THETIS
User Manual

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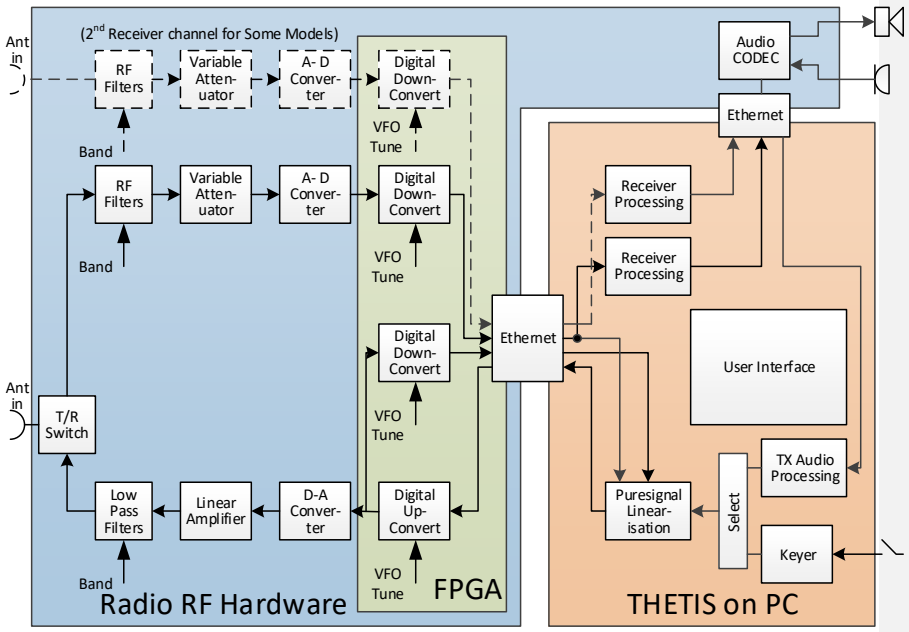
1 Introduction

THETIS is a PC based software defined radio user interface application that has been developed by the HPSDR project. It is one of several user interface applications available for PC and Linux platforms that can be used with HPSDR equipment.

In conjunction with suitable radio hardware, THETIS provides the user interface and Digital Signal Processing for HF Amateur Radio operations. Functionality offered by THETIS includes:

- True dual receiver operation;
- Complete Digital signal Processing chain;
- Comprehensive spectrum and waterfall displays for activity monitoring;
- User selectable and adjustable bandwidth for QRM reduction;
- Wideband noise blanking & noise reduction;
- Operation using CW, SSB/AM and FM modes;
- Interface to digital mode decoders for digital modes;
- Extensive voice processing and compression for TX operations;
- Transmitter linearization using Puresignal;
- Antenna diversity for weak signal enhancement and QRM rejection.

THETIS is a part of a complete radio system. That system includes the antenna, the RF processing, and the user interface. Your software defined radio unit provides some of the RF processing. THETIS provides some of the processing, and the user interface. See the diagram below.



1. Your radio hardware provides a transmit/receive path.

2. On receive, signals are filtered, attenuated then digitised using a high performance analogue-to-digital converter. The A-D converter covers the whole HF band. Digital processing in the Field Programmable Gate Array (FPGA) converts a part of the HF band to zero centre frequency, and transfers the data to the PC via Ethernet. The bandwidth provided can be selected, but is usually in the range 48KHz – 1.536MHz.
3. Depending on mode, your radio hardware may have one or two complete receiver chains.
4. The PC runs the THETIS program. THETIS has two halves: a user interface, and PC based signal processing.
5. THETIS connects to the receiver data stream and provides further signal processing to reduce noise, to select the signal of interest and demodulate it. Its user interface provides a view of the band activity in the downconverted signal is shown, and controls to tune to the required signal and demodulate it successfully.
6. Received audio can be connected to speakers either via the radio hardware, or via PC connected speakers.
7. On transmit, THETIS provides the initial signal processing to optimise the transmit signal. Audio processing is available to enhance a voice signal; a CW keyer is available. Sampled data is sent to the radio hardware via Ethernet.
8. The radio hardware upconverts the TX signal to the required frequency, sets its signal level, amplifies and filters it. Amplifier linearization is available: a sample of the signal from the linear amplifier is downconverted back through the receiver, and compared with the "intended" TX signal. The difference is processed by THETIS to apply pre-distortion so that the final output from the linear amplifier has approximately 20dB lower spurious signal content that a "normal" HF transmission.

None of this will work with just the antenna, just the radio hardware, or just THETIS. It is the combination of all three that provides a truly high performance radio station.

1.1 History

Thetis has been developed from a predecessor application "PowerSDR". PowerSDR was originally developed as a commercial product by Flex Radio Systems to control its SDR based products. PowerSDR was put into the public domain by Flex Radio Systems some time ago. It was adopted by the HPSDR project [1] and significantly developed from the original form, primarily by primarily by Bill Tracey, KD5TFD and Doug Wigley, W5WC.

THETIS represents a new development from PowerSDR, focusing on HPSDR's new "Protocol 2" radio interface. This development is led by Doug Wigley W5WC. It provides a familiar environment to existing users, but includes new interface and DSP technology to accommodate current and future radio products.

1.2 Purpose and Structure of this Document

There are existing on-line manuals for the original PowerSDR product [2]. However significant change has occurred and this document sets out to provide a new baseline documentation for THETIS.

It is important to recognise that this is not a user manual for a radio. Instead it is a user interface for a user interface application that can be used with many different radios – including those from the HPSDR family, and others. Details of specific radios, and capabilities that are present in some but not others, are not the scope for this document.

It consists of the following sections:

- Section 2 describes the different screen layouts available
- Section 3 describes installing and basic operations with THETIS
- Section 4 describes the commands available from the console and its menus
- Section 5 describes the operation forms available
- Section 6 describes the Setup form and its (many) tabs
- Section 7 describes how to configure various functions within THETIS

1.3 Writing Style

In this manual:

- A control / setting name is highlighted **bold**
- The user setting for that control is underlined.
- Menu > Equalizer means open the "
- Equaliser" setting on the program's menu
- Menu > Setup > DSP > RX2 means open the setup form using Setup on the menu, then select the DSP tab, RX 2 sub-tab

So for example this instruction would indicate a gain control setting: Set the **RX1 AF** slider to 30.

1.4 Alternatives to THETIS

THETIS is not the only application you can use with your radio. There are several others in common use:

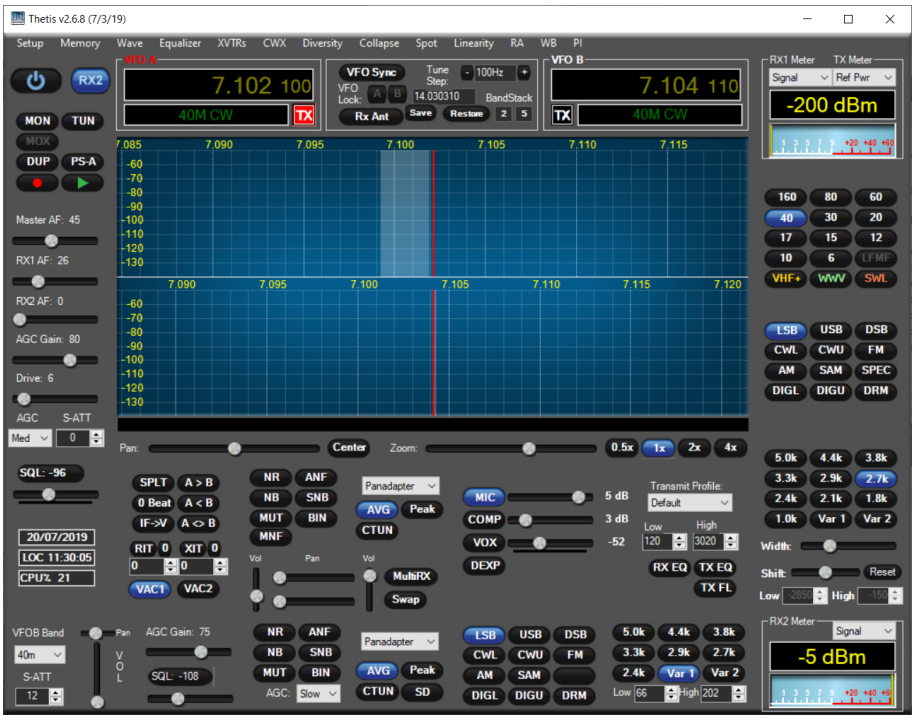
- PowerSDR mrx ps is in very common use with the original "protocol 1" [10]
- SDR Console is well respected application by Simon Brown G4ELI [11]
- LinHPSDR is a Linux application by John Melton G0ORX / N1LYT, and has support for up to 7 receivers [12]
- Pihpsdr is another Linux application by John Melton and is optimised for a 7" display. It can be run on a raspberry pi processor, or other Linux computers. [13]

2 THETIS Overview

THETIS is a program of two halves. It includes a high performance signal processing chain, to extract best performance from your radio. And it provides an intuitive user interface, to enable efficient operation of the overall radio. Firstly we will look at the user interface, then what the signal processing has to offer.

2.1 Screen Layout - Expanded view

The main THETIS view is the “Expanded” view. This provides a single screen showing most of the controls and settings that are likely to be used day-to-day, and a view of the spectrum to which the radio is tuned. This view is selected by clicking Menu > Expand on the main menu.



There are a number of other forms available for particular functions; the console is the main one.

2.2 Screen Layout - Collapsed view

The “Collapsed” views are alternate views onto the same spectrum and same controls. There are two different versions of collapsed view. In both cases, the top and bottom bars can be turned on or off.

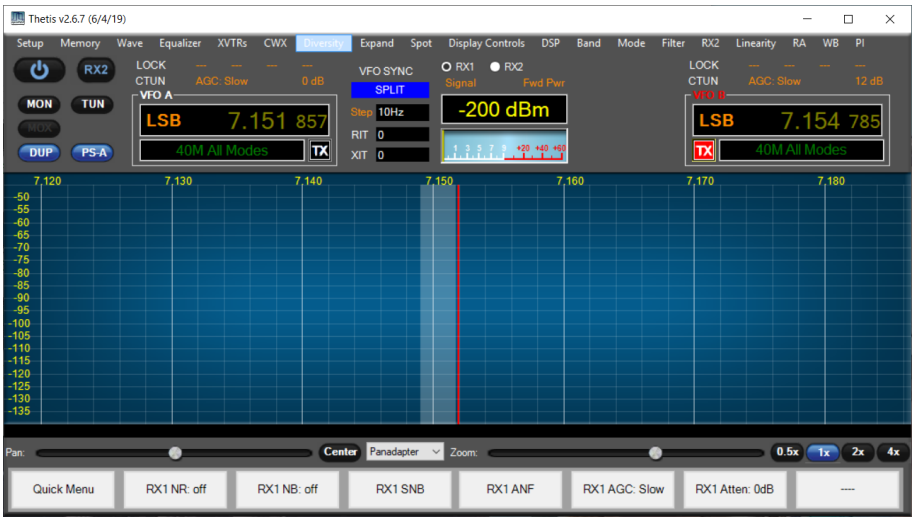
2.2.1 Classic

The “Classic” collapsed view removed most of the user controls from the display leaving most of the screen space displaying the signal spectrum. A top bar provides controls and information; the mode and band buttons for RX1 can be displayed as a bottom bar. Access to the various buttons and settings is primarily through additional items added to the main windows menu.

This view is selected by clicking Menu > Collapse, then selecting Menu > Display Controls > Top Controls and Menu > Display Controls > Band Controls and Menu > Display Controls > Mode Controls

2.2.2 Andromeda view

The “Andromeda” collapsed view has been created to support a new Radio family with front panel buttons and rotary controls, and equipped with a 7” touchscreen display. The display layout has been optimised to provide visibility of radio settings on that small screen, and providing access to further settings through a multi-level menu bar using buttons at the bottom of the screen. The philosophy is that most day-to-day settings should be accessed either through physical controls or through the touchscreen. This view is selected by clicking Menu > Collapse, then Menu > Display Controls > Andromeda Top Controls and Menu > Display Controls > Andromeda Button Bar.



The Andromeda view provides access to more forms, to give access to the controls that have been taken away from the console to fit the display. They will not need to be accessed often – but are available when needed.

