

JT65-HF Setup and Operations Guide

JT65-HF Version 1.0.7 ©2008...2010 J. C. Large – W6CQZ

JT65-HF is an adaptation of the JT65A protocol with an emphasis upon its usage in the high frequency Amateur bands to facilitate weak signal communications and experimentation.

JT65-HF would not be possible without the efforts of Joe Taylor – K1JT and his WSJT software upon which JT65-HF is, in part, based.

All users of JT65 whether with WSJT, MultiPSK or JT65-HF owe a debt of gratitude to K1JT and the WSJT development group for their efforts and generosity in having made the WSJT source code available and open.

While JT65-HF is based upon open source code both of my own creation and code from WSJT that has been adapted to JT65-HF it is not a part of the WSJT project and any questions/concerns with JT65-HF should only be addressed to its author – Joe Large – W6CQZ (I have also held the call sign W4CQZ).

The latest version of JT65-HF will always be available at;

<https://sourceforge.net/projects/jt65-hf/files/>

A support group where questions may be asked and for general discussion of JT65-HF is available at;

<http://groups.google.com/group/jt65-hf>

Anyone may read/search the group's archive, but posting requires registration through Google groups.

A real-time chat system for those interested in JT65 communications is available at;

<http://jt65.w6cqz.org>

For those stations reporting their receptions via the Reverse Beacon (RB) network a display of recent reports is available at;

<http://jt65.w6cqz.org/receptions.php>

For those stations reporting their receptions to the PSK Reporter network a display of recent reports is available at;

<http://pskreporter.info/pskmap.html?preset&callsign=ZZZZZ&what=all&mode=JT65&timerange=86400>

A very useful system that integrates reports from the RB Network, PSK Reporter and other spot sources is available at;

<http://hamspots.net/wsjt/>

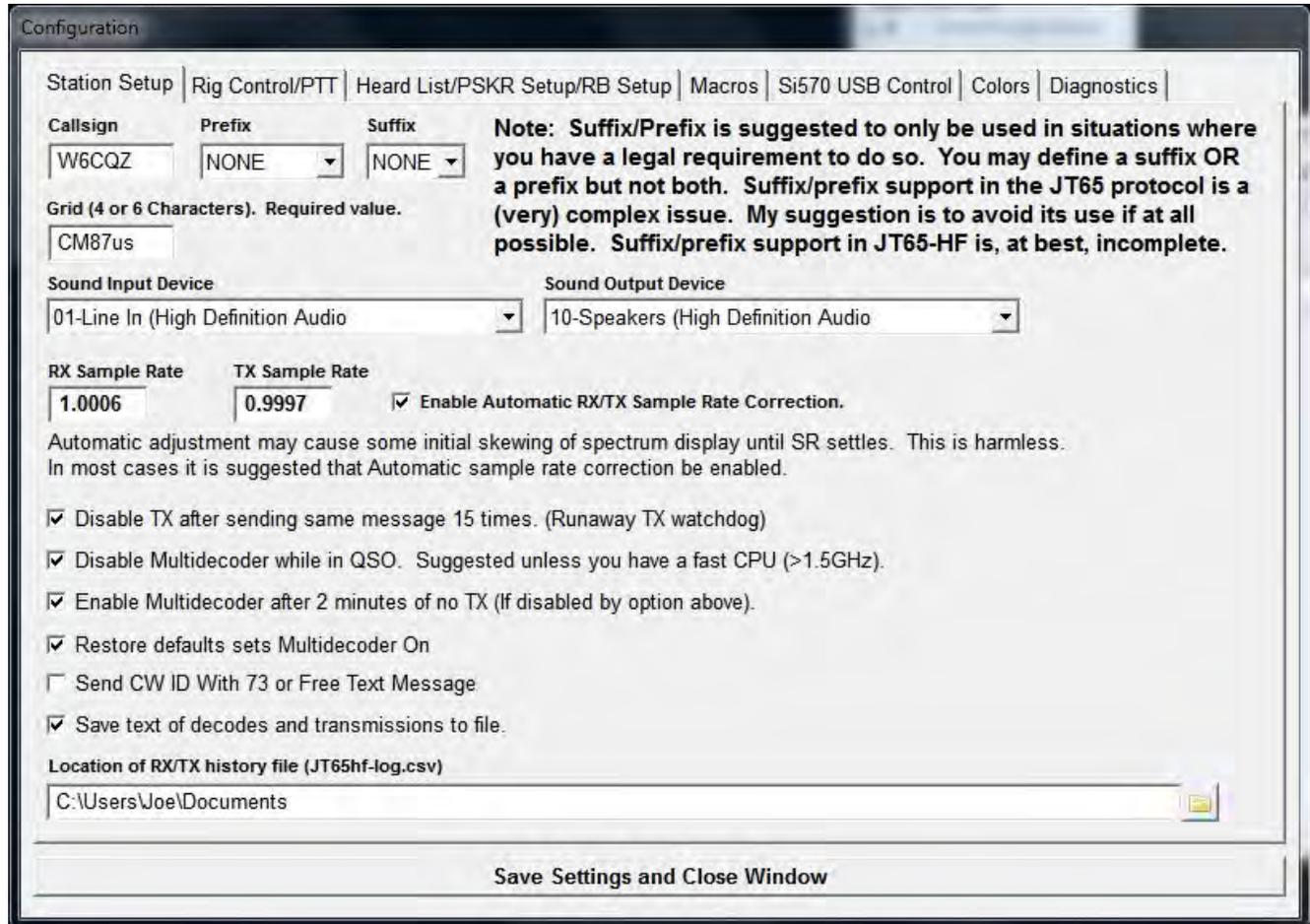
Warning!

JT65 is equivalent to 100% key down carrier for the 47 second TX duration. You can easily overheat your final amplifier if it can not handle this situation for the full duration. If you melt your finals you have only yourself to blame.

Running at full output power is seldom necessary or desirable due to the incredible sensitivity of JT65. Most users find 5 to 10 watts (or less) highly effective and 25 to 30 watts is considered 'high power'.

Initial Setup

Upon first launch of JT65-HF you will be presented with a window for configuration. While you will have many options available only a few represent critical items. Please refer to the following graphic as we work through the initial program setup.



The first item to set is your call sign and (if you must) a prefix or suffix value. As stated in the configuration screen it is strongly suggested that you avoid setting a prefix or suffix value unless you absolutely must use one to meet a legal requirement. If you must use a suffix/prefix or wonder why this is so complex please see Appendix A – The JT65 Protocol.

Grid is your Maidenhead grid square using either 4 or 6 character resolution. Your grid will only be transmitted to 4 character resolution over the air but will show to 6 character resolution when you submit reports via PSK Reporter or the RB Network. If you don't know your grid square you should be able to find yours using one of the following;

http://www.levinecentral.com/ham/grid_square.php

<http://www.qrz.com/gridfinder>

<http://f6fvy.free.fr/qthLocator/>

<http://no.nonsense.ee/qthmap/>

Sound input/output is reasonably simple if you only have one sound device within your system. In the simplest case the default values of Microsoft Sound Mapper In/Out will usually work. For more details see Appendix B – Sound Device Details.

Sample rate/display correction offers a means to correct errors in the absolute sample rate of your particular hardware. Generally you would run JT65-HF with Automatic RX/TX Sample Rate Correction enabled and let the software take care of this issue. While automatic correction works in most cases you may find that it doesn't work well with your particular hardware. To really understand this see Appendix B – Sound Device Details.

The next items offer some control over certain optional items and, in general, work well with the default selections.

Disable TX after sending same message 15 times. (Runaway TX watchdog)

This option will help prevent your station from accidentally being left in transmit enabled mode sending the same message until you (perhaps) hours later discover the program was left in TX enabled mode.

Disable Multidecoder while in QSO. Suggested unless you have a fast CPU (>1.5GHz).

In some cases a slower machine will fail to finish a decode cycle before the start of a new sequence leading you to miss being properly ready to transmit. With experience you will soon learn whether this option needs to be on with your system or not, but, I suggest leaving it enabled until you've ran the program and gathered experience to be comfortable in changing it.

Enable Multidecoder after 2 minutes of no TX (If disabled by option above).

This option will turn the multiple decoder on again if turned off by the preceding option.

Restore defaults sets Multidecoder On

Generally advisable to leave this enabled.

Send CW ID With 73 or Free Text Message

If you would like to send an ID in Morse at the end of your QSO you enable that here. Unless required legally it is a personal choice whether to enable this or not. For myself, I tend to leave it on as it was a lot of work to code and I like using it.

Save text of decodes and transmissions to file.

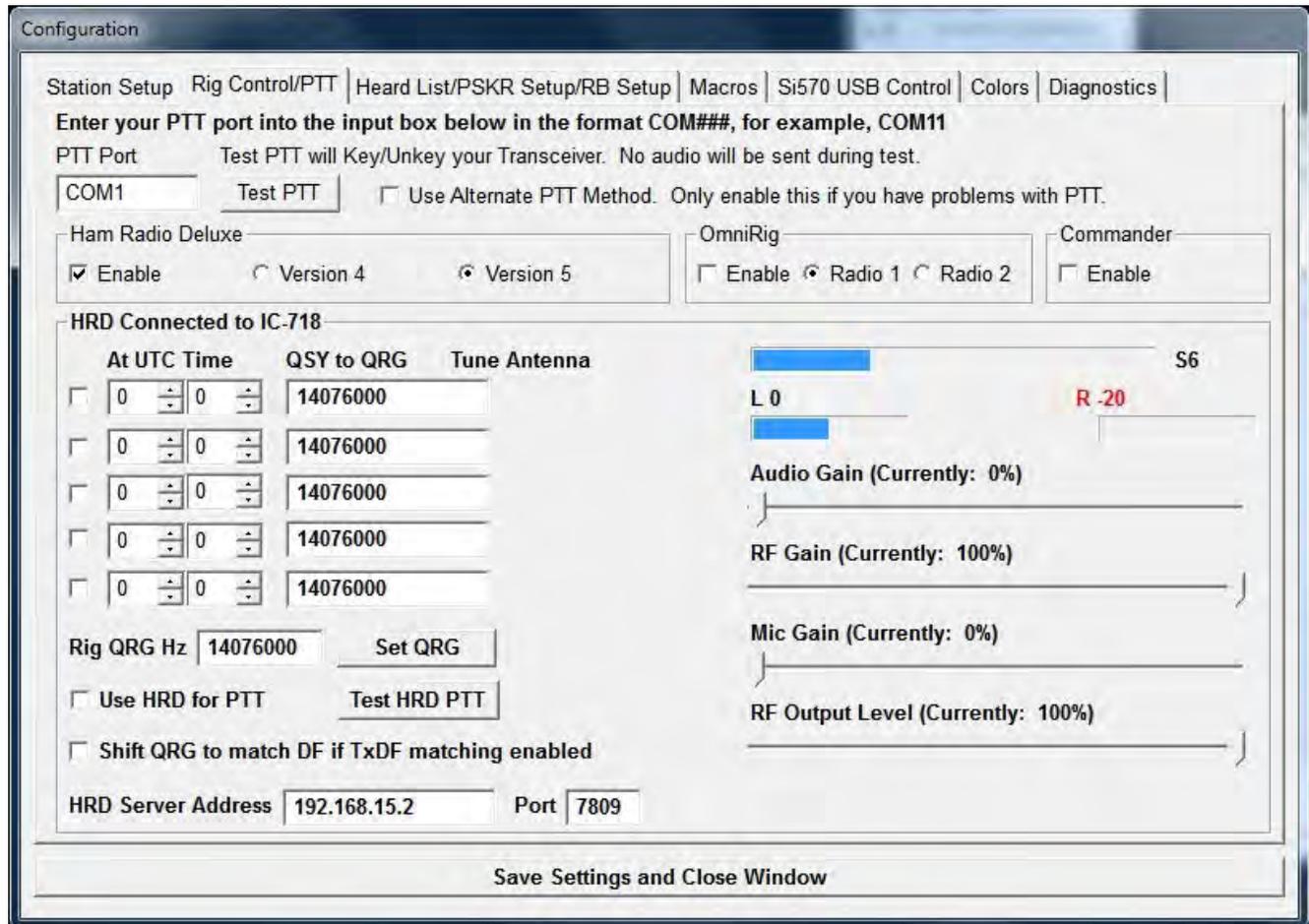
If enabled a log will be kept of your receptions and transmissions in a text file using CSV formatting. For details please see Appendix C – CSV RX/TX Log.

