

# FT8 – Avoiding Harmonics and Audio Settings

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The FT8 sound card mode is an MFSK mode with redundancy and error checking. If you have been hearing about this new mode or have been using it, this article can aid you to set up and operate the FT8 data mode with good clean signals. FT8 allows you to view and decode dozens of signals at once with the waterfall display. This means your audio setup and bandpass settings will be of utmost importance while operating the FT8 sound card mode.

FT8 is a very popular sound card mode thanks to the WSJT-X team's efforts. See <http://physics.princeton.edu/pulsar/K1JT/wsjt.html> for the software and check out the references for lots of details. A sound card mode is what you might call a poor-person's SDR (since the software is free you can be poor to enjoy it). All the FT8 relevant modulation/demodulation/bit-correction/error-checking is taking place in the WSJT-X software. During this process your FT8 messages (exchanges) are being encoded with additional information that allows for error detection and bit corruption correction which the receiving side can use to process and validate the received message. The WSJT-X software sound card modes can be used with any rig, new or old. FT8 can demodulate dozens of signals (50hz wide each) in up to 5000Hz of bandpass including overlapping signals. As you can see, many hams can operate at the same time in the same bandwidth. This approach allows new operating paradigms like FT8 Fox&Hound mode that DXCC teams are now using where they can process multiple QSOs simultaneously (see [http://physics.princeton.edu/pulsar/k1jt/FT8\\_DXpedition\\_Mode.pdf](http://physics.princeton.edu/pulsar/k1jt/FT8_DXpedition_Mode.pdf)).

One of the areas that seems to be misunderstood while operating FT8 is the how the radio's bandpass settings affect the operations of this mode. Many of the hams who operate some of the other modes like SSB and CW, use the default bandpass settings in their rig which are frequently too narrow for FT8. Note that most rigs can set the overall bandpass and not separate the Rx/Tx bandpass. Your rig's bandpass is hopefully at least 200Hz-2400Hz and preferably 200Hz-3000Hz since there are quite a few operators who transmit above 2500 (see Figure 1 with 200Hz-3000Hz). You can view your bandpass in the WSJT-X waterfall by turning off "Flatten", below that change the pulldown to "Current" and set "N Avg" to 3 or less and "Start 0 Hz" so we can see the changes more easily. What you should see is something like Figure 3, where you have a noise level signal rolling-off at lower and upper ends of the bandpass.

You should adjust the Bins/Pixel and window width, so you can see your entire FT8 signal bandwidth. Then you need to learn your bandwidth controls in your rig, so you can maximize both the low end and high end cutoff points. Once you have your bandwidth set in your rig as wide as you can make it you can change the "Start 0 Hz" to "Start 200 Hz". Then adjust the right side of graph until it is inside your upper bandwidth limit. Then turn on "Flatten". Note that Flatten does not like having the edges of your bandpass in the waterfall and will not behave as well if you adjust this incorrectly. The signal bandpass area between the lower and upper limits of the waterfall window is where the FT8 signals will be

displayed and decoded in the software. The frequency limits of the waterfall determine what gets decoded.

Remember your goal for FT8 is to adjust your rig for as much TX/RX bandwidth as possible...you can run it up to 5kHz for WSJT-X (as much as WSJT-X can do right now). Most rigs should do at least 200-2400Hz. Many rigs have bandwidth settings called NAR/MID/WID filters and the WID settings should always be used and it can usually be adjusted for the largest bandwidth. If you can't find your rig's bandwidth settings after consulting with your manual feel free to contact one of the authors.

Once you have your bandwidth set correctly you are now ready to set up your receive signals path:

#1 Open the sound control panel on your computer, right-click your rig sound device, select Properties, and set the Level of your sound card Playback device (and Recording device) to 0dB. You can get to the sound control panel in Windows 10 by right-clicking the speaker icon and select "Open Sound Settings" and find the "Sound Control Panel" entry and your audio is probably called "USB Audio CODEC". Right-click the device for your rig and select "Properties". Select the Level tab and right-click in the level slider to set the scale to dB instead of the default percentage.

#2 In the Advanced tab set your sample rate to 48kHz 16-bit. Also, ensure all enhancements or spatial sound effects are turned OFF.

#3 You are now ready to adjust the level in the WSJT-X meter to minimum 30dB and not more than 40dB when you have your rigs VFO tuned on a quiet spot. You can adjust your external sound card knobs if you are using one, and your rigs output level to achieve this. Do NOT make this adjustment using sound controls on the computer...in most cases that is not necessary. The meter in WSJT-X should look something like Figure 4. Again, note this is on a quiet spot on the band with no signals present.

