JUMA TRX2

Operation Manual
(Firmware Version 1.10k - 10 March 2014)

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JUMA TRX-2 Operating Manual
5B4AIY Firmware Version 1.10j

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 1.10j, 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 v1.10j
  OH2NLT OH7SV
```

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

```
IARU Region 1
```

or:

```
USA (Extra)
```

or:

```
USA (General)
```

Then the main display will be shown.

To power down the transceiver, press and hold the power button, and, in the default mode, a message will be displayed asking whether you wish to save the current settings. Briefly press the MODE button to save the current state, or the PWR button to exit without saving. At this point the display will clear, the backlighting will be turned off, and the button can be released.

Note: The type of power down mode is user adjustable. See the User Configuration section for further details.

During normal operation, a brief press of the power button will toggle locking the active VFO frequency. When the active VFO frequency is locked, a * symbol will be displayed between the VFO and the tuning rate designators. This lock is selective, and can be applied to any VFO memory. It will also prevent altering the memory or active VFO frequency until the lock is removed.

The power button is also used to acknowledge and cancel any alarms as well as being a general cancel button. If an alarm cannot be cancelled, then press and hold the power button for 500 mSec and you will enter the emergency shutdown mode. Release the button and the transceiver will immediately shut off. In this mode it will bypass saving the user settings in favour of a rapid power down. For full details of the alarms, please refer to Annex F.

If the optional Voice Memory module is installed, the PWR button can also be used to stop a record or playback operation.

If the power button is pressed and held whilst powering up, the System Calibration & Setup menu will be selected. The various operations and settings are fully covered in the System Calibration & Setup section of this document.

To exit from the System Calibration & Setup menu, select a normal display page, and briefly press the FAST/VFAST button. You will receive a prompt message asking you whether you wish to save the settings. To exit without saving the current changes, briefly press the PWR button, otherwise to save the changes briefly press the MODE button.

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.

When configured as the squelch control, the keyer speed defaults to the user adjustable preset speed. When set to the CW speed function, the speed of the keyer is controlled directly by this pot, except if the pot is rotated fully anti-clockwise, whereupon the keyer speed will default to the user preset speed.

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 400Ω, thus 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/CWR/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 the button and briefly press the PWR button to exit without making any changes, or the MODE button to save the changes.

If the DISPLAY/CONFIG button is pressed and held, and then the transceiver powered up, holding the button until a prompt is displayed will invoke the RS-232 loop-back test. Entering characters on a terminal program will echo the character back to the terminal, as well as displaying the character on the second line of the display, along with its hexadecimal value.

To exit the test, briefly press the PWR button, and the transceiver will resume its normal boot-up sequence.

AF GAIN
This is the normal volume control.

MODE
This multi-function button has four functions:

Mode Selection
The primary function is that of selecting the operating mode. A brief push will select in turn LSB, USB, CW, CWR, or the Tune function. If the button is pressed when displaying power, SWR, voltage or current, then the display will blink twice to display the mode change, then return to the previous display page.

Memory Copy
This function allows you to copy the contents of any active VFO to the User VFO Memory bank, or retrieve a frequency from this memory and restore it to the active VFO.

To access this function, press and hold the MODE button until you hear a long beep. Release the button, the display page is latched. To copy from the active VFO to a selected memory, rotate the VFO knob clockwise, the direction arrow will point right, and the right-hand VFO memory destination designator will increment.

To copy from a selected 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 then reverse showing that the direction of the transfer is from the VFO memory to an active VFO, and further rotation will select the source memory.

To initiate the copy, either briefly press the MODE or the PWR button, and the copy operation will be completed.

If the destination VFO is locked, this will be displayed, and the copy operation will be inhibited. If the direction is such as to store a new frequency in one of the VFO memories, then this data will be automatically saved to the EEPROM.

Fast User Configuration Page Select
As there are now 28 configuration pages, this feature allows you to rapidly select the desired configuration page. For details, see the User Setting Configuration section.

Reset Defaults
If the MODE button is held and then the transceiver powered up, the system defaults can be restored without the necessity of using the System Setup facility. With the transceiver off, press and hold the MODE button, and briefly press the PWR button. Wait until the screen displays the message asking whether you wish to restore the factory defaults. Release the MODE button. A momentary push of the MODE button will restore the defaults, a momentary push of the PWR button will abort the selection, and return you to normal operation.

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.

Note: The offset frequency is displayed to 2 decimal places, prefixed with either a sign (+/−) or a space. For offset frequencies from +1Hz to +1,000Hz, the + sign will be prefixed, for offset frequencies from −1Hz to −1,000Hz, the −sign will be prefixed. For an offset of exactly 0 Hz, the space symbol is prefixed.

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

A long push of this button will invoke the Rapid Band Selection feature. 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 flashing out-of-band indicator will show on the main display, and the nearest amateur band frequency will be displayed.

Note: In this version of the firmware, the decimal point blinks to signify that the frequency is outside a recognised amateur band.

Note: In this version the RIT button no longer needs to be held. When the long beep sounds, release the button, the function will latch the page. Rotate the VFO knob to select an amateur band. To effect the selection, briefly press either the RIT or the PWR button. To remind you that the function is latched, a rapid beep will sound.

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 to cycle you through all the available bands from 160 through 10 metres.

Note: The 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.

Note: In this version of the firmware, if the current mode is `A/B + Split` and the Rapid Bandswitch feature used, then the frequency of the inactive VFO will be checked. If the inactive VFO is tuned to a frequency that is not in the same amateur band as the active VFO, then the frequency and mode of the active VFO will be copied to the inactive VFO. This is done to prevent inadvertent split frequency operation taking place on different bands. However, if someone really has a need for split frequency operation on different bands, then by using the VFO Memory Copy function it is still possible to copy a frequency that is in a different band to either the active or inactive VFO.

Note: This version of the firmware now displays the current mode of the Rapid Bandswitch feature as: Default – User – Locked.

To save a favourite amateur band frequency, please refer to the FILTER button operation. If the current VFO is locked, then this will be displayed, and the frequency will not change.

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 1kHz. 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 bands in this mode for obvious reasons. In order to do so, select either VFO-A or VFO-B, but see the previous note regarding the Rapid Bandswitch feature.

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, the frequency of VFO-A will then be copied to VFO-B.

To copy the VFO-B frequency to VFO-A, first select VFO-B, and press and hold the button, and the frequency of VFO-B will be copied to VFO-A.

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 3 to 26 memories, then these can be selected sequentially by a brief press of the button, or if the button is held until the long beep is heard, after releasing the button, 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.

To exit from the function, briefly press either the VFO or the PWR button. Whilst the latched mode is in effect, a rapid beep will be heard to remind you that the function is latched.

If the destination VFO is locked, then this will be displayed, but the copy operation will not occur.

FILTER
This button is primarily used to select the receiver bandwidths, but also has a secondary function of storing user frequencies and returning to the CW mode from CWR.

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.

If this button is pressed when displaying power, SWR, voltage or current, the display will blink twice to show which filter has been selected, and then return to the previous display page.

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.

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. The new frequency is automatically saved to the EEPROM. By selecting the Locked mode, these frequencies can then be protected.

System Calibration & Setup

It is assumed that the initial adjustments and settings have been made. Note that when selecting the Calibration & Setup menu, VFO-A will be selected, the frequency will be set to 14.300MHz, and the Tune mode selected. The Tune Attenuator will be temporarily set to 0dB for power meter calibration, and output power setting. It will be restored to its initial value when leaving the setup mode unless the restore defaults option is selected, when it will be set to −3dB.

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