Location of RX/TX history file (JT65hf-log.csv)

Allows you to define the location for the RX/TX log. I strongly suggest you change this from

the default value if you use this feature.

The next phase of Setup is Rig Control/PTT and is illustrated in the following graphic.



Please note that you will not see the lower portion of the window shown above upon initial configuration. The details for HRD (Ham Radio Deluxe) only become visible when support for HRD has been enabled.

To configure PTT for JT65-HF you will need to have some information ahead of time. Firstly will you be controlling PTT (TX Keying) via a serial port interface where one of the RS-232 lines drives the PTT line or using VOX (voice activated keying) or PTT via a rig control method?

If using VOX simply leave the input box for PTT Port set to its default value of NONE.

If using a dedicated serial port interface enter its address as COM# or simply #. COM1 and 1 evaluate as the same. JT65-HF does not offer a listing of available ports or a method to 'search' for the proper port as seen in some programs. In some cases JT65-HF will fail to work properly with its default serial control routines. If you experience oddities with serial PTT control try ticking the User Alternate PTT Method check box.

Note: Users running JT65-HF with Wine in either Linux or Mac OS X may find the

alternate PTT method the only serial PTT method that works.

Once you've entered a port value you may press the Test PTT button to perform an RX to TX to RX cycle. No audio will be sent to your rig during this test so, less any noise on the audio line, you should not actually transmit any signal.

If using PTT via Rig Control you will be limited to using HRD as your rig control method as it is, so far, the only rig control interface with full functionality for controlling PTT. It is also presently the only interface that allows sending values to your rig from JT65-HF. At this time OmniRig and DX Labs Commander only support reading the rig's dial frequency.

For the most reliable setup I suggest not using rig control and using a serial interface PTT device or VOX, but, many (myself included) have had great success using full rig control.

Rig control setup begins with selecting a method. As stated above you must use HRD if you wish to control PTT via rig control (or in the Icom world CAT control). If you presently use HRD and can control PTT via it or DM-780 you should have no difficulty doing the same with JT65-HF.

If using HRD you will need to determine if you're running the older HRD version 4 or newer version 5 code. In my (limited) testing I've found that selecting version 5 support will work with HRD V4 and V5 but selecting version 4 will only work with HRD V4. To determine the version of HRD you have installed you may select the Help menu in HRD and click on About... to be presented with the needed information.

Once you've selected the appropriate HRD version support you may enable it by ticking the check-box labeled Enable. Please insure that HRD is running on your computer and properly communicating with your rig before doing this.

Assuming all is well you will then be presented with a window similar to that pictured above. You may not see all controls in the example as not all rigs support the same control set available on my rig (for instance, some don't have the controls for audio levels, power level so those would not appear).

Note: In the example graphic I have set JT65-HF to access HRD on a second computer. Normally you would always use the default value of localhost for HRD Server Address and port 7809! Only change those values if you absolutely know you need to. If you do change the address/port values you will need to disable HRD support and re-enable to have the change take effect.

If JT65-HF is able to connect with HRD you should, at least, see the caption change to HRD Connected to some rig and the Rig QRG Hz input box should show your rig's dial frequency setting. You may or may not see an S-Meter indication as some rigs don't convey this and others don't (yet) work with JT65-HF. Much of this support is totally new for version 1.0.7 and is still a work in progress.

If you wish to use PTT via HRD you may test its function with the Test HRD PTT button and, if it works, then enable its use with the Use HRD for PTT check box. If you do not see either the button for testing HRD PTT or the check box for enabling it HRD has reported to JT65-HF

that your rig does not support PTT control.

If you would like to test changing your rig's frequency you may enter a value in HERTZ and push the set QRG button. Future versions will allow entering frequency values in other units, but, for now you must do so in Hertz, for example, 21076000.

Shift QRG to match DF if TxDF matching enabled will become available in JT65-HF 1.0.8 as it's simply not quite ready for general use. Once available, this will enable a VFO QSY to match your frequency to a station you're calling versus the current method of shifting your audio tones to zero beat.

This leaves the boxes for automatic QSY functionality. If you wish to QSY on some schedule you may set a UTC hour and minute for the QSY, enter the frequency in HERTZ and tick the check box to the left side of the parameters. In version 1.0.8 the ability to run an auto antenna tune cycle upon QSY and/or change to different antenna selection(s) will be enabled for those rigs supporting those functions. Again, those items aren't quite ready for 1.0.7.

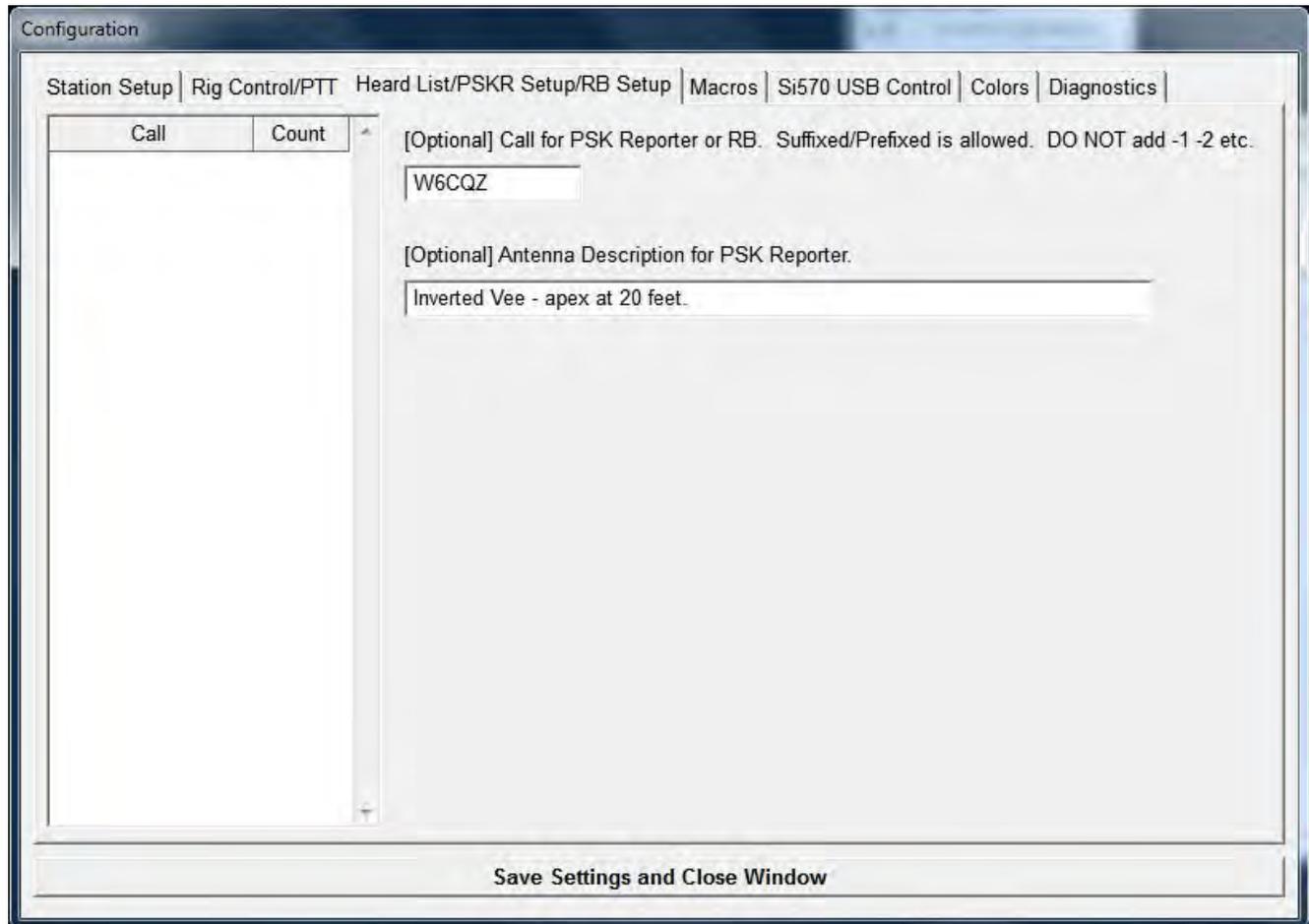
Alternate rig control methods – OmniRig and DX Labs Commander.

Follow the instructions accompanying the software, confirm it works, insure the desired program is running and enable.

Again, please note that with OmniRig and Commander you will only be able to read your rig's frequency. I hope to provide full support as seen with HRD in later versions for Commander then OmniRig.

Heard List/PSKR/RB Setup

This configuration window is all optional configuration and information display.



The heard list simply keeps track of all call signs heard and a count for each running of JT65-HF. In future versions much more will be done with this page like sorting calls and having triggers for actions if a certain grid is heard, but, that's all for the future for now.

If you wish to use a different call sign for your spots to PSK Reporter or the RB Network you may define it here as well. Normally you would simply let this default to your configured call sign, but, you might wish to define a custom version if you were operating from a different location than your normal one. For instance, here, I could define my call for PSKR/RB as W6CQZ/W4... of course, this has no bearing on what your over the air call sign is, only for internet reporting of receptions.

Macros. All optional, reasonably self-explanatory.

Configuration

Station Setup | Rig Control/PTT | Heard List/PSKR Setup/RB Setup | **Macros** | Si570 USB Control | Colors | Diagnostics

QRG Definitions.

1 - 1838 KHz Commonly used JT65 dial QRG values have been predefined for the first 12 slots. You may define 4 custom values. These will be usable when setting QRG from the main program screen by right clicking on the QRG entry box.

2 - 3576 KHz

3 - 7039 KHz

4 - 7076 KHz

5 - 10139 KHz

6 - 10147 KHz

7 - 14076 KHz

8 - 18102 KHz

9 - 18106 KHz

10 - 21076 KHz

11 - 24920 KHz

12 - 28076 KHz

13 -

14 -

15 -

16 -

Message Definitions

1 - Short Hand RO

2 - Short Hand RRR

3 - Short Hand 73

4 -

5 -

6 -

7 -

8 -

9 -

10 -

11 -

12 -

13 -

Message definitions is used for entering free text messages. You may define up to ten of these each limited to 13 characters and may only contain the 43 characters of the JT65 character set, which is;

0123456789ABCDEFGHIJKLMNO
PQRSTUVWXYZ +-.!/?

Right clicking in the Free Text entry box in the main program screen will present a dialog of these message definitions. Note. The first 3 fixed entries send the JT65 shorthand sequences and should only be used when absolutely necessary.

Do not begin a free text message with RRR, RO or 73 as it will be sent as shorthand even if you add text to the first 'word' (RRR, RO, 73). This will be corrected in future versions.

Save Settings and Close Window

Si570 USB Control. **VERY experimental feature. See Appendix D – Si570 Control.**

Configuration

Station Setup | Rig Control/PTT | Heard List/PSKR Setup/RB Setup | Macros | Si570 USB Control | Colors | Diagnostics

VERY experimental control of Si570 VFO using DG8SAQ USB Interface.

Enable Si570 Control.

VFO Frequency in Hertz. This will be multiplied X4 unless multiplier option is unchecked.
For SoftRock SDR devices you should use X4 multiplier!

Correction in Hertz. This will be added to QRG before setting Si570. Use - sign to have a negative correction.

