JUMA TRX-2 Operating Manual
5B4AIY Firmware Version 1.07j

The TRX-2 is an all-band QRP transceiver utilising a direct digital synthesiser and employing quadrature phase-shift detection in a direct-conversion arrangement for both transmission and reception, and capable of USB/LSB and CW modes of operation.

This document describes the operation and setup of this equipment using firmware version 1.07j, software modifications and changes made by Adrian Ryan, 5B4AIY.

It assumes that you have already performed the various hardware setup adjustments covering receiver AGC threshold setting, optimisation of sideband suppression, transmitter final amplifier bias current adjustments, amplifier gain compensation and microphone level setting.

Front Panel Controls

Control Description

PWR
This button is used to power-up and power-down the transceiver, as well as several secondary functions. To power up the transceiver, briefly press the button. The display will illuminate and a sign-on message will be displayed:

```
JUMA-TRX2 v1.07j
  OH2NLT OH7SV
```

After a short delay, the current frequency bands in use will be displayed either as:

```
IARU Freq Bands
```

or:

```
USA Freq Bands
```

Then the main display will be shown.

To power down the transceiver, press and hold the power button, and a message will be displayed showing a count-down to zero. At this point the display will clear, the backlighting will be turned off, and the button can be released.

During the count down period the current user settings are being written to the EEPROM. If the button is released during the count-down, it will be aborted, and the previous operation will be resumed.

During normal operation, a brief press of the power button will toggle locking the VFO frequency. Note that this simply disables the VFO tuning knob, the receiver frequency can still be changed by pressing either the VFO button or using the Rapid Band Switch feature.

If the power button is pressed and held whilst powering up, the system setup menu will be selected. The various operations and settings are fully covered in the System Setup section of this document. To exit the setup menu without making any changes, press and hold the power button to power the transceiver down.

CW Speed

This knob controls the speed of the internal keyer, or, can be used as a receiver squelch setting. The operation of this knob is controlled by a setting in the User Configuration menu, which is covered in the User Configuration section of this document.

MIC

The microphone/PTT switch is connected to this socket by means of a 3.5mm stereo jack. The wiring is:

> Tip   : Microphone/Line input
> Ring   : PTT switch
> Screen   : Ground/Shield

The PTT switch requires a dry contact closure to ground, or an open-collector connection capable of sinking 0.5mA from +5V.

The microphone is normally expected to be an electret, and there is a bias voltage of +5V via a source resistance of 5.7K. If a dynamic microphone is used, a DC blocking capacitor should be wired in series with the tip connection. Most dynamic microphones have an impedance of about 400 , for optimum speech quality and low frequency response, a capacitor of at least 2µF should be used. If using an electrolytic capacitor, wire the +ve to the tip of the plug.

DISPLAY/CONFIG

This multi-function button is normally used to control the transceiver's display. In the receive mode the normal display has the S-meter, either as a numeric or graphic indication at the top left of the screen, followed by the mode indicator, (LSB/USB/CW/Tune), and the receiver's filter, Wide (WID), Medium (MID), or Narrow (NAR).

A brief push of the DISPLAY/CONFIG button will over-write the mode and bandwidth with the PWR display, which is only active during either transmit or tune operations. The next

brief push will display the SWR, again only active during transmit or tune. The third push will show the current DC input voltage, the next push the transmitter's final amplifier's drain current, also only active in transmit, and finally back to the normal display.

If the button is pressed and held, after a short delay you will be presented with the User Configuration menu. This is more fully covered in the User Configuration section. To exit from this menu, press and hold the button until a long beep is heard, then release.

AF GAIN
This is the normal volume control.

MODE
This multi-function button has three functions:

Mode Selection
The primary function is that of selecting the operating mode. A brief push will select in turn LSB, USB, CW, or the Tune function.

Memory Copy
This function allows you to copy the contents of any active VFO to the User VFO Memory bank.

Copy VFO-A to VFO-P

To access this function, press and hold the MODE button until you hear a long beep. The display will alter as shown above. To copy from the active VFO to a memory, rotate the VFO knob clockwise, the direction arrow will point right, and the right-hand VFO memory designator will increment. In the example above, the active VFO, A whose frequency and mode is displayed on the lower line, is being copied to VFO memory P.

Copy VFO memory J to active VFOA

To copy from a VFO memory to the active VFO, turn the VFO knob anti-clockwise, and the source will decrement until you get to VFOA. The direction arrow will reverse showing that the direction of the transfer is from the VFO memory to an active VFO. In the example above, VFO memory J, whose frequency and mode is displayed on the lower line, is being copied to the active VFO, A.

When the MODE button is released, the copy operation will be completed.

Fast User Configuration Page Select
As there are now 21 configuration pages, this feature allows you to rapidly select the desired configuration page. For details, see the User Setting Configuration section.

Reset Defaults
If this button is held and then the transceiver powered up, the system defaults will be restored without the necessity of using the System Setup facility.

RIT
A brief push of this button will toggle the Receiver Incremental Tune On/Off. When on, the lower right-hand portion of the screen will display the current offset frequency up to a maximum of ±1kHz, controlled by the RIT knob.

If the Include RIT feature is enabled in the User Setup, then the frequency display will show the actual receiver frequency including the RIT shift.

Frequency Display Including RIT Offset

A long push of this button will invoke the Rapid Band Selection feature.

Rapid Band Select In Use

If this is invoked, the top line of the display will show the band to be selected, from 160 – 10 metres. If the current receiver's frequency is within an amateur band, then the selection will display this band, and the lower frequency display will show the selected frequency. If the frequency is not within a recognised amateur band, then the out-of-band indicator will show on the main display, and the 160m band's frequency will be shown, as illustrated above.

The frequency displayed can be either a default band-centre, or a user stored frequency. These user frequencies are in addition to those stored in the 26 VFO memories that are also available, but whereas the VFO memories can store any frequency, the user frequencies can only be valid amateur band frequencies relative to the current frequency band setting corresponding to either IARU Region 1, or the US bands.

To select an amateur band, simply rotate the VFO tuning knob which will cycle you through all the available bands from 160 through 10 metres. When the RIT button is released, the selected frequency will be used along with the mode stored.

