

Part I of this article explored the technology behind using JT65A, a mode designed for moonbounce, to make weak-signal contacts on HF. We conclude with a guide to installing and using the JT65-HF software so you can try this fascinating mode as well.

Communicating Under the Noise

JT65A on HF – Part II

BY DAVID T. WITKOWSKI,* W6DTW, with TOMAS HOOD,† NW7US

Last month¹, we explored the weak-signal mode known as JT65A, a mode engineered specifically for weak-signal communication. We looked at how effectively this unique mode can extend your radio signal far beyond the range of voice (SSB) or even Morse code (CW) transmissions. This month, let's take a more practical look at how we use JT65A. For illustration, we will use the JT65-HF software (see <<http://sourceforge.net/projects/jt65-hf/>> for the latest version).

Modulation and Protocol

There are actually three variants of the JT65 protocol: JT65A, B, and C. The latter two are simply wider-bandwidth versions of JT65A, and are used when VCO drift is too high to allow JT65A to decode; typically this happens on VHF and above. Since HF usage of JT65 is done with JT65A, that is the only variant we will discuss in this article.

JT65 uses a 65-tone MFSK modulation scheme with constant-envelope sinusoidal tones sent over 126 contiguous time intervals, each with a length of 0.372 seconds. Tone changes between time intervals are phase-continuous, perhaps to minimize spectral regrowth created by sharp transitions in the time domain.

QSOs are conducted on alternating minutes, referred to as “even” or “first” period (:00, :02, etc.) and “odd” or “second” period (:01, :03, etc.). Trans-

missions begin at 1 second after each minute and last for 46.8 seconds, during which 378 bits are sent. Decoding starts at 47.8 seconds and, depending on factors such as the speed of your PC's processor and the width of your decode window, usually takes about 1–4 seconds. This makes for an interesting operating experience, because during a QSO only 8–12 seconds every 2 minutes require action on the part of the operator, during which he must activate the next message sequence before the start of the next sending peri-

od. Talk about “hurry up and wait”! On the plus side, this leaves the operator a lot of time to do other things. Being a Type-A personality I (W6DTW) like to multitask, so JT65A is a perfect mode for me. I often clean out my e-mail inbox or file paperwork while working stations!

Inside a JT65 Signal

JT65 transmissions include a sync tone which is sent multiple times during the period at a frequency of 1270.5 Hz above the rig's dial frequency. The fre-

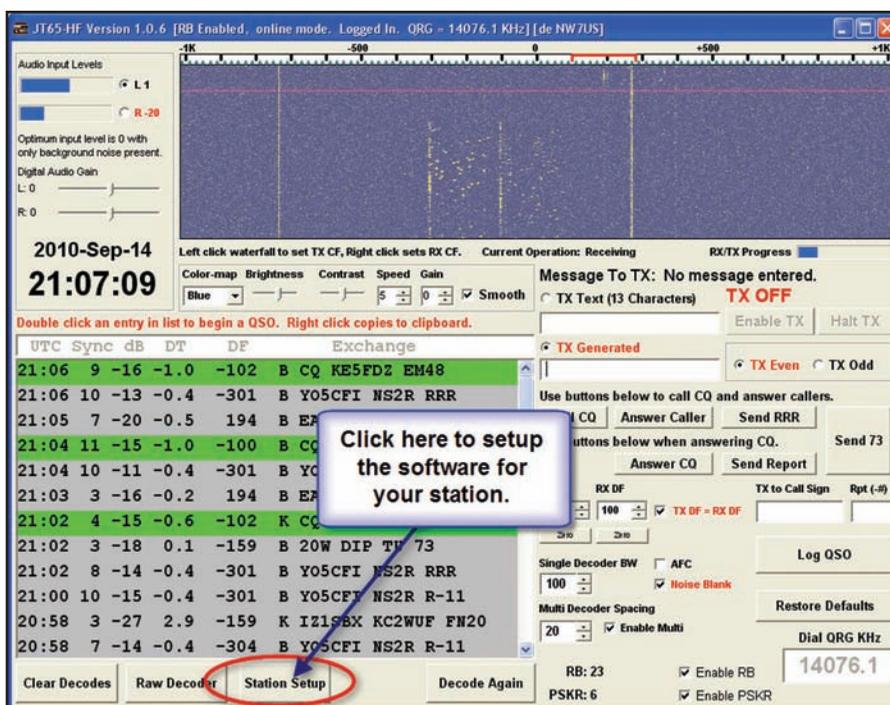


Fig. 1— Once the JT65-HF software is installed, start it up and click where indicated to begin the setup routine. See text for more. (All images from NW7US, using JT65-HF software)

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quency of this sync tone is referred to as the “DF” (differential frequency) and 1270.5 Hz is known as “DF = 0.” DF is varied by software, so there’s usually no need to adjust your rig’s dial frequency or RIT/XIT settings. We’ll look more closely at DF later in this article. See Table I for commonly-used JT65A HF frequencies.

