WSJT 4.6 User's Guide

WSJT is a computer program for VHF/UHF communication using state of the art digital techniques. It can decode signals propagated by fraction-of-a-second reflections from meteor trails, as well as steady signals 10 to 20 dB weaker than those needed for conventional CW or SSB.

Operating Modes

- **FSK441** for high speed meteor scatter
- **JT6M** for meteor/ionospheric scatter on 6 meters
- **JT65** for extremely weak troposcatter and EME
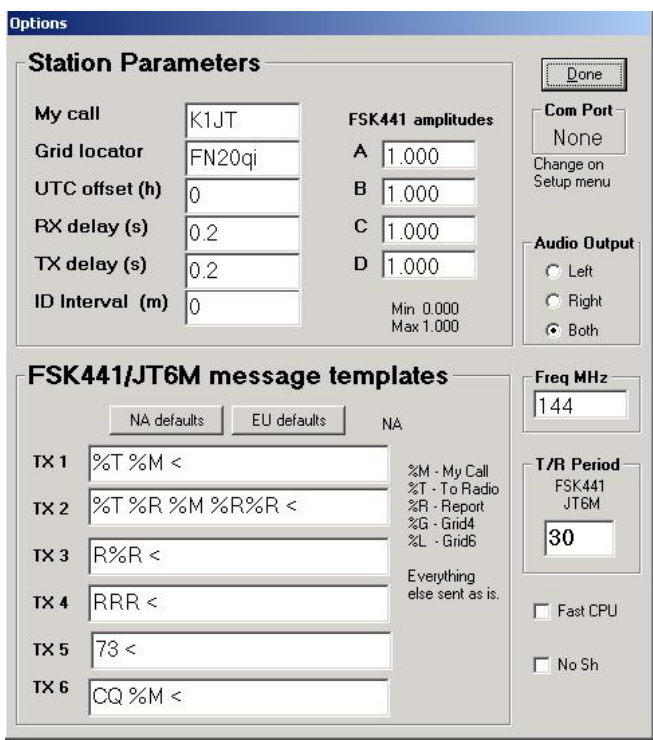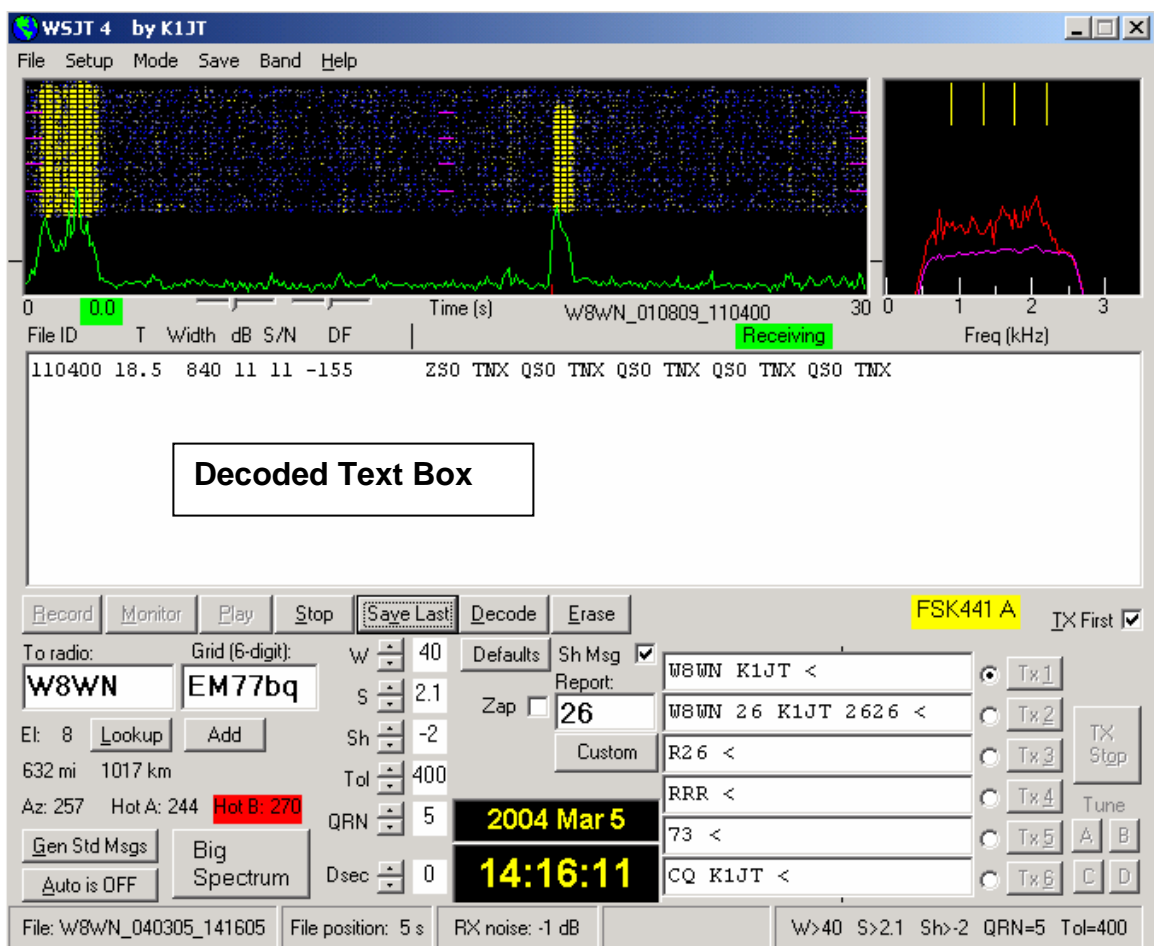- **EME Echo** for detecting your own echoes from the moon

System Requirements

- SSB transceiver and antenna for one or more VHF/UHF bands
- Computer running Microsoft Windows
- 200 MHz or faster CPU
- 32 MB of available RAM
- Monitor with 800 x 600 or higher resolution
- Windows compatible sound card
- Computer-to-radio interface using a serial port to key your PTT line (or use VOX)
- Audio connections between transceiver and sound card
- A means for synchronizing the computer's clock to UTC

Quick-Start Installation and Setup

1. Download WSJT from http://pulsar.princeton.edu/~joe/K1JT or the European mirror site, http://www.vhfdx.de.
2. Execute the downloaded file to install WSJT to a directory of your choice.
3. If you have not already done so, print a copy of this manual and keep it handy.
4. Connect appropriate interface cables between your computer and radio. (For help with the hardware interface, refer to one of the many descriptions of other sound card modes such as PSK31.)
5. To start the program, double-click on the desktop icon for WSJT.
6. Select **Options** from the **Setup** menu (see picture on next page) and enter your callsign, grid locator, and UTC offset. Click **Done** to dismiss the **Options** screen.
7. Select **Setup | Set COM Port** and enter the number of the serial port you will use for T/R control. Enter 0 if you will use VOX control.
8. Indicate on the **Setup** menu whether you wish to use the **DTR** or **RTS** line for PTT control. (If not sure, check both.)

