Introduction to Digital Modes in Amateur Radio For Voice and Text Use on HF and VHF/UHF

STEPHEN BREDEN

W5HK

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BACKGROUND

Stephen Breden was a Motorola Product Consultant for the HF SSB Product Group from 1977- 1982, focusing on the marine environment, followed by working on HF radio systems in Latin America (ASA in Mexico between regional airports – SSB Backup System)

- He has been an aficionado of digital modes in amateur radio since discovering HF RTTY in the late 70s

DIGITAL MODES USED ON VHF/UHF

VHF/UHF

- DSTAR is the original digital mode and is still supported by Kenwood and JVC
- C4FM is the Yaesu proprietary format and is a part of many VHF/UHF radios produced by that one manufacturer
- DMR is the world commercial standard promoted by Motorola and heavily used in public safety, and adopted for amateur radio in 2010
- DMR is the clear market leader in amateur radio and offers a number of practical and technical superiorities over the other modes. The HARC has two repeaters linked via the ChicagoLand Cbridge on DMR.
- Two HARC club members are monthly Net Controls for the TX Statewide DMR Net.

DIGITAL VOICE ON HF

THERE IS ONLY ONE DIGITAL MODE WIDELY USED ON HF VOICE, AND IT IS AN OPENSOURCE PROJECT

- FreeDV is a suite of digital voice modes for HF radio. Their flagship mode is the Radio Autoencoder (RADE) project.
- (You can run RADE using a free GUI application for Windows, Linux and OSX that allows any SSB radio to be used for high quality digital voice).
- I have personally used this mode a few years back, and it is a viable alternative to SSB communications on the HF bands. Interest has remained minimal…..

FREEDV

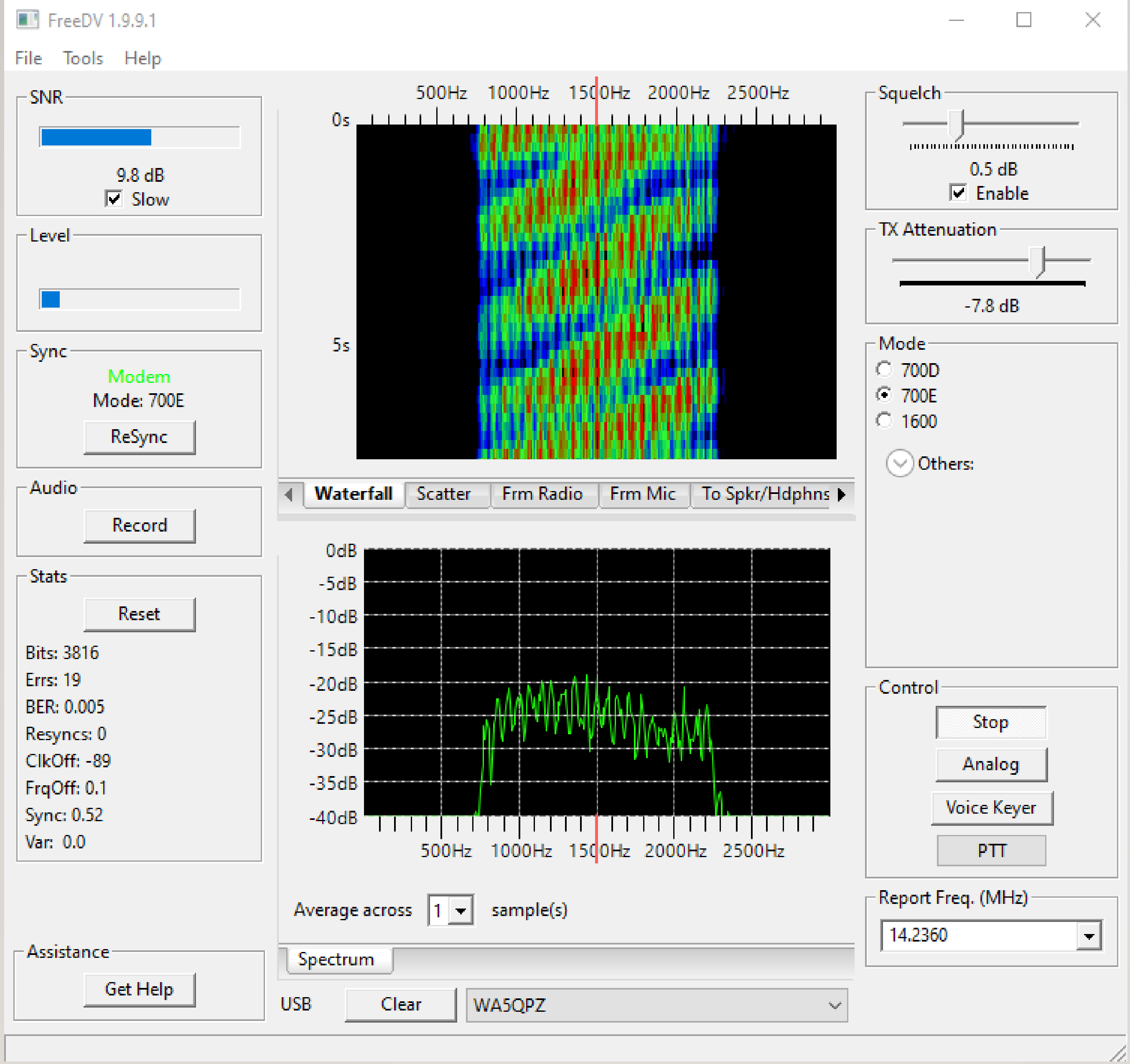
FreeDV is a GUI application for Windows, Linux and MacOS (BSD and Android in development) that allows any SSB radio to be used for low bit rate digital voice.Speech is compressed down to 1600 bits/s then modulated onto a 1.25 kHz wide 16QPSK signal which is sent to the Mic input of a SSB radio. On receive, the signal is received by the SSB radio, then demodulated and decoded by FreeDV. ***Communications should be readable down to 2 dB S/N, and long-distance contacts are reported using 1-2 watts power.***
FreeDV technology is being developed by an international team of radio amateurs working together on Machine Learning, DSP, coding, design, user interface and testing. The project is managed by a 6 person Project Leadership Team (PLT).

FreeDV is open source software, released under the GNU Public License version 2.1. The FreeDV modem and Codec 2 Speech codec used in FreeDV are also open source.

FREEDV.ORG

Links and Download

freedv.org - Main siteThe waveform consists of 14 differential quadrature phase-shift keying (DQPSK) carriers with 75-Hz spacing between centers and a *total bandwidth of 1.125 kHz*. A differential binary phase-shift keying (DBPSK) carrier is centered between the 14 DQPSK carriers, making a total of 15 carriers. The DBPSK carrier has approximately twice the power of the 14 DQPSK carriers and is used for frequency offset estimation and frame synchronization. The carriers operate at 50 symbols/s (50 baud) each. Combined, they carry the Codec 2 voice data, call sign text data, and synchronization information.



FREEDV requires two soundcards. You may monitor the traffic by using the built-in soundcard adapter now found on most HF radios.

DIGITAL MODES USED FOR "TEXTING"

FT8
Has revolutionized Amateur Radio on HF; accused of being "not real radio," it is a direct outgrowth of the pioneering work of K1JT in developing coding and algorithms allowing communications over modes with various issues (deep fading). I suspect he was inspired by deep space probes having the ability to communicate over vast differences back to earth.

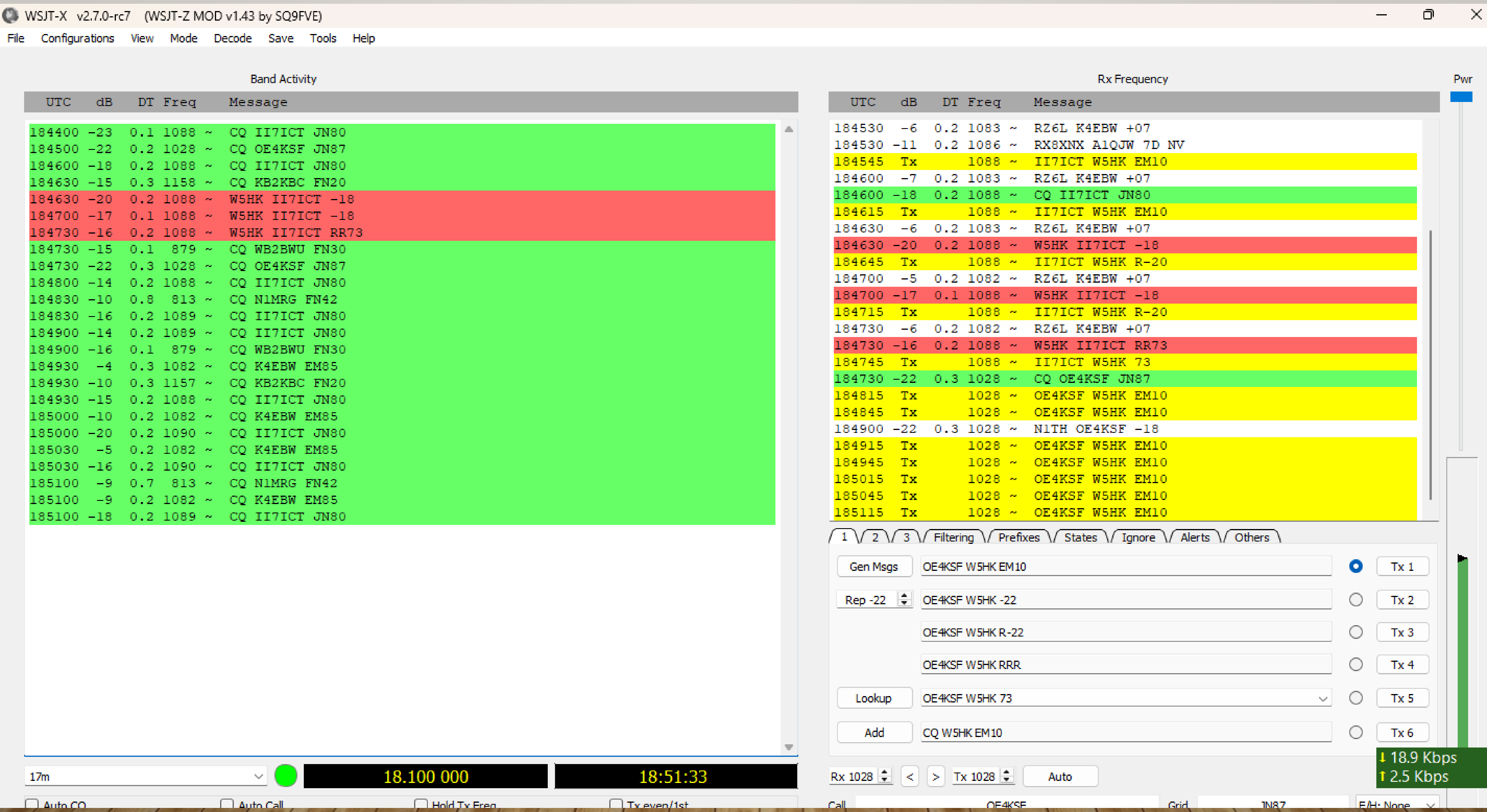
FT8 is part of the WSJT-X suite of applications developed by K1JT and his team.

It is easily the most popular mode in use for DXing and working DX stations easily.

It has the distinct advantage of allowing any amateur running 100 watts or less, with a minimal antenna, the opportunity to "compete" and work foreign entities that were prior available to stations running KW amplifiers, towers, and 3 element beam antennas up 50 feet.

Its big disadvantage – it is not set up for chatting and allows for a simple legal QSO that qualifies for awards.

A variant, JS8Call, uses the basic FT8 protocols to allow slow, keyboard to keyboard chatting.