```
JUMA-TRX2 v1.10j
Calibration Mode
```

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

Note: With this version of the firmware, the Fast Menu Page Select feature is available for both the User Configuration Menu and the System Calibration & Setup Menu. To use this feature, press and hold the MODE button until a long beep is heard then release the button. A rapid beep will be heard to remind you that the Fast Page Select function is engaged. Rotate the VFO knob to select the menu page you wish to edit. To exit from the Fast Menu Page Select, briefly press either the MODE or the PWR button.

To exit from the Calibration & Setup menu, select a normal adjustment page, and briefly press the FAST/VFAST button. You will receive a prompt. Briefly press the PWR button to exit without making any changes, or the MODE button to exit and save the current settings.

Set Reference Oscillator Frequency

Default: 180,000,000Hz

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 the 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.

Supply Voltage Calibration Factor

Default: 5300

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 +5.000V, this gives an incremental digital step size of 5.0mV. (See Annex F for complete details.) 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.

The accuracy of the internal measurement system has been enhanced with this version of the firmware, and the incremental quantisation steps are now such that it should be possible to set the voltmeter to exactly match your measured value

The range is checked, and values from 4000 – 6000 are acceptable, although values significantly different (more than ±250) from the default value suggest that the logic voltage should be checked, and investigated.

RF Amplifier Drain Current
Default: 2400
Using an accurate ammeter, measure the drain 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

Note: The transceiver's ammeter only measures the amplifier's drain current, not the total current.

Using an accurate ammeter, first measure the current drawn in the receive mode with the audio gain pot set to minimum, this is the idle current.

Next, measure the total current drawn in the Tune mode, which includes the idle current as well as the 60mA driver bias current and the 200mA power amplifier bias current. Subtract the idle current from the total to get the drain current and adjust the calibration factor to achieve the closest match. The default value is usually satisfactory. The limits are from 1200 – 3600.

Note: In the normal mode, the ammeter is a peak hold meter with a hold time of approximately 800mS. In the Service Mode the ammeter is an instantaneous reading meter.

Forward Power Calibration Factor
Default: 3550
Using a dummy load, and an accurate power meter, set the transmitter's output in the Tune mode with a Tune Attenuation of 0dB, and using the CARR control on the main board adjust the forward power to 10W. Adjust the calibration factor to achieve the closest match. The limits are from 1500 – 5000.

S-Meter Calibration Factor
Default: 20
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 50Ω 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, 5mV, −33dBm signal, 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, later transceivers are likely to have calibration factors close to the default, whilst earlier units will be in the range of about 34. The limits are from 5 – 70.

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.

Note: Although setting the beep time to zero disables the audio beeps for most operations, for major configuration changes and the Fast Page Select feature, a beep tone is always given.

High SWR Trip Limit
Default: 3.00
If the SWR exceeds the trip limit, an alarm will be generated and displayed on the main screen. The limit can be set from 1.00 – 10.00. Although a setting of 1.00 may seem odd, it allows you to check that the alarm is working. Set the limit to 1.00, and exit from the System Calibration menu by saving the settings.

Ensure you are displaying a normal page. Connect the transceiver to a dummy load, select Tune, and press the PTT switch. If the alarm is working, then after the extended delay time has expired, you should see a blinking message '`HIGH SWR`' on the top line of the display, along with a beep. To cancel the alarm, release the PTT switch, and briefly press the PWR button.

To check that the extended delay time is not used in other modes, select LSB or USB, press the PTT switch and talk into the microphone. The '`HIGH SWR`' alarm should appear almost immediately.

Switch off, and reselect the System Calibration menu again, and reset the SWR Trip to a suitable value. The SWR alarm is always enabled.

SWR Alarm Delay Time
Default: 5.0 Seconds
As explained elsewhere, in order to allow tuning a manual transmatch without provoking a high SWR alarm, when using the TUNE mode the alarm can be delayed to allow time for the adjustments to be made. The delay is governed by this setting.

The delay is adjustable from 1.0 seconds to 10.0 seconds in 1second increments. If you are using an auto-tuner, then the delay should be set to no more than a few seconds. If you are using a manual transmatch, then longer delays may be necessary. If you do not wish to use this feature, then set it to the '`Disabled`' setting, which is the same as the normal delay time when using the other modes.

Overcurrent Trip
Default: ON
This allows you to enable or disable this alarm. If the alarm is disabled, then the following page will be skipped, although its settings will be retained, and can be adjusted if the alarm is re-enabled.

Overcurrent Trip (Adjust)
Default: 2.5A
Adjust the limit to a suitable value. The default is usually satisfactory. The value can be set from 1.5A – 3.5A. Temporarily setting the trip to 1.5A allows you to verify that it is working.

As with the SWR test, save the calibration settings, using a dummy load and the Tune mode, press the PTT switch. The top line of the display will show the blinking message "`OVERCURRENT`", there will be a beep. Release the PTT switch and briefly press the PWR button to cancel the alarm. Switch off and reselect the System Calibration menu and reset the trip to a suitable value.

Note: The current measured is that of the final amplifier. The internal fuse is rated at 3.5A, and since the transceiver's logic and display sections can consume up to 450mA, the normal trip limit of 2.5A represents a conservative safety margin. Under some circumstances, especially if you are attempting to obtain the maximum power out of the transceiver, then it may be necessary to set the limit to the maximum permissible, 3.5A. Be aware however that with the logic and backlighting current as well, this is running very close to the fuse rating.

Overvoltage Trip
Default: ON
This allows you to enable or disable this alarm. If the alarm is disabled, then the following page will be skipped, although its settings will be retained, and can be adjusted if the alarm is re-enabled.

Overvoltage Trip (Adjust)
Default: 14.5V
Adjust the limit to your preference. The range is from 14.0V – 15.0V.

Undervoltage Trip
Default: ON
This allows you to enable or disable this alarm. If the alarm is disabled, then the following page will be skipped, although its settings will be retained, and can be adjusted if the alarm is re-enabled.

Undervoltage Trip (Adjust)
Default: 11.0V
Whilst the transceiver will continue to operate down to quite low voltages, when operating portable from a sealed lead-acid battery, most manufacturers recommend terminating the discharge when the terminal voltage falls to 10.5V.

The transceiver can be set to warn you with a blinking "`UNDERVOLTAGE`" display and a beep at any voltage from 10.50V – 11.50V.

Note: In addition to this final warning, there is a pre-limit warning which occurs at a voltage 100mV higher than this setting. This will display the blinking alarm message: "`Low Batt Voltage`", and beep.

Acknowledge and cancel the warning by briefly pressing the PWR button. This warning will only be given once – it will NOT repeat! Once you have acknowledged the warning it disappears. The only way to reset it is to power the transceiver off and back on again.

Band Limits
Default: IARU
The transceiver's band edge frequencies can be set to either the IARU Region 1 limits, or the USA limits. For the USA settings, you may choose between the Extra Class licence limits or the more restrictive General Class limits.

The settings will take effect when you exit the System Calibration & Setup menu, and will subsequently take effect each time the transceiver is powered up. There will be a brief message displaying the current setting.

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 then respond to the prompt. A brief press of the MODE button will restore the default settings, pressing the PWR button will abort the operation, and restore the current settings.

Otherwise, press the DISPLAY button briefly to return to the initial screen, and briefly press the FAST/VFAST button to save the current values. You will be prompted to save the current values. If you press the PWR button the save operation will be cancelled, and the previous settings restored. A brief press of the MODE button will save the current settings.

User Configuration Settings
To enter the User Configuration settings, press and hold the DISPLAY button until you hear a long beep. To exit from the User Configuration menu, press and hold the DISPLAY button until you hear a long beep. You will be prompted. Briefly press either the PWR button to exit without making any changes, or the MODE button to exit and save the new settings.

With version 1.10j there are now 28 settings that can be adjusted to your preferences. With this number of 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. Release the button, and the Fast Menu Page Select feature will be engaged. Rotate the VFO knob to select the desired configuration page. To adjust the setting, briefly press either the MODE or the PWR button. Whilst the Fast Page Select feature is engaged, you will heard a rapid beep to remind you.

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, Transmit – 2,678Hz
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: 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.

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: 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 Dot Priority, Iambic A, Iambic B, Vibroplex, or Straight key operation. See Annex L.

CW Release Delay
Default: 500mS
When using the Straight keyer mode, the release delay time, that is, the time for the transceiver to switch from transmit to receive, is governed by this setting.

The delay time can be set from 200mS – 1500mS, or if you set it to less than 200mS, it will revert to the previous mode of operation, where the delay time is controlled either by the setting of the CW Speed pot if the mode of this was set to CW Speed, or else the default CW speed release delay time which is 7 x Dot Time, 1 word space.

In the Iambic modes, the release delay is fixed at 7 x Dot Time, which is 1 word space time.

Note: If the key mode is set to an Iambic or the Vibroplex mode, then this display page will be skipped.

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 frequency used for the sidetone. See Annex K for a full explanation of the CW mode of operation.

CW Pot Mode
Default: 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.

There are two squelch modes. Mode A operates as before, if the backlighting timer feature is used, and it has timed-out, then a signal above the squelch threshold will not turn the backlighting on.

Mode B however will turn the backlighting on if a signal is above the threshold, and the backlighting will remain on until the signal level has once again fallen below the threshold, re-enabling the backlighting timer function.

CW Keyer Speed Adjust
Default: Locked, and 20wpm
When the CW Pot Mode is set to Squelch, the keyer speed is automatically set to the value saved in this menu page. If the CW Pot Mode is set to CW Speed, then the speed of the keyer

can be controlled directly from the CW Speed pot, except if it is rotated fully anti-clockwise, when the default preset speed will be selected. The speed is adjustable from 5wpm – 30wpm.

To unlock the speed adjustment, rotate the VFO knob anti-clockwise, to lock, rotate the VFO knob clockwise. To adjust the speed, unlock the setting, and rotate the CW Speed control to the desired speed. Once set, lock the speed with the VFO knob.

Note: Failure to lock the setting will cause it to be unpredictably changed depending upon the current setting of the CW Speed pot when stepping or scrolling through the User Configuration menu!

CW/CWR Swap
Default: Off
With the revision of CW operation and the introduction of the CWR mode, in order to precisely tune in a CW carrier it is convenient to adjust the VFO to obtain the same pitch in both CW and CWR modes.

To enable this to be achieved with the minimum of button pushes, this option has been introduced.

In the default mode, the mode selection options work as before, the MODE button simply cycles through the available modes. If this option is turned on, then when the CWR mode is selected you can re-select the CW mode with a brief push of the FILTER button.

Note: Filter selection is not possible when the CWR mode is selected, you will need to return to the CW mode and then select a filter.

LCD Backlight
Default: 300
The intensity of the LCD display can be adjusted with this setting. Values from 50 – 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 50 – 3,500.

LCD Timer
Default: OFF
The display can be automatically turned off after a preset time using this feature. The timer can be set to a value between OFF and 3,600 seconds in 5 second increments.

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

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.

JUMA TRX2
This mode is used to enable serial communication with the companion JUMA PA100D 100W linear amplifier. It can also be used with the TRX-Manager CAT software produced by Laurent Labourie, F6DEX. Please see Annex I for details.

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, ?, H, or h from the PC and the transceiver should respond with a screen of information. For a brief description please see Annex E.

Voice Memory
This mode is used with the accessory voice memory board. See Annex J for further details of its operation. This mode selection is only visible if the optional Voice Memory module is installed.

Baud Rate
Default: 9,600
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.

The VFO lock feature is applicable to individual VFO memories, and the status may be saved each time the transceiver is powered down.

Note: Setting the serial port protocol to either the Yaesu or Kenwood CAT modes will force the VFO mode to the A+B Split selection. To remind you that this is a forced fixed mode selection the display will show the message: `A/B + Split(CAT)`.

S-Meter
Default: Graphic
This 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.

S-Meter Hold Time
Default: 2.50 Seconds
After some considerable use of the numeric S-meter it was apparent that its response time was rather too fast, even with the AGC set to the slow decay time. This setting allows you to customise the peak hold time of the numeric S-Meter to your preference.

The timer for this is part of the main 1mS interrupt, and is thus reasonably accurate. The limits are 0.25 Seconds – 5.00 Seconds, the default of 2.5 seconds is usually satisfactory.

TX Disable
Default: ON
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, the decimal point will blink if the current receive frequency is outside the amateur bands. 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.

Note: In split mode if this feature is turned off, then the out-of-band indicator will be displayed in the receive mode for VFO-A, but will only display for the transmit VFO when the PTT switch or key is pressed. If its frequency is out-of-band the annunciator will be displayed, but transmission will not be inhibited. It is recommended that this feature is enabled at all times.

Auto Sideband Select
Default: ON
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
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:

```
12.345.67
```

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

1Hz Tuning Rate	:	`12.345678`
10Hz Tuning rate	:	`12.345680`
100Hz Tuning rate	:	`12.345700`
1kHz Tuning Rate	:	`12.346000`

Note: The precision is not affected, the frequency is rounded to the appropriate tuning rate's resolution if this mode is selected in the User Configuration menu. 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 B
The display is fixed at 10Hz resolution, independent of the tuning rate used.

Band S/W
Default: Default
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	3.600
40 metres	7.100
30 metres	10.125
20 metres	14.100
17 metres	18.118
15 metres	21.300
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.

When a new frequency is stored, the EEPROM data is automatically updated.

The out-of-band indication is dependent upon the mode in use. For USB, the carrier frequency has the transmit filter bandwidth 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. For CW, CWR, and Tune modes no corrections are required as the actual carrier frequency is used.

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

When using the Rapid Band-Switch feature, the frequency will be displayed using the currently selected frequency display mode, and the current band-switch mode will also be displayed, as: Default – User – Locked.

Include RIT
Default: Off
If this is turned on, then the RIT offset frequency will be used to modify the frequency displayed to show the actual receive frequency.

Tune Attenuation
Default: −3dB
A number of users have requested a way to tune the transceiver without using its maximum power. This is a sensible idea, both to avoid interference, as well as providing more protection for the PA from high SWR that may be encountered, and their resulting over-current events.

Using the VFO tuning knob, adjust the attenuation to the desired value, −3dB is recommended.

VFO Adjust
Default: Off
With the ability to adjust the VFO frequency in several steps, from increments of 1Hz to 1kHz, the need arose to be able to round the frequency to the nearest decade increment. This is particularly important if you use either the default frequency display or frequency Display B, as these only show to 10Hz.

If you select the slow (1Hz) tuning rate then the transmitted frequency's last digit could be anywhere in the 0Hz – 9Hz range when displaying only to 10Hz resolution. With this new feature, you can select whether to round the frequency to the nearest tuning step decade.

The default is OFF, and no rounding will occur when switching tuning rates.

If the 10Hz adjustment is selected, then when switching to this tuning rate the last digit will be rounded up or down to the nearest 10Hz boundary. Similarly, when the 100Hz/10Hz setting is selected, rounding will occur whenever you select either the 10Hz tuning rate or the 100Hz rate. If the ALL setting is chosen, then rounding will occur for all tuning rates, including the very fast 1kHz step rate.

Obviously, when the next tuning rate is selected the VFO will shift slightly in frequency, and for the 10Hz rate this could amount to ±5Hz, for the 100Hz tuning rate, ±50Hz, and for the 1kHz rate, ±500Hz.

For some applications, particularly digital modes, these rounding shifts might not be desirable, and thus you have to ability to select which rounding rates to use, or to completely disable this feature as you wish.

Meter Scale Type
Default: Original
The bar-graph scale can now be displayed three different ways. The original scale, a large scale marker and a small scale marker version.

Power-Off Mode
Default: Prompted
This menu item governs how the power down feature works. The choices are: Immediate – Prompted – Save State.

If you select the Prompted option, then when you press the power button you will be prompted whether you wish to save the settings. If you briefly press the PWR button the operation will be cancelled, and no settings will be saved. If you briefly press the MODE button the existing settings, including the VFO in use, mode, frequency, RIT On/Off, and, if the Last Page feature has been selected, the current display page will be saved.

If you choose the Immediate setting, then the transceiver will simply immediately power down without saving anything. Since both the Setup and User Configuration menus now have a prompted exit, there is little need for an automatic save to be made.

Note: If the Immediate mode is selected, the current VFO, frequency, mode, RIT On/Off will be lost. When the transceiver is next powered up the VFO, frequency, mode, and last page will be that which was last saved. In addition, since no configuration save is performed, the Last Page option is inconsistent, and therefore selecting this Power Off mode will reset the Start-Up Page to the standard default value.

If you choose the Save State option, then an immediate power down will occur, but the current transceiver state will be saved, and a message:

```
Configuration
    Saved!
```

will be displayed for about a second before the screen is cleared and the backlighting turned off waiting for you to release the PWR button.

Start-Up Page
Default: Mode/BW
This feature allows you to select which page is displayed on start-up. The previous firmware version always displayed the Mode and Bandwidth, but some users preferred to display the battery supply voltage on start-up.

Rotate the VFO knob to select the fixed page to display as Mode/BW, O/P Power, SWR, Voltage, PA Current, or Last Page.

If the Last Page is selected, then when the configuration is next saved the current display page is included. This is primarily intended to be used when the Power-Off Mode is set to Prompted.

Note: If the mode is subsequently changed from Last Page to one of the fixed pages, the existing last page will be deleted, and replaced with the default setting Mode/BW.

Note: If the Immediate Power-Off mode is selected in the previous page, then the Last Page option is skipped, and only one of the fixed display pages can be selected.

Graphic Limits Display

With this version of the firmware the display of the measurements has been enhanced. In the previous firmware in the receive mode, the bar-graph would display either the graphic or the numeric S-Meter. In the transmit mode, the bar-graph would only display the output power.

In the receive mode, as before, the bar-graph displays the current S-Meter reading, either graphically or numerically as set in the User Configuration menu.

In transmit, the bar-graph is used to displayed the measured values in relation to their alarm or trip points.

Voltmeter

The bar-graph is effectively a suppressed-zero voltmeter. The 'zero' end of the scale represents the current under-voltage trip point, the full-scale is the current over-voltage trip point.

For example, if the under-voltage trip is set at 11.00V and the over-voltage trip at 15.00V, then the scale length is 4V, and as there are 8 segments, each corresponds to 0.5V from 11.00V – 15.00V. If the current battery voltage is exactly 13.00V, then the bar-graph will indicate half full-scale. The digital meter will display the exact value.

Ammeter

The bar-graph displays the instantaneous drain current as a proportion of the current trip level.

SWR

The bar-graph displays the instantaneous SWR as a proportion of the current trip. For example, if the current trip is 3:1, and the measured value is 2:1, then the bar-graph indicates half full-scale, the zero setting being a SWR of 1:1.

In addition, the alarm system has been slightly modified. If you are in the `TUNE` mode, then the SWR alarm is delayed by an adjustable time. This is to allow you sufficient time to manually adjust your transmatch before a High SWR alarm is registered. It should be more than sufficient time for an auto-tuner to achieve a match.

When any other mode is being used, the High SWR alarm will appear as before after a few hundred milliseconds.

Power Meter

The RF power is now displayed, and the full scale of the bar-graph represents 10W. This is to remind you that the transceiver's maximum designed output power is 10W. Even though it is capable of significantly more output, it is inadvisable to use it as this risks blowing fuses as well as overheating the output transistors. The digital display will still indicate the actual output power, even if it is in excess of 10W.

Note: The digital power meter is a peak reading meter with a hold time of about 1 second, and a fairly fast release time.

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/CWR/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 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.

7. The spurious power-down count when locking or unlocking the VFO has been cleared.

8. The filter change points for the 2MHz and 4MHz filters have been moved up by 1kHz. It was particularly disconcerting that right at the 2.0MHz and 4.0MHz frequencies these filters would be changed. The new frequencies are 2.001MHz, and 4.001MHz.

9. The Serial Test facility has been enhanced with the addition of a dump of the attenuator settings corresponding to the various internal filters, as well as an Auto-Equalise function.

10. If the mode or filter bandwidth is changed when displaying the power, voltage, current or SWR, the display will blink twice and display the setting which has been changed, and then return to the previously selected display page.

11. The filter button is now ignored in the User Configuration menu except for the filter page itself where it is allowed to select the filter whose bandwidth you wish to adjust.

12. The Serial Test calibration and user configuration dump has been slightly altered so that the various parameters are now displayed in the same order as they occur in the setup menus.

13. The over-current trip has been changed from a single sample trip to an averaging trip. The number of samples is set to 64, giving a sample time of about 500mSec. This is sufficient to provide warning of a steady-state over-current, but will ignore transient peaks.

14. Power-up serial garbage. In other versions, if the user serial port speed was not the default of 9600 Baud, then the serial port would transmit garbage until the port speed was reset. This has now been fixed, no serial port output occurs until the port speed has been finalised during the boot-sequence.

15. The diagnostic serial terminal printouts are now only displayed if the serial port is set to the Test mode. This is also now the default serial port mode rather than the Yaesu CAT mode. This ensures that on initial load, or if a checksum error occurs, if you have a serial terminal connected you will see the boot sequence messages.

16. The squelch hold time has been slightly lengthened to 850mS versus the original 500mS. This allows a slightly longer time between syllables, and improves the operation of the squelch.

17. Minor cleanup of the serial test facility displays.

18. Reorganisation of the serial port protocol selections with significant internal code optimisations resulting in a useful reduction in code size.

19. Integration of the Voice Memory option into the firmware, and optimisation of the alarm sub-system display function.

20. Pressing the PTT switch or keying the transmitter forces the transceiver to send the current band data to the PA-100D when using the TRX-2 protocol.

21. A new CW mode, CWR has been implemented, and the existing CW mode greatly modified.

22. The TRX-2/PA-100D interface protocol has been greatly expanded to permit incorporation into the excellent TRX-Manager CAT program written by Laurent Labourie, F6DEX.

23. Fast power off has been implemented allowing a rapid power down without the necessity of always saving the User Configuration settings.

24. The jitter associated with the use of RIT has been eliminated.

25. The supply voltage display now uses a 50 sample running average to minimise jitter.

26. The transmit filter bandwidth is now adjustable.

27. The band limits have now been changed to accommodate the US Extra and General class licences.

28. The Rapid Band Select feature will now select the nearest amateur band to the current displayed frequency if it is out-of-band instead of defaulting to 160m.

29. An additional feature, CW/CWR Swap, has been added. Enabling this feature allows you to return to the CW mode from the CWR mode by a brief press of the FILTER button. This feature was suggested by Jan Wieck, WI3CK, and was implemented in close collaboration with him – thanks for the suggestion, Jan!

30. The Very Fast tuning rate has been changed from 10kHz to 1kHz. When there was no rapid band-switch facility the only way to quickly select another amateur band was to use the very fast tuning rate, which gave 4.8MHz/turn. However, with the Rapid Band-Switch feature this extremely rapid tuning rate is redundant, and a more useful 1kHz/step, giving 480kHz/turn has been implemented.

31. Choice of graphic meter scale display.

32. Revised SWR display and alarm.

33. Revised S-Meter calibration.

34. Graphic display of measured values in relation to trip points.

35. Calibration and User configuration adjustments are now optimised and all operate at the same adjustment rate.

36. When exiting the Calibration Mode, the previously saved transceiver setting are now restored.

37. The Serial Test Suite can now display the User Frequency settings for the Rapid Bandswitch feature along with the 26 VFO Memory frequency settings.

38. User adjustable CW Release Delay time for the straight keyer mode.

39. The lock status, current tuning rate, and selected VFO mode are now displayed when cycling through the VFO memories with the VFO knob in the multi-memory mode.

40. The Yaesu and Kenwood CAT command sets have been extended with a custom Extended Display feature. The Juma TRX-2 mode has also been extended with this. Most CAT program allow the user to define a custom command sequence, and this can be used to invoke this additional feature.

41. Replaced SPI bus display with a fully decoded display in the serial test suite.

42. Modified Squelch/Backlighting inter-operation

43. Rationalised the power down sequence.

44. Modified the digital ammeter to be a peak hold meter with a hold time of approximately 800mS.

45. Added the Vibroplex™ mode to the CW feature set, and cleaned up some code in the autokeyer.

45. Major re-write of the Voice Memory module.

47. Significant optimisation of the User Configuration and Calibration code to eliminate duplicate address calculation.

48. Added Fast Menu Page Select feature to System Calibration Menu.

49. Modified the Rapid Band-Switch feature to display the current mode setting.

50. Saved current display page whenever the User Configurations are saved.

51. Added choice to start-up display page.

52. Moved the Power-Off Mode to be next to the Display Page option in the Configuration Memory as they are no logically connected, and modified the operation of both options.

53. The Voice Memory Erase command is now a prompted command.

54. Added the latched page to the Rapid band Switch, VFO Memory Copy, VFO Select, Fast Page Select for the System Calibration and User Configuration menus.

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9/March/2014
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Annex A

JUMA Frequency Step Accuracy

The Juma TRX2 using the original 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, using the original firmware, 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:

$$f_{\text{local oscillator}} = N * 180{,}000{,}000 / 2^{33} \text{ Hz}$$

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.

In the original firmware 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 used to alter the existing frequency word for every step generated by the VFO encoder at the 100Hz tuning rate.

The actual frequency increment is therefore:

$$f_{\text{increment}} = 4{,}772 * 180{,}000{,}000 / 8{,}589{,}934{,}592$$

$$= 99.996{,}104{,}837 \text{ Hz}$$

There is thus an incremental step error of −0.003,895,164 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 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 0.020,955 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 performed 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

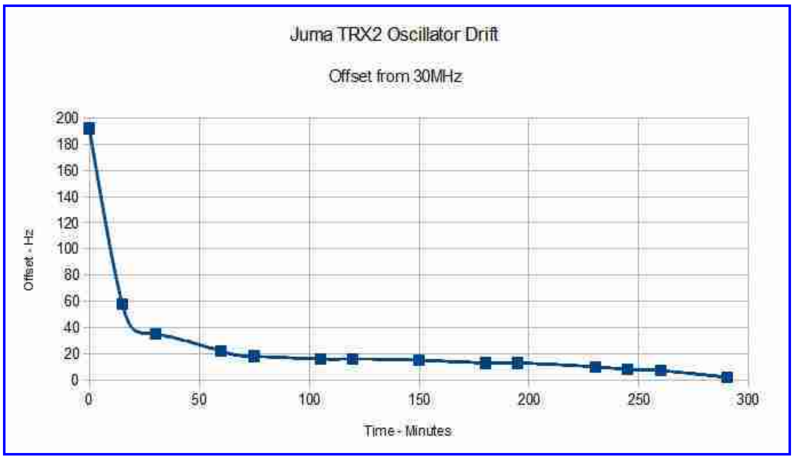
Reference Oscillator Calibration

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 ±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 overall accuracy of the frequency generating system.

Note: Before performing any oscillator corrections, the transceiver should be turned on and left to stabilise for at least two hours. A number of measurements have confirmed that the crystal oscillator tends to drift low in frequency by about 180 Hz at 30 MHz in the first 90 minutes of operation, as illustrated below.



Note: When calibrating the master oscillator it is most important that either USB or LSB is selected. If either CW mode is selected with the new CW operation the DDS frequency will be offset by the amount of the CW shift, leading to erroneous results.

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 ±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. For example, 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 ±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 = −50.60Hz

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

= 30,000,000 −303.60 Hz

= 29,999,696.40Hz

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.

Method 3 – Direct Carrier Calibration

With this method, the carrier frequency of the transceiver is measured with an accurate frequency counter as for the direct oscillator calibration. Set the Transmit Enable OFF. Connect the transceiver to a directional coupler with at least 30dB of coupling loss, and connect the main output port of the coupler to a dummy load. Set the Tune Attenuator to −3dB.

Tune the transceiver to exactly 30.000000MHz using the 1Hz tuning rate and Frequency A display. Select the Tune mode. Press and hold the PTT switch and measure the output frequency and average it over 10 measurements to at least 1Hz resolution.

Multiply the averaged value by 6 to obtain the reference oscillator calibration value.

Method 4 – Standard Frequency Transmission

With this method, and utilising the new CW/CWR facility, it is possible to accurately calibrate the reference oscillator using a known standard frequency. Whilst in principle any accurate frequency will suffice, it will make the subsequent calibration calculation easier if one of the normal standard frequency transmissions on 2.5MHz/5.0MHz/10MHz is used.

First, ensure that your reference frequency setting is set to the standard default, 180MHz. Next, enable the Frequency A display to a resolution of 1Hz, and use the 1Hz tuning rate. Also ensure that the CW/CWR Swap feature is enabled.

Set the mode to CW, select a suitable filter bandwidth, and tune to a standard frequency. Note the beat note, and select CWR. Re-tune the transceiver to obtain the same beat note. Briefly press the FILTER button to re-select CW, and re-adjust for the same beat note. Continue this process of alternately using the CW and CWR modes and adjusting the tuning until the beat note is the same for each mode. Note the transceiver’s displayed frequency.

The transceiver’s carrier frequency is now precisely set to the frequency of the standard frequency transmission.

In all probability the displayed frequency is somewhat offset from the precise carrier frequency, and by using the following calculation it is possible to correct this offset.

Let the standard frequency be : F_{std}
Let the displayed frequency be : F_{disp}
Let the oscillator frequency be : F_{osc}
Let the reference frequency be : F_{ref}

Then:

$$F_{osc} = 30{,}000{,}000 + ((F_{std} - F_{disp}) * 30{,}000{,}000 / F_{std})$$

$$F_{ref} = 6 * F_{osc}$$

To take an example. Assume the standard frequency is 5,000,000Hz, and the displayed frequency is 5,000,985Hz. In this case, as the displayed frequency is higher than the standard, the crystal oscillator's frequency is low.

$$F_{osc} = 30{,}000{,}000 + ((5{,}000{,}000 - 5{,}000{,}985) * 30{,}000{,}000 / 5{,}000{,}000)$$

$$F_{osc} = 30{,}000{,}000 + (-985 * 6)$$

$$F_{osc} = 29{,}994{,}090\text{Hz}$$

$F_{ref} = 6 * 29{,}994{,}090 =$ **179,964,540Hz**

To use another example, this time using an AM broadcast station's carrier as the standard. Assume that the broadcast station is transmitting on 6,195KHz, and the displayed frequency is 6,194,743Hz. In this case, the displayed frequency is lower, and thus the crystal oscillator is high in frequency.

$$F_{osc} = 30{,}000{,}000 + ((6{,}195{,}000 - 6{,}194{,}743) * 30{,}000{,}000 / 6{,}195{,}000)$$

$$F_{osc} = 30{,}000{,}000 + (257 * 30{,}000{,}000 / 6{,}195{,}000)$$

$$F_{osc} = 30{,}000{,}000 + 1{,}244.55$$

$F_{ref} = 6 * 30{,}001{,}244.55 =$ **180,007,467Hz**

This last example uses a short-wave broadcast station as the standard, and illustrates that the calculation becomes a little more complex in this case.

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	
Set Tuning Rate	: E0	Not part of original Yaesu protocol!
Set Extended Display	: F8	Not part of original Yaesu protocol!

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 : 00 00 00 00 03
Response : 14 54 32 10 xx
Where xx is the mode byte, with the following meanings:

00	LSB
01	USB
02	CW
03	CWR
0C	TUNE (PKT mode for FT-857)

There are a number of other values, but they are not applicable to the Juma TRX-2

Read RX Status

Command : 00 00 00 00 E7

Response : xx 00 00 00 00

Where 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 : 00 00 00 00 F7

Response : xx 00 00 00 00

Where 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 : 00 00 00 00 02

Split Mode OFF

Command : 00 00 00 00 82

VFO Select (Toggle VFO-A, VFO-B)

Command : 00 00 00 00 81

Set Operating Mode

Command : xx 00 00 00 07

Where xx has the following meanings:

00 LSB
01 USB
02 CW
03 CWR

0C TUNE (PKT mode in FT-857)

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

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

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

Lock VFO
Command : 00 00 00 00 00

Unlock VFO
Command : 00 00 00 00 80

Set Tuning Rate – Not Part Of Standard Yaesu Protocol
Command : xx 00 00 00 E0
Where xx has the following meanings:
00 Slow – 1Hz
01 Medium – 10Hz
02 Fast – 100Hz
03 Very Fast – 1kHz

Set Extended Display – Not Part Of Standard Yaesu Protocol
Command : xx 00 00 00 F8
Where xx has the following meanings:
00 Normal Display
01 RF O/P Power Display
02 SWR Display
03 Supply Voltage
04 Amplifier Drain Current

Annex D

Kenwood TS-480/590 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	
Set/Read Extended Display Status	: XD	Not in standard Kenwood protocol!

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

IFp1p1p1p1p1p1p1p1p1p1p1-p2p2p2p2p2-p3p3p3p3p3-p4-p5-p6-p7p7-p8-p9-p10-p11-p12-p13-p14p14-p15;

Note: For clarity a dash symbol - has been inserted between the parameter blocks, this is not present in the return string.

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, 7 = CWR, 8 = TUNE
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      +00000000002000000 ;`
RX Freq: 14.003920MHz RIT Freq: 0000Hz, RIT Off, RX, USB, VFO A, Scan Off, Simplex

Example 2: `IF00014003920      +01231000012000000 ;`
RX Freq: 14.003920MHz RIT Freq: +123Hz, RIT On, TX, USB, VFO A, Scan Off, Simplex

Example 3: `IF00014003920      -01231000002000000 ;`
RX Freq: 14.003920MHz RIT Freq: −123Hz, RIT On, RX, USB, VFO A, Scan Off, Simplex

Example 4: `IF00014003920      +00000000002001000 ;`
RX Freq: 14.003920MHz RIT Freq: +0000Hz, RIT Off, RX, USB, VFO A, Scan Off, Split

Set Mode
Transmitted from PC
MD1; LSB
MD2; USB
MD3; CW
MD7; CWR
MD8; TUNE

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
MD7; CWR
MD8; TUNE

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, taking into account the current bandwidth settings.

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 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

Read Extended Display Status
Transmitted from PC
XD;
Response from Juma TRX-2
XDn;
Where n has the following meanings:
0 Normal Display
1 RF O/P Power Display
2 SWR Display
3 Supply Voltage
4 Amplifier Drain Current

Set Extended Display
Transmitted from PC
XDn;
Where n has the following meanings:

0	Normal Display
1	RF O/P Power Display
2	SWR Display
3	Supply Voltage
4	Amplifier Drain Current

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 the DX-Labs CI-V Commander version 10.1.0, and it operates with this program.

Annex E

Serial Port Test Mode

When the serial port mode is set to the 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 v1.10k Build: 4 - 10/MAR/2014
Copyright Juha Niinikoski - OH2NLT & Matti Hohtola - OH7SV
(Additional features and modifications - Adrian Ryan - 5B4AIY)
---------------------[COMMAND TABLE]---------------------
I      Help - (This Screen)
A      Display A-D Convertor Samples
a      Alarm Function Test
b      LCD Bar Graph Test, any key exits.
C      Clear Factory Default reset counter
c      Continuous SPI write, any key exits.
D      UART1/UART2 character cross-copy test, ESC exits.
E      Dump EEPROM contents
f      Display SPI bus control bits
m      Display mSec counter
o      Reference Oscillator calibration value
p      Display scaled S-Meter & CW Speed Pot A-D value
Q      Auto Equalise RF Output Power
R      RF Attenuator Settings
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, ESC exits.
+      Increment RF Attenuator
-      Decrement RF Attenuator
Z      Divide-By-Zero Trap
```

