QRP Contesting and DXing

K6UFO - Mark “Mork” Aaker

HIGH Power

LOW Power

QRP

"**QRP**" is an old telegraph signal: "lower your power."

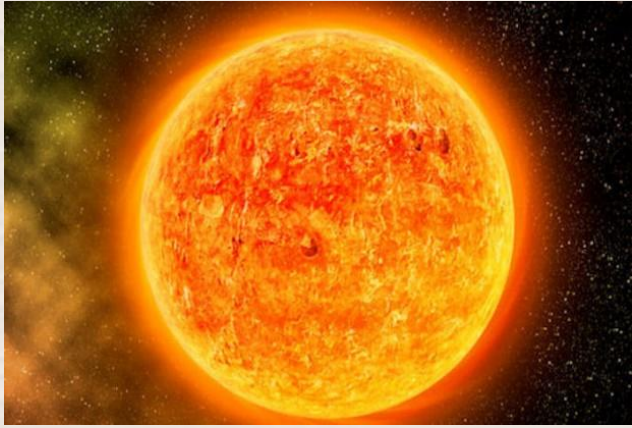
QRP? = Can you lower your power?

Today, the standard Amateur Radio meanings are :

- **QRP** = 5 Watts or less transmitter power.
- **Low Power** = up to 100 Watts, e.g., a "barefoot" radio. (up to 150 Watts in ARRL contests)
- **High Power "QRO"**, from 100 W (or 150 W) up to the contest limit (1,500 W) or the country's legal limit.

Canada: 2,250 W PEP
USA 1,500 W
Japan: 1,000 W
Italy: 500 W
U.K.: 400 W
Oman: 150 W

How MUCH Power?



- Total Energy Output of the Sun 10^26 W
- Nuclear reactor 1 Gigawatt = 10^9 W
- Shortwave Broadcast 1 Megawatt = 10^6 W
- AM/FM radio Broadcast 50,000 W
- Digital TV Broadcast 10,000 W
- Amateur Radio 1,500 W
- Microwave oven 1,000 W @ 2.45 GHz

How little Power?

- Amateur Radio 1,500 W – 100 W – 5 W
- Christmas tree bulb 7 W – 5 W
- CB Radio 4 W
- LED Flashlight 3 W – 1W
- Cell phone 2 W - 0.002 Watt
- FRS radio 500 milliwatt
- WiFi transmitter 100 milliwatt – 0.1 mW
- Equivalent light output of a Firefly 1 mW

Federal Communications Commission

It's the Law!

Code of Federal Regulations

Title 47 - Telecommunication

Volume: 5
Date: 1999-10-01
Original Date: 1999-10-01
Title: Section 97.313 - Transmitter power standards.
Context: Title 47 - Telecommunication. CHAPTER I - FEDERAL COMMUNICATIONSCOMMISSION (CONTINUED). SU
D - SAFETY AND SPECIAL RADIO SERVICES. PART 97 - AMATEUR RADIO SERVICE. Subpart D - Technical Stand

§ 97.313 Transmitter power standards.

(a) An amateur station must use the minimum transmitter power necessary to carry out the desired communications.

(b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

(c) No station may transmit with a transmitter power exceeding 200 W PEP on:

…as far as I can tell, no Amateur has ever been cited.

Let's get this out of the way, Can QRP really work?

ARRL Field Day 2012:

#3 highest score, station K6EI, **2,827** contacts, 5 watts.

#5 highest score, station W5YA , **1,937** contacts, 5 watts.

ARRL Field Day 2011:

#3 highest score, station K6EI , **2,252** contacts, 5 watts.

#4 highest score, station W0CQC **1,943** contacts, 5 watts.

Yeah, but what about DX?

ARRL DX Contest:

P40A (KK9A, op) in Aruba 2011 SSB Contest, **3,941** contacts, 5 watts.

K1ZM in Massachusetts 2001 CW Contest, **2,720** contacts, 5 watts.

CQ WW DX Contest:

P40W (W2GD, op) in Aruba 2000 SSB Contest, **3,599** contacts, 5 watts.

P40W (W2GD, op) in Aruba 1999 CW Contest, **3,277** contacts, 5 watts.

K3OO in Pennsylvania in the 2000 CW Contest, **1,299** contacts, 5 watts.

KR2Q in New Jersey in the 2000 SSB Contest, **1,181** contacts, 5 watts.

Yeah, but what about DXing outside of contests?

WG5G has worked **338** countries QRP, and is on DXCC Honor Roll.

W8ILC has **337** countries QRP, and **300** running only 1 watt.

K3OO has **330** countries at 2 watts, and **150** countries at 100 milliwatts.

ND0C has **315** countries QRP.

Hundreds of Amateurs have achieved DXCC while QRP.

QRP ARCI offers an award for working over **1,000 Miles per Watt.** Has been awarded to over three thousand Amateurs. (Example: SF to Tokyo is 5,100 miles, so just use 5 watts.)

Yeah, but what about from the West Coast?

CQ WW SSB Contest 2000, N6MU in California worked **100** countries on 10m alone! (86 on 15m, 64 on 20m,…)

CQ WW CW Contest 2011, NN7SS in Washington worked **126** countries on CW weekend and **116** on SSB weekend. In 2012 he did **119** CW /**102** SSB.

OK, QRP may work, but why should I care?

- Understanding "how it works" is useful in other operating, LP and QRO, DXing and Contesting.
- You may want to try QRP to sharpen your operating skills.
- You may want to try QRP because it provides a great satisfaction and sense of accomplishment with every contact!
- You may want to try QRP because it is fun.
- QRP is another category for Contest competition and Awards.

	2012 ARRL Sweepstakes - CW				TOTAL	TOTAL
	Call = Log	OP	STN	Class	QSOs	SCORE
15	W6NL	N5KO	W6NL	SO HP	1,346	220,026
16	NN7SS	K6UFO	NN7SS	SO QRP	1,247	207,002
17	W6NV	W6NV	W6NV	SOHP	1,155	189,420
18	N6JS	N6JS	N6JS	SO HP	1,173	188,732
19	N6PN	N6PN	N6TV	SO HP	1,119	185,754
20	W6OAT	W6OAT	W6OAT	SO U HP	1,142	183,452
21	N6RO	N6RO	N6RO	SO U HP	1,129	178,902
22	K7GK	K7GK	W6JZH	SO HP	1,069	177,454
23	N3ZZ	N3ZZ	N3ZZ	SO U HP	1,046	173,636
24	W6FB	W6FB	W6FB	SO HP	1,047	172,074
25	W6DR	W6DR, N9YS	W6DR	M/O HP	1,065	171,730
26	K9JM	K9JM	K9JM	SO HP	1,036	167,888
27	W6SX	W6SX	W6SX	SO HP	1,038	162,576

← QRP !