Now let's talk about your transmit signal path:

A rig that has too much input audio will create a dirty tx signal with very significant harmonics that can disrupt a QSO and everybody can see on the waterfall.... but...here is the problem...you won't know about it unless you can monitor your own transmitted signal. Any harmonics will show up at multiples of your Tx offset setting in the WSJT-X waterfall of everybody that receives your signal. For example, you can clearly see the noise bars at around 2480 in Figure 1 which is the 3<sup>rd</sup> harmonic of the signal at 829. In Figure 2 you can see an extreme example with multiple harmonics. Running WSJT-X's optional rig split mode or fake it mode will prevent harmonics from showing up in your transmitted signal since harmonics will show up above 3000Hz which is normally outside your transmit passband. But it's better not to generate them in the first place as your signal also gets affect by the clipping. ALC (Automatic Level Control) is one indicator of clipping and is an easy, roundabout way to know if you are clipping your signal. Another way is to ensure that dB level controls in WSJT-X and your soundcard behave as they should.

To set your transmit levels use the procedure below. This procedure is designed to ensure your signal is just enough to drive the rig without any ALC taking place. You MUST understand what your ALC meter is telling you.

Things you need to know to do this procedure:

- How much power your rig can transmit for FT8. Many rigs cannot use full power for this type of mode and some rigs can't even do their rated power on a constant envelope signal without hitting the ALC.
- How to read and understand your rig's ALC meter. Anything above 0dB ALC is bad for FT8/digital modes. The question is, how does your rig show 0dB ALC? For most older rigs 0dB is the left-hand side of the meter or just a red-light indicator when ALC is in effect. On newer SDR rigs you do want to see some ALC action as 0dB is not the left-hand side of the meter...read your manual. The procedure below will help you confirm how your meter behaves.
- How to set the rig output power level
- How to set rig audio input level (RAIL) – this is the audio level that the rig sees from the computer or the external sound card. We will also be adjusting any external sound card like a SoundBlaster or SignalLink (if you have one) and the RAIL together.

#1 Set your rig power level to the maximum it can do for CW mode (look at the rig specs – could be anywhere from 30-100% of full power). We just need to ensure we have enough “room” in the rig setting so that we can feed a signal and not be any more than 50% of the rig's power setting.

#2 Set WSJT-X to full power on the Pwr slider

#3 Confirm your sound card playback device is 0dB and 48kHz sample rate. Recording should be the same 0dB, 48kHz. Also ensure your sound card audio playback is NOT the default device. If you make it the default than all your windows sounds (beeps, YouTube, etc.) will playback through your rig.

#4 Set your RAIL to minimum and your playback/outgoing/transmit sound card to minimum.

#5 Set the TX offset to 1500 – we want to ensure the tone we generate is in this “sweet spot”.

#6 Press "Tune" on WSJT-X -- at this point you should have no power being transmitted. If you see power go check your settings again.

#7 Increase RAIL and external audio device level SLOWLY until you get about 20W (assuming your rig is set at 100W or use 20-50% of whatever your rig power setting is). Whatever your ALC meter says at that point is probably what you want and is below 0dB. On most rigs the ALC meter won't even move or barely move. If your ALC is more than minimal at this setting, then you probably have an Elecraft K3 which wants 4 bars + tickling the 5<sup>th</sup> bar to operate at capacity. It's important you understand what your ALC meter is telling you. You do not want any ALC on an FT8 signal (or any other digital signal).

#7 Bring up RAIL until ALC starts increasing, then decrease gain back to where it was. For the K3 and such you should be able to put out max power without exceeding the K3's 4bars+5<sup>th</sup>.

#9 Sanity check – the Pwr slider on WSJT-X should show 50% power loss for every 3dB down. So if you are 100W at full scale (0dB on the Pwr slider) then -3db should be 50W and -6dB should be 25W. If your power does not decrease then your audio is still wrong. You could be overdriving the A/D in your rig which may also clip your signal. An example is the FT-450D which has a 60mV input with a SignalLink that provides up to 100mV. If you put over 60mV into the FT-450D your signal will clip. The Pwr slider in WSJT-X is an indicator when this is occurring since dropping from 100mV to 80mV won't matter to the rig and the -3dB Pwr slider setting will still show 100W.