These settings should be adequate for learning your way around the program. If you are new to WSJT, work through the examples at the top of page 3 and then continue reading this manual, stopping to experiment with the program when it seems appropriate.

WSJT 4   by K1JT

File Setup Mode Save Band Help

0   0.0   Time (s)   W8WN_010809_110400   30 0   1   2   3
File ID   T   Width dB S/N   DF   Receiving   Freq (kHz)

110400 18.5   840 11 11 –155   ZS0 TNX QSO TNX QSO TNX QSO TNX QSO TNX

Decoded Text Box

Record   Monitor   Play   Stop   Save Last   Decode   Erase   FSK441 A   TX First ☑

To radio: Grid (6-digit):   W ⬍ 40   Defaults   Sh Msg ☑   W8WN K1JT <   ◉ Tx 1
W8WN   EM77bq   S ⬍ 2.1   Report: W8WN 26 K1JT 2626 <   ○ Tx 2   TX
                                  Sh ⬍ -2   Zap ☐   26   ○ Tx 3   Stop
El: 8   Lookup   Add   Tol ⬍ 400   Custom   R26 <   ○ Tx 4   Tune
632 mi   1017 km   QRN ⬍ 5   RRR <   ○ Tx 5   A B
Az: 257   Hot A: 244 Hot B: 270   2004 Mar 5   73 <   ○ Tx 6   C D
Gen Std Msgs   Big   Dsec ⬍ 0   14:16:11   CQ K1JT <
Auto is OFF   Spectrum

File: W8WN_040305_141605   File position: 5 s   RX noise: -1 dB   W>40 S>2.1 Sh>-2 QRN=5 Tol=400

**Main Screen
FSK441A mode**

Options

Station Parameters

My call   K1JT   FSK441 amplitudes   Done
Grid locator   FN20qi   A 1.000   Com Port
UTC offset (h) 0   B 1.000   None
RX delay (s)   0.2   C 1.000   Change on
TX delay (s)   0.2   D 1.000   Setup menu
ID Interval (m) 0   Audio Output
                            Min 0.000   ○ Left
                            Max 1.000   ○ Right
                                                   ◉ Both

FSK441/JT6M message templates

              NA defaults   EU defaults   NA   Freq MHz
                                                       144
TX 1   %T %M <   %M - My Call
TX 2   %T %R %M %R%R <   %T - To Radio T/R Period
TX 3   R%R <   %R - Report   FSK441
                                        %G - Grid4   JT6M
TX 4   RRR <   %L - Grid6   30
TX 5   73 <   Everything
                                        else sent as is. ☐ Fast CPU
TX 6   CQ %M <   ☐ No Sh

**Setup | Options
Screen**

Example Files

To gain some familiarity with the operation of WSJT, use the program to decode some example files provided with the standard installation. Hit function key **F7** to choose **FSK441A** mode, and select **Open** from the **File** menu. Navigate to the `RxWav\Samples` folder in your WSJT home directory and open the file recorded from W8WN. When this file has been decoded, the top of your screen should look like the picture on page 2. With a speaker or headphones connected to the soundcard output, listen to the recording by clicking the **Play** button. You will hear static crashes at the beginning of the file and a moderately strong ping from W8WN about 18 seconds later. Try clicking around the ping with both left and right mouse buttons, and observe the decoded text that appears. Click the **Big Spectrum** button to see what these signals look like on the large waterfall display. Click **Erase** on the main screen to clear the text and graphical areas.

Next, select **JT6M** from the **Mode** menu and open the sample file from AF4O. Nothing decodes automatically in this file—the signal is very weak—but try right-clicking on the green line at about t = 12.9 s, as displayed on the green label at lower left of the plot area. You will find that AF4O was calling K1JT. Try listening to this file: the signal is audible some of the time, but only barely. Finally, switch to **JT65A** mode and open the recording from OH7PI. The graphics window and decoded text boxes on your screen should look like the picture on page 5. Listening to this file, you will hear only random noise. OH7PI's 144 MHz EME signal was much too weak for CW communication at this time, but he was solid copy in JT65.

Adjusting Signal Levels

1. Turn on your radio and tune it to a clear frequency so that only background noise is sent to the sound card.
2. Press **F9** to select the EME Echo mode.
3. Select **Setup | Adjust RX Volume control** to bring up the sound card input mixer.
4. Click **Measure** to start a sequence of noise measurements
5. Adjust a slider on the audio mixer and/or your receiver gain control(s) so as to bring the signal level close to what WSJT calls "0 dB". The signal level is displayed numerically and illustrated by a green line in the plot area. The green curve should be approximately aligned with tick marks on the left and right border.
6. Press **F7** to enter FSK441A mode.
7. Click **Record** to start a receiving period. The program will record noise for 30 seconds and then attempt to decode it. This should produce a jagged green line in the large plot area, along with a waterfall-style spectrogram. The green line is a graph of received noise power vs. time. The waterfall is a time vs. frequency spectrogram in which frequency increases upward, time to the right.
8. Select **Setup | Adjust TX Volume control** to bring up the sound card output mixer.
9. Turn off your final amplifier (if any). Click one of the four **Tune** buttons **A, B**, **C**, or **D** to be sure that T/R switching works and an audio tone is sent from the computer to your radio.
10. Adjust the slider on the audio mixer to get the proper audio signal level for your transmitter. Watch the transmitter power output while sending each of the four tones **A, B, C,** and **D**. Variations of 10% or even 20% among the four tones are acceptable, but 50% differences will degrade your signal. You may find it useful to experiment with the setting of a speech processor or ALC control.

Basic Operating Instructions

Note: further details on commands in **boldface** *may be found in the alphabetical list starting on page 15.*

WSJT uses timed intervals of transmission and reception. By convention FSK441 and JT6M use 30 s periods, while JT65 always uses 60 s intervals. To prepare for making a QSO, enter the other station's callsign in the **To radio** box and click **Lookup** and **Gen Std Msgs** to generate a sequence of commonly used messages. If **Lookup** does not find the callsign in the database file CALLSIGN.TXT, you may enter the grid locator manually. Decide whether you or the other station will transmit first, and check or uncheck **TX First** appropriately. Click **Auto** to start an automatic sequence of transmission and reception intervals.