High Power

You may want to try QRP for portable or mobile operation.

- Light weight
- Low power consumption

QRP equipment can be easier to design and build when “Home-brewing” and kit-building.

But QRP operators are NOT required to use “poor” equipment.

QRP: “How” it works…

The signal strength at a receiving station depends on many factors:

1. **Distance** (which primarily appears as “Path Loss”)
2. **Propagation** (“Band Open?”)
3. **Antenna System** (Height, Terrain, Pattern, Gain, Capture Area, Efficiency, Feed line, …)
4. **Transmitter Power**

Let’s review them quickly, but only #2 really matters…

Propagation Path-Loss - Free Space Propagation

- ✓ The free space propagation model is usually used to predict received signal strength, when the transmitter and receiver have a clear, unobstructed line-of-sight (LoS) path between them.
- ✓ In free-space propagation environments the received signal power decays with the square of the propagation path length, and the received signal power can be expressed as

$$P_r(d) = 10\log_{10}\left[P_t G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2\right] \quad \textbf{dBm (dBW)} \qquad (1)$$

where $P_t, P_r(d)$: transmitted and received power, G_T, G_R: antenna gains, d: distance between the transmitter and receiver, and λ: wavelength of the radio signal.

DISTANCE:

Path:	**Approximate Loss due to distance**:
Earth-Moon-Earth (480,000 km) (K5RMG EME Path Loss Calculator)	190 dB
Earth orbiting satellite (44,000 miles) (Basic Radio: Principles and Technology By Ian Poole 1998)	170 dB
Cellular telephone network first 6 miles (Wikipedia entry “Path Loss”)	150 dB
Cellular telephone network first 1,000 yards	110 dB

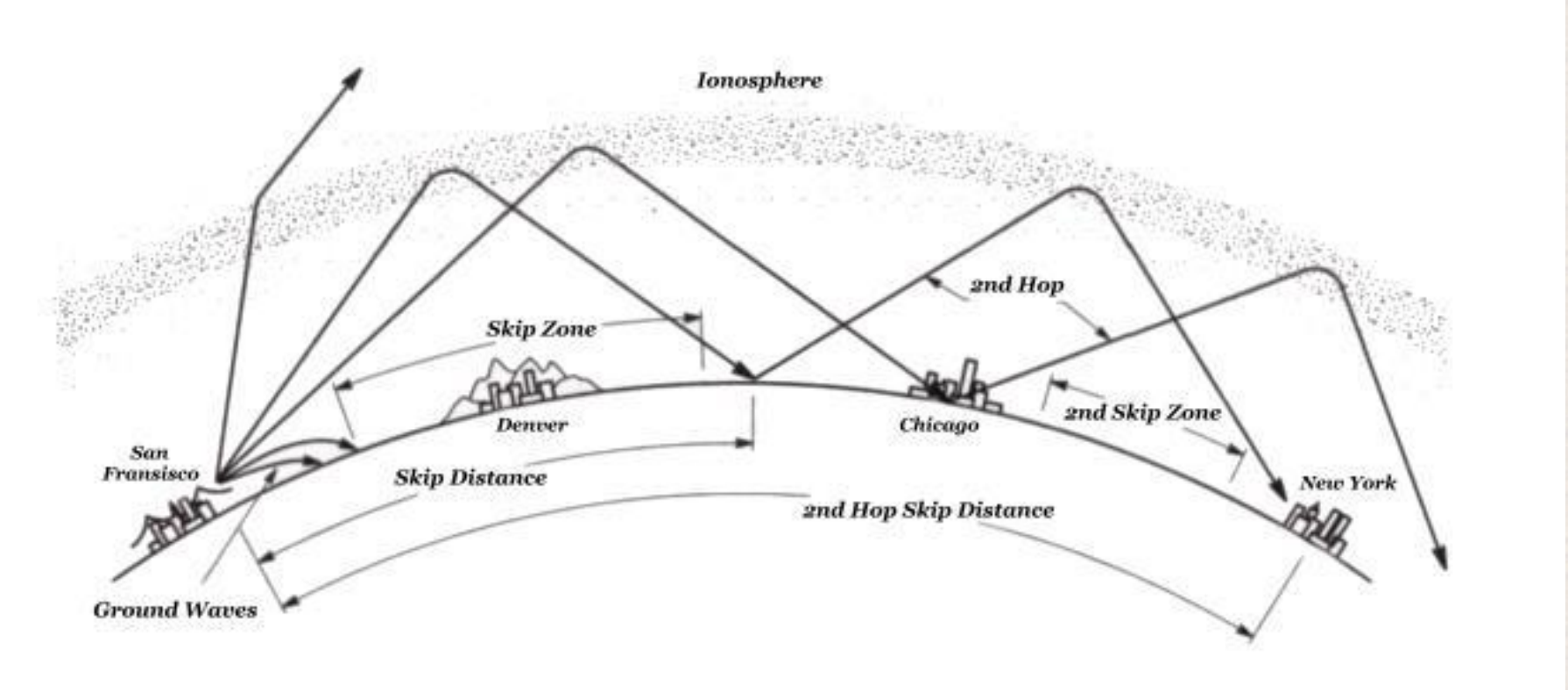
Bottom Line: for Amateur HF QRP operation 12 to 12,000 miles, distance (“path loss”) alone is a small factor in differing signal strengths (only about 20 dB)

Basic Propagation Mechanisms

- Reflection, diffraction, and scattering:
- Reflection occurs when a propagating electromagnetic wave impinges upon an object
- Diffraction occurs when the radio path between the transmitter and receiver is obstructed by a surface that has sharp edges
- Scattering occurs when the medium through which the wave travels
  - consists of objects with dimensions that are small compared to the wavelength, or
  - the number of obstacles per unit volume is large.

