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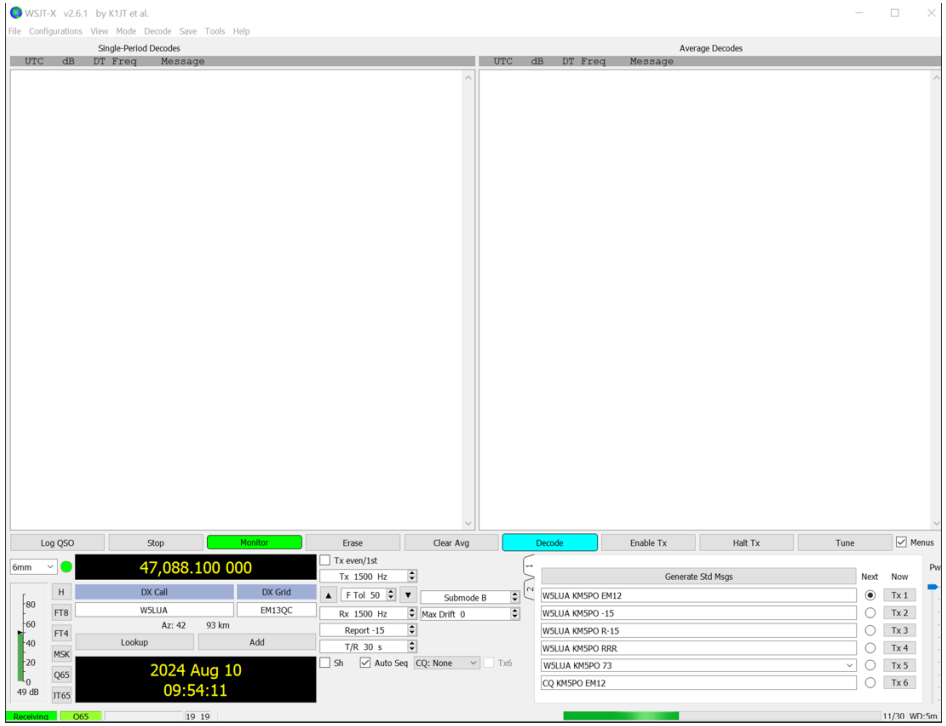
WSJT-X for Microwave
August 10, 2024
KM5PO



WSJT-X

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- A computer program designed to facilitate basic amateur radio communication using very weak signals.
- *WSJT-X* is free software: you may redistribute and/or modify it under the terms of the GNU General Public License.
- The WSJT project was started by K1JT in 2001. Since 2005 it has been an Open Source project, and it has included the programs WSJT, MAP65, WSPR, *WSJT-X*, and WSPR-X. G4WJS (since 2013), K9AN (since 2015), IV3NWV (since 2016), KG4IYS (since 2021), and DG2YCB (since 2021) have made major contributions to *WSJT-X.*
- Except where otherwise noted, all algorithms, protocol designs, source code, and supporting files contained in the *WSJT-X* package are the intellectual property of the program's authors.

Use at microwave frequencies

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- Terrestrial contacts are being made on 10 GHz beyond 500 km
- *WSJT-X* contacts are being made at 24 and 47 GHz
- Lower microwave bands and VHF/UHF are also exhibiting long range DX contacts including 6 meter EME
- There is NTMS Microwave Rover adoption of *WSJT-X* in Oklahoma and Texas since 2023. At minimum there are 5 rovers with digital.
- A variety of operating modes exist for different propagation states
  - Terrestrial scatter
  - Rain scatter
  - EME path
  - Many others ie. TEP, ionospheric scatter
- For purposes of this presentation, we will be discussing mode Q65

