Sensitivity Comparison of JT65A and Q65-60A

Joe Taylor, K1JT

JT65A has been the mode of choice for EME on the 6-meter band for nearly twenty years. Choosing this mode was easy: with its so-called “Deep Search” decoding algorithm, JT65A is effective at SNRs down to -29 dB in a 2500 Hz reference bandwidth, which is roughly 15 dB below the level required for copying CW by ear. By using “OOO” for a signal report, two-tone transmissions without callsigns for “RO”, “RRR”, and “73”, and a database of EME-active callsigns and their associated Maidenhead locators, JT65A QSOs can be completed with good efficiency when callsigns are in the database and received SNRs are -29 dB or higher. In such QSOs we can be confident about who we have worked, and about logical completion of the QSO. But the actual amount of information sent from station A to station B may be very small: perhaps 14 bits for a callsign and locator selected from a database of several thousand entries, plus a 1-bit signal report and a 1-bit acknowledgment.

Q65 offers essentially the same sensitivity while exchanging full callsigns and real signal reports and not using a database. All Q65 transmissions convey 78-bit message payloads. These bits normally encode two callsigns and a locator, signal report, acknowledgment, or sign-off word. At the very least, minimal QSOs convey an unknown arbitrary callsign of 29 bits, a numerical signal report of 7 bits, and a 1-bit acknowledgment. There is no need for any callsign (other than a transmitting station’s own call) to be known in advance, and no need for a database.

To facilitate a direct comparison of JT65A and Q65-60A, I generated a set of 10 .wav files in the *WSJT-X* format. Transmitted messages are those that might be sent by W9XYZ in response to a CQ from K1ABC. Each file has ten signals: five in the JT65A mode, and five Q65-60A. To simulate very weak EME signals that might be found on the 6 m band, every signal has SNR -29 dB and Doppler spread 1.0 Hz. The simulated data files are posted here:

https://physics.princeton.edu/pulsar/k1jt/JT65A_and_Q65-60A.zip

and the exact messages and sync-tone frequencies are as follows:

JT65A: “K1ABC W9XYZ EN37 OOO” at 700, 1100, 1500, 1900, and 2300 Hz

Q65-60A: “K1ABC W9XYZ -24” at 500, 900, 1300, 1700, and 2100 Hz

To reproduce my tests on these files you should configure *WSJT-X* with **MyCall** = K1ABC. For the JT65 tests it’s important to have a CALL3.TXT file with at least a few thousand callsigns and locators. (My tests used a file with 5908 entries.) Four distinct decoding tests should be carried out. In each test we attempt decoding at each of the five values of **RxFreq** listed above, processing all ten files at each target frequency and recording the total number of correct and false decodes. In principle up to 5 x 10 = 50 decodes would be possible in each of the four tests.

I used the following decoder settings. (Obviously, you could repeat the tests using your own favorite settings.)

JT65: Deep, Enable Deep Search, Enable AP, Random erasure patterns = 6, Aggressive decoding level = 9.

Q65: Fast, Enable averaging, Auto Clear Avg after decode.

Test results are summarized in Table 1, on the next page. Test 1 is done with a CALL3.TXT that does *not* have an entry for W9XYZ in grid EN37, so Deep Search is effectively not available. In contrast, Test 2 *does* have an entry for W9XYZ.

Table 1. – Summary of decoding results.

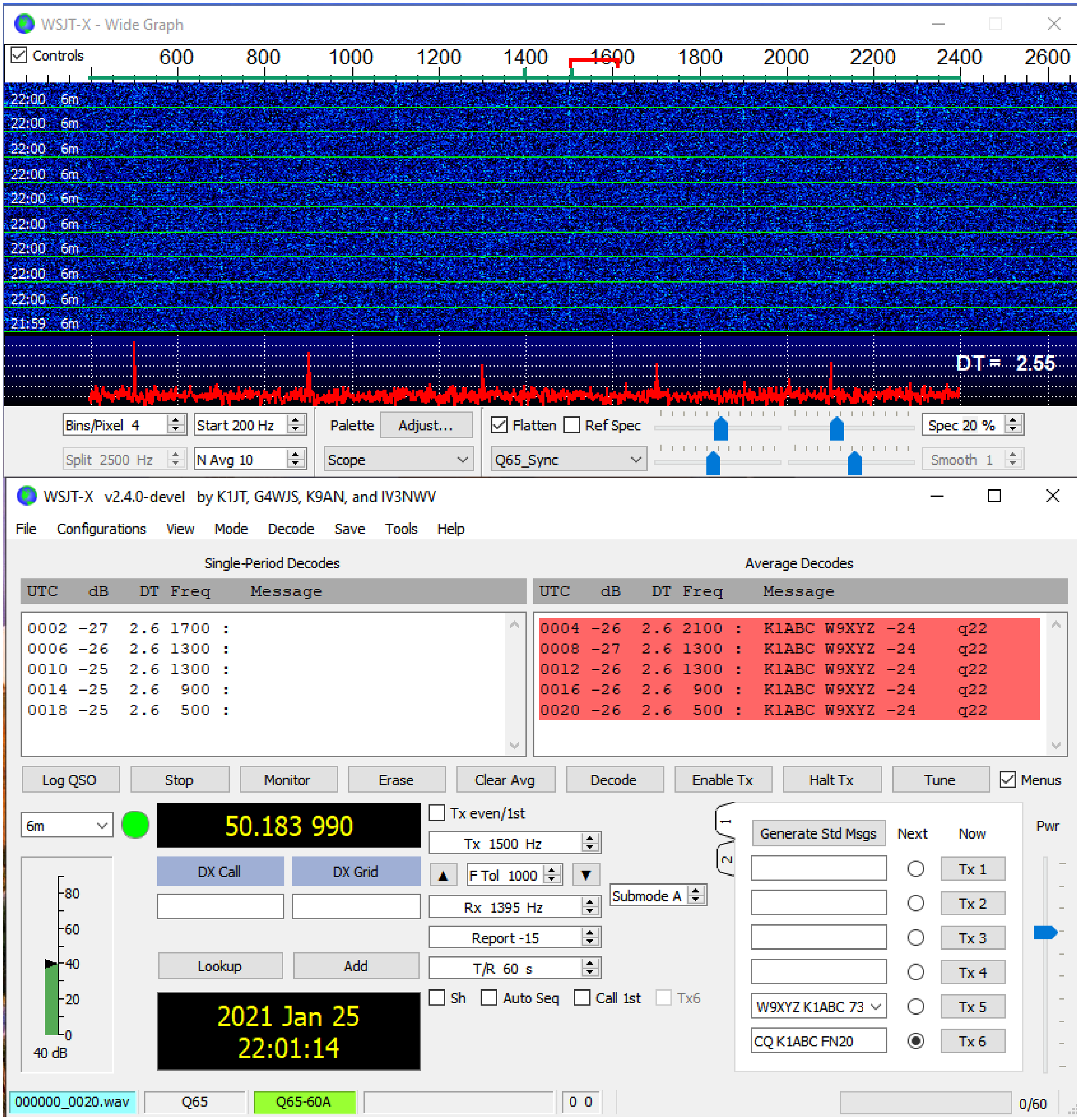
Test	Mode	DX Call	DX Grid	Deep Search ?	Good	Bad
1	JT65A	<blank>	<blank>	No	0	0
2	JT65A	<blank>	<blank>	Yes	28	1
3	Q65-60A	<blank>	<blank>	N/A	24	0
4	Q65-60A	W9XYZ	EN37	N/A	49	0