Propagation

For Amateur HF communication the primary propagation mode is ionospheric refraction or “skip.”

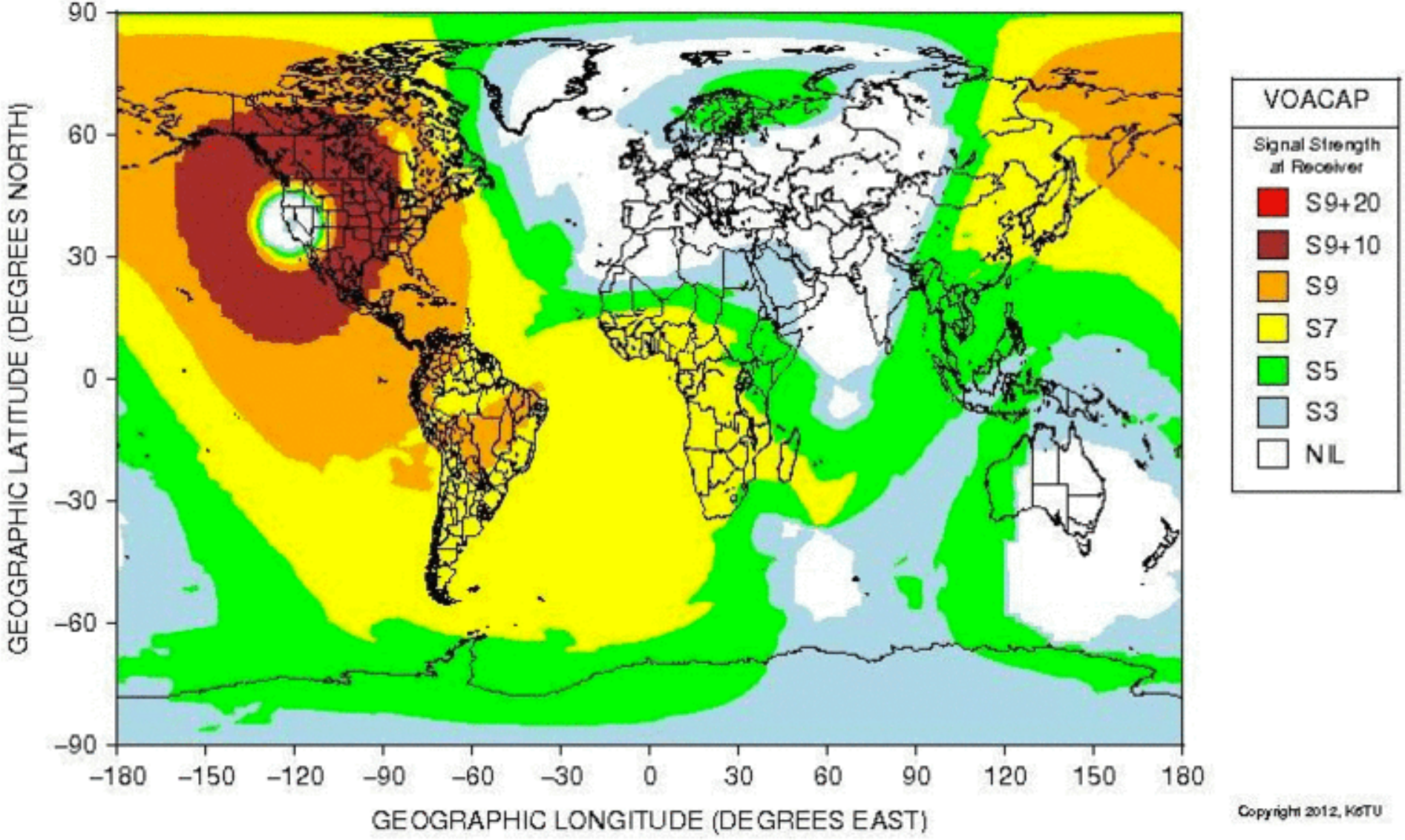


Ionosphere: Signals refracting from the ionosphere can experience from minimal loss (essentially path loss) to total loss (beyond MUF) or total absorption (daytime D layer).