Multiply Entered Frequency X4 Use Si570 PTT Control
 Multiply Entered Frequency X2
 Multiply Entered Frequency X1

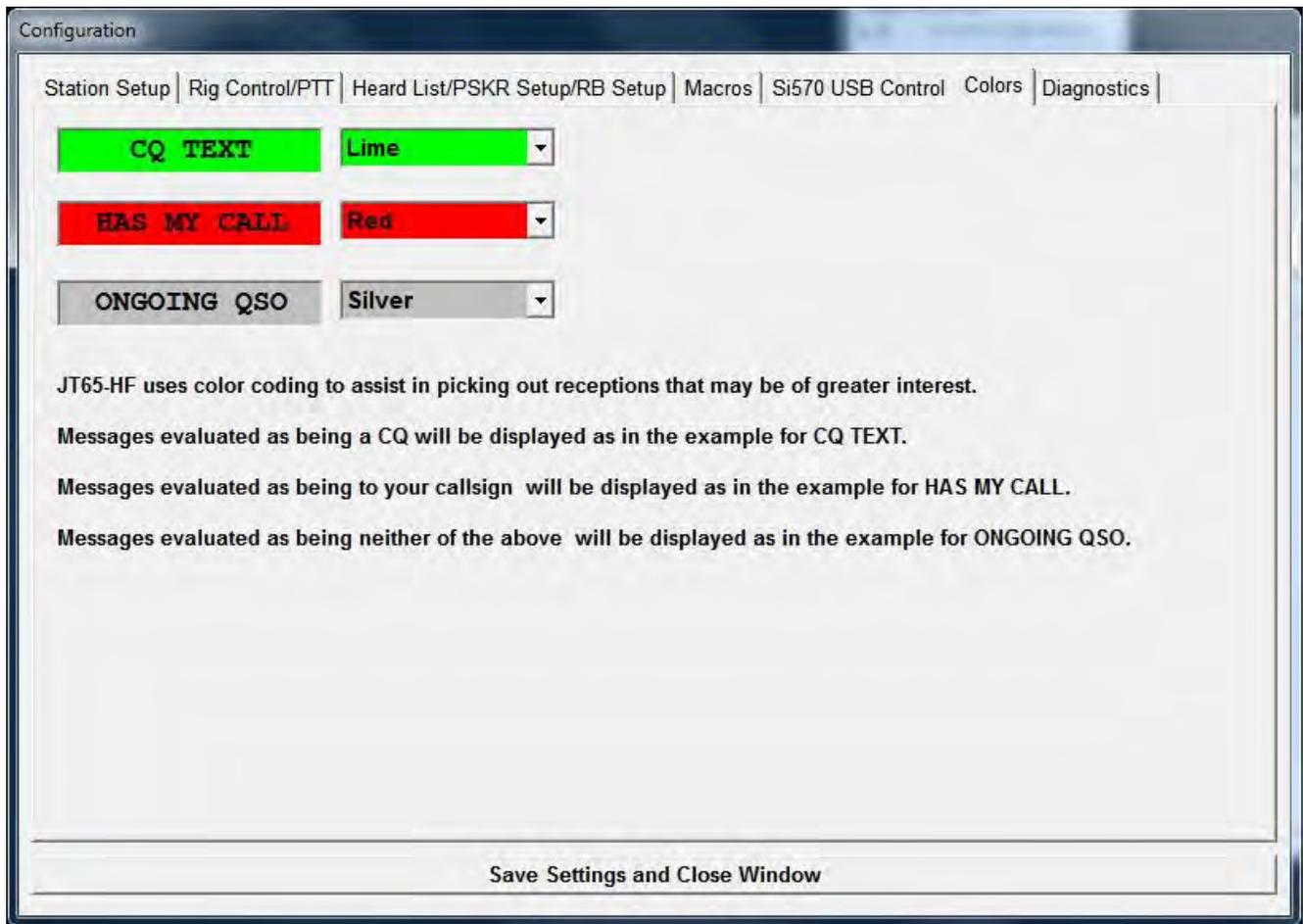
Indicated QRG KHz: 000000 Si570 QRG KHz: 000000

NOTE: This will only control an Si570 via USB connection. You must continue to use software such as Rocky or PowerSDR as the radio software!

JT65-HF does NOT implement an SDR RX/TX platform at this time.

Save Settings and Close Window

Colors. Optional, reasonably self-explanatory.



Diagnostics. Display various information about the inner working of JT65-HF and any (generally) non-critical issues. Please note the one check box at the bottom... as it says, do not tick the box unless you've been given specific reason to do so. Disabling optimal FFT could lead to a **much** longer time to complete decodes.



This completes station setup topics. You will have access to this configuration system from the main program window and each new version of JT65-HF will prompt you to review configuration as well.

Using JT65-HF

Before making your first attempt at a JT65a QSO please confirm you have completed the following checklist.

Your call sign and grid have been set to correct values. TX will not be available if either your call sign or grid is not properly configured.

PTT and (if used) Rig control is properly configured and tested.

Your computer's time is synchronized properly with UTC. **The built in time sync methods in Windows XP/Vista/7 is not an acceptable time sync solution.** For options see Appendix E – JT65 and Time Sync.

Know that JT65a is a transmission lasting (approximately) 48 seconds and running high power levels may overheat your rig.

Know that JT65a is meant to make exceedingly weak signal contacts and running more power than necessary is neither of use or 'friendly' to others sharing the limited space we have.

Know the proper sequence of a 'standard' JT65 QSO.

Before getting to using JT65-HF I would suggest that you skip ahead to Appendix A – The JT65 Protocol and, at least, get an idea of how the JT65 protocol works, its advantages and why it is so [seemingly] limited in some ways.

The proper sequence of a JT65 QSO (at least on HF).

Assume I see VE3ODZ calling CQ and I engage in a QSO with him it would run something like the following;

CQ VE3ODZ FN03	1 – VE3ODZ is calling CQ
VE3ODZ W6CQZ CM87	2 – I answer VE3ODZ with my call sign and grid
W6CQZ VE3ODZ -13	3 – VE3ODZ answers my call with a report (-13)
VE3ODZ W6CQZ R-08	4 – I acknowledge my report (R) and send his (-08)
W6CQZ VE3ODZ RRR	5 – VE3ODZ acknowledges my report (RRR)
VE3ODZ W6CQZ 73	6 – I end the QSO with a 73
W6CQZ VE3ODZ 73	7 – VE3ODZ ends the QSO with a 73

That's it. The 'perfect' JT65 QSO. Call signs exchanged, locations (grids) exchanged, signal reports exchanged and confirmed with R- and RRR and lastly QSO ended with the 73 messages.

Messages 6 and 7 could be replaced with free text messages, for instance I could send 10W DIPOLE 73 (and would ID with CW ID if I had it enabled – which I should since that would meet the [USA] legal requirement that I ID with my closing transmission. If I sent the standard 73 message the CW ID would be redundant since I sent my call sign in the message itself).

You could also use the shorthand RRR for the 5th frame and the shorthand 73 for the 6th and 7th, but, please remember that **JT65-HF does not decode shorthand messages if the multiple decoder is enabled**. This is due to the time required to run the decoder. Evaluating for shorthand messages can almost double the multiple decoder cycle's time requirement. It really only makes sense to use the shorthand sequences when working at the absolute lowest limits of JT65's detection ability (signal of -25 or less).

The example above is essentially all you can do with JT65. You can't send a 'brag tape' or convey War And Peace with it, but, you can complete a minimal QSO at often very very weak signal levels using low power and sub-optimal antennas. In comparison to other modes JT65 allows doing things with relative ease that would be impossible or very difficult. The price paid for this extraordinary weak signal capability is its restrictive 'vocabulary'. For many of us that is a small price to pay and not being able to have a rag chew QSO is worth being able to have an 'impossible' QSO.

JT65-HF, Main interface.

The screenshot shows the main interface of JT65-HF Version 1.0.7. The window title is "JT65-HF Version 1.0.7 [RB Enabled, online mode. Logged In. QRG = 14076.1 KHz] [de W6CQZ]". The interface is divided into several sections:

- Top Menu:** Setup, Rig Control, Raw Decoder, Stations Heard, Transmit Log, About JT65-HF.
- Waterfall Plot:** A frequency spectrum display with a red cursor at 0 Hz. The x-axis ranges from -1K to +1K Hz.
- Left Panel:** Audio Input Levels (L: 0, R: -20), Digital Audio Gain (L: 0, R: 0), and a date/time display showing "2010-Oct-06 22:01:44".
- Center Panel:** A list of decoded messages with columns for UTC, Sync, dB, DT, DF, and Exchange. The current message is highlighted in green: "21:59 5 -8 -0.4 740 K CQ VE3ODZ FN03".
- Right Panel:** TX controls including "Message To TX: No message entered.", "TX OFF", "TX Text (13 Characters)", "TX Generated", and buttons for "Call CQ", "Answer Caller", "Send RRR", "Answer CQ", and "Send Report".
- Bottom Panel:** TX DF, RX DF, TX to Call Sign, Rpt (-#), Single Decoder BW, AFC, Noise Blank, Enable Multi-decoder, RB: 20, PSKR: 8, and Dial QRG KHz (14076.1).

It's difficult at best to contain everything needed to operate JT65-HF in one window of a size that is usable on most systems. After two years work the image above represents hundreds of changes both graphically and functionally from where the program began.

In time, I hope, it will present less information overload than it must to a new user, but, realistically, you may ignore many portions of the UI until you've gained experience with both the program and the communications protocol it implements. With experience things that make little or no sense initially should become more clear.

Lets begin at the top and take a look around the UI.

The menu at the very top will allow you to access the setup, rig control, raw decoder output (more on this later), stations heard list, transmit log (a display of what you've transmitted during this running) and an informational screen about JT65-HF.

The screenshot shows the JT65-HF software interface. At the top, the title bar reads "JT65-HF Version 1.0.7 [RB Enabled, online mode. Logged In. QRG = 14076.1 KHz] [de W6CQZ]". The menu bar includes "Setup", "Rig Control", "Raw Decoder", "Stations Heard", "Transmit Log", and "About JT65-HF".

On the left, the "Audio Input Levels" section shows "L 0" and "R -20" with sliders. Below this, it states "Optimum input level is 0 with only background noise present." and "Digital Audio Gain" with sliders for "L: 0" and "R: 0".

The central waterfall display shows a spectrum from -1K to +1K Hz. A red vertical line is positioned at 0 Hz. The display shows several vertical lines of activity, with some highlighted in yellow and others in green.

Below the waterfall, there are controls for "Color-map" (set to Blue), "Brightness", "Contrast", "Speed", and "Gain". A "Smooth" checkbox is checked. The "Current Operation" is "Receiving".

The "Message To TX" section shows "No message entered." and "TX OFF". There are buttons for "Enable TX" and "Halt TX".

The "TX Generated" section has radio buttons for "TX Even" and "TX Odd".

The "Use buttons below to call CQ and answer callers." section has buttons for "Call CQ", "Answer Caller", and "Send RRR".

The "Use buttons below when answering CQ." section has buttons for "Answer CQ" and "Send Report".

The "TX DF" and "RX DF" sections have spinners set to 0. The "TX DF = RX DF" checkbox is checked. There are "Zero" buttons for both.

The "Single Decoder BW" section has a spinner set to 100. The "AFC" checkbox is checked, and the "Noise Blank" checkbox is unchecked.

The "Enable Multi-decoder" checkbox is checked. The "Dial QRG KHz" is set to 14076.1. There are checkboxes for "Enable RB" and "Enable PSKR", both of which are checked.

The "RB: 20" and "PSKR: 8" settings are visible.

At the bottom left, there is a "Clear Decodes" button. At the bottom center, there is a "Decode Again" button.