Entering the letter I, ?, H, or h will display the help facility, above.

Enter the letter A, and you will obtain a dump of the A-D convertor’s current measurements thus:

```
A-D Convertor Samples
 Channel   Sample   Scaled(V)   Displayed
------------------------------------------
    9         0      0.000        0.000A
   10      2578      3.147       13.663V
   11         0      0.000       S0
   12         0      0.000  Rev:  0.00W
   13         0      0.000  Fwd:  0.00W
   14      1901      2.321  CW Speed Pot
   15      2063      2.518  RIT:    0Hz
------------------------------------------
```

Each line of the display now identifies the channel number, its raw value from 0 – 4095, the scaled voltage to which this value corresponds, and the displayed measurement.

The above display show the A-D convertor output when using the factory default values for the measurement system. The next dump shows a more representative set of values obtained when keying the transceiver in the Tune mode operating into a dummy load:

```
A-D Convertor Samples
 Channel   Sample   Scaled(V)   Displayed
------------------------------------------
    9       1862      2.273        2.247A
   10       2531      3.090       13.591V
   11          0      0.000       S0
   12         16      0.020  Rev:  0.00W
   13       1785      2.179  Fwd: 11.31W
   14       1901      2.321  CW Speed Pot
   15       2063      2.518  RIT:    0Hz
------------------------------------------
```

By entering the letter ‘u’ (lower-case u), the transceiver’s calibration and configuration settings can be dumped thus:

```
System Settings
-----------------------------------
Reference Oscillator: 180000000 Hz
DC Voltmeter        : 5300
Ammeter             : 2400
Power Meter         : 2907
S-Meter             : 3900
Beep Time           :  50 mS
SWR Trip Setting    :  300
SWR Alarm Delay Time:  5.0 Secs
Over-Current Trip   : 2360 =  2.85A
Over-Voltage Trip   : 2756 = 14.80V
Under-Voltage Trip  : 2049 = 11.00V
Band Limits         :  IARU Region 1

User Settings
-----------------------------------
AGC Speed        : Slow
Filter Roll-Off Frequencies
Narrow           : 1000 Hz
Mid              : 2205 Hz
Wide             : 2500 Hz
Transmit         : 2586 Hz
Speech Processor :  Off
Audio Source     :  Mic
Keyer Mode       : Iambic A
CW Release Delay : 500mS
CW Pitch         : 700 Hz
CW Pot Mode      : CW Speed
Keyer Speed      : Locked   20 wpm
CW/CWR Swap      : Off
LCD Backlight    : 350
LCD Contrast     : 2000
LCD Timer        : 0 Seconds (OFF)
RS-232 Mode      : Test
Speed            :   9600 Baud
VFO Memory       : A/B + Split
S-Meter          : Graphic
```

```
S-Meter Hold Time: 2.50 Seconds
TX Disable       :  On
Auto-Sideband    :  On
Frequency Display: Fixed B
[12.34568 ]
[ 2.34568 ]
[ 0.34568 ]
[ 0.04568 ]
[ 0.00568 ]
[ 0.00068 ]
[ 0.00008 ]
Band Switch      : Default
Include RIT      :  No
Tune Attenuator  : -3dB
VFO Adjustment   : Off
Meter Scale Type : Original
Power-Off Mode   : Prompted
Start-Up Page    : Mode/BW
Voice Memory     : Installed
```

This shows the system calibration and configuration using the standard factory defaults. A representative display after calibration is:

```
System Settings
----------------------------------
Reference Oscillator: 179998470 Hz
DC Voltmeter        : 5370
Ammeter             : 2414
Power Meter         : 2907
S-Meter             :   17
Beep Time           :  50 mS
SWR Trip Setting    :  300
SWR Alarm Delay Time: 5.0 Secs
Over-Current Trip   : 2360 =  2.85A
Over-Voltage Trip   : 2756 = 14.80V
Under-Voltage Trip  : 2049 = 11.00V
Band Limits         :  IARU Region 1

User Settings
----------------------------------
AGC Speed        : Fast
Filter Roll-Off Frequencies
Narrow           : 1000 Hz
Mid              : 2205 Hz
Wide             : 2500 Hz
Transmit         : 2586 Hz
Speech Processor :  On
Audio Source     :  Mic
Keyer Mode       : Iambic B
CW Release Delay : 500mS
CW Pitch         : 700 Hz
CW Pot Mode      : CW Speed
Keyer Speed      : Locked   20 wpm
CW/CWR Swap      : On
LCD Backlight    : 300
LCD Contrast     : 2000
LCD Timer        : 0 Seconds (OFF)
RS-232 Mode      : Test
Speed            :   9600 Baud
VFO Memory       : A/B + Split
S-Meter          : Numeric
S-Meter Hold Time: 2.50 Seconds
```

```
TX Disable       :  On
Auto-Sideband    :  On
Frequency Display: New
[12.345678]
[ 2.345678]
[  345.678]
[   45.678]
[    5.678]
[      678]
[       78]
[        8]
Band Switch      : Default
Include RIT      :  No
Tune Attenuator  : -3dB
VFO Adjustment   : 10Hz decade(s)
Meter Scale Type : Original
Power-Off Mode   : Prompted
Start-Up Page    : Mode/BW
Voice Memory     : Installed
```

Enter the letter a, and you can exercise the alarm sub-system thus:

```
Set Alarm Flag
Enter 0, 1, 2, 3, 4, 5, or 6 ...
1 - Over-Current Alarm
Set Alarm Flag
Enter 0, 1, 2, 3, 4, 5, or 6 ...
2 - High SWR Alarm
Set Alarm Flag
Enter 0, 1, 2, 3, 4, 5, or 6 ...
3 - Over-Voltage Alarm
Set Alarm Flag
Enter 0, 1, 2, 3, 4, 5, or 6 ...
4 - Under-Voltage Alarm
Set Alarm Flag
Enter 0, 1, 2, 3, 4, 5, or 6 ...
5 - Low Battery (Under-Voltage Pre-Limit) Alarm
Set Alarm Flag
Enter 0, 1, 2, 3, 4, 5, or 6 ...
6 - All Alarms ON
Set Alarm Flag
Enter 0, 1, 2, 4, 8, or 9 ...
0 - All Alarms OFF
```

You will receive a prompt requesting you to enter a digit of 0, 1, 2, 3, 4, 5, or 9. The software will ignore other responses. The alarms are saved as flags in a single word, entering an appropriate digit will set that alarm flag, and the display will blink with the alarm message, and beep. Briefly press the PWR button to acknowledge the alarm and cancel it.

The alarm test now takes account of the alarm mask set in the System Calibration menu, and if you attempt to exercise an alarm that is disabled, then a message will be displayed to that effect. Using the ‘u’ (lower-case u) command to dump the current configuration will also display which alarms are enabled or masked.

Note that the alarm system can handle multiple alarms. Entering the digit 9 will set all the alarm bits on. The first press of the PWR button will cancel the highest priority alarm, and reveal the next lowest alarm. Pressing the PWR button again will cancel this alarm, and reveal the next, and so on until all the alarms have been acknowledged and cancelled.

If an alarm is permanent, then the only option is to power off the transceiver. Press and hold the PWR button, and the transceiver will enter the emergency power-down mode, as soon as you see the prompt, release the PWR button. No user settings are saved, the transceiver will simply drop the power latch line and shut down.

Note that switching off only removes power from the DDS, Main and Filter boards, the power amplifier is still connected to the power supply. If the fault is with this assembly then the power supply must be shut off as well. Only the main fuse will protect the power amplifier.

Entering the letter U will dump the contents of the User Band Memory thus:

```
VFO Memory Frequency Settings
-----------------------
VFO-A:  3.50500 MHz USB
VFO-B:  7.06000 MHz LSB
VFO-C:  3.60000 MHz LSB
VFO-D: 10.12500 MHz LSB
VFO-E: 14.10000 MHz LSB
VFO-F: 18.11800 MHz LSB
VFO-G: 21.30000 MHz USB
VFO-H: 24.94000 MHz USB
VFO-I: 28.85000 MHz USB
VFO-J:  1.90000 MHz USB
VFO-K:  3.60000 MHz USB
VFO-L:  7.10000 MHz USB
VFO-M: 10.12500 MHz LSB
VFO-N: 14.10000 MHz LSB
VFO-O: 18.11800 MHz LSB
VFO-P: 21.30000 MHz USB
VFO-Q: 24.94000 MHz USB
VFO-R: 28.85000 MHz USB
VFO-S:  1.90000 MHz USB
VFO-T:  3.60000 MHz USB
VFO-U:  7.10000 MHz USB
VFO-V: 10.12500 MHz LSB
VFO-W: 14.10000 MHz LSB
VFO-X: 18.11800 MHz LSB
VFO-Y: 21.30000 MHz USB
VFO-Z: 24.94000 MHz USB

User Frequency Settings
-----------------------
 160m:  1.90000 MHz LSB
  80m:  3.60000 MHz LSB
  40m:  7.10000 MHz LSB
  30m: 10.12500 MHz USB
  20m: 14.10000 MHz USB
  17m: 18.11800 MHz USB
  15m: 21.30000 MHz USB
  12m: 24.94000 MHz USB
  10m: 28.85000 MHz USB
-----------------------
```

Entering the letter R will display the RF filters and their corresponding attenuator settings:

```
RF Attenuator Settings
 Filter  Attenuator
--------------------
 250kHz     -3dB
 500kHz     -3dB
   1MHz     -1dB
   2MHz     -1dB
   4MHz     -1dB
   8MHz     -1dB
  12MHz     -1dB
  15MHz     -1dB
  19MHz     -1dB
  23MHz     -1dB
  26MHz     -1dB
  28MHz     -1dB
--------------------
```

These attenuator settings are the factory defaults; to equalise the RF output power across the amateur bands, the attenuation factors can be changed. Please refer to Annex H for further details of the manual method, or use the Auto-Equalise command.