WSJT-X v2.7.0-rc7 (WSJT-Z MOD v1.43 by SQ9FVE)
File Configurations View Mode Decode Save Tools Help
Band Activity
UTC dB DT Freq Message
184400 -23 0.1 1088 ~ CQ II7ICT JN80
184500 -22 0.2 1028 ~ CQ OE4KSF JN87
184600 -18 0.2 1088 ~ CQ II7ICT JN80
184630 -15 0.3 1158 ~ CQ KB2KBC FN20
184630 -20 0.2 1088 ~ W5HK II7ICT -18
184700 -17 0.1 1088 ~ W5HK II7ICT -18
184730 -16 0.2 1088 ~ W5HK II7ICT RR73
184730 -15 0.1 879 ~ CQ WB2BWU FN30
184730 -22 0.3 1028 ~ CQ OE4KSF JN87
184800 -14 0.2 1088 ~ CQ II7ICT JN80
184830 -10 0.8 813 ~ CQ N1MRG FN42
184830 -16 0.2 1089 ~ CQ II7ICT JN80
184900 -14 0.2 1089 ~ CQ II7ICT JN80
184900 -16 0.1 879 ~ CQ WB2BWU FN30
184930 -4 0.3 1082 ~ CQ K4EBW EM85
184930 -10 0.3 1157 ~ CQ KB2KBC FN20
184930 -15 0.2 1088 ~ CQ II7ICT JN80
185000 -10 0.2 1082 ~ CQ K4EBW EM85
185000 -20 0.2 1090 ~ CQ II7ICT JN80
185030 -5 0.2 1082 ~ CQ K4EBW EM85
185030 -16 0.2 1090 ~ CQ II7ICT JN80
185100 -9 0.7 813 ~ CQ N1MRG FN42
185100 -9 0.2 1082 ~ CQ K4EBW EM85
185100 -18 0.2 1089 ~ CQ II7ICT JN80
Rx Frequency
UTC dB DT Freq Message
184530 -6 0.2 1083 ~ RZ6L K4EBW +07
184530 -11 0.2 1086 ~ RX8XNX A1QJW 7D NV
184545 Tx 1088 ~ II7ICT W5HK EM10
184600 -7 0.2 1083 ~ RZ6L K4EBW +07
184600 -18 0.2 1088 ~ CQ II7ICT JN80
184615 Tx 1088 ~ II7ICT W5HK EM10
184630 -6 0.2 1083 ~ RZ6L K4EBW +07
184630 -20 0.2 1088 ~ W5HK II7ICT -18
184645 Tx 1088 ~ II7ICT W5HK R-20
184700 -5 0.2 1082 ~ RZ6L K4EBW +07
184700 -17 0.1 1088 ~ W5HK II7ICT -18
184715 Tx 1088 ~ II7ICT W5HK R-20
184730 -6 0.2 1082 ~ RZ6L K4EBW +07
184730 -16 0.2 1088 ~ W5HK II7ICT RR73
184745 Tx 1088 ~ II7ICT W5HK 73
184730 -22 0.3 1028 ~ CQ OE4KSF JN87
184815 Tx 1028 ~ OE4KSF W5HK EM10
184845 Tx 1028 ~ OE4KSF W5HK EM10
184900 -22 0.3 1028 ~ N1TH OE4KSF -18
184915 Tx 1028 ~ OE4KSF W5HK EM10
184945 Tx 1028 ~ OE4KSF W5HK EM10
185015 Tx 1028 ~ OE4KSF W5HK EM10
185045 Tx 1028 ~ OE4KSF W5HK EM10
185115 Tx 1028 ~ OE4KSF W5HK EM10
Pwr
1 2 3 Filtering Prefixes States Ignore Alerts Others
Gen Msgs OE4KSF W5HK EM10 Tx 1
Rep -22 OE4KSF W5HK -22 Tx 2
OE4KSF W5HK R-22 Tx 3
OE4KSF W5HK RRR Tx 4
Lookup OE4KSF W5HK 73 Tx 5
Add CQ W5HK EM10 Tx 6
17m
18.100 000
18:51:33
Rx 1028 < > Tx 1028 Auto
18.9 Kbps
2.5 Kbps
Auto CQ Auto Call Hold Tx Freq Tx even/1st
Call OE4KSF Grid JN87 E/H: None

WSJT-X

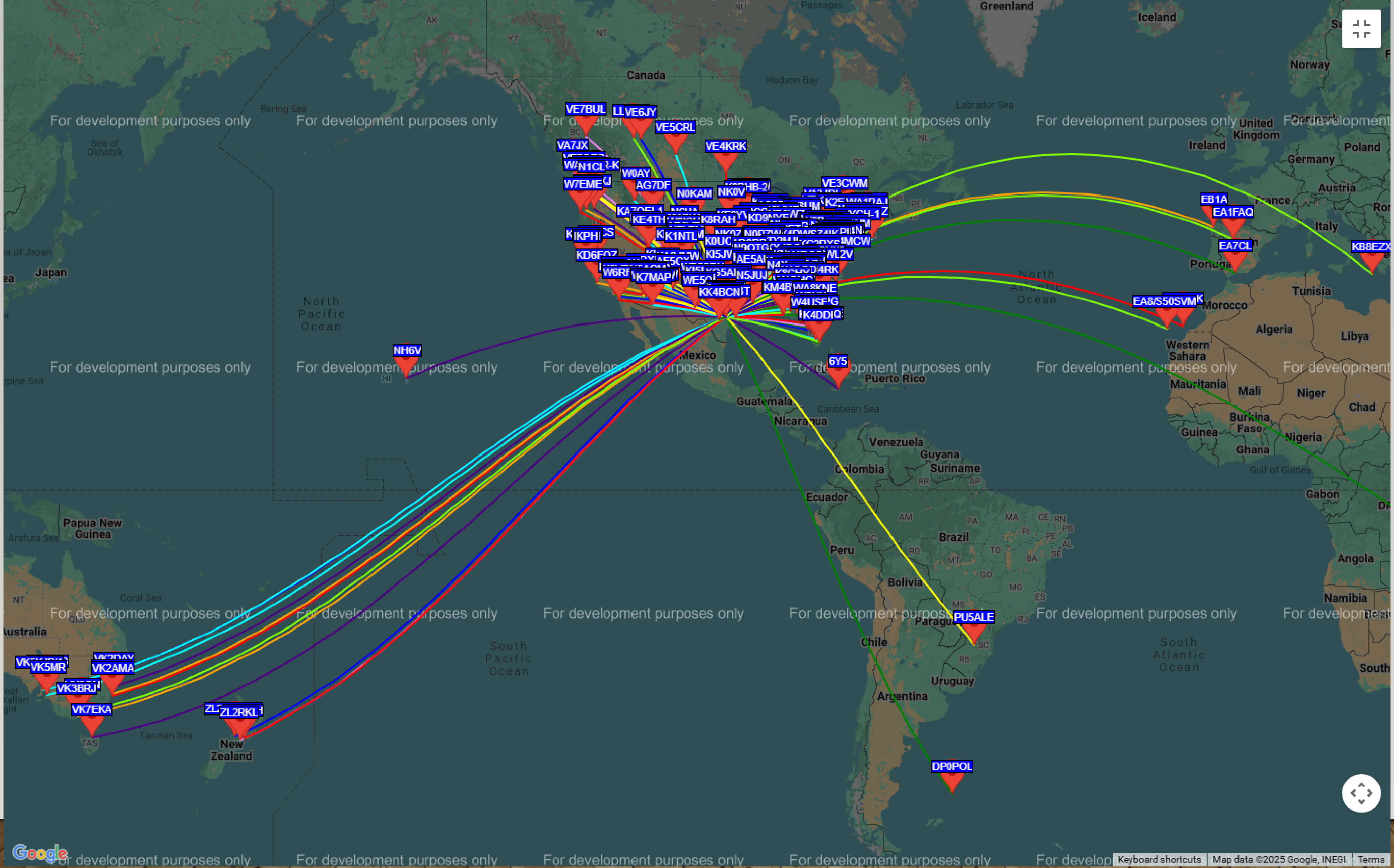
WSJT-X implements communication protocols or "modes" called **FST4, FST4W, FT4, FT8, JT4**, **JT9**, **JT65**, **Q65**, **MSK144**, and **WSPR**, as well as one called **Echo** for detecting and measuring your own radio signals reflected from the Moon. These modes were designed for making reliable, confirmed QSOs under extreme weak-signal conditions.

JT4, **JT9**, **and JT65** use nearly identical message structure and source encoding (the efficient compression of standard messages used for minimal QSOs). They use timed 60-second T/R sequences synchronized with UTC. **JT4** and **JT65** were designed for EME ("moonbounce") on the VHF/UHF/microwave bands. **JT9** is optimized for the MF and HF bands. It is about 2 dB more sensitive than **JT65** while using less than 10% of the bandwidth. **Q65** offers submodes with a wide range of T/R sequence lengths and tone spacings; it is highly recommended for EME, ionospheric scatter, and other weak signal work on VHF, UHF, and microwave bands.

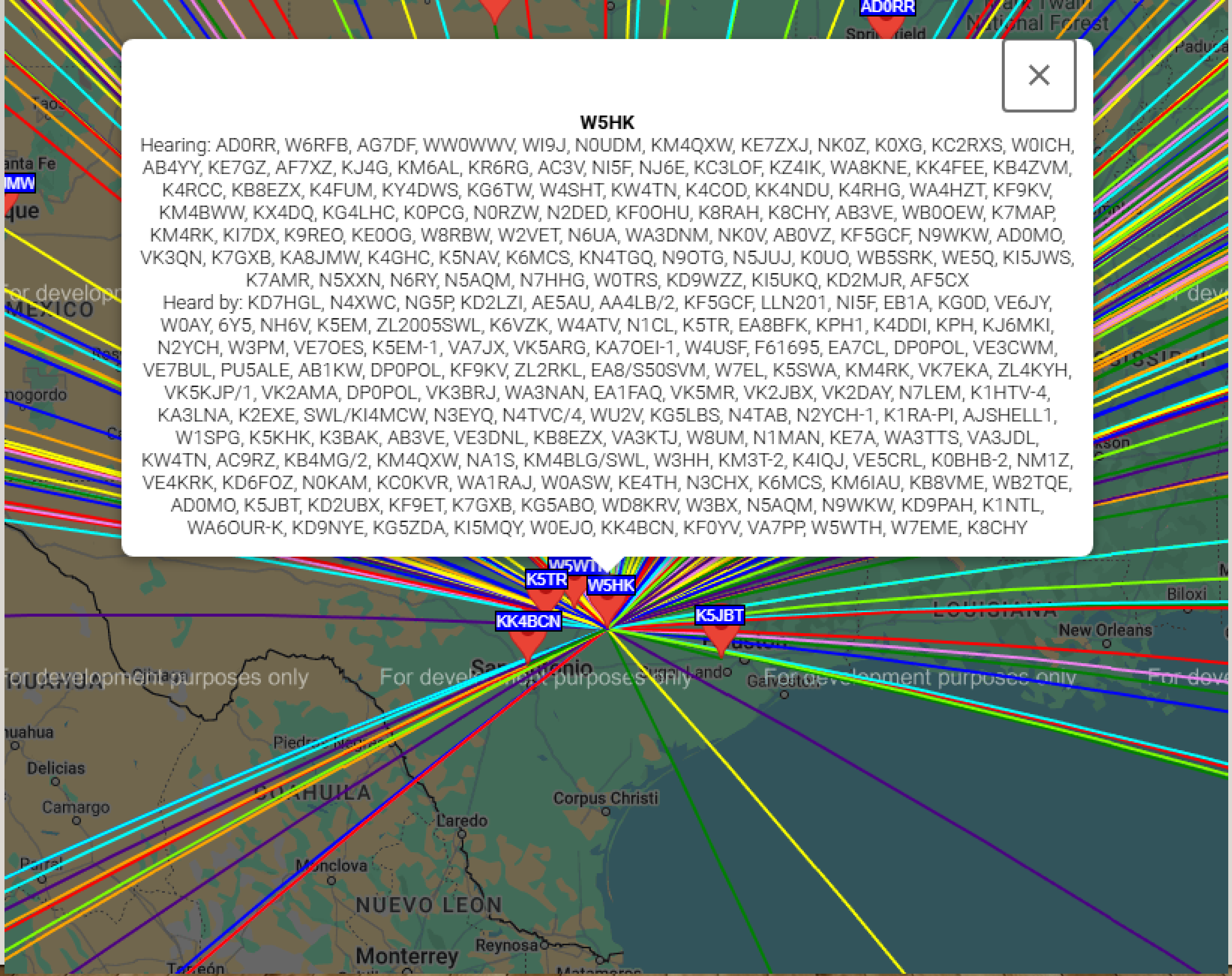
WSJT-X

FST4 and **FST4W** are designed particularly for the LF and MF bands. On these bands their fundamental sensitivities are better than other WSJT-X modes with the same sequence lengths, approaching the theoretical limits for their rates of information throughput. **FST4** is optimized for two-way QSOs, while **FST4W** is for quasi-beacon transmissions of **WSPR**-style messages. **FST4** and **FST4W** do not require the strict, independent time synchronization and phase locking of modes like EbNaut.

WSPR mode implements a protocol designed for probing potential propagation paths with low-power transmissions. **WSPR** is fully implemented within *WSJT-X*, including programmable "band-hopping".