At the end of each receiving period, WSJT displays various properties of a received signal graphically. A green line illustrates signal strength vs. time, and other lines or images display spectral information and synchronization results, depending on the mode. Decoded text appears in the large box near center screen. Refer to the pictures on pages 2, 4, and 5 for examples in the FSK441, JT6M, and JT65 modes.

When an **FSK441** or **JT6M** reception period has finished the program looks for signal enhancements produced by short-lived reflections from meteor trails. You can often hear such "pings" when they occur, and they can be seen as spikes on the green line and brighter colors in the waterfall spectrum. One or more lines of decoded text may result from each ping. By clicking on the green line with the mouse, you can force decoding of a particular spot in a record.

WSJT attempts to compensate for relative mistuning between transmitting and receiving stations. By default the frequency search range is ±400 Hz (±600 Hz in JT65). You can reduce the range by setting the value of **Tol** (for "tolerance") to a lower value. Several other decoding parameters can be adjusted, as well. In FSK441 mode **W** sets the minimum width and **S** the minimum strength (in dB) for acceptable pings. Adjustments can be made at any time by clicking on spinner controls next to the parameter labels, and all parameters can be reset to default values by clicking the **Defaults** button.
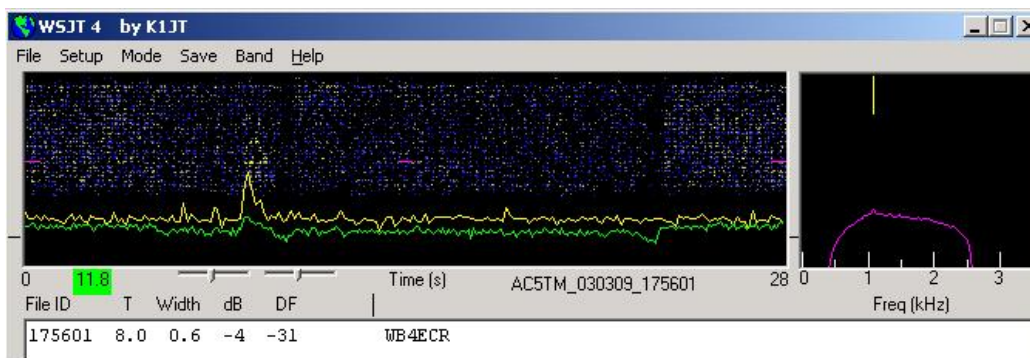
JT6M mode

In addition to the green line for overall signal strength, **JT6M** produces a yellow line showing the detected strength of a synchronizing tone. JT6M attempts to decode both individual pings and an "average message" based on the entire transmission (or selected portions thereof). An average message is flagged with an asterisk at the right end of the text line. Clicking with the left mouse button decodes a 4 s block of data near the mouse pointer, while the right button decodes a 10 s segment. You can also drag the mouse pointer with the

button down to select any desired region. As in FSK441, with marginal signals you should experiment as necessary for best decoding. JT6M can work with signals many dB weaker than those required for FSK441. You will sometimes find that clicking on a smooth green line, even where nothing was heard and nothing can be seen, causes callsigns or other information to pop up out of the noise.

Sync tone detected at DF=43 Hz (red line)

Time synchronization at DT = 1.9 s (blue line)

Graphics Window

Sun/Moon Data

Decoded Text Box

Average Text Box

TX Messages

Main Screen JT65A mode
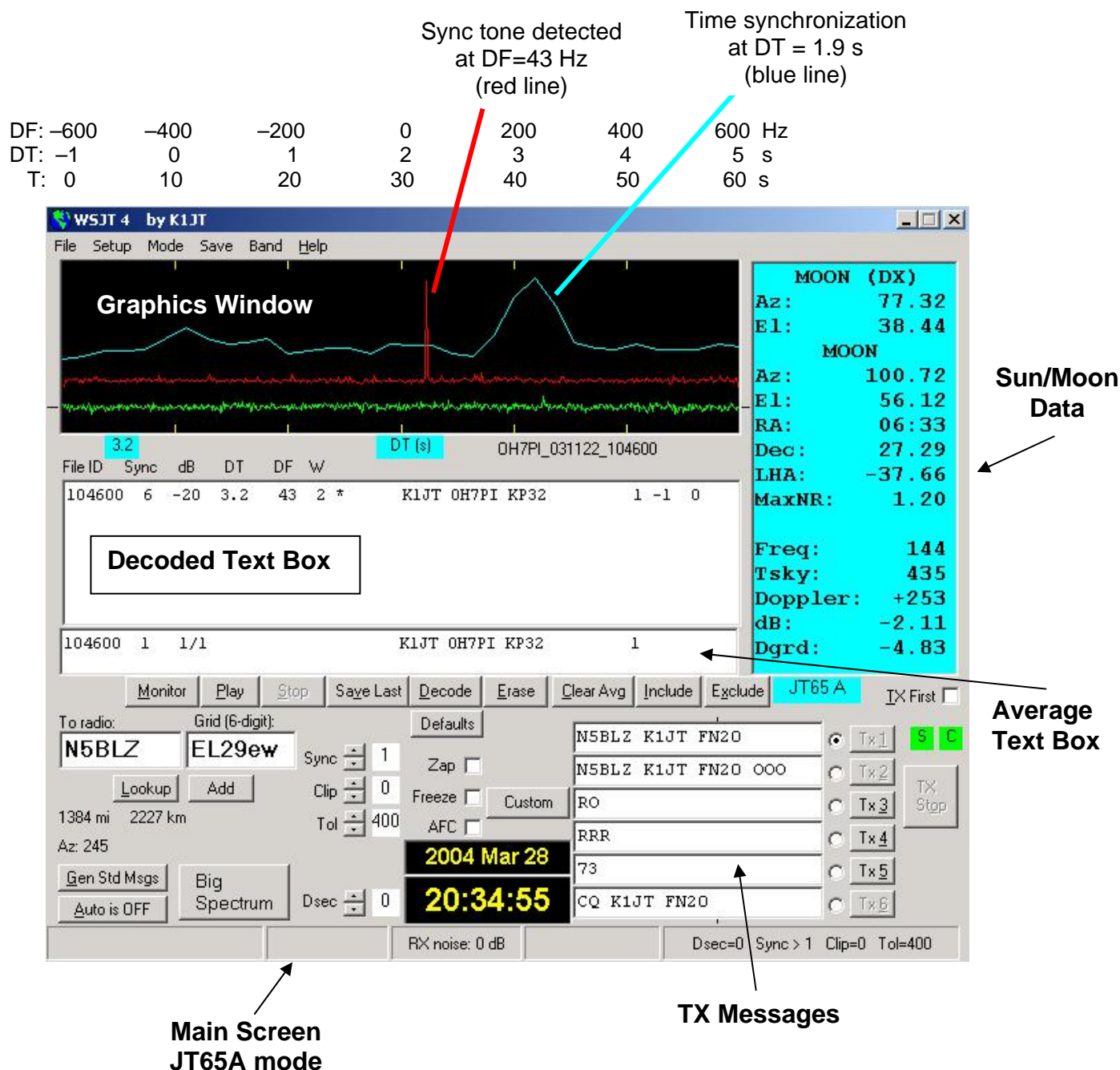
JT65 requires tight synchronization between transmitter and receiver, so in this mode the only way to initiate a transmission or reception interval is by toggling **Auto** to **ON**. As in other WSJT modes, an incoming signal is analyzed after a full receiving sequence is complete. The resulting graphical display includes red and blue lines along with the green line. The additional curves summarize the program's attempts to synchronize with the

