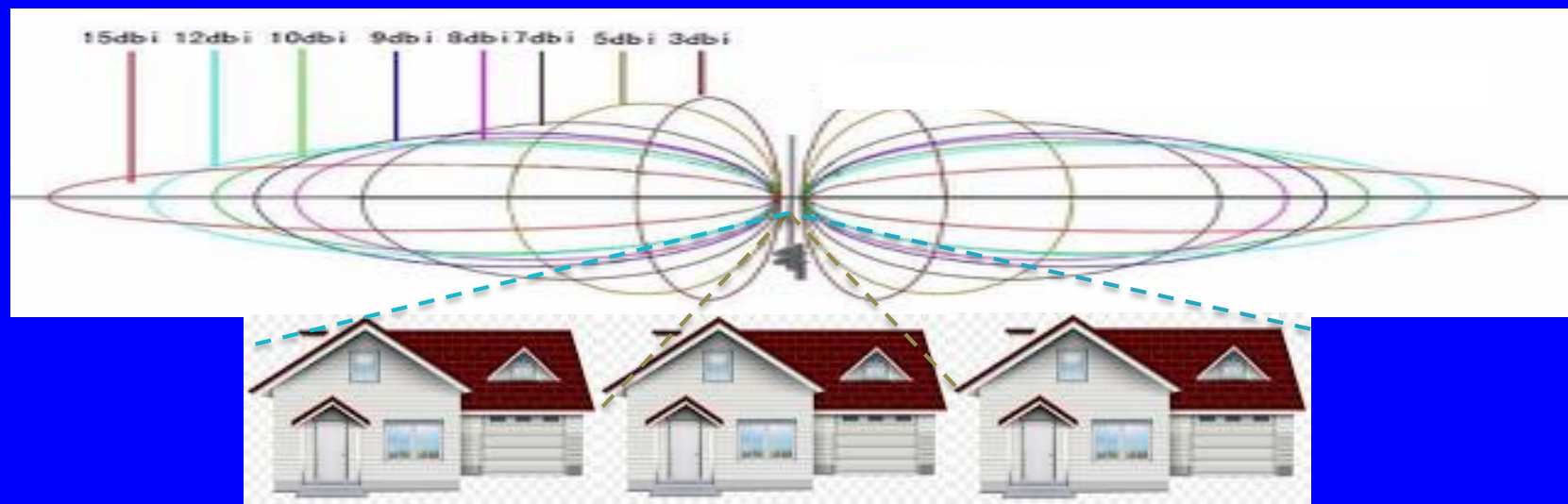
1. *Noise Sources* surrounding your location will be reduced in strength in *most* directions.
2. *Interference Sources* surrounding your location will be reduced in *most* directions.
3. *Reflected Signals*, or multipath, will be reduced depending on their direction by about 3-10dB for Signal 1 and almost entirely for Signal 2 as shown below...



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High Gain Omni Vertical *may* offer protection from noise and Interference sources *under* the antenna in the null or where vertical pattern has been flattened towards the horizon. It *may* offer *some* protection against neighboring house interference sources such as LED lights, Computers, etc.) but only if the Gain is high enough to narrow the vertical pattern sufficiently to reduce those sources (see the 5 and 15dBi patterns below, for examples).



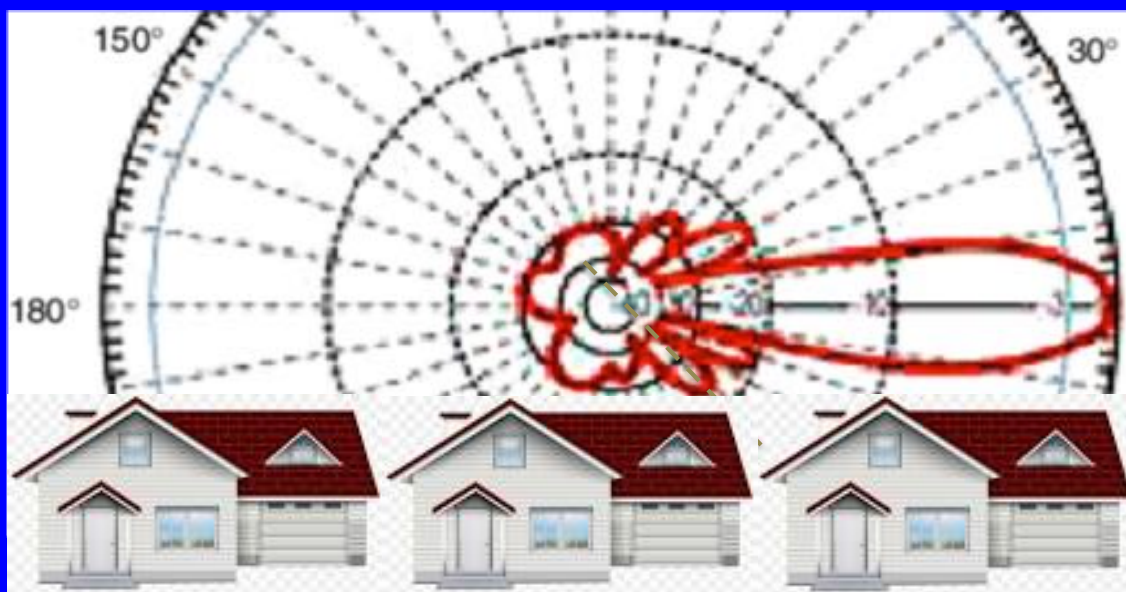
Note that the 7dBi antenna (Black Lines) has less gain over the length of the house on which it is mounted compared to the 3dBi antenna. The 15dBi antenna has less gain over both the center house *and* the houses on either side but will be physically quite large at 2m or even 70cm (432MHz).