The actual number of message bits per transmission is 72, with the rest coming from the Reed-Solomon RS(63,12) forward-error-correction (FEC) code. Reed-Solomon codes are very effective at reducing bit errors and are widely used in consumer electronics for CDs, DVDs, Blu-ray Discs, in data transmission technologies such as DSL and WiMAX, and

in ATSC (digital TV) broadcast systems. The RS(63,12) code consists of a set of “codewords” (groups of bits), and every codeword in RS(63,12) differs from every other one in at least 52 places. This means that it’s nearly impossible, even in cases of very low SNR (signal-to-noise ratio) for any JT65 sequence to be confused with another.

The redundancy ratio is 5.25-to-1, which, when combined with the FEC, results in a very robust transmission that functions well even in the presence of heavy QRM and QSB; only 20% of the 47.8-second message must be received to yield a valid decode, and the SNR can be as low as -24 dB! A transmission can be heavily corrupted, and very weak, but if the software decodes successfully, then the decoded data is virtually guaranteed to be valid.

Installing the JT65-HF Software

The JT65-HF software installation package can be found at <http://sourceforge.net/projects/jt65-hf/>. Download the most recent version (at press time, the latest version was 1.0.6), and then run the installation file (setupJT65-HF-1060). If you receive a security warning box, be sure to “allow” the installation to proceed. Follow the “Setup – JT65-HF” installation wizard prompts (accepting the license agreement and all defaults) until the software is fully installed.

After installation is complete, start JT65-HF and click on “Station Setup” (fig. 1). The “Configuration” dialog appears, defaulting to the first tab, “Station Setup” (fig. 2). Be sure to configure each setting and field with the

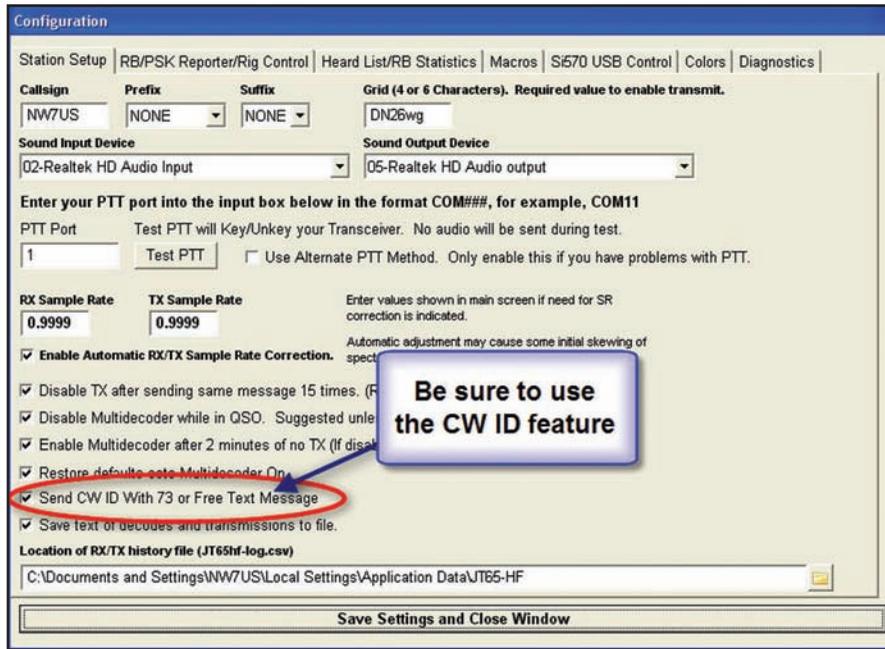


Fig. 2– This setup screen is where you configure your station. It also lets you toggle the CW ID option, a new feature in JT65-HF Version 1.0.6 (see text). When enabled, this feature transmits your callsign when the “73” message or a free text message is sent.