Entering the letter E will dump the EEPROM contents, thus:

```
Dump EEPROM contents
 ADDR                DATA
---------------------------------------------
 0000 DAF8 0036 EE80 0036 5660 006C 7EC8 009A
 0010 2620 00D7 7570 0114 0320 0145 8DE0 017C
 0020 3750 01B8 FDE0 001C EE80 0036 5660 006C
 0030 7EC8 009A 2620 00D7 7570 0114 0320 0145
 0040 8DE0 017C 3750 01B8 FDE0 001C EE80 0036
 0050 5660 006C 7EC8 009A 2620 00D7 7570 0114
 0060 0320 0145 8DE0 017C 3750 01B8 FDE0 001C
 0070 EE80 0036 5660 006C FDE0 001C EE80 0036
 0080 5660 006C 7EC8 009A 2620 00D7 7570 0114
 0090 0320 0145 8DE0 017C 3750 01B8 0000 0000
 00A0 02BC 14ED 0001 0000 0002 0000 0000 0000
 00B0 0000 0000 0001 0001 0001 0001 0001 0001
 00C0 0000 0000 0000 0001 0001 0001 0001 0001
 00D0 0001 0000 0000 0000 0001 0001 0001 0001
 00E0 0001 0001 0000 0000 0000 0000 0001 0001
 00F0 0001 0001 0001 0001 0000 0000 0000 0001
 0100 0000 0002 07D0 012C 0000 004B 0022 001E
 0110 001D 0002 0003 0001 0000 0003 0000 0001
 0120 0001 0003 0000 0000 0003 0000 09C4 8AF4
 0130 0000 0000 0000 0000 01F4 7298 FFFF FFFF
 0140 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 0150 9500 0ABA 0960 14B4 0014 0005 0DDE 0032
 0160 0303 0101 0101 0101 0101 0101 0101 012C
 0170 012C 000F 0AB0 0824 081C 0000 0DA9 FFFF
 0180 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 0190 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 01A0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 01B0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 01C0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 01D0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 01E0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
 01F0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF 0000
---------------------------------------------
```

It is beyond the scope of this document to give a detailed explanation of the contents and the layout. You will need to refer to the source code and particularly the file: `trx2_eeprom.h` for the layout of the EEPROM contents.

Note: The dump above is of the default settings, and is merely intended to be illustrative of what will be displayed, the actual contents will depend upon the various calibration and user settings.

Auto-Equalise
This is a new function, which automates the process of equalising the output power of the transceiver. To invoke, enter the letter Q, you will receive the following prompts:

```
Auto Equalise RF Output Power
Ensure transceiver is connected to a 50 Ohm dummy load.
This may alter your current attenuator settings.
Do you wish to continue (Y/N)?: Y
Press and hold the PTT switch to start...
Equalising...
Band:  10m Averaged Power:  7.3 Watts
Band:  12m Averaged Power:  8.7 Watts
Band:  15m Averaged Power:  8.4 Watts
Band:  17m Averaged Power:  7.3 Watts
Band:  20m Averaged Power:  9.4 Watts
Band:  30m Averaged Power:  7.8 Watts
Band:  40m Averaged Power:  9.6 Watts
Band:  80m Averaged Power:  9.5 Watts
Band: 160m Averaged Power:  8.2 Watts

Rel Power:  0.53dB Band: 160m Attenuator:  0dB
Rel Power:  1.15dB Band:  80m Attenuator: -1dB
Rel Power:  1.20dB Band:  40m Attenuator: -1dB
Rel Power:  0.28dB Band:  30m Attenuator:  0dB
Rel Power:  1.10dB Band:  20m Attenuator: -1dB
Rel Power:  0.00dB Band:  17m Attenuator:  0dB
Rel Power:  0.65dB Band:  15m Attenuator:  0dB
Rel Power:  0.76dB Band:  12m Attenuator:  0dB
Rel Power:  0.04dB Band:  10m Attenuator:  0dB
Release the PTT switch to complete.

Equalisation Complete
```

If you reply to the prompt with anything other than the letter y or Y, the process will abort without making any changes.

To continue, press and hold the PTT switch. The process takes less than 10 seconds, with the routine making a 10-sample averaged power measurement on each amateur band from 10 metres down to 160 metres. Since the frequency is being changed, this particular mode was chosen so that when the filter is changed the frequency is always below its natural cut-off frequency, thus avoiding any transient power absorption events.

During operation, the LCD will display the bar-graph and numeric power meter displays on the first line, and the frequency in use on the second.

Note: The tune attenuation is set to −1dB during the equalisation process, and restored to your configuration setting at the completion. This is to ensure that under nominal conditions the graphic power meter always reads on-scale, and gives you some idea of the levelling process.

If you release the PTT switch during the process, then it will abort gracefully without making any changes, as it will if it encounters any alarm conditions. Release the PTT switch at the conclusion to exit from the routine.

The new values will be saved to the EEPROM when you exit this test.

SPI Data Bus Display

The p command can be used to display the current data being sent via the SPI data bus to configure the transceiver. The bit meanings are:

D15	D14	Attenuation
0	0	0dB
0	1	−1dB
1	0	−2dB
1	1	−3dB

D13, D12, D11	Spare Bits (Always zero)
D10, D9, D8	RF Filter Select
D7	Dual-Band O/P Filter Select (3.5MHz/7MHz) – Not Used
D6	Microphone/Line I/P Select
D5	Noise Blanker On/Off (Not Used)
D4	Speech Processor On/Off
D3	AGC Speed Fast/Slow
D2	Active Filter Bandwidth Select Wide/Narrow
D1	Sideband Select USB/LSB
D0	Mode Select SSB/CW

```
Fully Decoded SPI Bus Data
Data            : 0x46D9
Attenuator      : 1dB
Spare Bits      : 0
Filter Bits     : 6
Frequency       :   15MHz
Dual-Band Filter: 7.0MHz
Audio Source    : Mic
Noise Blanker   : Off
Speech Processor: On
AGC Speed       : Fast
Active Filter   : Wide
Sideband        : USB
Mode            : SSB
```

UART1/UART2 Character Cross-Copy Test
By entering the character 'D' you can test that both UARTs are working. You will need to connect a terminal to each of the ports. Any character entered on UART1 will be echoed to UART2, and vice-versa. The characters will be displayed on the LCD, the top line displaying characters received from UART1, the bottom line displaying characters from UART2.

The ESC character exits the test. It is not necessary that both ports are configured for the same speed. UART2 speed is fixed at 9600 baud, but UART1 can be set to any speed in the range 1200 baud – 115,200 baud.

+(Increment) −(Decrement) Attenuator Settings
These keys allow you to adjust the preset attenuator settings for the currently selected band.

Note: These changes are not automatically saved. If you wish to preserve the changes, then ensure that you save the transceiver's settings when you power down.

RS-232 Echo Test
Although not part of the serial test suite commands, there is a low-level RS-232 echo test available that can help identify serial port problems.

To invoke this test, press and hold the DISPLAY/CONFIG button and power up the transceiver. Continue to hold the button until the display changes to show the message:

```
Serial Port Test
Awaiting data...
```

Entering characters on the terminal will display the character on the second line of the display as well as echoing the character to the terminal. The display will show both the printable version of the character, as well as its hexadecimal value. For characters that are unprintable, a space will be displayed. Briefly press the PWR button to terminate the test.

Annex F

Improved Accuracy Measurement Sub-System

The original measurement sub-system, whilst sufficient for general purpose indications of the voltage, current and power output of the transceiver, did not completely capitalise on the inherent accuracy available from a 12-bit A-D convertor.

The designers chose to optimise the speed of the main processing loop in the software, and used calibration constants and factors that lent themselves to easy integer manipulation, avoiding the use of floating point mathematics.

With further analysis, it was found that there was sufficient processing capability available to permit using a more comprehensive set of algorithms to significantly enhance the accuracy of the measurement sub-system with little impact on speed. This is because the processor, whilst not equipped with a full maths co-processor, is equipped with a fast hardware multiply and divide logic.

Voltage Measurement
The voltage measurement system uses a precision potential divider comprising resistors R27 (33K / 1%) and R28 (10K / 1%) placed across the system bus. At a nominal input voltage of 13.8V, the output from this potential divider will therefore be:

13.8 * 10 / (33 + 10)

= 3.2093V

The A-D convertor is a 12-bit device, and uses the main 5V logic supply as the reference.

Assuming for the moment that this reference voltage is exactly 5.000V, this gives a quantisation step of:

$5000 / 2^{12}$

= 1.2207mV

The scale factor for the voltage measurement is therefore:

10 / 43

= 0.23256

which gives a quantisation step for the voltage measurement system of:

1.2207 / 0.23256

= 5.249mV

Thus, in principle, it should be possible to adjust the calibration of the voltage measurement system to have an overall accuracy of about ±5.25mV

In the original firmware the actual calculation was:

$V_{display}$ = (ADC * Calibration Factor) / 256

If we insert some typical values, then the ADC value for 13.8V will be around 2629, and the default calibration value is 135, and thus:

$V_{display}$ = (2629 * 135) / 256

= 354915 / 256

= 1386.386

which, when divided by 100 displays as:

13.86V

If the calibration factor were increased to 136, then the raw value would be:

1396.656

which would display as:

13.96V

In other words, the quantisation step related to the calibration factor is 103mV, despite the inherent accuracy of the measurement system being 5.25mV.

If the measurement system's calibration factor and calculation is changed, the overall accuracy and resolution can be significantly improved.

The new calculation algorithm is:

$V_{display}$ = (ADC * Calibration Factor) / 10,000,000

If we perform a worst-case analysis, then the lowest output voltage from the potential divider will be when R27 is at its highest tolerance limit, and R28 at its lowest. In this case, the nominal 13.8V input voltage will be scaled down to:

13.8 * 9900 / (9900 + 33330)

= 13.8 * 9900 / 43230

= 3.16031V

Equally, the highest output voltage will occur when R28 is at its highest tolerance limit and R27 at its lowest. In this case, the nominal 13.8V input voltage will be scaled down to:

13.8 * 10100 / (10100 + 32670)

= 13.8 * 10100 / 42770

= 3.25883V

The tolerance of the voltage regulator's output is ±0.25V, and thus the lowest count from the A-D convertor will occur for the lowest input voltage and the highest reference voltage, and would be a count of: 2465. The highest count would be for the highest input voltage and the lowest reference voltage, and this would be: 2810.

From this the calibration factor limits can be calculated. The nominal count would of course still be 2629.

The calibration factor required therefore is:

13,800,000 / 2629

= 5249

and thus the calculation would be:

$V_{display}$ = (ADC * 5249) / 10,000,000

Inserting typical values:

Raw O/P = 2629 * 5249

= 13,799,621

Now, however, if the calibration factor is changed by 1 increment, the display would be:

Raw O/P = 2629 * 5250

= 13,802,250

This gives an increment of 2.6mV/ step, and thus allows the voltage to be more accurately approximated, as it is using the optimum step size of ±1/2LSB.

Whilst in practice temperature variations are likely to cause errors which exceed this, nevertheless a worthwhile improvement in accuracy has been achieved at no extra cost other than an alternative algorithm.

Current Measurement
The ammeter in the TRX2 only measures the drain current of the output amplifier, not the total current consumed by the transceiver. Nevertheless, in order to accurately set the bias currents for both the driver and power amplifier stages, it is essential that the current measurements are performed to as high an accuracy as possible.

The output current measurement is made by sampling the voltage developed across two low value resistors connected in parallel, R23 and R24, each of 0.22Ω. This gives a shunt resistance of 0.11Ω, giving a scaling factor of approximately 110mV/A.

The DC voltage is amplified by the non-inverting amplifier A1-A which has a gain of x11, giving an overall scaling factor of approximately 1.21V/A.

Assuming an amplifier current of 2.5A, this gives a voltage into the A-D convertor of 2.75V, and the raw output from the convertor will be:

2.75 / 5 * 4,096

= 2,253

The maximum full-scale value of this ammeter is thus 2.5 * 4,096 / 2,253 or 4.545A, with a quantisation step size of 4.545 / 4,096 or 1.1mA. This is the intrinsic resolution limit of the ammeter.

In order to take advantage of this resolution, at a nominal input current of 2.5A, the required calibration adjustment factor would be 2,220. Thus the actual current calculation would be:

$I_{display}$ = ADC * Calibration Factor / 2,000,000

As an example, assuming nominal settings:

$I_{display}$ = 2,253 * 2,220 / 2,000,000

= 5,001,660 / 2,000,000

= 2.5008 Amps

Power Measurement
This is the least accurate of the measurements. Since power is proportional to the square of the voltage, the output from the A-D convertor has to be squared. Any differences in construction, or differences in components will therefore lead to a squaring of the error terms, leading to a greater uncertainty in the measurement compared to the voltmeter and ammeter. In addition, the diodes used to rectify the RF voltage developed in the dual directional coupler are also non-linear, thus the accuracy of the measurement will degrade significantly at low power levels.

The forward power scaling factor is approximately 2.05V/10W, which results in a convertor output of:

2.05 / 5 * 4,096

= 1,679

This has to be squared:

2,819,041

the calibration factor to read 10W is therefore:

3,547

The incremental quantisation step is thus 2.8mW, which is a greater precision than actually required, nevertheless, the accuracy of the measurement is now largely determined by the sensor, and not the A-D convertor or its calibration factor.