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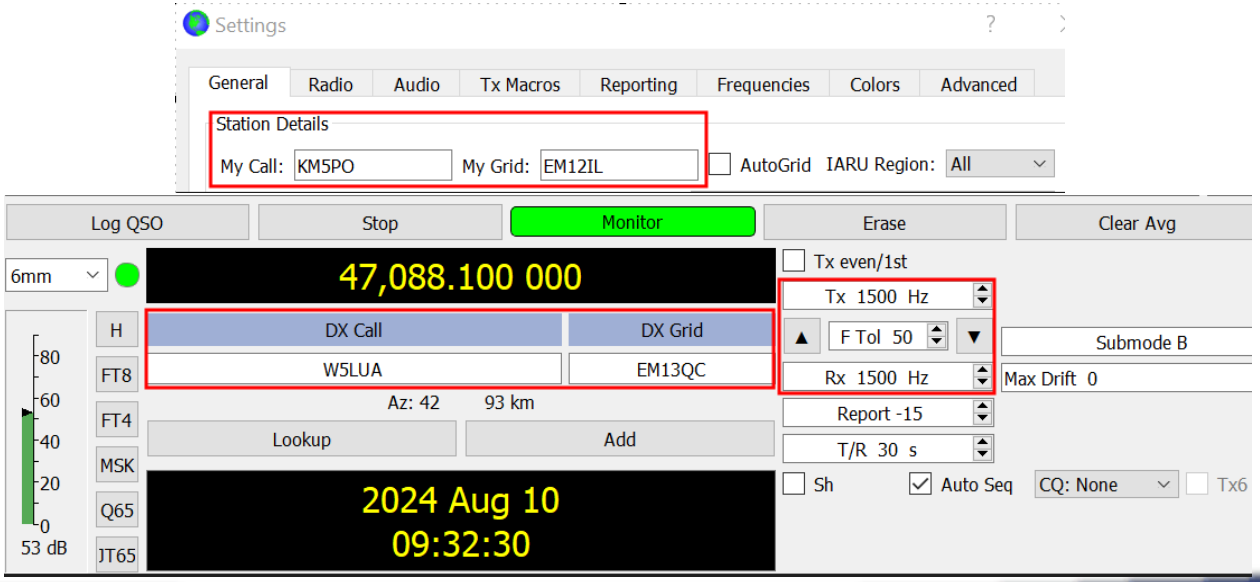
How it works

- *A priori* or “AP” decodes messages using heuristics and available information, adding several dB to the SNR.
- Key elements that assist AP:
  - Expected audio offset frequency
  - DX call sign and grid (and your call/grid via configuration)
  - Multiple message averaging



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Tone spacing

- Tone spacing varies with the T/R Period
  - Submodes A - E have tone spacings 1, 2, 4, 8, and 16 times the symbol rate

T/R Period (s)	A Spacing Width (Hz)	B Spacing Width (Hz)	C Spacing Width (Hz)	D Spacing Width (Hz)	E Spacing Width (Hz)
15	6.67 4.33	13.33 867	26.67 1733	N/A	N/A
30	3.33 217	6.67 433	13.33 867	26.67 1733	N/A
60	1.67 108	3.33 217	6.67 433	13.33 867	26.67 1733
120	0.75 49	1.50 98	3.00 195	6.00 390	12.00 780
300	0.29 19	0.58 38	1.16 75	2.31 150	4.63 301

- 15 seconds, -22.2 dB SNR, with a priori (AP) decoding -23.7 dB SNR.
- 30 seconds, -24.8 dB SNR, with AP decoding -26.6 dB.
- 60 seconds, -27.6 dB SNR, with AP decoding -30.2 dB.
- 120 seconds, -30.8 dB SNR, with AP decoding -32.5 dB.
- 300 seconds, -33.8 dB SNR, with AP decoding -37.4 dB.

Bandwidth Q65A

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Mode	FEC Type	(n,k)	Q	Modulation type	Keying rate (Baud)	Bandwidth (Hz)	Sync Energy	Tx Duration (s)	S/N Threshold (dB)
Q65-15A	QRA	(63,13)	64	65-FSK	6.667	433	0.26	12.8	-22.2
Q65-30A	QRA	(63,13)	64	65-FSK	3.333	217	0.26	25.5	-24.8
Q65-60A	QRA	(63,13)	64	65-FSK	1.667	108	0.26	51.0	-27.6
Q65-120A	QRA	(63,13)	64	65-FSK	0.750	49	0.26	113.3	-30.8
Q65-300A	QRA	(63,13)	64	65-FSK	0.289	19	0.26	293.8	-33.8

- QRA = Q-ary Repeat Accumulate
- n and k specify the sizes of the (equivalent) block codes
- Q is the alphabet size for the information-carrying channel symbols
- Sync Energy is the fraction of transmitted energy devoted to synchronizing symbols
- S/N Threshold is the signal-to-noise ratio (in a 2500 Hz reference bandwidth) above which the probability of decoding is 50% or higher
- Occupied bandwidths are 65 times the tone spacing, ranging from 19 Hz (Q65-300A) to a maximum of 1733 Hz (Q65-15C, Q65-30D, and Q65-60E)