2.3 Changing Appearance with "Skins"

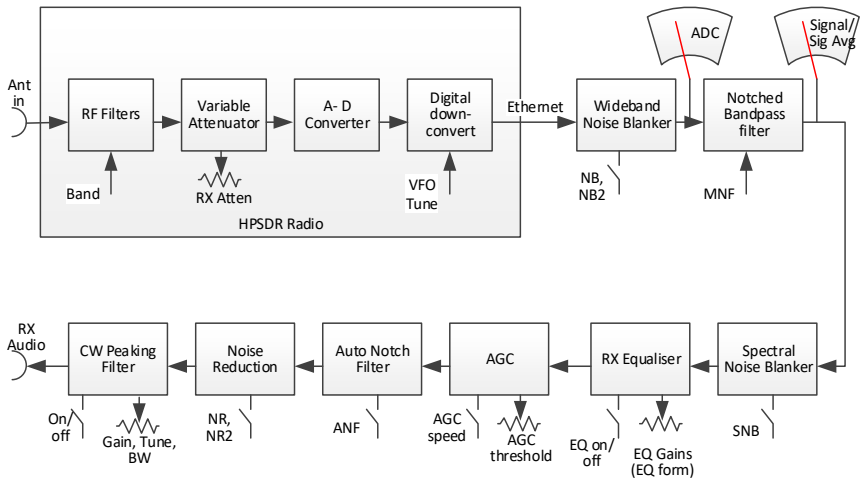
The appearance of THETIS can be changed by graphical "skins". A "skin" is a bitmap image for the screen background, and bitmap images for the various buttons. Skins are available from a several web pages (for example [3]), and can be created using bitmap image editing programs.

2.4 Signal Processing Chain

The signal processing chain is what gives THETIS its performance. The entire chain has been rewritten using the DWSP library created by Warren Pratt NR0V. The library is well documented and interested readers are encouraged to read its guide [4]. WDSP has also been ported to Linux by John Melton [14].

2.4.1 RX Block diagram

The diagram below shows a simplified view of the receiver processing chain. This deliberately omits detail – its purpose is to indicate the range of controls available and where they are applied. For an authoritative reference to the signal processing performed, consult the WDSP guide [4].



The function of the blocks shown is as follows:

Your radio hardware will provide the initial part of the signal path:

- RF filters may be used to band limit the signal to the band of interest.
- A variable attenuator sets the signal level arriving at the A-D converter. The radio's performance will be vastly impaired if the ADC overloads!
- The RF signal is digitised by a high performance Analogue-to-Digital Converter (ADC). This converts the frequency range DC-55MHz in one operation.
- Digital downconverters in the radio's Field Programmable Gate Array (FPGA) downconvert the selected centre frequency to zero, and reduce the bandwidth and sample rate. This

limits the amount of the band the PC will be able to “see”. The rate is settable by the software in the range 48KHz-1.536MHz BUT note that higher values require a higher performance PC! Depending on hardware you may between 2 and 7 of these.
- Depending on model, your radio may have a complete second receiver channel with its own ADC: this will enable Diversity reception.
- The data is transferred to your PC over an ether net interface. For the new “protocol 2” a gigabit connection is needed.

Thereafter the signal path is implemented in THETIS, using the PC processor to do the required signal processing. Because of the nature of the HPSDR project, there are many settings available to “tweak” its operation that may not be common on commodity radios. The principal user settable controls are shown. The functions are as follows:

- A wideband noise blanker removes “impulse” type noise. This is early in the flow graph to limit the impact those impulses have on later processing. Two algorithms (NB, NB2) can be selected on the console.
- A bandpass filter, with user settable bandwidth, limits the signal to the bandwidth required for the current mode. It also implements any manual notch filtering to remove interfering signals. The bandwidth is set by the mode selection and can be adjusted on the console.
- A Spectral Noise Blanker (SNB) provides another algorithm to remove impulse type noise.
- A 10 channel graphic equaliser provides an option to equalise the audio response of the radio using 3 or 10 bands across the audio spectrum.
- An Automatic Gain Control (AGC) limits the signal level of received signals, to keep signals above a user set threshold approximately constant. The speed at which it adjusts can be selected.
- An Automatic Notch Filter (ANF) will automatically attempt to remove constant carrier signals from the audio passband. This is useful for dealing with spurious signals.
- Two noise reduction algorithms (NR, NR2) are available. These attempt to preserve the signal content but reduce the noise content, to get rid of background band noise.
- An Audio Peaking filter (APF) is available for CW modes to further limit the bandwidth to the signal of interest.

Depending on your radio hardware you may have one or two RF chains with one or two Analogue to Digital converters. Your radio hardware includes several downconverters. How many there are, and how they are used, will depend on the radio model and the configuration of THETIS.

- If your radio has a single RF channel and a single A-D converter, it will be capable of providing three receiver paths through the one A-D converter (RX1, RX2 and Sub-receiver). If those are used on different RF bands, then the RF preselector filters will need to be disabled in the setup form.
- If your radio hardware has two complete RF paths and two A-D converters, those same capabilities are available but RX2 can operate on a different band while RX1 and its sub-receiver have preselector filters selected. Additionally, Diversity mode reception will be available allowing use of two receivers either to enhance one signal or to minimise noise.

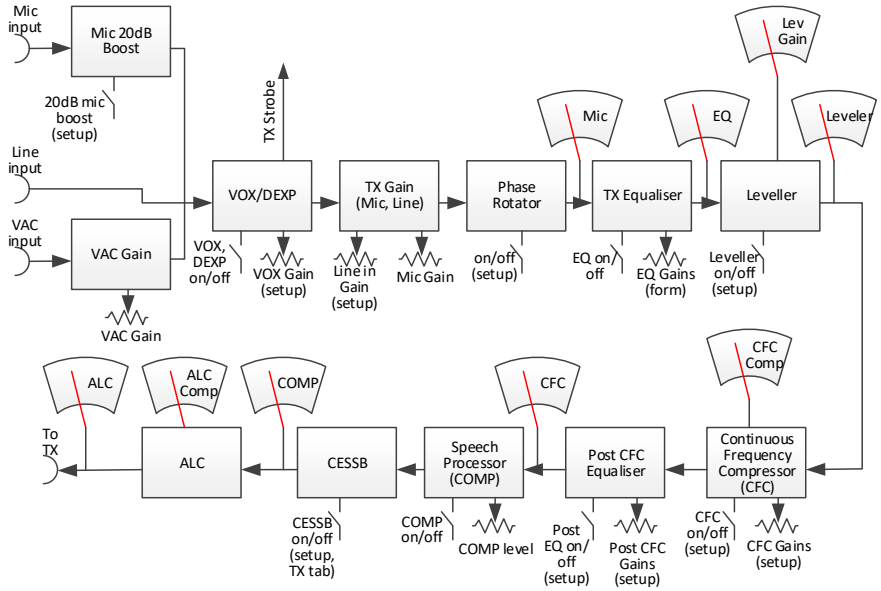
These options are summarised in a table:

Radio Hardware	Option Selected	Constraints?
Single A- D converter	RX1	None
	RX1 + RX2	If RX1 and RX2 are in different bands, preselector filters must be bypassed
	RX1 + Sub-RX	Sub-RX must be within the RX1 downconverted band segment
	RX1 + RX2 + Sub-RX	If RX1 and RX2 are in different bands, preselector filters must be bypassed Sub-RX must be within the RX1 downconverted band segment
	Diversity	Non available.
Dual A- D converter	RX1	None
	RX1 + RX2	None
	RX1 + Sub-RX	Sub-RX must be within the RX1 downconverted band segment
	RX1 + RX2 + Sub-RX	Sub-RX must be within the RX1 downconverted band segment
	Diversity	Available

2.4.2 TX Audio block diagram

Much of the TX path follows similar principles to the RX path. THETIS generates the TX waveform and sends it via Ethernet to the radio; the radio implements a digital upconverter to get to the final output frequency, then the RF signal (DC to 500MHz) is created using a high performance Digital-to-Analogue Converter (DAC). Most of this is controlled automatically; there is user control over the processing to optimise the audio signal.

The diagram below shows a simplified view of the transmitter audio chain for voice modes. Detail has deliberately been left out – this diagram is to show the controls available for the audio path, and the monitor points for the console meter in TX mode. Please note that several of these settings are in the setup form. A guide to setting up the audio path has been provided in section 7.1; many of these settings can be turned off and only brought into use as experience is built up. For an authoritative reference to the signal processing performed, consult the WDSP guide [4].



The algorithms are as follows:

- The first block performs the Voice Operated Transmit (VOX) processing and also a "downward expander" algorithm. If VOX is enabled, then if the audio in level is above a defined level transmission will be initiated. There is also "antivox" processing to avoid RX audio from triggering transmission. VOX on/off, DEXP on/off and VOX threshold are all available on the console screen.
- Audio gain is set. There are separate audio gain values for microphone, line in and VAC input; the latter two are on the setup form. There is a 20dB "boost" available for the microphone – this may be required with dynamic microphones.
- A phase rotator can be selected. This improves the symmetry of the audio waveform, allowing an increase in linear transmit power.
- A 10 channel graphic equaliser is provided. This allows the audio signal to be adjusted so that it is reasonably flat; this allows bass from a dynamic microphone to be reduced, or bass from an electret microphone to be boosted for example.
- A leveller is available to increase gain at low audio signal levels. This allows full TX output to be achieved if the audio is temporarily low because you have moved away from the microphone, for example.
- A Continuous Frequency Compressor (CFC) performs signal compression independently on each of 10 audio frequency bands to increase the mean-to-peak ratio. This will increase average TX power by limiting the amplitude of peaks in each band.
- A speech Compressor provides further amplitude limiting, if desired. This performance the same function as an RF speech compressor in high-end analogue radios.
- Controlled Envelope Single sideband (CESSB) algorithm can also be turned on at the same time as the speech compressor. This further limits speech peaks.
- Finally the automatic Level Control (ALC) ensures that the final signal level does not exceed the maximum allowed by the DAC.

Commented [LB1]: Warren: At some point, it may be worth explaining when one might want to use various audio tools. All tools can be operated simultaneously; however, I think our "audiophiles" use CFC with equalizers and not the COMP compressor and not CESSB. While COMP and CESSB are great to increase average power and signal "punch", they don't have the same level of fidelity as the solution centered around CFC. Also, if desired, you could reference the origin of CESSB – the inventor was Dave Hershberger, W9GR. Dave published his work in QEX … I'm sure you can google to find the issue.

- The CFC and equaliser frequency responses are not “flat” within fixed bands. User adjustments set the amplitude at each frequency point; the amplitude response is interpolated between those points, to avoid abrupt changes. The individual frequency points can also be adjusted for the TX equalisers and CFC.

The TX also includes an algorithm “Puresignal” to optimise the linearity of the power amplifier. This algorithm takes a sample of the transmitted signal and mixes it back down through the receiver, and compares it with the intended signal. This is then used to adjust the transmitted signal. This allows the amplifier to have much better intermodulation performance than uncorrected amplifiers and makes a substantial different to close-in noise on the HF bands.

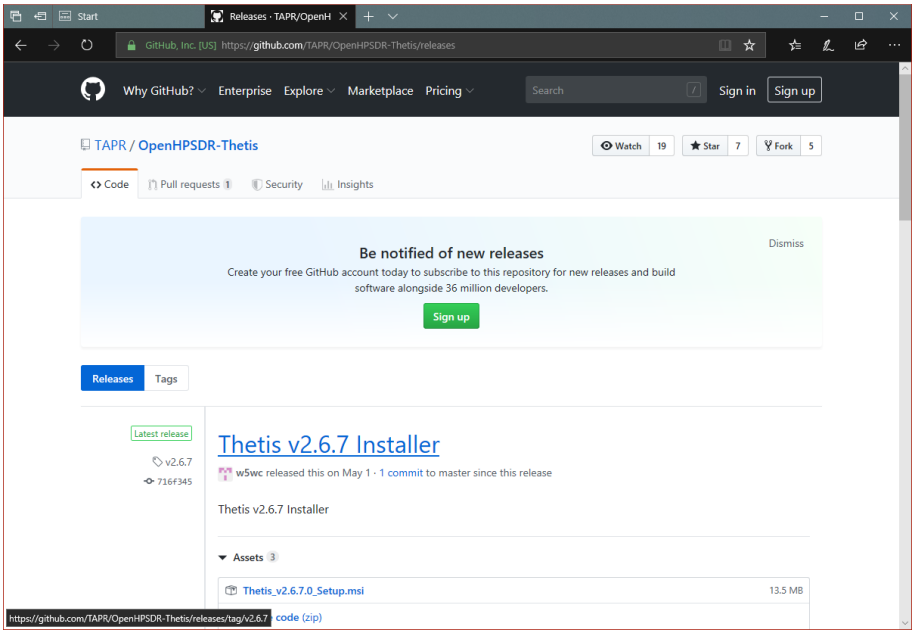
3 Installing & Using THETIS

3.1 Installing for the First Time

This describes how to install THETIS from scratch on a PC that has not previously had THETIS installed.