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A High Gain Directional Antenna should offer 10-20dB protection from Noise and Interference Sources *under* the antenna in all directions except in its main reception lobe as shown below. The amount of protection will depend on the minor lobes present in the particular beam pattern. Satellite and Moonbounce antennas will also pick up less surrounding Noise and Interference when aimed significantly above the horizon.



Note: When using *any* antenna that has Gain higher than your present antenna you may also see an increase of Noise and Interference levels *in the antenna's favored direction*. However the level of the Desired Signal will also be raised by the same amount.



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RX Range Improvement Due to Antenna Gain:

In *Free Space* with no interference or noise sources the additional range will be:

$$\text{RX Range Multiplication} = 10^{(\text{Gain in dB}/20)}$$

Example: 6dB Antenna Gain provides:

$$\text{Multiplier} = 10^{(6\text{dB}/20)} = \underline{1.99} \text{ times}$$

Thus 50 miles becomes $50 \times 1.99 = 99$ miles reception range, again assuming there are no noise or interference sources within the pattern of the antenna.

But...

Multipath reflection may also reduce the signal levels or distort signals or more likely it will be that objects or terrain may block the signal or create multipath reflections.



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Earth Curvature Negatively Impacts RX Range Improvement:

Free Space only applies to unobstructed Line-of-Site such as Earth to a Satellite.

Plane Earth losses follow a different formula:

$$\text{RX Range Multiplication} = 10^{(\text{Gain in dB}/40)}$$

Example: 6dB Antenna Gain over a curved earth actually provides:

$$\text{Multiplier} = 10^{(6\text{dB}/40)} = \underline{1.41} \text{ times}$$

Thus 50 miles becomes $50 \times 1.41 = \underline{70 \text{ miles reception range}}$, again assuming there are no noise or interference sources or blockage within the pattern of the antenna.