JT65A can be configured to include message averaging, thereby gaining additional sensitivity for repeated transmissions from an unknown caller. However, the averaging facility in JT65 is useful only for a single calling station that you may have identified on the waterfall. In contrast, Q65 message averaging is effective over the full displayed range of frequencies. You can identify potentially decodable signals on the Q65 red or orange "sync curve" and then decode a number of signals at different frequencies by double-clicking on the waterfall, perhaps during your next transmitting sequence. It's easy to try this technique with the posted test files. Refer to the screen shot on the next page and follow something like the following recipe:

1. Set **MyCall** = K1ABC, **RxFreq** near the center of the waterfall, and **FTol = 1000** Hz.
2. Open and process the first test file, 000000_0002.wav. When the decoding cycle is finished hit **Shift+F6** to process all the remaining files. Your results should be similar to the screen shot.
3. Examine the waterfall carefully. The sync tones of both modes are marginally visible, extending weakly over all ten files, but those for JT65 are somewhat brighter. That's because JT65 devotes half of its transmitted energy to sync tones, while Q65 devotes only one quarter. Nevertheless, the Q65 sync tones are easy to identify in the red **Q65 Sync** or orange **Q65 MultiSync** curve.
4. You can see that five independent decodes are produced from the ten Q65 files, each based on the average of two transmissions. The decoder always picks the best-looking frequency within the FTol range. With these files the five successful decodes occur at 2100, 1300, 1300, 900, and 500 Hz, but other orderings might just as well have occurred,
5. Double-click **Erase** and click **Clear Avg**, to get a fresh start. Set **FTol** = 50 and be sure that **RxFreq** is more than 50 Hz away from the nearest Q65 signal. Then open and process all 10 files again. You should see no decodes, and the message averaging-counters near the middle of the status bar should read "10 0".
6. Turn off "Auto Clear Avg after decode." You should now be able to double-click on the waterfall anywhere close to 500, 900, 1300, 1700, or 2100 Hz and obtain a decode from data averaged over all ten files. After doing this I found the following contents in the **Average Decodes** window:

```
0020 -26 2.6  500 : K1ABC W9XYZ -24    q0*
0020 -26 2.6  900 : K1ABC W9XYZ -24    q0*
0020 -26 2.6 1300 : K1ABC W9XYZ -24    q2*
0020 -27 2.6 1701 : K1ABC W9XYZ -24    q2*
0020 -26 2.5 2099 : K1ABC W9XYZ -24    q2*
```

In actual on-the-air practice, each one of these signals might be a different caller responding to your CQ.



Conclusions: The above tests (and many others not summarized here) show that for responses to one's CQ, Q65-60A has about the same sensitivity *for any unknown caller* as JT65A has *only for callers listed in CALL3.TXT*. For all other random callers, Q65-60A is at least 3 dB more sensitive than JT65A. For subsequent messages in a Q65 QSO, where both callsigns are already known, sensitivity is better still. Q65 uses message formats and default QSO procedures consistent with FST4, FT4, FT8, and MSK144, the other widely used modes in *WSJT-X*. Q65 has a far lower false decode rate than JT65 – so low, in fact, that it's hard to measure. When other special advantages are needed, Q65 offers sequence lengths of 30 s (for twice the QSO rate with relatively strong signals) and 120 s (for 3 dB more sensitivity in single transmissions).

In my view it's not a close call: Q65 is superior to JT65 in nearly every way.