Getting the MOST out of JT65B on 2m EME
Frequency Stability of the RX/TX

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Background

JT65B uses the FFT algorithm to locate the individual 63 'bauds' in discreet bins of the received audio stream, these 'bauds' are coded as unique frequency tones within its pass-band. If the RX or TX is drifting significantly then the data can become smeared and make the decoder's job difficult to impossible. Every tone that becomes smeared (ie. spread across baud boundaries) is reducing the chance the decoder will get enough of a quality signal to successfully decode the message. In reality, the received signal may not be over the noise. The decoder is looking for FFT bins that are on average 'noisier' then the others bin which contain Gaussian noise and that follow the pseudo-random sync pattern. Imagine your signal is spread over a few bins and you'll get the idea that it will become harder and harder to determine whether there is really a signal there and then WSJT will fail to detect it. Basically, you're wasting the signals energy and not focusing it where it needs to be. Therefore, frequency stability is an important consideration when optimizing your station on both your RX and TX.

Measurements

Obtain ARGO by Alberto I2PHD, Spectran or any other FFT based spectrum analyzer software package capable of viewing QRSS signals to display the frequency stability. If you're really ambitious one could do a custom setup in a program like Spectrum Lab by DL4YHF. Visit www.weaksignals.com for more info on ARGO or Spectran.

The other important consideration is an accurate frequency reference. One can easily build their own from a standard GPS unit with a 10KHz output synchronized to the UTC second. The Rockwell Jupiter GPS units can often be had for $50 on Ebay and have the 10KHz output. The designs often used are simply XOR based PLLs with a divider to take a 10MHz VCO down to 10KHz where a phase comparison is done with an XOR gate. See http://www.qro.it/i2phd/g4jnt/gpsdo.html for details on an ultra-simple design that will be more then enough for these kinds of tests.

My GPS disciplined oscillator uses an oven based oscillator for long term stability and even higher accuracy but this is really not required for this purpose.

The test setup is really very simple for 2m EME work. Set your receiver to 150MHz, which is the 15th harmonic of the reference oscillator, and turn on the GPS reference source and allow it to stabilize for a few hours or more. You may need to create some leakage from the oscillator assembly to get enough signal out to your 2m receiver. Now setup ARGO or other QRSS viewer for 30 second dot mode with the speed set to slow. If the signal is not visible on the screen you may need to increase speed to find it and then narrow in.

The next consideration to ensure accuracy of the test is to confirm your soundcard sampling rate is stable and accurate. This can be quickly done with WSJT by looking at the little box in the bottom left hand corner. See the WSJT docs for more details.