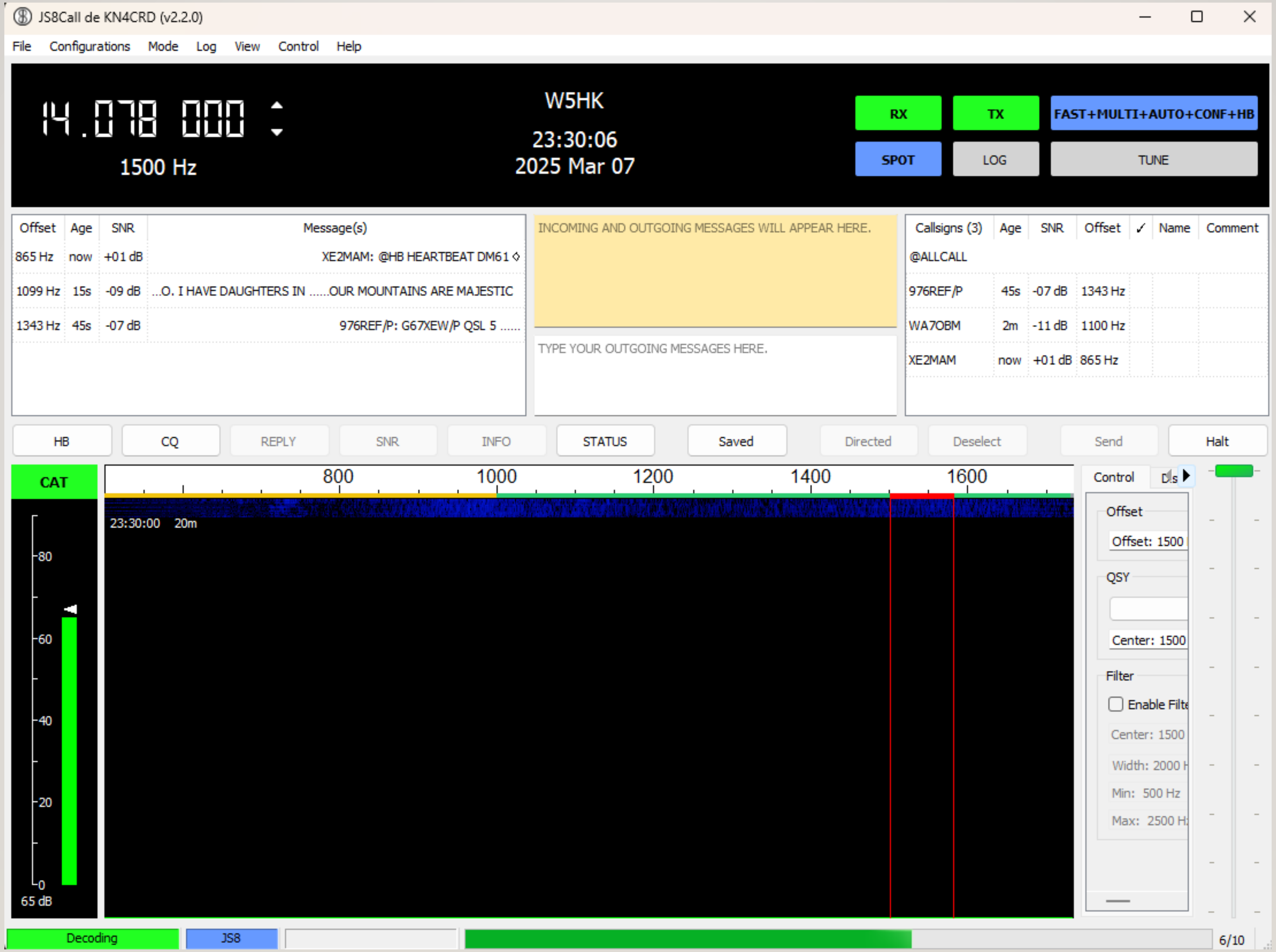


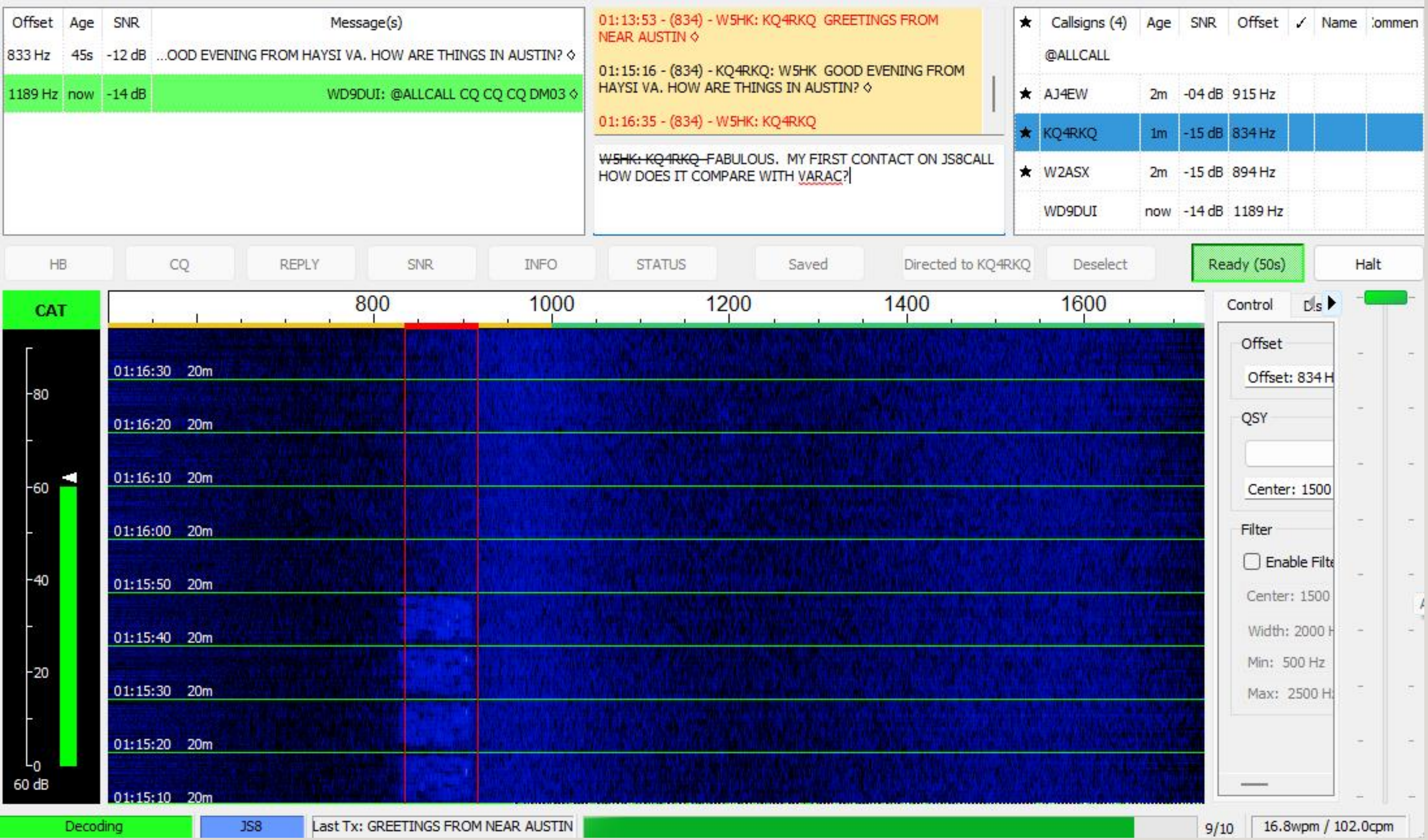
March 12, 2025 50 Watts on 20 Meters with EFW up 12 Feet



W5HK
Hearing: AD0RR, W6RFB, AG7DF, WW0WWV, WI9J, N0UDM, KM4QXW, KE7ZXJ, NK0Z, K0XG, KC2RXS, W0ICH, AB4YY, KE7GZ, AF7XZ, KJ4G, KM6AL, KR6RG, AC3V, NI5F, NJ6E, KC3LOF, KZ4IK, WA8KNE, KK4FEE, KB4ZVM, K4RCC, KB8EZX, K4FUM, KY4DWS, KG6TW, W4SHT, KW4TN, K4COD, KK4NDU, K4RHG, WA4HZT, KF9KV, KM4BWW, KX4DQ, KG4LHC, K0PCG, N0RZW, N2DED, KF0OHU, K8RAH, K8CHY, AB3VE, WB0OEW, K7MAP, KM4RK, KI7DX, K9REO, KE0OG, W8RBW, W2VET, N6UA, WA3DNM, NK0V, AB0VZ, KF5GCF, N9WKW, AD0MO, VK3QN, K7GXB, KA8JMW, K4GHC, K5NAV, K6MCS, KN4TGQ, N9OTG, N5JUJ, K0UO, WB5SRK, WE5Q, KI5JWS, K7AMR, N5XXN, N6RY, N5AQM, N7HHG, W0TRS, KD9WZZ, KI5UKQ, KD2MJR, AF5CX
Heard by: KD7HGL, N4XWC, NG5P, KD2LZI, AE5AU, AA4LB/2, KF5GCF, LLN201, NI5F, EB1A, KG0D, VE6JY, W0AY, 6Y5, NH6V, K5EM, ZL2005SWL, K6VZK, W4ATV, N1CL, K5TR, EA8BFK, KPH1, K4DDI, KPH, KJ6MKI, N2YCH, W3PM, VE7OES, K5EM-1, VA7JX, VK5ARG, KA7OEI-1, W4USF, F61695, EA7CL, DP0POL, VE3CWM, VE7BUL, PU5ALE, AB1KW, DP0POL, KF9KV, ZL2RKL, EA8/S50SVM, W7EL, K5SWA, KM4RK, VK7EKA, ZL4KYH, VK5KJP/1, VK2AMA, DP0POL, VK3BRJ, WA3NAN, EA1FAQ, VK5MR, VK2JBX, VK2DAY, N7LEM, K1HTV-4, KA3LNA, K2EXE, SWL/KI4MCW, N3EYQ, N4TVC/4, WU2V, KG5LBS, N4TAB, N2YCH-1, K1RA-PI, AJSHELL1, W1SPG, K5KHK, K3BAK, AB3VE, VE3DNL, KB8EZX, VA3KTJ, W8UM, N1MAN, KE7A, WA3TTS, VA3JDL, KW4TN, AC9RZ, KB4MG/2, KM4QXW, NA1S, KM4BLG/SWL, W3HH, KM3T-2, K4IQJ, VE5CRL, K0BHB-2, NM1Z, VE4KRK, KD6FOZ, N0KAM, KC0KVR, WA1RAJ, W0ASW, KE4TH, N3CHX, K6MCS, KM6IAU, KB8VME, WB2TQE, AD0MO, K5JBT, KD2UBX, KF9ET, K7GXB, KG5ABO, WD8KRV, W3BX, N5AQM, N9WKW, KD9PAH, K1NTL, WA6OUR-K, KD9NYE, KG5ZDA, KI5MQY, W0EJO, KK4BCN, KF0YV, VA7PP, W5WTH, W7EME, K8CHY
AD0RR
K5TR
W5HK
KK4BCN
K5JBT
LOUISIANA
New Orleans
Biloxi
Corpus Christi
Laredo
Monclova
NUEVO LEON
Monterrey
Reynosa
COAHUILA
Delicias
Camargo
For development purposes only

JS8Call – Based On the WSJT-X Protocols





AUSTIN ◊

01:15:16 - (834) - KQ4RKQ: W5HK GOOD EVENING FROM HAYSI VA. HOW ARE THINGS IN AUSTIN? ◊

01:16:35 - (834) - W5HK: KQ4RKQ FABULOUS. MY FIRST CONTACT ON JS8CALL HOW DOES IT COMPARE WITH VARAC? ◊

01:20:07 - (830) - W5HK: KQ4RKQ

01:18:38 - (833) - KQ4RKQ: W5HK I DID DO VARA FOR A WHILE TO ME THIS IS MUCH MORE USER FRIENDLY, VARAC WAS A LITTLE COMPLICATED FOR ME. I LIKE JS8 CALL, ITS AS EASY ...... ◊

01:22:36 - (830) - W5HK: KQ4RKQ UNPLUGGED I MAY HAVE SEEMS EASY. TNX FOR CONTACT. JUST GOT CALLED TO DINNER ◊

01:22:38 - (834) - ......

01:22:16 - (834) - KQ4RKQ: W5HK SORRY MY RADIO CAME UNPLUGGED I MAY HAVE ...... ◊

01:23:59 - (830) - KQ4RKQ: NO

01:24:06 - (834) - PROBLEM 73'S TO YOU MY FRIEND ◊

01:25:12 - (834) - W5HK: KQ4RKQ 73 ◊

What Is Q65???

There is a relatively new Q65 mode within the WSJT-X software suite. It works over long distances when nothing else is happening. It's said to operate via ionospheric scatter for terrestrial contacts and is becoming the go-to mode for moon bounce. This article provides a brief introduction along with current operating recommendations. The goal is to help you make QSOs when nothing else is working.

What is Q65?

Q65 uses a 65-tone frequency-shift keying modulation mode. It has a sync tone for both time and frequency synchronization. Q65 is particularly effective for tropospheric scatter, rain scatter, ionospheric scatter, TEP, and EME on VHF and higher bands, as well as other fast-fading signals.

Joe Taylor, K1JT, states: *"Q65 will enable stations with a modest Yagi and 100 W or more to work one another on 6 meters at distances up to ~2000 km on most days of the year, in dead band conditions. Ionospheric scatter is best near mid-day and in summer months but is present at all times."*

That's how it has worked for me. Moving to Q65 has made it happen from home or as a rover when nothing else is working. It, of course, helps to coordinate between the two stations, just as is done with meteor scatter contacts.

Courtesy K5ND.NET

With Q65, there are selectable transmit/receive sequences and sub-modes. For 6 meters, the general standard is 30-A, or 30-second t/r sequence and sub-mode A. For 2 meters, it's 60-C, or 60-second t/r sequence and sub-mode C. The K1JT Quick Start Guide to Q65 recommends the following t/r sequences and sub-modes.

•Trans-Equatorial Propagation (TEP) on 50 MHz: **15C, 30C**

•Ionospheric scatter on 50 MHz: **30A**

•QRP ionospheric scatter on 50 MHz: **120E**

•Ionospheric scatter on 144 MHz: **60C**

•Troposcatter and rain scatter at 10 GHz: **60D**

•Small-dish EME, 10 and 24 GHz: **120E**

•Other EME: 50, 144 MHz **60A;** 432 MHz **60B;** 1296 MHz: **60C;** 10 GHz: **60D**

The sub-modes provide different tone spacings. The available t/r sequences are 15, 30, 60, 120, and 300 seconds. Here's how those t/r sequences come into play with signal-to-noise ratios.

•15 seconds, -22.2 dB SNR, with *a priori* (AP) decoding -23.7 dB SNR.

•60 seconds, -27.6 dB SNR, with AP decoding -30.2 dB.

•300 seconds, -33.8 dB SNR, with AP decoding -37.4 dB.

A priori or AP decodes messages using heuristics and available information, adding several dB to the SNR.

Bouncing Signals Off of Satellites Other Than the Moon

The moon is a popular target for ham radio operators to bounce signals since it's fairly large and follows a predictable path. There are some downsides, though; it's not always visible from the same point on Earth and is a relatively long way away.