And

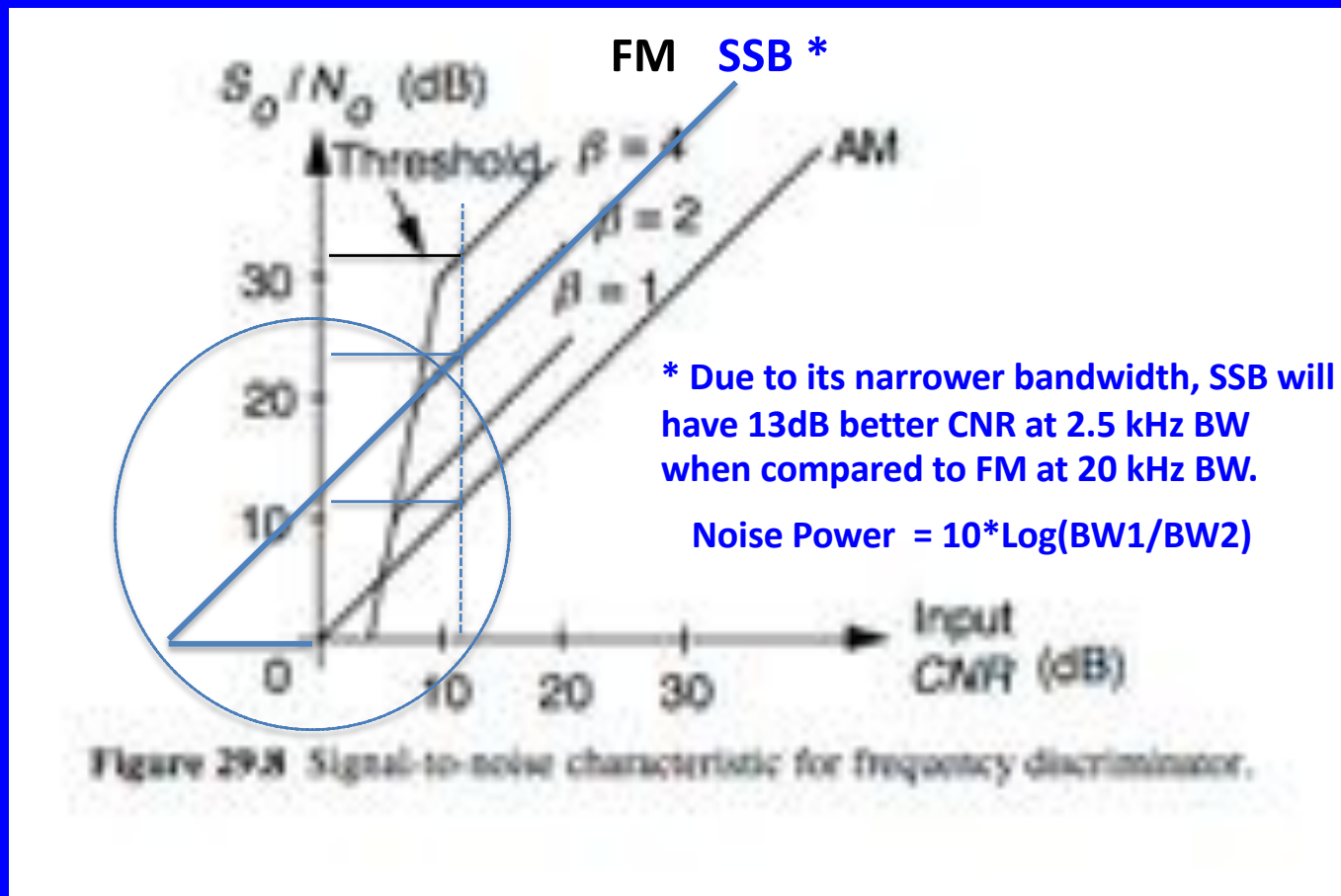
Multipath reflections may also reduce the signal levels or make signals distorted or even un-copiable plus the further away a signal can be received, the more likely it will be that objects or terrain may block the signal in addition to having more potential to produce multipath reflections.



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MODULATION Type vs Input Carrier-to-Noise Ratio to Output Signal-to-Noise Ratio:



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Demonstration of the weak signal advantage of SSB over FM for Simplex



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Basic Receiver Noise Levels

$$N_{RX} = -174 \text{ dBm} + 10 \cdot \text{LOG} (\text{BW})$$

RX Noise Level vs Rx Bandwidth:

$$\text{RX Noise in } \underline{1 \text{ Hertz Bandwidth}} = \underline{-174.0 \text{ dBm}}$$

		<u>RX Noise</u>	<u>(10dB CNR Sensitivity)</u>
N_{RX} in 500 Hz BW (CW Narrow)	=	<u>-147.0 dBm</u>	(-137.0 dBm or <u>0.032 uV</u>)
N_{RX} in 2200 Hz BW (SSB Narrow)	=	<u>-140.5 dBm</u>	(-130.5 dBm or <u>0.066 uV</u>)
N_{RX} in 2700 Hz BW (SSB Wide)	=	<u>-139.7 dBm</u>	(-129.7 dBm or <u>0.073 uV</u>)
N_{RX} in 6000 Hz Bandwidth (Digital Narrow)	=	<u>-136.2 dBm</u>	(-126.2 dBm or <u>0.112 uV</u>)
N_{RX} in 12000 Hz Bandwidth (Digital Normal)	=	<u>-133.2 dBm</u>	(-123.2 dBm or <u>0.154 uV</u>)
N_{RX} in 20000 Hz Bandwidth (Typical FM)	=	<u>-130.9 dBm</u>	(-120.9 dBm or <u>0.224 uV</u>)

Thus SSB Wide vs Typical FM = $-130.9 - (-139.7) = \underline{8.8 \text{ dB}}$ in favor of SSB.

And 500 Hz CW vs SSB Wide = $-139.7 - (-147.0) = \underline{7.3 \text{ dB}}$ in favor of CW.
(CW vs FM = 16.8 dB)

But...



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Expected Noise Levels in Urban, Suburban, Rural and Airport...