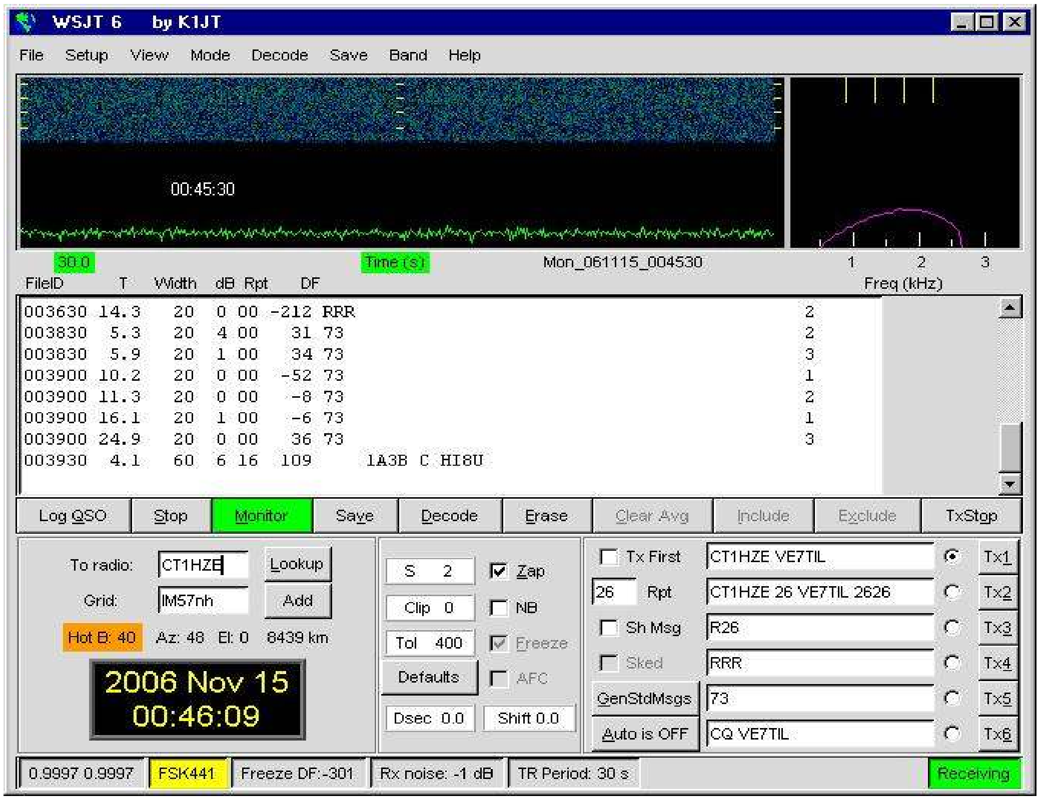

Figure 1: Note the box in the bottom rig hand corner '0.9997 0.9997' if these figures are way out of range or wildly moving around then your soundcard has issues and needs to be dealt with. See the WSJT docs for details.

By some of my other experiments using a technique known as 'clocklock' I was able to confirm the reliability of my soundcards sample rate. In fact, the 'clicklock' algorithm developed by Peter, G3PLX allows one to lock in software the sample rate in a given application and also correct the receiver's frequency drift! However, the later is another story… Hopefully someday I'll finish work on a driver to do just that or maybe someone else will? As it turns out most soundcards are pretty good and the error added to the measurement is negligible. But it is worth checking as this could also wreak havoc on JT65B operation if it is out whack and not setup correctly.

Now setup the ARGO capture feature for a full screens worth, hit start and find something else to do for a few hours.

What you should see after a time is something similar to:

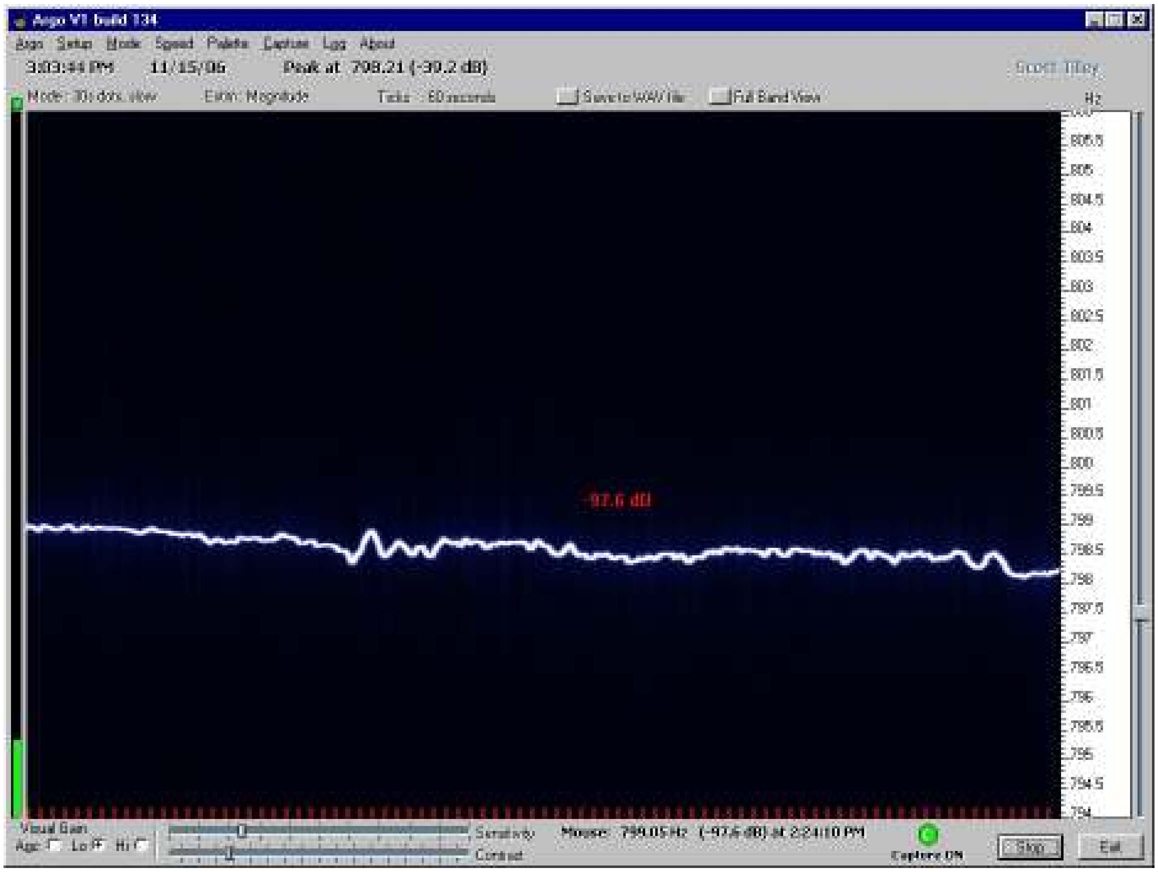

Figure 2: FT-897D w/ optional TXCO receive frequency stability at 150MHz.

So what's this mean? Well, the rig here under test is the FT-897D with the optional TXCO installed. This wiggly line is demonstrating how stable its 22.625 reference oscillator is at 150MHz. The shack temperature is fairly stable and I have already beefed up the TXCO with some Styrofoam insulation, as I'll point out in detail later. The plot shows frequency in the Y plane and time in the X. The red ticks indicate 60 second intervals. As you can see the system drifted less then 1Hz over about an hour!

We want the oscillator to be STABLE. Accuracy is of less concern as we can generally find the other guy within the pass-band of a typical RX and Doppler makes 'exact' frequency read outs somewhat suggestive. Joe, K1JT suggests in his paper *The JT65 Communications Protocol* that the JT65 decoder is somewhat resistant to small frequency drifts do to its ability to track over small groups of tone intervals. Depending on how small the groups are and the rate and relative stability of the TX and RX system things can and will get mucked up if the drifting is occurring at a level greater then the software's ability to compensate. I've asked Joe to provide a specification for the entire JT65B EME circuit.

Now we should examine the TX used here. Dave, W5UN in an EME QSO noted that my signal was difficult to decode and that he suspected that frequency drift was the problem. Suspecting the worst I fired up the old ICOM IC-251A used as my exciter for my 2m JT65B EME system. However, I soon noted that the darn thing wouldn't tune to 150MHz. No worries, I used a 7474 and divided the 10MHz reference by two and tuned the IC-251A to 145MHz to listen to the 29th harmonic of the new 5MHz reference signal. The first test I did with the IC-251A was to determine its RX frequency drift characteristic. It is shown below.