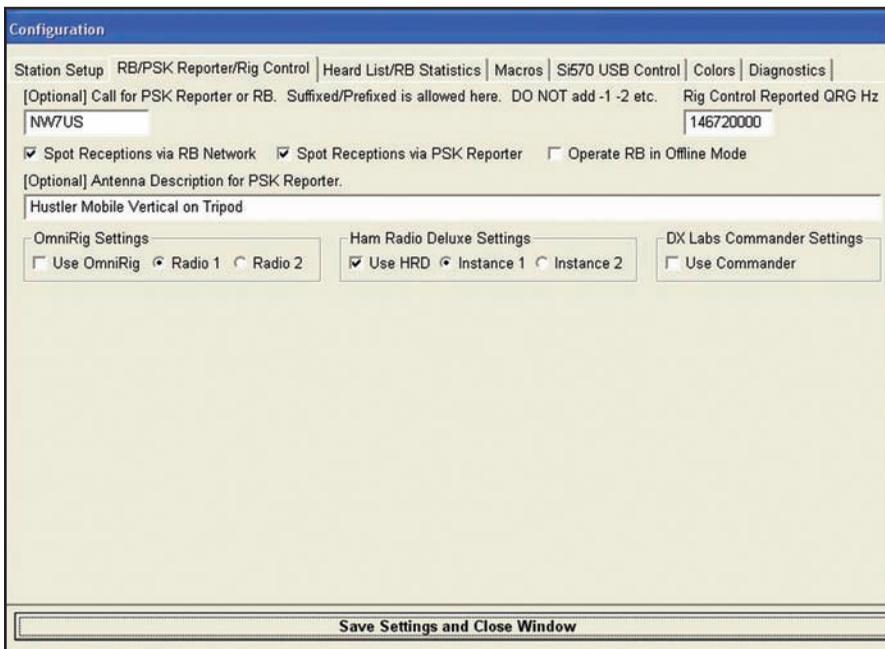


Fig. 3– The final setup step is configuring whether and how your station will communicate with the internet-based RB/PSK Reporter platforms.

| Freq (kHz) | Sideband | Note |
|------------|----------|------------------|
| 28076.0 | USB | |
| 24920.0 | USB | |
| 21076.0 | USB | |
| 18102.0 | USB | |
| 14076.0 | USB | |
| 10139.0 | USB | *see note |
| 7036.0 | USB | International |
| 7039.0 | USB | Typically Europe |
| 7076.0 | USB | USA |
| 3576.0 | USB | |
| 1838.0 | USB | |
| 1805.0 | USB | |

*Note: Do not use 10145–10150 kHz, because JT65A is *not compatible* with PSK31, MFSK, or RTTY and the other fast time-sharing modes such as PACTOR, ALE, PSKmail, and APRS.

Table I– The JT65A HF Frequency/VFO Dial Frequency. 1270.5 Hz above dial is DF = 0.

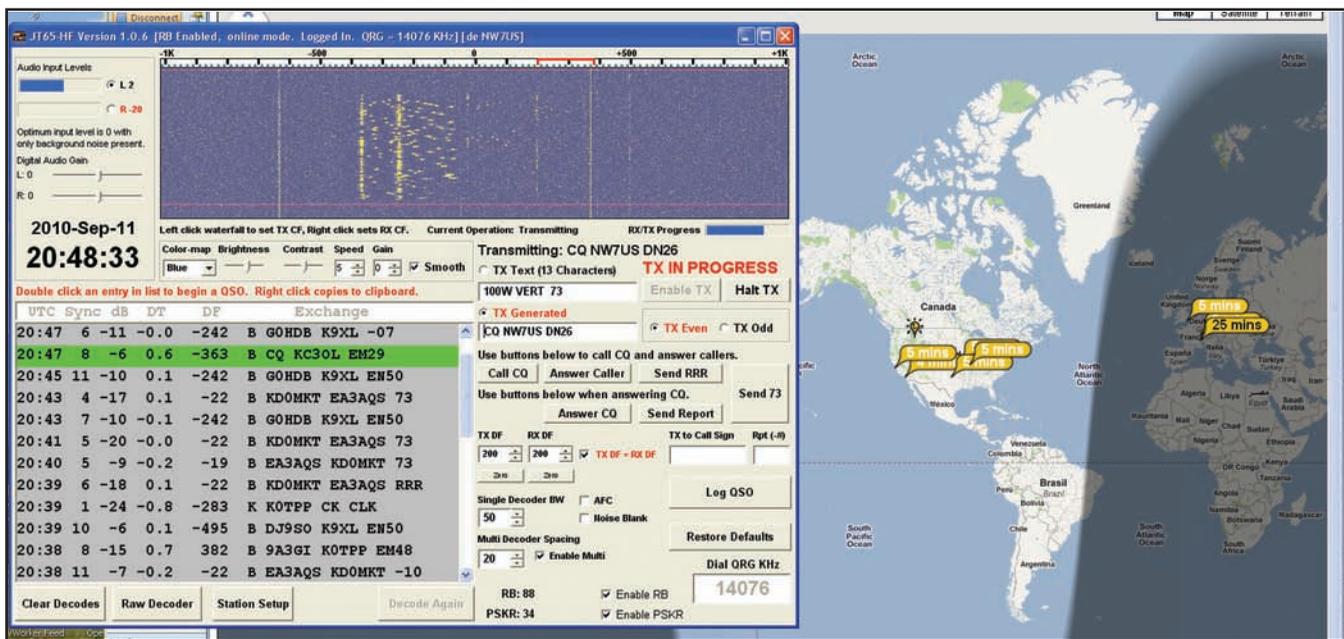


Fig. 4– NW7US calling CQ on the 20-meter JT65A weak-signal frequency of 14.076 MHz. Notice the PSKReporter map “behind” the JT65-HF window, displaying stations reporting that they “heard” NW7US. A full-screen image of this map is seen in fig. 8.

appropriate information (callsign, grid square, and so forth). We’ll discuss the CW ID option later on. When these fields are properly completed, click on the second tab, “RB/PSK Reporter/Rig Control” (fig. 3). This tab allows you to

select from several rig control options, including Ham Radio Deluxe software (which must be running if you select this option). Also on this tab are the options to report stations “decoded” by JT65-HF to the PSK Reporter web server, and

the reverse beacon server (see last month’s article about these DX aids).