How it works

- As an aid to the decoders, each protocol includes a “sync vector” of *known symbols* interspersed with the information-carrying symbols
- FEC:
  - Each Q65 payload contains 13 information symbols
  - A CRC is computed from the 13 information symbols which occupies 12 bits
  - The CRC is re-assembled on receive and provides a method of reducing false decodes to virtually zero.
- Additionally, a 22-symbol pseudorandom sequence spread throughout a transmission is sent as “tone 0” and used for synchronization
- Q65 is very intelligent and pretty much knows exactly what it is seeking in the received signal and noise.

Message averaging

- Piecing together multiple messages to achieve a decode
- Decodes are tagged with a “Q” followed by one or two numbers
  - The first number indicates the type of AP used
  - The second number indicates total number of receives used to produce decode
- Examples:
- Q0 — This is a decode obtained without using any AP information.
- Q1 — This usually means that AP has decoded the message as a CQ call, with the DX Call and Grid unknown to AP.
- Q2 — This usually means that AP has used your call as AP knowledge but has assumed nothing about the DX Call or Grid.
- Q3 — This usually means that AP has used AP knowledge of your Call and the DX Call in the decode. It then looks for a grid, a report, 73, etc.
- Q32 — This means that a Q3 decode has been obtained after averaging 2 transmissions.

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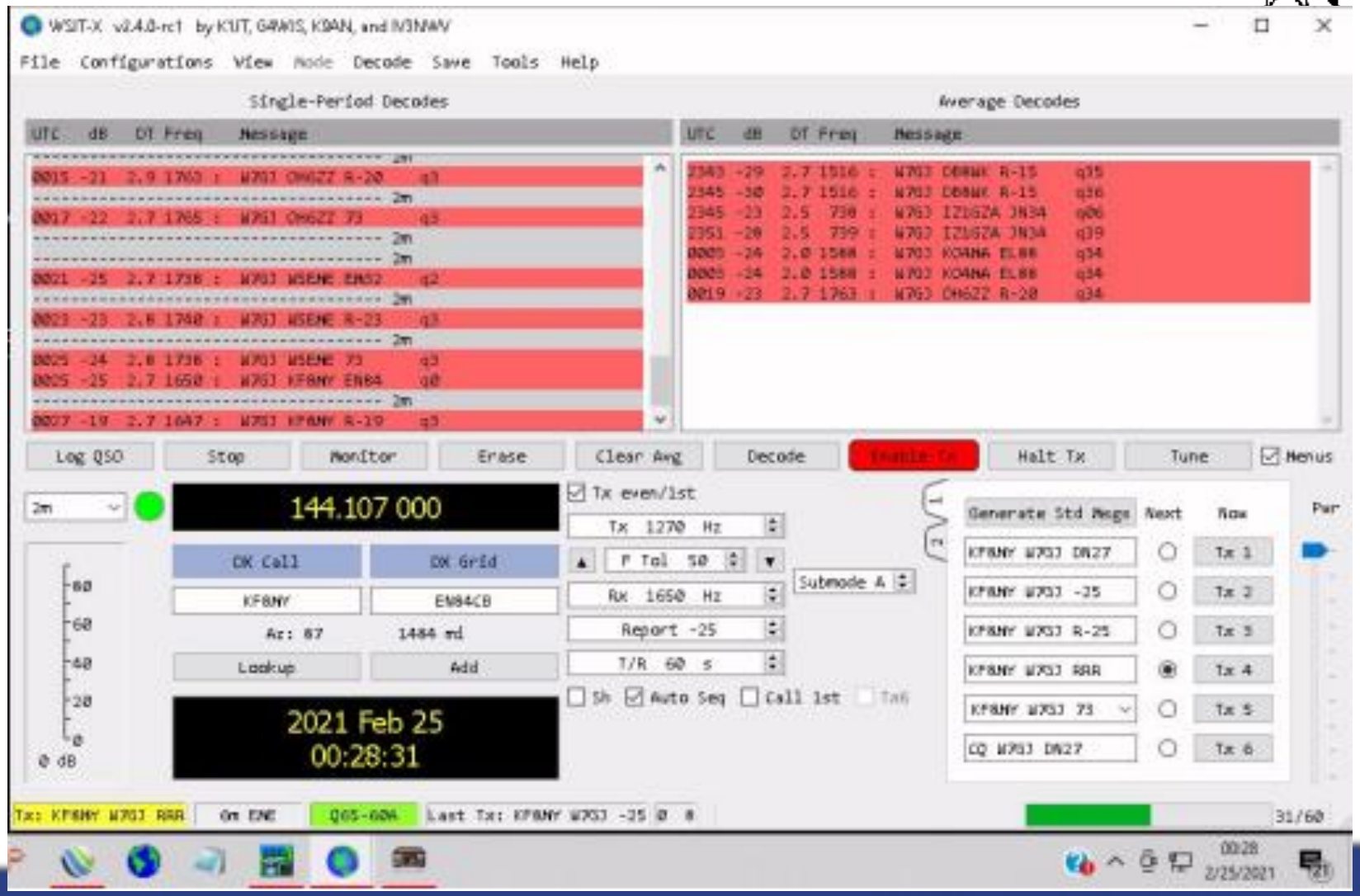
Message averaging