<http://users.okan.edu.tr/didem.kivanc/courses/EEE307.html>
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

ANALOG COMMUNICATION (10)
Fall 2013

Original slides by Yrd. Doç. Dr. Burak Kelleci
Modified by Yrd. Doç. Dr. Didem Kivanc Tureli



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VHF / UHF Noise Levels

WORLD METEOROLOGICAL ORGANIZATION DATA

CBS/SG-RFC 2005/Doc. 5(1)

<https://www.wmo.int/pages/prog/www/TEM/SG-RFC06/Ambient-RF-noise.pdf>

Horizontal Polarization

Measurement Range	Urban	Suburban	Rural	Airport
136 MHz - 138 MHz	-142.2	-144.5	-144.8	-148.4
162 MHz - 174 MHz	-142	-147.1	-147	-147.1
400 MHz - 420 MHz	-163.7	-165.1	-165.7	-167.7
440 MHz - 460 MHz	-164.9	-166.3	-166.9	-168.2
1.54 GHz - 1.545 GHz	-166.9	-167.4	-168.4	-167.6
1.670 GHz - 1700 GHz	-166.9	-167.1	-167.9	-167.2
2 GHz - 2.3 GHz	-167.1	-166.8	-167.1	-166.6

Urban Noise*

SSB FM
-108.4 / -99.0 dBm
0.9uV 2.5uV

-131.1 / -120.7 dBm
0.06uV 0.21uV

-133.1 / -123.9 dBm
0.05uV 0.14uV

-133.3 / -124.1 dBm
0.05uV 0.14uV

*SSB at 2.4 kHz BW
FM at 2.0 kHz BW



Noise vs BW = 10*LOG(BW1/BW2)

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Examples of modern receiver Digital Noise Reduction and Noise Blanking performance...Urban



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2 Meter SSB stations located in Santa Cruz (Tom), Fremont (Jim), and Clovis (Ken, near Fresno)...

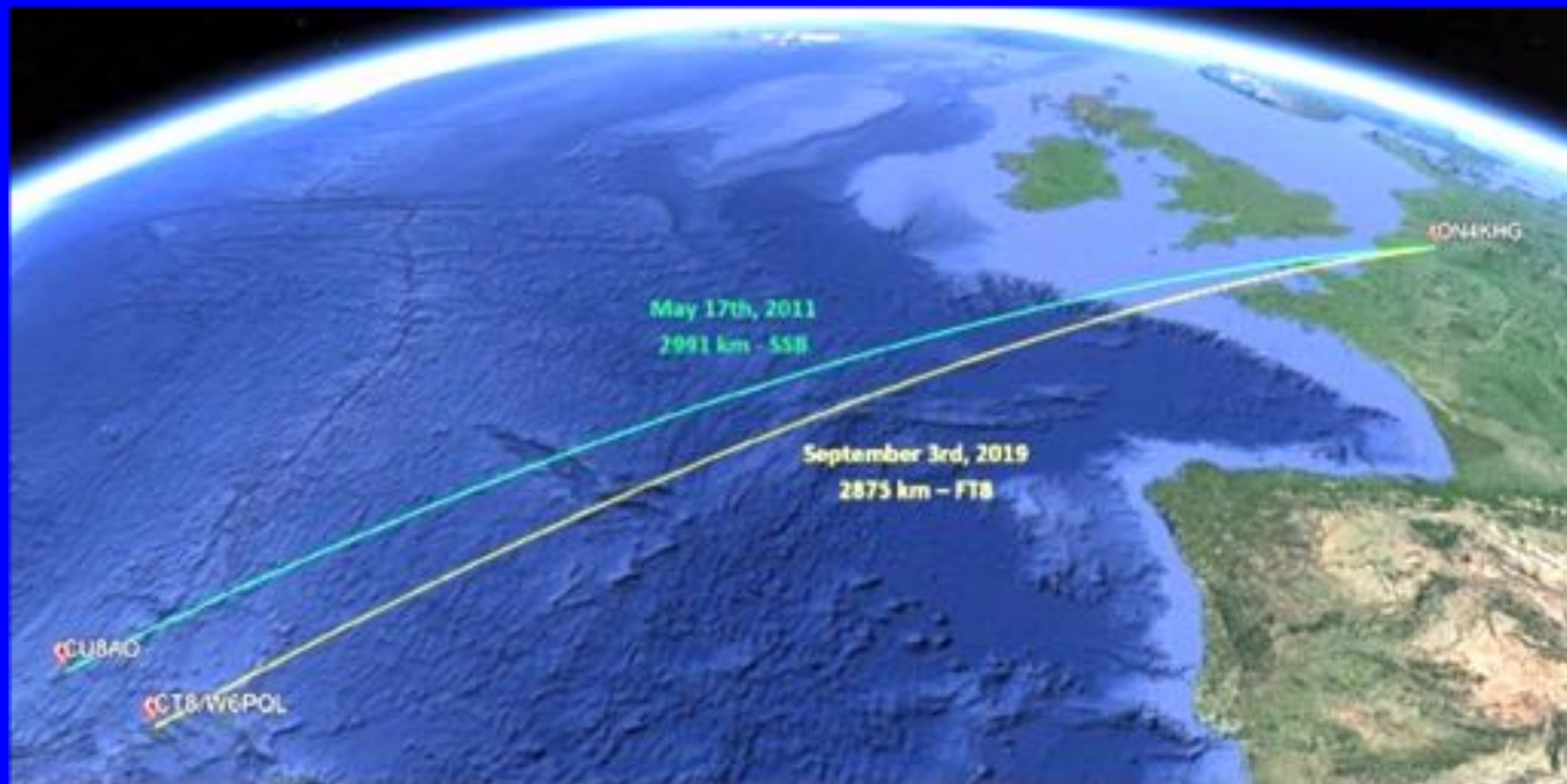


Signals as received at WB6JNN with a 9 element beam antenna.

