

Amateur Radio

Digital Communication Mode FT8

March 12, 2019

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Amateur Radio Modes

- CW
- AM
- SSB
- FM
- RTTY
- PSK, JT65, JT9 and many other “digital” modes
- FT8



What is FT8?

- Released June 29, 2017
- Written by
 - Steven Franke (K9AN University of Illinois - UC)
 - Joe Taylor (K1JT)
- FT8 features:
 - Very narrow bandwidth (50 Hz)
 - 8 tones, spaced 6.25 Hz apart
 - Fast (15s transmit/receive cycle) compared to JT65
- – FT8: **F**ranke & **T**aylor, **8**-frequency shift keying format.

Why FT8?

Weak-Signal Signal/Noise Ratio

| | |
|------|--------|
| SSB | +10 dB |
| CW | -15 dB |
| FT8 | -21 dB |
| JT65 | -25 dB |
| JT9 | -27 dB |
| WSPR | -31 dB |

* 2500 Hz bandwidth

Doubling power results in a 3 dB increase in SNR

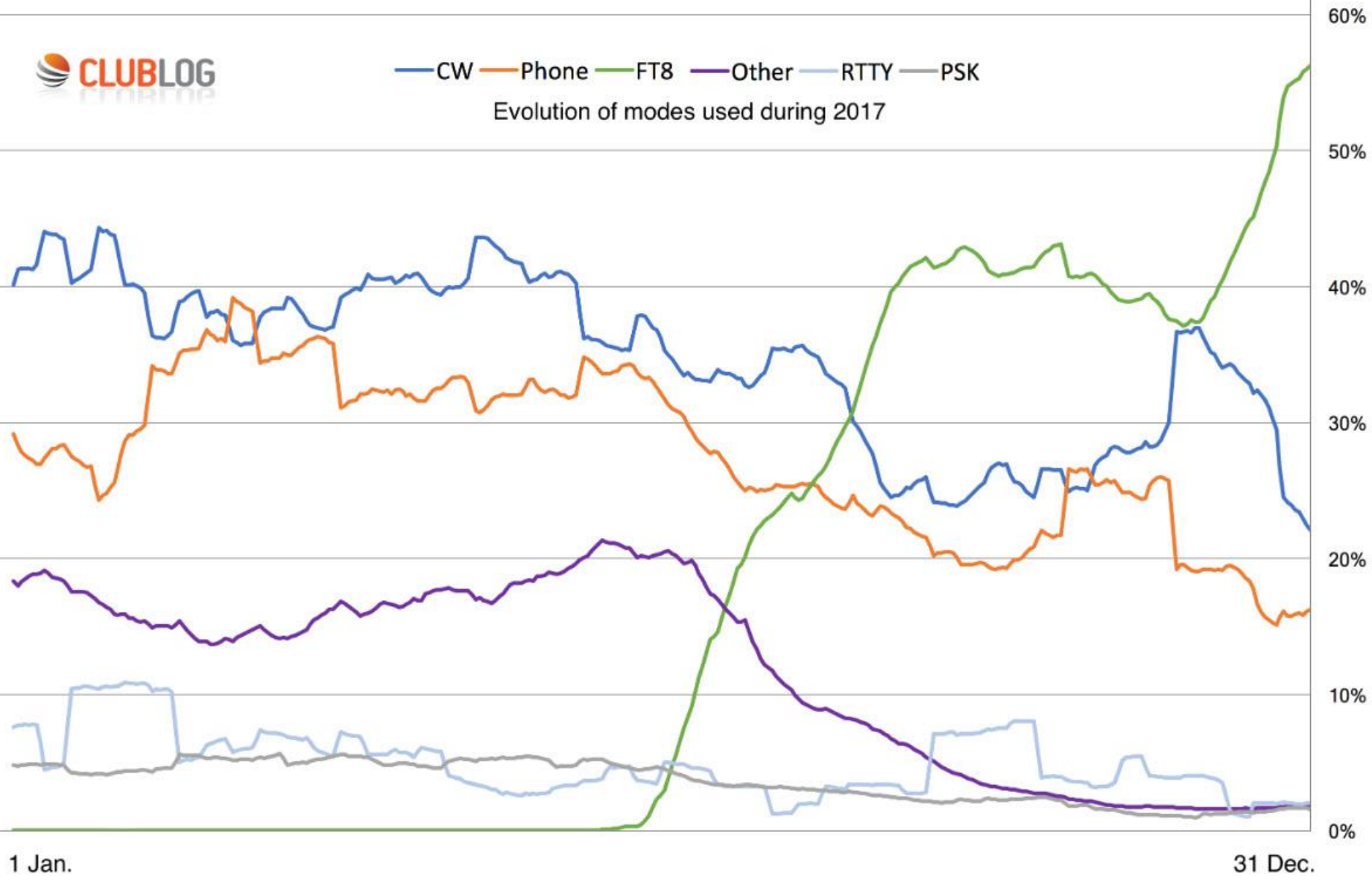
31dB difference is about $2^{10} = 1,024$