17M: 00 utc Dec 80ssn

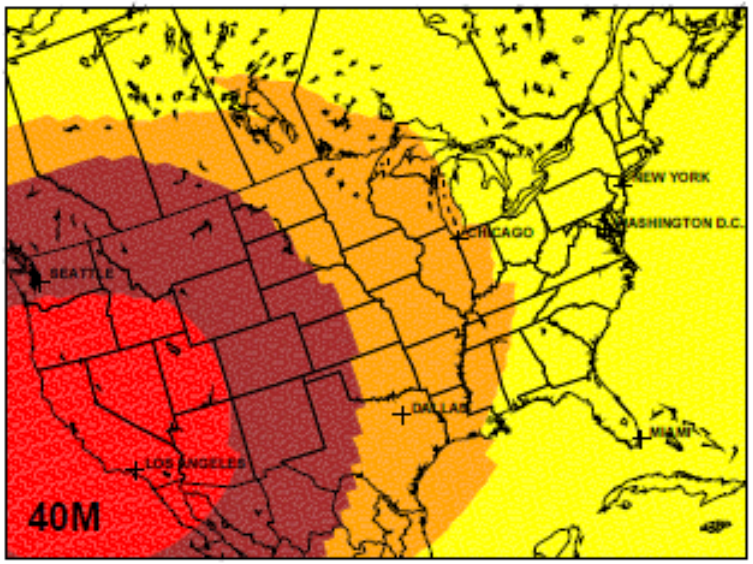
K6TU.NET

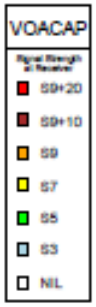
Prepared for: K6TU

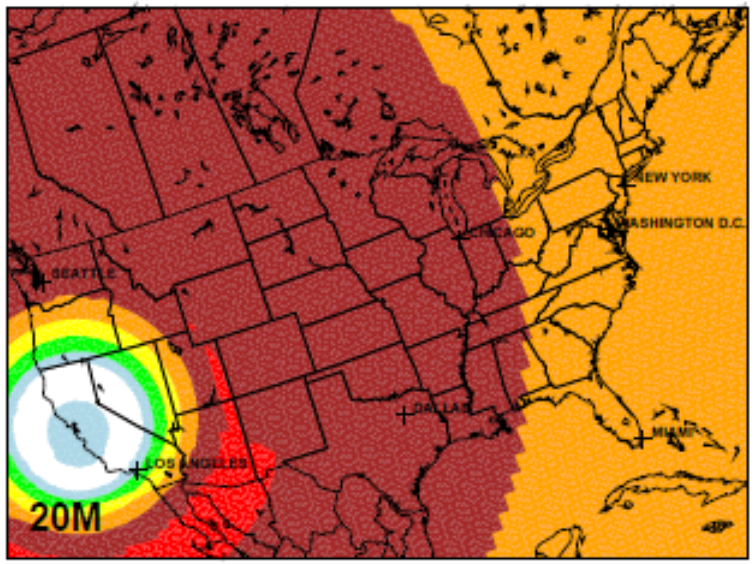


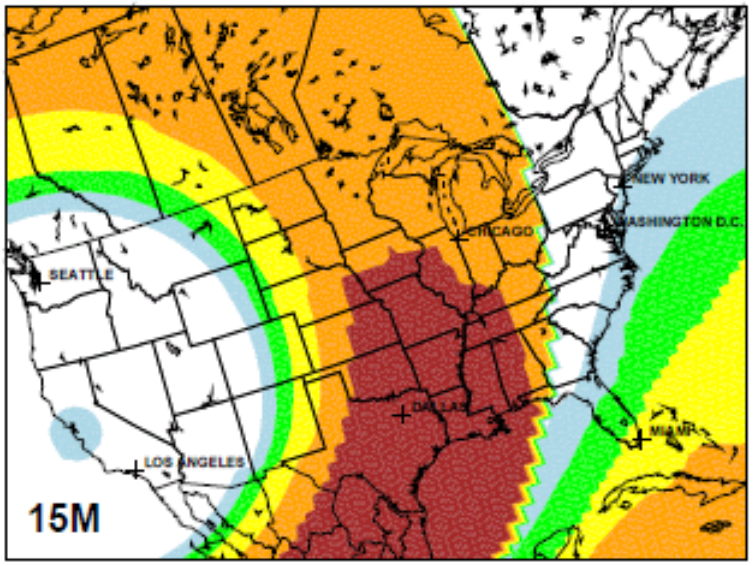
Prepared for: NCCC

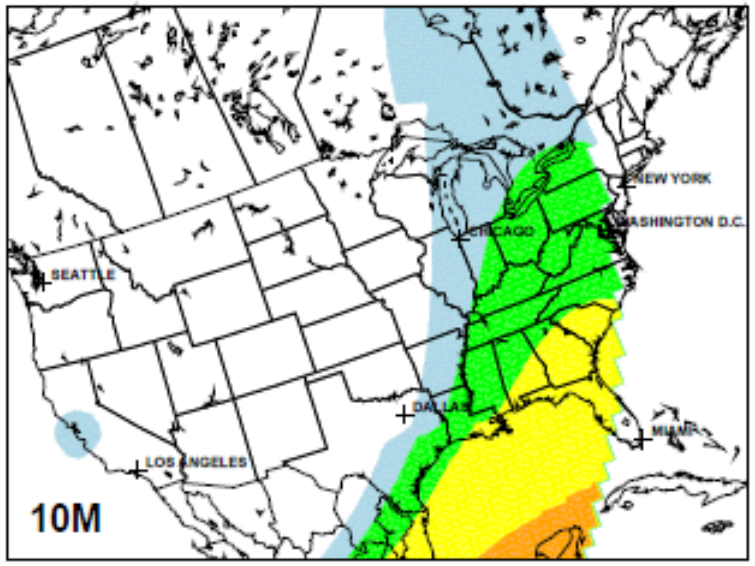
WOODSIDE 00 utc (16 pst) Mar03 62ssn











The ionosphere is the great equalizer...

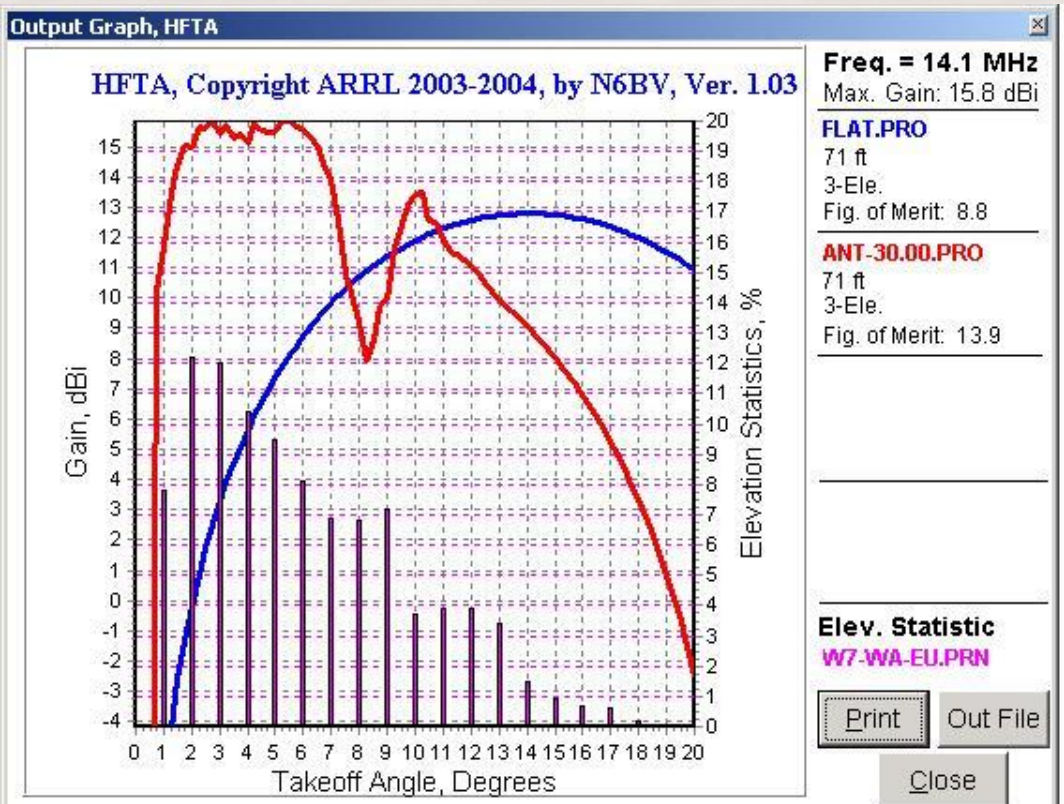
"The difference in signal strength between the most effective and the least effective amateur radio station is generally far less than the variations in ionospheric path loss." – KL7AJ