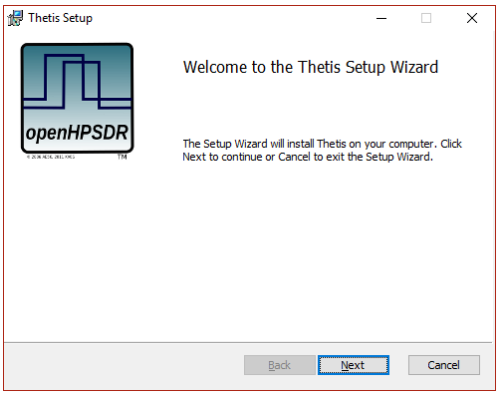
Firstly, begin by downloading the installer. THETIS releases are available from the internet at: https://github.com/TAPR/OpenHPSDR-Thetis/releases

1. Click on the installer (this will be a file with extension ".msi") and select RUN.

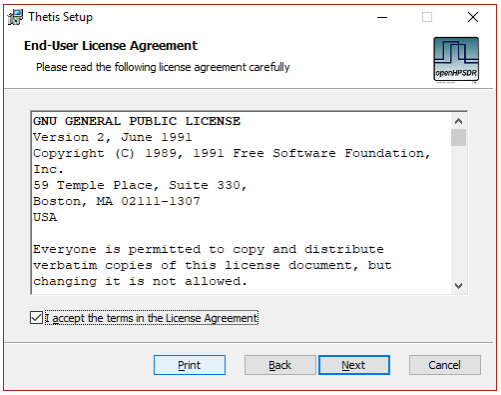


(You may get warnings from windows security products at this point)

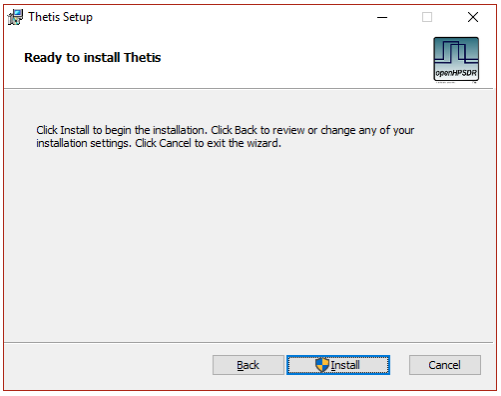
2. The install script will start. Click Next.



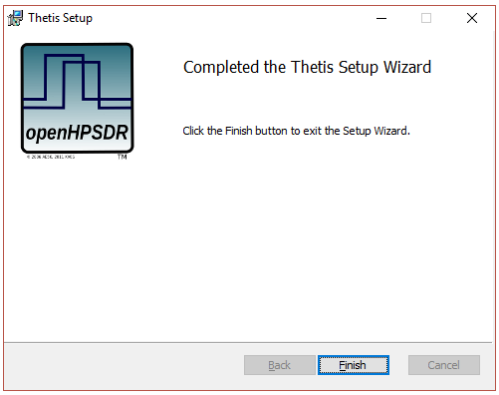
3. (Assuming that you agree with it) click to accept the terms of the license agreement and press Next



4. Select the typical option and press Install. You may get a windows User Account Control form asking **do you want this program to make changes to your PC** – press Yes if that pops up.

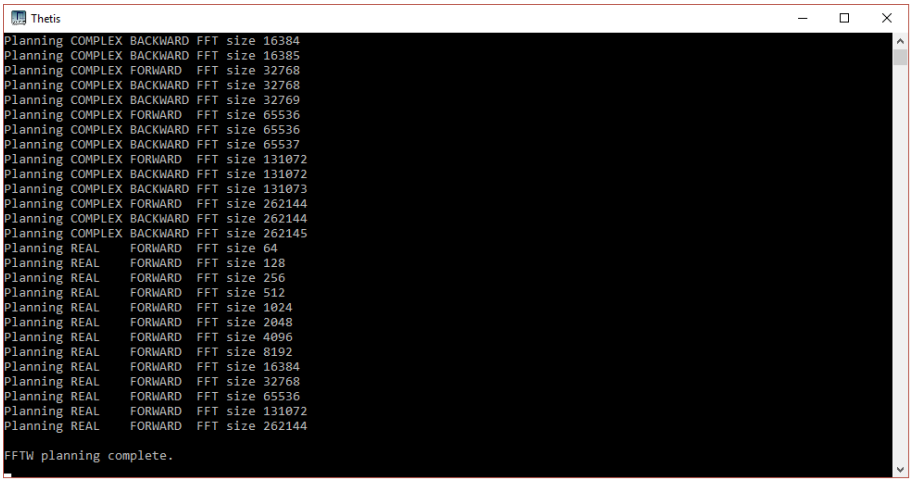


5. The installer copies THETIS onto the PC (this is very quick!). When compete click Finish

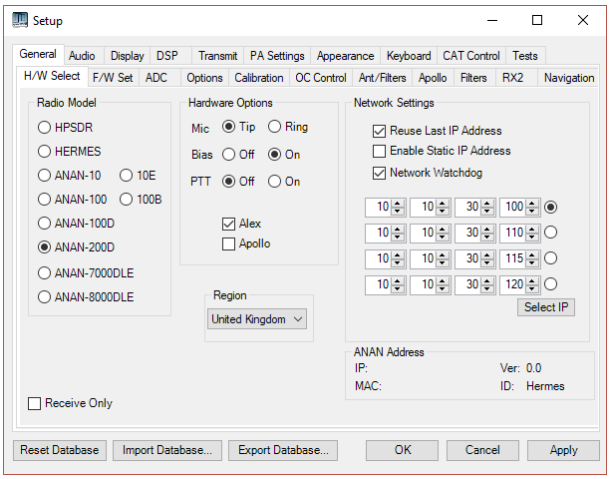


6. THETIS is now installed on your PC. You should have a new desktop icon.

7. Double click the Icon to run THETIS for the first time. A window will open up, saying that it is running a series of tests for how to conduct Fast Fourier Transform (FFT) operations. This may take 10-30 minutes to complete; when complete the window will look like this:



8. THETIS "proper" will now start, bringing you to the "expanded" display screen. Click Menu > Setup.



9. Select your radio from the list on the left, and make any other settings you want (I've also set the microphone connections in the centre correctly for a PC microphone). Press OK.
10. THETIS returns to the expanded display screen. Make sure your radio is connected to the network and powered up; click the top left **On/Off** button, and THETIS will string to life!

3.2 Getting Started with THETIS

This is necessarily dependent upon your radio as well as THETIS. However this should be a good starting point!

1. Connect your radio using Ethernet, via a suitable router capable of gigabit speeds
2. Connect an antenna to the "ANT1" terminal of your radio
3. Connect speakers or headphones to your radio. Set the **RX1 AF** and **Master AF** sliders to 20.

4. Power up your radio
5. Click the **on/off** button
6. If everything has gone well, THETIS should start. You should see activity on the central display.
7. Select your required band, and required mode.
8. Use the **AGC Gain** slider to set the green AGC line just above the local ambient noise level.
9. Audio should be head from your speakers or headphones; use the **RX1 AF** slider to set the volume.
10. The central display gives you a view of band activity. You will see a "noise" level, with signals emerging above the noise. In the centre, a red vertical line tells you the tuning frequency; a vertical grey bar shows you the current receiver passband.
11. There are several ways to tune:
    a. Hover over the **VFO A** displayed frequency, and type in a new value
    b. Hover your mouse over one of the digits in the **VFO A** frequency. The mouse scroll wheel will now step that digit up or down.
    c. Elsewhere in the display, use the mouse scroll wheel. That will move up or down by one tune step per "click". (The tune step is displayed in the central VFO area).
    d. Click in the spectrum display by a signal of interest and drag it to the centre. Then use the mouse scroll wheel for fine tuning. (Be careful not to do this while in the RX passband grey bar – you will move the RX IF filter instead. If you inadvertently move the receiver IF passband: click one of the **Filter** buttons to reset it.)

If you get a message "Error starting SDR hardware, is it connected & powered?" then THETIS has been unable to find a suitable radio on the network. Assuming that it is powered up, you will need to investigate the network connection. Physical cabling, router settings and windows security products could all intrude.

Look at the CPU utilisation at bottom left. If this is high (50% +) the program may not behave as expected. The principal way to reduce CPU loading is to reduce the sample rate of data being passed from the radio to the PC: see section 6.1.2. This will be able to make a huge difference!

3.3 Selecting & Tuning Antennas

Your radio probably supports more than one antenna. The HPSDR project radios generally support three antennas, plus options for the receiver to be connected to different sources. Consult the manual for your radio to find out what is available.

3.3.1 Selecting Antennas for each Band

When the software is newly installed with a "clean" database of settings, ANT1 will be selected for RX and TX on all bands. The antenna selection can be changed using the Menu > Setup > Ant/Filters. This is fairly self explanatory: it allows choice by band, and allows options for separate RX and TX antennas. Once those settings have been made, the antenna will automatically be selected when the band is changed.

If the settings you have chosen have a different antenna for RX and TX, there is a console button **Rx Ant** to switch the RX antenna between its normal antenna and the TX antenna. This may be useful in difficult propagation conditions, or if one is directional and the other is not.

See section 6.1.7.2 for more information.

3.3.2 Antenna Tuning

Current HPSDR project radio hardware does not include an automatic antenna tuner. The software does provide a way to key the transmitter to carry out tuning.

The console **TUNE** button, when pressed, puts the radio into a TX mode with a two tone audio signal. The power level is controlled using the Menu > Setup > Transmit. It is suggested, until you have reason to do different, that it be set to transmit at 10W when in tune mode. That will protect against damage caused by high VSWR and not overheat the PA. This should provide sufficient power to tune an external auto tuner, or to read VSWR and tune using a manual ATU.

The Console's meter can be configured to provide several possible displays during transmit operations. The function provided during Tune is set in the Menu > Setup > Transmit form.

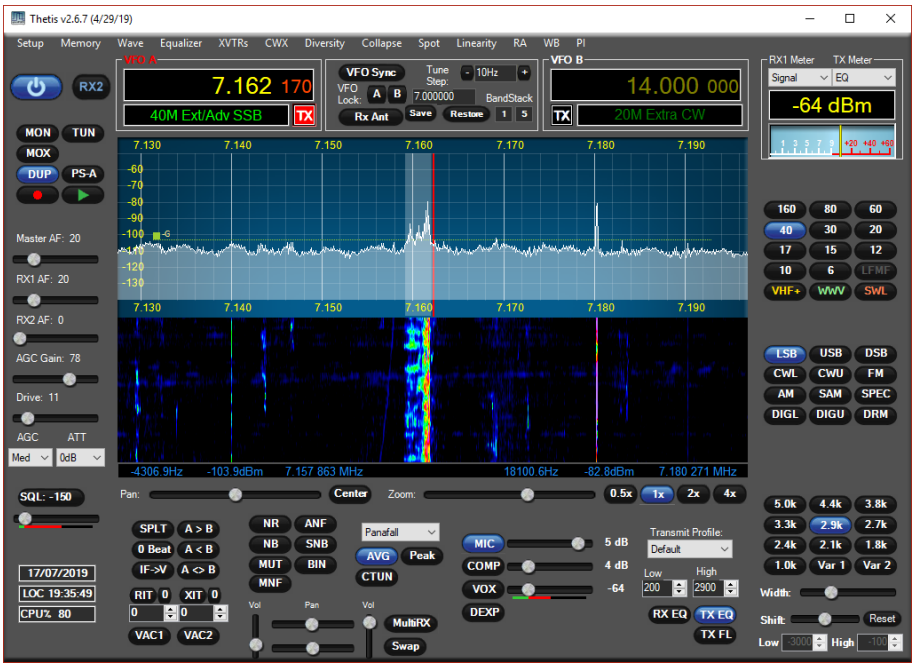
There is an option in the Menu > Setup > Ant/Filters > Antenna form to remove SWR protection when tuning at lower power levels. That will prevent the system from reacting to poor VSWR, which is likely to occur when tuning.

3.4 Voice Mode Operation

(If you are using the Andromeda "collapsed" display, the console settings are available through the menu bar; the "mode specific settings" should be selected to show the buttons and sliders)

3.4.1 Receiving Voice

1. Connect a suitable antenna to your antenna connector (ANT1).
2. Connect suitable speakers or headphones to your radio.
3. Set **RX1 AF** to 20 and **Master AF** to 20; **SQL** off.
4. Start the radio by pressing the console **On/Off** button
5. Select the band you want to operate, and the audio mode (LSB or USB in the first instance).
6. Select 2.7K as an initial filter width.
7. Set attenuation (**Att** or **S-Att**) to 0dB
8. If you get ADC overload indications: use the **ATT** or **S-ATT** controls to add attenuation in front of the receiver. It is suggested you should have at least 10dB margin in the first instance.
9. Select Panafall as the display mode. You will see a red line in the middle indicating your carrier frequency; the grey band will indicate your receiver passband.
10. You will see spectrum activity; probably a noise floor, with some signals.
11. Set **AGC** to Med. Use the **AGC Gain** slider to move the green bar to just above the noise floor.
12. SSB voice signals will be seen in the panadapter as "jittery" signals about 3KHz wide. Zoom the panadapter so that the display width is in the region 50-100KHz; SSB will be distinctly wider than CW or spurious tones and approximately the same as your displayed filter width.
13. Tune a signal. Click on or near the signal with a mouse and drag it to the centre; then use the mouse scroll wheel to fine tune.
14. Adjust **RX1 AF** and/or **master AF** for a comfortable volume.
15. The **RX1 meter** (top right) will normally be set to Signal: this indicates the signal strength on the normal "S units" scale.
16. You can use the RX1 DSP group of buttons to remove noise and improve reception.
17. If the signal of interest is very close to others, you may get interference into the top end or bottom end of the audio passband. You can select a smaller IF filter passband (either with a button or the **Width** slider). You can use the **Shift** slider to move the filter passband.



