WSJT-X User Guide

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Version 2.6.1

Table of Contents

1. Introduction

WSJT-X is a computer program designed to facilitate basic amateur radio communication using very weak signals. The first four letters in the program name stand for "**W**eak **S**ignal communication by K1**JT**," while the suffix "**-X**" indicates that *WSJT-X* started as an extended branch of an earlier program, *WSJT*, first released in 2001. Bill Somerville, G4WJS, Steve Franke, K9AN, and Nico Palermo, IV3NWV, have been major contributors to development of *WSJT-X* since 2013, 2015, and 2016, respectively.

WSJT-X Version 2.6 offers eleven different protocols or modes: **FST4**, **FT4**, **FT8**, **JT4**, **JT9**, **JT65**, **Q65**, **MSK144**, **WSPR**, **FST4W**, and **Echo**. The first seven are designed for making reliable QSOs under weak-signal conditions. They use nearly identical message structure and source encoding. JT65 was designed for EME ("moonbounce") on VHF and higher bands and is mostly used for that purpose today. Q65 is particularly effective for tropospheric scatter, rain scatter, ionospheric scatter, TEP, and EME on VHF and higher bands, as well as other types of fast-fading signals. JT9 was designed for the HF and lower bands. Its submode JT9A is 1 dB more sensitive than JT65 while using less than 10% of the bandwidth. JT4 offers a wide variety of tone spacings and has proven highly effective for EME on microwave bands up to 24 GHz. The "slow" modes use timed sequences of alternating transmission and reception. JT4, JT9, and JT65 use one-minute sequences, so a minimal QSO takes four to six minutes — two or three transmissions by each station, one sending in odd UTC minutes and the other even. FT8 is four times faster (15-second T/R sequences) and less sensitive by a few dB. FT4 is faster still (7.5 s T/R sequences) and especially well-suited for radio contesting. FST4 is designed especially for the LF and MF bands. Both FST4 and Q65 offer a wide variety of timed sequence lengths, and Q65 a range of tone spacings for different propagation conditions. On the HF bands, world-wide QSOs are possible with any of these modes using power levels of a few watts (or even milliwatts) and compromise antennas. On VHF bands and higher, QSOs are possible (by EME, scatter, and other propagation types) at signal levels 10 to 15 dB below those required for CW.

MSK144, and optionally submodes **JT9E-H** are "fast" protocols designed to take advantage of brief signal enhancements from ionized meteor trails, aircraft scatter, and other types of scatter propagation. These modes use timed sequences of 5, 10, 15, or 30 s duration. User messages are transmitted repeatedly at high rate (up to 250 characters per second for MSK144) to make good use of the shortest meteor-trail reflections or "pings". MSK144 uses the same structured messages as the slow modes and optionally an abbreviated format with hashed callsigns.

Note that some of the modes classified as slow can have T/R sequence lengths as short the fast modes. "Slow" in this sense implies message frames being sent only once per transmission. The fast modes in *WSJT-X* send their message frames repeatedly, as many times as will fit into the Tx sequence length.

WSPR (pronounced "whisper") stands for **W**eak **S**ignal **P**ropagation **R**eporter. The WSPR protocol was designed for probing potential propagation paths using low-power transmissions. WSPR messages normally carry the transmitting station's callsign, grid locator, and transmitter power in dBm, and with two-minute sequences they can be decoded at signal-to-noise ratios as low as -31 dB in a 2500 Hz bandwidth. **FST4W** is designed for similar purposes, but especially for use on LF and MF bands. It includes optional sequence lengths as long as 30 minutes and reaches sensitivity tresholds as low as -45 dB. Users with internet access can automatically upload WSPR and FST4W reception reports to a central database called WSPRnet (https://wsprnet.org/drupal/) that provides a mapping facility, archival storage, and many other features.

Echo mode allows you to detect and measure your own station's echoes from the moon and to make other measurements useful for optimizing your EME station's performance.

WSJT-X provides spectral displays for receiver passbands as wide as 5 kHz, flexible rig control for nearly all modern radios used by amateurs, and a wide variety of special aids such as automatic Doppler tracking for EME QSOs and Echo testing. The program runs equally well on Windows, Macintosh, and Linux systems, and installation packages are available for all three platforms.

Version Numbers: *WSJT-X* release numbers have major, minor, and patch numbers separated by periods: for example, *WSJT-X* Version 2.1.0. Temporary *beta release* candidates are sometimes made in advance of a new general-availability release, in order to obtain user feedback. For example, version 2.1.0-rc1, 2.1.0-rc2, etc., would be beta releases leading up to the final release of v2.1.0. Release candidates should be used *only* during a short testing period. They carry an implied obligation to provide feedback to the program development group. Candidate releases should not be used on the air after a full release with the same number is made.

A companion program *MAP65*, written by K1JT, is designed for EME communication using the JT65 and Q65 protocols. When used with RF hardware providing coherent signal channels for two orthogonal polarizations, the program provides automatic polarization-matched reception for every JT65 or Q65 signal in a 90 kHz passband. On the Windows platform, *MAP65* is installed automatically along with *WSJT-X*.

1.1. New in Version 2.6

- *WSJT-X 2.6* implements new features supporting the ARRL International Digital Contest and its distance based scoring. The **Call 1st** checkbox has been replaced by a drop-down control offering **CQ Max Dist** as an alternative. A new window labeled **Active Stations** displays a list of received but unworked callsigns, sorted in decreasing order of potential contest points. With option **CQ Max Dist** selected, the program will select the reply to your CQ that yields the most contest points. You can click on a line in the Active Stations window to call that station.
- Decoding performance for FT8 and Q65 has been improved in a variety of situations with available *a priori* (AP) information.
- **Echo** mode now offers a **Clear Avg** button and produces reliable measurements of SNR even when Doppler spread is large. Its **Monitor** function can be used to measure SNR for a received unmodulated carrier such as a key-down test signal emitted by another station and reflected from the Moon, and also to measure Sun, Moon, and ground noise as aids for optimizing an EME station's performance.
- New buttons on the main window allow quick changes between modes FT4, FT8, MSK144, Q65, and JT65, and toggling FT8 Hound mode ON/OFF.
- New convenience features allow Fox operators to react more quickly to particular QSO situations. A two-column table in Tab 2 provides an overview of the queue and of callsigns with QSOs in progress. Fox operator can change the ordering of callsigns in the queue, allowing reaction to changes in propagation. Fox now responds automatically for another two cycles to stations whose report has not been received, increasing the success rate for difficult QSOs.
- The Working frequency table now offers save/restore capability and better handling of more than one frequency per mode-band combination. You can set preferred frequencies, and WSJT-X will select these when you change band or mode. You can label a tabled frequency with a description, for example a DXpedition callsign, and set Start and End date and time so the frequencies automatically appear and disappear from the displayed options. You can load a publicly available frequency table from a file, to easily make such DXpedition data available to the program.
- Optional color highlighting is provided for specified DX Call and DX Grid, and for messages containing RR73 or 73.
- New options are provided for writing to file ALL.TXT. You can request automatic starting of a new file every month or every year, and you can disable writing altogether.
- Settings for T/R period and Submode are remembered by mode when you switch directly between modes: for example, MSK144-15, Q65-60A, or FST4-120.
- Tx and Rx audio frequencies are remembered and restored when you return from a mode that sets a default frequency 1500 Hz (MSK144, FST4W, Echo, WSPR, FreqCal), then switching back to FT4, FT8, Q65, FST4, or JT65.
- Rig control is provided for some new radios, and bug fixes for controlling others.

- New features in *MAP65* (available for Windows only) include an aid for measuring antenna pointing errors and an ability to read the file wsjtx.log (kept by *WSJT-X*) to recognize EME contest dupes. In addition, *MAP65* now sends additional information to file azel.dat and offers optional digital scaling of input I/Q data.

1.2. Documentation Conventions

We include screen shots that illustrate many of the settings and features of *WSJT-X*. Keep in mind that *WSJT-X* is a multi-platform application: the detailed appearance of windows and user controls may be significantly different in Windows, Linux, or macOS environments. The underlying functionality is the same on all operating systems, however. Where desirable we call special attention to important platform differences.

In this manual the following icons call attention to particular types of information:

Notes containing information that may be of interest to particular classes of users.

Tips on program features or capabilities that might otherwise be overlooked.

Warnings about usage that could lead to undesired consequences.

1.3. User Interface in Other Languages

The *WSJT-X* user interface (UI) is now available in many languages. When a translated UI is available for the computer's default System Language, it will appear automatically on program startup. The UI language may be overridden if desired by starting *WSJT-X* with a command line option. For example, to start *WSJT-X* with its user interface in Spanish, enter this command at the prompt:

```
wsjtx --language es
```

1.4. How You Can Contribute

WSJT-X is part of an open-source project released under the GNU General Public License (https://www.gnu.org/licenses/gpl-3.0.txt) (GPLv3). If you have programming or documentation skills or would like to contribute to the project in other ways, please make your interests known to the development team. We especially encourage those with translation skills to volunteer their help, either for this *User Guide* or for the program's user interface.

The project's source-code repository can be found at SourceForge (https://sourceforge.net/p/wsjt/wsjtx/ci/master/tree/), and communication among the developers takes place on the email reflector wsjt-devel@lists.sourceforge.net. Bug reports and suggestions for new features, improvements to the *WSJT-X* User Guide, etc., may be sent there as well. You must join the group before posting to the email list.

1.5. License

Before using *WSJT-X*, please read our licensing terms here.

2. System Requirements

- SSB transceiver and antenna
- Computer running Windows 7 or later, macOS 10.13 or later, or Linux
- 1.5 GHz or faster CPU and 200 MB of available memory; faster machines are better
- Monitor with at least 1024 x 780 resolution
- Computer-to-radio interface using a serial port or equivalent USB device for T/R switching, or CAT control, or VOX, as required for your radio-to-computer connections
- Audio input and output devices supported by the operating system and configured for sample rate 48000 Hz, 16 bits
- Audio or equivalent USB connections between transceiver and computer
- A means for synchronizing the computer clock to UTC within ±1 second

3. Installation

Installation packages for released versions on Windows, Linux, and OS X are found on the WSJT Home Page (https://wsjt.sourceforge.io/index.html). Click on the *WSJT-X* link at the left margin and select the appropriate package for your operating system.

3.1. Windows

Download and execute the package file wsjtx-2.6.1-win32.exe (https://sourceforge.net/projects/wsjt/files/wsjtx-2.6.1/wsjtx-2.6.1-win32.exe) (Windows 7 or later, 32-bit) or wsjtx-2.6.1-win64.exe (https://sourceforge.net/projects/wsjt/files/wsjtx-2.6.1/wsjtx-2.6.1-win64.exe) (Windows 7 or later, 64-bit) following these instructions:

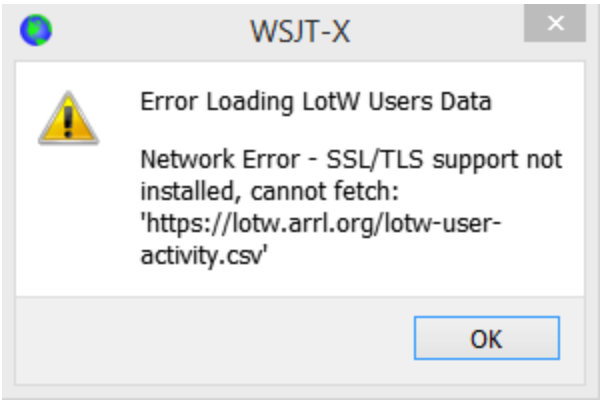
- Install *WSJT-X* into its own directory, for example `C:\WSJTX` or `C:\WSJT\WSJTX`, rather than the conventional location `C:\Program Files …\WSJTX`.
- All program files relating to *WSJT-X* are stored in the chosen installation directory and its subdirectories.
- Logs and other writeable files are normally found in the directory

`C:\Users\<username>\AppData\Local\WSJT-X`.

Your computer may be configured so that this directory is “invisible”. It’s there, however, and accessible. An alternative (shortcut) directory name is `"%LocalAppData%\WSJT-X\"`.

- The built-in Windows facility for time synchronization is usually not adequate. We recommend the program *Meinberg NTP Client*: see Network Time Protocol Setup (https://www.satsignal.eu/ntp/setup.html) for downloading and installation instructions. Recent versions of Windows 10 are now shipped with a more capable Internet time synchronization service that is suitable if configured appropriately. We do not recommend SNTP time setting tools or others that make periodic correction steps, *WSJT-X* requires that the PC clock be monotonically increasing and smoothly continuous.

Having a PC clock that appears to be synchronized to UTC is not sufficient. “Monotonically increasing” means that the clock must not be stepped backwards. “Smoothly continuous” means that time must increase at a nearly constant rate, without steps. Any necessary clock corrections must be applied by adjusting the rate of increase, thereby correcting synchronization errors gradually.



- *WSJT-X* requires installation of the *OpenSSL* libraries. Suitable libraries may already be installed on your system. If they are not, you will see this error shortly after requesting a fetch of the latest LoTW users database. To fix this, install the *OpenSSL*

libraries.

- You can download a suitable *OpenSSL* package for Windows from Windows OpenSSL Packages (https://slproweb.com/products/Win32OpenSSL.html); you need the latest **Windows Light** version. For the 32-bit *WSJT-X* build, use the latest Win32 v1.1.1 version of the *OpenSSL* libraries, for the 64-bit *WSJT-X* use the latest Win64 v1.1.1 version of the *OpenSSL* libraries (Note: it is OK to install both versions on a 64-bit system) which, at the time of writing, were Win32 OpenSSL Light Package (https://slproweb.com/download/Win32OpenSSL_Light-1_1_1s.msi) and Win64 OpenSSL Light Package (https://slproweb.com/download/Win64OpenSSL_Light-1_1_1s.msi) respectively.
- Install the package and accept the default options, including the option to copy the *OpenSSL* DLLs to the Windows system directory. There is no obligation to donate to the *OpenSSL* project. Un-check all the donation options if desired.

If you still get the same network error after installing the *OpenSSL* libraries then you also need to install the Microsoft VC++ 2013 Redistributable (https://www.microsoft.com/en-ph/download/details.aspx?id=40784) component. From the download page select `vcredist_x86.exe` for use with the 32-bit *WSJT-X* build or `vcredist_x64.exe` with the 64-bit build, then run it to install.

If you cannot install the *OpenSSL* libraries or do not have an Internet connection on the computer used to run *WSJT-X* 2.6, you can download the *LoTW* file manually. Go to https://lotw.arrl.org/lotw-user-activity.csv in a web browser, download the file, then move it to the *WSJT-X* log files directory. This directory can be opened by selecting **File|Open log directory** from the main menu.

- *WSJT-X* expects your sound card to do its raw sampling at 48000 Hz. To ensure that this will be so when running under recent versions of Windows, open the system's **Sound** control panel and select in turn the **Recording** and **Playback** tabs. Click **Properties**, then **Advanced**, and select **16 bit, 48000 Hz (DVD Quality)**. Switch off all audio enhancement features for these devices.
- You can uninstall *WSJT-X* by clicking its **Uninstall** link in the Windows **Start** menu, or by using **Uninstall a Program** on the **Windows Control Panel|Programs and Features** option or in **Settings|Apps** on Windows 10.

3.2. Linux

Debian, Ubuntu, and other Debian-based systems including Raspberry Pi OS:

The project team release binary installer packages targeted for one contemporary version of a Linux distribution. Although these may work on newer Linux versions or even different distributions, it is unlikely that they work on older versions. Check the notes provided with the release for details of the targeted Linux distributions and versions. If the binary package is not compatible with your Linux distribution or version, you must build the application from sources.