received signal, a necessary step toward decoding the message. Proper synchronization is indicated by a sharp upward spike in the red curve and a broader peak on the blue curve. Horizontal locations of the peaks correspond to the frequency and time offsets, DF and DT, between transmitter and receiver. EME QSOs have propagation delays of about 2.5 s and can have significant Doppler shifts. Along with clock and frequency errors, these effects contribute to the measured values of DT and DF.

Message Formats

Standard messages in FSK441 and JT6M are generated with the aid of templates defined on the **Setup | Options** screen (see p. 2). Default templates are provided conforming to standard practice in North America and Europe, and you can edit the templates to suit your own requirements. Normal FSK441 and JT6M messages can contain any arbitrary text up to 28 characters. The supported character set is 0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ.,/#?$ plus the space character.

FSK441 provides a special shorthand format to transmit a few simple messages in a highly efficient way. Check **Sh Msg** to activate shorthand messages. The supported messages are R26, R27, RRR, and 73. FSK441A sends pure tones at 882, 1323, 1764, or 2205 Hz to convey them, while FSK441B and C use alternating two-tone sequences with the lower tone at 861 Hz and the upper at 1206, 1550, 1895, or 2240 Hz.

JT65 messages are more constrained and must have one of three basic formats:
1. Four alphanumeric fields with specific contents as described below.
2. Any arbitrary text, up to 13 characters
3. Special shorthand messages ATT, RO, RRR, and 73

The four fields of a type 1 message usually consist of two legal callsigns, an optional grid locator, and the optional signal report OOO. CQ or QRZ can be substituted for the first callsign, and CQ may be followed by a space and three digits to indicate a desired callback frequency. If K1JT transmits on 144.140 and sends "CQ 113 K1JT FN20", it means that he will listen on 144.113 and respond there to any replies. A country prefix preceded by "/" or a signal report of the form "–NN" or "R–NN" may be substituted for the grid locator. For example, –24 might indicate that signals were received at –24 dB. The minus sign is required, and NN must lie between 01 and 30. A list of supported country prefixes is given in Appendix A. The following are all examples of legal messages of type 1:

F9HS K1JT	F9HS K1JT FN20	F9HS K1JT FN20 OOO
F9HS K1JT OOO	F9HS K1JT /KP4	F9HS K1JT /KP4 OOO
VK7MO K1JT –24	K1JT VK7MO R–26	CQ K1JT
CQ K1JT FN20	CQ 113 K1JT	CQ 113 K1JT FN20
QRZ K1JT	QRZ K1JT FN20	

The JT65 shorthand messages are powerful because they can be decoded at signal levels some 5 dB below those required for standard messages. They do not use tight time synchronization, so they provide no information on DT. The ATT message (for "Attention") is intended to help two stations find each other before a normal QSO begins. If a message starts with ATT, RO, RRR, or 73, the shorthand format will be sent. If it satisfies the requirements for message type 1, the full message of up to 22 characters will be compressed and sent. With any other entry, 13 characters of arbitrary text will be sent.

Standard QSO Procedures

Difficult contacts become easier if you follow standard operating practices. For minimal QSOs, the recommended procedure is as follows:

1. If you have received less than both calls from the other station, send both calls.
2. If you have received both calls, send both calls and a signal report.
3. If you have received both calls and a report, send R plus your signal report.
4. If you have received R plus signal report, send RRR.
5. If you have received RRR — that is, a definite acknowledgment of all of your information — the QSO is officially complete. However, the other station may not know this, so it is conventional to send 73s (or some other conversational information) to signify that you are done.

Slightly different procedures may be used in different parts of the world, or in the different operating modes. Typing the **F5** key will cause WSJT to pop up a screen that reminds you of the recommended procedures.

Select the message for your next transmission by clicking in the small circle to the right of the message text. In the FSK441 and JT6M modes, and for shorthand messages in JT65, you can switch messages while a transmission is in progress by clicking on one of the **TX** buttons to the right of the circles.

Operating Hints

After every decoding attempt, WSJT displays its best estimate of a detected signal's frequency offset. The accuracy of these estimates is approximately ±25 Hz for FSK441 signals, ±10 Hz for JT6M, and ±3 Hz for JT65. Within these tolerances (and subject to the stability of oscillators and the propagation path) you should see consistent numbers in the DF column during any QSO producing usable signals.

In the FSK441 and JT6M modes, if DF lies outside the range ±100 Hz it will help to retune your receiver to compensate. Do this with the RIT control, or by using split RX/TX VFOs. In general you should not change your transmitting frequency during a QSO, since your partner will be trying to tune you in at the same time.

JT65 is tolerant of frequency offsets up to ±600 Hz, and unless the "red spike" is close to one edge of the plot area (see picture on p. 5), retuning with RIT is optional. However, note that EME QSOs on bands above 432 MHz can have Doppler shifts of several kHz or more. In such cases you will certainly need to use RIT or split VFOs in order to acquire the received signal. Once the program has synchronized on a JT65 signal, it's best to click on the red spike, check **Freeze**, and reduce **Tol** to 100 Hz or less. In subsequent decodings, WSJT will search a range of frequencies only ±**Tol** Hz around the DF selected by clicking on the red spike.

Question marks in displayed JT65 text lines indicate "OOO" and shorthand messages about which there could be some doubt. These occur when the OOO flag has apparently been found but the full message text not decoded, or when a probable shorthand message is detected but you have not yet checked **Freeze** and reduced **Tol** to 100 Hz or less. Operator skill is required in order to make the best possible use of JT65 shorthand messages. Visual aids to decoding shorthand messages "by eye" are provided if you click on the sync-tone frequency in the **Big Spectrum** display.