3.4.2 Voice TX

Follow the instructions in section 7.1 to set up your microphone level. This is very important on first use!

Once you have done that, transmitting voice should be as simple as keying the radio and talking normally into the microphone. You will see a display of the transmitted spectrum; if you select **MON** (preferably using headphones rather than speakers) you will hear your transmitted audio.

THETIS can be keyed into transmit in several ways:

1. Through a hardwired switch connected to the microphone input on the radio itself.
2. Using the **MOX** button on the console.
3. Using the PC keyboard: by default the spacebar will toggle between TX and RX. Ensure that THETIS still has the Windows “focus” though if you open other forms!
4. Using CAT commands, from external units
5. Using a switch wired to a serial port strobe input (see section 7.9).

The RF output power can be controlled using the **DRIVE** control on the console. Drive indicates approximately the percentage of full power to be transmitted. It is possible to perform more accurate calibration – see section 3.8.

The console’s meter can be configured to provide several possible displays during transmit. The full set is described in section 4.1.14. In the first instance the following three are most likely to be useful:

Fwd Pwr	Displays the TX power being generated.
Mic	Displays the microphone signal level; you should be achieving 0dB peaks.

SWR Displays the VSWR presented by the selected antenna

Operating using VOX is simple. The ambient audio level is shown in a coloured bar below the **VOX** slider: adjust the **VOX** slider so that the audio level is shown as green to the left of the slider position, and not red to the right of the slider position. This means ambient audio will not trigger VOX. Then click the **VOX** button on the console. Thereafter speak normally; TX will be selected when you begin to speak, and will be released a short delay after you stop speaking.

If you find the radio keys onto transmit, and stays there, press **VOX** again to turn it off!

For more comprehensive VOX adjustments, see section 7.3.

THETIS includes speech compression algorithms. For details of how to use these, please see section 7.2.

3.5 CW operation

3.5.1 Connecting a Key

There are several options. A key can be connected to the radio, or to the PC. It can be a "straight" key, or an iambic keyer paddle.

To connect a key to your radio: follow the instructions in your radio manual carefully.

To connect a key direct to your PC, with will need access to a serial COM port. Nowadays these are USB plug-in devices but widely available from many sources. Install the appropriate driver so that when plugged into your radio, a COM port number is allocated that you can see in your PC Control Panel's Device Manager. See section 7.9 for more details.

3.5.2 Receiving CW

1. Connect a suitable antenna to your antenna connector (ANT1).
2. Connect suitable speakers or headphones to your radio.
3. Set **RX1 AF** to 20 and **Master AF** to 20; **SQL** off.
4. Start the radio by pressing the console **On/Off** button
5. Select the band you want to operate, and the audio mode (CWU in the first instance).
6. Select 1.0K as an initial filter width.
7. Set attenuation (**ATT** or **S-ATT**) to 0dB
8. Select **Pitch Freq (Hz):** to 600
9. Select **Show CW Zero line**
10. If you get ADC overload indications: use the **ATT** or **S-ATT** controls to add attenuation in front of the receiver. It is suggested you should have at least 10dB margin in the first instance.
11. Select Panafall as the display mode. You will see a red line in the middle indicating your carrier frequency; the grey band will indicate your receiver passband. The yellow vertical line indicates the centre frequency you should tune to.
12. You will see spectrum activity; probably a noise floor, with some signals.
13. Set **AGC** to Med. Use the **AGC Gain** slider to move the green bar to just above the noise floor.
14. CW signals will be seen in the panadapter as a single tone above the noise floor. Zoom the panadapter so that the display width in in the region 20-40KHz.
15. Tune a signal. Click on or near the signal with a mouse and drag it to the centre; then use the mouse scroll wheel to fine tune.

16. Adjust **RX1 AF** and/or **master AF** for a comfortable volume.
17. The **RX1 meter** (top right) will normally be set to Signal: this indicates the signal strength on the normal "S units" scale.
18. You can use the RX1 DSP group of buttons to remove noise and improve reception. Selecting **BIN** to enable Binaural mode is appropriate.
19. If the band is very busy and many signals are present, select **RX1** to enable the Audio Peaking Filter (APF). Set its **Tune** slider to 0, **Bandwidth** slider to 200, **Gain** slider to 10

3.5.3 Transmitting CW

1. Follow the tuning procedures to tune your antenna (section 3.3.2)
2. Select **Sidetone**
3. Tick **Semi Break-in** and set its **delay(ms)** to 300
4. Set **Master AF** to 20. This sets the sidetone audio level.
5. Move the **Drive** slider to select the CW power level you want to transmit. It is suggested that you start at 50 for 50% of max power.
6. Select **TX meter** to Fwd Pwr
7. If you are using an iambic keyer, set **Speed** to the number of words per minute you wish to transmit at
8. Press the key to begin transmission. The TX meter will indicate output power.
9. Adjust **Master AF** for a comfortable audio level.

Could someone with knowledge of CW contribute to this please?

3.5.4 QSK

Thetis version 2.6.3 and onwards supports operating QSK in CW modes, and REQUIRES Protocol 2 firmware as follows:

- ANAN-7000 (all versions) or ANAN-8000: Protocol 2 firmware version 1.7 or later.
- ANAN-200D: Protocol 2 version 1.6 or later.

A new button labelled QSK appears in the CW sub-panel of the main console when operating in CW modes (CWU or CWL). If the Protocol 2 firmware version currently loaded in your radio is older than that required (see above), the QSK button is disabled. With QSK (sometimes called "full break-in") enabled, receiver audio can be heard between CW elements (dots and dashes). This enables monitoring activity while transmitting. It's very useful when working a split-frequency or simplex DX pileup, operating in a contest, or any time the ability to hear what's going on while sending is desired.

Clicking the QSK button to activate the QSK features causes several settings to take effect that enable optimal QSK operation. These include:

- AGC is set to Custom mode (more on this later)
- PTT is disabled (it's handled in the firmware on CW when QSK is engaged)
- Semi break-in mode is enabled, and its delay is set to zero (0).
- Since Thetis MOX is not active in QSK (necessary for quick response), there is no transmit spectral displays and NO TRANSMIT METERING. Simply turning off QSK will resume the display and metering of normal transmit behaviour, either with PTT or semi-break-in.

When the QSK button is clicked to disable QSK (or when changing to a non-CW mode, including when this happens as a result of clicking a band button), everything is set back to the way it was before QSK was enabled.

While operating QSK, the sidetone level becomes tied to the monitor level, which can be set in the Menu > Setup > Transmit, monitor sub-panel, with the control labelled "TX AF". Since it is a separate control from the receiver audio, the sidetone can be adjusted to be louder or softer than the receive

audio according to preference. The setting remains in effect until QSK is disabled, at which time it returns to its previous value. TX AF levels will then switch back and forth between the QSK and non-QSK setting depending on the state of the QSK button.

With QSK enabled your own signal is heard in the receiver while transmitting. When operating with a single VFO (i.e. not split) the tone heard is identical to the CW pitch setting, since that determines the transmitter offset in CW when in tranceive mode. Depending on the sidetone volume, it may be possible to distinguish between the two tones due to a slight time difference between them. If the transmit frequency is moved slightly away from its transceiver offset, either by changing RIT/XIT or tuning the transmitter off frequency a bit using split mode, both tones will be clearly heard at different frequencies.

You will want to experiment with the Custom-mode AGC settings to tailor QSK behaviour to your liking. This is done by activating QSK, then going into Menu > Settings > DSP > AGC/ALC. The AGC settings are on the left. The following settings are a good starting place:

- Slope 5
- Max Gain 100
- Decay 1
- Hang 12.

Additional QSK Operating Notes:

1. Although semi-break-in can be manually enabled with a delay of 0 without QSK, this results in something less than true QSK. It will work but nothing will be audible between CW elements unless sending very slowly. The new QSK mode makes use of the AGC Custom mode setting and increases the AGC hang threshold to a high enough value so that AGC hang doesn't blank out the receiver between CW elements.
2. The key-down delay (Menu > Setup > General > Options) is now limited to permit a setting no shorter than 7ms to ensure a clean CW signal. Setting it lower than this would cause key clicks to be transmitted due to keying the CW signal before the relays have fully engaged. This is not healthy for the relays, and other operators on the band will not appreciate the resulting key clicks that are produced, which may extend up and down the band for 10s of KHz. Some external amplifiers may also need a longer delay, although this setting should work with most. Check your amplifier's manual and timing requirements before using its QSK capability. In the other direction, increasing key-down delay longer than about 10ms reduces the time available to hear signals between CW elements, defeating the purpose of QSK. Likewise, key-up delays longer than a few ms is unnecessary and you likely will find that the minimum of 1ms works fine.
3. When in QSK, the usual cycling of the MOX function in Thetis doesn't occur. As a result, checking for band boundaries doesn't happen and will not prevent you from transmitting out of band. Use caution! Prevention may come in the next release.

3.6 Digital Mode Operation

Data modes require an additional PC application, to act as the user interface and modulator / demodulator for an audio stream. There are many well-known programs available: for example DM780 (for PSK31, for example) and WSJT-X (for the JT65 like modes).

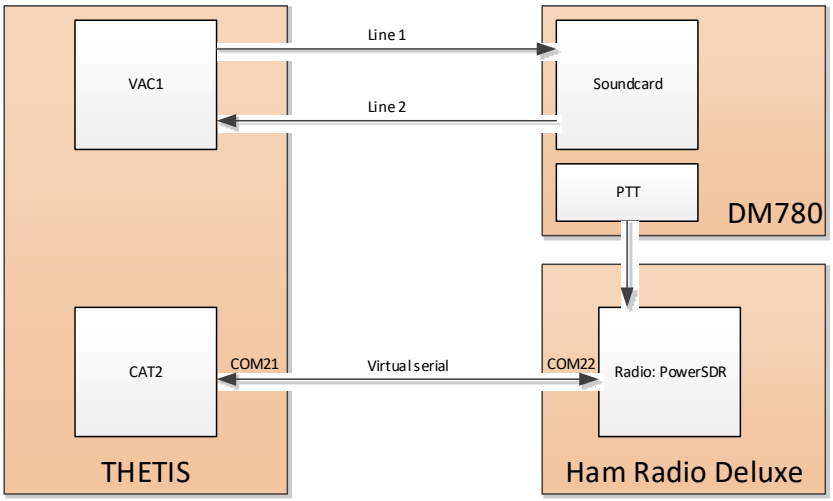
With an analogue transceiver, data modes are easy to configure. Simply connect the radio's audio in and out to a PC sound card via a transformer connection, connect the radio to the PC serial port, and the digital program will be able to access the radio through a sound card and control TX/RX by CAT commands.

With THETIS the process is similar. The key difference is: the audio is already "in" the PC. We need to connect the two programs internally to the PC. The solution is simple – use Virtual cables. These are software programs that run on the same PC as THETIS, and create a software interface for audio and serial. Both programs "see" a sound card and serial port connection. Section 7.4 describes how to download and configure the drivers required; there are several choices available.

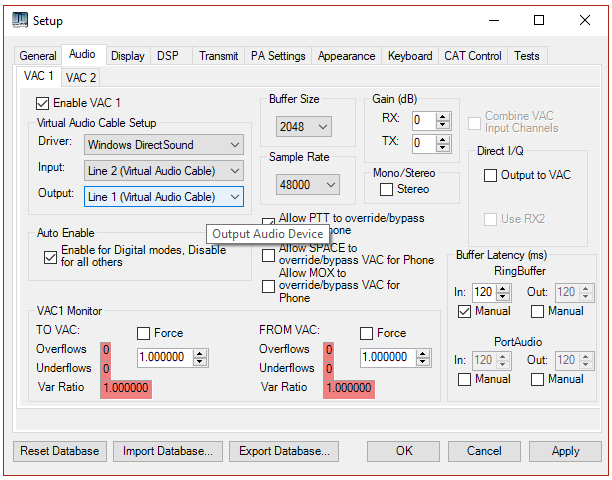
Remember that most data modes are high duty cycle. You will need to reduce the peak TX power to avoid overheating your PA.