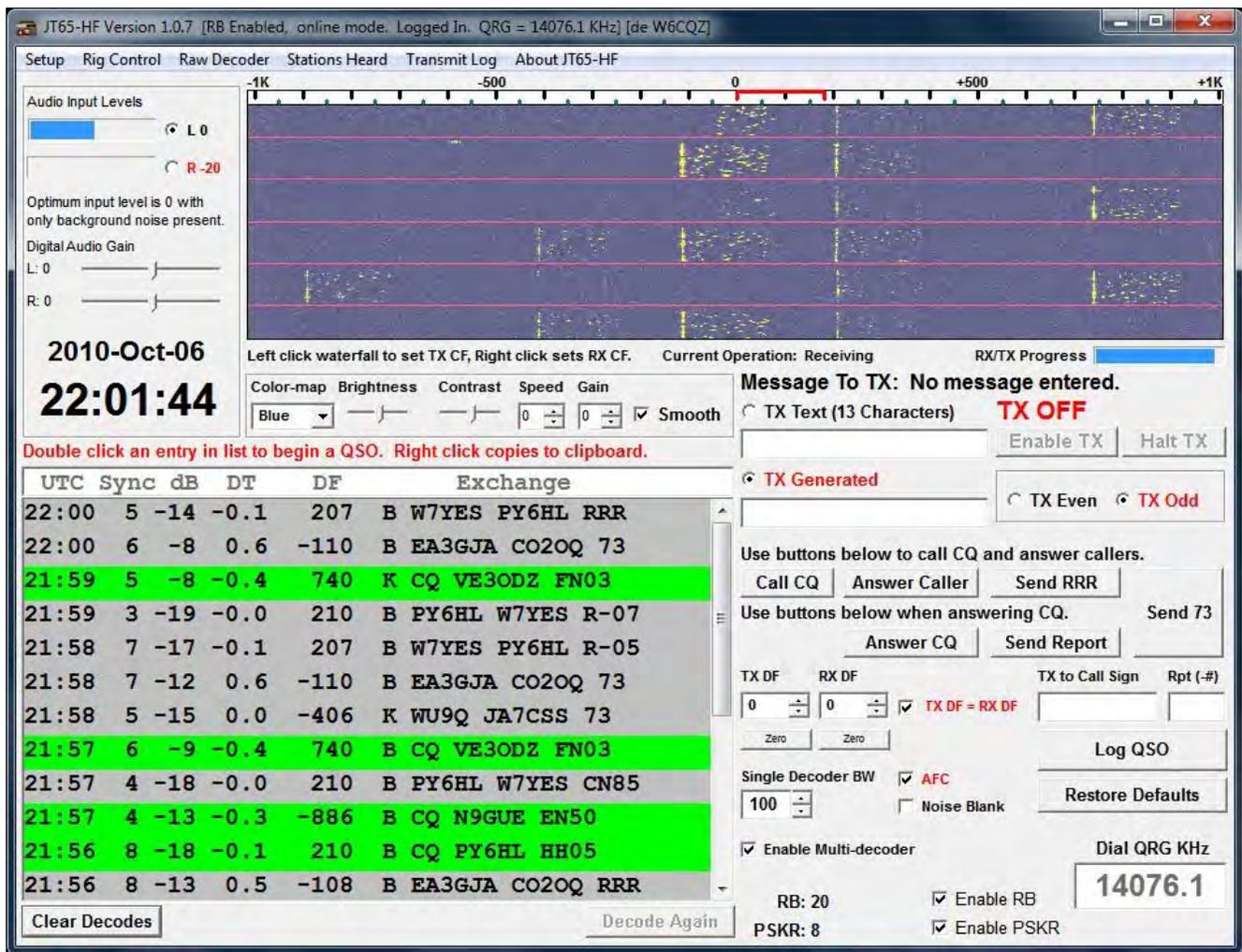
The main display area shows a list of decoded messages with columns for UTC, Sync, dB, DT, DF, and Exchange. Several rows are highlighted in green:

UTC	Sync	dB	DT	DF	Exchange
22:00	5	-14	-0.1	207	B W7YES PY6HL RRR
22:00	6	-8	0.6	-110	B EA3GJA CO2OQ 73
21:59	5	-8	-0.4	740	K CQ VE3ODZ FN03
21:59	3	-19	-0.0	210	B PY6HL W7YES R-07
21:58	7	-17	-0.1	207	B W7YES PY6HL R-05
21:58	7	-12	0.6	-110	B EA3GJA CO2OQ 73
21:58	5	-15	0.0	-406	K WU9Q JA7CSS 73
21:57	6	-9	-0.4	740	B CQ VE3ODZ FN03
21:57	4	-18	-0.0	210	B PY6HL W7YES CN85
21:57	4	-13	-0.3	-886	B CQ N9GUE EN50
21:56	8	-18	-0.1	210	B CQ PY6HL HH05
21:56	8	-13	0.5	-108	B EA3GJA CO2OQ RRR

Below the menu bar, starting on the left, you have the audio input controls/indicators. Notice in the example only one audio channel is active (the one showing 0) and it is the selected audio channel (the radio button is ticked). With background noise or weak(er) signals present the audio level ideally should be zero (0). Audio level is discussed in detail in Appendix B – Sound Device Details and, at some point, should be considered required reading.

The right portion houses the spectrum display (waterfall display) and its controls. Across the spectrum display's top is a marker indicating offset in 100 and 50 hertz increments from the audio pass band's center point. The red marker indicates where your transmitted tones will fall. The center frequency of the JT65-HF audio pass band is 1270.46 Hz (or ~1270.5 Hz) and knowing this you can easily calculate where the actual RF tones will fall. Simply take the dial QRG, add 1270.5 then add the offset to find the lower absolute edge in RF. Add 200 Hz to that and you'll have a close figure for the upper bounds. [A JT65a signal is not quite 200 Hz wide, but, for quick calculations it's close enough. The actual maximal width of JT65a is 174.9605 Hz.]

For example; Frequency = 14076000 Hz, TXDF = 0. Lower RF limit = 14076000 + 1270.5 + 0 = 14,077,270.5 Hz and the upper limit is then 14,077,470.5 Hz. It's important to understand where your actual RF tones fall in case you're ever operating near a band's edge, or simply to know what's happening... though it's not (usually) something you will have to think about.



The spectrum display is divided into periods (1 minute segments) by the horizontal red lines. In the example you can see several JT65 signals over about 6 minutes time. The 'real time' signal will always be at the top of display down to the first red line. Notice a weak JT65 signal at about +200 Hz offset, a stronger signal at about +750 and an unidentified signal at about -50 Hz. Take note that the transmitted tones would begin at offset 0 as indicated by the red TX marker should you begin transmit. And, more importantly, if you began, for instance, calling CQ without adjusting your TX DF (offset) you would potentially be transmitting partially over a signal at just under your TX marker.

[For those accustomed to WSJT you will find the spectrum display both familiar and different. It looks similar to SpecJT but it does not accept double clicks to force a decode at the clicked DF offset. JT65-HF's spectrum display may be single left clicked to set the TX tone offset or single right clicked to set the RX tone offset. If TxDF=RxDF is enabled then these clicks effectively do the same thing. More on this later.]

Below the spectrum display you see the controls for it, those being Color-map, brightness, contrast, speed, gain and smooth.

Color-map offers a choice of different color pallets for the colorized spectral data. There is no 'right' choice. I suggest trying them and see if, hopefully, one will be your favorite.

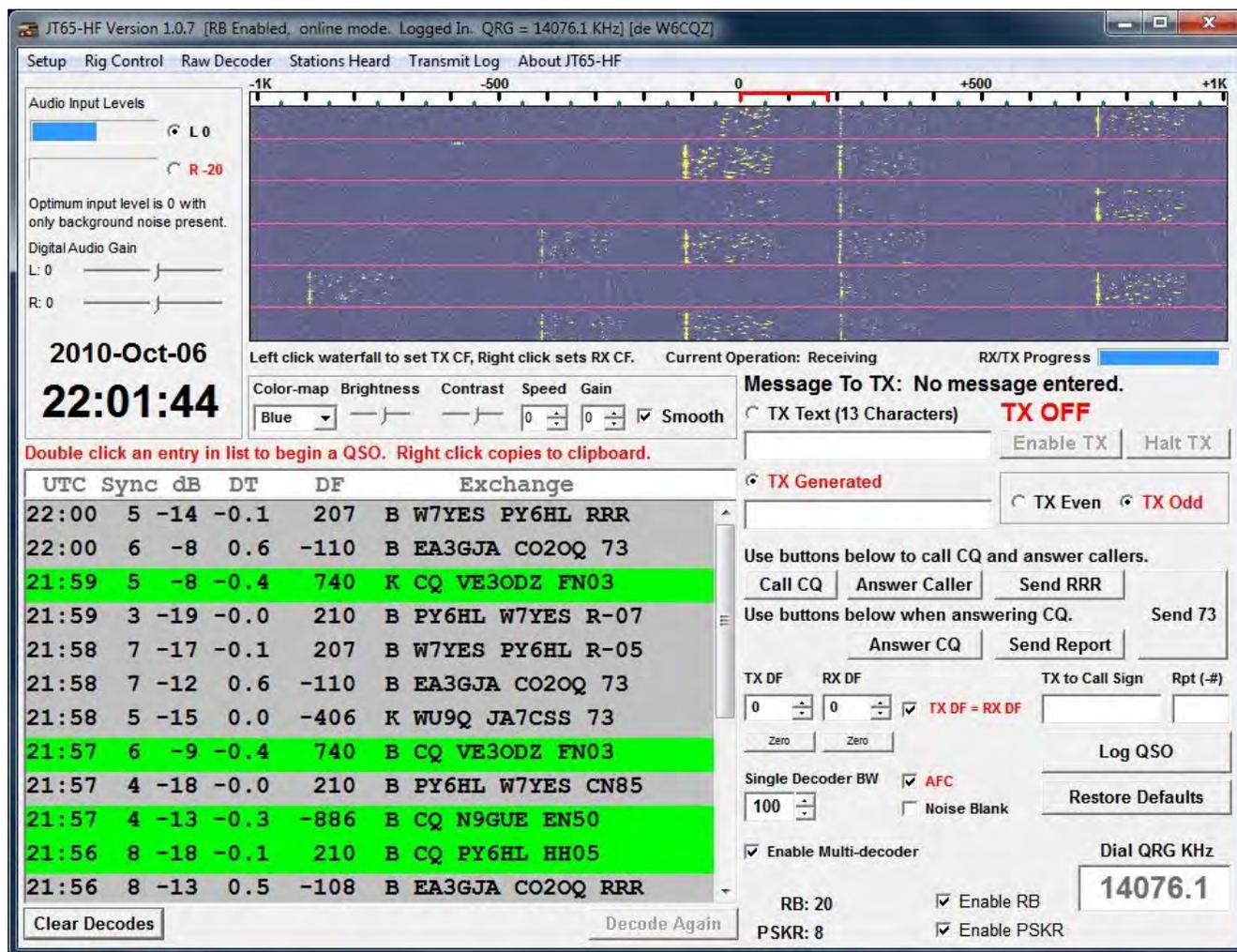
Brightness and contrast allow you to tailor the display to your own eyes. In my own experience I have never used the non-default (center) positions for either, but it's there if you need it. Double clicking the text Brightness or Contrast will reset the sliders to their defaults.

Speed controls the update interval of the spectrum with 0 being slowest and 5 being fastest. Slower update speed can provide a more sensitive display (due to averaging of spectrum intervals into single lines) and uses less CPU. Faster update speed allows you to see shorter duration signals more clearly to perhaps identify QRN/QRM or see non-JT65 signals of a brief duration.

Gain simply increases the 'visual strength' of the spectral lines. In some case where one has a weak, washed out looking display adding a little gain can improve it... but... generally you would leave gain at zero (0).

Smooth can drastically improve the spectrum display by some aggressive averaging of the spectra. This averaging tends to bring out the signals while dropping the noise. The only drawback to smoothing is that very strong signals will overload the calculations leading to gaps in the display.

The decoder output section.



The lower left portion of the program is where decoded sequences display. In the display above you can see a number of receptions. Along with the decoded text is information about strength, time offset, frequency offset and an indicator of the error correction method used to decode the signal.

UTC – Period signal was received.

Sync – A measure of strength of the synchronizing tones. Higher is better.

dB - The strength of the received signal in dB. Higher is better. 0 is the upper limit.

DT – The calculated offset of the received signal from your local clock. Values of .1 to .3 is typical.

DF – Offset in Hz from the center point (0).

B/K – Error correction algorithm used to validate the reception.

B = BM (Simple Reed Solomon algorithm, open source implementation)

K = KVASD (Higher complexity error correction algorithm based on closed source KV algorithm).

Exchange – The decoded text for the sequence.

Color coding. Notice the lines where a station is calling CQ have a green background while others have silver. Color coding helps to pick out 'more interesting' sequences quickly.

The default colors use green for sequences calling CQ, red for a sequence containing your call sign and silver for everything else. Double clicking a line with either a green or red background will generate an appropriate response message, set the proper transmission period (odd or even minute), enable TX and, if TX DF=RX DF is enabled, zero beat your TX tones to the station you wish to work.

QSO Controls.

The screenshot shows the JT65-HF software interface. At the top, there's a menu bar with options like Setup, Rig Control, Raw Decoder, Stations Heard, Transmit Log, and About JT65-HF. Below the menu bar is a waterfall plot showing frequency from -1K to +1K. To the left of the waterfall plot are audio input level controls for L and R channels, with a note that the optimum input level is 0. Below the waterfall plot is a status bar showing the current operation as 'Receiving' and a progress bar for RX/TX. Below the status bar is a message box that says 'Message To TX: No message entered.' and 'TX OFF'. Below the message box is a text input field for 'TX Text (13 Characters)' and buttons for 'Enable TX' and 'Halt TX'. Below the text input field is a section for 'TX Generated' with radio buttons for 'TX Even' and 'TX Odd'. Below the 'TX Generated' section are buttons for 'Call CQ', 'Answer Caller', and 'Send RRR'. Below these buttons are buttons for 'Answer CQ' and 'Send Report'. Below the buttons are controls for TX DF and RX DF, with a checkbox for 'TX DF = RX DF'. Below these controls are buttons for 'Log QSO' and 'Restore Defaults'. Below the buttons are controls for 'Single Decoder BW' (set to 100) and 'AFC' (checked). Below these controls are checkboxes for 'Enable Multi-decoder', 'Enable RB', and 'Enable PSKR'. Below the checkboxes are buttons for 'Clear Decodes' and 'Decode Again'. Below the buttons is a 'Dial QRG KHz' field set to 14076.1. At the bottom of the interface is a table of decoded messages.