You will need a method of setting your computer clock to an accuracy of one second or better, and keeping it set. Many operators use an internet clock-setting program, while others use a GPS or WWVB receiver.

Solar and Lunar Data

The light blue text box in JT65 and EME Echo mode presents data for tracking the moon, measuring sun noise, tuning your receiver, and evaluating EME path losses. The information includes azimuth and elevation (**Az** and **El**) for the sun and those quantities plus right ascension (**RA**), declination (**Dec**), and local hour angle (**LHA**) for the moon.   All coordinates are in degrees except for **RA**, which is given in hours and minutes. The moon's semi-diameter (**SD**) is given in arc minutes, and **Doppler** shift for the band in use in Hz. Since two-way Doppler shift depends on the other station's location as well as your own, the **Doppler** field is blank if the **Grid** box is empty. In EME Echo mode, the displayed **Doppler** is your own self-echo value. **Tsky** gives the galactic background temperature in the direction of the moon, scaled to the operating frequency, and **dB** the added signal loss at the moon's present distance, relative to perigee. **Dgrd** is an estimate of the total signal degradation in dB, relative to the best possible time when the moon is at perigee and in a cold part of the sky. Click with the mouse anywhere in the light blue text box to see the local coordinates (**Az** and **El**) of the moon at the DX station's location and the maximum non-reciprocity of the EME path, in dB. Click again to toggle back to the normal display.

Distinctions between the Submodes

Messages are encoded differently in the three FSK441 submodes, so a transmission in one mode must be decoded using the same mode. FSK441A uses a zero-redundancy code in which characters are transmitted with three successive tones, each at one of four assigned frequencies. The FSK441B and C modes use sequences of four and seven tones, respectively, with the additional information providing error-correcting capabilities. FSK441B can correct any single error in the four symbols that make up a character, while FSK441C can correct up to three errors in seven symbols.

JT65 transmits messages using 65-tone frequency-shift keying at 2.7 baud. The lowest tone at 1270.5 Hz is used to establish time and frequency synchronization; it is switched on for half of the time, according to a pseudo-random on-off pattern. The remaining tone intervals carry the user message, using a Reed-Solomon code for forward error correction. The three JT65 submodes all use the same code and modulation scheme, but the spacing between tones is different—approximately 2.7, 5.4, and 10.7 Hz for modes A, B, and C, respectively. A transmission in one submode must be received in the same submode. If the equipment and propagation path are stable enough that the measured width of the sync tone is consistently 4 Hz or less, JT65A will be about 1 dB more sensitive than mode B and 2 dB more sensitive than C.

Shorthand JT65 transmissions consist of alternating tones, each lasting 1.486 s. The lower of the two frequencies is always at the sync-tone frequency, 1270.5 Hz, and the separation between tones is given in the following table:

| Message	JT65A	JT65B	JT65C
ATT	26.9 Hz	53.8	107.7 Hz
RO	53.8	107.7 Hz	215.3
RRR	80.8	161.5	323.0
73	107.7	215.3	430.7

EME Echo Mode

EME Echo mode (see picture on next page) is designed to help evaluate the performance of your station for moonbounce communications. Activate it from the **Mode** menu or by pressing function key **F9**. Aim your antenna at the moon, pick a clear frequency, and toggle the **Auto** button to **ON**. The program will then start cycling through the following loop:

1. Transmit a fixed tone for 2.0 s
2. Wait about 0.5 s for start of return echo
3. Record the received signal for 2.0 s
4. Analyze, average, and plot the results
5. Repeat from step 1

At the start of each transmission the frequency of the transmitted tone is offset randomly around a nominal value of 1500 Hz. A number in the text box labeled **Dither (Hz)** controls the magnitude of the random offset. The observed spectrum of each echo is shifted by the dither amount before being accumulated into the average. This procedure is very effective in minimizing the impact of birdies in the receiver passband. In the average spectrum, a fixed-frequency birdie is smeared out over a wide range while the desired signal remains sharply defined.

EME Echo mode
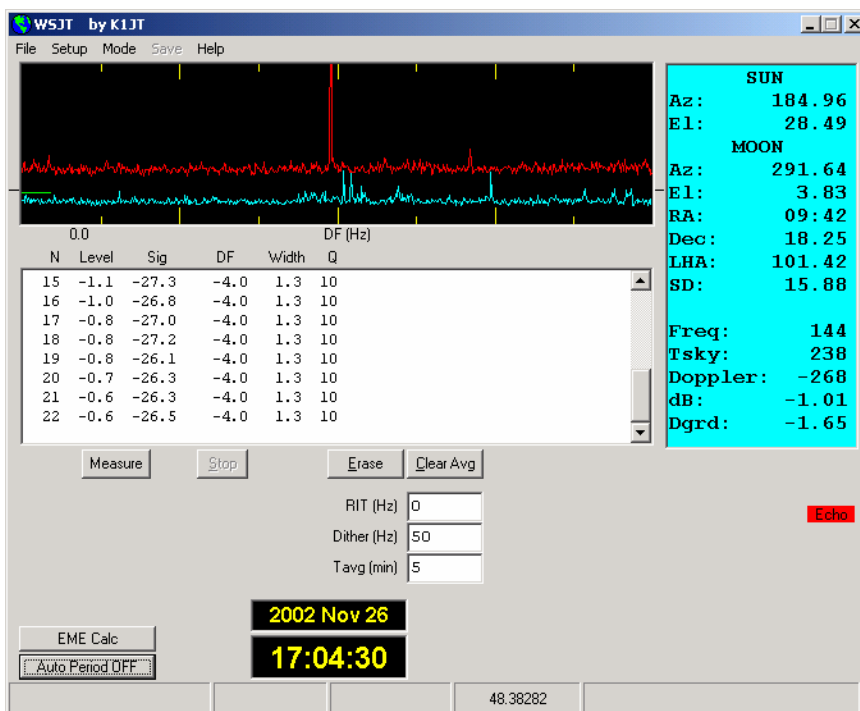
Two curves appear in the graphical area after each T/R cycle, each one representing the spectrum of received power over a 400 Hz range, centered on the expected echo frequency. The blue (lower) curve is a reference spectrum that you can use to be sure you have chosen a birdie-free passband. It is aligned to remove the Doppler shift computed at the start of the run and not subsequently adjusted for changes in Doppler or the programmed dithering of transmitted frequency. Stable birdies therefore stay fixed in the blue curve, making them easy to recognize. The red curve displays the average echo signal, adjusted to correct for changing Doppler shift and for the programmed frequency dithering. Your echo should appear as a narrow spike near the middle of the red curve, close to DF = 0.