Setup

- Get audio from radio into your computer. Computer records what you are receiving.
- Get audio from your computer into your radio. Radio will transmit the *WSJT-X* messages from your computer.
- Tigertronics SignalLink
- NTMS members are experienced and can provide assistance
- Another source of help in setting up your station or configuring *WSJT-X* is the WSJTX Group (https://groups.io/g/WSJTX) at email address wsjtx@groups.io. The chances are good that someone with similar interests and equipment has already solved your problem and will be happy to help.

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Setup

- Tigertronics SignaLink “Integrated USB Sound Card”
- Complete isolation between computer and radio
- No external power needed
- Built in low noise sound card
- External speaker support
- Works with virtually all computers and radios
- Cables available for all radios

Setup with IC-705/905

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- Single USB cable between radio and computer provides CAT control and audio connections
- Wireless WSJT-X is possible with the ICOM RS-BA1 software (costs $) which permits the radio (in Access Point mode) to connect to a virtual COM port on the computer. (IC-705 WLAN with WSJT-X – KC8JC)
- Free wireless software is available for 705/905 also – WFVIEW from wfview.org

Setup with IC-705/905

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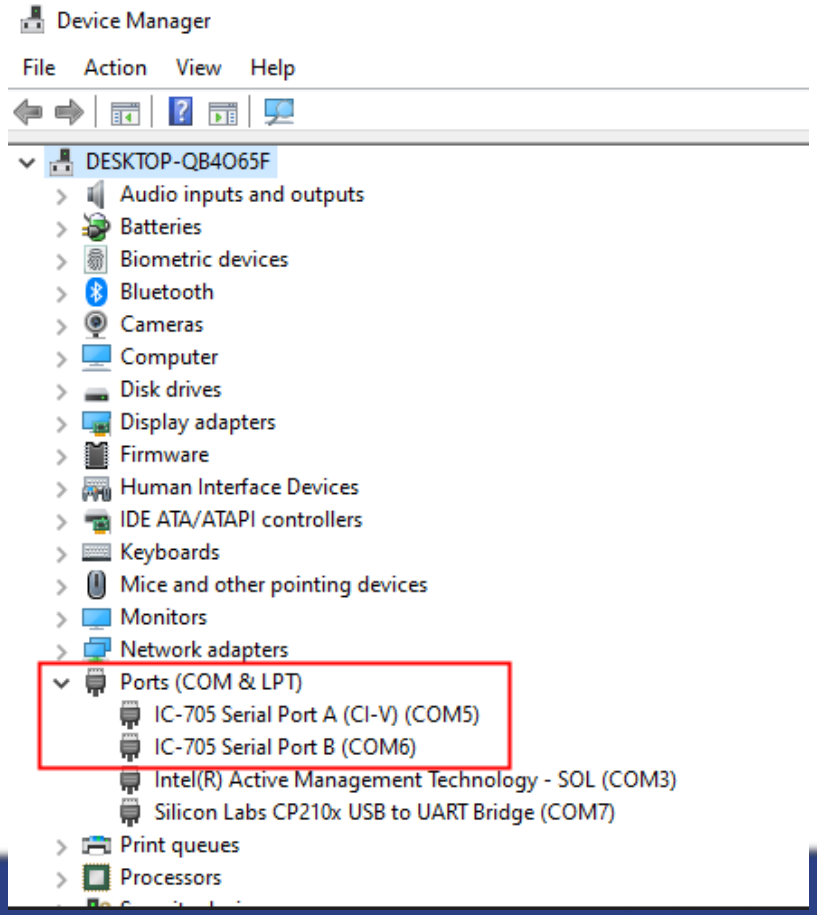
- If using the USB cable then download and install the ICOM drivers. This will install two com ports.