Note that this rapid band switching facility is disabled in both the Split mode of operation and if the transmitter is keyed either with the PTT switch or a key. It is also inoperative in the Service and User Configuration modes.

To save a favourite amateur band frequency, please refer to the FILTER button operation.

FAST/VFAST
This button is used to select the various tuning rates that are available. A brief press will cycle through the Slow (S) Medium (M) and Fast (F) tuning rates, corresponding to tuning rates of 1Hz, 10Hz, and 100Hz.

A long push will select the Very Fast (V) tuning rate of 10kHz. To exit the Very Fast mode, briefly press the button, and the default Medium 10Hz tuning rate will be selected.

VFO/A=B
This button selects which VFO will be used, as well as several secondary VFO related functions.

If the operating mode is set to A/B + Split in the User Configuration setup, then a brief push of the button will cycle through the VFO-A, VFO-B, and Split modes. In the Split mode the receive frequency and mode is stored in VFO-A, and the transmit frequency and mode in VFO-B.

In the Split mode, the rapid band switch and user frequency select/store operations are inhibited. It is highly inadvisable to change frequencies in this mode for obvious reasons. In order to do so, select either VFO-A or VFO-B.

To copy the VFO-A frequency to VFO-B, select VFO A, and press and hold the VFO button until you hear a long beep, and the display will show:

Split Mode Copy, VFOA to VFOB

To copy the VFO-B frequency to VFO-A, first select VFO-B, and press and hold the button, and a similar display will be shown except that the source will be VFOB, and the destination will be VFOA.

If the button is pressed and held whilst the Splt is displayed, this is the same as VFO-A to VFO-B.

If the User Configuration setting is for from 3 to 26 memories, then these can be selected sequentially by a brief press of the button, or if the button is held, they can be selected by rotating the VFO tuning knob. The last frequency/mode used for the selected VFO will be set. Any frequency in the range 0 – 30MHz can be stored in the 26 VFO memories.

FILTER
This button is primarily used to select the receiver bandwidths, but also has a secondary function of storing user frequencies.

A brief press of the button will cycle you through the Wide, Medium, and Narrow filter bandwidths. The actual bandwidths employed are adjustable via the User Configuration Menu.

A long press of the button will store the currently displayed frequency and mode into the user band memory. There are 9 such memories, one for each amateur band, and they are selected by the Rapid Band Switch feature assigned as a secondary function of the RIT button.
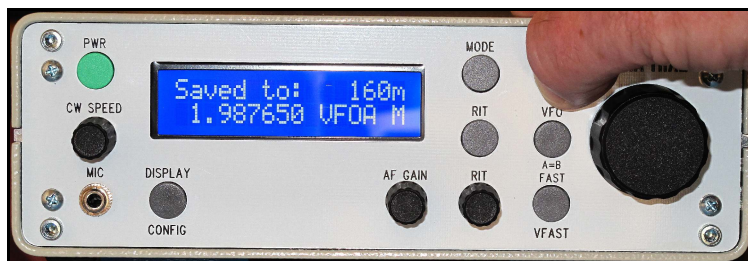
Saving A Frequency To A User Band

To use this feature, the User Configuration Band Switch setting has to be set to the User mode. In this mode, the current frequency can be stored. Note, only frequencies within a recognised amateur band can be stored. If an attempt is made to store an invalid frequency the top line of the display will show:

    Out Of Band!

Similarly, if the Band Switch setting is in the Default mode, then the display will show:

    Not In User Mode

If the Band Switch setting is in the Locked mode, then the display will show:

    User Mem Locked!

A successful storage operation will display the message:

    Saved to: nnn

where nnn will be replaced by a band from 160 – 10.

In this manner it is possible for the user to preset favourite frequencies for each amateur band, and to retrieve them on demand. By selecting the Locked mode, these frequencies can be protected.

System Calibration & Setup
It is assumed that the initial adjustments and settings have been made.

To enter the System Calibration & Setup menu, turn the transceiver off, and then press and hold the power button until the message:

```
JUMA-TRX2 v1.07j
   Service Mode
```

is displayed. To cycle through the various setting screens, briefly press the DISPLAY button.

Set Reference Oscillator Frequency
Default: 180000000Hz

The DDS is fed with the output of the precision crystal oscillator, and in the current models is a packaged component with an output frequency of nominally 30MHz. The worst-case tolerance for this oscillator is ±100ppm, which translates to a possible error of ±3kHz at 30MHz, and since this oscillator's frequency is internally multiplied by 6 in the DDS chip, this can be as high as ±18kHz at 180MHz.

To correct this, the reference frequency can be set to actual frequency resulting from a x6 multiplication of the crystal oscillator's actual output frequency.

In order to determine the necessary calibration factor, an accurate frequency counter is essential. If you have access to a counter which has an accuracy of better than at least ±1ppm, then measure the output frequency of the oscillator using the 10 second timebase, making at least 10 measurements. Average the results to 2 decimal places and multiply by 6. Round this figure to 1Hz, and this is the frequency to which the reference oscillator should be adjusted.

It is also possible to use a less accurate frequency counter if you can tune to a standard frequency transmission. These are usually maintained to an accuracy of better than 0.1ppm. For an example of how to use this method, please refer to Annex B.

The range of the input setting is checked, and there is an adjustment range of ±20kHz. Anything outside of this figure is cause for extreme suspicion regarding the crystal oscillator.

Even adjustment settings of more than ±10kHz would warrant further investigation as the vast majority of these oscillators have a basic frequency accuracy at room temperature of well within the stated worst-case figure.

Beep Time
Default: 50mS
This adjustment determines the time of all the audio annunciator signals. Adjust the value to your preference. The range is checked, and values from 0 – 100mS are allowed. If the value is set to 0, no audible annunciation will occur.

Supply Voltage Calibration Factor
Default: 132
The microprocessor chip uses an internal 12-bit A-D convertor, and this in turn is referenced to the +5V logic supply. Assuming that the regulator chip is exactly at +5V, this gives an incremental digital step size of 1.221mV. This is the basic resolution of the digital meter. Use an accurate digital multimeter and measure the supply voltage at the transceiver's input, and adjust the calibration factor to achieve a display as close as possible to that measured. Because of the lower resolution of the internal A-D convertor, you are unlikely to exactly match its reading.