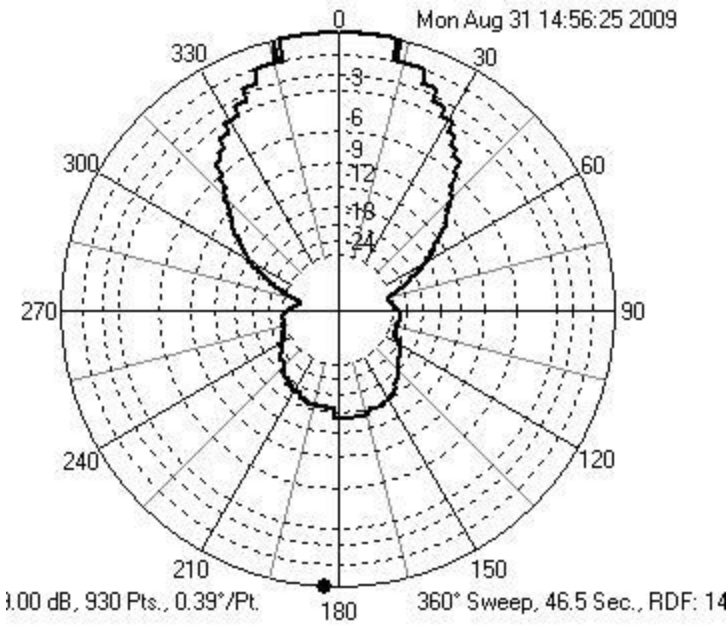
- When the "band is open" (correct frequency and distance), you can be heard.
- When the band is open, QRO will be louder than QRP (but not much.)
- When the band is open, even QRP will be louder than anyone where the band is closed.

Bottom Line: for Amateur HF QRP operation, propagation is the largest factor in different signal strengths. (S9+20 to non-existent)

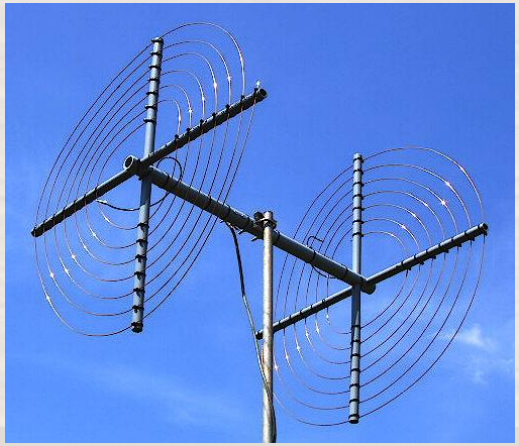
Antenna System

- The HFTA software by N6BV can help you determine the performance of an antenna at various heights over your specific terrain.
- The “Antenna Book” and modeling software can help you determine the pattern and gain of various antennas. Also the radiation efficiency and other characteristics.
- Your feed line and matching networks (“tuner”) if any, also affect signal strength.





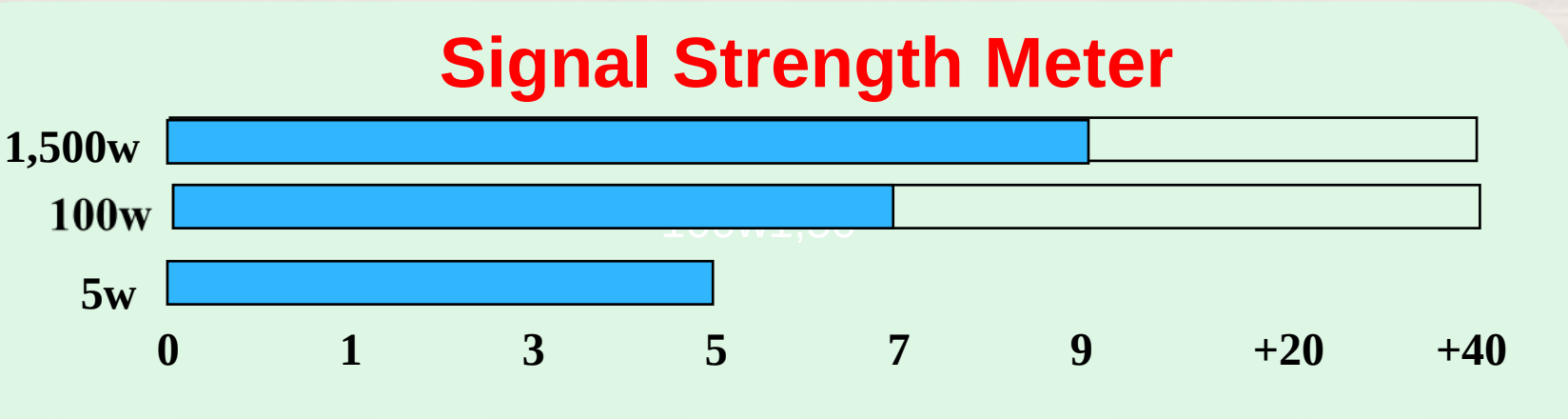
Antenna Systems NOT Recommended for QRP Operating



- “Miniature” antennas
- Lossy elements (“traps”)
- Old feed line
- Feed line operated at a high SWR (to add additional loss)
- Tuner losses
- TV Low Pass Filters

“*Anything works*, even a light bulb, it's just a matter of how well.– N6BT

Summary: Because propagation is the major limiting factor (not distance), a QRP station with a reasonable antenna and feed line will not sound that different from the QRO station.