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CT8/W6PQL in the Azores worked ON4KHG in Belgium via Tropo on FT8 in 2019
2875 km (1786miles)



And, of course, both stations have done this many times using Moonbounce)

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VHF/UHF weak signal equipment and operations

Jim's CT8/W6PQL Moonbounce and Tropo Circularly Polarized Array in the Azores



Jim is also active on HF using the vertical barely visible down on the rocks just right of the house in this picture. I have worked him using 250W into a dipole.

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VHF/UHF Propagation Modes in Northern CA

1. Reflections off Mountains: Mt. Umunuhm, Loma Prieta, Western Hills, Mt. Diablo
2. “Knife Edge” Signal Bending (Refraction)
3. Tropospheric Ducting (Temperature Inversion)
4. Airplane Reflections (Rapid Flutter)
5. Really tall towers such as Mt. Umunuhm, Loma Prieta, Canada College, Mt. Hamilton, Mt. Diablo, Fremont Peak (Salinas), Chews Ridge (SE of Carmel), Mt St Helena (North Bay)
6. Moonbounce (FT8 has open this up to 100-200W with a 9 to 12 element beam. Larger stations are able to work the “QRP” guys using moderate power and antennas.)



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Amateur Radio Satellites

1. Low Earth Orbit (LEO)
 1. FM – AO91, AO92, PO101, SO50
 2. Linear – CAS-4A, CAS-4B, XW-2A, XW-2B, XW-2F
 3. Other Modes – AISAT-1 (APRS), ISS (Int'l Space Station – FM, Packet, SSTV, APRS)
2. Medium Earth Orbit (MEO) – AO7 (Linear still active during sunlight hours-40 years old)
3. High Earth Orbit / Molniya (AO10, AO13 but these are no longer working)
4. Synchronous Orbit (Es'Hail QO100 CW, SSB, ATV - <https://eshail.batc.org.uk/nb/>)
5. GOLF (Greater Orbit, Larger Footprint – future AMSAT project, de-orbit issues)
6. Check the AMSAT, AMSAT-UK, AMSAT-DL, N2YO websites for further information.



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LEO (Low Earth Orbit) Satellites provide regional to full North and Central American coverage for up to 12- 15 minutes several times each day.