- 64-bit Intel/AMD: wsjtx_2.6.1_amd64.deb (https://sourceforge.net/projects/wsjt/files/wsjtx-2.6.1/wsjtx_2.6.1_amd64.deb)
  - To install:

```
sudo dpkg -i wsjtx_2.6.1_amd64.deb
```

- 32-bit ARM hardware FP: wsjtx_2.6.1_armhf.deb (https://sourceforge.net/projects/wsjt/files/wsjtx-2.6.1/wsjtx_2.6.1_armhf.deb)

- To install:

```
sudo dpkg -i wsjtx_2.6.1_armhf.deb
```

- 64-bit ARM: wsjtx_2.6.1_arm64.deb (https://sourceforge.net/projects/wsjt/files/wsjtx-2.6.1/wsjtx_2.6.1_arm64.deb)
  - To install:

```
sudo dpkg -i wsjtx_2.6.1_arm64.deb
```

- Uninstall for any of the above platforms:

```
sudo dpkg -P wsjtx
```

You may also need to execute the following command in a terminal:

```
sudo apt install libgfortran5 libqt5widgets5 libqt5network5 \
     libqt5printsupport5 libqt5multimedia5-plugins libqt5serialport5 \
     libqt5sql5-sqlite libfftw3-single3 libgomp1 libboost-all-dev \
     libusb-1.0-0 libportaudio2
```

Fedora, CentOS, Red Hat, and other rpm-based systems:

- 64-bit: wsjtx-2.6.1-x86_64.rpm (https://sourceforge.net/projects/wsjt/files/wsjtx-2.6.1/wsjtx-2.6.1-x86_64.rpm)
  - To install:

```
sudo rpm -i wsjtx-2.6.1-x86_64.rpm
```

- Uninstall:

```
sudo rpm -e wsjtx
```

You may also need to execute the following command in a terminal:

```
sudo dnf install libgfortran fftw-libs-single qt5-qtbase \
     qt5-qtmultimedia qt5-qtserialport qt5-qtsvg \
     qt5-qtserialport libgomp boost libusbx portaudio
```

3.3. OS X and macOS

macOS10.13 and later: Download the file wsjtx-2.6.1-Darwin.dmg (https://sourceforge.net/projects/wsjt/files/wsjtx-2.6.1/wsjtx-2.6.1-Darwin.dmg) to your desktop, double-click it and consult its `ReadMe` file for important installation notes.

If you have already installed a previous version, you can retain it by changing its name in the **Applications** folder (such as from *WSJT-X* to *WSJT-X_2.2*). You can then proceed to the installation phase.

Take note also of the following:

- Use the Mac's **Audio MIDI Setup** utility to configure your sound card for 48000 Hz, two-channel, 16-bit format.

If you are using macOS with an external audio device and find that Tx audio spontaneously switches to the motherboard sound device after a few transmissions, try setting the sample rate to 44100 Hz rather than the otherwise recommended 48000 Hz.

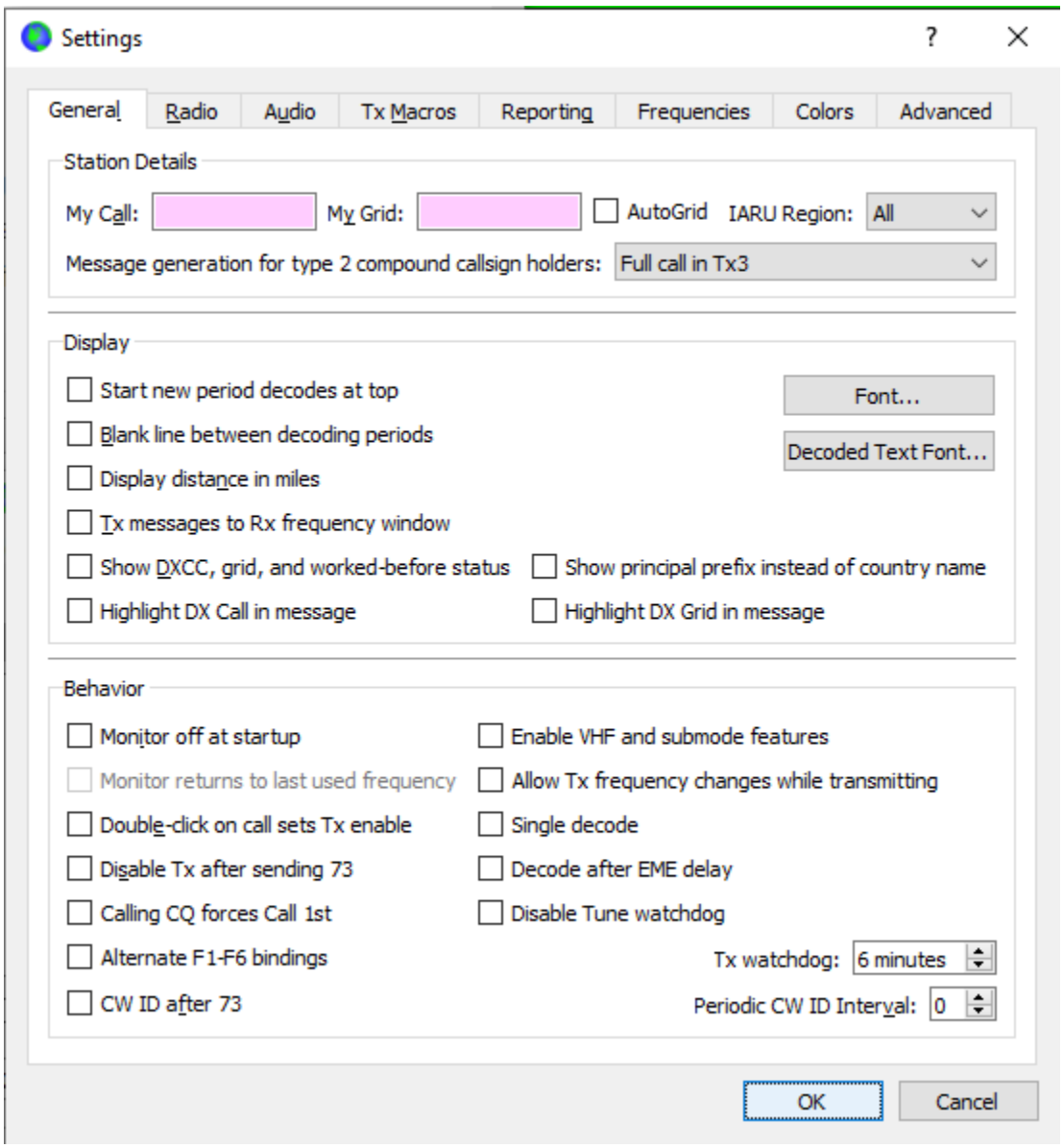
- Use **System Preferences** to select an external time source to keep your system clock synchronized to UTC.
- To uninstall simply drag the *WSJT-X* application from **Applications** to the **Trash Can**.

4. Settings

Select **Settings** from the **File** menu or by typing **F2**. (On Macintosh select **Preferences** from the *WSJT-X* menu, or use the keyboard shortcut **Cmd+,**). The following sections describe setup options available on eight tabs selectable near the top of the window.

4.1. General

Select the **General** tab on the **Settings** window. Under *Station Details* enter your callsign, grid locator (preferably the 6-character locator) and IARU Region number. Region 1 is Europe, Africa, the Middle East, and Northern Asia; Region 2 the Americas; and Region 3 Southern Asia and the Pacific. This information will be sufficient for initial tests.



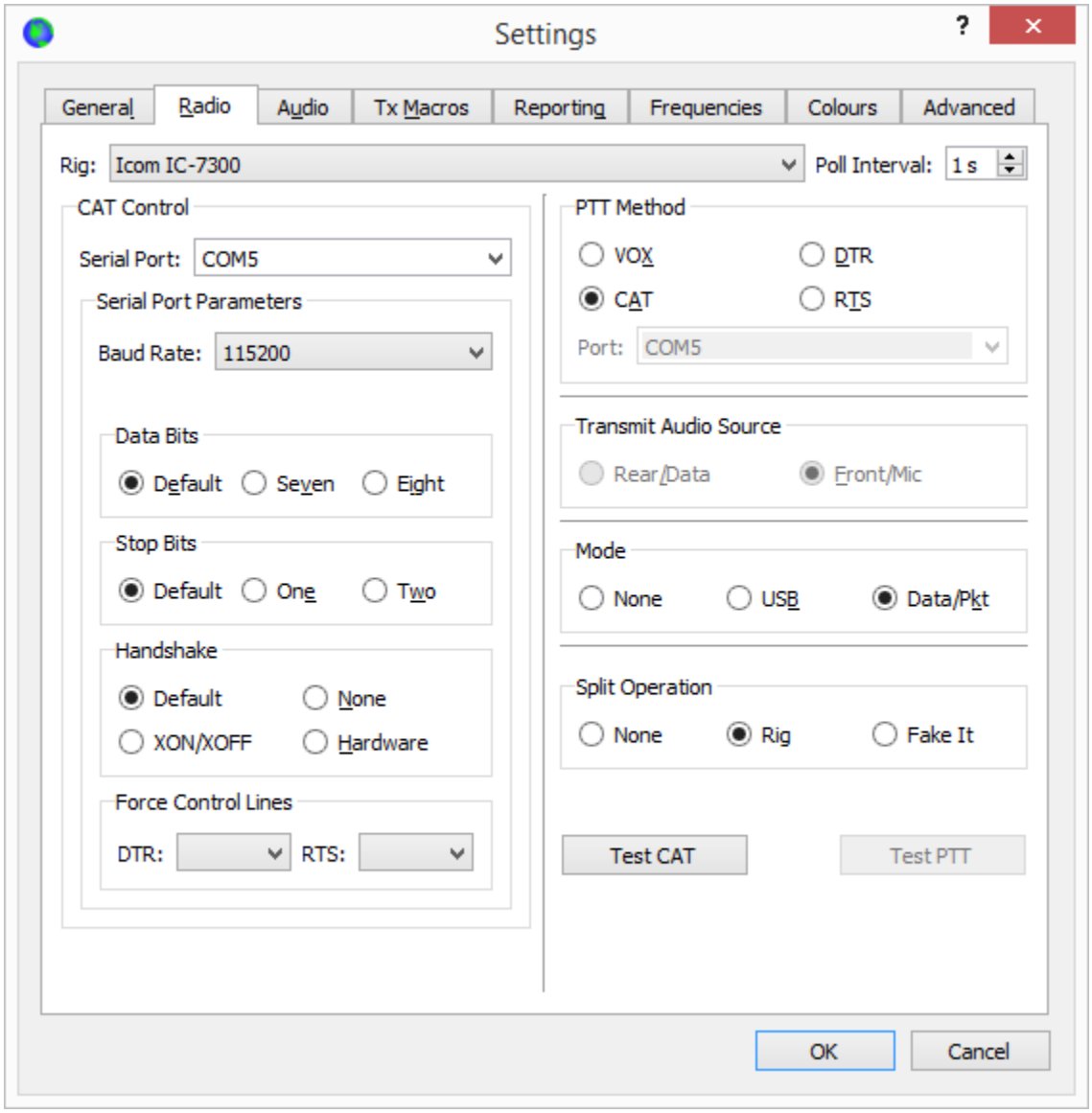
Meanings of remaining options on the **General** tab should be self-explanatory after you have made some QSOs using *WSJT-X*. You may return to set these options to your preferences later.

If you are using a callsign with an add-on prefix or suffix, or wish to work a station using such a call, be sure to read the section Nonstandard Callsigns.

Checking **Enable VHF/UHF/Microwave features** necessarily disables the wideband multi-decode capability of JT65. In most circumstances you should turn this feature off when operating at HF.

4.2. Radio

WSJT-X offers CAT (Computer Aided Transceiver) control of relevant features of most modern transceivers. To configure the program for your radio, select the **Radio** tab.



- Select your radio type from the drop-down list labeled **Rig**, or **None** if you do not wish to use CAT control.
  - Alternatively, if you have configured your station for control by **DX Lab Suite Commander**, **FIrig**, **Ham Radio Deluxe**, **Hamlib NET rigctl**, or **Omni-Rig**, you may select one of those program names from the **Rig** list. In these cases the entry field immediately under *CAT Control* will be relabeled as **Network Server**. Leave this field blank to access the default instance of your control program, running on the same computer. If the control program runs on a different computer and/or port, specify it here. Hover the mouse pointer over the entry field to see the required formatting details.
  - Select **Omni-Rig Rig 1** or **Omni-Rig Rig 2** to connect to an *Omni-Rig* server installed on the same computer. *Omni-Rig* will be started automatically by *WSJT-X*.

- Set **Poll Interval** to the desired interval for *WSJT-X* to query your radio. For most radios a small number (say, 1 – 3 s) is suitable.
- *CAT Control*: To have *WSJT-X* control the radio directly rather than though another program, make the following settings:
  - Select the **Serial Port** or **Network Server** including the service port number used to communicate with your radio.

    A special value of **USB** is available for custom USB devices like those used by some SDR kits. This is not the same as the virtual serial port provided by USB connected transceivers and CAT interfaces, for those use the COM or serial port name that refers to them.

  - *Serial Port Parameters*: Set values for **Baud Rate**, **Data Bits**, **Stop Bits**, and **Handshake** method. Consult your radio's user *guide for the proper parameter values.

    CAT interfaces that require handshaking will be non-responsive until the correct **Handshake** setting is applied.

  - *Force Control Lines*: A few station setups require the CAT serial port's **RTS** and/or **DTR** control lines to be forced high or low. Check these boxes **only** if you are sure they are needed (for example, to power the radio serial interface).
- *PTT Method*: select **VOX**, **CAT**, **DTR**, or **RTS** as the desired method for T/R switching. If your choice is **DTR** or **RTS**, select the desired serial port (which may be the same one as used for CAT control).

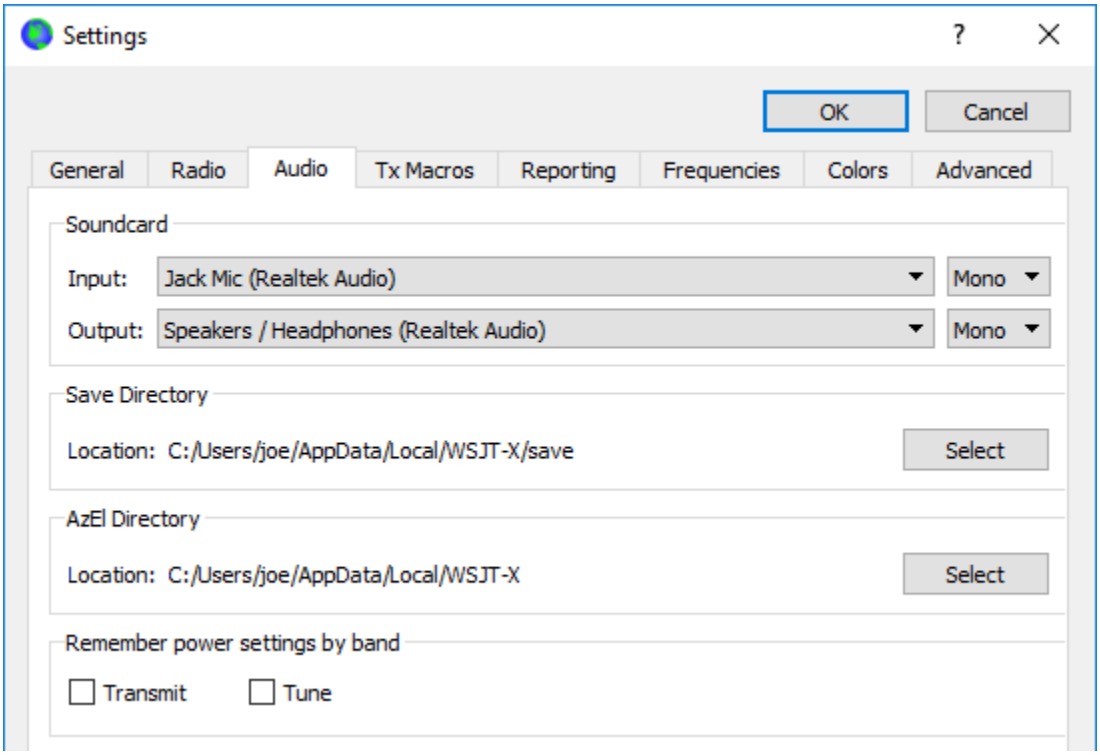
  When using a proxy application for rig control, **CAT** is usually the correct option for *PTT Method* assuming the proxy application is capable of keying your transceiver independently.