1W FT8 vs 1,024W SSB



— CW — Phone — FT8 — Other — RTTY — PSK

Evolution of modes used during 2017

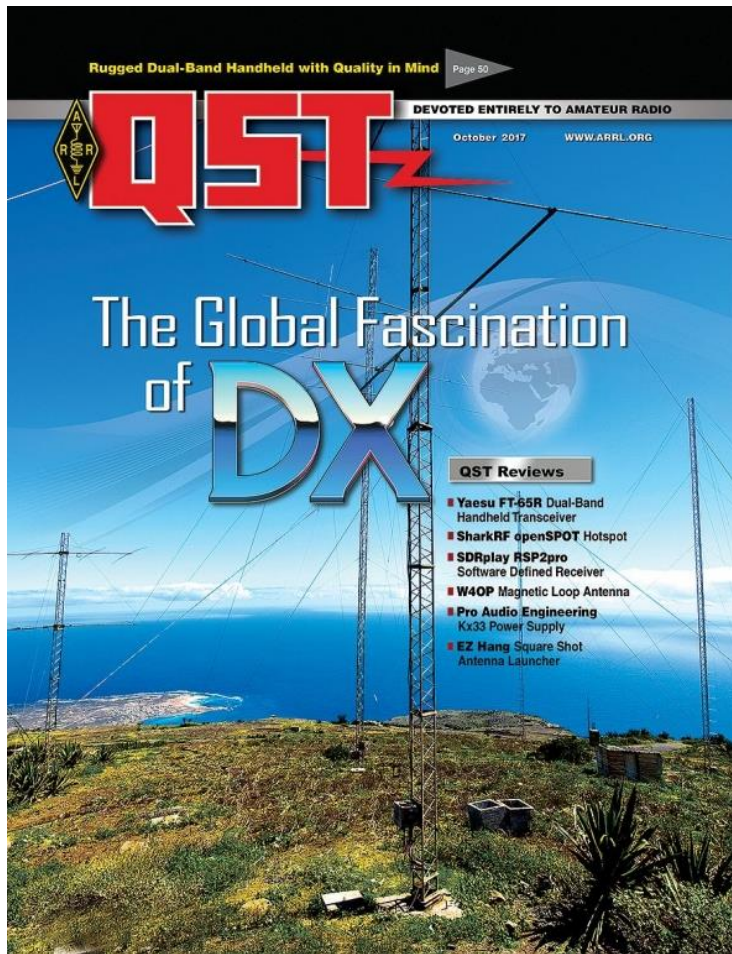


Club Log graph showing modes used by radio amateurs in 2017, and the emergence of FT8. Lines on the graph are based on 28-day moving averages. Data were smoothed to reduce the prominence of peaks related to mode-specific contests.