UTC	Sync	dB	DT	DF	Exchange
22:00	5	-14	-0.1	207	B W7YES PY6HL RRR
22:00	6	-8	0.6	-110	B EA3GJA CO2OQ 73
21:59	5	-8	-0.4	740	K CQ VE3ODZ FN03
21:59	3	-19	-0.0	210	B PY6HL W7YES R-07
21:58	7	-17	-0.1	207	B W7YES PY6HL R-05
21:58	7	-12	0.6	-110	B EA3GJA CO2OQ 73
21:58	5	-15	0.0	-406	K WU9Q JA7CSS 73
21:57	6	-9	-0.4	740	B CQ VE3ODZ FN03
21:57	4	-18	-0.0	210	B PY6HL W7YES CN85
21:57	4	-13	-0.3	-886	B CQ N9GUE EN50
21:56	8	-18	-0.1	210	B CQ PY6HL HH05
21:56	8	-13	0.5	-108	B EA3GJA CO2OQ RRR

TX Text (13 Characters) is an input box for simple text messages. This input box is editable and right clicking it will bring up a menu of 'macros' as defined in setup. **Do not begin a message with RO, RRR or 73 as those will be sent as shorthand sequences no matter if you add text after those 3 words or not.** [I hope to correct this in future revisions, but for now this exists both in JT65-HF and other programs implementing the JT65 protocol.]

TX Generated is an input box for messages generated by the program. You can not manually input text into this box or edit it. When you double click a decode in the decode output window this is where JT65-HF will display what 'it thinks' is the correct response. The set of buttons below this input box will also generate messages that display in it as well.

Enable TX – Halt TX are reasonably self-explanatory and will be enabled when a valid message is in the message buffer (input box) that is selected. Remember that TX will not begin until the proper time (the start of a new minute as determined by even/odd selection).

TX Even – TX Odd sets whether you TX on even numbered minutes 0, 2, 4, 6...58 or odd numbered minutes 1, 3, 5, 7...59.

The screenshot shows the JT65-HF software interface. At the top, it displays 'JT65-HF Version 1.0.7 [RB Enabled, online mode. Logged In. QRG = 14076.1 KHz] [de W6CQZ]'. Below this is a menu bar with 'Setup', 'Rig Control', 'Raw Decoder', 'Stations Heard', 'Transmit Log', and 'About JT65-HF'. The main area is divided into several sections:

- Audio Input Levels:** Shows L: 0 and R: -20. Optimum input level is 0 with only background noise present. Digital Audio Gain is also shown.
- Waterfall Plot:** A frequency spectrum plot with a red line indicating the current frequency.
- Message List:** A table of decoded messages with columns for UTC, Sync, dB, DT, DF, and Exchange. The third row is highlighted in green: '21:59 5 -8 -0.4 740 K CQ VE3ODZ FN03'.
- TX Controls:** Includes buttons for 'Call CQ', 'Answer Caller', 'Send RRR', 'Answer CQ', and 'Send Report'. There are also input boxes for 'TX to Call Sign' and 'Rpt (-#)'. The 'TX DF' and 'RX DF' are both set to 0, and 'TX DF = RX DF' is checked.
- Other Settings:** Includes 'Color-map' (Blue), 'Brightness', 'Contrast', 'Speed', 'Gain', and 'Smooth' options. There are also buttons for 'Log QSO' and 'Restore Defaults'.

Next you will see two rows of buttons labeled Call CQ, Answer Caller, Send RRR, Answer CQ, Send Report and Send 73. Working with these buttons you see two input boxes labeled TX to Call Sign and Rpt (-#).

If you have double clicked a line in the decoder output TX to Call Sign should be populated with the call sign you wish to contact while Rpt (-#) should be filled with the value of the signal strength of the station being called. For example, say you double clicked the third line to answer VE3ODZ's CQ.

If you fill in the box labeled TX to Call Sign and Rpt (-#) you can generate messages without need to double click a line. I don't suggest using this 'manual' method until you have full understanding of how JT65 works. It's there if you need it, but, generally the automatic setup of message by double clicking an output line is the easiest and most accurate method.

TX to Call Sign will show VE3ODZ

Rpt (-#) will show -08

TX DF will change to 740, RX DF will change to 740 (because TX DF = RX DF is enabled)

TX Generated will show (in my case) VE3ODZ W6CQZ CM87

TX Even will be selected (since VE3ODZ is TX on Odd)

TX will be enabled along with the button for Halt TX

The caption "Message to TX:" will read VE3ODZ W6CQZ CM87

Lastly, TX will begin at the next valid even numbered minute

Should you wish to stop this you would click Halt TX

JT65-HF, from its inception, has as its central concept the idea that the software will do all it can to direct its users into using proper JT65 techniques, thus promoting successful contacts.

This is why it disallows starting a transmission at arbitrary points in a minute, typing messages longer than can be sent into the free text buffer, attempts to insure you TX on the proper period and offers to zero beat your signal to the station you wish to work (TX DF).

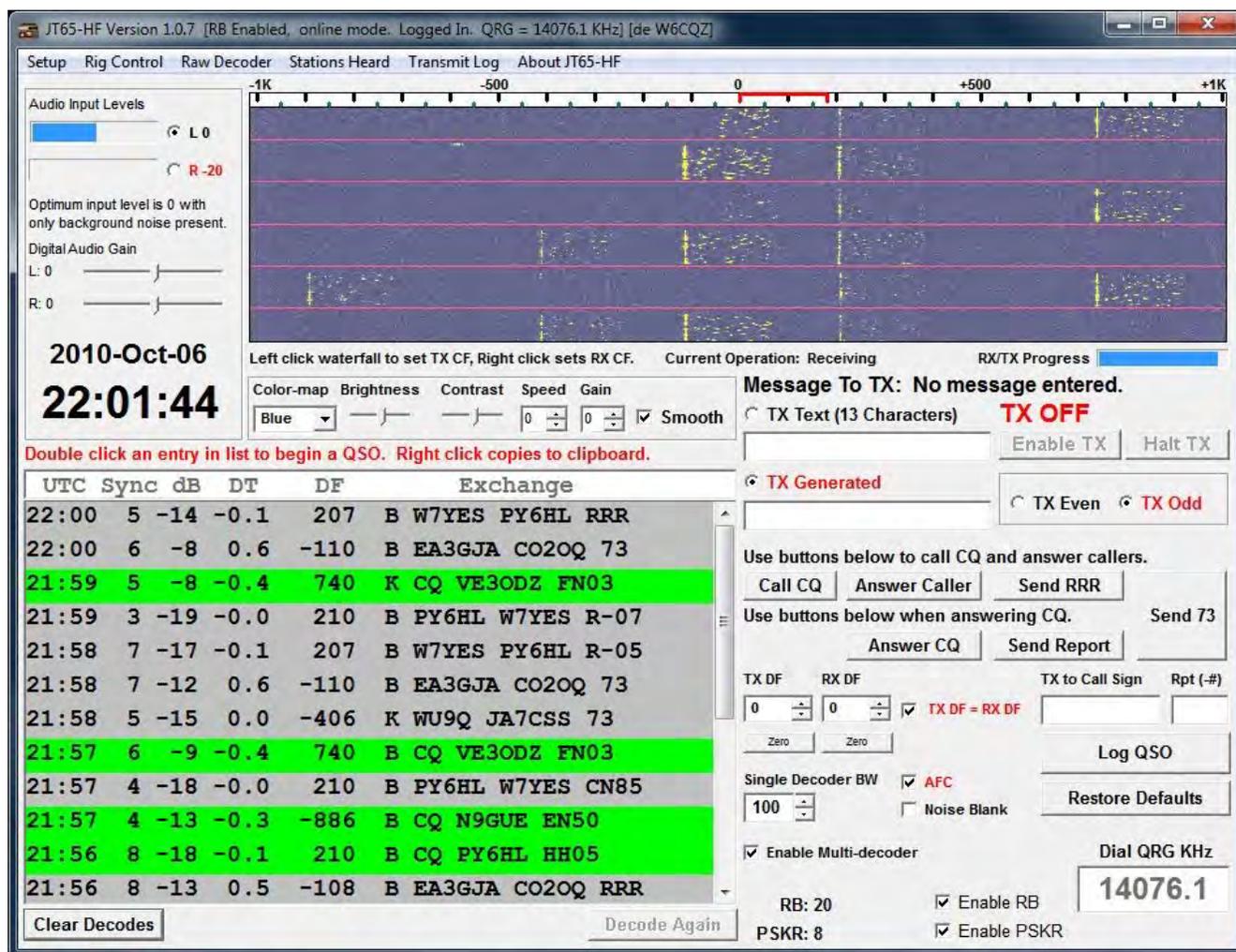
With experience JT65 really is a simple communications protocol to work with, but, for those not accustomed to its unique requirements of timing and message formatting it can be a little unforgiving. An inexperienced user of JT65 can, and often has, made a mess of things by trying to send text that can't actually be sent, starting/stopping TX at arbitrary points and not matching his signal offset with the other side. As if all this is not enough to worry about you have to add in things that JT65-HF can not control such as running too much power or having a local time reference that is not properly synchronized. So, JT65-HF attempts to control and guide where appropriate with the goal of making this easier for the end user and the rest of the community on the air.

While JT65-HF attempts to do many things for you and can even seem somewhat restrictive it, in fact, will allow you almost total manual control. The only thing you can not do with JT65-HF is start a TX cycle when it makes no sense to do so, or, better put, start a TX cycle where there is almost zero probability of it being properly received by any other station.

Many have agreed with me when I say much of this is harder to explain than to use, hopefully you will find yourself to be in agreement with this as well. My best advice is to take your time, watch how others run JT65 contacts (both correctly/incorrectly) and jump in when you feel you're ready. We have all been new users to this mode at one time or another and realize that patience with the learning curve is necessary. One other piece of advice is to listen to others if they're offering suggestions or pointing out problems and, above all else, ask questions if something is unclear. The JT65 community on the HF bands is a very knowledgeable group and will bend over backwards to help newcomers.

Now that how to answer a CQ call has been covered lets move on to how to call CQ properly.

Calling CQ



To call CQ you would begin by clicking the "Call CQ" button. This would fill in the TX Generated box with CQ CALL GRID, for example, CQ W6CQZ CM87.

Then "Enable TX" button will be enabled, but actual TX will not be enabled until you press the button. TX Even/TX Odd will be at whatever state as existed before clicking Call CQ as will TX DF and RX DF.

TX Period selection is really your choice. In the VHF bands some strict 'rules' exist for defining which station transmits on even versus odd slots, but on HF the reasoning behind the VHF rules make absolutely no sense. In time you'll see some reasons why one period might be better than the other, but, essentially it is meaningless for most cases.

TX DF should be considered carefully before you enable TX. Try to find an empty space in the spectrum where the Red TX marker will fall in open space. I try to keep 100 Hz or more between my signal and others, but, on a busy day you can squeeze down to 50 Hz separation and generally be fine.

Turn OFF TX DF = RX DF while calling CQ. While it is *almost* always best to have TX DF =

RX DF enabled there is, at least, one case where it is exactly what you *should not do*. That case is when calling CQ.

When calling CQ you have, hopefully, picked a clear spot in the pass band and receiving answers to your call. Now... you get an answer and you double click the decoder line to respond, but, you've left on TX DF = RX DF and the station calling you is at some offset to your CQ offset... what happens? You move to match. Then when the station comes back to you (assuming it has TX DF = RX DF enabled) it will have moved to match you. Then you double click again and move....

See where I'm going? You could end up walking up or down the pass band if both sides of the QSO is making TX DF moves. The easiest way to avoid this is to have TX DF = RX DF unchecked thus 'locking' your TX offset.