- *Transmit Audio Source*: some radios permit you to choose the connector that will accept Tx audio. If this choice is enabled, select **Rear/Data** or **Front/Mic**.
- *Mode*: *WSJT-X* uses upper sideband mode for both transmitting and receiving. Select **USB**, or choose **Data/Pkt** if your radio offers such an option and uses it to enable the rear-panel audio line input. Some radios also offer wider and/or flatter passbands when set to **Data/Pkt** mode. Select **None** if you do not want *WSJT-X* to change the radio's Mode setting.
- *Split Operation*: Significant advantages result from using **Split** mode (separate VFOs for Rx and Tx) if your radio supports it. If it does not, *WSJT-X* can emulate such behavior. Either method will result in a cleaner transmitted signal, by keeping the Tx audio always in the range 1500 to 2000 Hz so that audio harmonics cannot pass through the Tx sideband filter. Select **Rig** to use the radio's Split mode, or **Fake It** to have *WSJT-X* adjust the VFO frequency as needed, when T/R switching occurs. Choose **None** if you do not wish to use split operation.

When all required settings have been made, click **Test CAT** to test communication between *WSJT-X* and your radio. The button should turn green to indicate that proper communication has been established. Failure of the CAT-control test turns the button red and displays an error message. After a successful CAT test, toggle the **Test PTT** button to confirm that your selected method of T/R control is working properly, the button turns red if the rig has been successfully keyed. (If you selected **VOX** for *PTT Method*, you can test T/R switching later by using the **Tune** button on the main window.)

4.3. Audio

Select the **Audio** tab to configure your sound system.



- *Soundcard*: Select the audio devices to be used for **Input** and **Output**. Usually the **Mono** settings will suffice, but in special cases you can choose **Left**, **Right**, or **Both** stereo channels.
  - Be sure that your audio device is configured to sample at 48000 Hz, 16 bits.

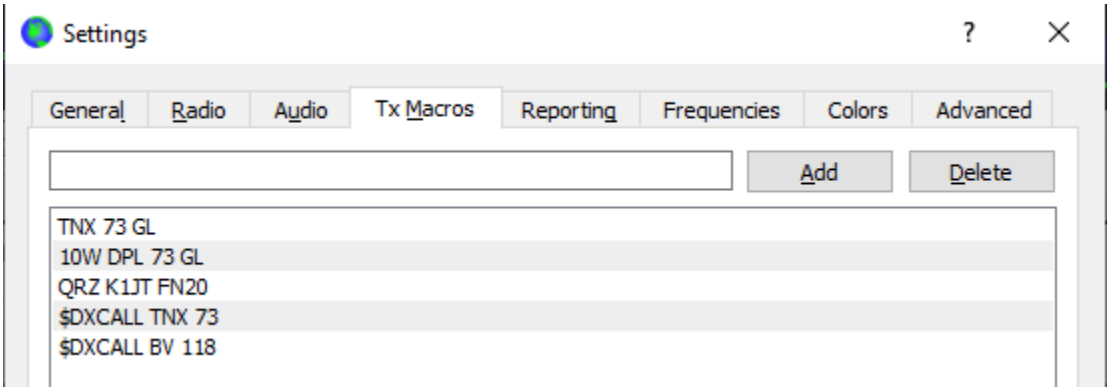
> If you select the audio output device that is also your computer's default audio device, be sure to turn off all system sounds to prevent inadvertently transmitting them over the air.

> Windows 7 and later may configure audio devices using the Texas Instruments PCM2900 series CODEC for microphone input rather line input. (This chip is used in many radios with built-in USB CODECs, as well as various other audio interfaces.) If you are using such a device, be sure to set the mic level in the Recording Device Properties to 0 dB.

- *Save Directory*: *WSJT-X* can save its received audio sequences as `.wav` files. A default directory for these files is provided; you can select another location if desired.
- *AzEl Directory*: A file named `azel.dat` will appear in the specified directory. The file contains information usable by another program for automatic tracking of the Sun or Moon, as well as calculated Doppler shift for the specified EME path. The file is updated once per second whenever the Astronomical Data window is displayed.
- *Remember power settings by band*: Checking either of these will cause *WSJT-X* to remember the **Pwr** slider setting for that operation on a band-by-band basis. For example, when **Tune** is checked here and you click the **Tune** button on the main window, the power slider will change to the most recent setting used for **Tune** on the band in use.

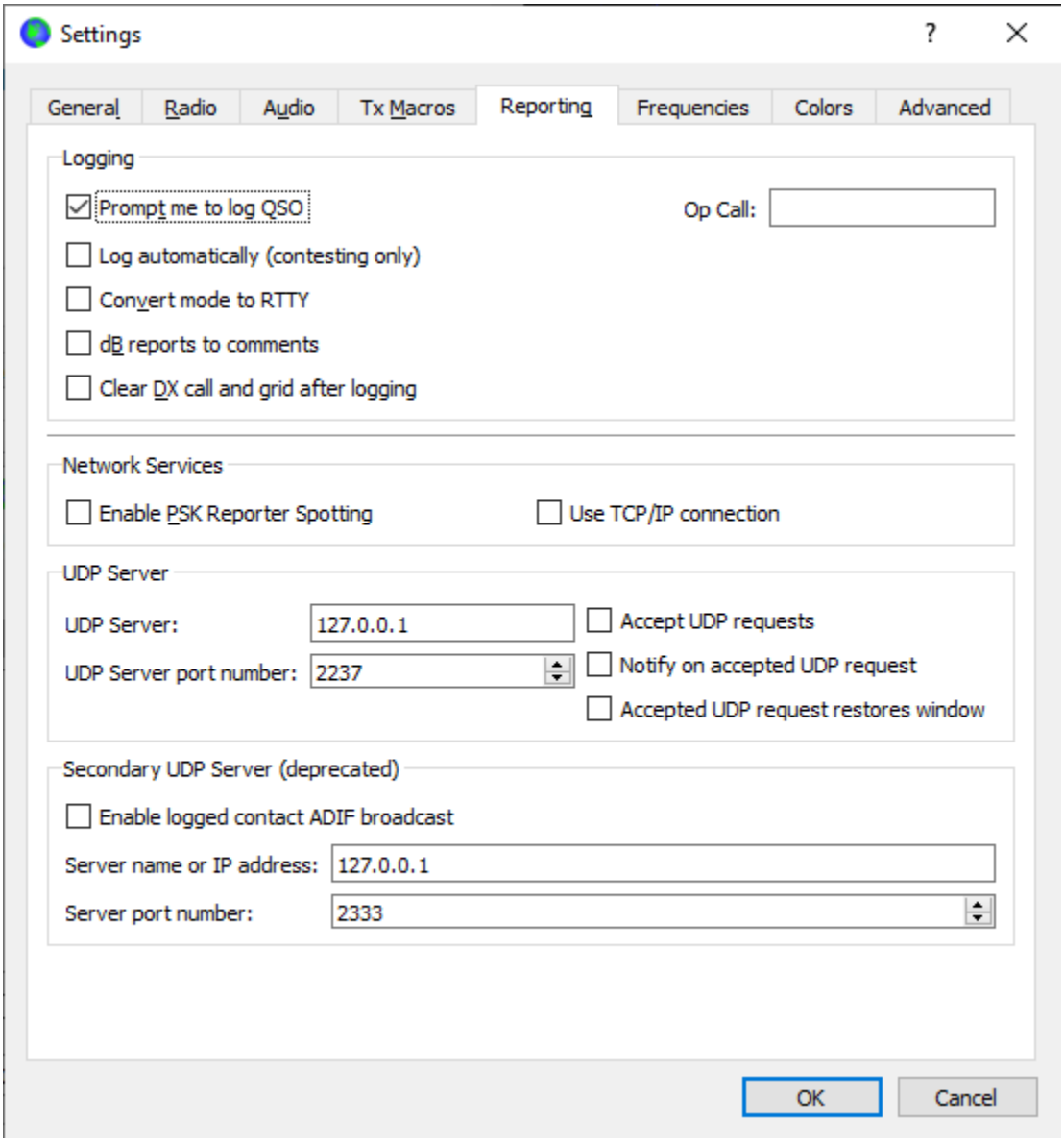
4.4. Tx Macros

Tx Macros are an aid for sending brief, frequently used free-text messages such as the examples shown below.



- To add a new message to the list, enter the desired text in the entry field at top, then click **Add**.
- Remember that a transmitted free-text message is limited to 13 characters, including blanks.
- To remove an unwanted message, click on the message and then on **Delete**.
- You can reorder your macro messages by using drag-and-drop. The new order will be preserved when *WSJT-X* is restarted.
- Messages can also be added from the main window's **Tx5** field. Simply hit [Enter] after the message has been entered.
- If the first word of a message is $DXCALL (or the shortened form $DX), that word will be replaced on transmission by the base callsign in the **DxCall** field.

4.5. Reporting



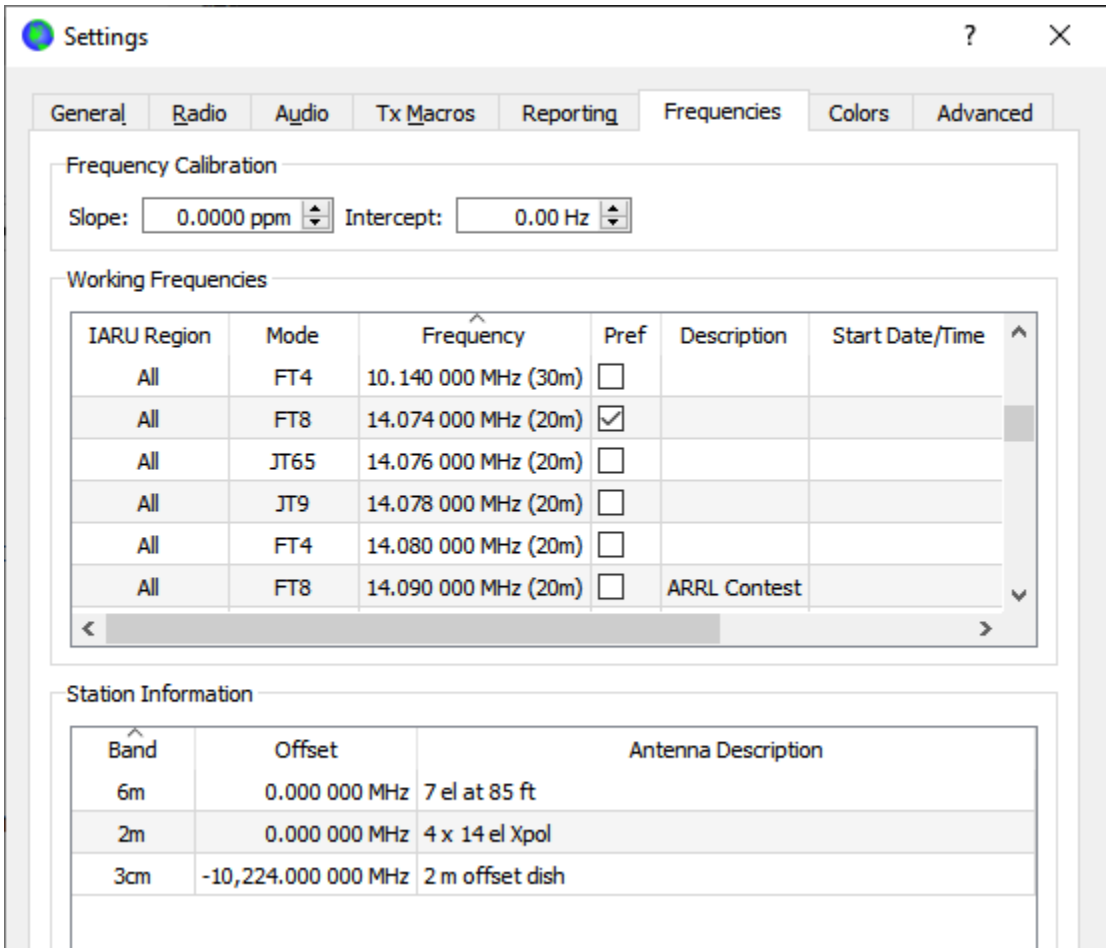
- *Logging*: Choose any desired options from this group. Operators in a multi-operator station may wish to enter their home callsign as **Op Call**.
- *Network Services*: Check **Enable PSK Reporter Spotting** to send reception reports to the PSK Reporter (https://pskreporter.info/pskmap.html) mapping facility.
- *UDP Server*: This group of options controls the network name or address and port number used to exchange information with a third party application that interoperates with *WSJT-X*. Exchanged information includes decoded messages, general program status, QSOs logged, highlighting of callsigns in the *WSJT-X* band activity window, and limited facilities to initiate QSOs in response to CQ or QRZ messages. Full details of the protocol can be found in comments at the top of this file in our source code repository: https://sourceforge.net/p/wsjt/wsjtx/ci/master/tree/Network/NetworkMessage.hpp

The **Outgoing interfaces** and **Multicast TTL** fields are only present when a multicast group IP address has been entered in the **UDP Server** field.

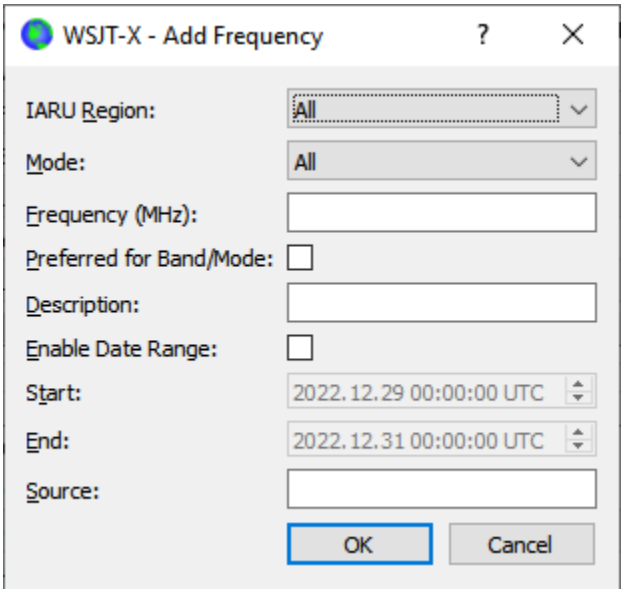
Programs like *JTAlert* use the *UDP Server* feature to obtain information about running *WSJT-X* instances. If you are using *JTAlert* to control *WSJT-X*, be sure to check the **Accept UDP requests** box.

4.6. Frequencies

By default, the **Working Frequencies** table contains a list of frequencies conventionally used for modes FT8, JT4, JT9, JT65, MSK144, WSPR, and Echo. Conventions may change with time or by user preference; you can modify the frequency table as desired.



- To change an existing entry, double-click to edit it, type a desired frequency in MHz or select from the drop-down list of options, then hit **Enter** on the keyboard. You can mark an entry as Preferred, provide a descriptive label, and indicate starting and ending dates and times for it to be displayed on the band-select control. The program will format your changed entries appropriately.
- To add a new entry, right-click anywhere on the frequency table and select **Insert**. Enter your desired information and click **OK**. The table may include more than one frequency for a given mode and band.



- To delete an entry, right-click it and select **Delete**, multiple entries can be deleted in a single operation by selecting them before right-clicking.
- Right-click anywhere within the table body and click **Reset** button to return the table to its default configuration.

Other more advanced maintenance operations are available on the right-click context popup menu that should be self-explanatory.