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Information in the text box gives the number **N** of completed echo cycles, the average **Level** of receiver background noise in dB, the average echo strength **Sig** in dB, its measured frequency offset **DF** in Hz (after correction for Doppler shift), its spectral **Width** in Hz, and a relative quality indicator **Q** on a 0–10 scale. Background noise level is given with respect to the nominal "0 dB" level used for all WSJT modes. Signal strength is measured in dB relative to the noise power in the full receiver passband, nominally 2500 Hz. **Q** = 0 means that an echo has not been detected or is very unreliable, in which case the values of **DF** and **Width** are meaningless and **Sig** is an upper limit. Larger values of **Q** imply increasingly believable echo measurements. If you can hear your own lunar echoes, you will see a large spike in the red curve within a few seconds after toggling **Auto ON**. If your echoes are 15 to 20 dB below the audible threshold you should see a significant spike on the red curve within a few minutes.

By default EME Echo mode assumes that your receiver and transmitter are tuned to the same frequency. An on-screen box labeled **RIT (Hz)** allows you to inform the program of any offset receiver tuning, for example to accommodate a large Doppler shift. Suppose you are running a test on 23 cm and the predicted Doppler shift at the start of the run is –1400 Hz. In that case the 1500 Hz transmitted audio tone would be detected at 100 Hz, probably well below the low-frequency cutoff in your receiver's passband. Use your transceiver's RIT control to offset the receiver tuning by the predicted Doppler shift or a nearby rounded value, and enter this offset in the RIT box before starting the echo measurement. The program will track subsequent Doppler changes up to about 800 Hz, if necessary, without any further adjustments. Your echo should appear near the center of the red curve, as usual. You won't need to use the RIT feature on 6 or 2 meters, where Doppler shifts are much smaller and echoes always fall within the transceiver's SSB passband.

The frequency of a valid echo should be well defined and stable. If you click **Clear Avg** to start a new measurement, the echo signal (the red spike) should build up again at the same DF. To be absolutely sure that you are seeing you own echo, offset your transmitter frequency by a known amount, say 50 Hz, while holding the receiver frequency constant. A valid echo will shift by the same 50 Hz.

Measure Mode

A button labeled **Measure** provides a means for measuring relative noise power from your receiver. Click it and your system will record audio for one second, compute the level of noise power, and display the result in dB relative to WSJT's standard level. This cycle is repeated every 2 seconds, with the results plotted as a green line and summary data displayed in the large text box.

If the file DECODED.CUM has been activated from the **File** menu, data will be written into that file as well, tagged with the Modified Julian Date on which you made the measurements. You can use this mode to measure sun noise, antenna temperature, ground noise, preamp gain, and a host of other useful quantities relative to a chosen reference level. Be sure to disable the receiver AGC if you intend to use the mode for quantitative measurements. It would also be wise to make some test measurements (for example, using a calibrated attenuator) to confirm that the reported dB readings are reliable in your system as configured.
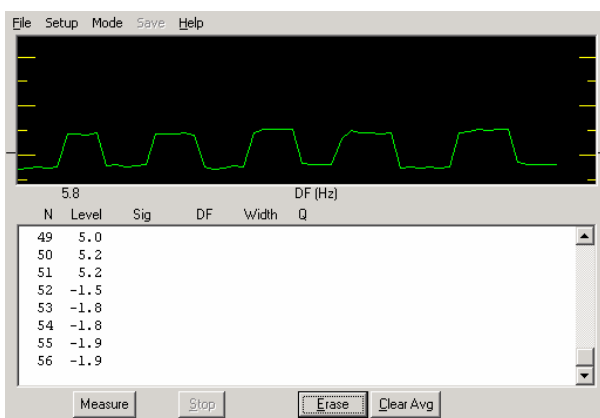
Measure mode, with
preamp turned
on and off repeatedly

EME Calc

Clicking the button labeled **EME Calc** at the lower left of the Echo-mode screen will pop up a utility program for predicting the strength of your echoes from the moon. Enter the requested quantities for your station and click **Compute;** if you enter parameters for a DX station as well, you will see the maximum strengths for both station's self-echoes and for each signal at the other location. Clicking **Now** will enter the frequency of the active band as specified on the **Setup | Options** form, and the sky background temperature at that frequency. You can **Save** a set of parameters to a file, and **Load** a saved parameter set at some later time.

EME Calc

Predicted echo strengths assume that your specified parameters are reliable, everything is working right, and Faraday rotation is cooperating (if relevant). There are many reasons why your actual echo strength at a given time may be less than the predicted value—and a few reasons why it might (briefly) be slightly greater.

Amplifier Considerations

WSJT sends a single-frequency sine wave at any instant when it is transmitting. Except during station identification, there is no "key up" time; signal amplitude is constant, and one tone changes to the next one in a phase-continuous manner. As a result, WSJT does not require a high degree of linearity in your power amplifier. You can use a class C amplifier without generating unwanted sidebands or splatter. Please note that full amplitude

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transmissions lasting 30 seconds or longer will put more stress on your final amplifier than SSB or CW operation. If this would cause the amplifier to overheat, you should take appropriate action: reduce power or add another cooling fan or blower.

Menus and the Setup | Options Screen
File
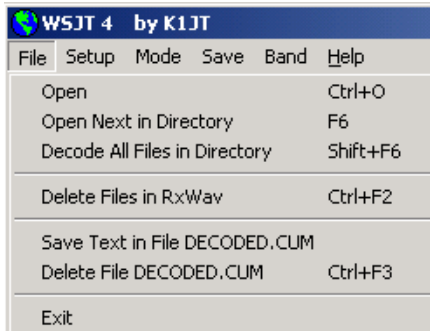
>   **Open:** read and decode a previously recorded file stored on disk. The file must be a standard wave file recorded in 8-bit monaural format with 11025 Hz sampling.
>
>   **Open Next in Directory:** read and decode the next file after one already opened.
>
>   **Decode All Files in Directory:** sequentially read and decode all wave files following the one already opened.
>
>   **Delete files in RxWav:** delete all `*.WAV` files in the `RxWav` subdirectory.
>
>   **Save text in file DECODED.CUM:** append decoded text to a file named `DECODED.CUM` in the WSJT installation directory.
>
>   **Delete file DECODED.CUM:** erase the cumulative text file.
>
>   **Exit:** terminate the program

Setup | Options   (see screen picture on p. 2)

>   **My call:** Enter your callsign
>
>   **Grid locator:** Enter your 6-digit grid locator
>
>   **UTC offset:** your timezone offset from UTC, in hours. Enter a negative value if you are east of Greenwich.
>
>   **RX delay:** enforce specified delay between end of transmission and start of next recording.
>
>   **TX delay:** enforce specified delay between activation of PTT line and start of first audio tone sent to transmitter.
>
>   **ID Interval:** set time in minutes between automatic station identifications. A value of zero disables the automatic identification. To use this feature you must provide an audio file named `ID.WAV` in the WSJT home directory. The file can identify your station using any desired mode, e.g., voice or CW. (See **Generate ID.WAV**).