Everything Else

The screenshot shows the JT65-HF software interface. At the top, it displays 'JT65-HF Version 1.0.7 [RB Enabled, online mode. Logged In. QRG = 14076.1 KHz] [de W6CQZ]'. The main window is divided into several sections:

- Waterfall Plot:** A spectral display showing signal activity across a frequency range from -1K to +1K. The current operation is 'Receiving'.
- Audio Input Levels:** Controls for L and R channels, with an optimum input level of 0.
- Message To TX:** A section for sending messages, currently showing 'No message entered' and 'TX OFF'.
- TX Generated:** Controls for TX Even and TX Odd.
- Call and Answer Buttons:** Buttons for 'Call CQ', 'Answer Caller', 'Send RRR', 'Answer CQ', and 'Send Report'.
- TX DF and RX DF:** Controls for TX and RX deviation, with a checked option for 'TX DF = RX DF'.
- Single Decoder BW:** A control for the decoder bandwidth, currently set to 100.
- Enable Multi-decoder:** A checked option to enable multiple decoding.
- RB and PSKR:** Controls for Repeat Bandwidth (RB: 20) and PSKR (PSK Repeat Keying: 8).
- Dial QRG KHz:** A control for the dial frequency, currently set to 14076.1.
- Log QSO:** A button to log the current QSO.
- Restore Defaults:** A button to restore the software to its default settings.

In the center, there is a list of decoded messages with columns for UTC, Sync, dB, DT, DF, and Exchange. The following table represents the data in this list:

UTC	Sync	dB	DT	DF	Exchange
22:00	5	-14	-0.1	207	B W7YES PY6HL RRR
22:00	6	-8	0.6	-110	B EA3GJA CO2OQ 73
21:59	5	-8	-0.4	740	K CQ VE3ODZ FN03
21:59	3	-19	-0.0	210	B PY6HL W7YES R-07
21:58	7	-17	-0.1	207	B W7YES PY6HL R-05
21:58	7	-12	0.6	-110	B EA3GJA CO2OQ 73
21:58	5	-15	0.0	-406	K WU9Q JA7CSS 73
21:57	6	-9	-0.4	740	B CQ VE3ODZ FN03
21:57	4	-18	-0.0	210	B PY6HL W7YES CN85
21:57	4	-13	-0.3	-886	B CQ N9GUE EN50
21:56	8	-18	-0.1	210	B CQ PY6HL HH05
21:56	8	-13	0.5	-108	B EA3GJA CO2OQ RRR

Having covered everything on the right side of the main interface but the lower right portion you are left with;

- Single Decoder BW
- AFC
- Noise Blank
- Enable Multi-decoder
- Log QSO
- Restore Defaults
- Dial QRG KHz
- Enable RB
- Enable PSKR
- Decode Again
- Clear Decodes

Single Decoder BW defines the decoder band width when the multiple decoder is disabled. Why would you disable multiple decoder? Perhaps your computer is not fast enough to decode a busy sequence in time to begin an on time response... or you want to decode a

shorthand response (remember, shorthand messages will not be decoded if multi is on)... or you just prefer to not be overloaded with many lines of decodes while in QSO. Regardless of the reason, the single decode mode has many uses. The default of 100 Hz for single band width should generally suffice. With experience it will become apparent where the other band width options apply.

AFC enables automatic frequency control and will attempt to follow a signal that exhibits drift. Its original intent is to compensate for Doppler shift when using JT65 for EME contacts, but it has application on HF as well. Not for Doppler shift compensation, but for stations who show VFO drift. Over the years I've found that having AFC on is the default condition for my station. It certainly helps at times and, as far as I can tell, never hurts.

Noise Blank attempts to limit impulse noise like atmospheric QRN from lightning. Living in California I can't remember ever using it, but, during my ten months in Florida it was more often on than off.

Enable Multi-decoder does exactly that. When enabled the decoder will attempt to find and decode all possible JT65 signals within the 2 KHz pass band.

Log QSO will be covered in the next section.

Restore defaults will clear the message buffers, set TX DF and RX DF to zero and is a quick way to clean up for doing a different contact or after calling CQ.

Dial QRG KHz is for entering the dial frequency of your radio. Unless you have RB and/or PSK Reporter enabled it is not strictly necessary to bother setting this.

Enable RB and Enable PSKR will be covered in their own section to follow.

Decode Again will attempt to run the decoder again on the previous minute's data perhaps with different settings. It will only be enabled when valid data for the previous minute exists and its running will not interfere with a 'real time' decoder cycle. As such you will see the button be enabled and disabled at certain times. This is still a relatively new feature in JT65-HF and still has some bugs as of 1.0.7. As time permits these will be addressed so, for now, don't expect decode again to always work just right.

Clear Decodes will clear the text output in the decoder section.

Logging

Log Contact

Call Grid

Date Start Time End Time

Sent Received Power Watts

Frequency MHz

Notes

Location of Log file (jt65hf_log.adi)

When you press the “Log QSO” button from the main window you will be presented with a window similar to the above. Depending upon when you click the log QSO button some items will be blank while others will not necessarily be what you would consider correct. As the QSO continues values, if received, will begin to fill in. For example, if I received a report back from N9GUE saying my signal level was -15 the Received box would be filled with -15.

For best results click the log QSO button at the end of the QSO and everything should be filled in for you that can be extracted by software.

Now, what does this actually do when you press “Log Contact And Close This Window”?

It will write a log entry to the file jt65hf_log.adi in the directory picked in standard ADIF format. Almost all known logging programs support importing log entries in ADIF format so the file from JT65-HF will provide a way to more easily manage your logs.

In the future I, if possible, intend to integrate the logging function with programs that offer interfaces to external programs thus doing away with the manual importing, but, that is for the more distant future at this point.

The Reverse Beacon (RB) Network

So what is a RB? The easiest way to explain this is to say what a 'Forward Beacon' or, more commonly labeled, a Beacon station is.

A beacon station transmits signals on a regular basis with the intent that many stations be able to receive it to determine band condition. A beacon station does not listen for replies, would like to occupy an exclusive segment of band space and, other than its intended purpose, is not useful beyond its one purpose.

A reverse beacon is exactly the opposite. An RB only listens to band activity and reports its receptions to a commonly accessible point (in this case via the internet). Every station simply having a QSO or calling CQ provides signals for the RB to receive and, as such, an RB occupies no band space while it listens and never transmits unless the operator does so to have a QSO.

The RB Network is not a new idea. I became interested in systems like the RB Network before I had discovered WSJT and JT65a via the PropNet PSK system and, to me, JT65 seemed a much better alternative for such a system. It didn't require active beacon stations sending specific text (as PropNet does) and worked more reliably at the weakest (most interesting) signal levels. Basically I saw that you could gather all the information necessary to determine a transmitter's location simply by watching the band for normal traffic and the highly structured JT65 messages makes extracting the details trivial.

So, just over three years later, the JT65 RB network has collected (and saved) near 10 million reports without ever having need to intentionally transmit a signal as a predefined beacon text. While less specific than data collected by PropNet or WSPRNet (in that with the former an indication of power and/or antenna gain is given) the JT65 RB Network, again, does not require stations to transmit specialized messages solely for the sake of beacon action and I consider this a positive consideration.

I don't know if the data collected will ever be of any use as a database of propagation conditions, but, it certainly is seen as a useful tool for day to day users of JT65 on the HF bands and I hope you will consider contributing your reports as well.

You may view reports sent to the JT65 RB Network at;

<http://jt65.w6cqz.org/receptions.php>

PSK Reporter (PSKR)

PSK Reporter is a system from Phil Gladstone – N1DQ that collects spots from a variety of sources/modes and provides a real time data display graphically at;

<http://pskreporter.info/pskmap.html?preset&callsign=ZZZZZ&what=all&mode=JT65&timerange=86400>

If for no other reason than its graphic display capability I suggest those who wish to submit reports at all do so to PSK Reporter as well as the RB Network.

Another system that does a great job of pulling in data from various sources is at;

<http://hamspots.net/wsjt/>

Hamspots uses data from the RB Network (I provide a direct feed of RB Data for it), PSK Reporter and DX Cluster spots. I find the data display to be superb and Laurie – VK3AMA is to be congratulated for providing such a useful and comprehensive service to the Amateur Radio community!

Appendix A – The JT65 Protocol

JT65 is a tightly structured protocol with a severely limited set of structured messages and a limited 'free text' message type limited to 13 characters in length.

In any one minute period you may send any one of the structured message types, 13 characters of text or any one of the 3 shorthand messages. Nothing more, nothing less (yes, you can send a CW ID at the end of certain message, so there is that as well).

JT65 is not a free form data transmission protocol like most other modes we use. Each transmitted 'frame' is of a fixed length, starting and ending at a predefined time. By using this restrictive timing arrangement and a fixed frame length it becomes possible to achieve some 'signal gain' by knowing when and where to look for signals.

It is much easier to find a weak signal when you know when it should begin and end and that each transmission will have a fixed format within its bit space.

The JT65 protocol states that a transmission will begin at precisely 1 second into a new minute and end 46.811 seconds later. The protocol further defines that a frame will convey 72 bits of information with an additional 306 bits of error correction data (FEC) for a total of 378 bits. *It is the structure of JT65, its timing, modulation method and heavy FEC that allows it to work so well at very low signal levels.*

Within that frame of 72 data bits you may contain any **one** of the set of structured messages, a 13 character free form text message or (while different in the actual details of transmission, but close enough for now) any one of the 3 shorthand message types.

Most of the sequences will follow the structured form with a precisely limited vocabulary.

Structured messages are as follows.

CQ CALLSIGN GRID
CALLSIGN CALLSIGN GRID
CALLSIGN CALLSIGN -##
CALLSIGN CALLSIGN R-##
CALLSIGN CALLSIGN RRR
CALLSIGN CALLSIGN 73

With structured messages the text is not sent character by character, but, instead, the software uses a mathematical formula to 'translate' a call sign or grid into a unique numerical value that takes less bit space to convey than a character by character transmission format.

*This is why structured messages can **appear** to exceed the 13 character limit.*

A structured message actually consists of 3 'fields' with the lengths of 28 bits, 28 bits and 15 bits for a total of 71 bits. The 72nd bit is used as a marker and when set (1) indicates the message is 13 character text or, if unset (0) the 71 bits contain a structured message.

Taken from the JT65 protocol definition is the following;

“An amateur call sign consists of a one or two character prefix, at least one of which must be a letter, followed by a digit and a suffix of one to three letters. Within these rules, the number of possible call signs is equal to $37 \times 36 \times 10 \times 27 \times 27 \times 27$, or somewhat over 262 million. (The numbers 27 and 37 arise because in the first and last three positions a character may be absent, or a letter, or perhaps a digit.) Since 2^{28} is more than 268 million, 28 bits are enough to encode any standard call sign uniquely. Similarly, the number of 4 digit Maidenhead grid locators on Earth is $180 \times 180 = 32,400$, which is less than $2^{15} = 32,768$; so a grid locator requires 15 bits in a message.”

This implies that any pair of call signs [*that fits the encoding rule*] and a grid can be sent in $28 + 28 + 15 = 71$ bits.

Take specific note of the idea of a call sign that fits the encoding rule. While most amateur call signs do indeed fit the rule some perfectly valid call signs do not. For example, some special event call signs (often seen in Europe) like DL2008WC [a made up example] will not resolve to a 28 bit computed call sign value thus can not, in practical terms, be used with JT65 no matter the program offering the implementation.

Sent character by character the exchange KC4NGO KG6CQZ CM87 would be 18 characters (count the spaces) and in free text format you simply could not send the text in the available bit space. So, structured messages use a sort of compression to fit more information into a restricted number of bits. Notice that under the *rules* of encoding (compressing) a call sign or grid that you have more values available than actually needed.

For call signs you have 262,177,560 possible unique values but in a 28 bit space you can represent 268,435,456 unique values leaving an 'extra' 6,257,896 values.

For the grid you have 32,400 actual grid values but in a 15 bit space you can represent 32,768 unique values leaving an 'extra' 368 values.

These 'extra' values are not wasted in JT65. In fact they're used to convey information that would not otherwise fit into a structured message frame and this further explains the rigidity of what JT65 allows/disallows.

For instance, take the structured message “CQ KC4NGO EL98”. From the explanation of the rules you can be sure that KC4NGO is converted to a 28 bit value and EL98 is converted to a 15 bit value, but what about CQ? It simply uses one of the 'surplus' 28 bit values left above the last possible call sign number. So “CQ KC4NGO EL98” still uses a pair of 28 bit numbers plus a 15 bit number for 71 bits.

CQ can in fact contain an extra offset value in hertz which the caller expects a responder to apply when answering. This is seldom, if ever, seen on HF and is not implemented in JT65-HF.