Frequency Calibration: If you have calibrated your radio using WWV or other reliable frequency references, or perhaps with the technique described in Accurate Frequency Measurements with your WSPR Setup (https://wsjt.sourceforge.io/FMT_User.pdf), enter the measured values for *Intercept* A and *Slope* B in the equation

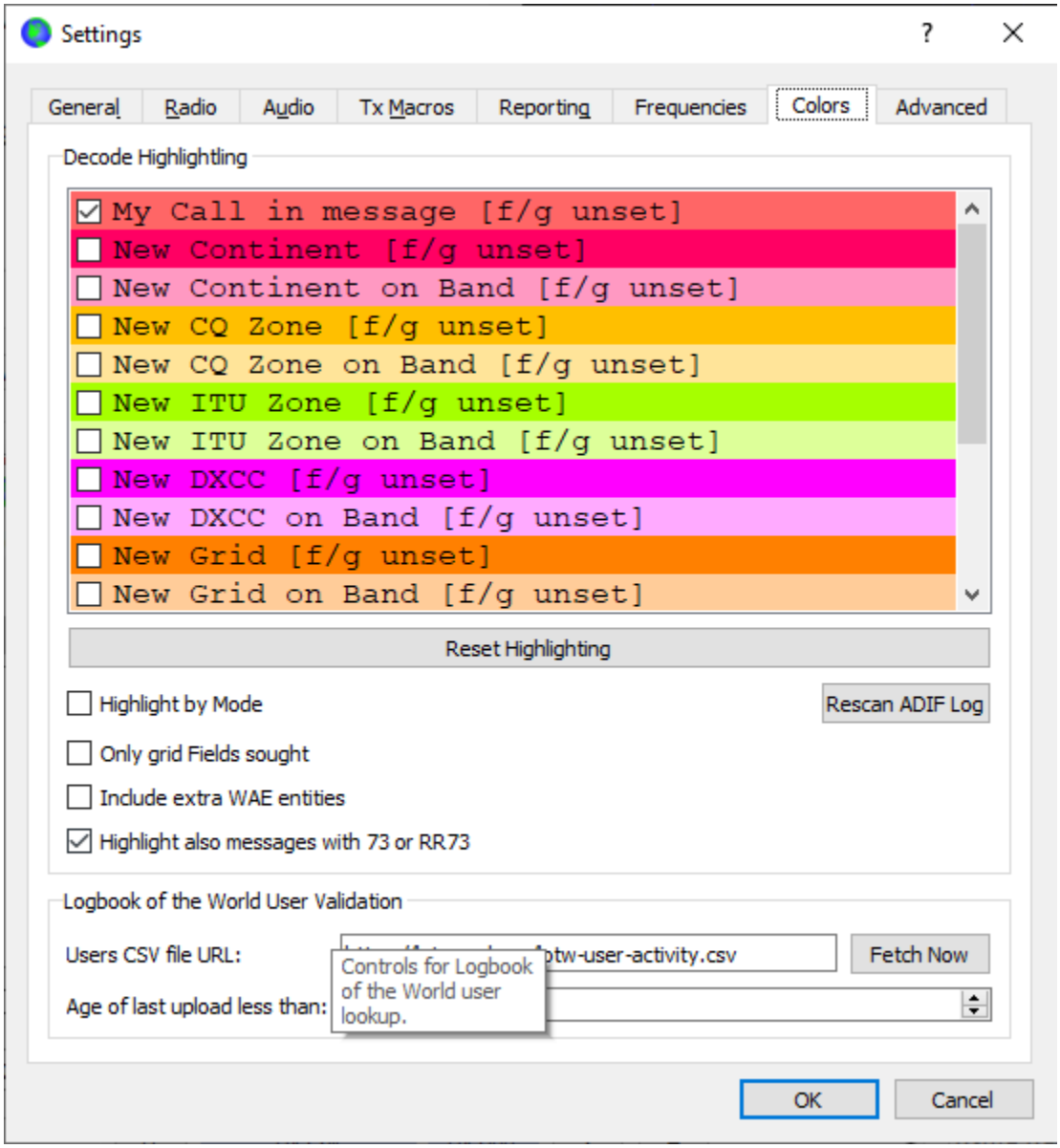
```
Dial error = A + B*f
```

where “Dial error” and A are in Hz, f is frequency in MHz, and B is in parts per million (ppm). Frequency values sent to the radio and received from it will then be adjusted so that frequencies displayed by *WSJT-X* are accurate.

Station Information: You can save **Band**, **Offset** and **Antenna Description** information for your station. The antenna information will be included in reception reports sent to PSK Reporter (https://pskreporter.info/pskmap.html). By default the frequency offset for each band is zero. Nonzero offsets may be added if (for example) a transverter is in use.

- To simplify things you might want to delete any unwanted bands — for example, bands where you have no equipment. Then click on a **Frequency** entry and type **Ctrl+A** to “select all,” and drag-and-drop the entries onto the *Station Information* table. You can then add any transverter offsets and antenna details.
- To avoid typing the same information many times, you can drag-and-drop entries between the lines of the *Station Information* table.
- When all settings have been configured to your liking, click **OK** to dismiss the **Settings** window.

4.7. Colors



Decode Highlighting

- *WSJT-X* uses colors to highlight decoded CQ messages of particular interest. Check the box **Show DXCC, grid, and worked-before status** on the **Settings | General** tab, and any boxes of interest to you on the **Colors** tab. You can drag any line up or down to raise or lower its logical priority. Right-click any line to set a new foreground or background color. Foreground and background colors are applied separately, and careful choices of foreground, background, and priority can provide two indications of worked-before status.
- Press the **Reset Highlighting** button to reset all of the color settings to default values.
- Check **Highlight by Mode** if you wish worked before status to be per mode.
- Check **Only grid Fields sought** if you are only interested in the leading two character grid locator Fields rather than teh four character grid locator Squares.
- Check **Include extra WAE entities** if you are interested in the extra entities defined for DARC WAE and CQ Marathon awards.
- Worked before status is calculated from your *WSJT-X* ADIF Logging file, you may replace ADIF log file with one exported from your station logging application, **Rescan ADIF Log** rebuilds the *WSJT-X* worked before indexes using the current ADIF log file.

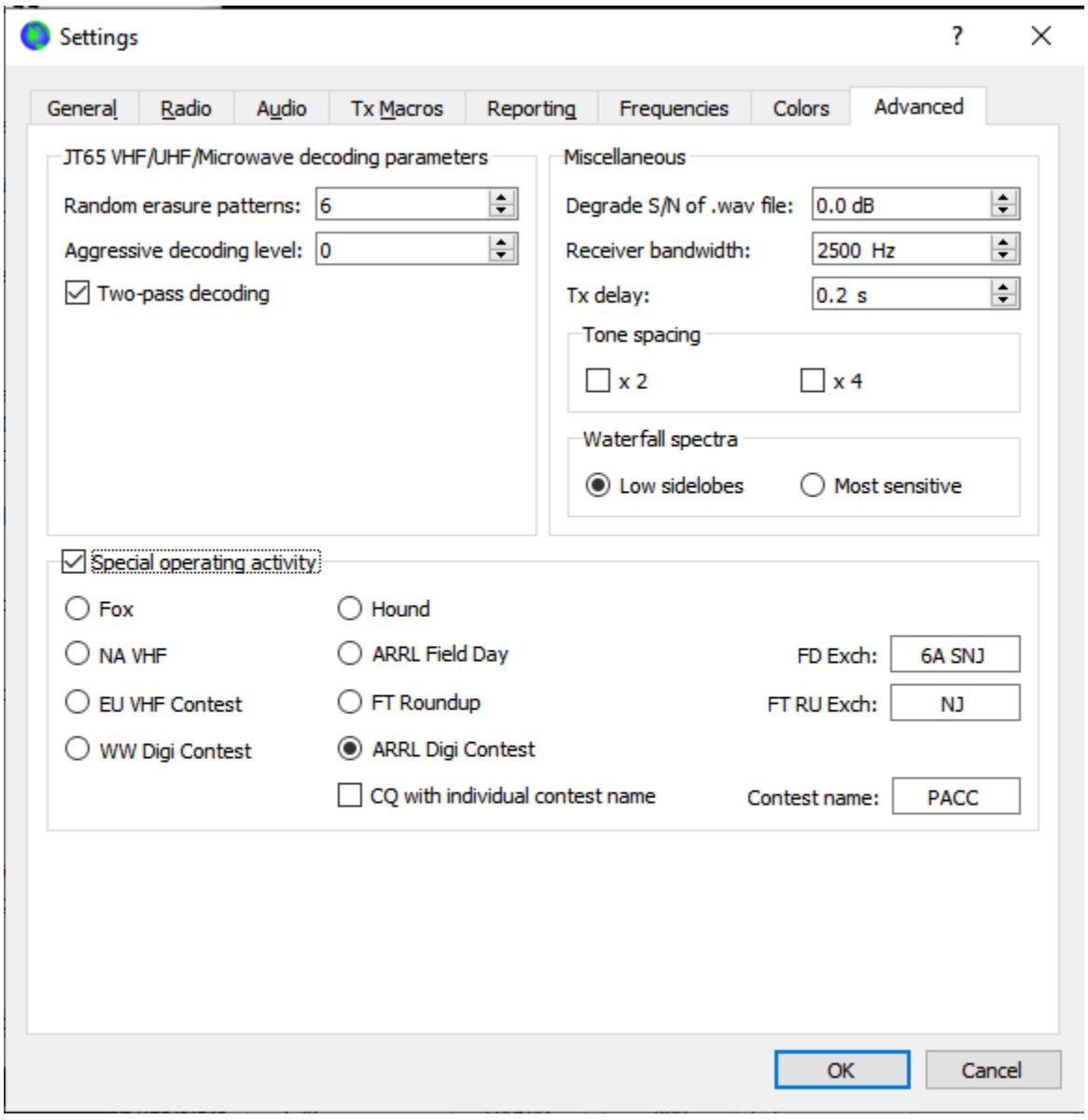
The *WSJT-X* ADIF file records must contain the "CALL" field. The "BAND", and "MODE", and "GRIDSQUARE" fields are optional depending on your DXing objectives. DXCC entity, continent, CQ, and ITU Zone data for call prefixes and certain well known overrides are derived from the cty.dat database which is bundled with *WSJT-X* (See Logging for details).

Logbook of The World User Validation

Stations who are known to have uploaded their logs to the ARRL LoTW QSL matching service can be highlighted. The data used to determine this is available online.

- **Fetch Now** will download a fresh dataset from the **Users CSV file URL**. The LoTW team normally update this data weekly.
- Adjust **Age of last upload less than** to set the period within which a station must have uploaded their log to LoTW to trigger highlighting.

4.8. Advanced



JT65 VHF/UHF/Microwave decoding parameters

- **Random erasure patterns** logarithmically scales the number of pseudo-random trials used by the Franke-Taylor JT65 decoder. Larger numbers give slightly better sensitivity but take longer. For most purposes a good setting is 6 or 7.
- **Aggressive decoding level** sets the threshold for acceptable decodes using Deep Search. Higher numbers will display results with lower confidence levels.
- Check **Two-pass decoding** to enable a second decoding pass after signals producing first-pass decodes have been subtracted from the received data stream.

Miscellaneous

- Set a positive number in **Degrade S/N of .wav file** to add known amounts of pseudo-random noise to data read from a .wav file. To ensure that the resulting S/N degradation is close to the requested number of dB, set **Receiver bandwidth** to your best estimate of the receiver's effective noise bandwidth.
- Set **Tx delay** to a number larger than the default 0.2 s to create a larger delay between execution of a command to enable PTT and onset of Tx audio.

For the health of your T/R relays and external preamplifier, we strongly recommend using a hardware sequencer and testing to make sure that sequencing is correct.

- Check **x 2 Tone spacing** or **x 4 Tone spacing** to generate Tx audio with twice or four times the normal tone spacing. This feature is intended for use with specialized LF/MF transmitters that divide generated frequencies by 2 or 4 as part of the transmission process.

Special Operating Activity

- Check this box and select the type of activity to enable auto-generation of special message formats for contesting and DXpeditions. For **ARRL Field Day**, enter your operating Class and ARRL/RAC section; for **FT Roundup**, enter your state or province. Use "DX" for section or state if you are not in the US or Canada. In the FT Roundup, Stations in Alaska and Hawaii should enter "DX".
- Check **Fox** if you are a DXpedition station operating in FT8 DXpedition Mode. Check **Hound** if you wish to make QSOs with such a Fox. Be sure to read the operating instructions for FT8 DXpedition Mode (https://wsjt.sourceforge.io/FT8_DXpedition_Mode.pdf).

4.9. Dark Style

An optional **Dark** style is available. To make it effective you will probably want to redefine your color settings. In Windows or Linux, start the program from a command-prompt window using the following command, or modify the *WSJT-X* desktop shortcut accordingly:

```
wsjtx --stylesheet :/qdarkstyle/style.qss
```

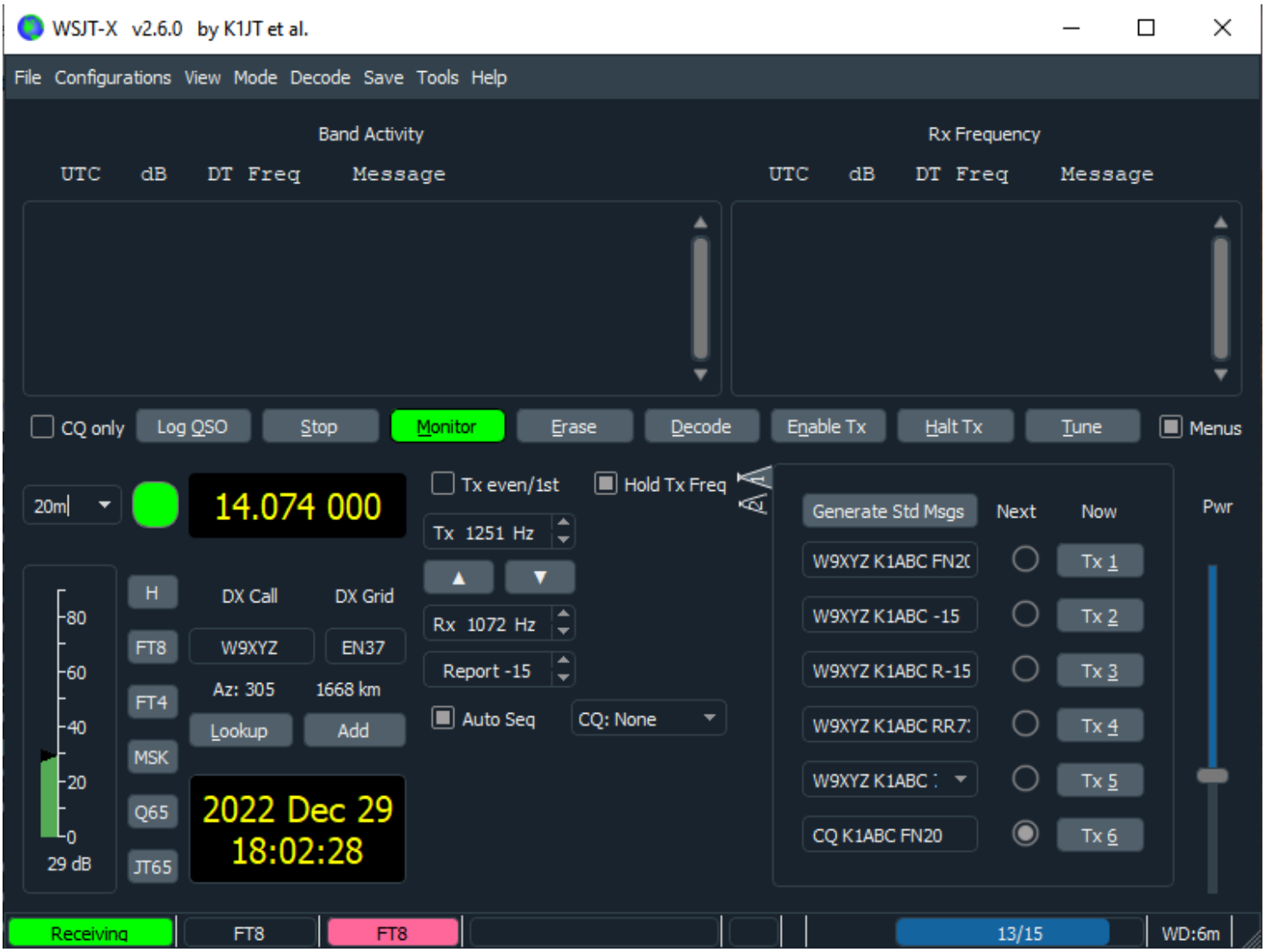
In macOS, enter the following command from a terminal:

```
open /Applications/wsjtx.app --args -stylesheet :/qdarkstyle/style.qss
```

In Linux using the Unity or GNOME GUI the following commands will update the *WSJT-X* start up:

```
sed '/Exec=wsjtx/ s/$/ -stylesheet :\/qdarkstyle\/style.qss/' \
  /usr/share/applications/wsjtx.desktop >~/.local/share/applications/wsjtx.desktop
update-desktop-database ~/.local/share/applications/
```

Depending on your operating system, the main *WSJT-X* window will look something like this:



5. Transceiver Setup

Receiver Noise Level

- If it is not already highlighted in green, click the **Monitor** button to start normal receive operation.
- Be sure your transceiver is set to **USB** (or **USB Data**) mode.
- Use the receiver gain controls and/or the computer's audio mixer controls to set the background noise level (scale at lower left of main window) to around 30 dB when no signals are present. It is usually best to turn AGC off or reduce the RF gain control to minimize AGC action.