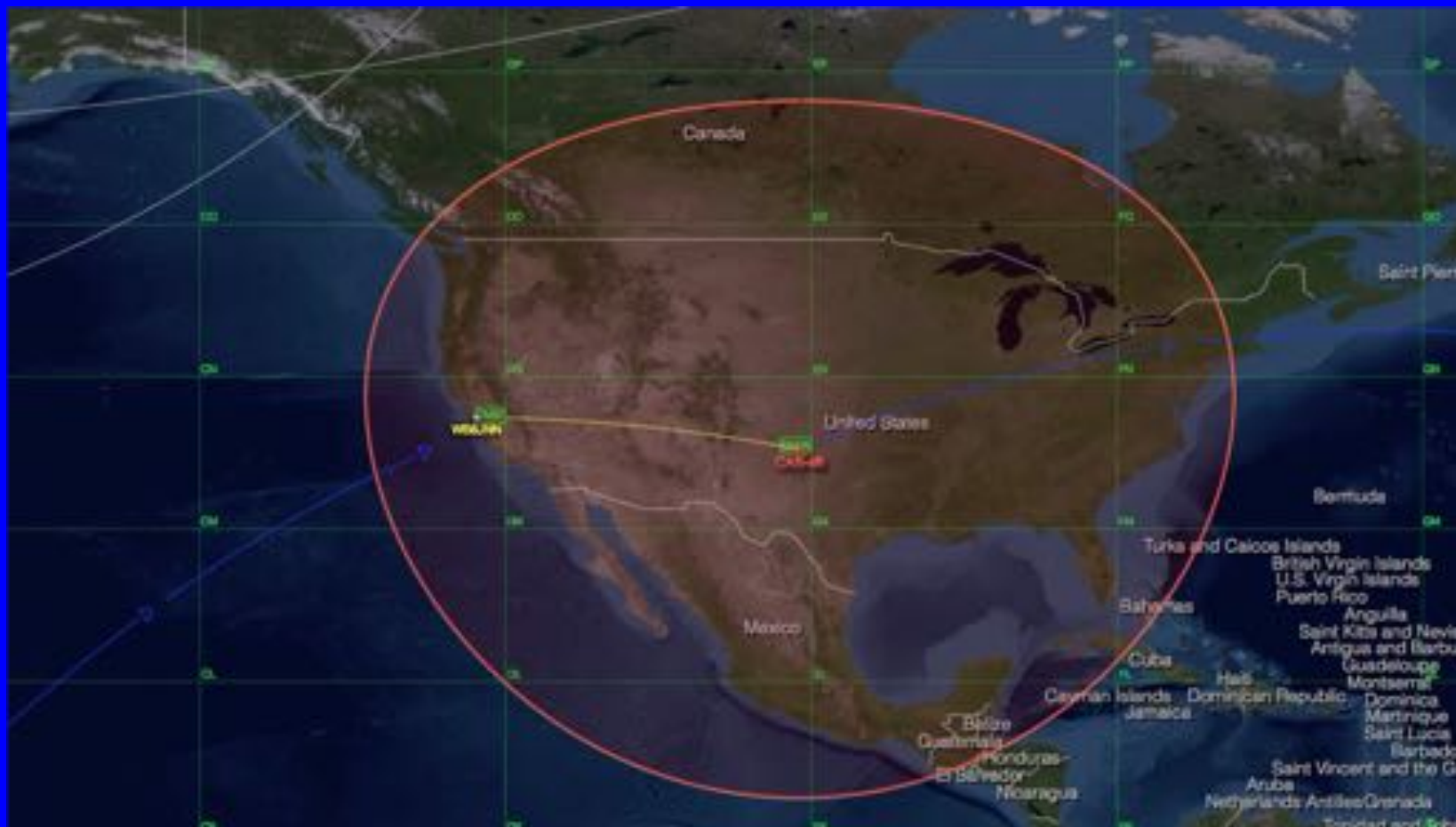


TI2VLM QSO with KI7USA through AO-91 using its FM transponder

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Each LEO (Low Earth Orbit) Satellite provides regional to full North and Central American coverage for up to 12- 15 minutes several times each day.



XE2YWH contact with WX5T using CAS4B Linear transponder

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Qatar-OSCAR 100 Narrowband WebSDR

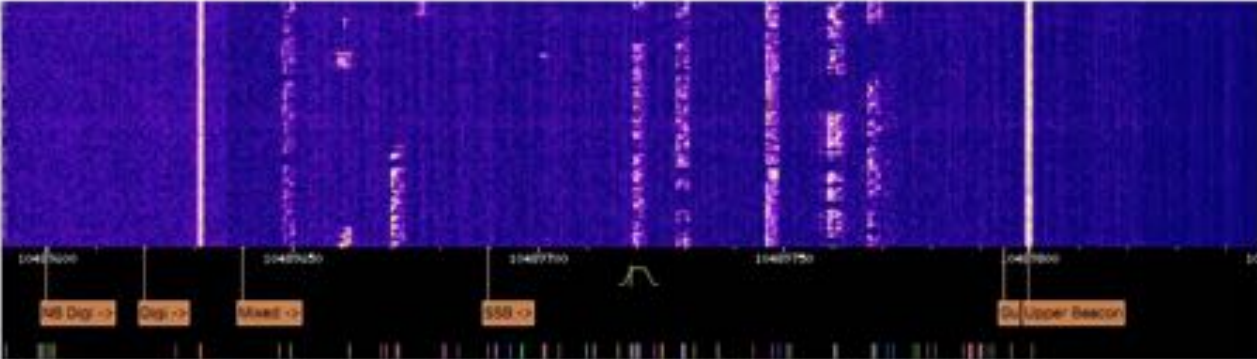
This WebSDR, hosted at Goonhilly Earth Station in Cornwall, enables you to listen to the Qatar-OSCAR 100 Narrowband transponder onboard the Es'hail-2 satellite.

You can read more about the WebSDR & Spectrum Viewer station at wiki.batc.org.uk/Es'hail-2 Ground Station

- For more details on Qatar-OSCAR 100 see amsat-dl.org/eshail-2-amsat-phase-4-a
- The QO-100 wideband spectrum monitor can be found here eshail.batc.org.uk/wb/
- More information about the WebSDR software can be found on www.websdr.org
- Dish Pointing Calculator & Map: eshail.batc.org.uk/point/
- [QO-100 Bandplan & Operating Guidelines](#)



View: ☒ waterfall ☐ blind Allow keyboard: ☐ Waterfall: HTML5 Sound: HTML5 Narrowband listeners: 132



10489719.01 kHz ☒ labels Filter: 2.49 kHz ☐ squelch ☐ autonotch

CW LSB USB ☒ CW ☐ LSB ☐ USB

Memories: recall erase store (new)

Audio recording start

Signal strength plot: none

Waterfall zoom

Speed: medium Size: large View: waterfall

-85.5 dB; peak -72.9 dB; Volume: mute ☐

QO-100 via Web SDR (wiki.batc.org.uk/Es'hail-2 Ground Station)

VHF/UHF weak signal equipment and operations

Some currently available transceivers HF/VHF/UHF operations with older DSP features. and High Stability Frequency Calibration and Control...