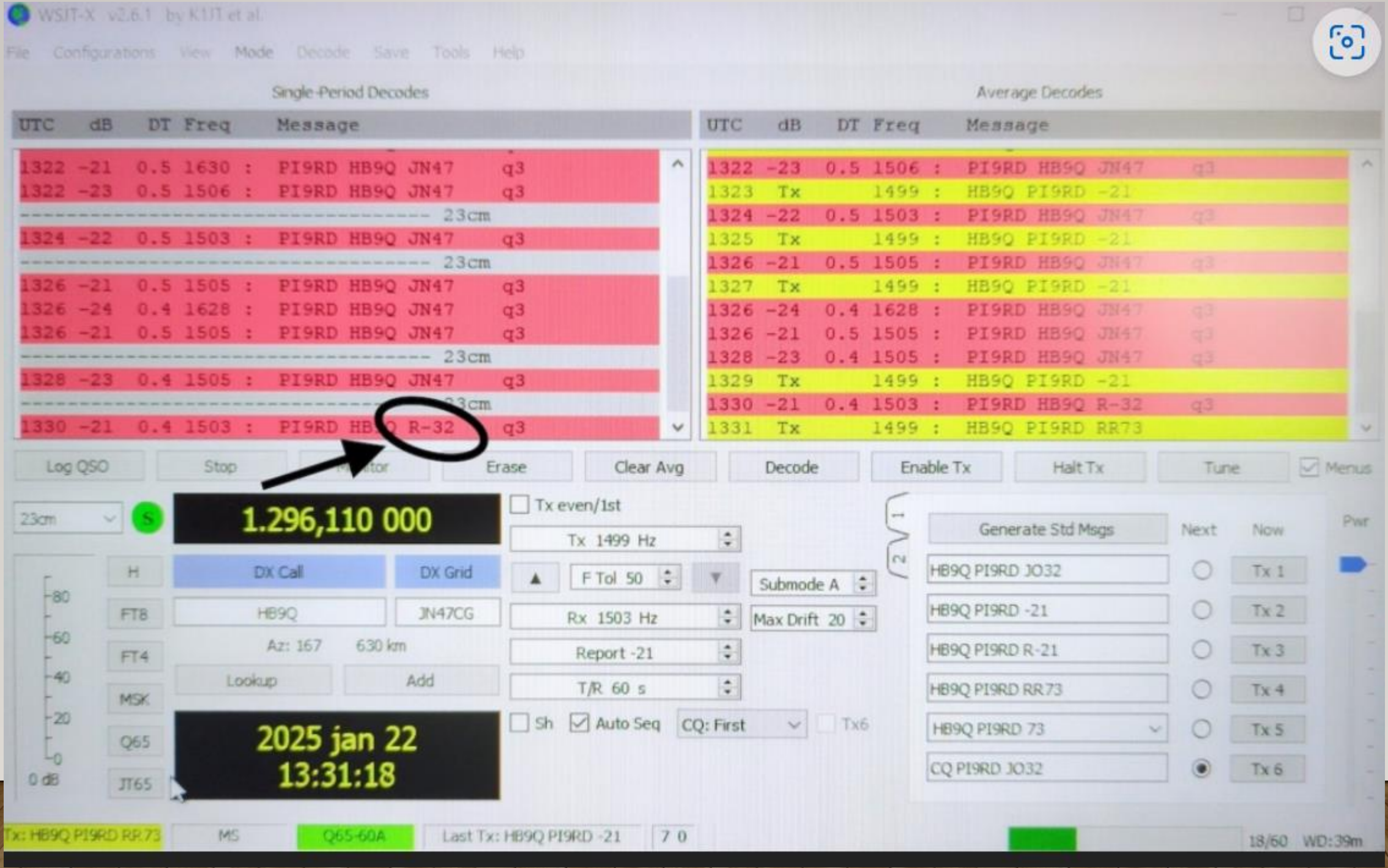
Thinking they could trade some distance for size, an amateur radio group from the Netherlands was recently able to use a radio telescope pointed at a geostationary satellite to reflect a signal back down to Earth, using this man-made satellite to complete the path instead of the more common natural one.

While there are plenty of satellites in orbit meant for amateur radio communication (including the International Space Station, although it occasionally does other things too), these all have built-in radio transmitters or repeaters specifically meant for re-transmitting received signals. They're also generally not in geostationary orbit. So, with a retired radio telescope with a 20-meter dish aimed directly at one of the ones already there, they sent out a signal which bounced off of the physical body of the satellite and then back down where it was received by a station in Switzerland.

Of course, the path loss here is fairly extreme as well since the satellite is small compared to the moon and geostationary orbit is a significant distance away, so they used the Q65 mode in WSJT-X which is specifically designed for recovering weak signals.

The FCC has updated amateur radio regulations to allow 2.8 kHz bandwidth digital modes on the bands below 30 MHz. This means that MSK144 and Q65A can be operated on 10 meters and lower. I'm seeing that the current Q65 mode A calling frequency is 28.140 MHz.

From: hackaday.com By: Brian Cockfield


WSJT-X v2.6.1 by K1JT et al.
File Configurations View Mode Decode Save Tools Help
Single-Period Decodes
Average Decodes
UTC dB DT Freq Message
1322 -21 0.5 1630 : PI9RD HB9Q JN47 q3
1322 -23 0.5 1506 : PI9RD HB9Q JN47 q3
23cm
1324 -22 0.5 1503 : PI9RD HB9Q JN47 q3
23cm
1326 -21 0.5 1505 : PI9RD HB9Q JN47 q3
1326 -24 0.4 1628 : PI9RD HB9Q JN47 q3
1326 -21 0.5 1505 : PI9RD HB9Q JN47 q3
23cm
1328 -23 0.4 1505 : PI9RD HB9Q JN47 q3
1330 -21 0.4 1503 : PI9RD HB9Q R-32 q3
UTC dB DT Freq Message
1322 -23 0.5 1506 : PI9RD HB9Q JN47 q3
1323 Tx 1499 : HB9Q PI9RD -21
1324 -22 0.5 1503 : PI9RD HB9Q JN47 q3
1325 Tx 1499 : HB9Q PI9RD -21
1326 -21 0.5 1505 : PI9RD HB9Q JN47 q3
1327 Tx 1499 : HB9Q PI9RD -21
1326 -24 0.4 1628 : PI9RD HB9Q JN47 q3
1326 -21 0.5 1505 : PI9RD HB9Q JN47 q3
1328 -23 0.4 1505 : PI9RD HB9Q JN47 q3
1329 Tx 1499 : HB9Q PI9RD -21
1330 -21 0.4 1503 : PI9RD HB9Q R-32 q3
1331 Tx 1499 : HB9Q PI9RD RR73
Log QSO
Stop
Erase
Clear Avg
Decode
Enable Tx
Halt Tx
Tune
Menus
23cm
1.296,110 000
Tx even/1st
Tx 1499 Hz
F Tol 50
Submode A
Rx 1503 Hz
Max Drift 20
Report -21
T/R 60 s
Sh
Auto Seq
CQ: First
Tx6
H
FT8
FT4
MSK
Q65
JT65
DX Call
DX Grid
HB9Q
JN47CG
Az: 167
630 km
Lookup
Add
0 dB
2025 jan 22
13:31:18
Generate Std Msgs
Next
Now
Pwr
HB9Q PI9RD JO32
Tx 1
HB9Q PI9RD -21
Tx 2
HB9Q PI9RD R-21
Tx 3
HB9Q PI9RD RR73
Tx 4
HB9Q PI9RD 73
Tx 5
CQ PI9RD JO32
Tx 6
Tx: HB9Q PI9RD RR73
MS
Q65-60A
Last Tx: HB9Q PI9RD -21
18/60
WD:39m

Don’t break out the tape measure Yagi antenna to try this yourself just yet, though. This path is not quite as reliable as Earth-Moon-Earth for a few reasons the group is not quite sure about yet. Not every satellite they aimed their dish at worked, although they theorize that this might be because of different shapes and sizes of the satellites or that the solar panels were not pointing the correct direction. But they were able to make a few contacts using this method nonetheless, a remarkable achievement they can add to their list which includes receiving a signal from one of the Voyager spacecraft.

Sending Signals To the Moon and Back

Understanding Moon Bounce

Moon bounce communication is a fascinating aspect of amateur radio, allowing operators to leverage the Moon as a natural satellite reflector for radio signals. The concept might sound like science fiction, but it’s a practice that has been in use since the late 1950s. Despite the significant path loss incurred during the journey to the Moon and back—approximately 250,000 miles each way—advancements in technology have made EME accessible even to amateurs with modest setups.

The Basic Requirements

To start with EME, you’ll need a few key components:

- **Transceiver**: A radio capable of both transmitting and receiving signals. For EME, most enthusiasts use the 144 MHz (2 meters), 432 MHz (70 centimeters), or 1296 MHz (23 centimeters) bands.
- **Antenna**: A high-gain directional antenna, like a Yagi, is essential for focusing your signal towards the Moon.
- **Power Amplifier**: Boosting your signal strength is crucial to overcome the path loss.
- **Low Noise Pre-amplifier (LNA)**: Improving the reception of the weak signals reflected back from the Moon.
- **Digital Modes**: Modern digital communication modes, such as JT65, are highly efficient for EME, making it possible to decode signals that are below the noise level.
- Courtesy KD7OKK February 18, 2024

Lunar DX on 144 Mc! [1953]

W4AO and W3GKP Bounce 2-Meter Signals Off the Moon

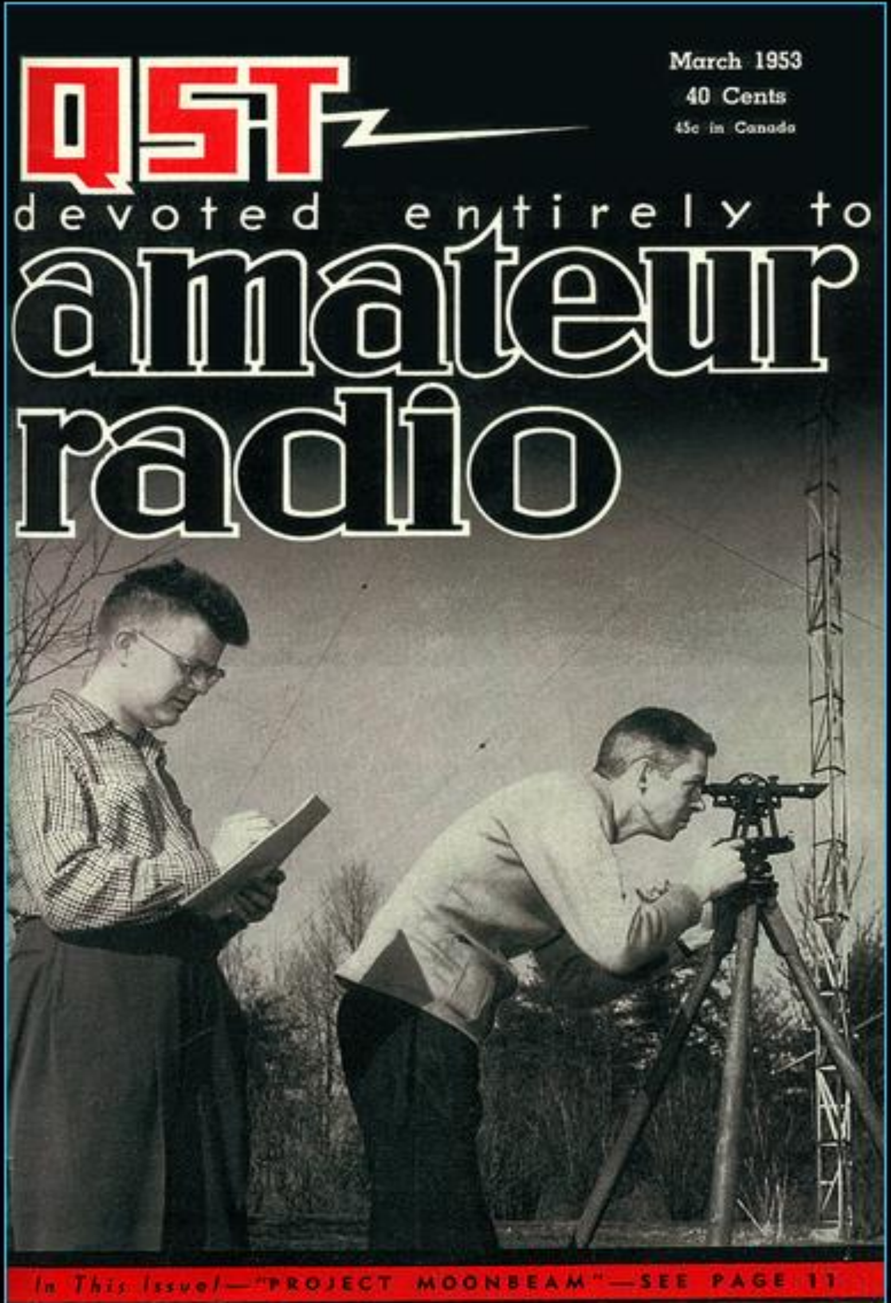
Listening to the wire recording from which the above graph was made, it doesn't sound like much; a one-second beep, an interval of receiver noise, then a wavering trailing bee-e-e-e-p barely discernible in the midst of the slightly musical rushing sound that is characteristic of high-selectivity reception. You wouldn't be impressed if you happened to hear it casually, but to Ross Bateman, W4AO, and Bill Smith, W3GKP, it was music of the sweetest sort; evidence that more years of thinking, figuring, building, re building and testing were not in vain. An amateur signal had been sent to the moon and back, at last!

Bouncing signals off the moon is not new, of course. It was done on 110 Mc. by the Signal Corps back in 1946[1] and something approximating intelligence was sent from Cedar Rapids, Iowa, to Washington, D. C., on 400 Mc. more recently, using the moon as a reflector. These were high-power projects, however, and their slim margin of success indicated that lunar DX for amateurs was a long-chance proposition. It was an end that just might be achieved, but only after the most painstaking effort, if at all.