← When band is “dead” When band is “open” →

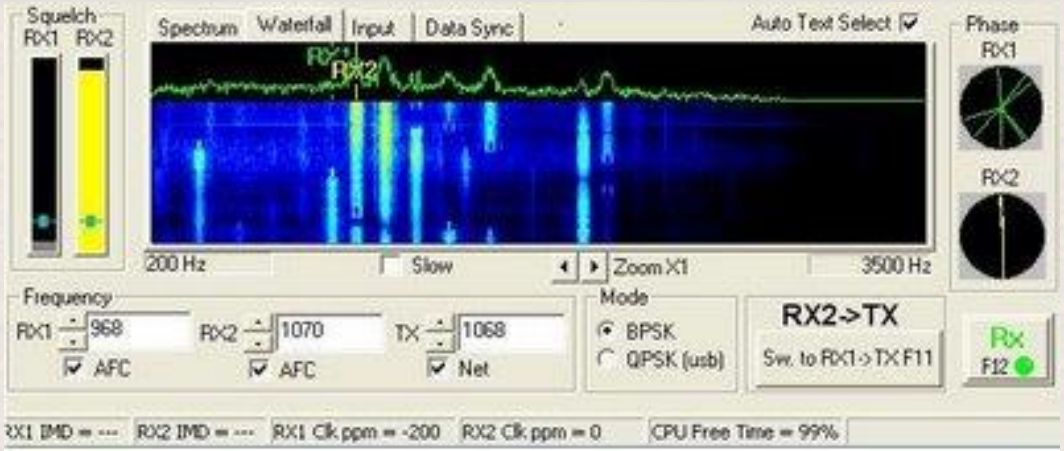
5 watts is only two “S-units” below 100 watts,
… only four “S-units” below 1,500 watts.

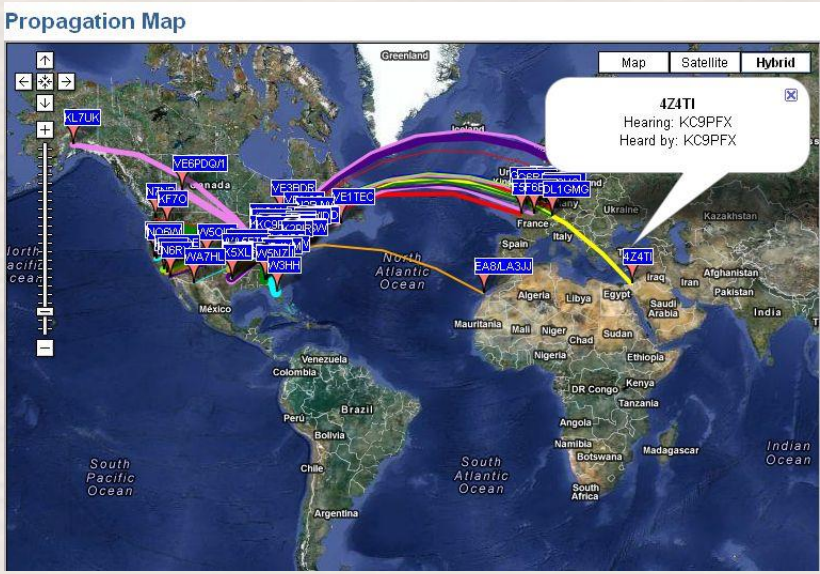
Bottom Line: Your 5 watt signal *CAN* be heard!

The “Mode” also affects QRP success.

Narrow bandwidth, clever encoding or slow rates make some modes more efficient than others.

- 5 watts of CW is equivalent to 100 W SSB.
- 5 watts of PSK is equivalent to 400 W SSB
- 5 watts of JT65 is equivalent to 2000 W SSB
- 5 watts of JT9 is equivalent to ???? W SSB





After Signal Strength (set by propagation, antenna system and mode) - the next major factor in QRP Operating Success is …

Operating Skill

My favorites:

- **Timing**
- **Not Zero Beat**
- **Tuning, Search and Identify**
- **SO2V and SO2R**

But first, remember that …

- DX and Contest stations don't care if you are QRP – they work anyone they hear.
- DX and Contest stations don't care if you are QRP – After they have worked the hundred loudest signals, they need another hundred, and another hundred…
- DX and Contest stations don't care if you are QRP – Do not sign "…/QRP" and do not bother telling them during the QSO.
- DX and Contest stations don't care if you are QRP – Send the exchange ONCE at their full speed, and let them ask if they need a fill.

More about Operating Skill

Timing - Transmit when the operator is listening. “In the gaps” when other operators fail to use proper timing. Try calling in the “second round” or “last” in a pileup (but not endless tail-ending.) Full Break-in can help you know when to send and when to stop. Full Break-in is easy at QRP levels.

Zero Beat - Be Zero Beat when needed. Not Zero Beat in pileups. Know how to rapidly “place” your signal anywhere in a 500 Hz window. Know that your signal usually has the “opposite pitch.” Know how to reverse that…

Tuning, Search and Identify - In any contest , there are another thousand contacts for you elsewhere on the bands. How fast can you find and work them? Use a Bandmap to speed up the second pass. Use SCP and Prefill (Call History) to help identify stations. When you are new to a band “WFWL.”

SO2V and SO2R – QRP mostly uses the extra receiving capability. (You are unlikely to be running two pileups.) Sitting in packet pileups is not efficient. So at least be tuning and identifying opportunities elsewhere as you wait.

Other useful QRP Operating Skills

Patience/Impatience – Be willing to wait and call someone several times. But know when to move on and try later. If CQing, be willing to have a “low” rate – if its still higher than S&P. When tuning, don’t just sit listening to a station, go find the next one!

Alertness - If waiting in a pileup, don’t stop listening when the DX calls someone else. Try to identify why that station got through. Pretend you are the DX station – where will you listen next? Be alert to “dead space” where you can position your signal, and be alert to “dead air” time when you can drop in your call (“tail-end”).

Aggressive/ Forgiving - Be ready to jump in, be ready to call again, be willing to respond to partial calls “The W6?”. You will rarely “QRM” anyone when you are QRP. When other stations “clobber” you, give up on you, QRM you, or steal your frequency – accept it as part of the game, and move on.

These are useful skills for any power level…

Other QRO Operator Benefits from trying QRP?

Even when Propagation is against you – you will have the skills to make a contact.