Yaesu FT-991A 100W
HF/50/140/430MHz
All-Mode Amateur
Radio

**100W HF & 6m
50W PEP VHF/UHF
AM, FM, SSB, CW
Compact Base or
Portable. IF DSP,
Half Duplex VHF
UHF Crossband**



Yaesu FT-818 Yaesu FT-818 6W
HF/VHF/UHF Transceiver

**6W PEP HF/VHF/UHF
AM, FM, SSB, CW
Mobile/Portable
QRP. Audio DSP**



Icom IC-9700 IC-
9700
VHF/UHF/1.2GHz
Transceiver

**50W PEP VHF/UHF
10W at 1296 MHz
AM, FM, SSB, CW
Base Station IF DSP
Full Duplex (Satellites)**



Icom IC-7100 Icom
IC-7100 100W
HF/6M/2M/70CM
Amateur Mobile
Radio

**100W HF & 6m
50W PEP
VHF/UHF
AM, FM, SSB, CW
Base, portable or
Mobile**



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VHF/UHF weak signal equipment and operations

Some Recommended used transceivers HF/VHF/UHF operations with older DSP features...



- Features**
- 160-2 meters +440
 - Electronic Keyer
 - 200 Alpha Memories
 - DSP-2 Based Built-in
 - 100 Watts HF Output
 - 50 Watts 2 Meter Output
 - 20 Watts 440 MHz Output
 - Spectrum Display

FT-857D
100W HF & 6m
50W PEP VHF
20W PEP UHF
AM, FM, SSB, CW
Mobile Audio DSP



- Features**
- IF DSP Main Band
 - AF DSP Sub Band
 - HF by V/U, V by V
 - U by U and V by U
 - PCT Packet Cluster Tuning
 - Transverter Frequency Display
 - [IF Auto Notch](#)
 - 5+1 Antenna Ports
 - [Keypad](#)
 - Built-in TNC (1200/9600)
 - Built-in [Auto Tuner 1.9-54 MHz](#)
 - Built-in keyer with 3 Memories
 - [High Stability TCXO](#)
 - [RC-2000](#) Optional Mobile Controller
 - [Backlit Front Panel](#)
 - 300 Memories (290 Alpha)
 - Variable IF AGC (20 step)
 - [RIT/XIT](#)

TS-2000, TS2000x
100W PEP HF/VHF/50W UHF
AM, FM, SSB, CW
Base Station Audio & IF DSP
Full Duplex (Satellites)



IC-706MKIIG
100W HF & 6m
50W VHF
30W UHF
AM, FM, SSB, CW
Mobile, older DSP



FT-897D HF, VHF, UHF



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More recommended used transceivers HF/VHF/UHF operations with older DSP features...



Yaesu Ft-897 Ft897
Hf Vhf Uhf
Transceiver Radio
Technical Service

**100W HF & 6m
50W PEP VHF
20W PEP UHF
AM, FM, SSB, CW
Mobile Audio DSP**



ICOM IC-9100
HF/VHF/UHF
Transceiver

**HF/VHF/100W, UHF 75W
AM, FM, SSB, CW
Base Station Audio & IF DSP
Full Duplex (Satellites)**



YAESU FT-817ND
ultra-small HF / VHF /
UHF multi-mode
portable shortwave
car radio transmitter

**5W HF, VHF, UHF
AM, FM, SSB, CW
Mobile, older DSP**










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Linear Amplifiers: q5signal.com now supplies amplifiers designed by Down East Microwaves...

Q5 SIGNAL
The Source for Down East Microwave VHF/UHF Transverters and Amplifiers



 <p>144MHz High Power 150W Transverter \$799.00</p> <p>ADD TO CART</p>	 <p>144MHz High Power 75W Transverter \$649.00</p> <p>ADD TO CART</p>	 <p>144MHz High Power 50W Transverter \$599.00</p> <p>ADD TO CART</p>
 <p>144MHz 25W Transverter \$479.00</p>	 <p>2M Low-Drive Power Amplifier \$399.00</p>	 <p>2M 30W Linear Amplifier - Fully Assembled \$219.00</p>

Others: M2INC.com, W6PQL.com (High Power)



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Transverters: Q5 Signal now supplies VHF/UHF transverters designed by Down East Microwaves...

Q5 Signal will now produce and manufacture all DEMI transverters and power amplifiers through 1.3GHz. They will also provide complete repair and support of all previously manufactured transverters and power amplifiers including kits within this frequency range.