#8 Repeat #9 for the lower and upper limits of what you believe is your bandpass. You should see the same power level behavior for your entire bandpass. If you see the maximum power level reduce at any point then your bandpass or notch filters may be the reason...double check them. If you run WSJT-X in either “Rig Split” or “Fake It” (in Settings/Radio) than your audio will always be 1500-2000Hz and actually allow you to work signals beyond your bandwidth (i.e. if you can decode them you can work them).

You should now be seeing maybe 80-100% of your rig's power level (depending on rig) with no ALC being tickled (or the 4bars+ as explained above). That's how you want to operate FT8 to ensure a clean signal.

You can leave your rig power level at the maximum and adjust your transmitted power from WSJT-X (except for the K3 where you should adjust on the rig only due to the K3's power hunting feature) and your signal will always be clean. Changing rig power on the rig or audio levels in the rig or sound card that you have already set may end up triggering the ALC again so be vigilant that the ALC is always where it should be.

Hope to see you on the bands with a clean FT8 signal!

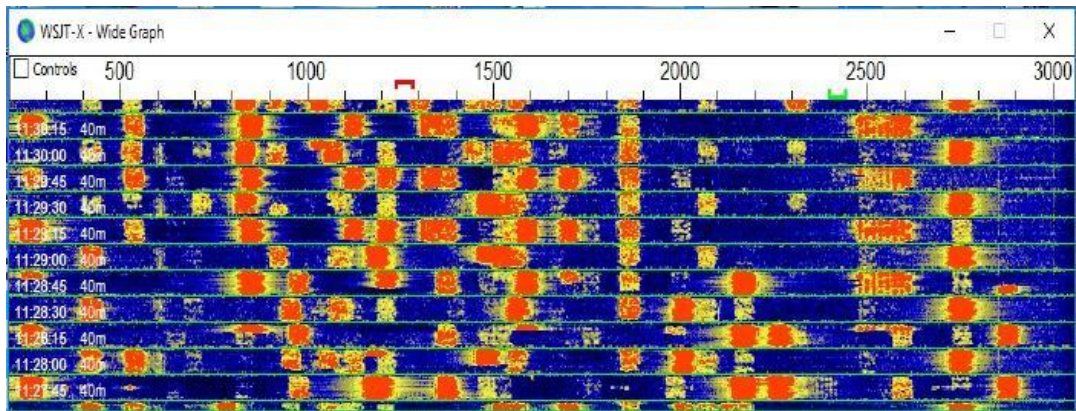


Figure 1 – Example noise typically seen

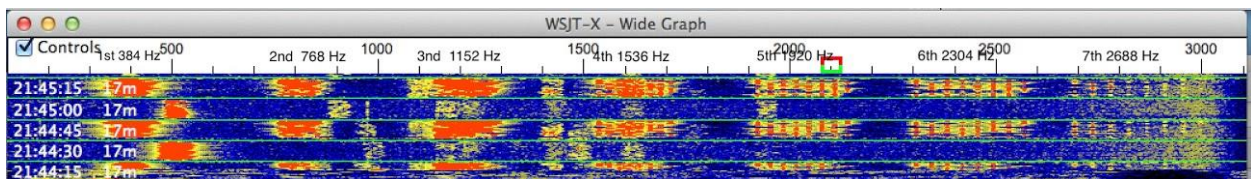


Figure 2 – Thanks to Dave K4DET for generating this image of clipping noise.

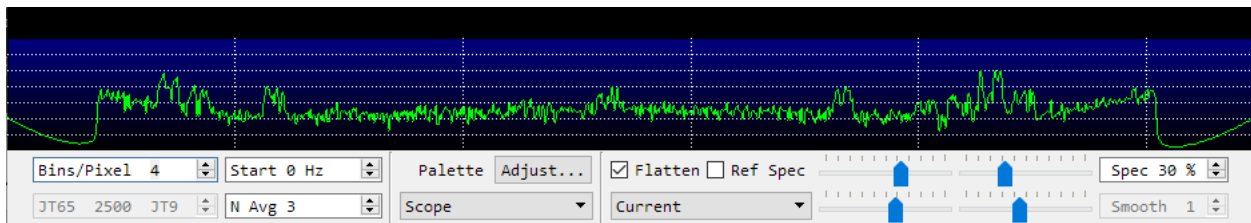


Figure 3 – Bandwidth view

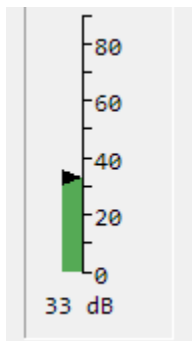


Figure 4