3.6.1 Setting up THETIS for Data Modes

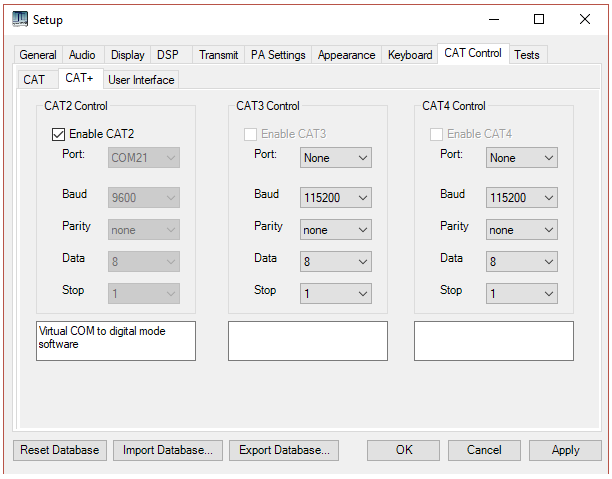
This is how we will be configuring the programs:



1. Run THETIS
2. Select DIGU as the operating mode
3. Tune to around 7.04 to 7.07MHz
4. Set **Drive** to 25 or below.
5. Set the filter width to 2.7KHz
6. Open the Menu > Setup > Audio > VAC1 form
7. Click **Enable VAC1**
8. Choose **Driver**: Windows Direct Sound
9. Choose **Input**: Line 2
10. Choose **Output**: Line 1
11. Tick **Auto Enable: enable for digital modes, disable for all others**
12. Set RX Gain and **TX gain** to 0dB



13. Open Menu > Setup > CAT Control >CAT + form
14. Select **CAT2 port** COM21
15. Set **Baud** to 9600
16. Add some text to indicate what this CAT connection is for
17. Click **Enable CAT2**

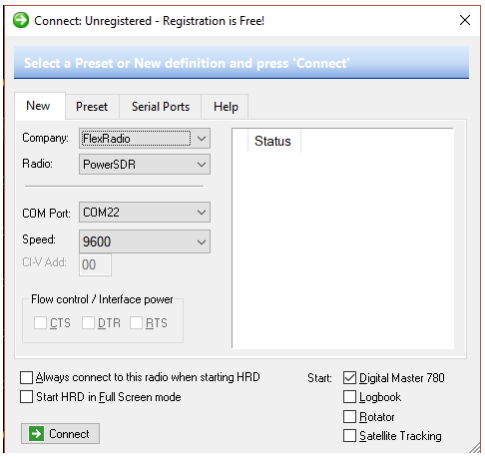


18. Close the setup form; THETIS is ready.

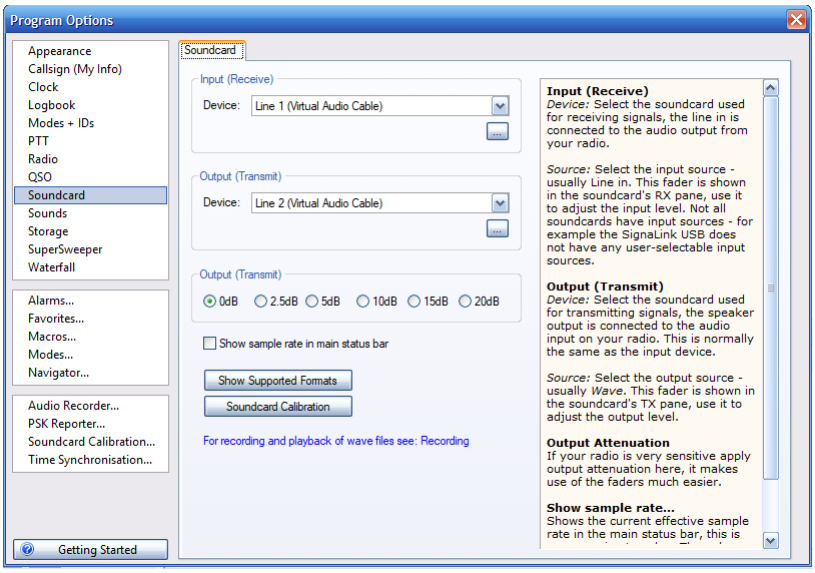
3.6.2 Setting up the DM780 program

1. Run the Ham Radio Deluxe program on your PC
2. You will need to establish a connection to your radio. Select that you want a new connection.
    a. **Company**: Flex Radio
    b. **Radio**: PowerSDR
    c. **Com Port**: COM22
    d. **Speed**: 9600

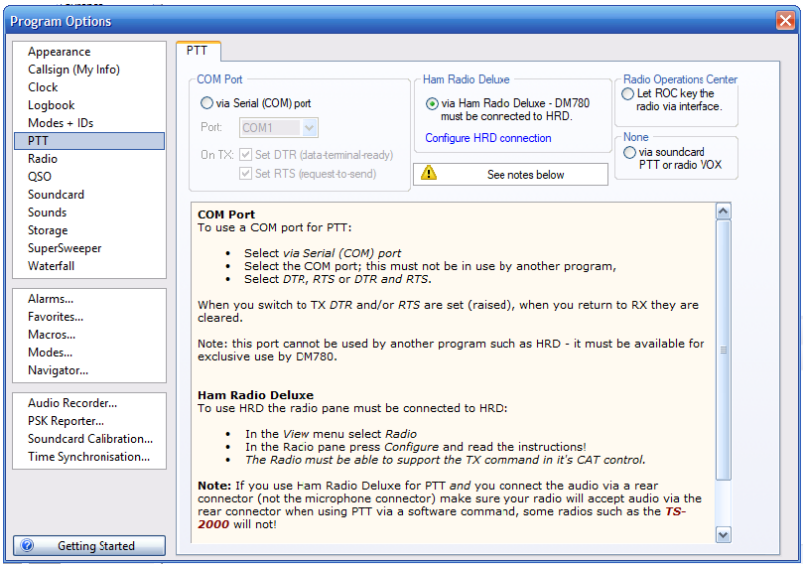
3. Press Connect
4. HRD connects to THETIS, and THETIS (if it wasn't already) will turn on.



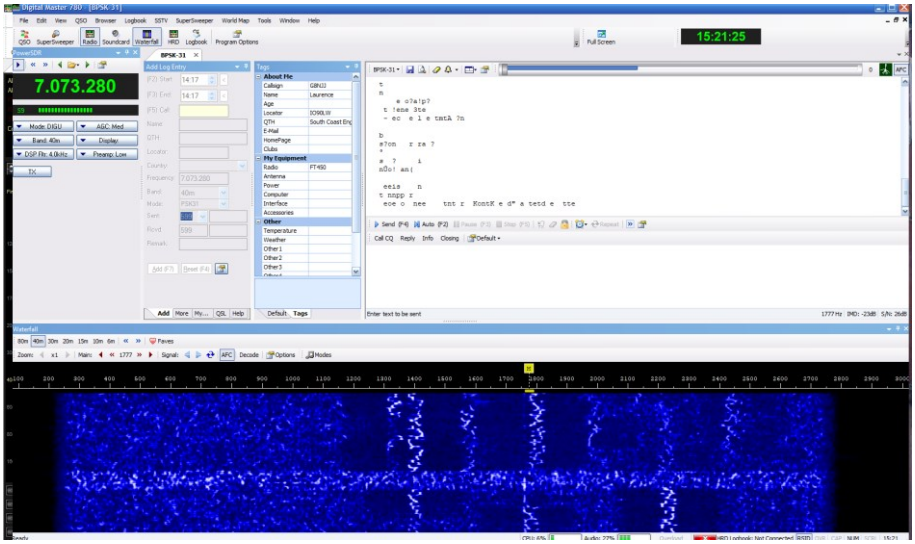
5. Click on the **DM780** icon on the HRD window. The digital mode program will start.
6. Click **Program Options**
7. Click **Soundcard**
    a. Choose **Input**: Line 1 (Virtual audio Cable)
    b. Choose **Output**: Line 2 (Virtual audio Cable)



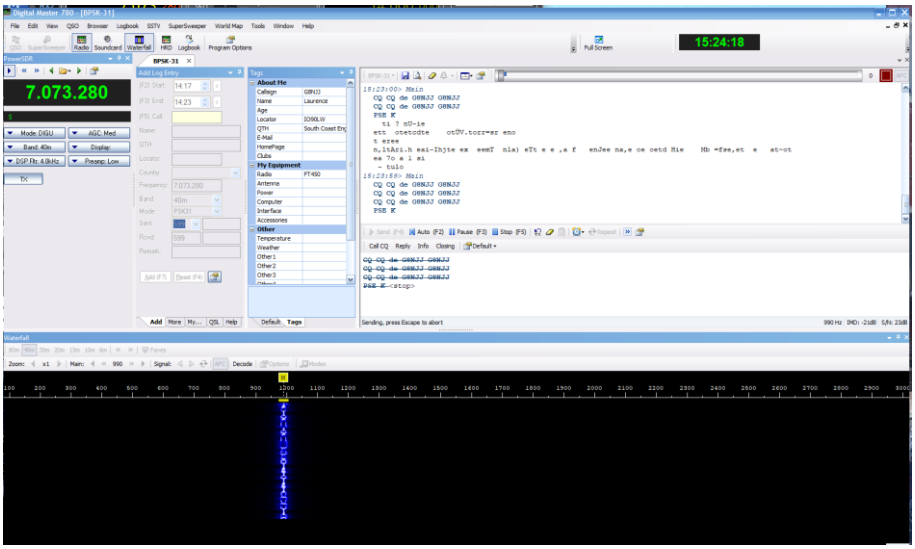
8. Click **PTT**
    a. Select Via Ham Radio Deluxe



9. Close the Program options form. DM780 starts attempting to decode



10. The radio is controlled by DM780. You can change modes and adjust tuning.
11. To TX, click Send and you can send a CQ call. THETIS will enter TX mode, and get the TX audio from DM780.



Using other data mode programs is similar, and advice is available on the internet.

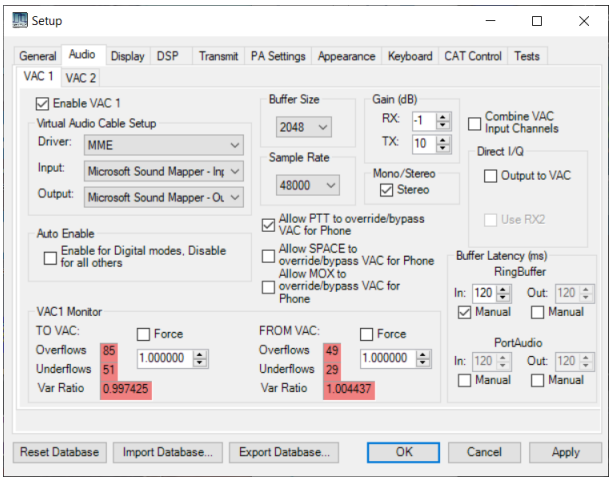
3.7 Using PC Audio Connections

The radio can be operated in two ways: with microphone, speakers etc connected to the radio; and with microphone/speaker audio routed through the PC. The latter is useful if the PC is in a different location from the radio.

To use the radio's connections: make sure **VAC1** and **VAC2** are turned off on the console. Consult your radio manual regarding speaker, headphone and microphone connections. Menu > Setup Transmitter form has a selector to choose between **Mic In** and **Line In** (probably on your radio rear panel).

To use PC audio, it is necessary to select a sound card for VAC1 (for RX1) and possibly VAC2 (for RX2). The settings will be PC dependent but these work on one windows 10 laptop:

1. Open Menu > Setup > Audio > VAC1 (see section 6.2)
2. Click **Enable VAC1**
3. Select **Driver**: MME
4. Select **Input**: Microsoft sound mapper – input
5. Select **Output**: Microsoft sound mapper - output
6. Select **RX gain** and **TX gain** initially to 0dB



You will now be able to hear RX1 audio through your PC speakers, and use a PC microphone for TX.

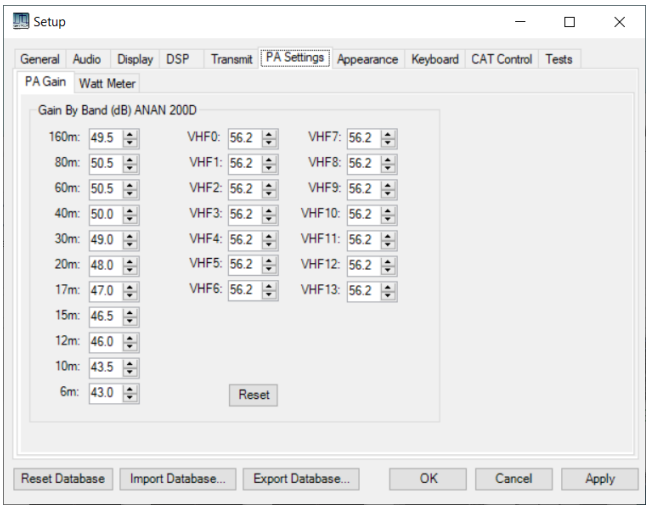
For digital modes, it is necessary to run the digital mode decoder program on the same PC and then interconnect that program with THETIS using Virtual Audio Cables. The procedure is described in section 7.4.

3.8 TX Power Calibration

As shipped, your radio should provide RF output at approximately the level set by the **Drive** slider. If you have access to a calibrated power meter, it is possible to adjust the THETIS settings so that the delivered power will be as measured by the power meter. This process can only be as good as the quality of the power meter: if that is inaccurate, then this process will not be helpful!

If you have a good quality, trusted, and preferably calibrated, meter - then please read on.

1. Set your radio to use the ANT1 antenna connector (Menu > Setup > General > Ant/Filters)
2. Connect your power meter to the ANT 1 connector, and an appropriately rated dummy load to the power meter.
3. Select the **160m** band
4. Open the Menu > Setup > Transmit form
5. Set the **Tune Power** level to 10 and untick **Use Drive Power**
6. Open the Menu > Setup > PA Settings form



7. Press the console **Tune** button to on
8. You should see *approximately* 10W on the power meter.
9. Adjust the **Gain by band** box for 160m to achieve 10W. Do not change in jumps bigger than 1dB!
10. Press the console **Tune** button to off
11. Go on to the next band and repeat.