CLOSE X

October and November 2017 QST

Two part series on FT8



FT8 – The Math

- 15 second block supports 13 characters
- $15 - 12.64 =$ less than 2.5 seconds to decode & respond
 - Turn ON auto-sequence
- Effective data rate of 5 words per minute
 - Forward error correction (FEC) in FT8 uses a low-density parity check (LDPC) code with 77 information bits, a 14-bit cyclic redundancy check (CRC), and 83 parity bits making a 174-bit codeword. It is thus called an LDPC (174,91) code.
 - Modulation is 8-tone frequency-shift keying (8-FSK). The total occupied bandwidth is $8 \times 6.25 = 50$ Hz.
 - Synchronization uses 7×7 Costas arrays at the beginning, middle, and end of each transmission ($7 \times 3 = 21$).
 - Each transmitted symbol carries three bits ($8 = 2^3$), so the total number of channel symbols is $174/3 + 21 = 79$.
 - Transmission duration: $79 \times 1920 / 12000 = 12.64$ s

A sidetrip into the FT8 Costas Array

- In addition to Forward Error Correction FT8 uses 7x7 Costas arrays, originally developed to provide better SONAR and RADAR pings by tagging each transmission with unambiguous combinations of frequency hops and time intervals.
- There are 200 unique frequency and time combinations in a 7x7 Costas Array.
- For background visit the Ted Talk “[The World’s Ugliest Music²](#)” created using a Costas Array, guaranteed NOT to be running through your brain all day long once you hear it.

Let's use WSJT-X FT8 Mode



Setup and Operating Hints

- Radio w/ SSB, Sound Interface, and a PC are required
 - Rig interface is very helpful (t/r and frequency)
- Download WSJTX
 - Enter your callsign, grid square, sound card, radio interface
 - Select frequency / band
 - Adjust AF input level – receive
- Synchronize your clock!
- Synchronize your clock!!
- Synchronize your clock!!!
- Adjust RF power output
 - 100% duty cycle – full output NOT recommended
 - Adjust AF output level – transmit (barely move ALC)
- Enable logging & reporting to pskreporter.info
- Turn on auto-sequence

- **Listen** to familiarize yourself with the sequence

What's my Grid Square?

http://www.levinecentral.com/ham/grid_square.php

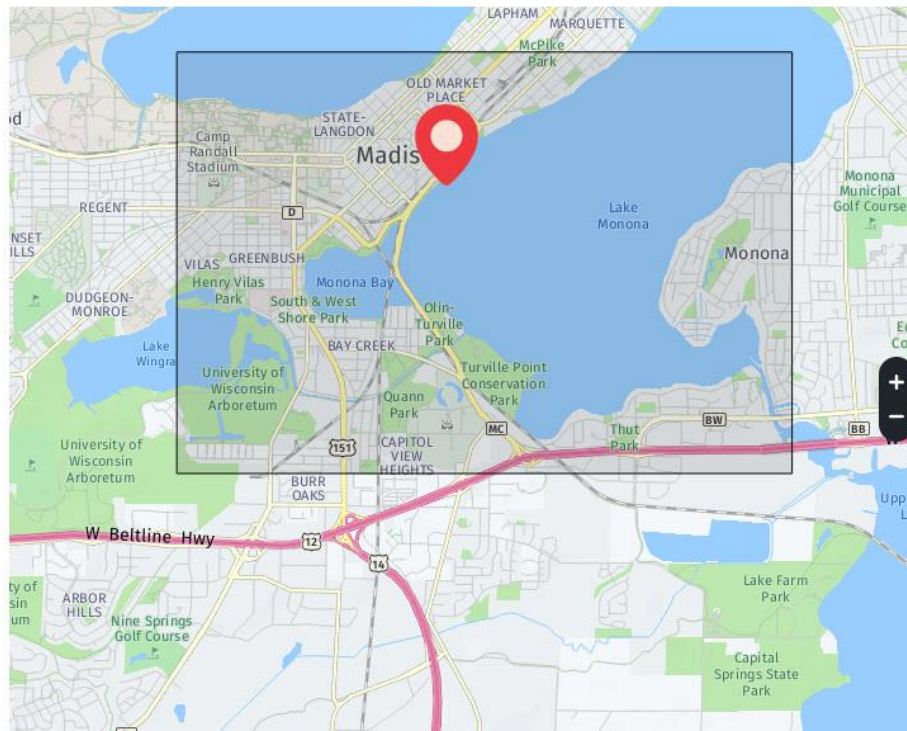
Amateur Radio Ham Radio Maidenhead Grid Square Locator Map

Enter any address, city & state or zip:
or Enter any call sign: Data provided by QRZ.com
or Enter any a 4 or 6 character grid square:

[?? How does this work? Why doesn't this work? ??](#)