The best available information indicated that it would take the level amateur power limit, pushed to the last watt. An antenna gain of at least 20 dB was required, and a degree of receiver performance to tax the ingenuity of the best engineers in the business was called for. Obviously, a 144 Mc. WAS, lunar style, was a long way off, but it was a challenge that a few enter prising and infinitely patient hams were bound to accept.

One such ham was Bill Smith, W3GKP, then of Silver Spring, Maryland. Smitty knew what he was about, and he went at the job with no illusions about aiming his beam at the rising moon some night and then sitting back to listen to the W6s. He knew the requirements, in a general way, and he felt sure that the trick could be turned, eventually. The first step was to find a co-worker, so that the burden of equipment development and construction could be shared. A ham with a kilowatt rig and a big beam for 144 Mc. would be a fine start. Several prospects were lined up, and early in 1950 a few transmitting tests were made, while W3GKP worked on his receiving gear, but none of the prospects had sufficiently good equipment to make reception possible at that stage of the game.

Other amateurs, among them W4AO, Falls Church, Va., had been working along similar lines. Learning of W3GKP's interest, Ross joined forces with Smitty, and Project Moonbeam was on its way in earnest. Ross brought to the operation the technical know-how and the enthusiasm and perseverance Smitty had been looking for, and he had a 2-meter rig capable of a full and efficient kilowatt, a 32-element array, a low-noise receiver and a quiet suburban location. After many evenings of discussion, planning and construction, the stage was set for a series of tests with a set-up that appeared to have some chance of succeeding.

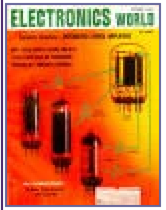


Ham Radio Earth-Moon-Earth Contact

October 1960 Electronics World

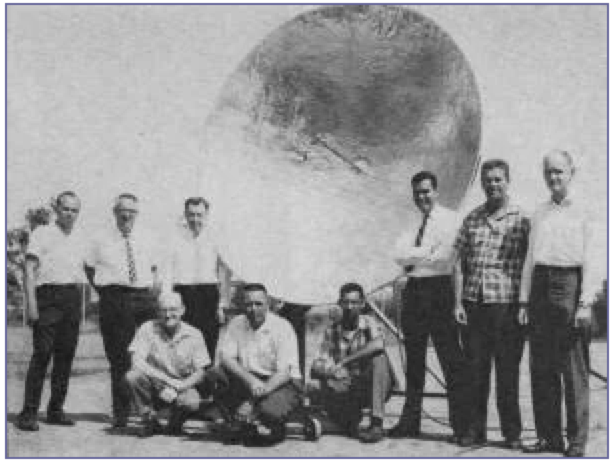
We recently passed the 62nd anniversary of the first successful earth-moon-earth (EME) communication path by amateur radio operators. What is today a routine operation by Hams was a big deal back in the day. The moon was still a mystery to most of the world since at the time not even an unmanned probe had been sent for exploration. As reported in this 1960 issue of *Electronics World* magazine, 1,296 MHz was the frequency of choice using a 1 kW klystron on the transmit end and a highly sensitive parametric amplifier on the receive end, with high gain parabolic antennas on both ends. The Federal Communications Commission (FCC) has allocated the 144.00-144.20 MHz (2 m), 222.0-222.025 MHz (1.25 m), 432.00-432.07 MHz and (70 cm), 902.8-903.0 MHz (33 cm), 1295.8-1296.05 MHz (23 cm), and 2303.9-2304.2 MHz bands for various modes of EME operation per Part 97 rules.

October 1960 Electronics World



 Wax nostalgic about and learn from the history of early electronics. See articles from *Electronics World*, published May 1959 - December 1971.

Ham Radio Earth-Moon-Earth Contact



Some members of the Eimac Radio Club in San Carlos, California, who participated in the moon-bounce circuit are shown here with their make-shift parabolic dish.

Details on the first amateur radio moon-bounce two-way microwave contact between California and Massachusetts.

The first amateur radio moon-bounce two-way microwave communication took place on Sunday, July 17 between two distant points. This contact marks an important milestone in the development of amateur radio. The historic contact was between the members of the Eimac Radio Club in San Carlos, California and Mr. Sam Harris, Rhododendron Swamp VHF Society in Medfield, Mass.

After months of personal effort by the radio amateurs concerned with this project, signals were transmitted in both directions on 1296 mc. The equipment was then refined and the first successful two-way communication was made. The first transmission was from West (W6HB) to East (W1BU). The pattern was then reversed and the first amateur coast-to-coast communication via the moon completed. At each end of the circuit, a 1000-watt klystron was used in the transmitter and a very sensitive parametric amplifier in the receiver.

This successful

Military Interest in Moonbounce in the 1950s

On July 24, 1954, a Navy engineer named James Trexler sat in a room at the Naval Research Center in Maryland talking to himself. To the outside observer, the situation would certainly look strange. But Trexler hadn't gone mad—he'd just inaugurated electronic warfare.

To be more specific, Trexler was speaking into a microphone connected to a large antenna at the Stump Neck radio facility at the Naval base. This antenna was directed toward the moon and when Trexler spoke into microphone, his words returned to him two and a half seconds later after traveling a 500,000 mile circuit to the moon and back. Although the first radio signal had been bounced off the moon nearly 30 years earlier, Trexler was the first to send and receive a voice transmission via the moon.

The origins of this landmark experiment lie in Trexler's college days, when he first realized that the moon's ionosphere could serve as a reflector for radio waves. When he joined the Naval Research Center in the late 1940s, he pushed his hypothesis even further and pondered whether the moon might be used as a "radar intercept device" capable of spying on Soviet communications. Over the next two years, Trexler focused most of his energies on proving that a moon radio intelligence program was viable.

By 1950, the US Navy was convinced that there was some validity to Trexler's idea and constructed two large antennas in an attempt to monitor Soviet radio communication signals. And so the top secret Passive Moon Relay (PAMOR) project was born.

By: Daniel Oberhaus "How the Moon Was Turned Into a Cold War Spy Weapon"

The PAMOR project only enjoyed moderate success. In 1964, it managed to use the moon to intercept a Soviet signal from the sophisticated "Hen House" radio dish in the Southeastern Soviet Union. This dish had long been a fascination of the US military since it had first been discovered after radio waves were refracted from the cloud of a nuclear bomb test in the USSR. Other attempts to turn the moon into a passive eavesdropping device were only moderately successful.

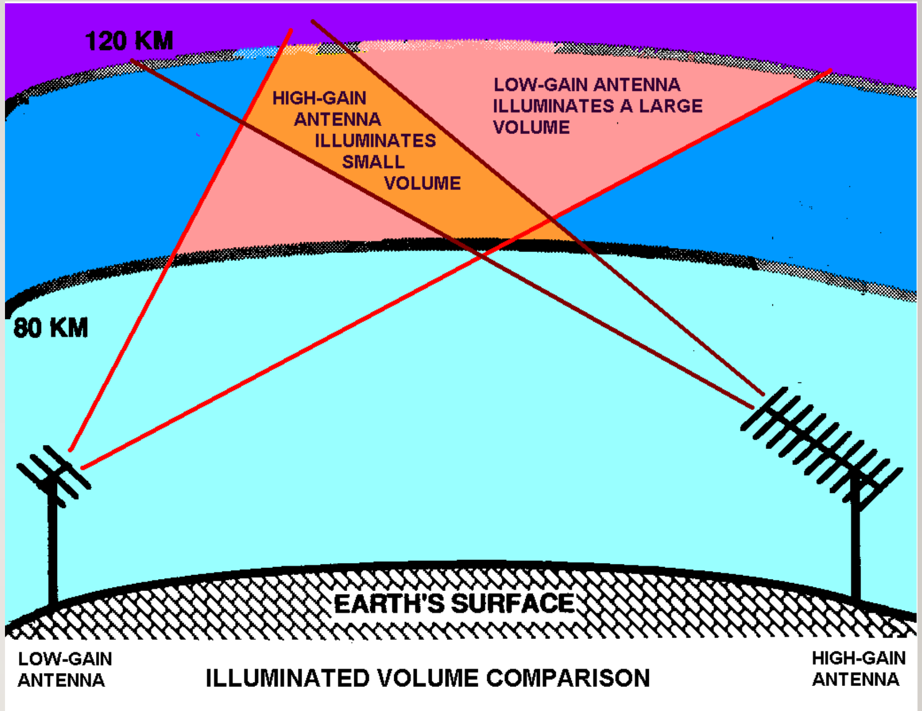
Shortly after the creation of PAMOR, Trexler and his supervisor Howard Lorenzen (the "father of electronic warfare") established radar contact with the moon in October of 1951. The project only involved sending and receiving a series of short pulses to test the fidelity of using the moon as a communications relay device.

This was six years before the first artificial satellite would be placed in orbit, and the military was still dependent on skywave transmission to send its radio signals to its deployments around the world. This involved refracting radio waves from the Earth's ionosphere—an upper layer of the atmosphere with a high concentration of electrically charged atoms—in order make contact with its units on the other side of the world. While this worked well enough, it was also an unreliable communication mechanism—solar flares and geomagnetic storms made skywave transmissions impossible.

Information from an article that originally appeared on Motherboard.

Note: (In December 1957 The IRE Journal was devoted to meteor scatter as a viable reliable communications mode for terrestrial communications out 100s of miles; Interest cooled immediately with the launch of Sputnik in October of that year as the US military reacted with an immediate shift to satellite communications)

Meteor Scatter (Burst Communications) on 6 or 2 Meters
For Reliable 200-400 km Paths…..



Antennas do not need to have high gain
Lower-gain antennas illuminate more trails
Higher-gain antennas illuminate weaker trails
MS contacts on 6m can be made with a 2 element yagi or quad

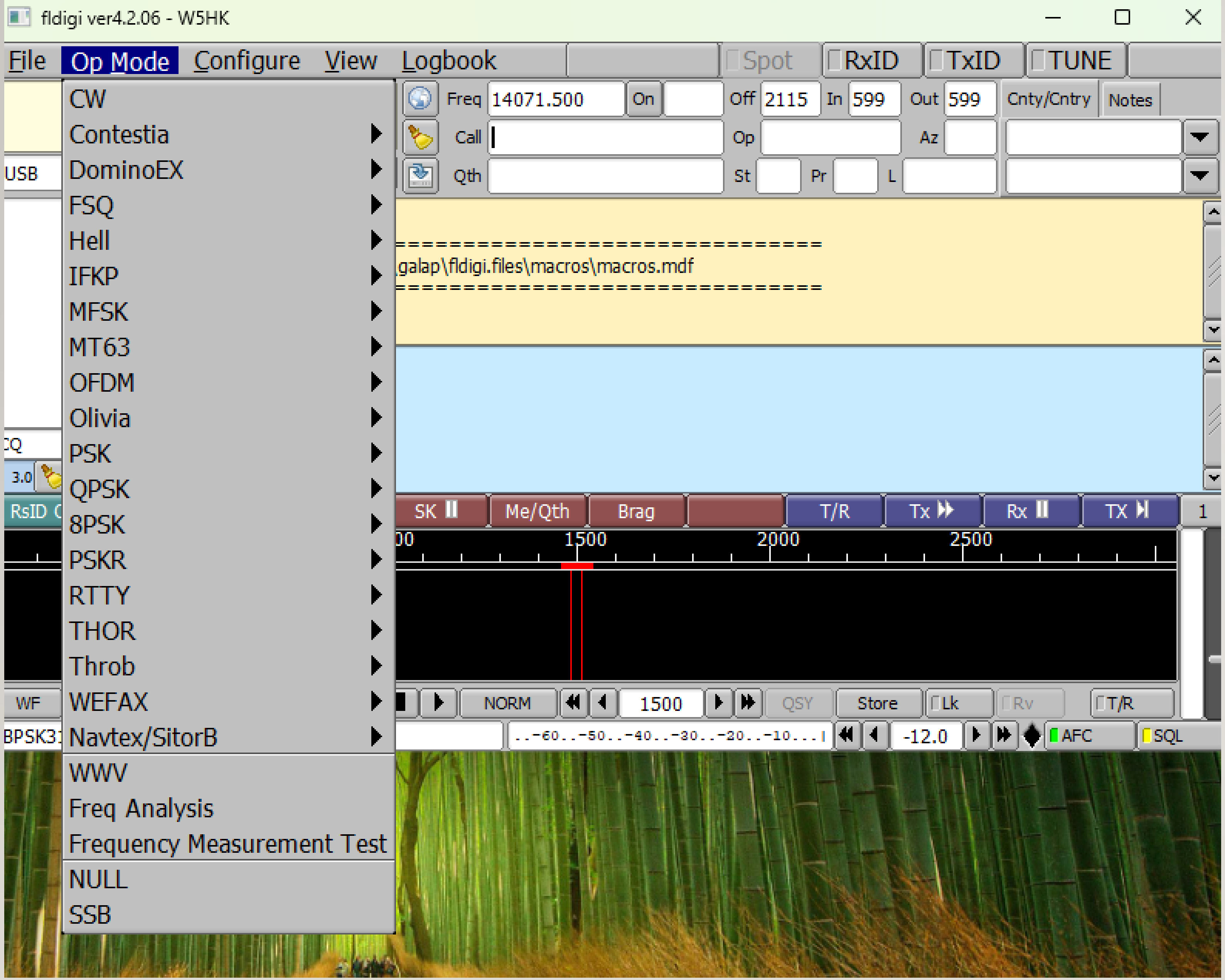
RF output at least 100 W
Good VHF transceiver or transverter with MDS of -125 dBm (3 KHz BW)
Mast-mounted pre-amp, gain > 10 dB
Horizontally polarized beam antenna, gain > 10 dB

MSK144 is designed for Meteor Scatter on the VHF bands. It is a part of the WSJT-X program suite.