When you have configured your station settings and operating preferences, click the “Save Settings and Close Window” button.

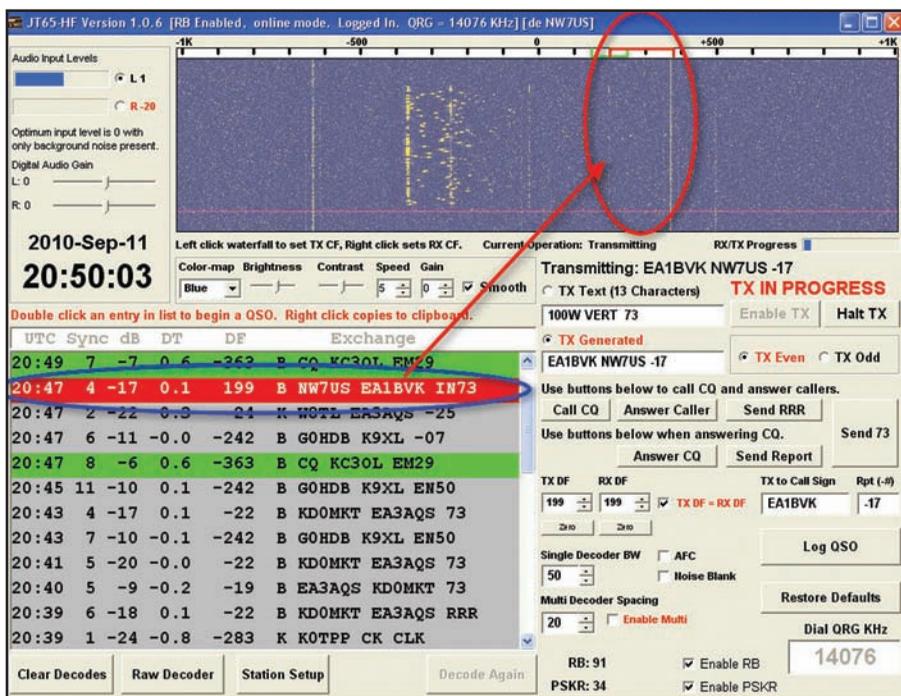


Fig. 5– EA1BVK (Spain) answers NW7US (Montana). Notice the waterfall trace of the JT65A signal from EA1BVK; the signal barely shows up in the waterfall, yet this signal (measured at -17 dB by the JT65-HF software running at NW7US) is successfully decoded. NW7US is sending the report (R-17) back to EA1BVK during the response period (see text).

The JT65A QSO

As you might have already guessed, 72 bits per period doesn’t enable a lot of rag-chewing. The JT65 protocol makes use of compression to pack as much info into the period as possible, but even with compression, a maximum of 13 characters can be sent in a random-text message (and you thought a “tweet” was short!—ed.). Supported characters are limited to 0–9, A–Z (caps only), space, and some punctuation (+ - . / ? [not including parentheses]).

A standard JT65 QSO contains everything necessary for a valid QSO: callsigns, grid squares, and signal reports. The standard QSO requires 6 periods (i.e., 6 minutes; see figs. 4–7) and proceeds like this:

CQ K1JT FN20

(First station calls CQ; note that grid square is included in CQ)

K1JT W6DTW CM97

(A second station answers CQ w/grid square)

W6DTW K1JT -18

(CQ station sends signal report)

K1JT W6DTW R-16

(Answering station sends “R” + sig report)

W6DTW K1JT RRR

(RRR indicates that the R+signal was received OK)

K1JT W6DTW 73

(RRR was received OK; end of QSO)

You may have noticed that some of these messages contain more than 13 characters. This is because the JT65 protocol uses a few clever tricks to increase the data compression efficiency, but *only if the message is written in a standard pattern*, such as those shown above. The 13 character-per-message limit applies only to random text.

Some JT65A ops have taken to using their 73 sequence to offer info on their setup, so it's not uncommon to see "K1JT W6DTW 73" replaced with "VERT25W W6DTW" (indicating 25 watts on a vertical) or "DPL10W W6DTW" (indicating 10 watts on a dipole). Sometimes when people are having trouble, you will see messages such as "CHECK CLOCK" or "NO COPY QRZ?" The use of "TU7" (short for "thank you and 73") has been gaining popularity.