The range is checked, and values from 100 – 200 are acceptable, although values significantly different (more than ±10) from the default value suggest that the logic voltage should be checked, and investigated.

S-Meter Calibration Factor
Default: 1920
This adjusts the accuracy of the S-Meter display, and requires careful consideration. Early transceivers had a JFET type SST112 used for the AGC amplifier in position TR4 of the variable gain amplifier A4-B on the main board. Later transceivers had a substitute device type PMBFJ112, and the threshold voltage of this transistor differs from that of the SST112. This leads to a significant difference in the two calibration settings.

In both cases, the adjustment procedure involves terminating the receiver in a 50 dummy load, rotating R53 fully anticlockwise to achieve maximum gain, and then carefully rotating clockwise until the audio noise just starts to decrease. This is the AGC threshold.

Using a signal generator inject an S9+40dB signal, 5mV, −33dBm, and adjusting the calibration factor until either the numeric S-Meter just indicates S9+40dB, or the graphical S-Meter just fills the horizontal display. Then lower the signal to S9, 50μV, −73dBm and by a combination of R53 and the calibration factor adjustments try and achieve the best compromise between full-scale and S9 for the two signal levels.

Since the threshold voltage of the two transistors is significantly different, early transceivers are likely to have calibration factors close to the default, whilst later units will be in the range of about 3,500 – 4,000. The limits are from 1,000 – 7,000.

Forward Power Calibration Factor
Default: 23
Using a dummy load, and an accurate power meter, set the transmitter's output in the Tune mode using the CARR control on the main board to a forward power of 10W. Adjust the calibration factor to achieve the closet match, bearing in mind the limited resolution of the 12-bit A-D convertor. The default value is usually close enough. The limits are from 5 – 40.

RF Amplifier Drain Current
Default: 6613
Using an accurate ammeter, measure the current drawn by the amplifier when supplying 10W in the Tune mode to a dummy load. The value is usually in the range of approximately 2.0 to 2.5A Adjust the calibration factor to achieve the closest match. The default value is usually satisfactory. The limits are from 5,000 – 10,000.

The next screen displays the message:

```
Push FAST long =
factory defaults
```

Only in this screen can you reset the transceiver to these default values. Push and hold the FAST button until you hear a long beep, and the values will have been reset.

Otherwise, press the DISPLAY button briefly to return you to the initial screen, and briefly press the FAST button to save the current values.

To abort the whole process, press and hold the PWR button to turn the transceiver off.

User Configuration Settings
To enter the User Configuration settings, press and hold the DISPLAY button until you hear a long beep.

With version 1.07, there are now 21 settings that can be adjusted to your preferences. With this many configurable settings there is now an additional feature allowing you to rapidly access any configuration page.

To use this feature, press and hold the MODE button until you hear a long beep. Rotate the VFO knob to select the desired configuration page. To adjust the setting, release the MODE button, and use the VFO knob to adjust the current setting.

AGC Speed
Default: Slow
Use the tuning knob to select either Fast or Slow AGC action.

Low-Pass Filter Cut-Off Frequencies
Default: Wide – 2,500Hz, Mid – 2,205Hz Narrow – 1,000Hz
Use the FILTER button to select the filter whose cut-off frequency you wish to adjust. Use the tuning knob to select the desired cut-off frequency. Note that the frequency resolution is

relatively coarse due to the methods used to clock the SCAF filter, but this is of little consequence, since precise cut-off frequencies are not required.

Noise Blanker Option
Default: OFF
This is set to ON/OFF with the tuning knob. If no accessory board is installed, it should be set to OFF.

Speech Processor
Default: OFF
The transceiver is equipped with a simple speech processor which uses a soft-clipping method to achieve a higher peak to average ratio for speech to increase the average talk-power.

However, this also leads to a certain amount of distortion, and thus this setting has to be carefully related to the transmit SSB gain setting, R26. Too little gain, and no compression will occur, too high a gain, and excessive distortion will occur. Turn the Speech Processor on, and listen on another receiver when operating into a dummy load to determine the optimum gain setting.

Audio Input Source
Default: Mic
Use the tuning knob to select microphone or line. When set to line, the gain is reduced by about 30dB. This allows the connection of the transceiver to the output of a computer's audio system for digital mode operation.

Note however that to satisfactorily use digital modes the speech processor must be turned off, and the transceiver's microphone amplifier circuit slightly modified to completely disable the speech processor in the off mode.

Keyer Mode Selection
Default: Iambic B
Select Iambic A, Iambic B, Dot Priority, or Straight key operation.

CW Pitch
Default: 700Hz
Use the tuning knob to select the desired pitch for CW signals. The range is checked and values from 300Hz – 1,100Hz are acceptable. This is also the offset used when transmitting. The actual transmit frequency is lower than the receive carrier by this amount.

CW Pot Mode
Deafult: CW Speed
The CW pot can be used either as a keyer speed setting or a receiver squelch control. Use the tuning knob to select the desired function.

LCD Backlight
Default: 350
The intensity of the LCD display can be adjusted with this setting. Values from 0 – 1,100 are accepted.

LCD Contrast
Default: 2000
This setting adjusts the display contrast. The default of 2,000 is usually acceptable. The range of values accepted is from 0 – 3,500.

LCD Timer
Default: OFF
The display can be automatically turned off after a preset time using this feature. Adjust the timer to a value between OFF and 3,600 seconds.

RS-232
Default: Yaesu CAT
This setting governs a number of peripheral features. It can be set to the following modes:

JUMA TRX2
This mode is used to enable serial communication with the companion JUMA PA100D 100W linear amplifier.

Yaesu CAT
This allows communication with PC logging programs, and emulates a Yaesu transceiver. For a list of commands that are emulated, please see Annex C.

Kenwood CAT
This allows communication with PC logging programs, and emulates a Kenwood TS-480 transceiver. For a list of commands that are emulated, please see Annex D.

Voice Memory
This mode is used with the accessory voice memory board.

Test
This mode is used to verify the integrity of the transceiver's internal circuitry and software, as well as check that the serial communications port is working correctly. In this version of the firmware several serial port bugs were corrected, and a user help feature added which briefly describes the operation of each command.