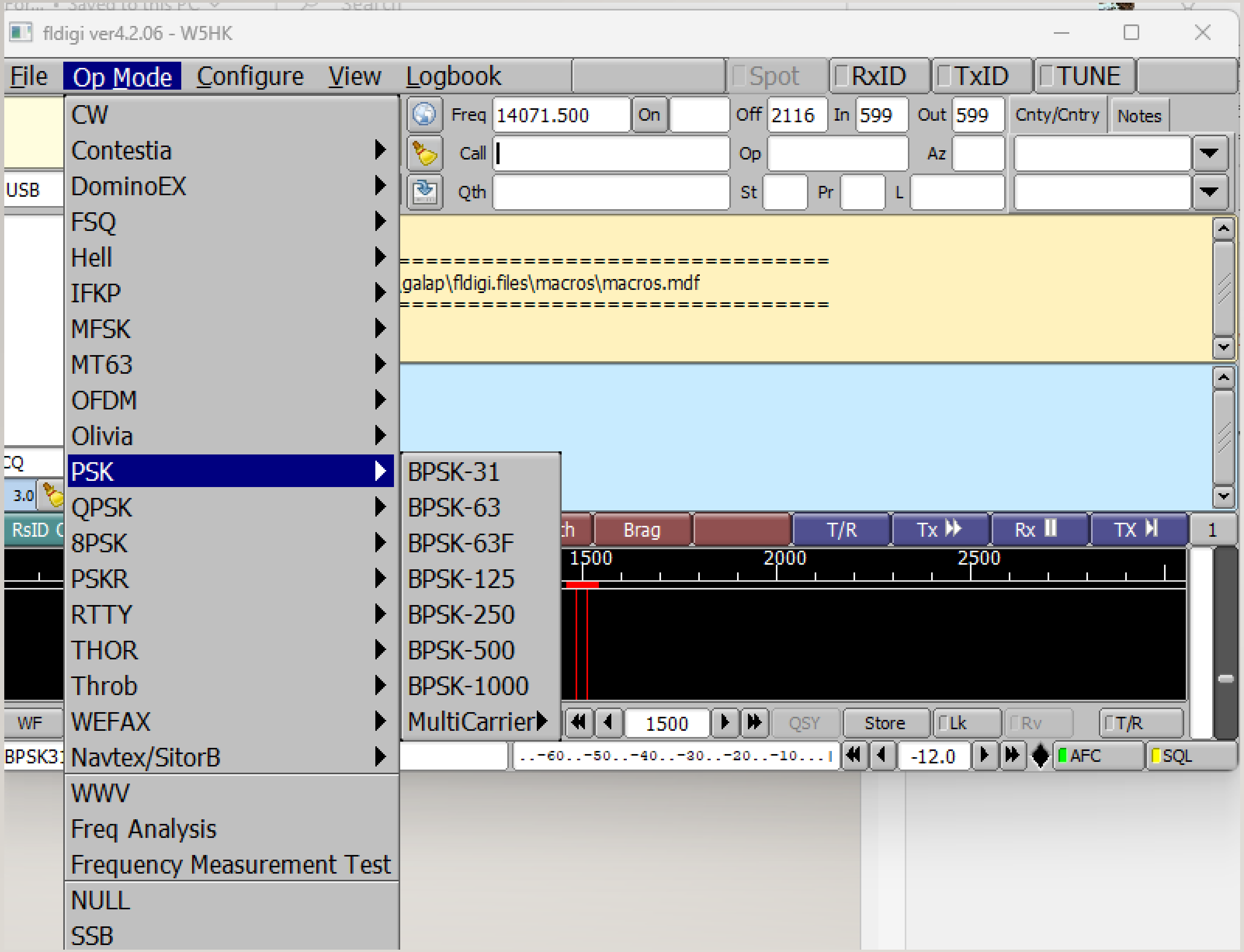
FLDIGI and Associated Programs

Software By W1HKJ & Associates

- fldigi / flarq - modem / arq
- flamp - Amateur Multicast Protocol - file transfer program
- flwrap - file encapsulation / compression
- flmsg - NBEMS messaging system, forms manager/designer and transport front end
- flrig - rig control program, cooperates with fldigi
- flwkey - modem program for the K1EL Winkeyer series
- fllog - can use same data file as fldigi
- flnet - voice net controller database / check-in application
- flcluster - telnet client to remote DX cluster servers
- flaa - Rig Expert Antenna Analyzer control program
- kcat - Kachina 505DSP controller
- kcts - Kachina 505DSP test suite
- test suite - includes linsim, comptext and comptty

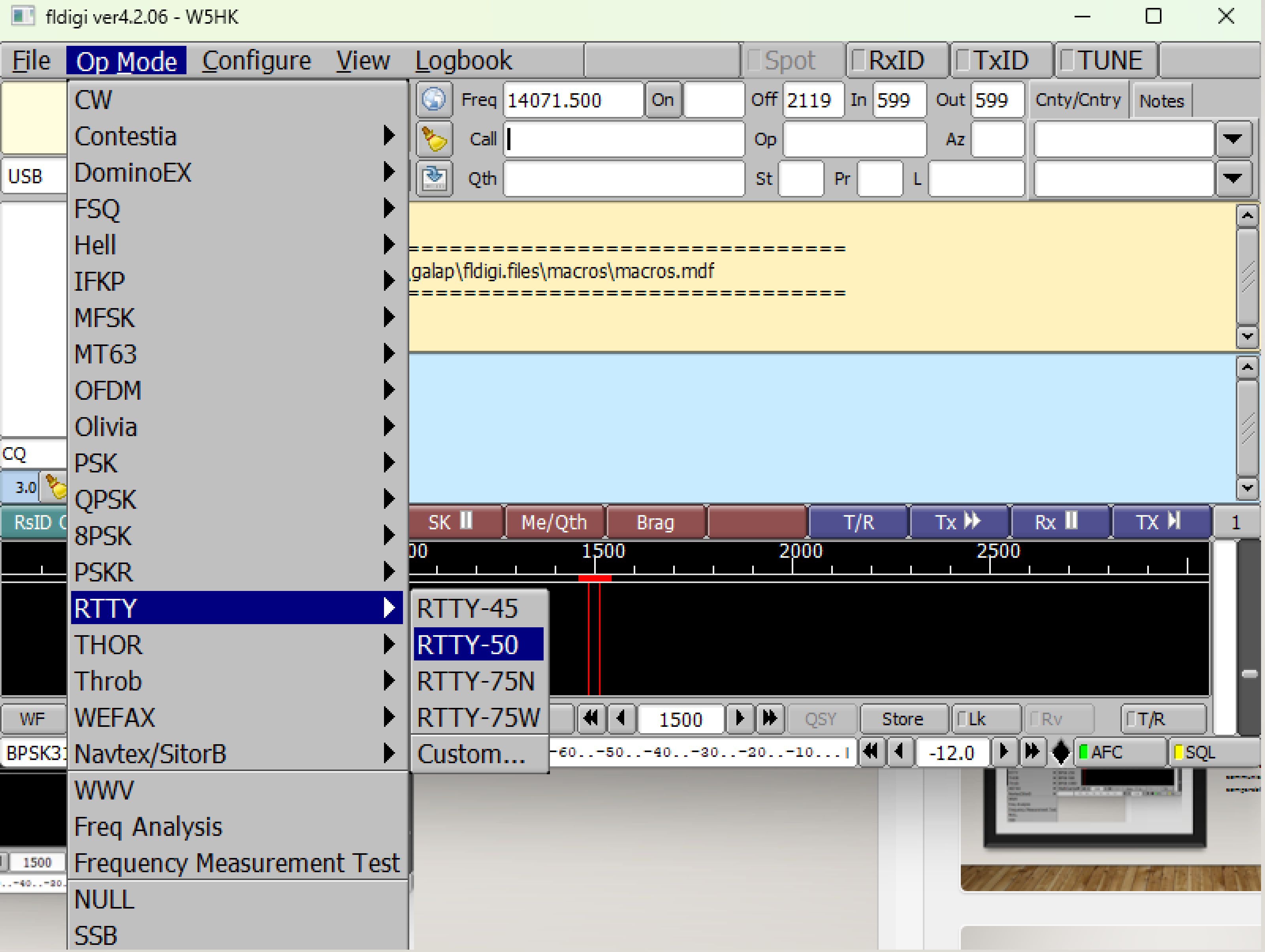


FLDIGI offers a dazzling array of modes you can play with…..too many I think…… for my attention span



PSK31 Enjoyed considerable interest from 2003 to 2017 when FT8 was introduced

It allowed keyboard to keyboard communications with SNR comparable to CW



The granddaddy of all amateur radio digital modes, if you don't count CW

When everything fails
VarAC delivers

When confronted with a crisis, VarAC stands as the sole platform offering a complete and all-encompassing emergency communications solution.

VarAC takes on the responsibility of efficiently delivering your critical messages, allowing you to concentrate on effectively managing the crisis at hand.

VarAC features & values for EmComm

Reliable link

under poor conditions

Low power? Small antennas? Bad location? Portable setup? VarAC has got you covered. VarAC is built from the ground up for QRP operations with challenging SNR levels. Even at -22dB, VarAC is still able to maintain a link and decode incoming traffic.

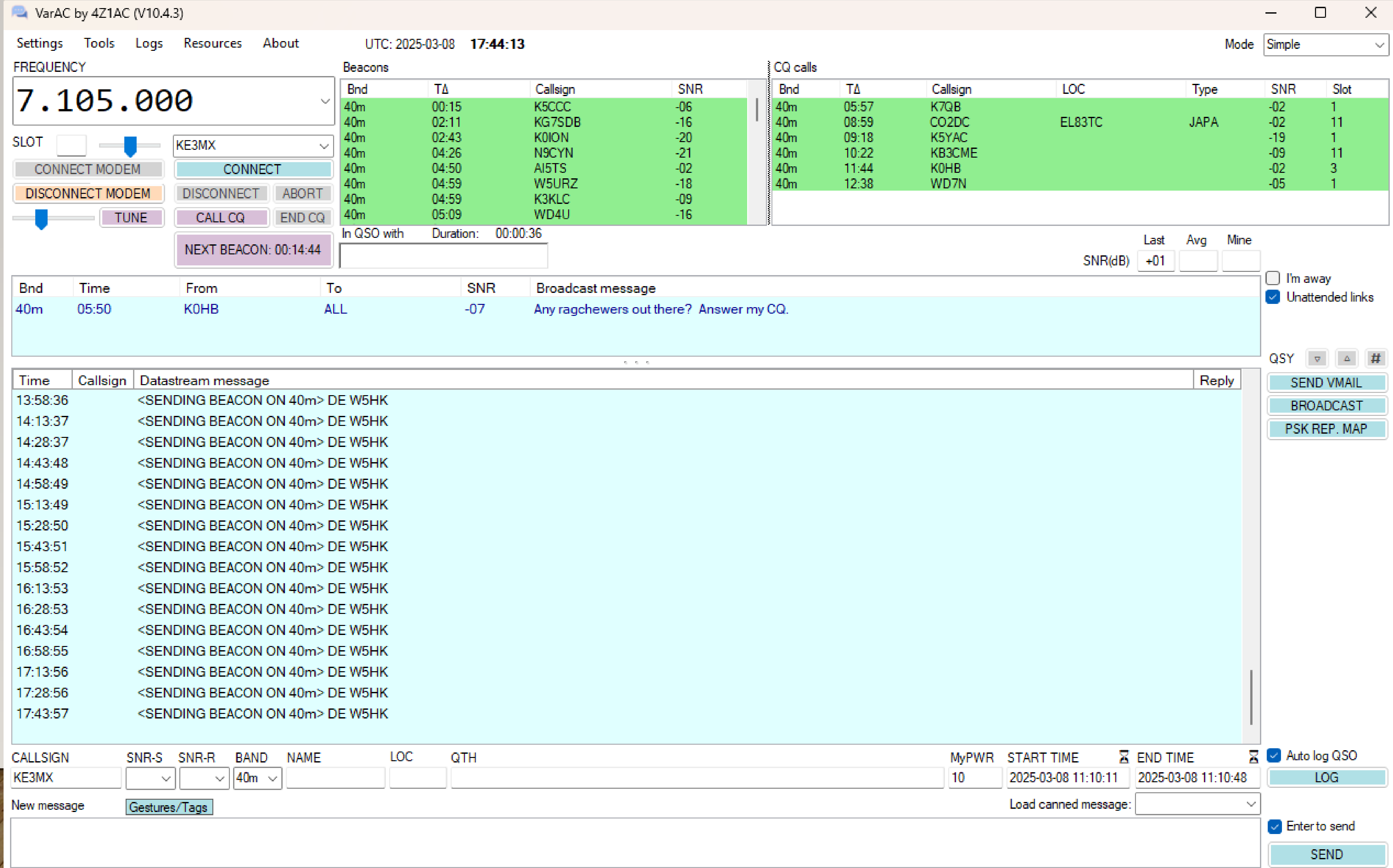
Fast!

Lightning fast!