It should be noted that the worldwide reverse beacon network will only upload received messages if they're in standard pattern. Thus, if you write "GUD LUK W6DTW" or "CQ EU W6DTW" the reverse beacon network will ignore the message and you won't see yourself on the spotting lists or maps (fig. 8).

Usage and Best Practices

Once you have your soundcard interfaced, your PC's clock accurately set (see Part I), and understand the odd/even QSO pattern, you're close to making your first QSO! Using JT65A on HF is fairly straightforward; it's very much like PSK31 in that there is a waterfall display of signals in the audio pass-band. Recall from earlier discussion that by default, JT65A transmissions occur at a "DF" (differential frequency) of 1270.5 Hz above the rig's dial frequency; this point in the waterfall is referred to as "DF = 0." However, the DF can be adjusted in software to zero-beat with signals above and below this frequency. Thus, a station transmitting at 830 Hz above dial frequency would be said to be at "DF = -440." Transmission of the 65 JT65A tones occurs within a bandwidth of just under 175 Hz, but in practice ops will try to keep their DFs at multiples of 200 Hz to avoid overlapping interference. That being said, using multiples of 200 Hz is not a hard and fast rule, and you will see QSOs at almost any point in the waterfall.

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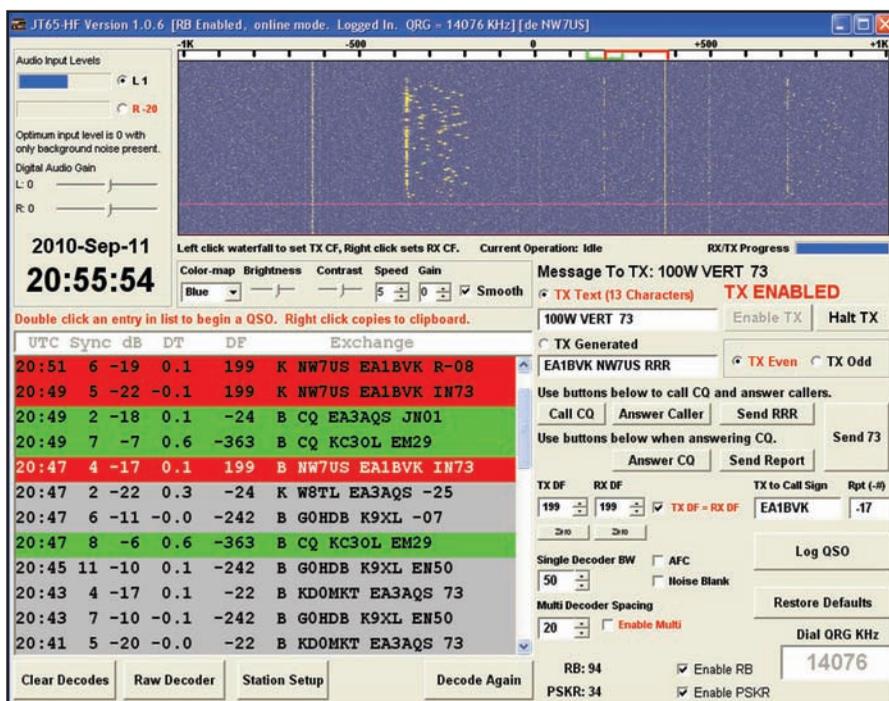


Fig. 6— EA1BVK sends the initial answer to the CQ from NW7US. This is a repeat because EA1BVK could not decode the first response transmission from NW7US. A transmission is resent if the expected reply is not decoded. Notice that EA1BVK's signal on the resent response was -22, hinting that it was as weak or weaker at his station. After the response from NW7US was successfully decoded at EA1BVK, that station sent the signal report for NW7US (R-08). NW7US then sent "RRR" to confirm reception of the report (see text).