Connect the transceiver to a PC, use a suitable terminal program, ensure that the speed settings are correct. Send the letter 'I' from the PC and the transceiver should respond with a screen of information. The actual usage of these commands in beyond the scope of this document, and in any case is only likely to be of interest to those wishing to customise the software.

Note that these commands are not in any way destructive – they cannot permanently affect the overall operation of the transceiver. For a brief description please see Annex E.

Baud Rate
Default: 9600
This allows setting the speed of the serial port from 1,200 – 115,200 Baud. The default of 9,600 is usually satisfactory.

VFO Memory Operation
Default: A/B + Split
This setting governs how the various VFO memories are used and organised. The settings range from A/B + Split mode, to 3 – 26 memories.

Split mode operation involves transmitting on one frequency, and receiving on another. The frequencies can be anywhere in the tuning range of the transceiver. VFO A is used for the receive frequency; VFO B for transmit.

When not using Split mode, you can select the number of VFO memories available to you from 3 – 26, which will be indicated on the display by the letters VFOA – VFOZ. The current displayed frequency and mode is automatically stored in the selected VFO.

These VFOs can be selected by a brief press of the VFO button, or the VFO button can be held down and the memories selected by the tuning knob.

S-Meter
Default: Graphic
This new feature allows you to select either a graphical S-Meter (Original) or a numeric S-Meter. The gain characteristics of a correctly adjusted and calibrated receiver are almost exactly logarithmic over the dynamic range of the receiver, which lends itself to an easy implementation of either display with reasonable accuracy. Use the tuning knob to select either type of display.

TX Disable
Default: ON
This is a new feature. The original firmware allowed transmission on any frequency, including those outside the amateur bands. This meant one had to pay careful attention when operating close to the band edges in order to avoid an infraction of your licence conditions.

By enabling this feature, if you attempt to transmit in any mode on a frequency outside the recognised band, the transmitter is inhibited, and the display will show a message:

```
Out Of Band!
```

In addition, in the receive mode, there is a small annunciator displayed immediately between the frequency display and the VFO selection/mode section of the lower line of the screen if the current receive frequency is outside the amateur bands.

Transmit Inhibit

Even if this feature is turned off, the receive annunciator is still displayed, and storage of a frequency in the User Band memory is inhibited.

Auto Sideband Select
Default: ON
This is a new feature. Conventionally, for frequencies above 10MHz USB is the preferred mode for voice communication, conversely, LSB for frequencies lower than 10MHz. This feature will automatically select the correct sideband when tuning to an amateur band using the Rapid Bandswitch Feature. It does not affect tuning when using the tuning knob. Even with auto sideband selected, you may still choose any operating mode on any band.

Frequency Display Selection
Default: Fixed B
This is a new feature. The original frequency display was limited to 10Hz resolution, and used two decimal points, between the MHz and 100kHz digits and between the kHz and 100Hz digits. This feature now permits a variety of display options.

Original
The frequency will be displayed as:

Original Frequency Display

New
The frequency will be displayed depending upon the tuning rate being used, thus:

Slow Tuning Rate – 1Hz

Medium Tuning Rate – 10Hz

Fast Tuning Rate – 100Hz

Very Fast Tuning Rate – 10kHz

Note that the precision is not affected, the display is merely rounded to the appropriate tuning rate's resolution, but selecting a higher resolution tuning rate will reveal the rounded digits.

With version 1.07g and later, the accuracy of the synthesiser has been improved. See Annex A for a full explanation.

Fixed A
The display is fixed at 1Hz resolution independent of the tuning rate used. For frequencies below 1MHz the decimal point will move to the kHz position, and no leading zeros are used. (See note 6 at the end of this document.)

Fixed Resolution – 1Hz

Fixed B
The display is fixed at 10Hz resolution, independent of the tuning rate used.

14

Fixed Resolution – 10Hz

Band S/W
Default: Default
This is a new feature. This setting governs how the Rapid Bandswitch feature operates.

Default
In this mode, when selecting an amateur band, the frequency used will be fixed at the band's centre.

BAND	FREQUENCY MHz
160 metres	1.900
80 metres	3.650
40 metres	7.100
30 metres	10.125
20 metres	14.175
17 metres	18.118
15 metres	21.225
12 metres	24.940
10 metres	28.850

User
In this mode, initially when the firmware is first loaded the frequencies are set to match the default settings. However, the user can store new frequencies as desired, provided that they are within the amateur band in question. The upper and lower frequencies to be used as the band edges are determined by the setting of the Band Limits parameter in a following menu.

The out-of-band indication is dependent upon the mode in use. For USB the carrier frequency has the transmit filter bandwidth of 2.6kHz added to ensure that the entire upper sideband falls within the upper band edge, no correction is applied to the lower band edge.

For LSB, the frequency has the transmit filter bandwidth subtracted to ensure that the entire lower sideband falls within the lower band edge. Similarly for CW, where in this case the CW Pitch is used.

For the Tune mode, no corrections are applied, as the carrier frequency itself is used.

Locked
This mode uses the currently preset User frequencies, but the memory is locked so that no alteration can occur.

Include RIT
Default: NO
This is a new feature. If this is turned on, then the RIT offset frequency will be used to modify the frequency displayed to show the actual receive frequency.

Band Limits
Default: IARU
This is a new feature. The transceiver's band edge frequencies can be set to either the IARU Region 1 limits, or the USA limits. When altering this setting note that it will take effect when the transceiver is next powered up.

Minor Enhancements

1.   The RIT, VFO, and FAST/VFAST buttons are locked out when in the User Setup mode. The MODE button is used to rapidly access the configuration pages. Note that although the MODE button is active in the User Setup mode, no mode changes will occur, that is, the existing mode (LSB/USB/CW/Tune) will not be disturbed.

2.   The MODE, FILTER, RIT, VFO, and FAST/VFAST buttons are locked out when in the transmit mode.

3.   The power-down sequence timing is no longer critical. In the previous software, one had to time the release of the power button fairly accurately to avoid either aborting the sequence or powering the transceiver back up. In this version, as soon as the display blanks you can release the button, holding it down will no longer cause a power-up to occur.

4.   Various audio glitches when changing frequencies or modes have been eliminated or greatly suppressed, although there are still a few stubborn candidates left. Work in progress.