Annex G

The TRX2 Alarm System

Version 1.07k of the firmware introduced an additional feature to the transceiver, an alarm system to provide the user with a critical warning of potentially damaging factors.

The system can provide a warning for high SWR, power amplifier over-current, and high and low input voltages.

The thresholds for these alarms are set in the revised System Setup & Calibration mode, as described earlier.

High SWR

The original firmware was already provided with a SWR alarm, triggered if it exceeded 3:1, but it simply displayed this value. Now, the user can adjust the threshold at which the alarm is given from 1.00:1 to 10.00:1 in 0.01 increments. If the SWR exceeds the threshold then a message is displayed and a repetitive beep sounds.

The only active button when an alarm is present is the PWR button. Briefly press this to acknowledge and cancel the alarm. Obviously, if the event is still present, then the alarm will return. If the alarm cannot be cleared, for example, a permanent under-voltage, then press and hold the PWR button to invoke the emergency shutdown. This will occur faster than the regular shutdown, and no user settings will be saved to the EEPROM.

Note: When using the TUNE mode, the SWR alarm delay time is extended by a variable user adjustable time. This gives sufficient time for you to manually adjust a transmatch without provoking the alarm. An auto-tuner should achieve a match in considerably less time than this. When using any other mode, the alarm delay time is a few hundred milliseconds.

Over-Current

This alarm is triggered if the measured final amplifier’s drain current exceeds the preset threshold.

Note: The current sensed only applies to the power amplifier’s output transistors. Excessive current elsewhere in the transceiver is not sensed. Only the input fuse can protect the unit.

The usual reason for an excessive current is a high SWR, in which case this alarm is also likely to exist. If the alarm is present, release the PTT switch or the key and acknowledge the alarm, and investigate its cause.

I considered carefully whether to force the transmitter off in the event of either a high SWR or high PA current, but decided that in doing this it would make matching an antenna to the transceiver a frustrating business if the transceiver kept tripping off whilst attempting to achieve a match when the high SWR might only persist for a short time. It is left to your judgement as to what level to set the alarm, but 2.5A is suggested.

The current is averaged over 64 samples, representing a sampling interval of about 300mSec. This will ensure that transient peaks are ignored, but a steady-state over-current will be registered and will trip the alarm.

Over-Voltage
This alarm is only really likely to occur when operating mobile using a vehicle electrical system. Be aware that automobile electrical systems can have supply voltages as high as 14.8V or sometimes higher, especially if the battery is old, or has a high internal resistance, or the electrical connections are unsatisfactory, or the alternator is faulty. Although the transceiver can tolerate input voltages up to about +15V, it is unwise to continue to use it if you experience a significant number of over-voltage alarms.

Under-Voltage
Low input voltages are not damaging to the transceiver, but are worth investigating. If the equipment is being operated under portable conditions, then it is likely that the power supply will be a small sealed lead-acid battery. These deep-cycle batteries are a very suitable power source, but to ensure optimum life they do need to be used in a careful and considerate way.

Most manufacturer's recommend that the discharge be terminated when the voltage has fallen to 10.5V. It is certainly very bad for the battery to be discharged beyond this point, as it severely shortens its service life.

To maximise the life, the cut-off voltage should be somewhat higher than this, and 11.0V is a reasonable compromise between maximum operating time and service life of the battery. If it is discharged down to these voltages it must be placed on charge immediately afterwards or within as short a period of time as possible. Do not leave a sealed lead-acid battery in a discharged state, at low voltages a secondary electrochemical reaction occurs which leads to sulphation, which is unrecoverable.

To prevent this, the undervoltage alarm is provided. To give you warning of the approach of the cut-off threshold, a pre-limit warning is given at a voltage 100mV higher than the preset threshold. This will display the warning message: `Low Batt Voltage`.

To cancel the warning, briefly press the PWR button. This warning will only be given once, and when cancelled will not re-appear. The only way to reset this warning alarm is to turn the transceiver off and then back on again.

If operation is continued down to the threshold setting, then the alarm will persist, no buttons other than the PWR button, or other functions will be operative, the only recourse is to turn the transceiver off.

Any or all of the alarms, with the exception of the high SWR, can be disabled, if you wish. If the undervoltage alarm is disabled, then the pre-limit alarm is also disabled.

Annex H

Equalising the TRX-2 Output Power

The Juma TRX-2 has a somewhat ‘hidden’ feature whereby you can set the output power of the transmitter on all bands to be essentially the same despite minor variations in insertion loss of filters, and the varying gain of the output amplifier with frequency.

This attenuator selection feature is enabled by selecting the band whose attenuator you wish to adjust, setting the mode to TUNE, pressing the PTT switch, and then briefly pressing and releasing the PWR button. The attenuator display will be shown, and a short beep every 500mS will be given to remind you that this is a latched mode.

To select an attenuator, rotate the VFO knob, and you can select one of four attenuation levels from 0dB to −3dB in 1dB steps. To save and exit this function, release the PTT switch. The alarms are being monitored, and if any alarm is raised, the function will terminate without saving the current settings.

To equalise the output power you will need to measure the output on all bands and at all attenuator settings, and tabulate the results:

Band, Metres	**0dB**	**−1dB**	**−2dB**	**−3dB**
160	7.2W	5.6W	4.2W	3W
80	7.4W	5.8W	4.5W	3.3W
40	7.5W	6.1W	4.9W	3.7W
30	5.6W	4.9W	3.6W	2.8W
20	7.0W	5.6W	4.5W	3.4W
17	5.2W	4.2W	3.3W	2.6W
15	5.9W	4.8W	3.8W	2.9W
12	6.2W	5.0W	3.9W	3.0W
10	4.9W	4.0W	3.2W	2.5W

In this case you can see that using the 0dB attenuator the highest output power was 7.5W, and the lowest 4.9W.

Examine the results, and set the attenuators such that on the band with the lowest output power the attenuator is set to 0dB, and the other band’s attenuator setting give a matching output power. In my case this would be:

Band:	**160**	**80**	**40**	**30**	**20**	**17**	**15**	**12**	**10**
Atten:	−1	−2	−2	−1	−2	0	−1	−1	0
Atten:	−2	−2	−3	−2	−2	−1	−2	−2	−1

Note that the second row shows an alternative setting using slightly lower overall gain, but achieving the same result. As you select the various bands, the attenuator setting will be preserved and saved to the EEPROM when the transceiver is powered down, thus you only really need to “calibrate” the transmit chain once. If you wish to obtain a record of the attenuation settings, then use the serial test facility to dump the current values.

If you restore the factory default settings, as well as inserting the measurement system’s calibration values, you will have to re-select the various attenuation settings for each band.

It was whilst making these adjustments that I discovered that initially my 40m output was about 3dB lower than the rest. A careful check with my sampling oscilloscope showed that the culprit was the 4Mhz – 8MHz input filter formed with C25, L15, C26, L16, C27, C28, L17, and C29. A close examination showed that one side of C26 had not been soldered. When this was corrected, the measured filter insertion loss was:

Band (Metres)	**Filter (MHz)**	**Input (mV P-P)**	**Output (mV P-P)**	**Attenuation dB**
160	1 – 2	808	648	−1.92
80	2 – 4	808	688	−1.40
40	4 – 8	752	744	−0.09
30	8 – 15	920	680	−2.63
20	8 – 15	744	752	+0.09
17	15 – 30	904	656	−2.79
15	15 – 30	792	688	−1.22
12	15 – 30	752	680	−0.87
10	15 – 30	784	670	−1.36

The output power was set to about 1.8W on 160m just to keep the signal levels well within the derating range of both the oscilloscope input and the x10 probe used.

Whilst this manual method can still be used, please examine the Serial Test Suite for the Auto-Equalise function that effectively replaces this somewhat tedious manual method.

Annex I

Juma TRX-2 TRX-Manager Command Protocol

This document describes the command formats and responses to be used when using a personal computer to remotely control the transceiver's operation using the TRX-Manager application written by Laurent, F6DEX.

The commands take one of two forms, the first is a query, whereby the transceiver will send a formatted response indicating the particular state of the transceiver. For example, in response to a band query the transceiver will respond by echoing the command back plus a number indicating the amateur band to which the current VFO is tuned.

The second form is a command, used to set the transceiver to a particular operating mode. For example, the band set command will set the current VFO to a particular amateur band.

All query commands send a response; all set commands cause an action to occur, and, if the Auto-Update function is enabled, will cause a response, in other circumstances no response will be sent, for example if the command does not actually change the status. (For example, sending the same frequency.)

QUERY COMMANDS

All query command take the general format:

```
=?<c>\n\r
```

where <c> is the upper-case query character, or characters if this is an extended query, and \n is the linefeed character (0x0A), and \r is the carriage return character, (0x0D).

All responses echo the command letter(s) followed by an ASCII numerical value for the parameter, and terminated with the \n\r sequence.

As an example, the band query command is: `=?B\n\r`, and if the transceiver is currently set to a frequency in the 20m band the response would be: `=B5\n\r`

CMD	Name	Response	Meaning
A	Audio Filter	=An:Wnnnn	n = 0 – 2 0 = Narrow 1 = Mid 2 = Wide Wnnnn – As for filter width

B	Band Query	=Bn	n = 0 – 9 0 = Out Of Band (Frequency < 1MHz) 1 = 160m 2 = 80m 3 = 40m 4 = 30m 5 = 20m 6 = 17m 7 = 15m 8 = 12m 9 = 10m
C	Speech Processor	=Cn	n = 0 – 1 0 = Off 1 = On
F	Frequency In Use	=Fnnnnnnnn	n = 0 – 9 Ex: 7.123456 MHz = F7123456
FA FB	Extended Frequency In Use	=FBnnnnnnnn =FBnnnnnnnn	FA – VFO-A FB – VFO-B nnnnnnnn – Frequency in Hz
G	AGC Speed	=Gn	n = 0 – 1 0 = Slow 1 = Fast
I	Auto-Update	=In	n = 0 – 3 0 = Off 1/2/3 = On See later section for full details of this mode.
J	CW Shift	=Jnnnn	n = 0 – 9 Ex: 700 Hz = 700
L	VFO Lock Status	=Ln	n = 0 – 1 0 = Unlocked 1 = Locked
LA LB	Extended VFO Lock Status	=LAn =LBn	LA – VFO-A LB – VFO-B
M	Mode	=Mn	n = 0 – 4 0 = LSB 1 = USB 2 = CW 3 = CWR 4 = Tune
MA MB	Extended Mode	=MAn =MBn	MA – VFO-A MB – VFO-B
Q	Tuning Rate	=Qn	n = 0 – 2 0 = Slow (1Hz) 1 = Medium (10Hz) 2 = Fast (100Hz)

R	RIT	=Rn:+/-nnnn	n = 0 – 1 0 = Off 1 = On :+/-nnnn – RIT offset frequency
S	Meter	=Snn	n = 0 – 9 00 – 48 Scaled power in transmit, S-meter in receive.
T	TX/RX	=Tn	n = 0 – 1 0 = Receive 1 = Transmit
V	VFO In Use	=Vn	n = 0 – 2 0 = VFO-A Simplex 1 = VFO-B Simplex 2 = VFO-A Rx, VFO-B Tx, Split Mode
VA VB	Extended VFO Status	=VA:FnnnnnnnnMnLn =VB:FnnnnnnnnMnLn	VA – VFO-A VB – VFO-B Fnnnnnnnn – As for frequency data Mn – As for Mode data Ln – As for Lock data
W	Bandwidth	=An:Wnnnn	n = 0 – 9 Ex: 2750Hz = 2750 See Note-1
WN WM WW	Extended Filter Bandwidth	=WNnnnn =WMnnnn =WWnnnn	WN – Narrow WM – Mid WW – Wide
Y	Extended Display	=Yn	n = 0 – 4 0 = Normal Display 1 = RF O/P Power Display 2 = SWR Display 3 = Supply Voltage 4 = Amplifier Drain Current

COMMANDS

All commands take the format:

```
=<c><p>\n\r
```

Where <c> is the upper-case command letter or letters, <p> is a numeric string of ASCII characters representing the parameter value. For example, to set the current VFO to the centre of the 20m band the command is: `=B5\n\r`

CMD	Name	Syntax	Comment
A	Select Audio Filter	=An	n = 0 – 2 0 = Narrow 1 = Mid 2 = Wide

B	Select Amateur Band	=Bn	n = 1 – 9 1 = 160m 2 = 80m 3 = 40m 4 = 30m 5 = 20m 6 = 17m 7 = 15m 8 = 12m 9 = 10m See Note-2
C	Set Speech Processor	=Cn	n = 0 – 1 0 = Off 1 = On
G	Set AGC Speed	=Gn	n = 0 – 1 0 = Fast 1 = Slow
E	Equalise VFO Settings	=En	n = 0 – 1 0 – VFO-A = VFO-B 1 – VFO-B = VFO-A
F	Set Frequency Of Current VFO	=Fnnnnnnnn	n = 0 – 9 Ex: 7.123456 MHz = 7123456
FA FB	Set Frequency Of Specific VFO	=FAnnnnnnnn =FBnnnnnnnn	FA – VFO-A FB – VFO-B
G	Set AGC Speed	=Gn	n = 0 – 1 0 = Fast 1 = Slow
I	Auto-Update	=In	n = 0 – 3 0 = Off 1/2/3 = On See later section for full details.
J	Set CW Shift	=Jnnnn	n = 0 – 9 Ex: 700Hz = 700 See Note-3
L	Lock Current VFO	=Ln	n = 0 – 1 0 = Unlock 1 = Lock See Note-4
LA LB	Lock Specific VFO	=LAn =LBn	LA – VFO-A LB – VFO-B
M	Set Mode Of Current VFO	=Mn	n = 0 – 4 0 = LSB 1 = USB 2 = CW (Normal) 3 = CWR (Reverse) 4 = Tune

MA MB	Set Mode Of Specified VFO	=MAn =MBn	MA – VFO-A MB – VFO-B
P	Power OFF	=Pn	n = 0 – 1 See Note-5
Q	Set Tuning Rate	=Qn	n = 0 – 2 0 = 1Hz 1 = 10Hz (Default) 2 = 100Hz
R	Set RIT On/Off	=Rn	n = 0 – 1 0 = Off 1 = On
T	TX/RX	=Tn	n = 0 – 1 0 = Receive 1 = Transmit
V	Select VFO	=Vn	n = 0 – 2 0 = VFO-A 1 = VFO-B 2 = Split Mode, see Note-7
W	Set Current Filter Bandwidth	=Wnnnn	n = 0 – 9 See Note-6
WN WM WW	Set Specific Filter Bandwidth	=WNnnnn =WMnnnn =WWnnnn	WN – Narrow WM – Mid WW – Wide
Y	Select Extended Display	=Yn	n = 0 – 9 0 = Normal Display 1 = RF O/P Power Display 2 = SWR Display 3 = Supply Voltage 4 = Amplifier Drain Current

NOTES

Note-1: The filter bandwidths can only be approximately set. This is a hardware limitation of the transceiver. As a result, the displayed bandwidth in response to a query command may not precisely match that sent as a bandwidth set command.