The PC audio mixer normally has two sliders, one for each application attached which should be set to maximum (0dB FS) as it cannot help with distortion from overly high or low input levels from your receiver and another **Master** level which is analogue attenuator on the sound card before the Analogue to Digital Converter (ADC). The **Master** level can be used to adjust the signal level received by *WSJT-X*.

Bandwidth and Frequency Setting

- If your transceiver offers more than one bandwidth setting in USB mode, it may be advantageous to choose the widest one possible, up to about 5 kHz.
- If you have only a standard SSB filter you won't be able to display more than about 2.7 kHz bandwidth. Depending on the exact dial frequency setting, on HF bands you can display the full sub-band generally used for one mode.

Transmitter Audio Level

- Click the **Tune** button on the main screen to switch the radio into transmit mode and generate a steady audio tone.
- Listen to the generated audio tone using your radio's **Monitor** facility. The transmitted tone should be perfectly smooth, with no clicks or glitches. Make sure that this is true even when you simultaneously use the computer to do other tasks such as email, web browsing, etc..
- Adjust the **Pwr** slider (at right edge of main window) downward from its maximum until the RF output from your transmitter falls slightly. This is generally a good level for audio drive.
- Toggle the **Tune** button once more or click **Halt Tx** to stop your test transmission.

6. Basic Operating Tutorial

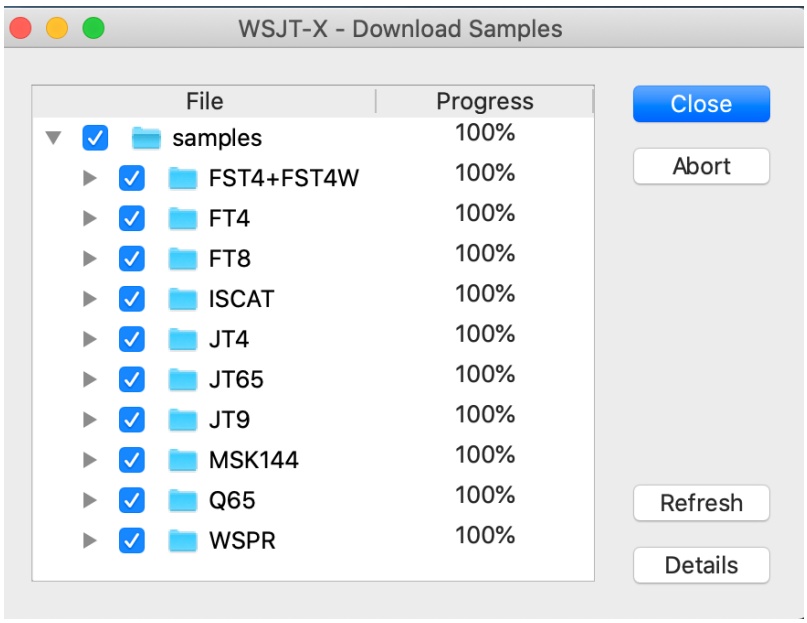
This section introduces the basic user controls and program behavior of *WSJT-X*, with particular emphasis on the FT8 mode. We suggest that new users should go through the full HF-oriented tutorial, preferably while at your radio.

Subsequent sections cover additional details on Making QSOs, WSPR mode and VHF+ Features.

6.1. Download Samples

The following steps will download sample audio Wave files that were originally recorded by WSJT-X. These files can be read in and processed by WSJT-X to simulate realtime operation.

- Select **Download samples…** from the **Help** menu.
- Download some or all of the available sample files using checkboxes on the screen shown below. For this tutorial you will need at least the FT8 files.



6.2. Wide Graph Settings

The WSJT-X Wide Graph window displays the frequency spectrum of the received audio. Usually, the upper portion of the window shows a waterfall plot of the frequency spectrum (a spectrogram) and a line plot of the current or average spectrum. Controls at the bottom of the window are used to set up the displayed audio frequency range, color palette, and scaling of the spectrum displays. A control on the bottom right of the Wide Graph (displayed as **Spec nn%**) lets you control the vertical fraction of the window occupied by the spectrum line plot. It is important to set appropriate lower and upper audio frequency limits for the Wide Graph because these limits define the FT8 decoder's search window. For this tutorial, the limits will be set to cover 100-3300 Hz:

- Set **Start** = 100 Hz.
- Set **Bins/Pixel** = 5. Smaller/larger values make the Wide Graph cover a smaller/larger frequency range.
- Use the mouse to grab the left or right edge of the **Wide Graph**, and adjust its width so that the upper frequency limit is about 3300 Hz.

The **N Avg** setting controls how many spectra are averaged to produce each line in the spectrogram. Smaller values make the

spectrogram update more frequently, resulting in signals being more spread out in the vertical (time) direction. On the other hand, larger values make it easier to detect very weak signals:

- Set **N Avg** = 2.

The **Palette** setting controls the color scheme used for the spectrogram:

- Set **Palette** = Fldigi

When **Flatten** is checked, WSJT-X attempts to correct for slope or curvature in the receiver's passband shape.

- **Flatten** = checked

The line plot can be set to display the current (un-averaged) spectrum or the cumulative (averaged) spectrum:

- Select **Cumulative** for data display
- Set the **Gain** and **Zero** sliders for the waterfall and spectrum to near midscale

The **Spec nn%** setting determines what fraction of the vertical extent of the Wide Graph will be used for the line plot of the spectrum. Setting **Spec** to 0 will eliminate the line plot and a setting of 100 will eliminate the spectrogram and show only the line plot:

- Set **Spec** = 50%

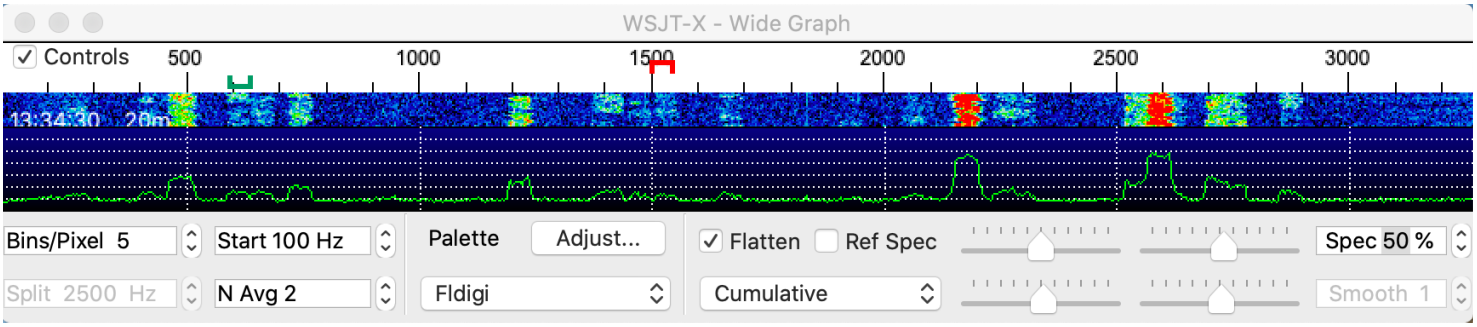
6.3. FT8

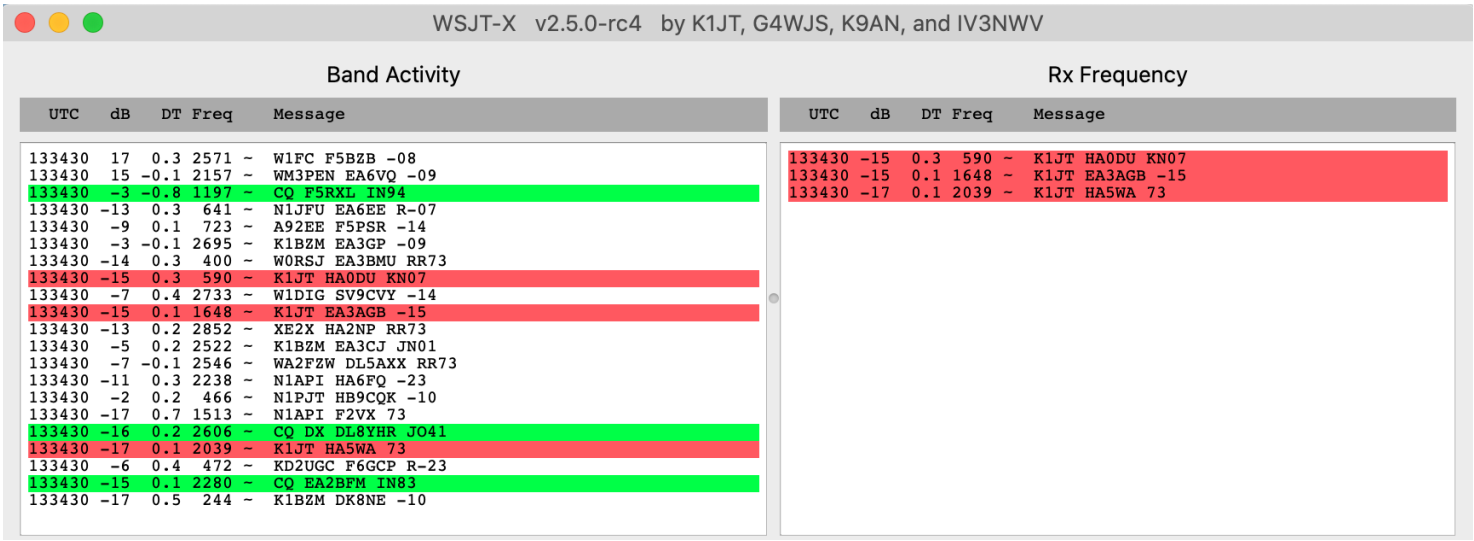
Main Window:

- Click the **Stop** button on the main window to halt any data acquisition.
- Select **FT8** from the **Mode** menu and **Deep** from the **Decode** menu.
- Double-click on **Erase** to clear both text windows.

Open a Wave File:

- Select **File | Open log directory** and navigate to ...\save\samples\FT8\210703_133430.wav. The waterfall and Band Activity/Rx Frequency windows should look something like the following screen shots:
- You may want to pretend you are K1JT by entering that callsign temporarily as **My Call** on the **Settings | General** tab. Your results should then be identical to those shown in the screen shot below. Don't forget to change **My Call** back to your own call when you are done!





Decoding Overview

Decoding takes place at the end of a receive sequence. With **Decode** set to **Deep**, three decoding passes will be done and the **Decode** button on the mainwindow will illuminate three times, once for each pass. The first decoding attempt in each decoding pass is done at the selected Rx frequency, indicated by the U-shaped green marker on the waterfall frequency scale. All decodes appear in the left (**Band Activity**) window. The right (**Rx Frequency**) text window displays any decodes obtained at the current Rx frequency along with any decodes addressed to **My Call** (K1JT in this case). The red marker on the waterfall scale indicates your Tx frequency.

Twenty-one FT8 signals are decoded from the example file. The number of decodes is shown in a box at the bottom of the main window. When this file was recorded HA5WA was finishing a QSO with K1JT, and his 73 message is shown in red because it is addressed to **My Call** (in this case K1JT). By default, lines containing `CQ` are highlighted in green, and lines with **My Call** (K1JT) in red. Notice that K1JT has two callers; HA0DU and EA3AGB.

Decoding Controls

To gain some feeling for controls frequently used when making QSOs, try double-clicking with the mouse on the decoded text lines and on the waterfall spectral display. You should be able to confirm the following behavior:

- Double-click on one of the decoded **CQ** messages highlighted in green. These actions produce the following results:
  - Callsign and locator of the station calling CQ are copied to the **DX Call** and **DX Grid** entry fields.
  - Messages are generated for a standard minimal QSO.
  - The **Tx even** box is checked or cleared appropriately, so that you will transmit in the proper (odd or even) minutes.
  - The Rx frequency marker is moved to the frequency of the CQing station.
  - You can modify the double-click behavior by holding down the **Shift** key to move only the Tx frequency or the **Ctrl** key to move both Rx and Tx frequencies. (On a Mac computer, use the **command** key instead of **Ctrl**).
  - In addition, if **Double-click on call sets Tx enable** is checked on the **Settings | General** tab then **Enable Tx** will be activated so that a transmission will start automatically at the proper time.

You can prevent your Tx frequency from being changed by checking the box **Hold Tx Freq**.

- Double-click on the decoded message `K1JT HA0DU KN07`, highlighted in red. Results will be similar to those in the previous step. The Tx frequency (red marker) is not moved unless **Shift** or **Ctrl** is held down. Messages highlighted in red are usually in response to your own CQ or from a tail-ender, and you probably want your Tx frequency to stay where it was.
- Click with the mouse anywhere on the waterfall display. The green Rx frequency marker will jump to your selected frequency, and the Rx frequency control on the main window will be updated accordingly.
- Do the same thing with the **Shift** key held down. Now the red Tx frequency marker and its associated control on the main window will follow your frequency selections.
- Do the same thing with the **Ctrl** key held down. Now both colored markers and both spinner controls will follow your selections.
- Double-clicking at any frequency on the waterfall does all the things just described and also invokes the decoder in a small range around the Rx frequency. To decode a particular signal, double-click near the left edge of its waterfall trace.
- Ctrl-double-click on a signal to set both Rx and Tx frequencies and decode at the new frequency.
- Click **Erase** to clear the right window.
- Double-click **Erase** to clear both text windows.

To avoid QRM from competing callers, it is usually best to answer a CQ on a different frequency from that of the CQing station. The same is true when you tail-end another QSO. Choose a Tx frequency that appears to be not in use. You might want to check the box **Hold Tx Freq**.

Keyboard shortcuts **Shift+F11** and **Shift+F12** provide an easy way to move your Tx frequency down or up in 60 Hz steps.

Sliders and spinner controls respond to **Arrow** key presses and **Page Up/Down** key presses, with the **Page** keys moving the controls in larger steps. You can also type numbers directly into the spinner controls or use the mouse wheel.

An online FT8 Operating Guide (https://www.g4ifb.com/FT8_Hinson_tips_for_HF_DXers.pdf) by ZL2IFB offers many additional tips on operating procedures.

FT8 DXpedition Mode:

This special operating mode enables DXpeditions to make FT8 QSOs at very high rates. Both stations must use *WSJT-X* Version 1.9 or later. Detailed operating instructions for FT8 DXpedition Mode (https://wsjt.sourceforge.io/FT8_DXpedition_Mode.pdf) are available online. Do not try to use DXpedition mode without reading these instructions carefully!

FT8 DXpedition mode is intended for use by rare-entity DXpeditions and other unusual circumstances in which sustained QSO rates well above 100/hour are expected. Do not use the multi-signal capability unless you satisfy this requirement, and do not use DXpedition Mode in the conventional FT8 sub-bands. If you are contemplating operation as Fox using DXpedition Mode, find a suitable dial frequency consistent with regional band plans and publicize it for the operators you hope to work. Remember that on-the-air signal frequencies will be higher than the dial frequency by up to 4 kHz.

When finished with this Tutorial, don't forget to re-enter your own callsign as **My Call** on the **Settings | General** tab.

6.4. FT4

FT4 is designed for contesting, particularly on the HF bands and 6 meters. Compared with FT8 it is 3.5 dB less sensitive and requires 1.6 times the bandwidth, but it offers the potential for twice the QSO rate.