5.   The lowest frequency to which the transceiver can be tuned is 0Hz. Whilst the frequencies below about 30kHz have no real importance, the very low frequency output at audio frequencies does allow the user to verify that the DDS chip is operating. By tuning down into the audio range you will hear an audio beat note which can be measured with a frequency counter to provide an approximate indication that the frequency synthesis is correct.

6.   Version 1.07h and later slightly modified the way that the Fixed-A display operates. After careful consideration, I decided that displaying frequencies below 1MHz with leading zeros was simply ugly. The display now shows a decimal point at the MHz

position for frequencies above 999.999kHz, and simply moves the decimal point to the kHz position and fills the leading spaces with blanks for frequencies from 1kHz to 999.999kHz. For frequencies below 1kHz, no decimal point is displayed.

Adrian Ryan – 5B4AIY
28 September 2011

Annex A

JUMA Frequency Step Accuracy

The Juma TRX2 using firmware revision 1.06 has an inherent frequency resolution of 10Hz. This means that the actual frequency to which the transceiver is tuned is within ±5Hz of the displayed frequency, if we neglect the reference oscillator errors. Or is it?

If we carefully examine the frequency display, we can observe some interesting quirks. Try this, tune the transceiver to, say, 10.00000Mhz, and select the fast tuning rate of 100Hz, now rapidly rotate the VFO knob to increase the frequency and carefully observe the least significant (10Hz) digit. After a large number of steps the digit will suddenly change by 1. Select the slow (10Hz) tuning rate and carefully go back and find the exact frequency at which the 10Hz digit changed, and note it. As an example, in my case it was 10.20840MHz.

Now re-select the fast tuning rate and increase the frequency, and in my case at 10.46510 the 10Hz digit changed again and with a single increment from the tuning knob the display changed from 10.46510 to 10.46519, and the next increment was to 10.46529.

The reason for this anomaly is not hard to find. The output frequency of the synthesiser is:

$$f_{\text{local oscillator}} \ = \ N * 180000000 \ / \ 2^{33} \ \text{Hz}$$

Where N is the 32-bit binary word used to load the DDS chip. In fact, the actual output frequency is twice this, but the synthesiser's frequency is divided by two to obtain the phase-quadrature local oscillator signal.

The frequency steps are obtained from an array of steps and for a step increment of 100Hz the value is 4,772. This is the binary increment that is added to the existing frequency word for every step generated by the VFO encoder at the 100Hz tuning rate.

The actual frequency increment is therefore:

$$f_{\text{increment}} \ = \ 4772 * 180000000 \ / \ 8589934592$$

$$= \ 99.996104837 \ \text{Hz}$$

There is thus an incremental step error of −0.003895164 Hz for each step, and eventually these step errors accumulate until there is sufficient error for the next step to cause the 10Hz digit to change. In fact, after every 2,567 steps this anomaly will appear, corresponding to a frequency change of about 256Khz.

Now, one could reasonably say, "So what?" and I would entirely agree that for all practical purposes this is of no real significance, the actual frequency of the transceiver is always within ±5Hz of the displayed frequency, which is more than adequate – even on the lowest amateur band this represents a tuning accuracy of ±2.5ppm, and even better at the higher frequencies.

But, I'm a perfectionist, you might even say obsessive, and it occurred to me that the synthesiser could do better. After all, when you increment the DDS word by 1 the local oscillator's frequency changes by 0.020955 Hz, and thus there is the potential for the transceiver's actual resolution accuracy to be improved by a factor of 250.

The problem arises because all the frequency calculations are done in the DDS domain, and thus the approximation errors accumulate. If the calculations and increments are performed entirely in the decimal domain, then there are no display anomalies, and with the decimal frequency being converted only once to its DDS equivalent word, the worst error that can occur is a ±1 bit quantisation error leading to a worst-case resolution error of 0.04Hz allowing for rounding errors in the calculation.

I have thus changed the complete frequency synthesis numerical base from DDS units to decimal, and modified the `load_dds()` function so that it is passed a decimal frequency and the conversion to the DDS word is performed once.

As a result, and confirmed with an accurate frequency counter, the accumulating step errors are eliminated.

Firmware versions from 1.07h on incorporate this change, as well as a number of other minor internal changes.

By correcting for the production tolerances of the 30MHz oscillator, the transceiver can now achieve a frequency accuracy on a par with almost anything on the market – what a really nice little 'gem' this is!

Adrian Ryan 5B4AIY

Annex B

Reference Oscillator Calibration

The accuracy of the reference oscillator determines the overall frequency accuracy of the transceiver. The master oscillator is the 30MHz package oscillator on the DDS board, and its output is used both to clock the microprocessor, as well as provide the reference for the DDS synthesiser chip.

The IQD IQX-350 series of packaged oscillators have a worst-case frequency tolerance of $\pm$100ppm over a temperature range of $0°C – 70°C$. In fact, at room temperature, the actual output frequency is usually well within the worst-case specification. Nevertheless, your oscillator is unlikely to be at exactly 30MHz, and thus since this frequency is multiplied by 6 in the DDS chip, the output frequency will have an offset error. By inserting the appropriate calibration frequency this offset can, to a large extent, be eliminated, thus greatly improving the accuracy of the frequency generating system.

Method 1 – Direct Calibration
The first method of calibrating the system simply involves measuring the output frequency of the 30MHz oscillator directly using a stable, accurate frequency counter. The time-base of the counter has to be a precision reference, preferably locked to a rubidium standard, and certainly within $\pm$1ppm.

This is a fairly stringent specification to meet, and the average frequency counter from, for example, eBay is unlikely to meet this. It really requires access to a laboratory grade counter whose calibration is current.

If you have access to such a counter, then carefully measure the output frequency to an accuracy of 1Hz using the 10 second time-base setting and collect at least 10 measurements. Average these to 2 decimal places. Multiply the result by 6 and round to 1Hz, and this is the reference oscillator calibration frequency to be inserted.