Note-2: When selecting an Amateur Band, the current VFO will be set to the approximate centre of the selected band. The frequencies used will be the default frequencies as identified in the Rapid Band Switch feature description. Only valid amateur band frequencies will be set. To set a VFO to a frequency outside an amateur band, use the Frequency Set command.

Note-3: The CW Shift frequency will be checked, and if it outside the range, then it will be set to either the minimum value, 300Hz, or the maximum value, 1,100Hz.

Note-4: Locking the current VFO will only prevent frequency changes from the front panel. The band, frequency and mode can still be altered remotely.

Note-5: If the command =P or =P0 is sent, the Power OFF command will display a message: "Remote Power OFF" for about 1 second, and then the transceiver will power off. Unlike the front panel power switch, no settings will be saved to the EEPROM. The current VFO selection, frequency, and mode will be lost, as will any configuration changes that may have been made. However, if the command: =P1 is sent, the current User Configuration settings are saved.

Note-6: The bandwidth figure will be checked, and if it is outside the range for the filter selected, either the minimum or the maximum bandwidth will be set. For the Narrow filter, the limits are 500Hz – 1,300Hz, for the Mid filter, the limits are 500Hz – 2,300Hz, and for the Wide filter, the limits are 500Hz – 4,000Hz. As a consequence of the relatively coarse resolution, the actual bandwidths are: Narrow – 500Hz – 1,293Hz, Mid – 1,293Hz – 2,272Hz, Wide – 2,272Hz – 4,166Hz.

Note-7: If the transceiver is in the Multi-Memory mode when this command is first issued, then it will be forced to the A/B+Split mode of operation, and the default VFO-A will be selected. If it is already in the A/B+Split mode then selecting V0 or V1 will select either VFO-A simplex mode, or VFO-B simplex mode. Selecting V2 will again select Split Mode, with VFO-A as the receive VFO, and VFO-B as the transmit VFO.

AUTO-UPDATE

The Auto-Update function allows updating of the remote terminal/computer of the status changes that may occur if a user makes any adjustments to the transceiver whilst connected to the TRX-Manager program.

This function can only be enabled remotely, it is normally disabled, and there are no user settings that can enable it locally. In this way, if the TRX-2 is connected directly to its companion linear amplifier, the PA-100D, there is no adverse effect upon the normal operation.

To enable the function, the remote terminal sends the command:

```
=I1\n\r
```

Note: The numeric value can be 1, 2 or 3. The value is used to determine the latency time. 1 = 50mSec, 2 = 100mSec, 3 = 150mSec. For port speeds from 4,800 Baud to 115,200 Baud a 50mSec time is sufficient. For 2,400 Baud 100mSec is recommended, and for 1,200 Baud, 150mSec.

Sending the command: =I1, =I2, or =I3 will always return the current complete status of the transceiver. Subsequent loops will cause the function to examine each parameter, and if a change is detected an appropriate status message will be sent to the terminal program. These status messages are the same as the responses to specific polled query commands.

For example, if the current VFO is VFO-A, and the user rotates the VFO knob, thus changing the frequency, the A-U response will indicate the new frequency:

```
=F12345678
=F12345680
```

will be transmitted. Since VFO-A is in use, and these changes can only apply to the selected VFO, this status return is the same as if a remote frequency query command had been sent.

Similarly, if the mode is changed the response is as if a remote mode query command had been sent, thus:

```
=M1
```

All responses are terminated with the newline and carriage return symbols as for the query responses.

When enabling Auto-Update, if the current mode is not the A/B+Split mode, then this will be selected, and the default VFO will be A. This is equivalent to sending the command:

```
=V2
```

Equally, any time the Auto-Update function is enabled, the complete transceiver's status will be sent. It is not necessary to disable the function in order to re-enable it.

The following automatic status responses will occur:

Name	Response	Notes
VFO	=Vn	V0 = VFO-A V1 = VFO-B V2 = Split Mode Rx = VFO-A, Tx = VFO-B
VFO Lock	=Ln =LAn =LBn	Current VFO LA = VFO-A LB = VFO-B 0 = Unlocked 1 = Locked
Filter	=An:Wnnnn	n = 0 – 2 0 = Narrow 1 = Mid 2 = Wide Wnnnn – Filter Bandwidth, Hz

Selected VFO	=Vn	n = 0 – 2 0 = VFO-A (Simplex) 1 = VFO-B (Simplex) 2 = Split, A = Rx, B = Tx
Tuning Rate	=Qn	n = 0 – 2 & 4 0 = 1Hz 1 = 10Hz 2 = 100Hz 4 = 10kHz
RIT On/Off	=Rn:+/-nnnn	n = 0 – 1 0 = Off 1 = On +/-nnnn – RIT Offset Frequency, Hz
RIT Frequency	=R1:+/− nnnn	n= 0 – 9 Frequency preceded by + or −
CW Shift	=Jnnnn	n = 0 – 9
Transmit/Receive	=Tn	n = 0 – 1 0 = Receive 1 = Transmit
Speech Compressor	=Cn	n = 0 – 1 0 = Off 1 = On
AGC Speed	=Gn	n = 0 – 1 0 = Slow 1 = Fast
S-Meter	=T0:Snn	n = 0 – 9 Value from 0 – 48 See Note-1
Output Power	=T1:Snn	n = 0 – 9 Value from 0 – 48 See Note-2

Note-1: The S-meter reading is a scaled approximate representation of the signal strength in S-units. The values range from 0 to 48, with the following scaled values:

0 – 3	S0
4 – 8	S3
9 – 12	S5
13 – 15	S6
16 – 18	S7
19 – 20	S8
21 – 24	S9
25 – 29	S9+10dB
30 – 36	S9+20dB
37 – 44	S9+30dB

45 – 48 S9+40dB

Note-2: The output power is scaled linearly from 0 – 40 representing a full-scale value of 10 Watts.

Note-3: The PA-100D can still be used with this protocol to receive automatic band change data. Simply connect the TRX-2 transmit data to the receive data line of both the PC and the PA-100D. Connect the TRX-2 receive data line to the transmit data line of the PC. Leave the PA-100D transmit data line unconnected, and set its Polling Time to zero (Off). Alternatively, you can use the Frequency Sense mode of the PA-100D for automatic band changes rather than the TRX-2 mode.

SAMPLE AUTO-UPDATE INITIALISATION

```
=VB:F14199740M1L0 Opposite VFO Status
=F14199740        Frequency = 14.99740MHz
=M1               Mode = USB
=L0               Lock = Unlocked
=V0               Current VFO (A)
=VA:F1900000M0L0  Current VFO Status
=F1900000         Frequency = 1.900000MHz
=M0               Mode = LSB
=L0               Lock = Unlocked
=WN1271           Narrow Filter BW 1271Hz
=W2272            Current Filter (Mid) BW 2272Hz
=WW3571           Wide Filter BW 3571Hz
=A1:W2272         Current Filter (Mid) & BW
=Q1               Tuning Rate = 10Hz
=R0:+0            RIT Off & 0Hz
=J700             CW Offset 700Hz
=T0               Receive
=C1               Speech Processor On
=G1               AGC Speed = Fast
=T0:S0            Receiver S-Meter
=T1:S0            Transmit Power Meter
```

Note: These commands, queries, and responses can be examined by using a simple terminal program.

Annex J

Juma Voice Memory Option

The voice memory option board is a solid-state recorder that can be incorporated into the transceiver to permit recording the receiver audio output or a microphone signal, and subsequently replaying these recordings to either the internal speaker or transmitting them.

The module's memory is divided into 10 sections or slots, slot 0 has a maximum time of 120 seconds and is reserved for recording from the receiver audio, slot 1 is 20 seconds, slots 2 through 8 are 10 seconds, and slot 9 is 14 seconds. Slots 1 through 9 are reserved for recording from the microphone.

Unfortunately, because of the relatively small number of controls available on the front panel of the TRX2, the voice memory module can only be controlled from the serial ports of the transceiver.

The normal serial RS-232 port (UART1) connected to the rear panel's RS-232 socket can be configured in the User Configuration menu as the Voice Memory control port, and when connected to either the external keyboard option or a PC running a suitable serial terminal program, the voice memory operation can be controlled.

Note-1: The serial port Voice Memory Mode option is only selectable if the voice memory module is installed.

The external keyboard option is a small printed circuit board containing a low-power pre-programmed micro-controller and a number of buttons with which to control the voice memory. It obtains its power from the transmit data line of the serial port to which it is connected, and thus does not require any batteries or other source of power. As it is pre-programmed to operate only at 9600 baud, it is important that the serial port's speed is set accordingly.

It is also possible to use the auxiliary RS-232 port (UART2) available on the DDS board, but bear in mind that this port is dedicated as the Voice Memory control port at a fixed speed of 9600 baud. This port can only be used as the control port if both a Voice Memory module is present, and UART1 is not configured as the control port.

You can use a terminal program, or the Windows Voice Memory control program available from the Juma website which essentially replicates the external keyboard's functionality.

The available commands are:

P	Playback
M	Record from microphone (See Note-2)
R	Record from receiver audio output (See Note-3)
T	Transmit (See Note-5)
S	Stop (The PWR button can also be used.)
E	Erase all (See Note-6)

Note-2: If an attempt is made to record from the microphone to Memory 0, then an error message is displayed, as this memory is dedicated to recording from the receiver's audio output.

Note-3: The memory is organised so that Memory 0 is reserved for recording from the receiver audio output. As a result, when the R command is issued the voice memory module will immediately erase slot 0 and commence recording, as Memory 0 is already preset.

Note-4: In the original firmware, the commands were case sensitive, only upper-case letters were accepted. In this version of the firmware this case sensitivity has been eliminated, either case is acceptable.

Note-5: If the transceiver's mode is other than LSB or USB, when this operation is selected a Voice Memory Error message will be displayed. Similarly, if the current transceiver's frequency is not within a recognised amateur band, the Out-Of-Band error message will be displayed, and the command terminated.

Note-6: The Erase command is only available from a serial terminal program, neither the Juma Windows voice memory control program nor the external keyboard are configured to send this command. This does not affect recordings, since a new recording will over-write an existing one, it is not necessary to erase first. Note that this is now a prompted command. Briefly press the PWR button to cancel, or the MODE button to execute.

After selecting a function (P/M/T), start the operation by selecting a memory from 0 – 9. At the end of the selected memory's time, the operation will automatically stop.

If you enter the command S, click on the STOP button if using the voice memory program, or momentarily press the PWR button before the assigned time has elapsed, then the operation will be stopped.

When the recording is replayed it will stop either at the end of the assigned time, or earlier if the recording was stopped. The playback can also be halted by sending S, pressing any other key, pressing the STOP button if using the Voice Memory program, or momentarily pressing the PWR button.

During recording operations, the time will be displayed, decrementing from the designated memory’s assigned time. During replay operations, the time will be displayed, incrementing until either the end-of-message is reached or the end of memory, whichever occurs first.

As the clock for the ISD-17240 voice memory chip is derived from a resistor, it is not synchronised in any way with the main microprocessor clock. As a result, because the display timer is accurately derived from the microprocessor’s 1mS main interrupt, the first second may well be displayed slightly shorter than normal.

Furthermore, as a result of resistor and chip internal logic tolerances, the actual displayed memory time may well be slightly shorter or longer than the nominal values. These ‘quirks’ are simply the result of the way the voice memory chip works, and are not ‘bugs’.