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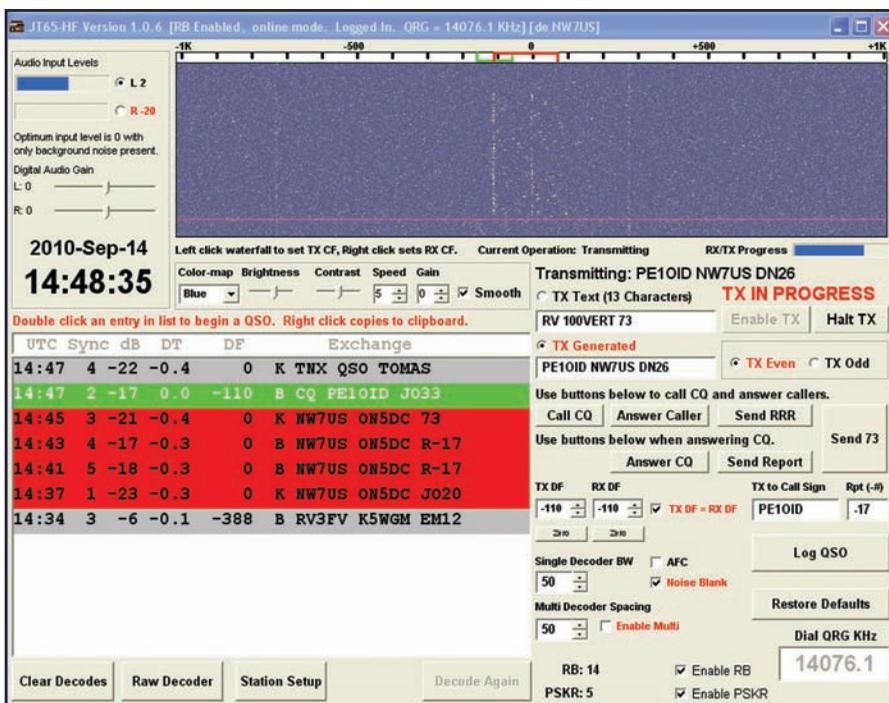


Fig. 7— A full QSO between ON5DC (Belgium) and NW7US. Notice the variation in signal strengths from period to period during the QSO (ranging from -17, best, to -23, weakest). Also notice how the signal from PE1OID is overlapping the signal from ON5DC, yet both signals are successfully decoded by the JT65-HF software, even though PE1OID's signal is barely visible on the waterfall.

Unlike WSJT, which (if set to wide decode) only decodes the strongest message, W4CQZ's JT65-HF software will decode *all* messages in the 2000-Hz receive bandwidth "window" (which is shown on the "waterfall").

When using the JT65-HF software, you'll need to adjust your thinking about the waterfall display. Clicking on the waterfall will adjust the TX and RX DF, and you can add the target's callsign and signal report manually into text fields, but there is another way.

Let's say that I just decoded a CQ from Valery, RW6BN, in Russia at DF = -332 and want to respond. Rather than click the waterfall, write "RW6BN W6DTW CM97" in the random text field, select the proper even or odd period, and click "Enable TX" (all of which would be hard to do within the 10 or fewer seconds I have between decode and the start of the next period), I can simply double-click on RW6BN's message in the decode window. This adjusts the TX and RX DF to match RW6BN's DF, generates a standard message, populates the signal-report field, sets the even/odd period to be the opposite of RW6BN, and activates "Enable TX." My message back to Valery will begin automatically at the beginning of the next period. Valery will double-click my message to him, click "Answer Caller" and "Enable TX," which will generate his response to me with a signal report. I will then click "Send Report," Valery clicks "Send RRR," and I will either click "Send 73" or enter a message such as "DPL50W W6DTW" field in place of a 73. For those of you who don't type very fast, this is a great mode!

Best Practices

Aside from standard amateur practices, using JT65A on HF requires a few additional considerations for best practice operation. This is mostly due to the sensitivity of the JT65A decoder. Excessive power, splatter, poorly-filtered TX audio lines, etc., can create interference for ops hundreds or even thousands of miles away! For example, in spring of 2010 I (W6DTW) noticed that a station in Japan was generating harmonics at 100-Hz intervals above and below his DF. I contacted him and it turns out he had a noisy power supply and the noise (50-Hz line rectified) was mixing with his transmission. From across an ocean, other JT65A ops and I could clearly see his problem, and it was generating strong enough harmonics to be decoded at various points in the waterfall.

The JT65 decoder also expects to see

the received signal level remain within a fairly narrow range of ± 5 as viewed on the audio-input-level meter. Sometimes we see new ops getting started with JT65A who think that to work DX they need to run QRO (high power), which is simply not true. In fact, doing this creates havoc for other users, because the QRO signal will often overload the decoders of everyone within 1000 miles. Fifty watts ERP is usually more than enough to work anywhere, presuming that propagation exists. WY5R has a confirmed contact with ZS2ACP (South Africa) in February 2010 from Amarillo, Texas on 40 meters using 5 watts. ZS2ACP gave WY5R an initial signal report of -10 dB, which meant that WY5R could have reduced his power by 10 times or more and still remained well within the margin for a reliable decode. Texas to South Africa using 500 milliwatts on 40 meters—talk about QRP! Stories like this are fairly common in the JT65A community.

Hardware settings are largely similar to other digimodes such as PSK31: Set the rig to max power, upper sideband, no compression or equalization, and then adjust the audio levels from the PC during transmit to control RF power out. Adjust the audio levels to control power out rather than the rig's RF power control, because at lower RF power levels the ALC is more likely to kick in and you'll start spluttering.

Owners of the Elecraft K3 should note that when running digimodes, the first five bars on the LCD scale labeled "ALC" are technically just an indication of audio drive level, like a VU meter. The bars *after* the first five *do* indicate ALC.