Main Window:

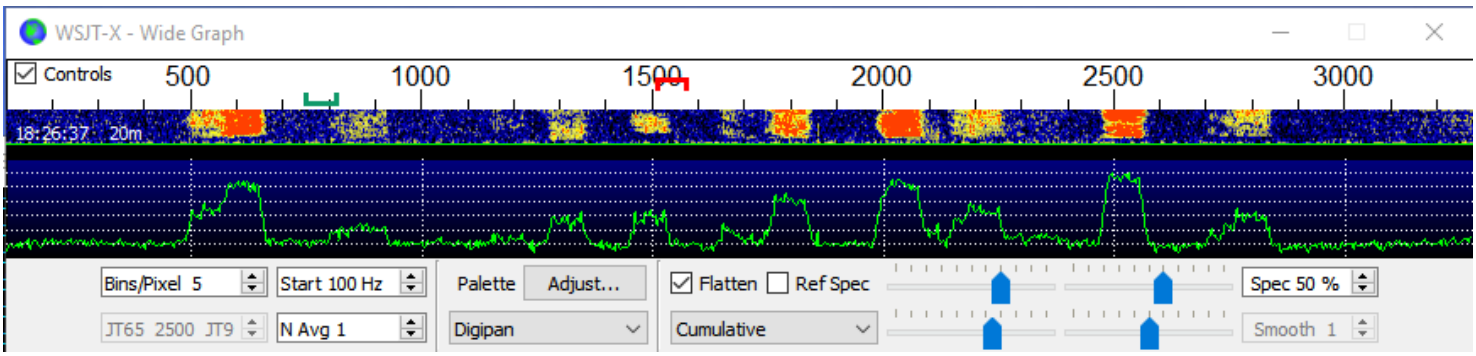
- Select **FT4** on the **Mode** menu.
- Double-click on **Erase** to clear both text windows.

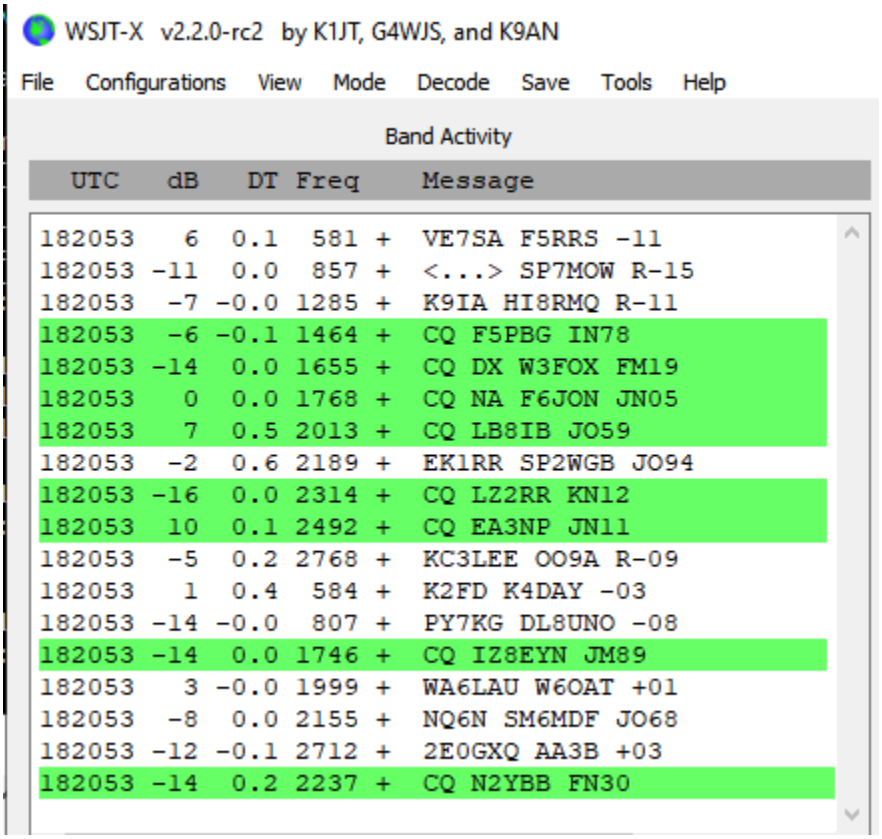
Wide Graph Settings:

- **Bins/Pixel** = 5, **Start** = 100 Hz, **N Avg** = 1
- Adjust the width of the Wide Graph window so that the upper frequency limit is approximately 3300 Hz.

Open a Wave File:

- Select **File | Open** and navigate to ...\save\samples\FT4\200514_182053.wav. The waterfall and Band Activity window should look something like the following screen shots. This sample file was recorded during a practice contest test session, so most of the decoded messages use the **FT Roundup** message formats.

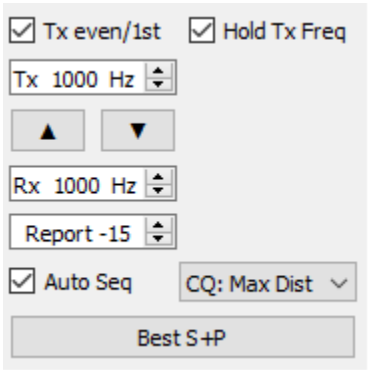




- Click with the mouse anywhere on the waterfall display. The green Rx frequency marker will jump to your selected frequency, and the Rx frequency control on the main window will be updated accordingly.
- Do the same thing with the **Shift** key held down. Now the red Tx frequency marker and its associated control on the main window will follow your frequency selections.
- Do the same thing with the **Ctrl** key held down. Now both colored markers and both spinner controls will follow your selections.
- Now double-click on any of the lines of decoded text in the Band Activity window. Any line will show similar behavior, setting Rx frequency to that of the selected message and leaving Tx frequency unchanged. To change both Rx and Tx frequencies, hold **Ctrl** down when double-clicking.

Best S+P Button

The FT4 user interface includes a button labeled **Best S+P**.



Clicking **Best S+P** during an Rx cycle arms the program to examine all CQ messages decoded at the end of the Rx sequence. The program will select the best potential QSO partner (from a contesting perspective), and treat it as if you had double-clicked on that

line of decoded text. Here "best potential QSO partner" means "New Multiplier" (1st priority) or "New Call on Band" (2nd priority). "New Multiplier" is currently interpreted to mean "New DXCC"; a more broadly defined multiplier category (for the FT Roundup rules) will be implemented in due course. We may provide additional priority rankings, for example “New Grid on Band” (useful for North American VHF contests), sorting by signal strength, etc.

Best S+P is a useful feature only if you have defined what "best" is supposed to mean. This is done by configuring suitable options on the **Settings | Colors** tab. Selection and ordering of color-highlighting options determines what potential QSO partners will be chosen by the "Best S+P" feature. Optimum choices will be different for different contests. In a contest using FT Roundup rules we recommend activating **My Call in message**, **New DXCC**, **New Call on Band**, **CQ in message** and **Transmitted message**, reading from top to bottom.

Keyboard shortcuts **Shift+F11** and **Shift+F12** provide an easy way to move your FT4 Tx frequency down or up in 90 Hz steps.

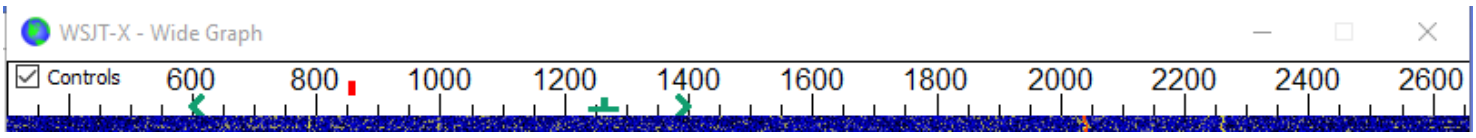
For easy keyboard control of transmitted messages, check **Alternate F1–F6 bindings** on the Settings | General tab. In contest-style operation you can then hit **F1** to solicit a QSO by sending CQ. Similarly, keys **F2** to **F5** will send the messages in entry fields **Tx2** to **Tx5**. More details on contest-style operation can be found in The FT4 Protocol for Digital Contesting (https://wsjt.sourceforge.io/FT4_Protocol.pdf).

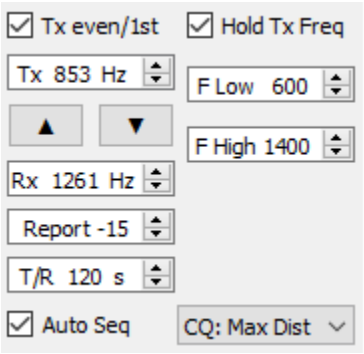
When finished with this Tutorial, don’t forget to re-enter your own callsign as **My Call** on the **Settings | General** tab.

6.5. FST4

Do not confuse FST4 with FT4, which has a very different purpose! FST4 is designed primarily for making weak-signal 2-way QSOs on the LF and MF bands. T/R periods from 15 s up to 1800 s are available. Longer T/R periods provide better sensitivity only if Tx and Rx frequency instability and channel Doppler spread are small enough so that received signals remain phase coherent over periods spanning several transmitted symbols. Generally speaking, Rx and Tx frequency changes during the transmission and channel Doppler spread should each be small compared to the symbol keying rate shown for each T/R duration in Table 7 within section Protocol Specifications. For example, the keying rate for the 1800 s T/R period is 0.089 Baud, so successful operation using this T/R length requires Tx and Rx frequency stability better than 0.089 Hz over the duration of the 1800 s transmission in addition to channel Doppler spread smaller than 0.089 Hz.

Operation with FST4 is similar to that with other *WSJT-X* modes: most on-screen controls, auto-sequencing, and other features behave in familiar ways. However, operating conventions on the 2200 and 630 m bands have made some additional user controls desirable. Spin boxes labeled **F Low** and **F High** set lower and upper frequency limits used by the FST4 decoder, and these limits are marked by dark green angle-bracket symbols **< >** on the Wide Graph frequency scale:



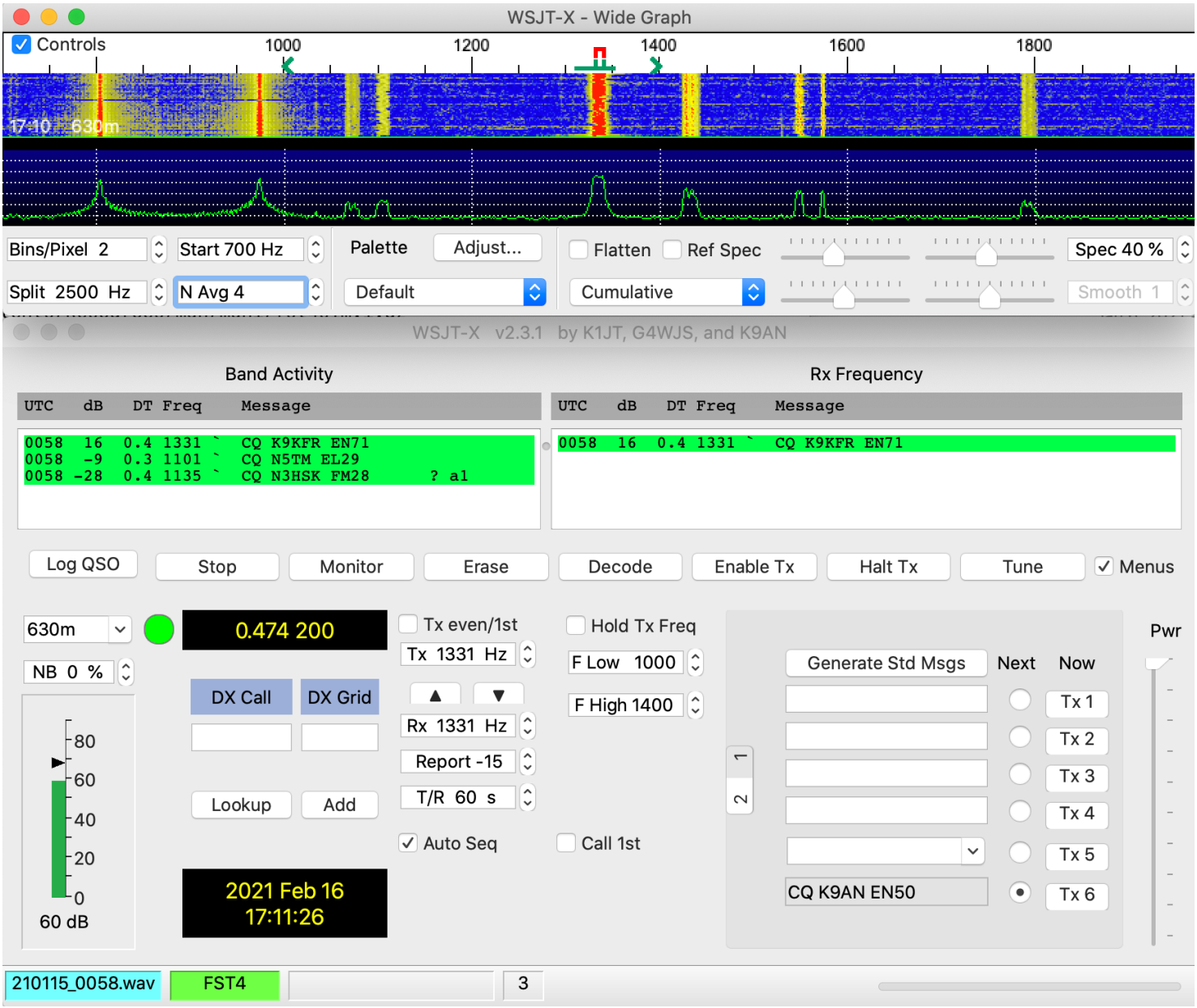


It's best to keep the decoding range fairly small, since QRM and transmissions in other modes or sequence lengths will slow down the decoding process (and of course will be undecodable). By checking **Single decode** on the **File | Settings | General** tab, you can further limit the decoding range to the setting of **F Tol** on either side of **Rx Freq**.

A noise blanker can be enabled by setting the **NB** percentage to a non-zero value. This setting determines how many of the largest-amplitude samples will be blanked (zeroed) before the data is submitted to the decoder. Most users find that settings between 0% (no blanking) and 10% work best. If the noise blanker percentage is set to -1%, then the decoder will try 0, 5, 10, 15, and 20 % in succession. Similarly, a setting of -2% causes the decoder to loop over blanking percentages 0, 2, 4, … 20 %. To save time, the multiple blanking percentages triggered by negative **NB** settings are tried only for signal candidates located near (within +/- 20 Hz) of the **Rx** frequency setting.

Open a sample Wave File:

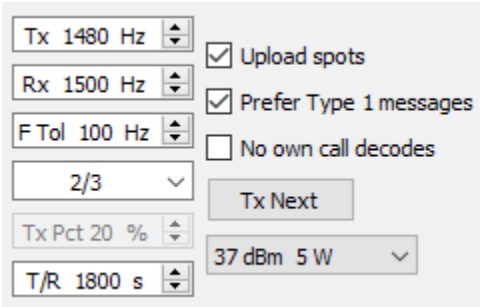
- Select **FST4** on the **Mode** menu. Set **T/R** to 60 s and **Decode | Deep**.
- Set **NB** (noise blanker) to 0%.
- Set up the Wide Graph display with settings appropriate for the FST4-60 mode. For example, try **Bins/Pixel** 2 and **N Avg** 4. Set the **Start** frequency and the width of the Wide Graph to include the frequency range that you want to decode. For this example, make sure that **Start** is less than 1000 Hz and that the Wide Graph extends to above 1400 Hz.
- Set **F Low** 1000, **F High** 1400. These settings define the decoder's frequency search range.
- Open a sample Wave file using **File | Open** and select the file …\save\samples\FST4+FST4W\210115_0058.wav. After *WSJT-X* has processed the file you should see something similar to the following screen shot:



6.6. FST4W

FST4W is used in the same way as WSPR, but FST4W has significant advantages for use on the 2200 m and 630 m bands. By default the central **Rx Freq** is 1500 Hz and **F Tol** is 100 Hz, so the active decoding range is 1400 to 1600 Hz. However, for added flexibility you can select different center frequencies and **F Tol** values. We expect that usage conventions will soon be established for FST4W activity on 2200 and 630 m.

A new drop-down control below **F Tol** offers a round-robin mode for scheduling FST4W transmissions:



If three operators agree in advance to select the options **1/3**, **2/3**, and **3/3**, for example, their FST4W transmissions will occur in a fixed sequence with no two stations transmitting simultaneously. Sequence 1 is the first sequence after 00:00 UTC. For WSPR-like scheduling behavior, you should select **Random** with this control.