Now we come to the structured message “KC4NGO KG6CQZ DM06”. This is more obvious in that it is a pair of 28 bit encoded call signs plus a 15 bit encoded grid for, again, 71 bits.

Now things change a bit. “KG6CQZ KC4NGO -10”. Here you have the pair of 28 bit call signs but the grid has been replaced by a signal report. Again, as in CQ, JT65 uses some of the excess values, but this time in the 15 bit 'grid space' to convey the signal report. The 15

bit grid space can take on the following values;

An actual grid locator (like CM87), a signal report (like -11), a signal report with acknowledgment (like R-06), an acknowledgment (RRR) or a closing (73).

In a free text message the 13 character limit comes from what can be fit into 71 bits. As it happens with the character set of JT65 and 71 bits you can send 13 characters, thus the hard limit of text message length.

So. There is nothing arbitrary about a JT65 frame. The protocol is limited to what it can convey not due to anything other than it is doing all it can possibly do while still being JT65.

The reason I state this is that I've often been asked why can't we send more than 13 characters or, more often, why can't I just make my call sign what I want/need it to be rather than this restrictive suffix/prefix mechanism where my prefix/suffix does not even exist?

This leads into the messy situation of using a suffix or prefix with JT65.

Going back to how JT65 encodes a frame it can be seen that you can convey a pair of call signs, grids, reports and CQ message using the 71 bits. But how do you convey a call sign that can not be represented in the 28 bit format, for instance, how do you send W6CQZ/4? It does not follow the rules for being encoded into a 28 bit value so the base call sign has to be sent in one 28 bit space as usual, but where do you put the /4?

Unfortunately, this is a difficult process.

CQ W6CQZ CM87 is easy.

CQ W6CQZ/4 CM87 is impossible. 28 bits is taken by CQ. 28 bits is taken by W6CQZ. 15 bits is taken by CM87. Nothing is left for /4. So the only choice is to drop an item. Only one portion can be seen as 'expendable' and that is the 15 bit grid space.

When using a suffixed or prefixed call sign the standard messages have to be modified.

Using suffix	Using prefix	No Suffix/prefix
CQ W6CQZ/4	CQ XE/W6CQZ	CQ W6CQZ CM87
W6CQZ/4 W1A	XE/W6CQZ W1A	W6CQZ W1A FN02
W1A -10	W1A -10	W1A W6CQZ -10
W6CQZ/4 R-10	XE/W6CQZ R-10	W6CQZ W1A R-10
W1A RRR	W1A RRR	W1A W6CQZ RRR
W6CQZ/4 73	XE/W6CQZ 73	W6CQZ W1A 73
W1A 73	W1A 73	W1A W6CQZ 73

This is why I strongly suggest you not use a suffix or prefix value with JT65 unless you must under the legal rules you operate. It is far better, where possible, to run without any suffix/prefix data and use a closing free text message to convey your modified call sign. For example "DE KC4NGO/6" or "DE W6CQZ/4 73". Of course this is a less than optimal

situation, but, it is the JT65 protocol's limitation, not something that just a bit of clever programming can fix.

A subtle and less often realized implication of JT65 suffix/prefix rules is that it is totally impossible for a station using a suffix or prefix to work another station using a suffix or prefix. There is not combination of reworking the bit space that will allow for two 28 bit call signs and two 15 bit prefix/suffix allocations.

Having covered the contents of a JT65 frame I can now speak to the physical transport method, or, more clearly put, its modulation format.

JT65 uses 65 tone AFSK modulation. Each tone is of a specific duration and sent singly without overlap or phase changes between tones. That JT65 is FSK implies that it does not require a linear (Class A/AB) but can use Class C. While this is true in theory it is less clear in actual practice. It is unfortunate that JT65 has a reputation as being immune to the consideration one must take when running modes (such as PSK31) where overdrive can produce a severely distorted signal. While JT65 is far less prone to producing a 'dirty' signal as seen with too much drive in PSK31 it **is not immune to it**.

To understand this you have to consider the A in AFSK. A = Audio, FSK = Frequency Shift Keying.

Any modulation method that uses an AUDIO input to a transmitter can produce a distorted signal regardless of it being FSK, PSK, MFSK or any other possible way to modulate a transmitter.

While operating JT65 with an SSB transmitter you should always consider that you could be producing a poor signal if you are over driving your transmitter or have distortion/noise on the input line.

While it is, relatively, uncommon to see a distorted JT65 signal it is usually quite bad when you do see one. In my own station I found, much to my own embarrassment, that for a short time I was producing a poor JT65 signal. I checked my drive level and ALC indication finding nothing wrong and after much checking I found that the ground shield had lost connection on my audio input line... this created a very noisy input to the transmitter that then mixed with the JT65 tones creating what can only be described as a nightmare on the air. So. Keep in mind that no matter how many times you hear that JT65 is FSK and can't produce a dirty signal that that is dead wrong. Mind your levels, signal integrity and listen if someone says you're splattering over the entire pass band as it certainly can happen.

Another warning is to watch your transmitter when running at higher power levels. JT65 is equivalent to 100% key down for the 47 second TX duration. You can easily overheat your final if it can't handle this situation for the full duration. If you melt your finals you have only yourself to blame.

The specific modulation for JT65 is, again, 65 tone AFSK. A JT65 transmission begins at 1 second into a new minute and lasts 46.811 seconds. Essentially a TX begins at 1 second into a new minute and ends at 48 seconds. JT65-HF will key the transmitter at the top of a new minute (second=0) but tone will not begin until second=1. Of the 65 tones 64 convey data while the first tone conveys a synchronization chain that aides

in 'finding' the signal. The sync chain, or vector, is mathematically structured such that it stands out from other signals or random noise. A full 50% of the transmission is devoted to sending the sync vector and this along with the known timing contributes greatly to distinguishing a JT65 signal from other components present in the decoder pass band.

Earlier I mentioned that a JT65 frame consists of 72 bits plus 306 bits of FEC coding for a total of 378 bits. This string of 378 bits is divided into 63 6 bit pieces and this explains why 64 tones. A 6 bit value can range in decimal value from 0..63 for 64 distinct values so each of the 64 tones can represent the entire value of a single 6 bit segment.

Now we know that a JT65 frame will be modulated by sending 63 6 bit values represented by 1 of 64 tones and 63 sync tones represented by the 'extra' 65th tone value.

Each tone in the transmission is defined in length as being 4096 samples long at 11025 samples per second. In time this is $(1/11025) * 4096 = 0.37152$ seconds per tone, giving reason for the frames overall length of $.37152 * 126 = 46.811$ seconds, or completely rounded to integer, 47 seconds.

This now allows for a discussion of how the decoder works.

The JT65 decoder uses a multiple step process to extract a JT65 frame. It first searches the entire audio pass band (2 KHz wide with a center point of 1270.5 Hz) for occurrence(s) of the synch vector. In JT65-HF the decoder returns a list of all potential sync detects with a signal level of more than -30 dB then attempts to decode the data tones that should accompany each sync vector. The attempt to decode data results in two sets of values, one being the most probable content of the data and the second being the next most probable values. The next step in extraction is to run the first set of values through an error correction routine (the BM method) that, using the 306 bits of FEC data, returns either a valid 72 bit message or fails. If the first set of probables fail it attempts again with the second set. If neither set of probable data decodes as valid the decoder then attempts decoding with the more sophisticated KVASD algorithm again trying the most probable data and then the second most probable data. If after all attempts to decode no valid message is extracted the decoder moves on to the next potential decode (if more than one point has been found).

In WSJT the default is to attempt all decodes using the KVASD routine and only use BM if KV returns an error condition. In JT65-HF I decided to use BM as the default as it's faster, easier to work with and less prone to making decodes that should no be made. A side effect is that JT65-HF returns somewhat less false decodes than WSJT while still allowing for the KV method when needed.

Another difference between WSJT and JT65-HF is the multiple decoder where all potential signals in the pass band is evaluated (if enabled to do so) versus WSJT only decoding the strongest signal present within the decoder pass band.

One implication of the strong FEC and structure of JT65 is that is should not present decoded sequences that are not valid. While in theory this is true it is not in practice, especially with the KV decoder. While there really is no such thing as a false decode in one sense, again, in practice such occur (though, relatively infrequently). The reason for this is complex, but, basically, through a random process of man-made and natural noise a signal can be detected that passes all the FEC processing and decodes but makes no sense in human terms. These

false decodes are, generally, easily spotted as they don't look like anything you'd expect to see.

Another source of invalid decodes is a bug in JT65-HF code that will lead to a sequence that was decoded earlier coming back as a ghost. If you begin seeing this you will need to restart the program and you may be assured that finding the source of this bug and squashing it is a high priority item. Until corrected please accept my apology in advance if you experience this.

It requires a huge number of calculations to detect and extract JT65 signals. In JT65-HF I have taken care to optimize some of the routines far beyond what it would be worth to do if it were not for the multiple decoder. Early versions of JT65-HF used a [very] crude method to achieve multiple decodes. It sliced the 2 KHz pass band into small segments and ran X passes of the traditional single decoder algorithm. Assuming 100 Hz segments this meant the decoder ran 20 passes and it was, at best, a struggle to optimize the decoder to achieve this in a reasonable length of time. This is where calculation of optimal FFT values came from. By using machine specific optimized FFT constructs versus generic works on anything routines I found I could cut the decode time by about 50%. This allowed enough time to refine the routines to the current state.

Previously the decoder ran a number of passes often in segments that had nothing but noise or non JT65 signal present or a JT65 signal that could not possibly decode due to signal strength (too little). This was a huge waste of time and in version 1.0.5 a new algorithm was introduced that is the first step in a fully optimized decoder routine.

The new routine searches for all possible sync vectors and then runs the full decode attempt in segments where a decode has possibility. This offered a dramatic increase in decoder speed and is, almost, enough. But, one further optimization can be made in that I'm still repeating one step needlessly as I run the individual decode points, so, I may be able to shave another 10 to 25% of the decoder cycle time once I find time to implement the last decoder enhancement steps. Another possible way to greatly increase decoder speed will be to take full advantage of system with multiple CPU cores and run certain calculations in parallel, but, this is for the far distant future if ever.

Appendix B – Sound Device Details

JT65-HF does not require a 'high quality' sound device as is suggested for applications like SDR (Software defined radio) usage. A high quality sound card (better SNR, linearity, ADC accuracy, sample rate accuracy) may make a decode that a cheaper card will miss at the extreme lower limits of possibility, but, overall, the expense of purchasing such a card will hardly be worth the returns. In general almost any sound device can and will work with JT65-HF.

That being said I will discuss things that will help you get the most out of whatever sound device you use.

Input levels from your radio come first.

When using an ADC (Analog to digital convertor), which is exactly what the input to a sound device is, you have to treat it with the same care you would, hopefully, treat the audio input to your transmitter. You would not wish to overdrive your TX input and generate a distorted output signal or under drive it such that you had to turn the gain up so far that induced noise could compete with the input signal.

The exact same considerations apply to an ADC. Too much input level will result in distortion and too little will begin to allow noise to begin dominating the input.

To set an ideal input level for JT65-HF requires a series of steps. First you will set your input level to exactly mid-scale for your sound device through the Windows (or whatever) control application. Then you want to see the audio input indicator in JT65-HF indicate a value of zero (0) with only normal background noise present in your receiver pass band. This allows plenty of room for strong levels to not overload the ADC while still offering enough gain such that light signals are not lost in the ADC noise floor.

Using the digital gain controls offered by JT65-HF should be a case of last resort. Either attenuating or amplifying the signal with digital gain leads to unavoidable distortions in the samples and can decrease decoder sensitivity by as much as 2 dB.

Ideally you would be able to take your receiver output and adjust it such that (at 50% input level via the sound card control) you have the 0 level in JT65-HF with no strong signals present, or simply with normal background noise and no signals present. In some cases this can not be accomplished. In the case where the level is too high a simple resistive attenuator is a great solution. I use a 1K potentiometer with the middle leg attached to the audio from the rig, one remaining leg attached to ground and the other out to the sound card. This allows you to make a finer adjustment and not have to resort to digital gain or running the input gain to the ADC at very low levels (again yielding no gain for very weak signals versus large signals).

Obviously, the attenuator adds some noise to the signal, but, compared to the distortion of over/under driving the ADC it is of no matter.