Annex K

CW Mode

Interrupted Continuous Wave telegraphy, ICW, or simply CW, was the earliest form of radio communications. It merely required the operator to interrupt or key the radio frequency output of the transmitter, and used Morse as the means of coding the signal.

Even today, despite most licensing authorities having dropped the requirement for the applicant to be able to send and receive Morse code, the simplicity and popularity of this mode of communication remains. It is bandwidth and power efficient, and is capable of being used reliably in conditions where even sophisticated digital modes have extreme difficulty.

In order to receive a CW signal, it is necessary to reproduce the on/off keying of the RF carrier as an on/off keyed audio tone which is then audible to the listener.

In the early days of radio, where transmitters and receivers were separate pieces of equipment, this conversion to an audio tone was achieved in a superheterodyne receiver by ‘beating’ or mixing the intermediate frequency signal with an oscillator tuned to a frequency slightly removed from that of the carrier. The resultant difference or ‘beat’ frequency was then within the audio range, and was thus audible.

Typically, in those days, you would tune in a CW signal, and then either tune your transmitter to zero-beat with the incoming signal so that your keyed carrier was at the same frequency as that of the distant station, or else tune your transmitter so that the local beat note in your receiver was at the same frequency as that of the received signal. In either case the transmitters of both stations would be on approximately the same frequency. This process was usually referred to as ‘netting’.

With the demise of AM and the use of SSB, the transmitter and receiver became combined into a transceiver, and this required a different approach.

For the CW operator, the transceiver presented a problem. Suppose you are using a transceiver set to USB, and you are listening to a CW signal whose carrier is at exactly 10,000kHz. In order to hear the keyed signal you would have to set your receiver to 9,999kHz to give a 1,000Hz beat note using USB. If the other station was also using a transceiver, and it was also set to USB, then he would not hear your reply. He would only hear it if it was set to LSB, whereupon his 10,000kHz oscillator would ‘beat’ with your 9,999kHz carrier to also give a 1,000Hz tone, and a QSO would be possible.

This could also lead to each of you chasing the other across the band if either made the slightest adjustment to your frequencies.

In order to overcome this inherent defect of transceiver operation, it was common practice to either offset the receiver frequency, or to offset the transmitter. Suppose your transceiver is set to USB, and you tune in a signal whose carrier is at exactly 10,000kHz. Once again, your local oscillator would need to be at 9,999kHz to give a 1kHz beat note, but now when you key your transmitter if it is arranged that the radiated carrier is 1kHz higher than the receiver, then the carrier is radiated at 10,000kHz and since both transmitted carriers are on the same frequency it no longer matters whether the other operator is using USB or LSB, or even a separate receiver, he will listen to your signal on exactly the same frequency as his carrier, and no problem exists. If instead, the transmitter's frequency is held constant but when receiving CW the local oscillator is detuned by 1kHz, then again both station's transmitted carriers are at the same frequency.

The original Juma firmware utilised the first method, and the transmit carrier was always lower in frequency than the receive carrier by the amount of the CW offset as set in the User Configuration menu. Most modern transceivers, such the Kenwood TS-2000 or the Yaesu FT-857 use the second method.

Since most modern transceivers generally operate CW by offsetting the receiver, rather than the transmitter, in this version of the firmware I decided to make the transceiver compatible with other modern rigs. In the new firmware this means that you now have a choice of CW operating modes, CW – CW Normal, displayed simply as CW, and CWR – CW Reverse, displayed as CWR.

In the CW – Normal mode, the transceiver is switched to USB, and the receiver's local oscillator frequency is lower than the carrier frequency by the amount of the CW shift.

To use the same figures as before, if you tune to a carrier at exactly 10,000kHz and you wish to have a 1kHz audio tone, then the actual DDS synthesiser frequency in the receive mode will be 9,999kHz. The displayed frequency will still be 10,000kHz, because the transceiver always displays the actual carrier frequency being used. When you key the transceiver this offset is removed, and the CW carrier at 10,000kHz is transmitted.

In the CWR – Reverse mode, the transceiver is switched to LSB, and the receiver's local oscillator frequency is higher than the carrier frequency by the amount of the CW shift.

To use the same figures as before, if you tune to a carrier at exactly 10,000kHz and you wish to have a 1kHz audio tone, then the actual DDS synthesiser frequency will be 10,001kHz. The displayed frequency will still be 10,000kHz, because the transceiver always displays the actual carrier frequency being used. In this case when you key the transceiver, the offset is again removed, and once more the carrier frequency of 10,000kHz is transmitted.

This type of operation allows you to switch sidebands without affecting the actual communications, which may allow you to reject some interference.

If you wish to be able to rapidly switch between CW and CWR, ensure that you have set the CW/CWR Swap feature to ON in the User Configuration section.

Note: When calibrating the transceiver's master oscillator it is vital that you use either USB or LSB as the receiver mode to avoid this internal offset, unless using the CW/CWR method. In this latter case, the offset is taken into account when switching between

CW and CWR, and the actual value of the offset is unimportant. (See *Annex B, Reference Oscillator Calibration, Method 4 – Standard Frequency Transmission*)

Annex L

CW Keyer Operating Modes

Dot Priority
With this mode selected, pressing the dash paddle sends continuous dashes, releasing the dash paddle and pressing the dot paddle sends continuous dots. If both paddles are squeezed, then continuous dots are sent. Note that if you hold the dash paddle, and then squeeze the dot paddle you can inject dots, and dashes will resume when you release the dot paddle.

Iambic A
In this mode of operation, when both paddles are squeezed, the keyer will send a string of alternating dots and dashes. If the dot paddle is close slightly before the dash paddle, then the sequence will start: dit dah dit dah. If the dash paddle is closed slightly before the dot paddle, then the sequence is: dah dit dah dit.

When the paddles are released, the keyer will complete the last element, in other words, if it was sending a dot, it will complete the dot, if it was sending a dash, it will complete the dash.

Iambic B
This mode of operation resulted from a bug in an original keyer, but, in software, a bug is only a bug until you find a use for it – then it becomes a feature!

The operation of the keyer in this mode is identical with Mode A until you release the paddles. If you released the dot paddle last, then the keyer will complete the dot and then send an additional dash. If you released the dash paddle last, then the dash is completed, and then the keyer will send an additional dot.

Vibroplex
This mode emulates the semi-automatic mechanical bug key. It is primarily intended to be used with a single-paddle key. With this key, pressing the paddle to the right with your thumb will cause the keyer to send dots. Pressing the paddle to the left with your finger will send a continuous carrier that you manually interrupt to send dashes.

If you use a dual-paddle key, then the operation is the same except that squeezing both paddles causes the current operation to stop. Releasing a paddle will cause the appropriate operation to restart.

For example, if you are sending dots and you close the dash paddle the dots will cease and after the CW release time has expired the transceiver will switch to receive. If you now release the dash paddle, the transceiver will recommence sending automatic dots.

Similarly if you were sending dashes and you closed the dot paddle, once again with both paddles closed the operation will cease and eventually the transceiver will switch to receive. If you now release the dot paddle, the transceiver will switch to transmit and commence sending a continuous carrier until you key it with the dash paddle.

Straight
With this mode selected, the keyer simply follows the dot paddle input. The dash paddle contact is ignored.

Release Delay Time
This is the time taken for the transceiver to switch back to the receive state. When using an Iambic or the Vibroplex mode, the time is fixed at 7 x Dot Time which equates to a word space time. If you are using the Straight mode for the keyer, then the release delay time is adjustable.

In the User Configuration Menu there is an adjustment that can be made to set the CW Release Delay time to a value between 200mS and 1,500mS. If you prefer, simply set the time to less than the minimum by rotating the VFO knob anti-clockwise whereupon either the Default setting will be used or the setting from the CW Speed pot.

If the CW Speed pot mode is set to CW Speed, then the pot controls the delay with values approximating from 200mS to 1500mS. However, if the pot is rotated fully anti-clockwise then the Default setting, corresponding to the default keyer speed is used. This is also the value used if the mode for the CW Speed pot is set to Squelch.

Standard Paddle Connections
The standard wiring for the paddle is to connect the dot contact to the tip, and the dash contact to the ring contacts of a 3.5mm stereo plug, with the screen/shield connection being ground.

The standard ‘sense’ of the paddle for a right-handed operator is for a push to the right with your thumb to send dots, and a push to the left with your finger to send dashes.

To use a straight key, connect the contact to the tip, leaving the ring contact open, and the shield as ground.

QUICK REFERENCE GUIDE

BUTTON	SHORT PUSH	MEDIUM PUSH	LONG PUSH (Latched Mode)
PWR	Power ON Cancel RS-232 Test (With DISP) Cancel Alarms Cancel Save operation Lock/Unlock VFO Stop Record/Playback of Voice Memory data	Power OFF (Normal) Emergency Power OFF (From alarm mode) Select System Calibration Setup (From power OFF state, press and hold.)	Select band attenuator setting with VFO knob. (Requires Tune mode to be selected, PTT switch closed, and PWR button to be briefly pressed to latch this function.)
DISPLAY / CONFIG	Select display page (Normal – RF Power – SWR – Voltage – Current) or User Configuration or System Setup pages	Select User Configuration Setup and exit. Select RS-232 Test Mode (With PWR, from power OFF state, press and hold.)	Not Assigned
MODE	Select Mode (LSB – USB – CW – CWR – Tune) Save Settings	Select Restore Default Settings (From power OFF state with PWR, press and hold.)	Copy VFO to/from memory (With VFO knob) Fast Menu Page select (With VFO knob)
RIT	Toggle RIT ON/OFF	Not Assigned	Rapid Band Select (With VFO knob)
FILTER	Select RX Filter (NAR – MID – WID) In User Configuration Setup also select TX filter Swap CWR/CW (If enabled)	Copy VFO Freq/Mode to User Band Memory	Not Assigned
VFO	Select VFO	Select VFO (Multi-Memory mode) Copy VFO-A to VFO-B (Split Mode) Initiate Flash Memory Write (From power OFF state with PWR, press and hold.)	Select VFO in multi-memory mode (With VFO knob)
FAST / VFAST	Select tuning rate (Slow – 1Hz / Medium – 10Hz / Fast – 100Hz) Save System Calibration Settings	Select very fast tuning rate (1kHz)	Not Assigned

USA Extra & General Class Frequency Allocations

US Extra Class Frequency Privileges

160	1.800 – 2.000
80	3.500 – 4.000
40	7.000 – 7.300
30	10.100 – 10.150
20	14.000 – 14.350
17	18.068 – 18.168
15	21.000 – 21.450
12	24.890 – 24.990
10	28.000 – 29.700

US General Class Frequency Privileges

160	1.800 – 2.000
80	3.525 – 3.600 3.800 – 4.000
40	7.025 – 7.125 7.175 – 7.300
30	10.100 – 10.150
20	14.025 – 14.150 14.225 – 14.350
17	18.068 – 18.168
15	21.025 – 21.200 21.275 – 21.450
12	24.890 – 24.990
10	28.000 – 29.700

SYSTEM CALIBRATION SETTINGS

DATA	VALUE	DEFAULT
Reference Oscillator		180,000,000MHz
Voltage Calibration Factor		5,300
RF Drain Current Factor		2,400
Power Meter Factor		3,550
S-Meter Calibration Factor		1,920
Beep Time		50mS
SWR Trip		3.00
SWR Alarm Delay Time		5.0
Over Voltage Trip		On
Over Voltage Trip (Adjust)		14.50V
Over Current Trip		On
Over Current Trip (Adjust)		2.50A
Under Voltage Trip		On
Under Voltage Trip (Adjust)		11.00V
Band Limits		IARU Region 1

USER CONFIGURATION SETTINGS

DATA	VALUE	DEFAULT
AGC Speed		Slow
Filter Bandwidth – Narrow		1,000Hz
Filter Bandwidth – Medium		2,205Hz
Filter Bandwidth – Wide		2,550Hz
Filter Bandwidth – Transmit		2,678Hz
Power Off Mode		Prompted
Speech Processor		Off
Audio I/P		Mic
Keyer Mode		Iambic B
CW Release Delay		500mS
CW Pitch Frequency		700Hz
CW Pot Mode		Speed
CW Keyer Default Speed		Locked, 20wpm
CW/CWR Swap		Off
LCD Backlight		350
LCD Contrast		2,000
LCD Timeout Setting		Off
RS-232 Protocol		Test
RS-232 Speed		9600 Baud
VFO Memory Mode		A/B + Split
S-Meter Type		Graphic
S-Meter Hold Time		2.50 Seconds
TX Auto Disable		On
Auto Sideband Select		On
Frequency Display Select		Fixed B
Rapid Bandswitch Select		Default
RIT Setting		No
Tune Attenuation Setting		-3dB
VFO Rounding		Off
Meter Scale Type		Original

USER MODE BAND FREQUENCIES

BAND	USER FREQUENCY	DEFAULT
160m		1,900kHz
80m		3,600kHz
40m		7,100kHz
30m		10,125kHz
20m		14,100kHz
17m		18,118kHz
15m		21,300kHz
12m		24,940kHz
10m		28,850kHz

AUTO EQUALISE ATTENUATOR SETTINGS

BAND	DEFAULT	USER
160m	−1dB	
80m	−1dB	
40m	−1dB	
30m	−1dB	
20m	−1dB	
17m	−1dB	
15m	−1dB	
12m	−1dB	
10m	−1dB	