Therefore, K3 owners should ensure that they are showing no more than four or five bars on the ALC meter during JT65A transmit.

Be sure to check the manufacturer's rating for your rig's recommended duty cycle; JT65A transmissions are a continuous sinusoid that lasts for about 48 seconds. Most rigs are rated for 50% duty cycle, which means that if yours is rated for 100 watts SSB, you should keep the RF power out to 50 watts or below.

On the receive side, some care should be taken to maintain an audio level that's as close as possible to zero on the audio-input-level meter. This is usually set on a quiet channel, or during the 10-second pause between periods, presuming no other signals such as Olivia, RTTY, etc., are present. If you've set your receive audio level to zero and then find that the level exceeds $+5$ during someone's transmission, you'll probably be OK, but if the signal gets over $+10$, the decoder will start having trouble and so you'll want to consider adjusting the receiver gain or even activating some attenuation (see fig. 9).

It is important to remember that JT65A is an FSK mode in that it transmits distinct single tones from a tone set of 65 values. However, JT65A is not transmitted using your transceiver's FSK mode! JT65A, using whatever software you choose, uses AFSK. This is a critical distinction. Please be sure to avoid ALC action if possible with an AFSK signal. Much like any other audio input to an SSB transmitter, JT65

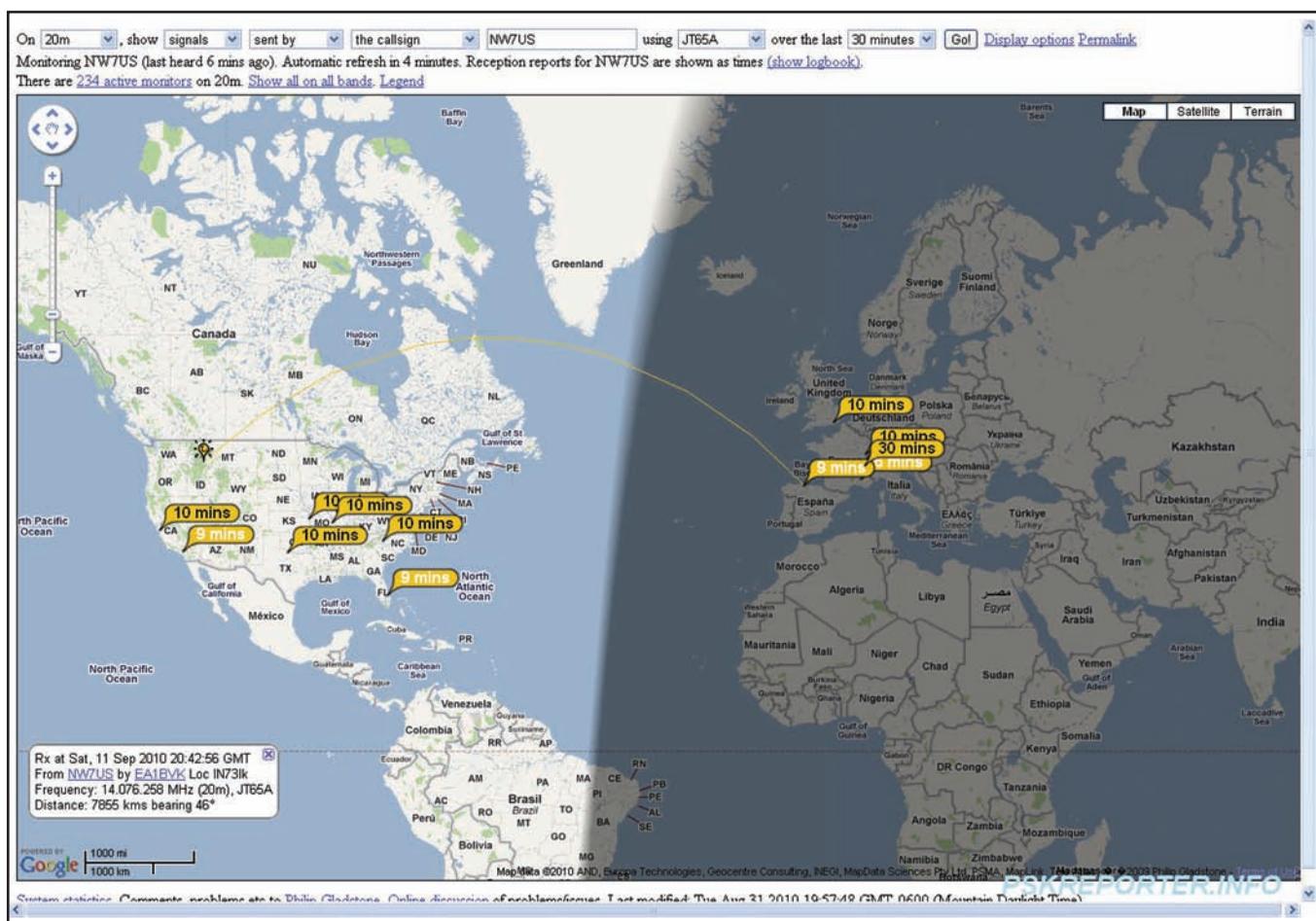


Fig. 8— The “footprint” of the JT65A signal from NW7US as revealed by the stations reporting (via PSKReporter) the reception/decoding of the signal. The great-circle plot between EA1BVK and NW7US is also shown.