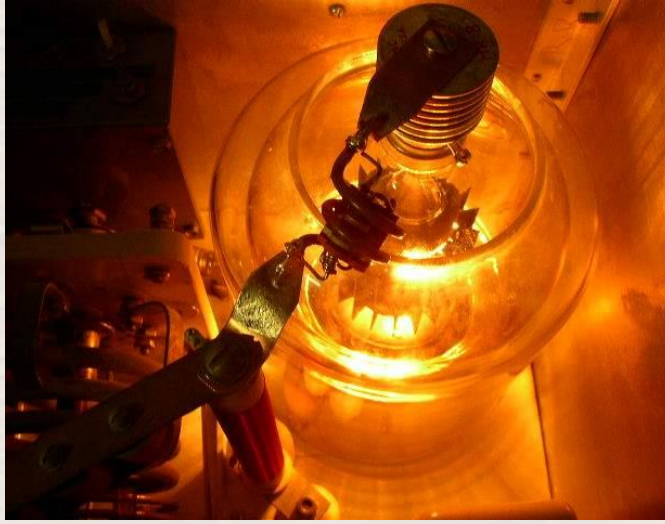
“Running” a pileup, keeping control of the callers, and keeping the frequency - is a lot harder when QRP. The “management skills” you learn will help you with your later QRO Pileups.

Operating QRP will quickly identify any weakness in your antennas, feed line, equipment or operating technique.

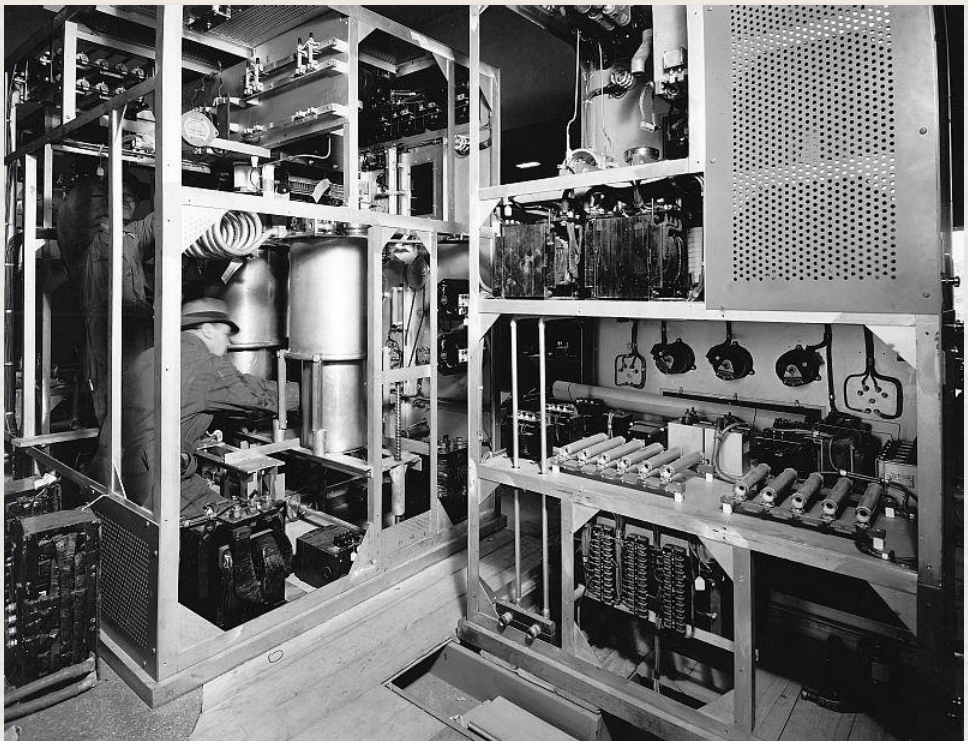
Allows you to practice SO2R before investing in expensive band-pass filters, second amplifier, …

Less RFI in the shack to cause problems with computers, audio, …

Alternate Views:



- Life is too short for QRP!
- All knobs to “11”
- Loud is good. Louder is better!



Voyager 1 Spacecraft

- February 8, 2012, NASA reported that *Voyager 1* is over 10 Billion miles from the Earth … Radio signals traveling at the speed of light between *Voyager 1* and Earth take 16.5 hours.

- The Voyager 1 spacecraft uses a 23 watt radio.