NA/EU Defaults: insert default templates for generating standard FSK441 and JT6M messages. The templates can be edited, for example to append a suffix or prefix to a callsign, or to properly format a contest exchange. For example, if G4FDX changes the template for message TX1 to read "`%T W9/%M`", the message "`K1JT W9/G4FDX`" will appear in the box for TX message 1 when he presses **Gen Std Msgs** to call K1JT.

FSK441 Amplitudes: set relative voltage to be generated for each FSK441 tone. If necessary, one or more of these numbers can be decreased from the nominal 1.0 to compensate for nonuniform frequency response in your TX audio system.

Audio output: select which audio channel carries signal from the sound card to the radio: **Left**, **Right**, or **Both**.

Freq MHz: nominal frequency in MHz, used for computing Doppler shifts and sky background temperatures. (See also **Band** menu.)

T/R Period: set length of T/R intervals for FSK441 and JT6M modes, in seconds.

Fast CPU: decode JT65 signals immediately after a recording has finished. Check this box only if your computer is fast enough to allow decoding in 5 seconds or less. It permits you to see a decoded message before your next transmission begins.

No Sh: disable all decoding of shorthand messages in FSK441.

Other Setup Items
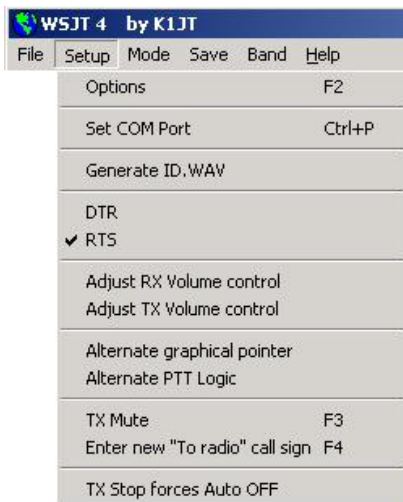
Set COM port: set number of the COM port that will activate T/R switching. To disable COM port T/R switching, enter 0.

Generate ID.WAV: create a CW wave file in the WSJT home directory with "My call" sent at 25 WPM, 440 Hz.

DTR, RTS: select the serial-port signal line that will control your T/R switching sequence.

Adjust RX/TX Volume controls: display sound mixer controls.

Alternate graphical pointer: use "arrow" instead of "crosshairs" as the mouse's graphical pointer.

Alternate PTT Logic: activate slightly different program logic for controlling your T/R switching via the COM port. (A few combinations of hardware and operating system drivers seem to work better with this option checked.)

Tx Mute: mute the transmitter. Use with **Auto ON** to monitor one side of a QSO.

Enter new "To radio" callsign: clear the **To radio** and **Grid** boxes in preparation for new entries.

Tx Stop forces Auto OFF: if this item is checked, clicking **TX Stop** during a transmission will toggle **Auto** to **OFF**.

Mode

Select desired operating mode from this menu.

Save

Save Decoded: save any files producing decoded text in subdirectory RxWav under your WSJT home directory.

Save All: save all recorded files in subdirectory RxWav of your WSJT home directory.

Band

Select your operating band from displayed list. The selected frequency is used for computing EME Doppler shifts and sky background temperatures.

Help

Help: displays a brief message urging you to download and read the *WSJT 4.6 User's Guide* (the manual you are reading now).

About WSJT: displays version and copyright information.

Which message should I send? Choosing this item (or using shortcut **F5**) will pop up a text box with reminders about the standard message sequences used for minimal QSOs with FSK441, JT6M, and JT65.

Alphabetical List of On-Screen Controls

Note: some controls are visible only in certain operating modes.

Add: causes the displayed callsign and grid locator to be added to the database file CALLSIGN.TXT. If an entry for this callsign already exists, you will be asked if you want to replace it.

AFC: activate automatic frequency control in JT65 decoding algorithm.

Auto: toggles **ON** or **OFF** timed sequencing of transmit and receive periods.

Big Spectrum: display large waterfall spectrogram for most recently decoded file. Time increases from top to bottom, frequency from left to right. This display can help you to identify different types of signals and noise, distinguish wanted signals from birdies, etc.

Brightness: adjust brightness of waterfall spectrogram (FSK441 and JT6M only; slider below large graphics area). Click **Decode** to see effect of change.

Clear Avg: erase text in average message box, and clear message accumulator.

Clip: normally set to zero. Increase its value to 1, 2, or 3 to apply soft, moderate, or hard clipping to a signal before attempting to decode its message. May be useful to reduce the effects of static crashes, etc.

Contrast: adjust contrast of waterfall spectrogram (FSK441 and JT6M only; slider below large graphics area). Click **Decode** to see the effect of a change.

Custom/Standard Texts: toggles between two sets of TX messages. Custom texts can be used to store messages such as grid locator or contest information.

Decode: analyze most recently recorded or opened file, perhaps after one or more decoding parameters (such as **Freeze**, **Tol**, **Zap**, **AFC**, or **Clip**) have been changed.

Defaults: reset parameters **W**, **S**, **Sh**, **Sync, Clip**, **Tol**, and **QRN** to default values.

Dsec: adjust UTC clock reading in ±1 s increments to manually resynchronize with UTC or with your QSO partner's computer. (In general, it is best to keep the Windows clock set accurately and **Dsec** set to zero.)

EME Calc: activate the EME signal-level calculator.

Erase: clear all information in main text box and graphical areas.

Exclude: remove most recent recording from the average message accumulator. Use this option when you are sure that the program has synchronized incorrectly (for example, because DF and/or DT differ substantially from expected values) and you wish to avoid contaminating the average message with bad data.

Freeze: search only frequencies within ±**Tol** Hz of target DF set by clicking on red spike.

Gen Std Msgs: generate standard messages; also reset **TX** message to 1 and **Tol** to 400 Hz.

Include: if signal level is greater than –32 dB, add most recent recording to average message accumulator even if **Sync** is less than stated threshold.

Lookup: search database file CALLSIGN.TXT for entry in **To radio**. If callsign is found, the station's grid locator is retrieved and used to calculate distance, azimuth, elevation, and Doppler shift.