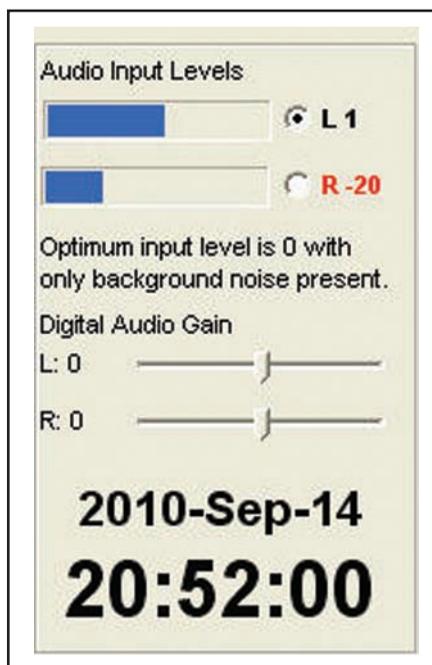


Fig. 9—It is important to be sure that you set the audio level between the radio and soundcard so that it is not overdriven. Also, it is important to set the soundcard “input” level so that the JT65-HF receive audio is at “zero.” This allows the decoding to work effectively.

can generate a poor signal if your transmitter is overdriven.

For WSJT Users

While this article focuses mainly on W4CQZ’s JT65-HF program, I wanted to offer a suggestion to users in general, and especially those who choose to operate with WSJT. Both JT65-HF and WSJT support the use of EME “shorthand” sequences for “OOO,” “RRR,” and “73.” These were created for use in extreme cases (such as the 250-dB path loss during a signal’s round trip to the Moon and back) and are strongly discouraged on HF. It’s really not necessary, because if you’ve made contact and exchanged calls, you almost certainly will be able to send standard messages containing signal reports and your 73. Besides, Part 97.119(a) of the FCC rules requires that you identify at the end of a QSO, and a “shorthand 73” doesn’t meet that requirement. To that end you should note that WSJT offers a feature for sending your callsign in CW, as does the latest public version of JT65-HF.

Recent JT65-HF Improvements

Joe Large, W4CQZ, the author of the JT65-HF software, has added experi-

mental suffix/prefix callsign support in version 1.0.6 (the version released just before press time). A lot of testing was under way at that time to see if this addition is working correctly. Joe will continue to improve this feature, as time allows. You should be able to work stations with a suffixed/prefixed call or use a suffix/prefix for your own call (say, if you are on a JT65A DXpedition to Mongolia).

Also added in this version (as noted above) is the CW ID. The CW ID feature can be enabled so that your callsign is sent when transmitting a “73” message or the free text message. The toggle for this is in the setup screen on the first tab (fig. 2).

For those using an DG8SAQ Si570 USB controller, the tab for working with it is now enabled. If you know why you need this, you’ll likely understand its options; if not, it can safely be ignored.

Closing Thoughts

JT65 is a weak-signal mode that is gaining in popularity on all of the HF bands. Because of its effectiveness with weak-signal decoding, you need to rethink your power levels. Often a few milliwatts will do amazing things. Some situations call for much higher power levels, but in day-to-day HF usage, a maximum of 10 to 20 watts is probably enough, if not too much. Of course, it is assumed that you are using a no-loss antenna system; the critical idea is that your station’s effective radiated power (ERP) is not too high. This is why stations that are operated at low power (QRP), using the most meager antenna systems (a short wire, no counterpoise, matched with a lossy antenna tuning circuit), inside a first-floor residential environment still can work DX on JT65A.

Be sure to join several of the JT65A groups and pages, especially the JT65A Facebook page at <<http://www.facebook.com/jt65mode>>, and the JT65A Google Group at <<http://groups.google.com/group/jt65-hf>>. The software package for JT65-HF is available at <<http://sourceforge.net/projects/jt65-hf/>>, and an older (soon to be updated) User’s Guide is located at <http://hfradio.org.uk/jt65-hf_setup.pdf>. If you wish to see the current JT65A spots and activity, browse to <<http://jt65.w6cqz.org/>>, <<http://www.chris.org/cgi-bin/jt65talk>> or <<http://pskreporter.info/pskmap.html?mode=JT65A>>.

Note

1. Witkowski & Hood, “Communicating Under the Noise; JT65A on HF – Part I,” CQ, October 2010, p. 32.