VarAC, powered by the VARA protocol, offers the fastest data transfer rates for HF/VHF/UHF, surpassing any other on the planet:

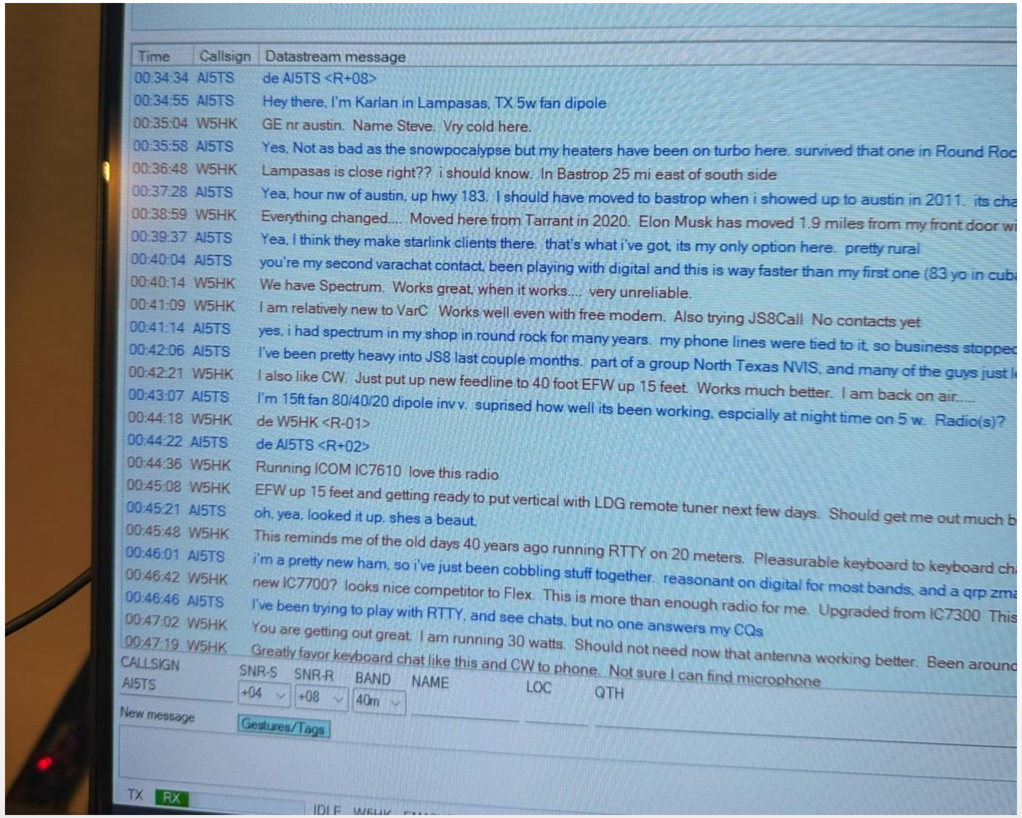
HF: 1500 Bps (500Hz BW) / 7050 Bps (2300Hz BW)

V/UHF FM 13,000 Bps (Narrow BW) / 25,000 Bps (Wide BW)

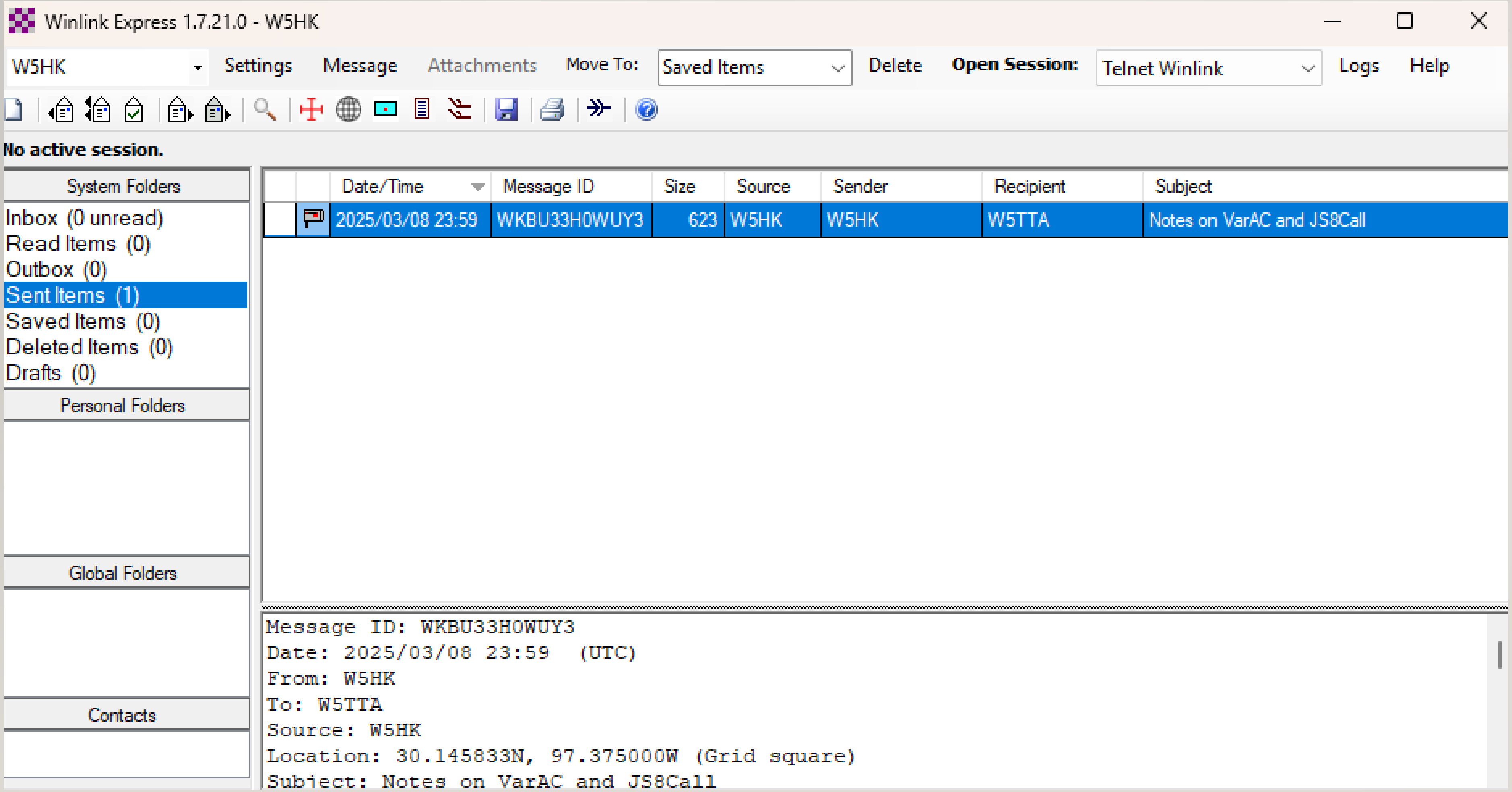

VarAC by 4Z1AC (V10.4.3)
Settings
Tools
Logs
Resources
About
UTC: 2025-03-08 17:44:13
Mode
Simple
FREQUENCY
7.105.000
SLOT
KE3MX
CONNECT MODEM
CONNECT
DISCONNECT MODEM
DISCONNECT
ABORT
TUNE
CALL CQ
END CQ
NEXT BEACON: 00:14:44
Beacons
Bnd TΔ Callsign SNR
40m 00:15 K5CCC -06
40m 02:11 KG7SDB -16
40m 02:43 K0ION -20
40m 04:26 N9CYN -21
40m 04:50 AI5TS -02
40m 04:59 W5URZ -18
40m 04:59 K3KLC -09
40m 05:09 WD4U -16
CQ calls
Bnd TΔ Callsign LOC Type SNR Slot
40m 05:57 K7QB -02 1
40m 08:59 CO2DC EL83TC JAPA -02 11
40m 09:18 K5YAC -19 1
40m 10:22 KB3CME -09 11
40m 11:44 K0HB -02 3
40m 12:38 WD7N -05 1
In QSO with
Duration: 00:00:36
Last
Avg
Mine
SNR(dB) +01
I'm away
Unattended links
Bnd Time From To SNR Broadcast message
40m 05:50 K0HB ALL -07 Any ragchewers out there? Answer my CQ.
QSY
Time Callsign Datastream message Reply
13:58:36 <SENDING BEACON ON 40m> DE W5HK
14:13:37 <SENDING BEACON ON 40m> DE W5HK
14:28:37 <SENDING BEACON ON 40m> DE W5HK
14:43:48 <SENDING BEACON ON 40m> DE W5HK
14:58:49 <SENDING BEACON ON 40m> DE W5HK
15:13:49 <SENDING BEACON ON 40m> DE W5HK
15:28:50 <SENDING BEACON ON 40m> DE W5HK
15:43:51 <SENDING BEACON ON 40m> DE W5HK
15:58:52 <SENDING BEACON ON 40m> DE W5HK
16:13:53 <SENDING BEACON ON 40m> DE W5HK
16:28:53 <SENDING BEACON ON 40m> DE W5HK
16:43:54 <SENDING BEACON ON 40m> DE W5HK
16:58:55 <SENDING BEACON ON 40m> DE W5HK
17:13:56 <SENDING BEACON ON 40m> DE W5HK
17:28:56 <SENDING BEACON ON 40m> DE W5HK
17:43:57 <SENDING BEACON ON 40m> DE W5HK
SEND VMAIL
BROADCAST
PSK REP. MAP
CALLSIGN SNR-S SNR-R BAND NAME LOC QTH MyPWR START TIME END TIME
KE3MX 40m 10 2025-03-08 11:10:11 2025-03-08 11:10:48
Auto log QSO
LOG
New message
Gestures/Tags
Load canned message:
Enter to send
SEND

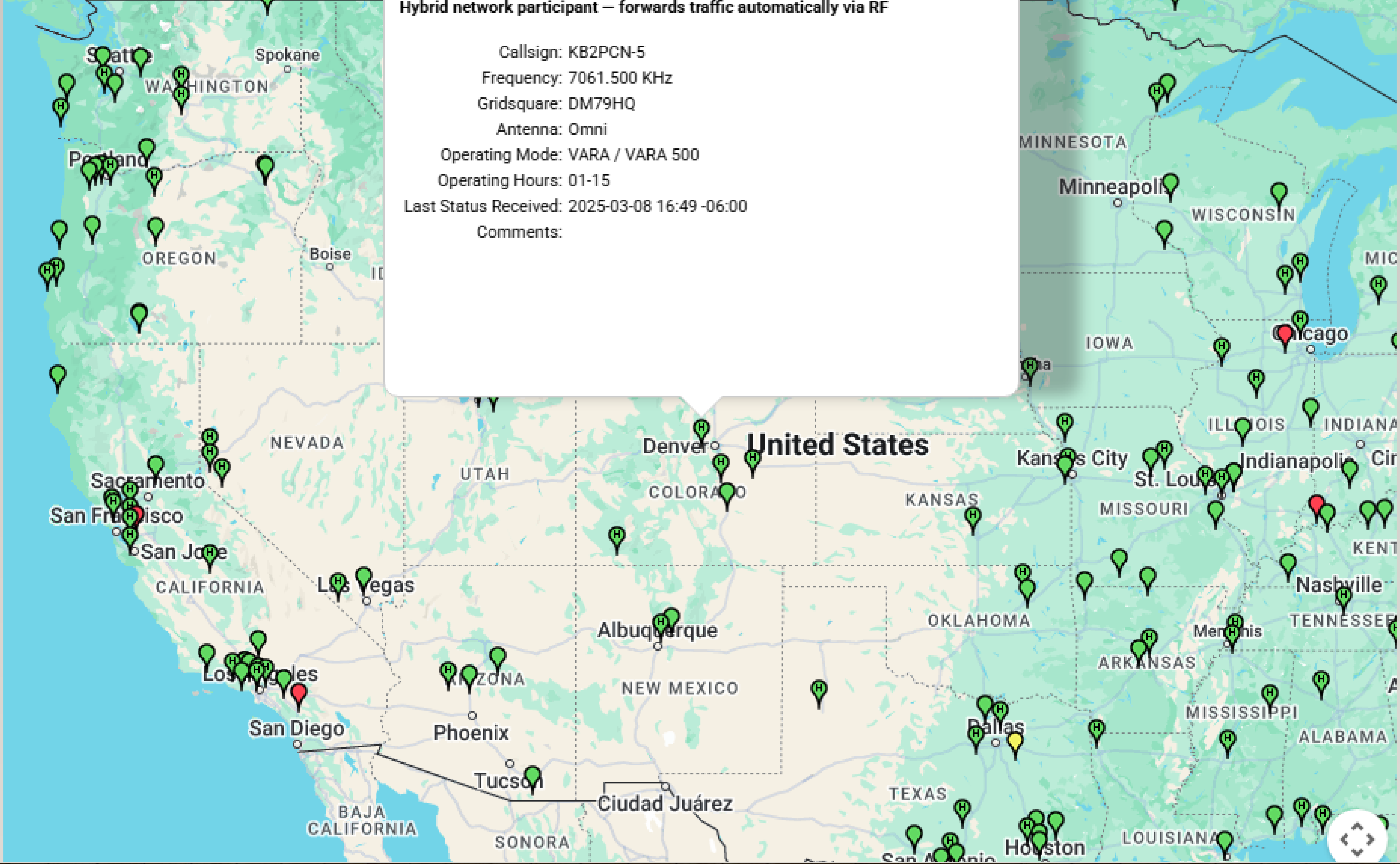
- Chatting near Vertical Incidence antenna on 40 meters; 99 mi NW; running 30 W, he was running 5. Armchair copy

- Like the old days on PSK31 or RTTY



Email via HF on WinLink – A great adjunct to VarAC




Hybrid network participant — forwards traffic automatically via RF
Callsign: KB2PCN-5
Frequency: 7061.500 KHz
Gridsquare: DM79HQ
Antenna: Omni
Operating Mode: VARA / VARA 500
Operating Hours: 01-15
Last Status Received: 2025-03-08 16:49 -06:00
Comments:
United States
Spokane
WASHINGTON
MINNESOTA
WISCONSIN
OREGON
Boise
IOWA
NEVADA
UTAH
Denver
Sacramento
Kansas City
Indianapolis
Chicago
KANSAS
MISSOURI
San Jose
CALIFORNIA
Las Vegas
OKLAHOMA
Nashville
TENNESSEE
Albuquerque
ARKANSAS
NEW MEXICO
MISSISSIPPI
ALABAMA
Phoenix
San Diego
Dallas
Tucson
Ciudad Juárez
TEXAS
BAJA CALIFORNIA
SONORA
Houston
LOUISIANA

RTTY   Radio Telegraphy

Radioteletype (**RTTY**) is a telecommunications system consisting originally of two or more electromechanical teleprinters in different locations connected by radio rather than a wired link. Radioteletype evolved from earlier landline teleprinter operations that began in the mid-1800s.[1] The US Navy Department successfully tested printing telegraphy between an airplane and ground radio station in 1922. Later that year, the Radio Corporation of America successfully tested printing telegraphy via their Chatham, Massachusetts, radio station to the RMS *Majestic*. Commercial RTTY systems were in active service between San Francisco and Honolulu as early as April 1932 and between San Francisco and New York City by 1934. The US military used radioteletype in the 1930s and expanded this usage during World War II. From the 1980s, teleprinters were replaced by personal computers (PCs) running software to emulate teleprinters.