Open a Wave File:

- Select **FST4W** on the **Mode** menu. Set **T/R** to 1800 s and **Decode | Deep**.
- Set **NB** to 0%.
- Select appropriate wide graph settings. For example, try **Bins/Pixel** 1, **Start** 1200 Hz and **N Avg** 150.
- Open a sample Wave file using **File | Open** and select the file …\save\samples\FST4+FST4W\201230_0300.wav. When it is finished you should see a single decode as shown in the screenshot:

Note that the weak signal associated with the single decode is all but invisible on the widegraph spectrogram.

7. Making QSOs

7.1. Standard Exchange

By longstanding tradition, a minimally valid QSO requires the exchange of callsigns, a signal report or some other information, and acknowledgments. *WSJT-X* is designed to facilitate making such minimal QSOs using short, structured messages. The process works best if you use these formats and follow standard operating practices. The recommended basic QSO goes something like this:

```
CQ K1ABC FN42                       #K1ABC calls CQ
                 K1ABC G0XYZ IO91   #G0XYZ answers
G0XYZ K1ABC -19                     #K1ABC sends report
                 K1ABC G0XYZ R-22   #G0XYZ sends R+report
G0XYZ K1ABC RRR                     #K1ABC sends RRR
                 K1ABC G0XYZ 73     #G0XYZ sends 73
```

Standard messages consist of two callsigns (or CQ, QRZ, or DE and one callsign) followed by the transmitting station's grid locator, a signal report, R plus a signal report, or the final acknowledgements RRR or 73. These messages are compressed and encoded in a highly efficient and reliable way. In uncompressed form (as displayed on-screen) they may contain as many as 22 characters. Some operators prefer to send RR73 rather than RRR. This is workable because RR73 is encoded as a valid grid locator, one unlikely ever to be occupied by an amateur station.

Signal reports are specified as signal-to-noise ratio (S/N) in dB, using a standard reference noise bandwidth of 2500 Hz. Thus, in the example message above, K1ABC is telling G0XYZ that his signal is 19 dB below the noise power in bandwidth 2500 Hz. In the message at 0004, G0XYZ acknowledges receipt of that report and responds with a –22 dB signal report. JT65 reports are constrained to lie in the range –30 to –1 dB, and values are significantly compressed above about -10 dB. JT9 supports the extended range –50 to +49 dB and assigns more reliable numbers to relatively strong signals.

Signals become visible on the waterfall around S/N = –26 dB and audible (to someone with very good hearing) around –15 dB. Thresholds for decodability are around -20 dB for FT8, -23 dB for JT4, –25 dB for JT65, and –27 dB for JT9.

Several options are available for circumstances where fast QSOs are desirable. Double-click the **Tx1** control under *Now* or *Next* to toggle use of the Tx2 message rather than Tx1 to start a QSO. Similarly, double-click the **Tx4** control to toggle between sending `RRR` and `RR73` in that message. The `RR73` message should be used only if you are reasonably confident that no repetitions will be required.

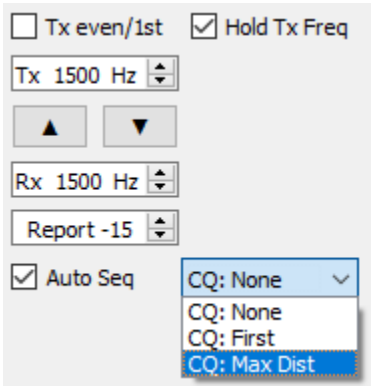
7.2. Free-Text Messages

Users often add some friendly chit-chat at the end of a QSO. Free-format messages such as "TNX ROBERT 73" or "5W VERT 73 GL" are supported, up to a maximum of 13 characters, including spaces. In general you should avoid the character / in free-text messages, as the program may then try to interpret your construction as part of a compound callsign. It should be obvious that the JT4, JT9, and JT65 protocols are not designed or well suited for extensive conversations or rag-chewing.

7.3. Auto-Sequencing

The T/R cycles of many *WSJT-X* modes allow only a few seconds to inspect decoded messages and decide how to reply. Often this is not enough time, so for FST4, FT4, FT8, MSK144, and Q65 the program offers a basic auto-sequencing feature.

Check **Auto Seq** on the main window to enable this feature:



When calling CQ you may choose to select **CQ: First** to reply automatically to the first decoded responder, or **CQ: Max Dist** to reply to the most distant responder.

When **Auto-Seq** is enabled, the program de-activates **Enable Tx** at the end of each QSO. It is not intended that *WSJT-X* should make fully automated QSOs. Auto-sequencing is an operator aid, not an operator replacement.

7.4. Contest Messages

The FT4, FT8, and MSK144 protocols support special messages optimized for **NA VHF** and **EU VHF** contests. FT4 and FT8 also support messages for **ARRL Field Day**, **FT Roundup**, and the **WW Digi** contest. The decoders recognize and decode these messages at any time. Configure the program to automatically generate the required message types for contest exchanges and carry out suitable auto-sequencing by selecting a supported operating activity on the **Settings | Advanced** tab. Model QSOs then proceed as follows, for each event type:

NA VHF Contest and **ARRL International Digital Contest**

```
CQ TEST K1ABC FN42
                      K1ABC W9XYZ EN37
W9XYZ K1ABC R FN42
                      K1ABC W9XYZ RRR
W9XYZ K1ABC 73
```

Either callsign (or both) may have /R appended to signify a Rover in a VHF contest. You can use RR73 in place of RRR, and the final 73 is optional.

EU VHF Contest

```
CQ TEST G4ABC IO91
                                 G4ABC PA9XYZ JO22
<PA9XYZ> <G4ABC> 570123 IO91NP
                                 <G4ABC> <PA9XYZ> R 580071 JO22DB
PA9XYZ G4ABC RR73
```

Either callsign (or both) may have /P appended.

Messages conveying signal reports, QSO serial numbers, and 6-character locators have been changed in *WSJT-X v2.2* and are **not compatible** with the formats used in earlier program versions. Be sure to upgrade *WSJT-X* if you will use **EU VHF Contest** messages.

ARRL Field Day

```
CQ FD K1ABC FN42
                      K1ABC W9XYZ 6A WI
W9XYZ K1ABC R 2B EMA
                      K1ABC W9XYZ RR73
```

FT Roundup

```
CQ RU K1ABC FN42
                      K1ABC W9XYZ 579 WI
W9XYZ K1ABC R 589 MA
                      K1ABC W9XYZ RR73
```

WW Digi Contest

```
CQ WW K1ABC FN42
                      K1ABC S52XYZ JN76
S52XYZ K1ABC R FN42
                      K1ABC S52XYZ RR73
```

Contest QSOs are generally treated as invalid when they appear in one station's log and not the supposed QSO partner's. To avoid Not-in-Log (NIL) penalties for yourself and others, we recommend the following guidelines for contest logging with FT4, FT8, and MSK144:

- Activate and learn to use the **Alternate F1-F6 bindings** selectable on the **Settings | General** tab.
- Always log a QSO when you have received RRR, RR73, or 73 from a station you are working.
- Log a QSO when you send RR73 or 73 if you are reasonably confident it will be copied. But be sure to watch for any indication that it was not copied, and then take appropriate action. For example, if you receive the Tx3 message (R plus contest exchange) again, and if you have activated the **Alternate F1-F6 bindings**, hit **F4** to re-send your RR73.

7.5. Nonstandard Callsigns

Modes with 77-bit message payloads: FST4, FT4, FT8, MSK144, and Q65

Compound callsigns like PJ4/K1ABC or K1ABC/3 and special event callsigns like YW18FIFA are supported for normal QSOs but not for contest-style messages. Model QSOs look something like this:

```
CQ PJ4/K1ABC
                      <PJ4/K1ABC> W9XYZ
W9XYZ <PJ4/K1ABC> +03
                      <PJ4/K1ABC> W9XYZ R-08
<W9XYZ> PJ4/K1ABC RRR
                      PJ4/K1ABC <W9XYZ> 73
```

The compound or nonstandard callsigns are automatically recognized and handled using special message formats. One such callsign and one standard callsign may appear in most messages, provided that one of them is enclosed in < > angle brackets. If the message includes a grid locator or numerical signal report, the brackets must enclose the compound or nonstandard callsign; otherwise the brackets may be around either call.

Angle brackets imply that the enclosed callsign is not transmitted in full, but rather as a hash code using a smaller number of bits. Receiving stations will display the full nonstandard callsign if it has been received in full in the recent past. Otherwise it will be displayed as < . . . >. These restrictions are honored automatically by the algorithm that generates default messages for minimal QSOs. Except for the special cases involving /P or /R used in VHF contesting, *WSJT-X 2.6* offers no support for two nonstandard callsigns to work each other.

Using a nonstandard callsign has definite costs. It restricts the types of information that can be included in a message. It prevents including your locator in standard messages, which necessarily impairs the usefulness of tools like PSK Reporter.

Modes with 72-bit message payloads: JT4, JT9, and JT65

In the 72-bit modes, compound callsigns are handled in one of two possible ways:

Type 1 compound callsigns

A list of about 350 of the most common prefixes and suffixes can be displayed from the **Help** menu. A single compound callsign involving one item from this list can be used in place of the standard third word of a message (normally a locator, signal report, RRR, or 73). The following examples are all acceptable messages containing **Type 1** compound callsigns:

```
CQ ZA/K1ABC
CQ K1ABC/4
ZA/K1ABC G0XYZ
G0XYZ K1ABC/4
```

The following messages are *not* valid, because a third word is not permitted in any message containing a **Type 1** compound callsign:

```
ZA/K1ABC G0XYZ -22        #These messages are invalid; each would
G0XYZ K1ABC/4 73          # be sent without its third "word"
```

A QSO between two stations using **Type 1** compound-callsign messages might look like this:

```
CQ ZA/K1ABC
                    ZA/K1ABC G0XYZ
G0XYZ K1ABC -19
                    K1ABC G0XYZ R-22
G0XYZ K1ABC RRR
                    K1ABC G0XYZ 73
```

Notice that the full compound callsign is sent and received in the first two transmissions. After that, the operators omit the add-on prefix or suffix and use the standard structured messages.

Type 2 Compound callsigns

Prefixes and suffixes *not* found in the displayable short list are handled by using **Type 2** compound callsigns. In this case the compound callsign must be the second word in a two- or three-word message, and the first word must be CQ, DE, or QRZ. Prefixes can be 1 to 4 characters, suffixes 1 to 3 characters. A third word conveying a locator, report, RRR, or 73 is permitted. The following are valid messages containing **Type 2** compound callsigns:

```
CQ W4/G0XYZ FM07
QRZ K1ABC/VE6 DO33
DE W4/G0XYZ FM18
DE W4/G0XYZ -22
DE W4/G0XYZ R-22
DE W4/G0XYZ RRR
DE W4/G0XYZ 73
```

In each case, the compound callsign is treated as **Type 2** because the add-on prefix or suffix is *not* one of those in the fixed list. Note that a second callsign is never permissible in these messages.

During a transmission your outgoing message is displayed in the first label on the **Status Bar** and shown exactly as another station receives it. You can check to see that you are actually transmitting the message you wish to send.

QSOs involving **Type 2** compound callsigns might look like either of the following sequences:

```
CQ K1ABC/VE1 FN75
                    K1ABC G0XYZ IO91
G0XYZ K1ABC -19
                    K1ABC G0XYZ R-22
G0XYZ K1ABC RRR
                    K1ABC/VE1 73
```

```
CQ K1ABC FN42
                    DE G0XYZ/W4 FM18
G0XYZ K1ABC -19
                    K1ABC G0XYZ R-22
G0XYZ K1ABC RRR
                    DE G0XYZ/W4 73
```

Operators with a compound callsign use its full form when calling CQ and possibly also in a 73 transmission, as may be required by licensing authorities. Other transmissions during a QSO may use the standard structured messages without callsign prefix or

suffix.

If you are using a compound callsign, you may want to experiment with the option **Message generation for type 2 compound callsign holders** on the **File | Settings | General** tab, so that messages will be generated that best suit your needs.

7.6. Pre-QSO Checklist

Before attempting your first QSO with one of the WSJT modes, be sure to go through the Basic Operating Tutorial above as well as the following checklist:

- Your callsign and grid locator set to correct values
- PTT and CAT control (if used) properly configured and tested
- Computer clock properly synchronized to UTC within ±1 s
- Audio input and output devices configured for sample rate 48000 Hz, 16 bits
- Radio set to **USB** (upper sideband) mode
- Radio filters centered and set to widest available passband (up to 5 kHz).

Remember that in many circumstances FT4, FT8, JT4, JT9, JT65, and WSPR do not require high power. Under most HF propagation conditions, QRP is the norm.

8. VHF+ Features

WSJT-X supports a number of features designed for use on the VHF and higher bands. These features include:

- **FT4**, for contesting
- **FT8**, for fast QSOs with weak, fading signals
- **JT4**, for EME on the microwave bands
- **JT9 fast modes**, for scatter propagation on VHF bands
- **JT65**, for EME on VHF and higher bands
- **Q65**, for ionospheric scatter, tropospheric scatter, rain scatter, TEP, and EME
- **MSK144**, for meteor scatter
- **Echo** mode, for detecting and measuring your own lunar echoes
- **Doppler tracking**, which becomes increasingly important for EME on bands above 1.2 GHz.

8.1. VHF Setup

To activate the VHF-and-up features:

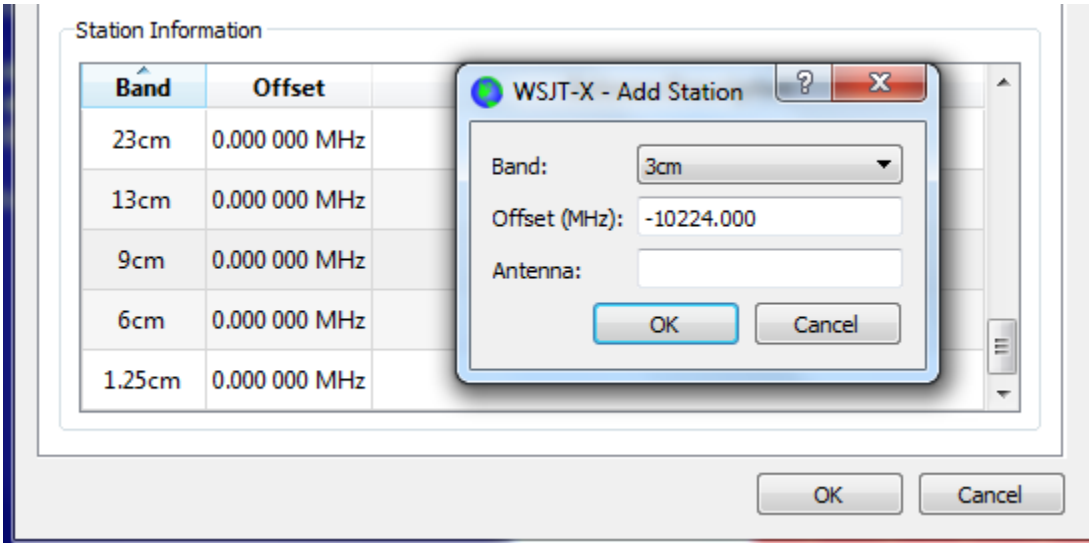
- On the **Settings | General** tab check **Enable VHF/UHF/Microwave features** and **Single decode**.
- For EME, check **Decode after EME delay** to allow for extra path delay on received signals.
- If you will use automatic Doppler tracking and your radio accepts frequency-setting commands while transmitting, check **Allow Tx frequency changes while transmitting**. Transceivers known to permit such changes include the IC-735, IC-756 Pro II, IC-910-H, FT-847, TS-590S, TS-590SG, TS-2000 (with Rev 9 or later firmware upgrade), Flex 1500 and 5000, HPSDR, Anan-10, Anan-100, and KX3. To gain full benefit of Doppler tracking your radio should allow frequency changes under CAT control in 1 Hz steps.

If your radio does not accept commands to change frequency while transmitting, Doppler tracking will be approximated with a single Tx frequency adjustment before a transmission starts, using a value computed for the middle of the Tx period.