Latitude: 43.07 / 43° 4' 12" N Longitude: -89.38 / 89° 22' 47" W

Grid: **EN53hb**



Getting Started

Set the band, tune up as normal

Use Tune to check power level

Adjust slider until transmit power drops (half your rig's power or even 25 or 10% is a good place to start)

The screenshot shows a radio software interface with several key elements:

- Band and Frequency:** A dropdown menu is set to '40m'. The main display shows a frequency of 7.073 300.
- Call and Grid:** The DX Call is 'KE6SCS' and the DX Grid is 'DM04'. The location is 'Az: 247' and '2183 km'.
- Time and Date:** A large display shows '2018 Mar 10' and '11:35:39'.
- Buttons and Controls:** Buttons include 'Log QSO', 'Stop', 'Monitor' (highlighted in green), 'Erase', 'Decode', 'Enable Tx', 'Halt Tx', 'Tune', and 'Menus'. There are also 'Tx even/1st', 'Tx 2011 Hz', 'Tx ← Rx', 'Rx 2010 Hz', 'Rx ← Tx', 'Hold Tx Freq', 'Auto Seq', 'Call 1st', and 'NA VHF Contest' checkboxes.
- Message Queue:** A list of messages is shown with 'Generate Std Msgs' buttons and 'Next'/'Now' columns. The 'Now' column shows 'Tx 1' through 'Tx 6'. The 'Tx 6' button is selected.
- Power and Volume:** A vertical slider on the right is labeled 'Pwr'. A volume indicator on the left shows a level of 74 dB.
- Status Bar:** At the bottom, it shows 'Receiving', 'FT8', 'Last Tx: KE6SCS N0DL 73', and '9/15 WD:6m'.

Adjust RF gain to keep receive level below red, between 40 and 80 is ok

You will probably need to adjust your sound card's audio levels to get everything to play. This can take some time and a separate sound card is highly recommended (set and forget)