3.9 Using Puresignal

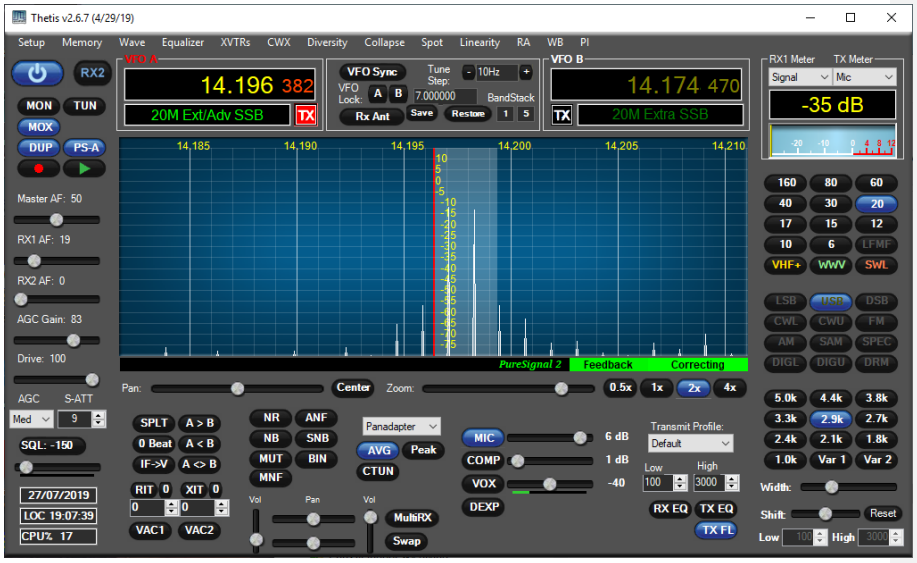
Puresignal provides an algorithm to correct the non-linearity. It does that by measuring the difference between the *actual* output and the *intended* output, and correcting the TX samples to allow for the difference. This algorithm was designed by Warren Pratt NR0V and leads to TX signals 20-30dB "cleaner" than those with no correction. This all happens in the background, once it has been initialised.

Depending on your radio model, you may need a signal coupler to select a sample of your TX signal for the adaptive correction process. More recent radios have included that within the unit. If you use an external linear amplifier, then you will definitely need a suitable coupler (which could be built into your amplifier).

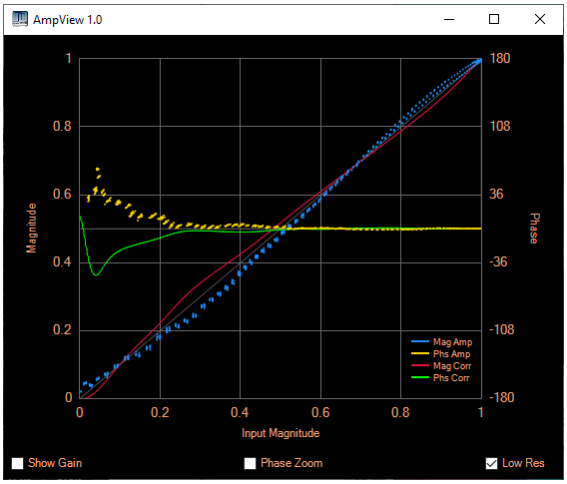
3.9.1 Setting Up Puresignal

1. Follow the guidance to set up your microphone, drive, antenna and filter selection for "normal" TX.
2. Select the Menu > Linearity form. The Puresignal Control form will be shown.
3. Click the **AmpView** button. You will see the AmpView form, ready to show linearity corrections.
4. Use the **Drive** slider to select the power level you want to operate at.
5. Connect a dummy load with appropriate power rating to your antenna connector (ANT1, unless you have selected a different antenna).
6. Click the **DUP** console button to on.
7. Click The console display zoom **2X** button

8. Click **Two-tone** to on in the Puresignal window. You will see your TX signal as two tones in the panadapter display area. Puresignal will rapidly adapt the signal to reduce harmonics to much lower values.



9. After a few seconds the TX display should be stable. Click **Two-tone** to off to complete the calibration test.
10. The **AmpView** button will have updated to show the amplitude and phase behaviour of the amplifier, and the correction that has been made.

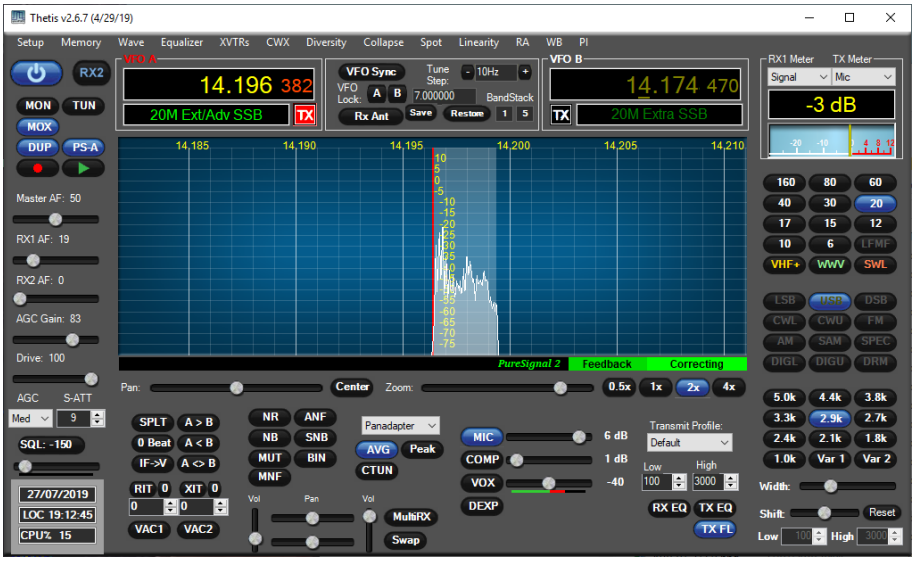


3.9.2 Operating with Puresignal

Once enabled, Puresignal will automatically apply corrections during transmission. It is important to have your microphone properly adjusted – you need to be getting 0dB speech peaks to drive Puresignal hard enough!

A green box “Feedback” under the panadapter indicates that a good signal level is being received from the feedback path. To its right a green box “Correcting” indicates that corrections are being made.

Further calibration is not normally required.



4 Console Controls

This section describes the screen controls available to operate your radio using THETIS. The "expanded" view of THETIS provides most controls in an immediately accessible form. In the "collapsed" views many of the controls described in this section aren't visible, or the appearance may have changed; most can be accessed in other ways. The "Classic" view adds several tables to the application menu to access settings. The "Andromeda" view allows many settings to be accessed through a set of buttons at the bottom of the screen, and via additional "popup" screens available via those buttons.

4.1 Console Screen Buttons

This section describes the controls available on the primary "Console" screen. Please be aware that the "skins" can alter the appearance, and the text, displayed on the buttons. The guide here has been prepared using the "IK3VIG special" skin. Most controls have "tooltips" which describe their function if the mouse hovers over them.

4.1.1 Master Buttons Group

These buttons provide on/off controls for a number of critical functions:

Radio On/Off	Turns on/off the connection through the network to the radio, and initiates software defined processing.
RX2 On/Off	Turns on/off the second receiver channel. When selected an addition RX2 Group appears at the bottom of the console.
Monitor	When selected, TX Audio is replayed to the speakers for monitoring of TX audio quality. The **Master AF** Gain function sets the volume (see section 4.1.6)
Tune	When selected, initiates a transmit operation with a steady tone at the power level selected in the setup form (see section 6.5). Note that the TX Meter function is set to the setting assigned in the setup form.
MOX	When selected, initiates a normal transmit operation at the power level set by the drive control (see section 4.1.6).
Duplex	When selected, displays the received signal on the display when transmission is active. If not selected, the TX drive signal is displayed.
PS-A	When selected, the Puresignal TX linearization function is enabled during transmission.
Quick Record	Activates the "Quick record" function to record a signal for later playback. See section 5.3.
Quick play	Activates the "Quick replay" function to replay a previously recorded signal - either through the receiver to the speakers, or to the transmitter. See section 5.3.

4.1.2 VFO Group

This group includes three panels: displays for VFO A and B frequency; plus VFO controls in the middle.

4.1.2.1 VFO A/B Displays

The tuned frequency and band segment are displayed for each of VFO A and VFO B. The functions assigned to these controls depends on the settings for **RX2**, **MultiRX** and **SPLT** as described below. Additional display information is included in these boxes in "collapsed" display modes.

The VFO selected for TX is indicated by the red "TX" indicator.

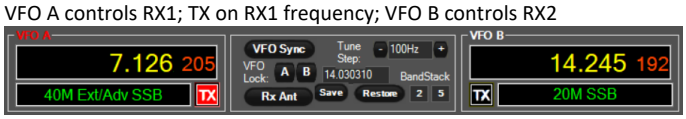
4.1.2.2 VFO Settings

The central section contains several controls:

VFO Sync	When selected, the two VFOs are locked together in frequency. This necessary for the "Diversity" feature (see section 5.7).
Tune Step	This section sets the tuning step. The VFO frequency is increased or decreased by this amount for each tuning event (keyboard press, scroll wheel step or front panel encoder step).
VFO Lock	Two buttons allow the settings for VFO A and VFO B respectively to be locked, to prevent inadvertent tuning.
RX Ant	If the antenna setup (see section 6.1.7.2) for the current band has different antenna for RX and TX, this button selects whether the receiver is connected to the assigned RX antenna or to the TX antenna.
Save, Restore	These controls access the "quick memory" function to allow rapid recall of a setting. The "save" button causes the current frequency, mode and filter for VFO A to be saved to the Quick memory; its frequency is displayed. The "restore" button causes the quick memory setting to be copied back to VFO A.
Bandstack	Two numbers display the current bandstack (left) and total number of bandstack memories for the current band (right). Clicking in either displays the bandstack form (see section 5.1).

4.1.2.3 VFO Settings for RX1, RX2 and RX1 Sub-receiver

The functions of VFO A and VFO B change depending on what combination of **RX2**, **MultiRX** and **SPLIT** are selected. This table indicates which VFO controls those functions.

RX1	VFO A controls RX1; TX on RX1 frequency 
RX1 + **MultiRX**	VFO A controls RX1; TX on RX1 frequency; VFO B controls Sub-RX 
RX1 + **RX2**	VFO A controls RX1; TX on RX1 frequency; VFO B controls RX2 

RX1 + **RX2** + **MultiRX**	VFO A controls RX1; TX on RX1 frequency; VFO B controls RX2; Sub-RX frequency in VFO A band segment box 
RX1 + **SPLT**	VFO A controls RX1; TX on VFO B frequency 
RX1 + **MultiRX** + **SPLT**	VFO A controls RX1; VFO B controls both Sub-RX and TX 
RX1 + **RX2** + **SPLT**	VFO A controls RX1; VFO B controls RX2; TX frequency in VFO A band segment box 
RX1 + **RX2** + **MultiRX** + **SPLT**	VFO A controls RX1; VFO B controls RX2; both TX and sub-RX frequency in VFO A band segment box 

If the RX1 **multiRX** feature is activated, an additional sub-receiver with similar settings to RX1 is activated. This can be used as an additional receiver.

4.1.3 Band Group

This group provides a quick way to select the RX1 operating band. The current band will be indicated by one of the buttons being highlighted.

To change band, simply click the button for the desired new band and the radio will re-tune to that band. It will select the last used frequency, mode and filter setting for that band. Be aware that the antenna selection will be changed according to the per-band antenna settings defined on the setup form (see section 6.1.7.2)

There are 3 sets of buttons available, which can be selected by buttons on the bottom row:

- One set provides access to the HF amateur bands;

- One set provides access to transverter settings to access VHF/UHF/microwave bands. For more information on transverter settings, see section 5.5.
- One set provides access to various short wave bands of interest to Short Wave Listeners.

There are other methods available to change band – for example where these controls are hidden:

- Andromeda provides front-panel controls to step up one band, or step down one band, within the HF amateur bands.
- The "classic" collapsed view optionally presents these buttons at the bottom of the screen
- Andromeda menu buttons can be assigned to step up and down similarly
- An Andromeda menu button allows the band setting popup form to be displayed (see section 5.13.2) which provides similar functionality to this group
- Using PC keyboard keys: by default "M" and "N" step up / down one band respectively.

4.1.3.1 Bandstacks

"Bandstacks" provide memories storing several pre-defined settings for quick access to different parts of each band. For example if you want to move quickly between a CW section, a digital modes section and the SSB section of the 20 metre band, you can set up a "bandstack" for each and that rapidly switch between them. Bandstack memories are only available for RX1.