It is, to my knowledge, relatively uncommon to have too little input signal to the sound card, but, if you find you're having to turn the input mixer controls up to maximum you will need to find some way to increase your audio levels, otherwise you will have a much less reliable decode result compared to more optimum levels.

I also use another potentiometer on my TX audio line so I can better control my output level. Using the pot on the TX line I can easily get do to $\frac{1}{2}$ W using the accessory input on my IC-718 with a clean output signal where without it I can only get down to about 5 watts. When playing with extreme QRP experiments it is of great use to get the transmitter down to such low levels where I can then use simple 50 ohm attenuation pads to further decrease my output. I have ran well below 1mW at times and covered considerable distance when conditions were favorable. This, for me, is the true magic of JT65.

Now to less easily correctable sound card issues.

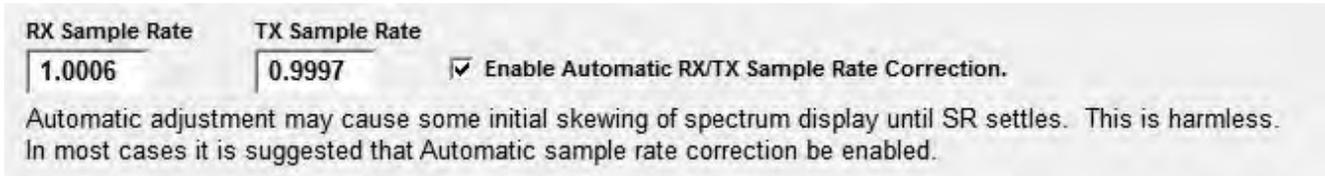
If you read (or already understand) the section on how the JT65 protocol works you may have noticed that the strict timing requirement of JT65 has two components. First is the requirement for stations agree on the absolute time of day and for this we sync to UTC. Secondly, and far more subtly, is a second timing constraint invoked by the length of each tone in a JT65 transmission. Remember that each tone is 4096 samples at a 11025 samples per second rate. So, you have two potential sources of timing error. First your time of day could be so far off as to make your JT65 signal unreadable and secondly you could have a level of deviance from the 11025 samples per second rate that you would, again, produce an unreadable signal.

To better understand the contribution (negative) of sample rate error it may help to think about how the decoder searches for a signal.

During a receive cycle the sound card (ADC) saves samples to a buffer until the end of a transmission window (about second = 48) then begins processing these samples in an attempt to find the synchronization signal. Remember that the sync signal is a fixed sequence of tones that form a pattern that should stand out from noise and other signals.

If the transmitting station had a large error in its local sample rate the length of the individual tones could be different that what the decoder expects.. the decoder might begin to find the sync signal but with a sample rate error it might not, after 47 seconds, retain the proper 'shape' and be lost. Again, the sync detect looks for 63 tones starting at a strictly defined time with each tone being a strictly defined length and in a strictly defined position in the overall frame. A substantial sample rate error will lead to the sync tones being too long or too short and, eventually, if error is severe, will lead to a signal that looks like JT65 but no longer can be decoded.

Unfortunately the base sample rate of 11025 samples per second is not well supported by some sound devices and these devices may show a substantial error figure. Whether this is a problem that prevents your use of JT65 depends upon stability. If the error figure is stable it can be corrected even if it is relatively large. If the error value constantly changes then no amount of correction will yield an accurate sample rate.



The image above is a portion of the main configuration screen and you can see that my sound card is exhibiting a sample rate error of 1.0006 for the input and .9997 for the output. Those figures seem reasonably common and do not represent large errors, but should be corrected (as they are since Enable Automatic RX/TX Sample Rate Correction is enabled).

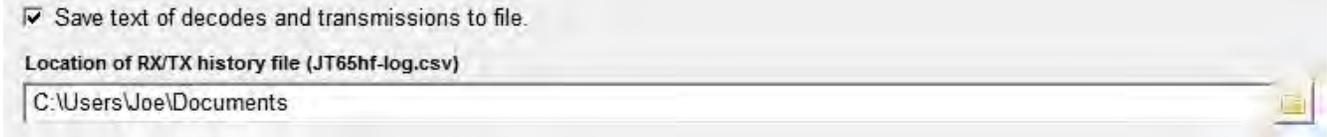
When JT65-HF first begins you will notice, if you have the configuration screen open, that both sample rate indicators will undergo a substantial and reasonably quick change until the figures settle on stable values. This is normal as the overall sample rate figures are an average. If after 5 minutes the values continue to show large changes then you most likely have a problem. You will normally see (taking the numbers shown above) some small fluctuations say from 1.003 to 1.009 for the RX and this is not a problem, but, if you saw the SR numbers moving from .990 to 1.380 and never settle that is a problem.

Unfortunately some sound devices simply can not provide a stable 11025 sample rate and there is little to nothing I can do to address this. In the case where you have unstable figures I would suggest that you make sure your sound device driver is the most recent version from the manufacturer of your sound card (or computer/motherboard for integrated sound devices) as some of the default drives supplied by Microsoft have been shown to be suboptimal. If after exhausting this option you still have an erratic SR indication you **should not** use JT65-HF and consider purchasing a different sound device. Running JT65-HF with a sound device that is erratic will lead to nothing but problems both for your decoding of signals and for those attempting to decode yours.

While I have no specific suggestions I have seen USB sound devices for under \$20 that offer good performance and stable SR figures.

I will likely add code to versions beginning at 1.0.8 to warn of unstable sample rate errors and, in extreme conditions, disable TX with very bad hardware.

Appendix C – CSV RX/TX Log



From the main configuration screen you may enable a 'journal' of all decoded receptions and transmissions which will be saved in a file named "JT65hf-log.csv" in the directory of your choice. Please note that the default location of the log is in a place that is not (always) easily accessible to 'normal' users. I suggest that, if you use this feature, that you change the directory to a more convenient location.

Below is a copy of a small portion of my CSV file;

```
"Date","Time","QRG","Sync","DB","DT","DF","Decoder","Exchange"  
"2010-10-06","21:31","14076100","6","-21","-0.2","-646","K","K6NLX KD5YPC 73","65A"  
"2010-10-06","21:38","14076100","3","-16","8.5","390","B","CQ N9GUE EN50","65A"  
"2010-10-06","21:41","-","-","-","-","T","N9GUE W6CQZ CM87  "  
"2010-10-06","21:42","14076100","6","-18","-0.1","-646","B","WU9Q JA1KEV -19","65A"  
"2010-10-06","21:42","14076100","9","-7","0.5","-100","B","CQ CO2OQ EL83","65A"
```

The first line defines the fields. In the second line you can see that I heard...

At 2010-10-06 (October 6, 2010) 21:31 UTC on 14076100 Hz with sync level 6 and dB level -21 and delta time of -.2 at an offset of -646 Hz from dial QRG decoded with **KVASD** KD5YPC said 73 to K6NLX in mode (JT)65A.

At 21:41 UTC I Transmitted N9GUE W6CQZ CM87.

This file can get quite large over time so do keep that in mind. CSV is a standard format so you can manipulate the data with various programs or simply look at it in a text editor.

Future versions will fill in the dial frequency and offset fields for transmissions as well.

Take note that if you do not have rig control enabled or have not entered your dial QRG on the main screen the frequency data in the CSV file will be subject to error.

Appendix D – Si570 Control

Coming soon. For now, if you do not know precisely what to do with Si570 control and why you are doing it simply stay away from this.

JT65-HF does not implement an IQ receiver or transmitter! It may control an Si570 but that is all. If you use an SDR receiver you must continue to use an SDR software such as Rocky or PowerSDR. Si570 control is only a convenience option for those using DG8SAQ USB Si570 VFO units and wish to have control of the VFO via JT65-HF.

Appendix E – JT65 and Time Sync

The most common user error leading to failure with communications using JT65 is that of having a local time value that is in error compared to the standard of UTC.

As your local time difference with UTC increases your ability to decode (and be decoded) will degrade until a point where it becomes impossible for you to receive any frames or be received.

If you have internet access there is no reason that this should be an issue as a number of free programs exist to keep your time in synchronization with UTC.

The built in time sync feature of Windows XP, Vista and 7 **do not** provide an acceptable level of accuracy in most cases.

If you search the JT65-HF support group message archive for time sync you will find numerous tips for the various programs available.

My preferred method is to use a software package implementing the NTP protocol for Windows provided by Meinberg at;

<http://www.meinberg.de/english/sw/ntp.htm>

Another option is Dimension4 at;

<http://www.thinkman.com/dimension4/>

And several other programs also offer similar functions and can be found via internet search.

Unfortunately, much as mentioned with SR errors in the sound device section, some hardware clocks have instabilities where the system time will vary in an erratic fashion and can not be kept in sync. I had one motherboard that gained 6 seconds per minute and nothing could correct this error leading me to replace the motherboard. Hopefully this is a rare occurrence, but, if you can not maintain time sync it is something to investigate.

For those running JT65-HF under Linux or Mac OS X with Wine you have less work to do. Simply enable network time support in either Linux or OS X and you will be using NTP and all should be well.

If you can not use the internet as a time sync provider then your only choice is to find some source of UTC time (perhaps WWV on HF) and make your best attempt to set your clock by hand. If you can get within +/- 1 second you should be able to operate JT65.

How JT65-HF Came to be.

In the early Summer of 2007 I saw a [very] small article about using JT65 on the HF bands in QST magazine, probably the May or June issue. It explained that a few amateurs were using this Earth Moon Earth purposed mode on HF and, being an EME mode, that it could do seemingly amazing things with weak signals. This intrigued me as with my location in a dense urban area and little room for decent antennas all the signals I could pick up seemed weak.

So I downloaded WSJT, read Andy's (K3UK) Bozo's guide to JT65 and the rest is history. (Thank you Andy! I don't know if I would have figured out how to actually use JT65 and stuck with it to this point without the Bozo's Guide.)

I became almost instantly hooked on using JT65... I could suddenly work stations in areas with ease that, even on a good day, were near impossible to get through to with other modes. To be able to work South Africa using 1 watt from Northern California was quite exciting considering the poor state of prop and my antenna situation.

As time passed I came to understand that WSJT produces a file containing a log of all its receptions and, at first, I started looking at this file after leaving WSJT running to see what I had heard while away... then the epiphany came. If I could do this so could others and what if we could share this over the internet and see what each other was receiving... I wrote a program that would read the file, send the reports to a server on the internet and anyone who wanted to participate could submit their spots in real time for all interested to see. Over time more stations joined the RB Network and it was a very exciting time (and still is).

The name, 'Reverse Beacon' was suggested by KC2QII when I originally started working out how the system would work in the Summer of 2007. I had thought of several other names for the system, but, Javier's suggestion of Reverse Beacon seemed so correct that I quickly adopted it as the system's name.

None of this would have come to be without the encouragement I received from those first early users of the RB system and RB operators. Thanks to KC2QII, N9DSJ, PR8ZX, VE3CDX/W7, VK2IT, GI8HXY, DL2RMM, EA1FAQ, PY8ELO, GW6TYO, JE5FLM and GW8ASA for keeping me motivated through those first few weeks/months of the RB project and for being early RB stations when the RB online list was small compared to now.

So... this really all began with the RB Network and JT65-HF began its development as a program to improve the data flow into the JT65 RB Network sometime in 2008. In fact I had originally thought of JT65-HF as being a receive only platform for those running RB stations. It quickly changed to what it is now, both a full featured JT65 QSO platform and a much enhanced RB platform.

The original system of using WSJT plus the RB helper program was lacking, both in long term viability and overall function. Since WSJT did not do multiple decodes you would only decode the strongest transmission in any period unless you manually forced a decode of any additional signals, also, I began to find issues with keeping the RB program working with WSJT as people migrated to Windows Vista and, later, Windows 7 as the location of the

WSJT data file kept changing. So began the quest to build my own program that would *receive* JT65a transmissions and submit reports to the RB Network without need for WSJT. This resulted in JT65-HF.

What does the future hold for JT65-HF?

I want to finish the program to the point that all known bugs have been handled, rig control is complete for all supported methods and, if possible, direct logging to external logging software is in place. Beyond that there is little remaining to squeeze out of JT65 and I anticipate turning my efforts to improving the RB System and its data display, searching and analysis.

Beyond that I have some ideas for something entirely new that will take some of the best features of JT65 and address some of its worst weaknesses, but, that is far in the future if ever.

I hope you enjoy using JT65 on the HF bands and JT65-HF. I'm always interested in hearing of ideas, bug reports or satisfaction reports.

73 – Joe - W6CQZ