WSJT-X Main Screen

All QSO activity in the receive spectrum

WSJT-X v1.3.0 by K1JT

File Configurations View Mode Decode Save Tools Help

| Band Activity | | | | | Rx Frequency | | | | |
|---------------|-----|------|------|---------------------|--------------|-----|------|------|-------------------|
| UTC | dB | DT | Freq | Message | UTC | dB | DT | Freq | Message |
| 113130 | -7 | 0.2 | 1393 | ~ CQ W1LLE EL87 | 112616 | Tx | 1005 | ~ | N4BP N0DL EN14 |
| 113130 | -13 | -0.6 | 1814 | ~ CQ CO3NR EL82 | 112630 | -2 | 0.1 | 2053 | ~ W3DWJ N4BP -17 |
| 113130 | -8 | 0.0 | 2010 | ~ CQ KE6SCS DM04 | 112645 | Tx | 1005 | ~ | N4BP N0DL EN14 |
| 113145 | -18 | 0.2 | 1227 | ~ CQ HK7JA FJ35 | 112700 | -2 | 0.1 | 2054 | ~ W3DWJ N4BP RRR |
| 113145 | -8 | -0.0 | 1409 | ~ JA1BJI RM6NAP -08 | 112715 | Tx | 1005 | ~ | N4BP N0DL EN14 |
| 113145 | -6 | 0.1 | 1792 | ~ DS1AAK LU5VV FE48 | 112730 | -2 | 0.2 | 2054 | ~ W3DWJ N4BP 73 |
| 113145 | 2 | 0.1 | 2133 | ~ ED7OXK WD6DEM -19 | 112730 | -12 | -0.6 | 1816 | ~ CQ CO3NR EL82 |
| 113200 | -17 | -0.6 | 1814 | ~ CQ CO3NR EL82 | 112747 | Tx | 2053 | ~ | CO3NR N0DL EN14 |
| 113200 | -12 | 0.0 | 2011 | ~ CQ KE6SCS DM04 | 112815 | Tx | 2053 | ~ | CO3NR N0DL EN14 |
| 113200 | -16 | 0.0 | 1469 | ~ KD2DNJ YV1GIY -07 | 112830 | -12 | -0.6 | 1815 | ~ CQ CO3NR EL82 |
| 113230 | -9 | -0.6 | 1814 | ~ CQ CO3NR EL82 | 112845 | Tx | 1450 | ~ | CO3NR N0DL EN14 |
| 113300 | -10 | -0.0 | 2010 | ~ CQ KE6SCS DM04 | 112900 | -14 | -0.1 | 1815 | ~ CQ CO3NR EL82 |
| 113300 | -9 | -0.6 | 1066 | ~ KB1ODO CO3NR -08 | 112915 | Tx | 1450 | ~ | CO3NR N0DL EN14 |
| 113315 | -8 | 0.1 | 1363 | ~ K1VWQ W2DEN 73 | 112930 | -12 | -0.6 | 1815 | ~ CQ CO3NR EL82 |
| 113315 | -5 | 0.1 | 1728 | ~ B14IGJ LU5VV FE48 | 113000 | -13 | -0.6 | 1815 | ~ CQ CO3NR EL82 |
| 113315 | -3 | 0.0 | 2054 | ~ N4BP K4ADR EL96 | 113030 | -9 | 0.1 | 2054 | ~ CQ N4BP EL96 |
| 113315 | -2 | 0.1 | 2133 | ~ ED7OXK WD6DEM -19 | 113048 | Tx | 1450 | ~ | N4BP N0DL EN14 |
| 113330 | -12 | -0.0 | 2011 | ~ CQ KE6SCS DM04 | 113100 | -9 | 0.2 | 2054 | ~ CQ N4BP EL96 |
| 113330 | -11 | -0.6 | 1066 | ~ KB1ODO CO3NR RRR | 113115 | Tx | 1450 | ~ | N4BP N0DL EN14 |
| 113330 | -10 | 0.0 | 1469 | ~ KD2DNJ YV1GIY 73 | 113130 | -6 | 0.2 | 2054 | ~ CQ N4BP EL96 |
| 113400 | -8 | -0.0 | 2010 | ~ N0DL KE6SCS -11 | 113200 | -12 | 0.0 | 2011 | ~ CQ KE6SCS DM04 |
| 113430 | -14 | 0.0 | 2010 | ~ N0DL KE6SCS RRR | 113217 | Tx | 2054 | ~ | KE6SCS N0DL EN14 |
| 113430 | -9 | 0.0 | 1469 | ~ W2DEN YV1GIY -06 | 113245 | Tx | 2054 | ~ | KE6SCS N0DL EN14 |
| 113430 | -14 | -0.6 | 1660 | ~ CQ CO3NR EL82 | 113300 | -10 | -0.0 | 2010 | ~ CQ KE6SCS DM04 |
| 113500 | -9 | -0.0 | 2011 | ~ N0DL KE6SCS 73 | 113330 | -12 | -0.0 | 2011 | ~ CQ KE6SCS DM04 |
| 113500 | -11 | 0.0 | 1469 | ~ W2DEN YV1GIY RRR | 113348 | Tx | 2011 | ~ | KE6SCS N0DL EN14 |
| 113500 | -12 | -0.6 | 1660 | ~ CQ CO3NR EL82 | 113400 | -9 | -0.0 | 2010 | ~ N0DL KE6SCS -11 |
| 113515 | -15 | 0.2 | 1235 | ~ CQ HK7JA FJ35 | 113415 | Tx | 2011 | ~ | KE6SCS N0DL R-09 |
| 113515 | -11 | 0.0 | 1414 | ~ D54GKA N07E -11 | 113430 | -14 | 0.0 | 2010 | ~ N0DL KE6SCS RRR |
| 113515 | -5 | 0.1 | 1468 | ~ YV1GIY W2DEN 73 | 113445 | Tx | 2011 | ~ | KE6SCS N0DL 73 |
| 113515 | 5 | 0.1 | 2133 | ~ ED7OXK WD6DEM -19 | 113500 | -9 | -0.0 | 2011 | ~ N0DL KE6SCS 73 |