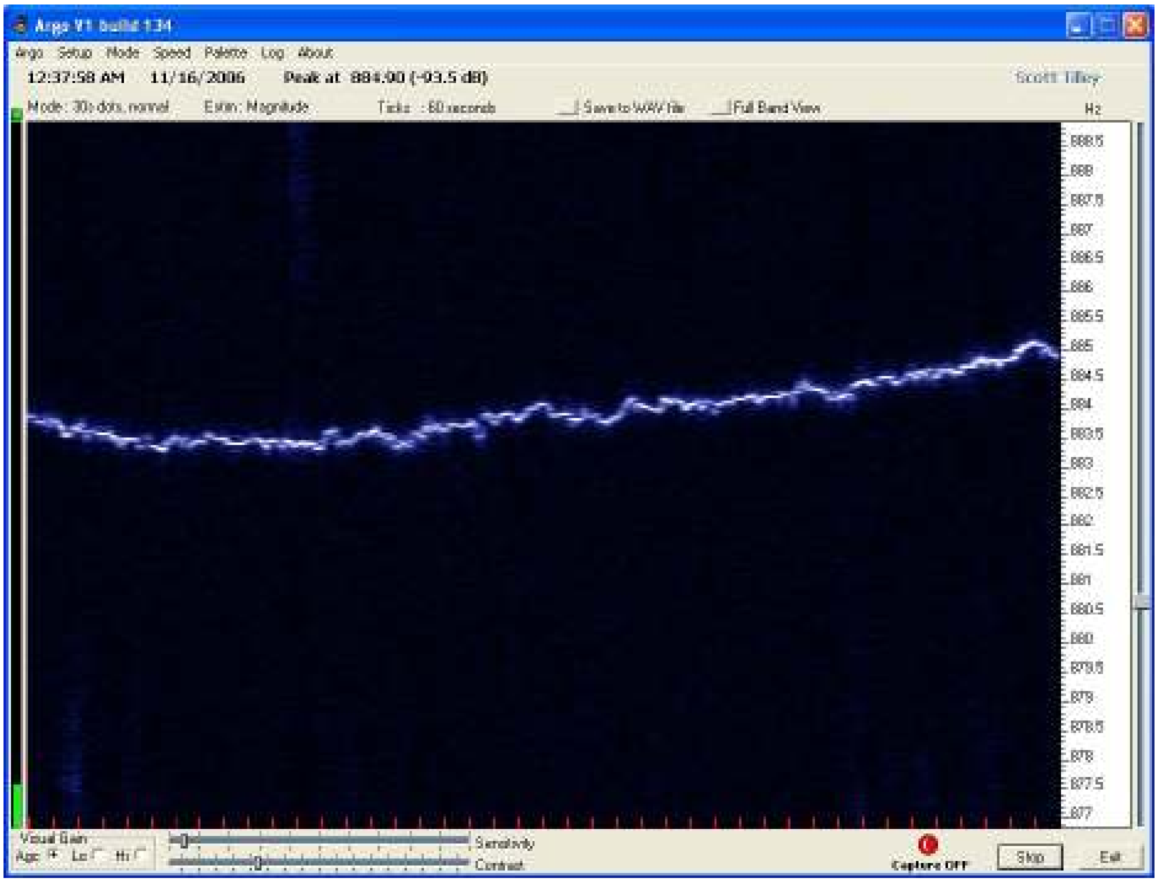

Figure 3: IC-251A receiver frequency drift.

The next test was to determine the frequency drift characteristics of the IC-251A during transmission of a test carrier. The test setup here was alittle more complex then the receive test. I used the FT-897D as the test receiver and setup the test on 145MHz once again. The GPS referenced oscillator was used to provide a reference carrier in the same receive window as the IC-251A's test carrier. This allowed me a measure of confidence control over the test to ensure the phenomenon I was observing was the effect of transmission on the IC-251A rather then some wild drift in the FT-897D. The IC-251A was driven to the level normally required to get full power out of my linear amplifier. The result is depicted below.