Down East Microwave Inc will continue the manufacturing of 2GHz and above transverters and Microwave power amplifiers along with our VHF thru Microwave LNA product line, accessories and new future products.



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Down East Microwave Inc. 19519 78th Ter., Live Oak FL 32060

Phone: 386-364-5529 (Voice) <http://www.downeastmicrowave.com>



DEM V/U XVERTER -VHF/UHF Multiband Transverter

Preliminary Information Modified Jan 7th, 2020

4m=70 MHz, 2m=144MHz, 1.25m=222MHz, 70cm=432MHz, 23cm=1296MHz, 13cm=2304MHz

Description:

The DEM V/U XVERTER is a multiband transverter with six separate I/O ports covering up to 6 separate amateur radio bands between 4M and 13 cm. All frequencies convert to/from 28/29 MHz.

only. The transmit output level is approximately 1 watt and will exhibit a 2 dB noise figure with greater than 15 dB gain on all bands except for being de-rated on 13 cm. The Transverter has a couple of I/O port options. It may be configured with 6 separate bands or have one duplicate band that may be utilized as an AUX RF port for connection to a higher frequency transverter such as our future DEM MICROVERTER. As an option, the AUX port could be configured as a 4M, 13 cm, or any other frequency within the range of the transverter. Other special options will be covered in detail later in this product description.



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VHF/UHF weak signal equipment and operations

VHF / UHF SSB NETS - Northern California

Sunday 7:00 -7:30pm: Bozo Net 432.100 MHz (70cm)

Mike K6MYC near Fresno or WA6IKE Lincoln (Sacramento Area)
(Pre-net chatter & early check-ins sometimes around 6:45pm.)

Sunday 7:30-8:30pm: Bozo Net 144.240 MHz (2m)

Mike K6MYC near Fresno. Starts with Nevada and goes counter-clockwise through Sacramento, Clear Lake, Delta Area, SF Bay Area and Santa Cruz/Monterey. (SF Bay Area approximately 8-8:15pm.)

Monday 7:30-8:15pm: Bozo Net 222.100 MHz (1.25m)

Informal gathering with Jim W6PQL (Fremont), Paul K6WIS (Santa Clara), Mike K6MYC (Fresno) and 5-8 others, typical.
“DX” towards Southern CA attempted between 7:45-8:15pm 222.090 MHz

Tuesday 7:30-8:15pm: Bozo Net 1296.100 MHz (23cm)

Informal gathering with Jim W6PQL (Fremont), Paul K6WIS (Santa Clara), Mike K6MYC (Fresno) and 5-8 others, typical.
“DX” towards Southern CA attempted between 7:45-8:15pm 1296.090 MHz

Wednesday 7:30-8:30pm: Bozo Net 144.240 MHz (2m)

Mike K6MYC near Fresno or WA6IKE Lincoln (Sacramento Area) Starts in Bay Area and goes Clockwise through Delta, Clear Lake, Sacramento, and Nevada. Some pre-net chatter in Bay Area.

Wednesday 8:45-9:00pm: Informal 50.140 MHz (6m)

Mike K6MYC near Fresno. Informal net. Others may be on the air after about 8:30pm.



Jim , WB6JNN, jeagleson945@gmail.com and youtube/jimeagle1 (see Radio Electronics Stuff)

VHF/UHF weak signal equipment and operations

VHF / UHF Technical Resources

Pacific Northwest VHF Society: www.pnwvhfs.org

Central States VHF Society: www.csvhfs.org

Bozo Nets www.bozonets.com

AMSAT (satellites): www.amsat.org

AMSAT UK (satellites): www.amsat-uk.org

AMSAT DL (satellites): www.amsat-dl.org

Gunther's Space Page: space.skyrocket.de

Getting Started on Satellites: www.work-sat.com

N2YO online Satellite Tracking www.N2YO.com

MacDoppler Satellite Tracking Software www.dogparksoftware.com

General Satellite Tracking Software www.amsat.org/amsat-new/tools/software.php#shareware

M2INC.com (Antennas, Amps)

W6PQL.com (General Information, Amps, DIY components/PC Boards/modules)

[Down East Microwave \(DEMI\)](http://DownEastMicrowave.com) (Microwave equipment at downeastmicrowave.com)

[Q5 Signal](http://Q5Signal.com) (VHF/UHF/1296 MHz Transverters at www.q5signal.com)

[Transverter Store](http://TransverterStore.com) (Inexpensive, 5-7W transverters at www.transverters-store.com)

[SG Labs](http://SGLabs.com) (23cm, 13cm transverters, amplifiers at www.sg-lab.com/amateur.html)

[Directive Systems](http://DirectiveSystems.com) (Antennas) at www.directivesystems.com



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