Log QSO Stop Monitor Erase Decode Enable Tx Halt Tx Tune Menus

40m 7.073 300 Tx even/1st

Tx ← Rx

Rx 2010 Hz Rx ← Tx

Az: 247 2183 km Hold Tx Freq

Lookup Report -14 Auto Seq Call 1st

NA V-F Contest

2018 Mar 10 11:35:39

Receiving FT8 Last Tx: KE6SCS N0DL 73 9/15 W/D:6m

Stations calling "CQ" will be highlighted in green

Your call will show up highlighted in red

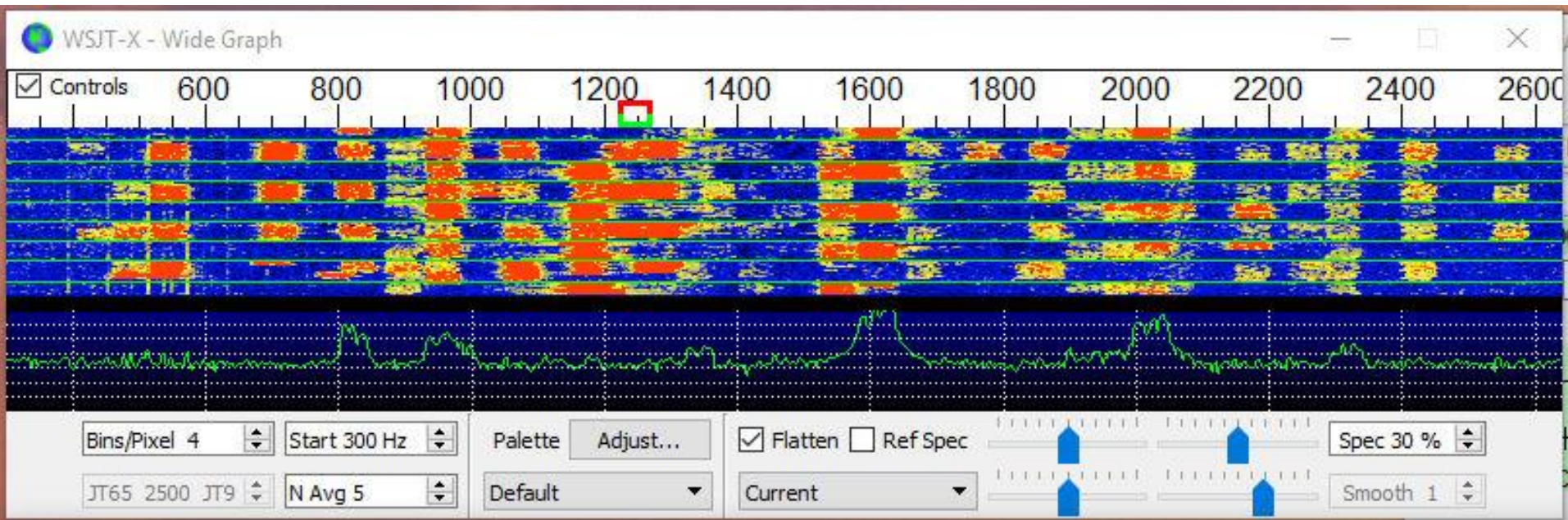
All activity shown on the Rx frequency

Your transmissions are highlighted in yellow

The message transmissions are generated automatically and sent in sequence

Your transmissions are sent in a 50 Hz-wide slot at the base frequency + the audio offset