Teletype communications is as old as Morse Code…..

From: Wikipedia

It may surprise some that the RTTY (Radioteletype) mode we use today can be traced back nearly 190 years. Carl Friedrich Gauss and Wilhelm Weber constructed the first telegraph in 1833, connecting two departments within the University of Gottingen, Germany. In 1849, the first landline teleprinter connection was made between Philadelphia and New York City.

Twenty years later in 1870, Frenchman Emile Baudot invented the Baudot 6-bit code that is the foundation of RTTY communications today. Emile was a farmer's son who left agriculture as a young man to join the French Post & Telegraph Administration as an apprentice operator in 1869. His primary schooling as a child was his only formal education, yet it was just a year into his telegraph apprenticeship that he devised the code we still use today.

Even more impressive, Emile made two additional contributions by the time his Baudot code was patented in 1874. He made use of the inherent dead time during transmission to create a time-multiplex system where several messages could be transmitted in parallel on a single telegraph line.

Emile also designed an electro-mechanical teletype system to transmit his multiplexed code based on adaptations of a printing mechanism invented by Bernard Meyer in 1871 and the Gauss/Weber telegraph from 1833. In 1876, he also modified his 6-bit code to 5 bits based on the Gauss/Weber code work. A simple 5-key piano-like keyboard was used by the telegrapher to type in the code, much like using a hand key for sending Morse code.

Author: Ed Muns, W0YK From: https://www.onallbands.com/author/ed-muns/

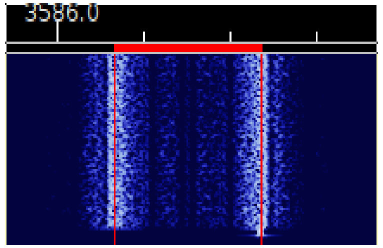


ST-6000
LIMITER SENSE

- During the early days of Amateur RTTY, the RTTY Worked All Continents Award was conceived by the RTTY Society of Southern California and issued by RTTY Journal.[30] The first amateur radio station to achieve this WAC – RTTY Award was VE7KX.[31] The first stations recognized as having achieved single band WAC RTTY were W1MX (3.5 MHz); DL0TD (7.0 MHz); K3SWZ (14.0 MHz); W0MT (21.0 MHz) and FG7XT (28.0 MHz).[32] The ARRL began issuing WAC RTTY certificates in 1969.
- By the early 1970s, amateur radio RTTY had spread around the world and it was finally possible to work more than 100 countries via RTTY. FG7XT was the first amateur radio station to claim to achieve this honor. However, Jean did not submit his QSL cards for independent review. ON4BX, in 1971, was the first amateur radio station to submit his cards to the DX editor of *RTTY Journal* and to achieve this honor.[33] The ARRL began issuing DXCC RTTY Awards on November 1, 1976.[34] Prior to that date, an award for working 100 countries on RTTY was only available via RTTY Journal.
- In the 1950s through the 1970s, "RTTY art" was a popular on-air activity. This consisted of (sometimes very elaborate and artistic) pictures sent over RTTY through the use of lengthy punched tape transmissions and then printed by the receiving station on paper.

From: Wikipedia

RTTY Modes



Baudot 45 / 170
Spectrum
Sound

all signals shown in x2 waterfall mode, tick marks at 100 Hz intervals, waterfall palette is "blue-2"

General Description

RTTY has been used by radio amateurs since the 1950s. Initially an electromechanical system designed for use on telephone wires, it was not conceived as a radio system, and could not be used by radio until the development of the Ratio Detector during the 1939-1945 war. RTTY (the name means simply Radio Teletype) uses FSK to avoid noise on the transmission path, but requires high power and is still prone to propagation effects, especially selective fading and multi-path timing.

Early RTTY equipment used separate oscillators for each of the tones, and so could produce very wide key clicks, requiring extra filters. Modern software uses phase coherent switching between tones, which somewhat improves the signal bandwidth.

With no error correction, and a start-stop system that is prone to false starts on noise, RTTY is not the best mode for amateur use. However, it is easy to use, easy to tune, fast, tolerant of drift, and is widely used for contesting for these reasons alone. A linear transmitter is not required.

Effective SNR Ratios for Various Modes

For various amateur digital modes, the Signal-to-Noise Ratio (SNR) is typically reported in a negative range, with values between -27dB and -1dB, meaning the signal is technically below the noise floor, but due to the narrow detection bandwidth and error correction capabilities of these modes, they can still be decoded reliably; with modes like FT8, JT65, and JT9 often being referenced against a 2500Hz bandwidth, even though the actual signal occupies a much smaller bandwidth.

The Signal to Noise Ratio (SNR) quoted for amateur radio modes is traditionally based on a receiver bandwidth of 2500 Hz, because these modes are usually received with a normal SSB receiver, whose IF filter is about 2500 Hz wide. The actual signal usually is much narrower, e.g. about 6 Hz in case of WSPR. So this is rather weird: we compare the power of a 6 Hz wide signal to the noise power received in the total 2500 Hz wide filter. It would make more sense to measure the SNR in the bandwidth that's really used by the receiver; but it may be hard to determine or define that "true" receive bandwidth.

From: Pieter-Tjerk de Boer, PA3FWM web@pa3fwm.nl

Effective SNR Ratios for Various Modes
One Analysis Among Many

Mode	Needed SNR in 2500 Hz	Net data speed in bits/s	Needed Eb/N0
SSB voice	+10 dB	20*	+31 dB
CW (ZRO-test, by ear)	-18 dB	0.54	+16 dB**
CW (QRSS-3, waterfall)	-26 dB	0.13	+14 dB**
CW (RSCW, 12 wpm)	-12 dB	4	+13 dB**
OPERA-2	-23 dB	0.23	+14 dB***
RTTY	-5 dB	32	+14 dB
PSK31	-10 dB	31	+9 dB
WSPR	-29 dB	0.45	+5 dB****
WSPR-15	-38 dB	0.056	+5 dB****
JT65 (for EME)	-24 dB	1.54	+5 dB****
Coherent BPSK on VLF	-57 dB	0.0058	-1 dB
Theoretical limit			-1.59 dB

* very crude estimate
** based on peak average power; peak power 3 dB higher
*** peak power is 3 dB higher; 2 dB lower if counting CRC-bits as information
**** not counting energy in synchronization bits; otherwise 3 dB more

From: Pieter-Tjerk de Boer, PA3FWM web@pa3fwm.nl

Bit Rate vs Bandwidth vs Transmission Time etc….

This confusion makes it very difficult to recommend one mode over any other….

Most hams compare SNR and efficiency relative to an SSB transmission occupying 2500 plus Hz bandwidth

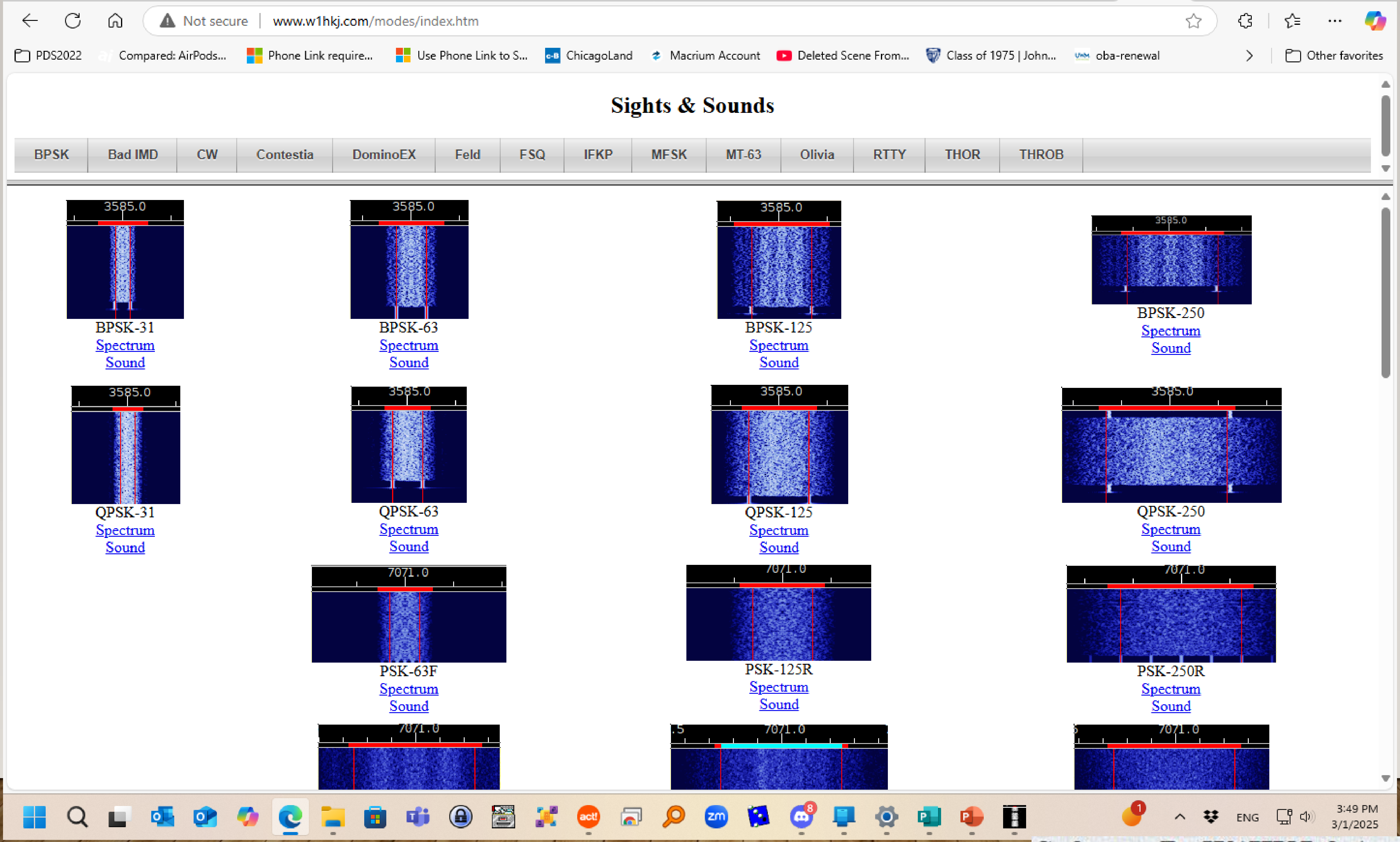
CW is ultimately more efficient because all the power resides in one narrow bandwidth signal, coupled with the world's best signal processing techniques - the human brain

One SSB width channel can accommodate 50 CW signals, given high quality filtering, at a reduced bit rate vs normal speech on SSB

RTTY has a significant advantage over SSB (even more against the AM mode used in the 30s and 40s)

PSK31 utilizes 50 Hz bandwidth and is about as effective as CW

- Modern modes such as FT8 rely on time integration of the signal with minimal bit rate requirements
- WSPR requires even less bandwidth and relies on 120 s transmission time to allow integration of a signal with minimal information
- VarAC allows near RTTY level speeds with modern coding techniques and error correction with low power
- There is no free lunch….. Higher bit rates at faster speeds require more bandwidth



Software By W1HKJ & Associates

Some Irony in Modes Available in Modern VHF/HF Equipment

The Icom IC7100, IC7300, and IC7610 feature RTTY as a standard menu item. The IC7100 features Dstar for digital voice. These are the oldest digital standards in amateur radio for voice and data, and are barely in use today

The Xiegu X6100 will decode CW. That was hard to test because of the tuning step issue but it did work, and if it's based on the same firmware as the G90, it should work well. It will also decode PSK31 and RTTY.

Elecraft K3's internal keyer will allow you to directly transmit RTTY. You can also copy RTTY on the K3's text display, making it a self-contained RTTY station. There is a built-in PSK feature on the Elecraft K4.

The Kenwood TS590SG features a CW Decoder and reader, and no RTTY

Final Thoughts

- You will frustrate yourself if you go to WSJT-X or FLDIGI and try to explore all the various digital modes

- Once you have mastered FT8, consider the other modes available there, particularly WSPR, which allows you to see how well your station is getting out (invaluable if you are HOA limited….)

- Consider some of the exotic and not so commonly used digital modes, such as FREEDV digital voice, or meteor scatter, or even EME

- ***If you want to have the most reliable and efficient keyboard communications available now, set up on VarAC, unquestionably the gold standard. We will do a tech talk specifically on this mode, and its associated Winlink email program, in a few months.***

- If you are a retro fan of amateur radio, like bugs, high speed CW etc, then you need to try RTTY. It is easy to tune, works well in moderate signal conditions, and is really where this whole thing started.



ANTENNAS FOR THE HOA IMPAIRED