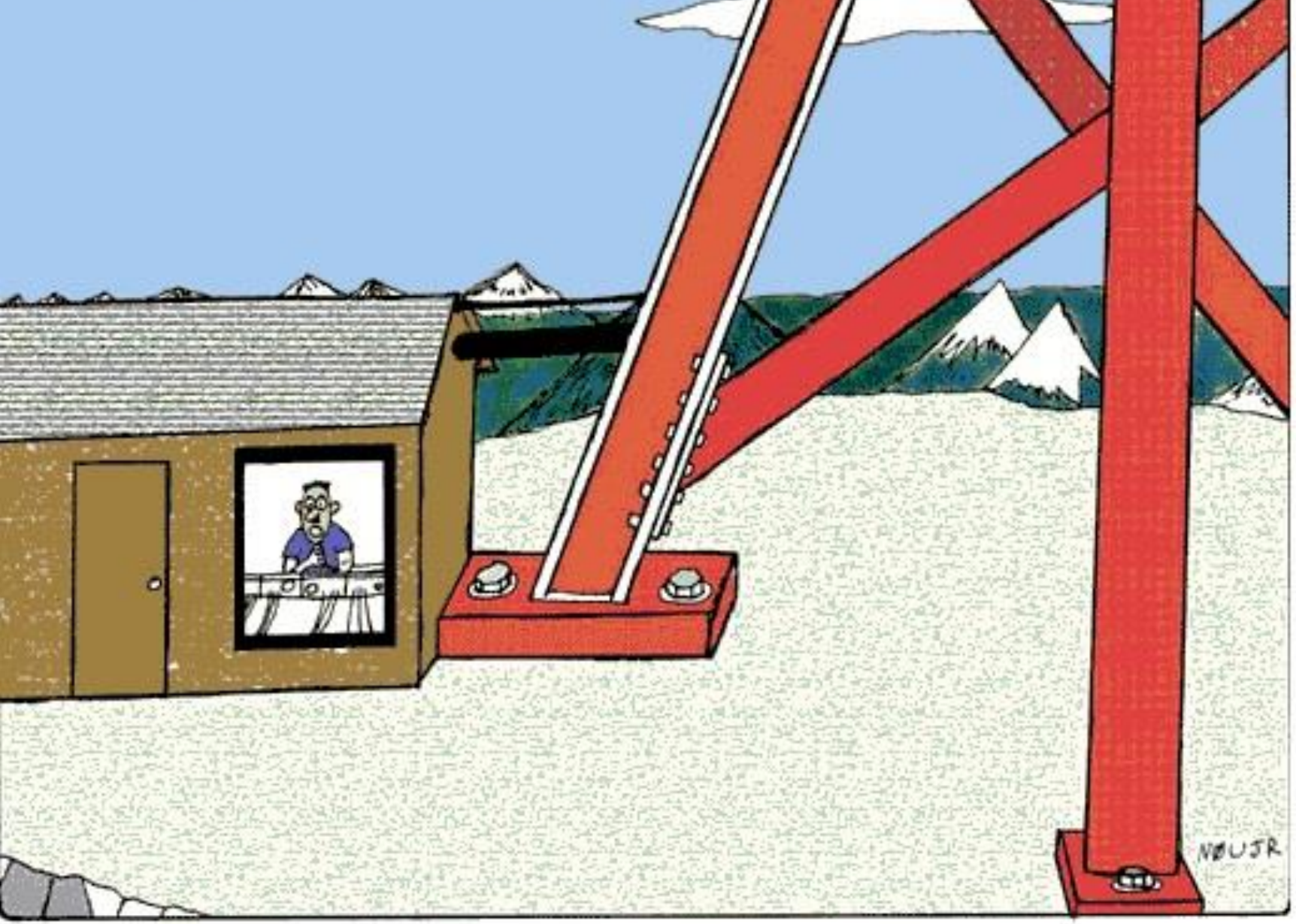
- **400 Million Miles per watt!**

Sorry NASA, It's not Rocket Science …

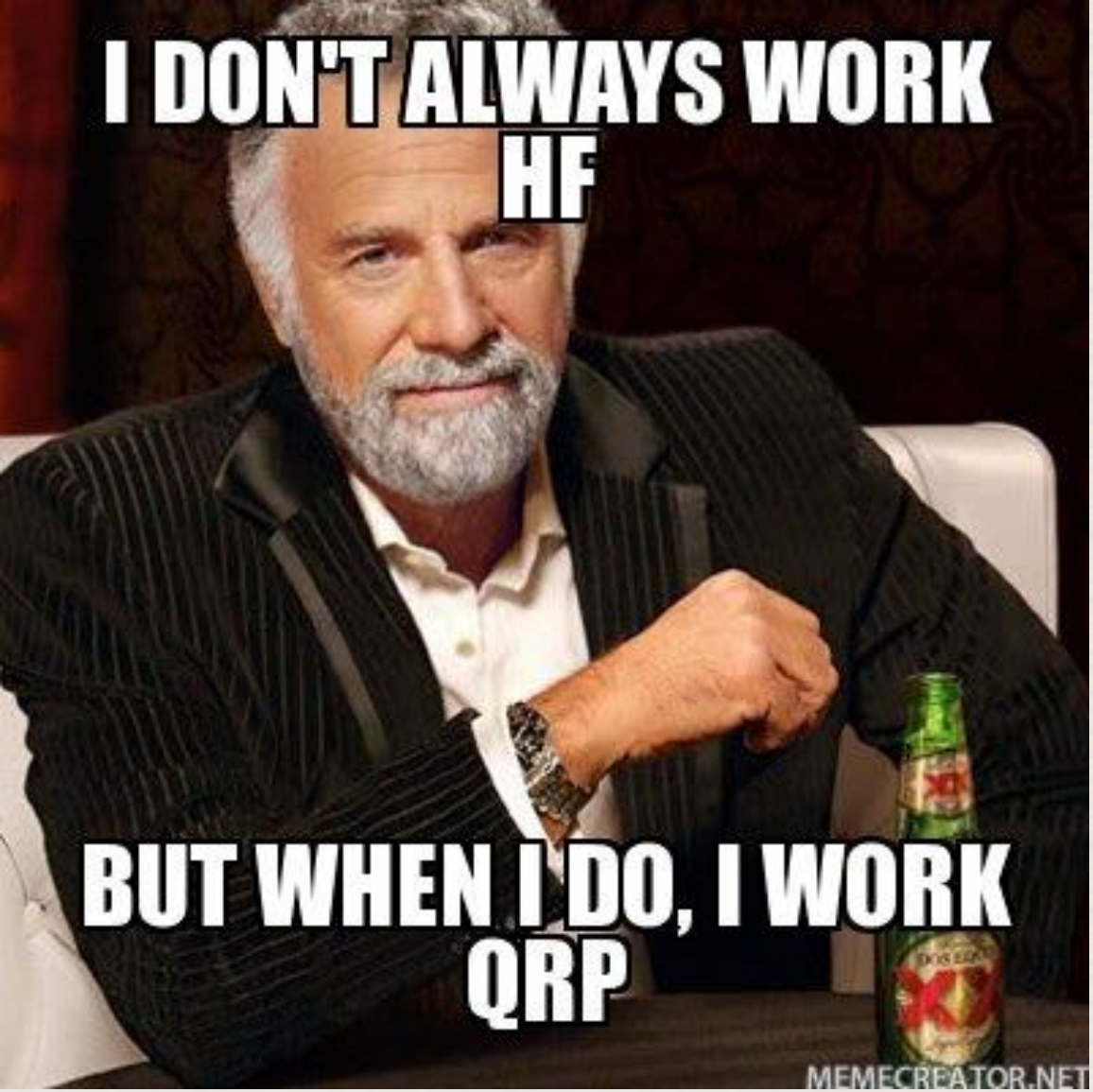
The long-distance low power record is held by KL7YU and W7BVV using ***one micro-watt*** *over a distance of* ***1,650 mile*** *on a 28 MHz path between Alaska and Oregon in 1970.*

- According to Rich Arland, K7YHA (now K7SZ), in World Radio magazine (Feb. 1990, pp. 46-47.)

1.6 Billion Miles per watt!



"Yes I really am running just 5 watts QRP...although I suppose I do have an above average antenna system..."



QRP: When you care enough to send the very least!

“Power is no substitute for skill”

“Use wits, not watts”

“73” = Best Regards
“72” = Best Regards QRP!

Thank you!