WSJT-X - The Waterfall

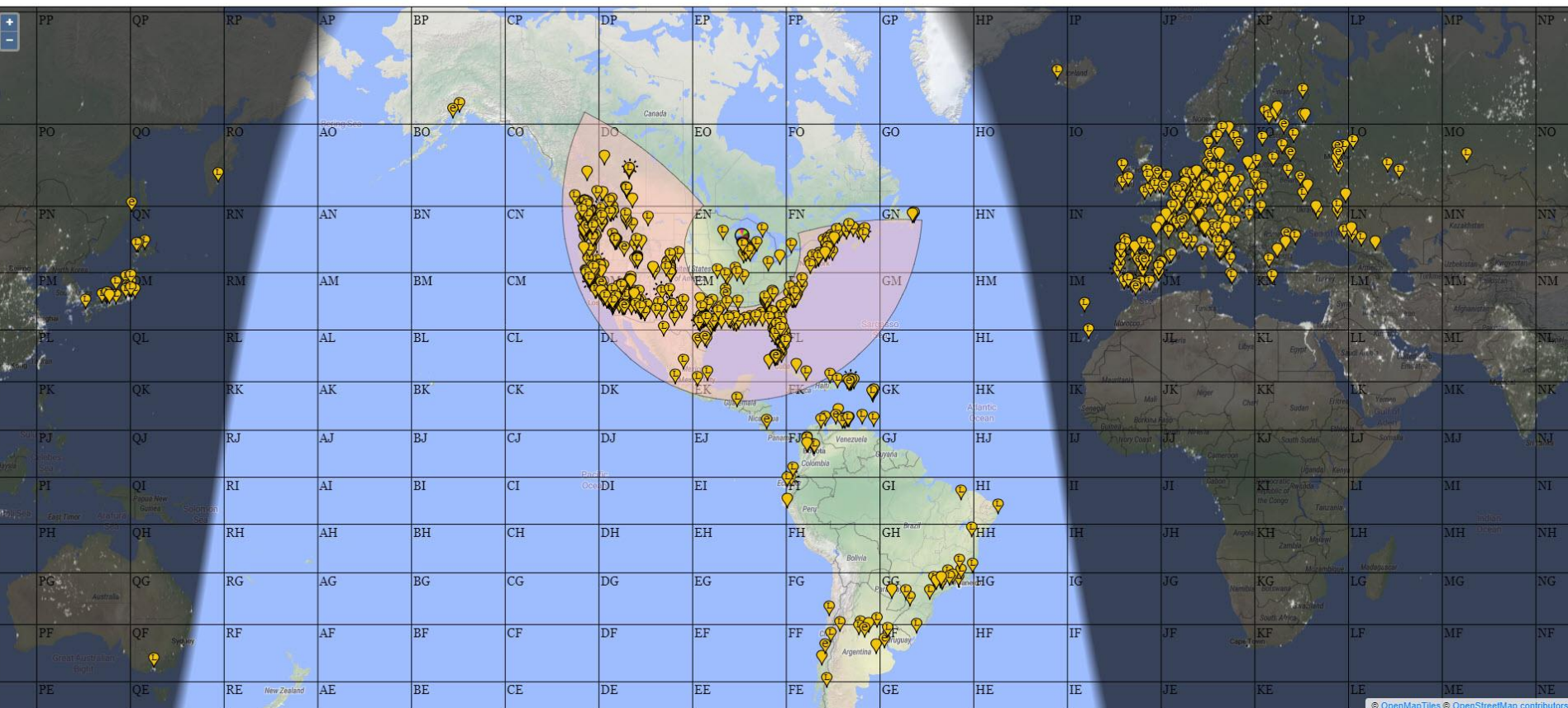


www.PSKreporter.info

On , show , rcvd by using over the last [Display options](#) [Permalink](#)

Automatic refresh in 5 minutes. Small markers are the 977 transmitters (show logbook) heard (distance chart) at KA9SWE (1830 reports, 68 countries last 24 hours; 12951 reports, 78 countries last week).

There are 3405 active FT8 monitors: 868 on 20m, 819 on 40m, 629 on 30m, 299 on 17m, 269 on 80m, 194 on 2m, 127 on 160m, 106 on 60m, 46 on 15m, 20 on unknown, 19 on 6m, 5 on 10m, 3 on 12m, 1 on 2200m. Show all on all bands. Legend



References

- WSJT-X Homepage with downloads <http://physics.princeton.edu/pulsar/K1JT/wsjtx.html>
- FT8 Operating Guide ZL2iFB (very good) www.g4ifb.com/FT8_Hinson_tips_for_HF_DXers.pdf
- FT8 DXpedition Mode JT http://physics.princeton.edu/pulsar/k1jt/FT8_DXpedition_Mode.pdf
- JAlert Helper App <https://hamapps.com/>
- PC Time Sync Programs (Windows / PC clock usually not good enough)
 - <https://www.maniaradio.it/en/bkktimesync.html> (pool.ntp.org)
 - <http://thinkman.com/dimension4/download.htm>
 - <https://sourceforge.net/projects/nettime/>
 - <https://www.meinbergglobal.com/english/sw/ntp.htm>
 - <https://time.is>
- PSKreporter <https://www.pskreporter.info>
- Grid Square locator http://www.levinecentral.com/ham/grid_square.php
- WSJT-X FT8 Joe Taylor video presentation https://www.youtube.com/watch?v=233HQs_8JGQ
- Video - FT8 Facebook Page Group <https://www.youtube.com/watch?v=-dO7m4XZzOI&t=21s>