A bandstack memory is a combination of a frequency, an operating mode and a filter setting. In conjunction with the mode-dependent settings (see section 4.1.10) this provides most of the settings likely to be needed in a new part of the band. The VFO group (see section 4.1.2) indicates the number of programmed bandstack memories for the current band, and the most recently selected bandstack.

1. To select the next bandstack memory in the current band: press the band button.
2. To edit a bandstack memory entry: press the band button until that bandstack memory is selected. Then tuned the radio, change mode and/or change the filter settings. The press the band button again.
3. A bandstack form (see section 5.1) provides an ability to edit the bandstack memory settings. Andromeda provides a button to switch between each bandstack memory in the current band.
4. An Andromeda menu button allows stepping between bandstack entries for the current band.

4.1.4 Mode Group

This group provides a quick way to select the RX1 operating mode. The current operating mode will be indicated by one of the buttons being highlighted.

To change mode, simply click the button for the desired new mode. The mode will be selected, and the mode-dependent radio settings will be updated according to those selected for the new mode (see section 4.1.10).

The modes available are as follows:

Mode	Type	Description
LSB	Voice (Phone)	Lower Sideband suppressed carrier. Typically used below 10MHz.
USB	Voice	Upper Sideband suppressed carrier. Typically used above 10MHz.
DSB	Voice	Double Sideband suppressed carrier. Not in common use.
AM	Voice	Double sideband, with carrier. No longer in common use.
SAM	Voice	Double sideband, with carrier. Synchronous tuning to the received carrier.
CWL	CW	CW (Morse) in the lower sideband
CWU	CW	CW (Morse) in the upper sideband
FM	Voice	Narrow band Frequency Modulation; common of VHF & above bands
SPEC	Digital	Full spectrum mode. Provides access to the full receiver channel bandwidth.
DIG L	Digital	Digital modes, using upper sideband (most commonly used). Provides a filtered digital audio stream to an external digital mode application.
DIG U	Digital	Digital modes, using lower sideband (less commonly used). Provides a filtered digital audio stream to an external digital mode application.
DRM	Digital	Digital Radio Mondiale. Provides a filtered digital audio stream to an external application.

There are other methods available to change mode – for example where these controls are hidden:

- The “classic” collapsed view optionally presents these buttons at the bottom of the screen
- Andromeda provides front-panel controls to step up or down one mode
- Andromeda menu buttons can be assigned to step up and down similarly
- An Andromeda menu button allows the mode setting popup form to be displayed (see section 5.13.3) which provides similar functionality to this group
- Using PC Keyboard keys. By default “X” and “Z” stepping up / down between modes.

4.1.5 Filter Group

This group provides a quick way to select the RX1 receiver bandwidth. The current filter bandwidth will be indicated by one of the buttons being highlighted. The bandwidth offered are mode dependent. To change filter, simply click the button for the desired new bandwidth.

These filters are the principal means by which the receiver selects the station of interest, and rejects the nest one only a few 100Hz away. In a crowded band – for example during a contest – it may be necessary to select a smaller than normal bandwidth to reject interference from an adjacent station.

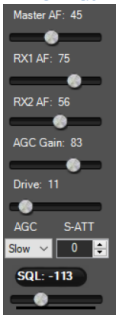
Through DSP, the filter bandwidths and centre frequencies are fully variable. Two buttons marked **Var 1** and **Var 2** select variable filters: the bandwidth and centre frequency (equivalent to “IF Shift”) can be changed to reject interference. Sliders are provided to select centre frequency and bandwidth, or the “low” and “high” cut-off points can be manually edited. The **reset** button will reset the filter centre frequency (but leave bandwidth unchanged).

To observe filter settings, the filter bandwidth is shown in the signal display as a grey vertical band. As the centre and bandwidth are changed, so the grey band is changed and that can be compared with the spectrum activity for the wanted signal and the interfering signal(s).

There are other methods available to change filters – for example where these controls are hidden:

- An Andromeda menu button allows the filter settings popup form to be displayed (see section 5.13.4) which provides similar functionality to this group
- Using PC Keyboard keys. By default “B” and “V” step up / down between filter bandwidths.
- The Odin and Andromeda panels both provide filter “low cut” and “high cut” encoders. These move the lower audio edge and upper audio edge respectively. If you hear a high frequency interfering signal, adjust “high cut”. If you hear a low frequency interfering signal, adjust “low cut”.

4.1.6 Gain Group



Master AF	This sets the audio gain for the transmit monitor function and CW sidetone. TX audio is replayed to the speakers when **MON** is selected.
RX1 AF	Sets RX1 AF gain
RX2 AF	Sets RX2 AF Gain
AGC Gain	Sets the AGC threshold level. This is the level above which the AGC reduces the signal level. It should be set just above the band noise floor and is indicated with a green “G” line on the display.
Drive	Sets the TX level, as a relative value 0-100% of full power.
AGC	Sets the Automatic Gain Control operating speed. Two time constants are controlled: the normal “decay” time setting the rate at which AGC restores gain after a large signal was present; and a ”hang” time that prevents gain increase until a certain period has expired. (There is also a fast decay action after AGC-detected impulses). Values available are as follows: Fixed: No AGC action; receiver has constant gain Long: Long hang time, long decay time Slow: Medium Hang time, medium decay time Medium: Medium decay time, no hang Fast: Short decay time, no hang Custom: The AGC settings are controlled by user-entered parameters in the Menu > Setup > DSP > AGC/ALC form
Attenuation	Sets the receiver front-end attenuation. This is adjusted to make sure the A-D converters do not overload in strong signal conditions. The settings available will be receiver dependent. If your receiver has a 1dB step attenuator, double clicking on the text label will change this between “ATT” and “S-ATT” ATT: coarse step attenuator, with 10dB steps

S-ATT: fine stepped attenuator with 1dB steps

SQL — The button turns on/off the receiver squelch function. When active, the receiver output is blanked for signals below the set threshold.
The squelch slider sets the squelch threshold value

4.1.7 VFO Buttons Group

These buttons control VFO operation.

SPLT — This button activates "split frequency" TX / RX operation.
- If RX2 is disabled: VFO A will be used for RX, and VFO B will be used for TX
- If RX2 is enabled: VFO A provides both. The RX frequency is displayed as normal; the TX frequency is displayed in the band segment display.

A > B — Copies the VFO A frequency to VFO B

A < B — Copies the VFO B frequency to VFO A

A <> B — Swaps the VFO A and B frequencies

Zero Beat — Centres the VFO onto the largest signal within the RX passband. This is likely to be useful for CW and possibly data modes, but not voice modes.

IF -> V — If the IF filter has been shifted: this button clears the filter shift, and retunes the VFO so that the "unshifted" IF filter is at the same frequency as it was before. Useful if IF shift had been used to follow a moving signal.

RIT — Receiver Independent Tuning: these controls shift the receiver up or down in frequency from the VFO setting, leaving the TX unchanged. The RIT button turn RIT on/off; The **0** button clears the RIT offset.

XIT — Transmitter Independent Tuning: these controls shift the transmitter up or down in frequency from the VFO setting, leaving the RX unchanged. The XIT button turn XIT on/off; The **0** button clears the XIT offset.

4.1.8 RX1 DSP Group

NR — Activates noise reduction, to minimise random noise. This attempts to reduce the noise in the channel while preserving signal content.
- Unlit: Noise reduction inactive
- NR lit: Activates the LMS noise reduction algorithm
- NR2 lit: Activates the spectral noise reduction algorithm

NB — Activates the wideband noise blanker, to remove impulse interference.
- Unlit: Noise Blanker inactive
- NB lit: Noise Blanker active, and sets receiver input to zero during impulse
- NB2 lit: Noise Blanker active, and estimates the signal the receiver would have seen during an impulse.

MUT — Mutes the RX1 audio feed to the radio's speakers and headphones. (Note that this does not mute audio to a VAC channel, eg to PC speakers).

MNF	Activates the manual notch frequency. Notch frequencies are entered in the Menu > Setup > DSP > MNF form (see section 6.4). This should be used as a last resort!
ANF	Activates the Automatic Notch Filter. This filter will attempt to notch out interfering carrier signals within the receiver passband.
SNB	Activates the spectral Noise Blanker. The SNB detects impulse interference and attempts to estimate the "correct" receiver signal during the presence of the impulse.
BIN	Turns on/off Binaural mode. Binaural mode is a tuning aid for CW reception with stereo speakers or headphones. In this mode higher frequencies move to the right of the stereo field and lower frequencies to the left. A signal will be correctly tuned in the centre of the stereo field.

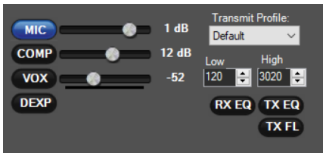
4.1.9 MultiRX Group

Vol (left)	This duplicates the RX1 AF gain control.
Vol (right)	Sets the Sub receiver AF gain, when it is enabled.
Pan (top)	Moves the RX1 signal to the left or right of the stereo audio channel; when in the centre, equal signals go to left and right channels.
Pan (bottom)	Moves the Sub receiver signal to the left or right of the stereo channel
MultiRX	Enables the sub receiver. This provides a second receiver channel using the RX1 RF channel and A-D converter. If RX2 is disabled, VFO B sets its frequency. If RX2 is enabled, the frequency is set in the band segment box for VFO A.
Swap	Swaps the left/right settings of the PAN controls. A signal that had been only in the left audio channel would be only in the right audio channel.

4.1.10 Mode Dependent Group

Four sets of controls can be shown here, depending on the currently selected operating mode. The correct set is selected and displayed automatically. These settings provide controls specific to that type of mode.

4.1.10.1 Voice

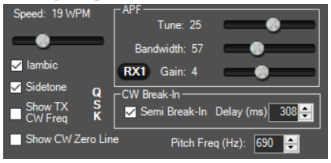


This panel is selected automatically for "voice" modes other than FM.

Mic	Enables the radio microphone input. (when unlit the microphone is muted)
Mic Gain	Adjusts the microphone gain. A 20dB boost is available on the setup form if sufficient gain isn't available.
COMP	Selects the speech compressor.
Comp Gain	Sets the gain value for the speech compressor.
VOX	Enables Voice Operated Transmit.
Vox Threshold	Sets the audio threshold at which VOX activates the TX.
DEXP	Enables the downward Expander. Only available when VOX is selected.
Filter Low	Sets the low edge of the AM/SSB TX filter (typically 300Hz)

Filter high	Sets the upper edge of edge of the AM/SSB TX filter (typically 2700Hz-3000Hz)
RX EQ	Activates or deactivates the receiver audio band equaliser (see section 5.4)
TX EQ	Activates or deactivates the transmitter audio band equaliser (see section 5.4)
TX FL	If selected, shows the TX filter bandwidth on the main display
Transmit Profile	This combo box shows the current selected profile, and allows a new profile to be selected. The profile consists of all of the TX audio chain settings; this allows different settings for different kinds of operation, eg for different bands, for contests or for "ragchewing".

4.1.10.2 CW



This panel is selected automatically for CW modes (CWL, CWU).

Speed	This sets the keyer speed, in words per minute
Pitch freq	Sets the frequency expected for CW audio. This sets the offset from carrier for TX operation.
Iambic	When ticked, the keyer generates timed dots and dashes triggered by an Iambic keyer. When unticked a "straight" key is assumed.
Sidetone	Turns on/off audio sidetone for CW (either normal key or iambic keyer)
Show TX CW Freq	If ticked, shows a yellow marker in the main display for the actual TX frequency (this may be different from RX frequency because if RIT or XIT).
Show CW Zero line	If ticked, shows a yellow marker in the main display for the centre RX frequency.
QSK	Turns on "full breakin" operation.

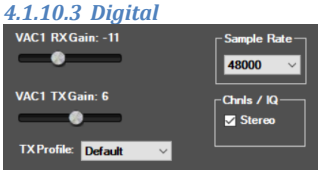
Audio peaking filter section

Enable (marked RX1 or RX2)	Activates the APF: this is a narrow peak filter but not "brick wall". The amplitude will be greatest at centre frequency, but mis-tuned signals will be heard at lower amplitudes. There are three APF algorithms – one for each of RX1, RX2, Sub RX. Settings for the others are available on the Menu > Setup > DSP > Audio form
Tune	Sets the APF centre frequency, relative to the sidetone frequency
Bandwidth	Sets the bandwidth of the APF, in Hz
Gain	Sets the gain (amplitude enhancement) of the APD

CW Break-in section

Semi break-in	If ticked, the RX will be re-enabled a short period after the keyer is released. The delay time (ms) is adjustable.

4.1.10.3 Digital



VAC RX gain	Adjusts the gain of the selected VAC RX audio channel (note that VAC1 is selected for digital operation unless RX2 is active AND VAC2 is enables AND VFOB is selected for TX)
VAC TX Gain	Adjusts the gain of the selected VAC TX audio channel
Sample Rate	Sets the sample rate for the VAC audio channel
Chnls/IQ	Selects the VAC channel to be mono or stereo
Transmit Profile	This combo box shows the current selected profile, and allows a new profile to be selected. The profile consists of all of the TX audio chain settings; this allows different settings for different kinds of operation, eg for different bands, for contests or for "ragchewing".