Setup with IC-705/905

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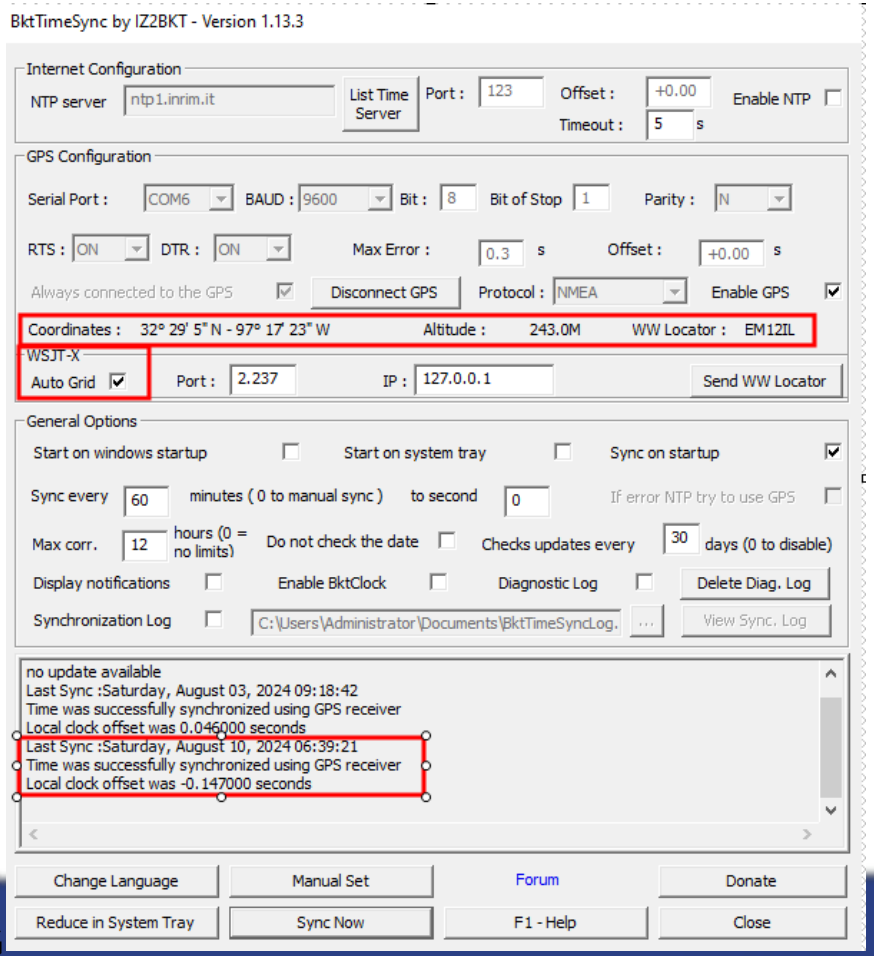
- Time sync software from BktTimeSync by IZ2BKT will use the GPS in the rig to provide time sync and lat/long info



Testing/Learning

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- KI5EMN test bench.
  - Two IF rigs IC-705 and FT-290
  - Windows Surface USB cabled to IC-705 and Mac laptop using SignalLink and mic cable to FT-290

Q65 Review

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- A new low-rate Q-ary Repeat Accumulate code for forward error correction
- User messages and sequencing identical to those in FST4, FT4, FT8, and MSK144
- A unique tone for time and frequency synchronization. As with JT65, this “sync tone” is readily visible on the waterfall spectral display. In addition, Q65 provides a sensitive “sync curve” near the bottom of the waterfall window. Unlike JT65, synchronization and decoding are effective even when meteor pings or other short signal enhancements are present.
- A new, highly reliable list-decoding technique for messages that contain previously copied message fragments. No use is made of a callsign database.
- Highly effective message averaging for situations where single transmissions are too weak or signal enhancements too sparse for a signal to be decoded.
- A “multi-decode” option that attempts to decode all Q65 signals in the received passband.

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Questions?