Method 2 – Indirect Calibration
This second method uses a combination of a transmitted standard frequency and a frequency counter of nominal accuracy. In this method the audio beat frequency will be used, and the accuracy of the frequency counter is less important. Even a counter whose time-base is in error by 100ppm will suffice. If the time-base error is 100ppm, then at an audio frequency of 1,000Hz, the actual reading will be between 999.9Hz and 1000.1Hz. Although this will lead to an uncertainty of about $\pm$5Hz at 180MHz, this is still accurate enough.

Tune the receiver to a standard frequency transmission, and set the display to be exactly 1,000Hz higher than the carrier frequency. For example, suppose we use a transmitter on 5MHz. Set the display to 5.001000 (Use the 1Hz tuning rate, and the 1Hz frequency display option, and lock the VFO.) Select LSB, and MID filter.

Connect the frequency counter to the phone output socket, and adjust the audio gain for a suitable level to trigger the counter. In order to avoid excessive jitter the signal must be reasonably clean and reasonably free from noise.

Set the frequency counter to display to 1Hz using the 10 second time-base. Make at least 10 measurements, and average the results to 2 decimal places.

If the reference oscillator were at its exact frequency, then the audio beat note would be exactly 1,000Hz. Any error will cause the frequency to be higher or lower than this. Subtract the 1,000Hz from the averaged result. Since the standard frequency in this example is 5MHz, to find the error at 30MHz multiply the error by 30/5 and this is the frequency offset at 30MHz. Add this to 30MHz and multiply by 6, and this is the reference oscillator calibration frequency. A numerical example should make this clear.

Assume the standard frequency is 5MHz, and the receiver is tuned to 5.001000MHz, LSB.

Measured Beat Frequency
950
949
949
950
950
948
949
949
950
950

Averaging these results gives a beat frequency of: 949.40Hz

Error: $949.40 - 1000 = -50.60$Hz

Crystal Oscillator Frequency $= 30,000,000 + ((30,000,000 / 5,000,000) * -50.60)$

$= 30,000,000 - 303.60$ Hz

$= 29,999,696.40$Hz

Reference Oscillator Frequency = 29,999,696.40 * 6

　　　= **179,998,178Hz**

In this case, the crystal oscillator was low by about 10ppm.

Now an example where the oscillator is high in frequency.

For this example, assume the standard frequency is 10MHz. Tune the receiver to a display setting of: 10.001000MHz, LSB.

Measured Beat Frequency
1250
1251
1251
1250
1249
1250
1251
1250
1250
1251

Averaging these results gives a beat frequency of: 1250.00Hz

Error: 1250.00 – 1000 = +250.00Hz

Crystal Oscillator Frequency = 30,000,000 + ((30,000,000 / 10,000,000) * +250.00)

　　　= 30,000,000 + 750.00 Hz

　　　= 30,000,750.00Hz

Reference Oscillator Frequency = 30,000,750.00 * 6

　　　= **180,004,500Hz**

In this case, the crystal oscillator was high by about 25ppm.

Annex C

Yaesu CAT Command Emulation

If the RS-232 serial port mode is set to Yaesu CAT, then the transceiver will respond to the following command sequences:

Yaesu Command Description

Yaesu CAT commands are organised as a 5-byte sequence, with the parameters first, and the last byte being the command byte.

The following commands are emulated (values are in hexadecimal):

Read RX frequency & mode : 03
Read RX status   : E7
Read TX status   : F7
Split Mode ON   : 02
Split Mode OFF   : 82
VFO Select   : 81
Set operating mode   : 07
Set frequency   : 01
PTT ON (TX)   : 08
PTT OFF (RX)   : 88
Lock VFO   : 00
Unlock VFO   : 80

Command Format
The commands take the form of a 5-byte string terminating with the command byte. The leading 4 bytes are the parameter values required. If a command does not require any parameters, then these bytes can contain any value, but nulls are preferred.

Read RX Frequency and Mode
Assume the transceiver's frequency is 145.43210Mhz
Command To Transceiver   : 00 00 00 00 03
Transceiver Response   : 14 54 32 10 xx

xx is the mode byte, with the following meaning: 00 = LSB, 01 = USB, 02 = CW
There are a number of other values, but they are not applicable to the Juma TRX-2

Read RX Status
Command To Transceiver   : 00 00 00 00 E7
Transceiver Response   : xx 00 00 00 00

xx is the data byte, and the bits have the following meanings:

7	Squelch Status 0 = OFF, Signal present, 1 = ON, Receiver squelched
6	CTCSS/DCS code. For Juma = 0
5	Discriminator Centering, for SSB/CW = 0
4	Dummy Data 0
3	S-Meter Bit 3
2	S-Meter Bit 2
1	S-Meter Bit 1
0	S-Meter Bit 0

The S-meter value is coded into 15 levels from S0 to S9+40dB

Read RX Status
Command To Transceiver   : 00 00 00 00 F7
Transceiver Response   : xx 00 00 00 00

xx is the data byte, and the bits have the following meanings:

7	PTT Status 0 = TX, 1 = RX
6	High SWR 0 = OFF, 1 = ON
5	Split Mode 0 = ON, 1 = OFF
4	Dummy Data 0
3	PWR Meter Bit 3
2	PWR Meter Bit 2
1	PWR Meter Bit 1
0	PWR Meter Bit 0

The PWR-meter value is coded into 15 levels from 0 – 100W

Split Mode ON
Command To Transceiver   : 00 00 00 00 02

Split Mode OFF
Command To Transceiver   : 00 00 00 00 82

VFO Select (Toggle VFO-A, VFO-B)
Command To Transceiver   : 00 00 00 00 81

Set Operating Mode
Command To Transceiver   : xx 00 00 00 07
Where xx has the following meanings: 00 = LSB, 01 = USB, 02 = CW

Set Operating Frequency
Command To Transceiver   : aa bb cc dd 01
Assume the frequency is: 14.23456MHz, aa = 01, bb = 42, cc = 34, dd = 56

PTT ON (Transmit)
Command To Transceiver   : 00 00 00 00 08

PTT OFF (Receive)
Command To Transceiver   : 00 00 00 00 88

Lock VFO
Command To Transceiver   : 00 00 00 00 00

Unlock VFO
Command To Transceiver   : 00 00 00 00 80

Annex D

Kenwood TS-480 CAT Command Emulation

If the RS-232 serial port mode is set to Kenwood CAT, then the transceiver will respond to the following command sequences:

Read/Set VFO-A Frequency	: FA	
Read/Set VFO-B Frequency	: FB	
Select/Read Receiver VFO	: FR	
Select/Read Fine Tune	: FS	
Select/Read Transmitter VFO	: FT	
Read Transceiver Status	: IF	
Set/Read CW Keyer Speed	: KS	(Not implemented)
Read Current Mode	: MD	
Set/Read Noise Blanker	: NB	
Set/Read Speech Processor	: PR	
Clear RIT Offset Frequency	: RC	(Not implemented)
Move RIT Down	: RD	(Not implemented)
Move RIT Up	: RU	(Not implemented)
Set/Read RIT Function	: RT	
Set/Read DSP Low Frequency	: SL	
Set/Read DSP High Frequency	: SH	
Read S-Meter Status	: SM	
Set/Read Squelch Level	: SQ	(Not implemented)
Turn TX ON	: TX	
Turn RX ON	: RX	
Read Transceiver Status	: RS	

The command format is a two-letter ASCII command followed by a variable length parameter string of ASCII characters. The command is always terminated by the semi-colon (;) character. Note that a command can have zero parameters, in which case it is generally a data request.

Set VFO-A Frequency
Transmitted From PC (Assume the frequency is: 14.195MHz)
FA00014195000;

Read VFO-A Frequency
Transmitted from PC
FA;
Response from TS-480 (Assume the frequency is: 14.195MHz)
FA00014195000;

Set VFO-B Frequency
Transmitted From PC (Assume the frequency is: 14.195MHz)
FB00014195000;

Read VFO-B Frequency
Transmitted from PC
FB;
Response from TS-480 (Assume the frequency is: 14.195MHz)
FB00014195000;

Select Receiver VFO
Transmitted from PC
FR0;   Select VFO-A
FR1;   Select VFO-B

Read Receiver VFO
Transmitted from PC
FR;
Response from TS-480
FR0;   VFO-A selected
FR1;   VFO-B selected

Select Fine Tune (1Hz)
Transmitted from PC
FS0;   Fine Tune function OFF (Select 10Hz tuning rate)
FS1;   Fine Tune function ON (Select 1Hz tuning rate)

Read Fine Tune
Transmitted from PC
FS;
Response from TS-480
FS0;   Fine Tune function OFF (10Hz tuning rate)
FS1;   Fine Tune function ON (1Hz tuning rate)

Select Transmitter VFO (See Split Mode Note)
Transmitted from PC
FT0;   Select VFO-A
FT1;   Select VFO-B

Read Transmitter VFO
Transmitted from PC
FT;

Response from TS-480
FT0;   VFO-A selected
FT1;   VFO-B selected

Read transceiver ID number
Transmitted from PC
ID;
Response from TS-480
ID020;

Read Transceiver Status
Transmitted from PC
IF;
Response from TS-480

IFp1p1p1p1p1p1p1p1p1p1p1p2p2p2p2p2p3p3p3p3p3p4p5p6p7p7p8p9p10p11p12p13p14p14p15;
p1   : 11 digits of receiver frequency to 1Hz, example: 14.234567MHz = 00014234567
p2   : 5 spaces
p3   : RIT frequency ±nnnn Hz
p4   : 0 = RIT Off, 1 = RIT On
p5   : 0 = XIT Off, 1 XIT On (Not Applicable)
p6   : 0 (Always 0)
p7   : Memory Channel number 00 – 99 (Not Applicable)
p8   : 0 = RX, 1 = TX
p9   : 1 = LSB, 2 = USB, 3 = CW
p10   : 0 = VFO A, 1 = VFO B
p11   : 0 = Scan Off
p12   : 0 = Simplex, 1 = Split
p13   : 0 (Not Applicable)
p14   : 00 (Not Applicable)
p15   : space character
;   : End-Of-Command character

Example 1: `IF00014003920      0000000000020000080;`
RX Freq: 14.003920MHz RIT Freq: 0000, RIT Off, USB, VFO A, Scan Off, Simplex

Example 2: `IF00014003920      0123010000020000080;`
RX Freq: 14.003920MHz RIT Freq: +123, RIT On, USB, VFO A, Scan Off, Simplex

Example 3: `IF00014003920     -0123010000020000080;`
RX Freq: 14.003920MHz RIT Freq: -123, RIT On, USB, VFO A, Scan Off, Simplex

Example 4: `IF00014003920      0000000000020010080;`
RX Freq: 14.003920MHz RIT Freq: 0000, RIT Off, USB, VFO A, Scan Off, Split

Set Mode
Transmitted from PC
MD1; LSB
MD2; USB
MD3; CW

Read Current Mode
Transmitted from PC
MD;

Response from TS-480 (Other modes are possible, but not applicable to a TRX-2)
MD1; LSB
MD2; USB
MD3; CW

Set Noise Blanker
Transmitted from PC
NB0;   Noise Blanker OFF
NB1;   Noise Blanker ON

Read Noise Blanker
Transmitted from PC
NB;
Response from TS-480
NB0;   Noise Blanker OFF
NB1;   Noise Blanker ON

Set Speech Processor
Transmitted from PC
PR0;   Speech Processor OFF
PR1;   Speech processor ON

Read Speech Processor
Transmitted from PC
PR;
Response from TS-480
PR0;   Speech Processor OFF
PR1;   Speech processor ON

Set RIT Function
Transmitted from PC
RT0;   RIT OFF
RT1;   RIT ON

Read RIT status
Transmitted from PC
RT;
Response from TS-480
RT0;   RIT OFF
RT1;   RIT ON

Set Low Frequency Filter DSP Settings
Transmitted from PC
SLnn;

where nn can have the following meanings:

00: 10, 01: 50, 02: 100, 03: 200, 04: 300, 05: 400, 06: 500, 07: 600, 08: 700, 09: 800, 10: 900, 11: 1000, all frequencies in Hz. The Juma emulation ignores this command.

Read Low Frequency DSP Settings
Transmitted from PC
SL;
Response from transceiver
SL04; Essentially, ignore, but satisfy the CAT program.