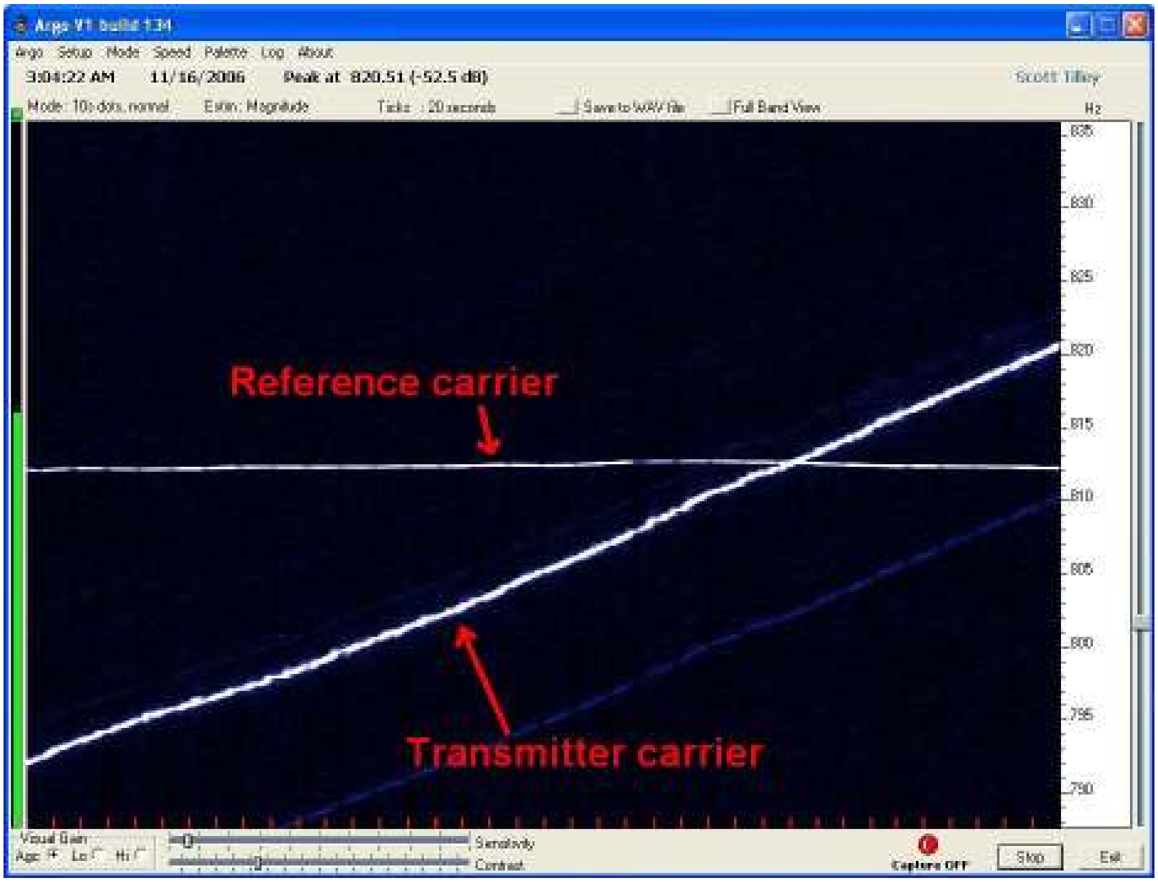

Figure 4: IC-251A transmission test results. See text for description of test method. **NOTE: that the frequency and time resolution are different then in the previous tests.**

As one can plainly see there is considerable frequency drift on the test transmitter carrier. The measured rate is approximately +2.3Hz/min. This rate of drift continues on and didn't abate much in over 30 minutes of testing.

Results

As we can see the FT-897D and IC-251A have fairly good stability on receive. However, the IC-251A exhibits a fairly considerable frequency drift at the power levels required to drive my amplifier.

Conclusion

It is yet to be determined if the dramatic drift seen in the IC-251A during transmit is significant enough to effect JT65B effectiveness over the EME path. I have sent Joe, K1JT a request for more information regarding the specification for the mode and will determine this in the near future. However, based on the information provided in *The JT65 Communications Protocol* paper it is very possible this could be a significant factor that an operator should take care to minimize during station commissioning.