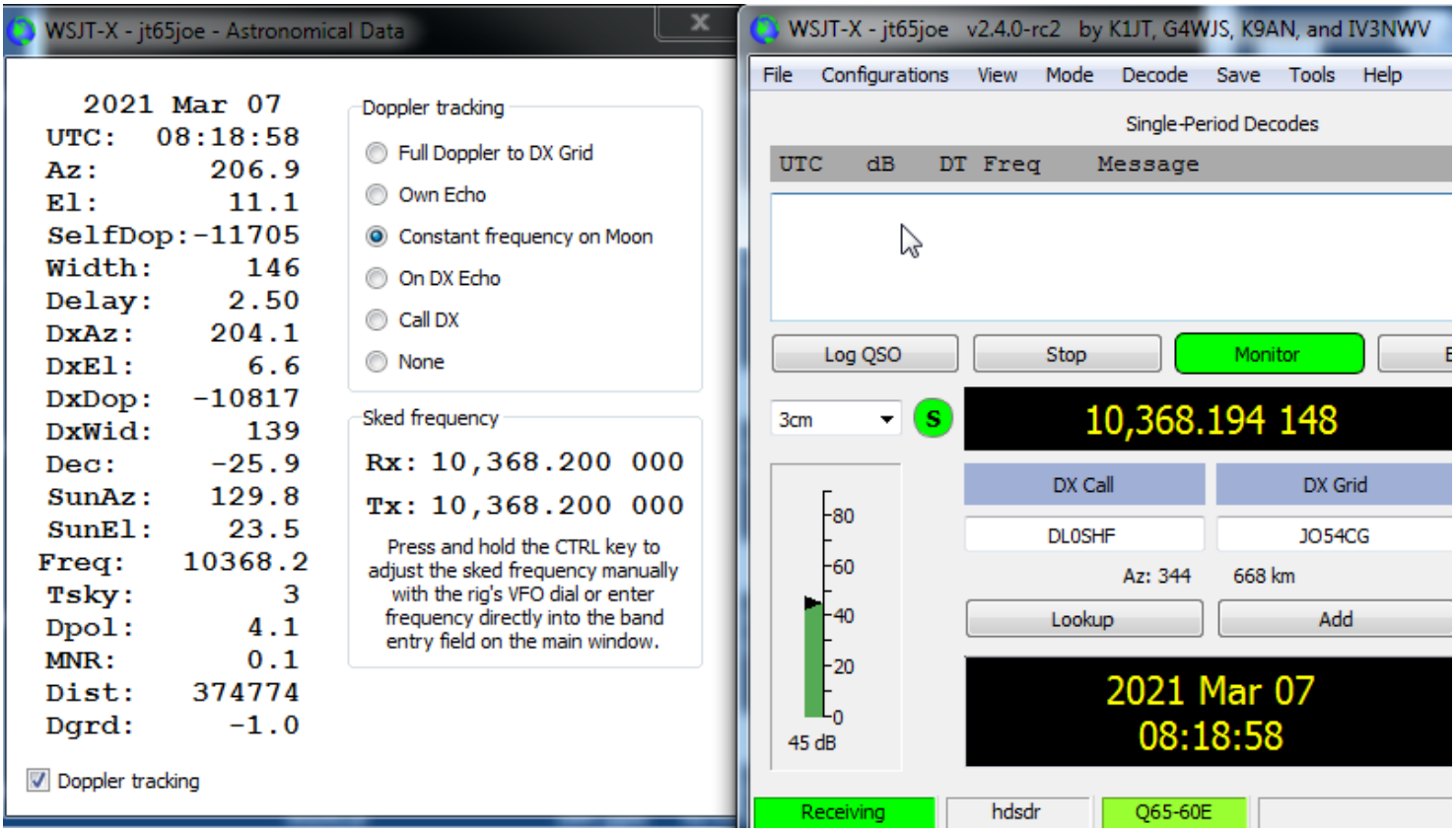
- On the **Radio** tab select **Split Operation** (use either **Rig** or **Fake It**; you may need to experiment with both options to find one that works best with your radio).
- On the right side of the main window select **Tab 1** to present the traditional format for entering and choosing Tx messages.

The main window will reconfigure itself as necessary to display controls supporting the features of each mode.

- If you are using transverters, set appropriate frequency offsets on the **Settings | Frequencies** tab. Offset is defined as (transceiver dial reading) minus (on-the-air frequency). For example, when using a 144 MHz radio at 10368 MHz, **Offset (MHz)** = (144 - 10368) = -10224.000. If the band is already in the table, you can edit the offset by double clicking on the offset field itself. Otherwise a new band can be added by right clicking in the table and selecting **Insert**.



- On the **View** menu, select **Astronomical data** to display a window with important information for tracking the Moon and performing automatic Doppler control. The right-hand portion of the window becomes visible when you check **Doppler tracking**.



Five different types of Doppler tracking are provided:

- Select **Full Doppler to DX Grid** if you know your QSO partner's locator and he/she will not be using any Doppler control.
- Select **Own Echo** to enable EME Doppler tracking of your receive frequency to your own echo frequency. Your Tx frequency will remain fixed and is set to the Sked frequency. This mode can be used when announcing your CQ call on a specific frequency and listening on your own echo frequency. It can also be used for echo testing with Echo mode.
- Select **Constant frequency on Moon** to correct for your own one-way Doppler shift to or from the Moon. If your QSO partner

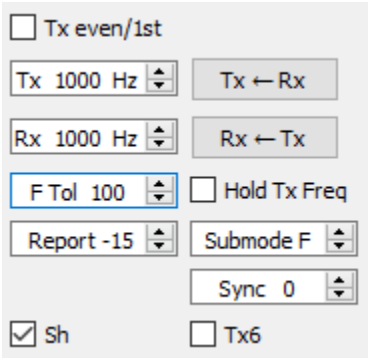
does the same thing, both stations will have the required Doppler compensation. Moreover, anyone else using this option will hear both of you without the need for manual frequency changes.

- Select **On Dx Echo** when your QSO partner announces his/her transmit frequency and that they are listening on their own echo frequency. When clicked, this Doppler method will set your rig frequency on receive to correct for the mutual Doppler shift. On transmit, your rig frequency will be set so that your QSO partner will receive you on the same frequency as they receive their own echo. Sked frequency in this case is set to that announced by your QSO partner.
- Select **Call DX** after tuning the radio manually to find a station, with the Doppler mode initially set to **None**. You may be tuning the band looking for random stations, or to a frequency where a station has been seen on an SDR display. It is usually necessary to hold down the Ctrl key while tuning the radio. From the moment **Call DX** is pressed, your transmit frequency is set so that your echo will fall on the same frequency you (and the DX station) are listening.
- See Astronomical Data for details on the quantities displayed in this window.

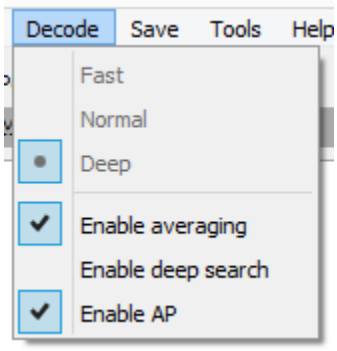
8.2. JT4

JT4 is designed especially for EME on the microwave bands, 2.3 GHz and above.

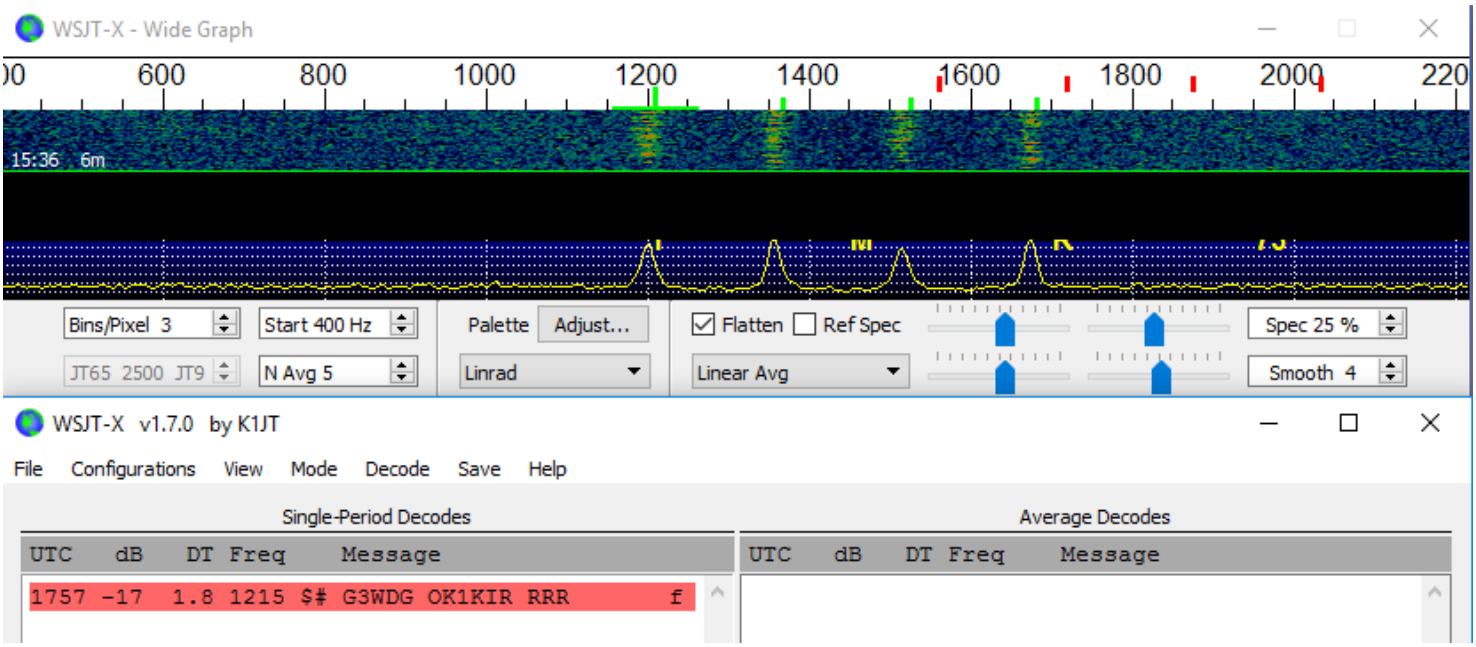
- Select **JT4** from the **Mode** menu. The central part of the main window will look something like this:



- Select the desired **Submode**, which determines the spacing of transmitted tones. Wider spacings are used on the higher microwave bands to allow for larger Doppler spreads. For example, submode JT4F is generally used for EME on the 5.7 and 10 GHz bands.
- For EME QSOs some operators use short-form JT4 messages consisting of a single tone. To activate automatic generation of these messages, check the box labeled **Sh**. This also enables the generation of a single tone at 1000Hz by selecting Tx6, to assist in finding signals initially. The box labeled **Tx6** toggles the Tx6 message from 1000Hz to 1250Hz to indicate to the other station that you are ready to receive messages.
- Select **Deep** from the **Decode** menu. You may also choose to **Enable averaging** over successive transmissions and/or **Enable deep search** (correlation decoding).



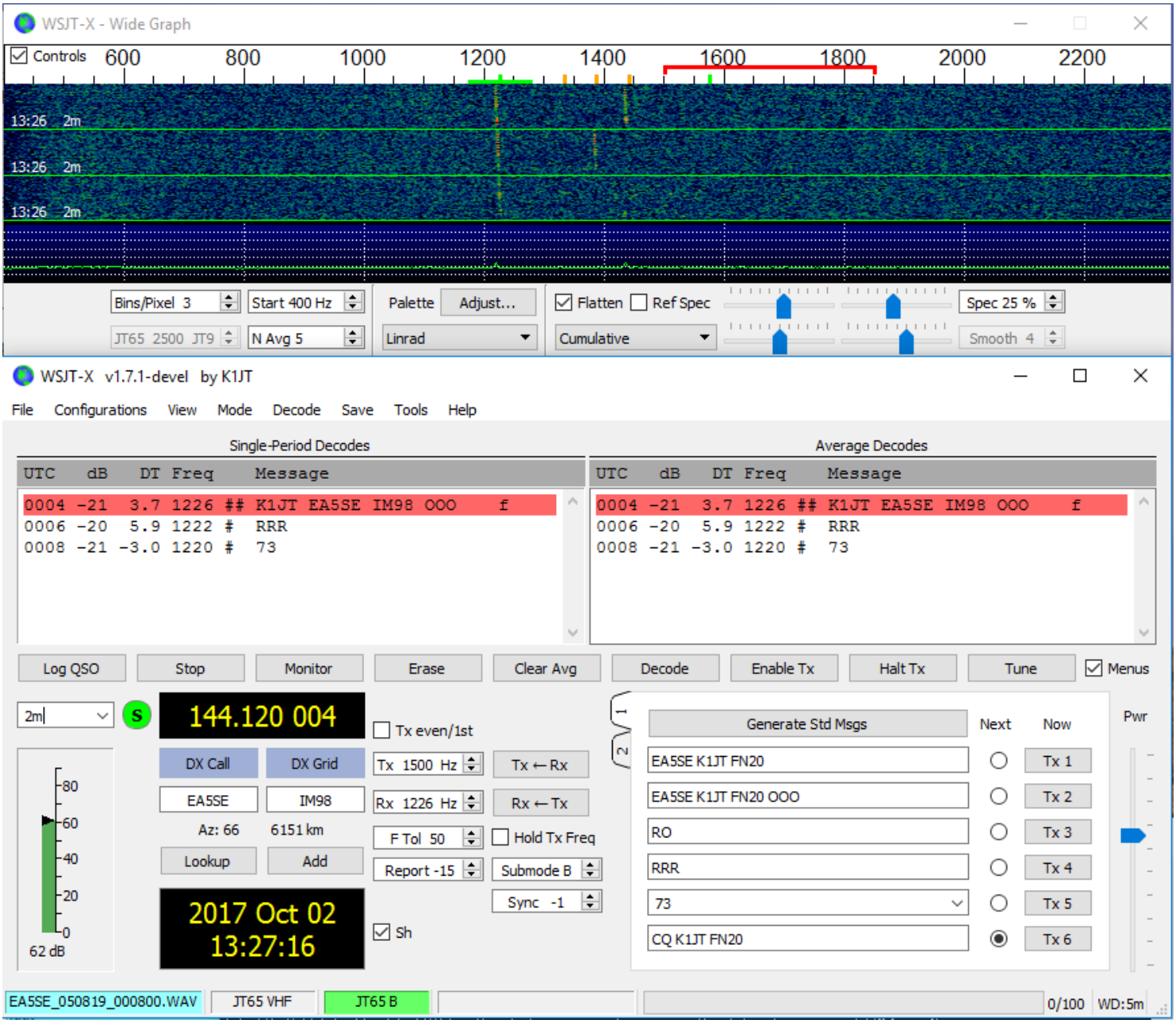
The following screen shot shows one transmission from a 10 GHz EME QSO using submode JT4F.



8.3. JT65

In many ways JT65 operation on VHF and higher bands is similar to HF usage, but a few important differences should be noted. Typical VHF/UHF operation involves only a single signal (or perhaps two or three) in the receiver passband. We recommend that you check **Single decode** on the **Settings** → **General** tab, and do not check **Two pass decoding** on the **Advanced** tab. With VHF features enabled the JT65 decoder will respond to special message formats often used for EME: the OOO signal report and two-tone shorthand messages for RO, RRR, and 73. These messages are always enabled for reception; they will be automatically generated for transmission if you check the shorthand message box **Sh**. **Deep** on the **Decode** menu will be automatically selected. You may optionally include **Enable averaging**, **Enable Deep search**, and **Enable AP**.

The following screen shot shows three transmissions from a 144 MHz EME QSO using submode JT65B and shorthand messages. Take note of the colored tick marks on the Wide Graph frequency scale. The green marker at 1220 Hz indicates the selected QSO frequency (the frequency of the JT65 Sync tone) and the **F Tol** range. A green tick at 1575 Hz marks the frequency of the highest JT65 data tone. Orange markers indicate the frequency of the upper tone of the two-tone signals for RO, RRR, and 73.



8.4. Q65

Q65 is designed for fast-fading signals: tropospheric scatter, rain scatter, ionospheric scatter, trans-equatorial propagation (TEP), EME, and the like. The following screen shot shows a series of ionospheric scatter QSOs using submode Q65-30A on the 6 meter band. The received signals were barely audible most of the time.