Measure: initiate a series of noise power measurements.

Monitor: start a series of recordings, perhaps to monitor a calling frequency or to copy two other stations engaged in a QSO.

Play: play most recently decoded file through sound card speaker output. This button functions much like the "Play" button on a cassette recorder.

QRN: adjust to higher values (default=5) to suppress false decodings caused by atmospheric noise.

Record: start recording audio noise from radio. The program will record for the time entered in **T/R Period**, or until you press **Stop**. If **Auto** is **ON**, recording will stop when the present T/R interval is finished; the data will then be plotted and decoded. This control works much like the "Record" button on a cassette recorder.

S: set minimum increase in signal that will be accepted as a ping.

Save Last: save most recently recorded file. (See also **Save Decoded** and **Save all**, on the **Save** menu).

Sh: set minimum strength in dB of an acceptable FSK441 shorthand message.

Sh Msg: enable transmission of FSK441 shorthand messages R26, R27, RRR, and 73.

Stop: terminate a **Record**, **Monitor**, or **Play** operation. This control functions much like the "Stop" button on a cassette recorder.

Sync: set synchronizing threshold (default=1) for the JT65 decoder.

Tol: set decoder tolerance (in Hz) to frequency offsets. When DF has been established and reduced to a small value by retuning the receiver, decrease the value of **Tol** to reduce the probability of false decodings.

Tune A, B, C, D: generate steady tones at one of the four standard FSK441 frequencies 882, 1323, 1764, or 2205 Hz.

Tx 1–6: transmit selected message. Transmission will continue until the end of the present TX sequence or, if **Auto** is **OFF**, for the duration listed in the **T/R Period** box.

TX First: check this box if you want to transmit during the first period of the timed T/R cycle. Uncheck it if your QSO partner is transmitting in the first period. In this context, "first" is defined as transmitting during the first T/R interval of an hour.

TX Stop: terminate a transmission in progress.

W: set the minimum width of pings considered for automatic decoding.

Zap: filter out birdies (narrowband signals of approximately constant amplitude) before attempting to decode.

Main Screen Text Boxes

Average Text: displays average messages in JT65 mode.

Decoded Text: displays decoded messages and other signal information.

Dither (Hz): sets maximum random offset applied to transmitted tones in Echo mode.

Grid: after a successful **Lookup**, displays the six-digit grid locator of the callsign in the **To radio** box. You can also enter a grid locator manually. If only four digits of the locator are known, add a space.

Report: enter the signal report you wish to send to the other station, then click **Gen Std Msgs**.

RIT (Hz): your receiver RIT setting in Hz.

Status Bar: panels at the bottom of the WSJT screen for displaying information such as file name, file position, RX audio level, and decoding parameters.

Sun/Moon Data: current coordinates of sun and moon and EME path information. Click anywhere in this box to display lunar coordinates for the DX station and **MaxNR**, the maximum non-reciprocity of the EME path (caused by spatial polarization and Faraday rotation). Click again to toggle back to the normal display.

Tavg (min): sets averaging time in EME Echo mode.

To radio: callsign of station being called. Text entered in this box becomes leading part of recorded file names.

Appendix A: Supported Country Prefixes

If you are operating under the licensing authority of another nation, you can substitute the portable country prefix (preceded by "/") for your grid locator in the standard JT65 type 1 message. The supported three-character country prefixes are listed below:

```
1A   1S   3A   3B6  3B8  3B9  3C   3C0  3D2  3DA  3V   3W   3X   3Y   4J
4L   4S   4U1  4W   4X   5A   5B   5H   5N   5R   5T   5U   5V   5W   5X
5Z   6W   6Y   7O   7P   7Q   7X   8P   8Q   8R   9A   9G   9H   9J   9K
9L   9M2  9M6  9N   9Q   9U   9V   9X   9Y   A2   A3   A4   A5   A6   A7
A9   AP   BS7  BV   BV9  BY   C2   C3   C5   C6   C9   CE   CE0  CE9  CM
CN   CP   CT   CT3  CU   CX   CY0  CY9  D2   D4   D6   DL   DU   E3   E4
EA   EA6  EA8  EA9  EI   EK   EL   EP   ER   ES   ET   EU   EX   EY   EZ
F    FG   FH   FJ   FK   FM   FO   FP   FR   FT5  FW   FY   H4   H40  HA
HB   HB0  HC   HC8  HH   HI   HK   HK0  HL   HM   HP   HR   HS   HV   HZ
I    IG9  IS   IT9  J2   J3   J5   J6   J7   J8   JA   JD   JT   JW   JX
JY   K    KG4  KH0  KH1  KH2  KH3  KH4  KH5  KH6  KH7  KH8  KH9  KL   KP1
KP2  KP4  KP5  LA   LU   LX   LY   LZ   M    MD   MI   MJ   MM   MU   MW
OA   OD   OE   OH   OH0  OJ0  OK   OM   ON   OX   OY   OZ   P2   P4   PA
PJ2  PJ7  PY   PY0  PZ   R1F  R1M  S0   S2   S5   S7   S9   SM   SP   ST
SU   SV   SV5  SV9  T2   T30  T31  T32  T33  T5   T7   T8   T9   TA   TA1
TF   TG   TI   TI9  TJ   TK   TL   TN   TR   TT   TU   TY   TZ   UA   UA2
UA9  UK   UN   UR   V2   V3   V4   V5   V6   V7   V8   VE   VK   VK0  VK9
VP2  VP5  VP6  VP8  VP9  VQ9  VR   VU   VU4  VU7  XE   XF4  XT   XU   XW
XX9  XZ   YA   YB   YI   YJ   YK   YL   YN   YO   YS   YU   YV   YV0  Z2
Z3   ZA   ZB   ZC4  ZD7  ZD8  ZD9  ZF   ZK1  ZK2  ZK3  ZL   ZL7  ZL8  ZL9
ZP   ZS   ZS8
```

Further Reading

1. A separate *WSJT 4.6 Technical Manual* (in preparation) provides technical specifications and details on how the WSJT modes work. The *Technical Manual* will be posted at http://pulsar.princeton.edu/~joe/K1JT, the WSJT home page, when available.

2. In the meantime, technical information can be found in the Version 3.0 *WSJT User's Guide and Reference Manual,* which is still available at http://pulsar.princeton.edu/~joe/K1JT/WSJT300.PDF.

3. The first WSJT mode, FSK441, was described in *QST* for December 2001, in an article starting on p. 36.

4. JT44, a predecessor to the JT65 mode, was described in *QST* for June 2002 in "The World Above 50 MHz," p. 81.

Acknowledgments