Set High Frequency Filter DSP Settings
Transmitted from PC
SHnn;

where nn can have the following meanings:

00: 1400, 01: 1600, 02: 1800, 03: 2000, 04: 2200, 05: 2400, 06: 2600, 07: 2800, 08: 3000, 09: 3400, 10: 4000, 11: 5000, all frequencies in Hz.

At present, the emulation examines the transmitted request and selects the wide, mid, or narrow filter that matches as close as possible.

Read High Frequency DSP Settings
Transmitted from PC
SH;
Response from transceiver
SHnn;

where nn has the following meanings:
00: 1400, 01: 1600, 02: 1800, 03: 2000, 04: 2200, 05: 2400, 06: 2600, 07: 2800, 08: 3000, 09: 3400, 10: 4000, 11: 5000, all frequencies in Hz.

The Juma emulation calculates the current wide, mid, and narrow cut-off frequencies currently in use, and responds with the code that is closest to the filter/bandwidth currently selected.

Read S-Meter Status
Transmitted from PC
SM0; Main transceiver S-Meter
SM1; Sub-receiver
SM2; Main transceiver S-Meter level
SM3; Sub-receiver S-Meter level

Response from TS-480
SM0nnnn;
SM1nnnn;
SM2nnnn;
SM3nnnn;   Where nnnn is 0000 – 0030 (main receiver) 0000 – 0015 (Sub receiver)

Turn TX ON
Transmitted from PC
TX0;   Transmit from MIC (TS-480)
TX;   Transmit (TS-2000) If TS-2000 is already in transmit mode, response is ?; otherwise
       no response.
Response from TS-480
TX0;

Turn RX ON
RX;
Response from TS-480
RX0;
No response from TS-2000. If TS-2000 is already in RX mode, response is: ?;

Read Transceiver Status
Transmitted from PC
RS;
Response from TS-480
RS0;   Normal
RS1;   Busy

Split Mode
To enable Split Mode first set the frequency of VFO-B. This will be accomplished by the FB
command, then the FT1; command will be sent to use VFO-B as the transmit VFO, this is the
signal to turn split mode on in the TRX2.

The emulation has been tested using CI-V Commander version 5.8.7, and it operates with this
program.

Annex E

Serial Port Test Mode

When the serial port mode is set to Test Mode, the user can investigate the current settings of the transceiver via a terminal program. Set the terminal program to the same settings as the TRX-2, typically, 9600 Baud, 8 data bits, 1 stop bit, no parity.

If the terminal is connected and the transceiver powered up, the following data will be printed:

```
JUMA-TRX2 Firmware v1.07j, Build 28/09/2011
Copyright Juha Niinikoski, OH2NLT

System Clock = 7500 kHz

EEPROM checksums, Cal = 0, Def Cs = 0, Factory default resets = 0
Set UART1 user baud rate to #3,     9600bd

JUMA-TRX2 copyright OH7SV & OH2NLT
Software version v1.07j, Copyright Juha Niinikoski OH2NLT
```

Enter I, and the transceiver will respond with an abbreviated command list:

```
~~~~~~~~~~~~~~~~~~~~~[COMMAND TABLE]~~~~~~~~~~~~~~~~~~~~~
I     Help - (This Screen)
A     ADC & PWM DAC Channels
b     LCD Bar Graph Test
C     Clear Factory Default reset counter
E     Dump EEPROM contents
f     Display SPI bus control bits
o     Reference Oscillator calibration value
p     Display scaled S-Meter and CW Speed pot A-D value
S     Start SCAF (Audio On)
s     Stop SCAF (Audio Off)
t     Single SPI write
U     Dump User Frequency Memory
u     Dump Transceiver Configuration Settings
W     Write ASCII to LCD
c     Continuous SPI write
+     Increment RF Attenuator
-     Decrement RF Attenuator
Z     Divide-By-Zero Trap
```

Enter u and the transceiver will respond thus:

```
System Settings
Reference Oscillator: 180000000 Hz
Beep Time       : 50 mS
DC Meter        : 132
S-Meter         : 1920
Power Meter     : 23
Ammeter         : 6613

User Settings
AGC Speed       : Slow
Filter Roll-Off Frequencies
```

```
Wide              : 1000 Hz
Mid               : 2205 Hz
Narrow            : 2500 Hz
Transmit          : 2586 Hz
Noise Blanker     : OFF
Speech Processor  : OFF
Audio Source      : Mic
Keyer Mode        : Dot Priority
CW Pitch          : 700 Hz
CW Pot Mode       : CW Speed
LCD Backlight     : 350
LCD Contrast      : 2000
LCD Timer         : 0
RS-232 Mode       : Test
Speed             : 9600 Baud
VFO Memory        : A/B + Split
S-Meter           : Graphic
TX Disable        : ON
Auto-Sideband     : ON
Frequency Display : Fixed B: 12.34568
Band Switch       : Default
Include RIT       : No
Band Limits       : IARU Region 1
```

Enter U and the transceiver will respond with the current User Memory settings:

```
VFO-A:  3.70000 MHz  LSB
VFO-B:  7.06000 MHz  LSB
VFO-C:  3.70500 MHz  LSB
VFO-D: 10.12500 MHz  LSB
VFO-E: 14.17500 MHz  LSB
VFO-F: 18.11800 MHz  LSB
VFO-G: 21.22500 MHz  USB
VFO-H: 24.94000 MHz  USB
VFO-I: 28.85000 MHz  USB
VFO-J:  1.90000 MHz  USB
VFO-K:  3.65000 MHz  USB
VFO-L:  7.10000 MHz  USB
VFO-M: 10.12500 MHz  LSB
VFO-N: 14.17500 MHz  LSB
VFO-O: 18.11800 MHz  LSB
VFO-P: 21.22500 MHz  USB
VFO-Q: 24.94000 MHz  USB
VFO-R: 28.85000 MHz  USB
VFO-S:  1.90000 MHz  USB
VFO-T:  3.65000 MHz  USB
VFO-U:  7.10000 MHz  USB
VFO-V: 10.12500 MHz  LSB
VFO-W: 14.17500 MHz  LSB
VFO-X: 18.11800 MHz  LSB
VFO-Y: 21.22500 MHz  USB
VFO-Z: 24.94000 MHz  USB
```

Note that the above settings are the standard defaults, your printout will depend upon your configuration and calibration settings.