Demonstration (RealVNC - VNC Viewer)

WSJT-X v2.0.0 by K1JT

File Configurations View Mode Decode Save Tools Help

Band Activity

| UTC | dB | DT | Freq | Message | Rx Frequency |
|--------|-----|------|------|--------------------|--------------|
| 194345 | -5 | 0.3 | 1555 | IU8D5P WC3W EL96 | |
| 194400 | -12 | 0.1 | 400 | KF4BI EA8ACW -20 | |
| 194400 | -7 | 0.2 | 633 | WV4V N5EDG EM10 | |
| 194400 | 6 | 0.2 | 700 | OH8JK KJ7G CN87 | |
| 194400 | -11 | 0.1 | 760 | W7HMT K1SCZO -11 | |
| 194400 | -17 | 0.2 | 1258 | CQ HA7IM JN97 | |
| 194400 | -18 | 0.2 | 1387 | K9FE VA1UAV 73 | |
| 194400 | 5 | 0.1 | 1495 | ZS6LKF KF7PBM R-17 | |
| 194400 | -7 | 0.1 | 1914 | ZS6LKF K2EK EL97 | |
| 194400 | -8 | 0.3 | 1975 | M10SAI NR7RR R-01 | |
| 194400 | -15 | 0.2 | 2452 | ND20 J73WA RR73 | |
| 194400 | -5 | 0.1 | 2601 | EA1ZR W7CAI R-12 | |
| 194400 | -9 | 0.1 | 690 | CQ VE6BTC D033 | |
| 194415 | -21 | 0.1 | 401 | EA8ACW KF4BI R-04 | |
| 194415 | -22 | 0.1 | 559 | 4Z5KU K7ZYV EM50 | |
| 194415 | 8 | 0.1 | 805 | ON1AEY WA9LJK EN53 | |
| 194415 | 1 | 0.1 | 975 | CQ N7QT CN87 | |
| 194415 | -10 | 0.2 | 1192 | VE1GG AK6A -07 | |
| 194415 | -10 | 0.1 | 1212 | AB8CW EA4DB RRR | |
| 194415 | -19 | 0.2 | 1373 | W9IB K1SDAK -15 | |
| 194415 | 3 | 0.3 | 1556 | IU8D5P WC3W R-09 | |
| 194415 | -23 | 0.1 | 1684 | K87EM EA5CH RRR | |
| 194415 | -14 | -0.5 | 1837 | 1W9FFD N4LDF EL95 | |
| 194415 | -12 | 0.2 | 1894 | CQ W5MEU DM81 | |
| 194415 | -19 | 0.6 | 1968 | R6XW HC2AO RR73 | |
| 194415 | -18 | 0.1 | 2073 | VA1UAV CT11UA IM67 | |
| 194415 | 0 | 0.1 | 2365 | VE7HBS KK4SIB EL88 | |
| 194415 | -2 | 0.2 | 2391 | KE0KDX DJ5FI RR73 | |

14.074 000

DX Call: EW8W, DX Grid: KO42

Az: 35, 7889 km

2019 Feb 27 19:44:35

Receiving FT8 5/15 WD:0m

| | | | | | | | | |
|------------|-------------------|-------------|------------------|-------------|--------------|--------|-----------|-------|
| KF4BI - GA | K7ZYV - MS | WA9LJK - WI | N7QT - B4 | AK6A - OR | EA4DB | K1SDAK | WC3W - FL | EA5CH |
| U.S.A. | U.S.A. | U.S.A. | U.S.A. - WA | U.S.A. | Spain | U.S.A. | U.S.A. | Spain |
| N4LDF - FL | W5MEU - TX | HC2AO | CT11UA | KK4SIB - FL | DJ5FI | | | |
| U.S.A. | U.S.A. | Ecuador | Portugal | U.S.A. | F.R. Germany | | | |