4.1.10.4 FM

Transmit Profile	Sets the profile settings used for TX. It will be worth creating a unique profile for FM operation.
Mic Gain	Adjusts the mic gain used for FM operation
Deviation	Sets the deviation in use: 2.5 or 5KHz. 2.5KHz is more common nowadays!
CTCSS	Activates a TX CTCSS tone, with user settable frequency. Use for privacy or keying repeaters. (Note received RX CTCSS can be removed – see Menu > Setup > DSP > FM form)
RPTR offset	Sets offset frequency between RX and TX. Activated by the buttons below.
-	Sets a TX frequency below RX
Simplex	Sets TX frequency same as RX frequency
+	Sets TX frequency to be above the RX frequency
Rev	Swaps the RX and RX frequencies (a quick way to listen on repeater input for example)
Memory	Activates use of a stored frequency from one of the memories (see memory form, section 5.2). A list of memories is provided, with up/down buttons to step between them.

4.1.11 RX2 Group

The RX2 group is at the bottom of the screen. If a second receiver is not selected, this group is hidden. The group provides the same controls for RX2 as the other controls provide for RX1, with a few minor changes.

The RX2 band is selected using a combo box at the left hand side of the group. Bandstacks are not available for RX2.

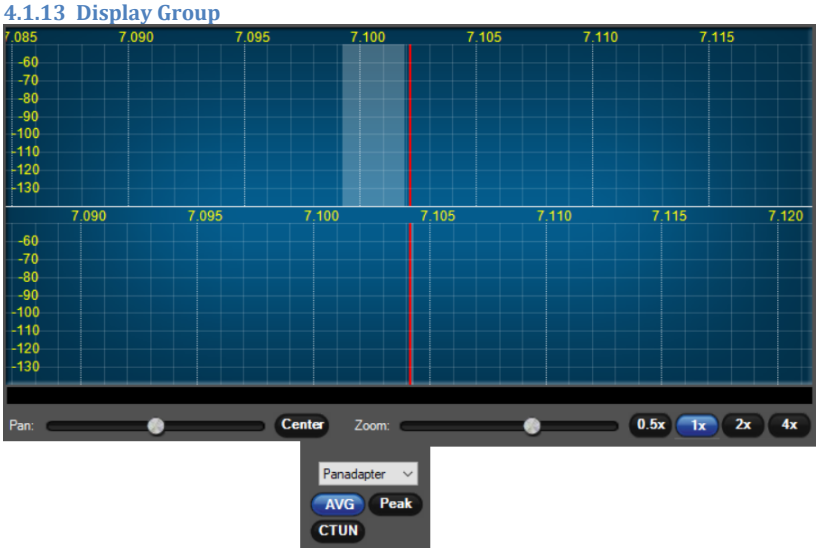
SD Enables the Stereo Diversity feature. In this mode RX2 and RX1 are both tuned by VFO A. You should ensure that RX1 audio is presented to the left audio channel and RX2 to the right.

4.1.12 Miscellaneous Group

The three boxes to the left provide information: date, time and CPU usage. Clicking inside either time or data box goggles between LOCal time, UTC time and display off. CPU usage is useful to determine whether the settings selected are within the capability of the PC being used.

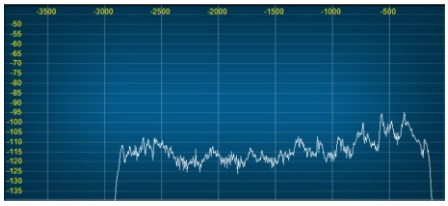
The two buttons to the right turn on / off the two Versatile Audio Connection[1] (VAC) channels. These can be used to connect to an audio device (e.g. a sound card) or to an external program via 3rd party software.

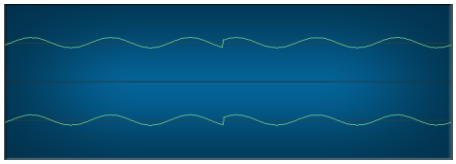
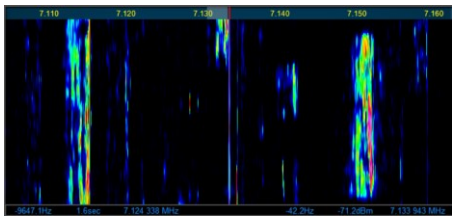
4.1.13 Display Group

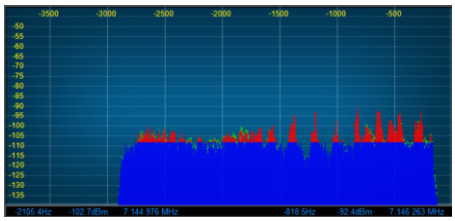
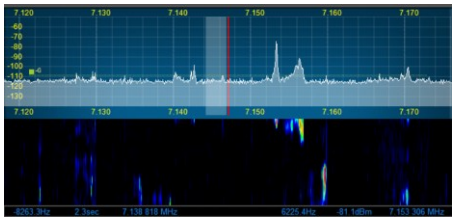
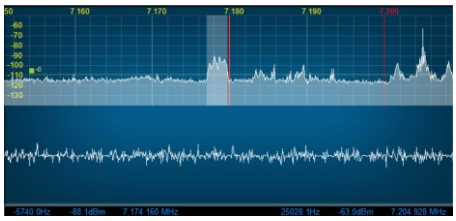
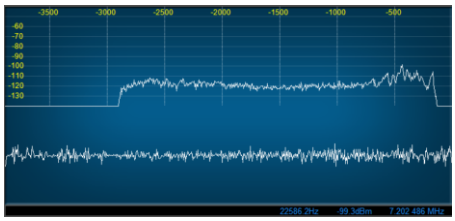


[1] Originally "Virtual audio Cable" but Thetis VAC ports can be used for many PC audio connections.

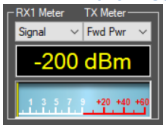
This is the main operating display for the radio.

Visual Display	Provides a display of the signal seen through the receiver, or the TX signal when transmitting. If RX2 is active, this display will be split into two halves: RX1 above, RX2 below, with the same scales.
Zoom	Allows the display to be zoomed into a part of the band covered. If the slider is at the extreme left, the full band provided by the radio is displayed. If it is moved to the right, the display zooms into a smaller segment of the band. If the sample rate is set to 384KHz: with the slider at the left, 384KHz span is available.
Zoom buttons	Zoom the display to preset amounts. This has the same effect as moving the zoom slider to that position.
Pan	Pans the displayed part of the band across the bandwidth available from the receiver. If the zoom slider is fully to the left, this will have no effect.
Center	Centres the displayed part to the middle of the band.
Display mode	Chooses the display mode selected for RX1.
AVG	Time averages the amplitude at each point of the display. The averaging parameters are set in Menu > Setup > Display > RX1 (or RX2)
PEAK	"Peak holds" the display: this provides persistence to spot fleeting signals
CTUN	Activates "Click Tune". When active, clicking or dragging the display doesn't pan the display but instead moves the tuned signal away from the centre. This is useful if you want the view of activity to stay "as is".
Several display modes are available; "Panafall" and "Panadapter" will be the most useful for normal operations:	
Spectrum	Displays the spectrum (amplitude vs frequency) within the receiver passband 
Panadapter	Displays amplitude vs frequency of the whole RX band provided by the receiver. This is useful to see spectrum activity and find signals of interest. 

Scope	This displays amplitude vs time for the RX passband. This is most likely to be useful for monitoring TX audio to see the peal-to-average ratio. 
Scope 2	Provides two identical amplitude vs time displays. 
Phase	This displays the signal within the receiver passband as an Argand diagram showing phase around a unit circle. Useful for setup and receiver debugging. 
Phase 2	This shows an Argand diagram but I can't tell what of! 
Waterfall	This displays frequency (horizontal) covering the full band provided by the radio vs time (vertically, most recent at the top). Each successive updates provide a new row of pixels at the top; the display scrolls down. Amplitude is displayed as a colour with higher amplitudes being brighter. This shows activity "running downwards": for example the signal three quarters of the way across the display is an SSB signal. 

Histogram	This shows the spectrum view within the RX passband. It is coloured according to activity: red shows very recent activity, green shows peaks that are slightly older and blue the average background. 
Panafall	This is potentially the most useful view. It combines a panadapter covering the full band provided by the receiver, together with a waterfall display. This shows immediate spectrum activity (top) and an indication of activity over the last few seconds (bottom). 
Panascope	A combined display: combines a full band panadapter with an oscilloscope view of the RX passband 
Spectrascope	A combined display: combines a spectrum view of RX passband with an oscilloscope view within RX passband 
Off	

4.1.14 Multimeter Group



This group contains the multi-function "multimeter" analogue display, a "current value" box, and combo boxes to choose meter mode for each of receive and transmit.

RX1 Meter The RX1 multimeter can be selected from the following options:

Signal	RX1 Peak reading S meter
Sig Avg	RX1 Average reading S meter
ADC L	RX1 ADC peak (expressed in dB relative to full scale)
ADC R	RX1 ADC peak (expressed in dB relative to full scale)
ADC2 L	RX2 ADC peak (expressed in dB relative to full scale)
ADC2 R	RX2 ADC peak (expressed in dB relative to full scale)
Off	(May be useful to reduce CPU utilisation)

(note that the RX2 meter has the same options; Signal & Sig Avg display RX2 S meter values; the ADC displays for both receivers available in both meters)

Commented [LB2]: Warren: I'm not sure we've ever bothered to calibrate the ADC readings to the ADC full-scale. That's easy to check since the point of ADC Overload would be full-scale. Secondly, at some point, perhaps in an appendix, it may be worth explaining how Signal and Sig Av relate to each other AND how they relate to signal strength readings on the panadapter. These questions have been asked MANY times and it would be nice to have them answered in the manual.

TX Meter The TX multimeter can be selected from the following options:

Fwd Pwr	Estimate of transmitter forward output power in watts
Ref Pwr	Estimate of transmitter reverse power in watts
SWR	Estimate of SWR
Mic	Peak microphone audio level (dBV)
Fwd SWR	(same as "Fwd Pwr")
EQ	Peak post-equaliser audio level (dBV)
Leveler	Peak post-amplitude leveller audio signal level (dBV)
Lev Gain	Displays the amplitude leveller gain (dB)
CFC	Peak post-CFC (continuous frequency compressor) audio level (dB)
CFC Comp	Displays the CFC gain (dB)
COMP	Displays post-speech processor & CESSB audio level (dBV)**
ALC	Displays post-ALC audio level (dBV)**
ALC Comp	Displays the ALC gain (dB)
Off	(May be useful to reduce CPU utilisation)

The estimates of forward and reverse power are radio dependent.

** COMP and ALC values can be set in the Menu > Setup > Transmit form to be peak or instantaneous values using **use peak meter readings for TX COMP and ALC**)

(Note that the TX meter setting used in TUNE mode is defined in the Menu > Setup Transmit form)

4.2 Main Menu commands

Setup	Displays the setup form (see section 6)
Memory	Displays the memory form (see section 5.2)
Wave	Displays the audio record/replay form (see section 5.3)
Equalizer	Displays the graphic equalizer form (see section 5.4)
XVTRs	Displays the Transverters form (see section 5.5)
CWX	Displays the CW transmit form (see section 5.6)
Diversity	Displays the Diversity form (see section 5.7)
Collapse	Changes the display to one of the "collapsed" views (see section 2.2)
Spot	Displays the DX spotting form (see section 5.8)
Linearity	Displays the Puresignal form (see section 5.9)
RA	Displays the Radio Astronomy utility (see section 5.10)
WB	Displays the wideband display form (see section 5.11)
PI	Displays the RF Paths form (see section 5.12)
If the "Collapsed" display is selected additional menus become available:	
Expand	Restores the display to the normal "expanded" console view
Display Controls	Controls the top/bottom bars in the "collapsed" displays Top Controls — Shows the "classic" top display bar Band controls — Shows the band buttons below the display Mode controls — Shows the mode buttons below the display Andromeda Top Controls — Shows the "Andromeda" top bar Andromeda Button Bar — Shows the "Andromeda" menu buttons
DSP	Allows several DSP modes and display modes to be selected
Band	Allows the band to be selected from the menu
Mode	Allows the operating mode to be selected from the menu
Filter	Allows the filter bandwidth to be selected from the menu
RX2	Allows the band / mode / filter / DSP settings for RX2 to be selected

4.3 Andromeda Menu Bar

In the "Andromeda" collapsed view, this bar shows a row of 8 buttons. These provide a set of configurable commands in a row of 8 menu entries. Buttons can call up a different row, allowing very capable menu structures to be created.

- A button marked "menu" will call up a different menu row when pressed.
- When pressed, buttons will change a setting or call up a form.
- If highlighted, the button indicated the current "on/off" state of something.
- Button text can be changed to indicate something – e.g. whether it is controlling RX1 or RX2.

For example: the menu above shows the “quick menu”;

- RX1 NR is enabled, and pressing the second button would step to RX2 NR2 selected.
- Buttons are also available for RX1 NB, SNF, ANF, AGC and Attenuation.
- Pressing each button will select the next option for that control. Attenuation is stepped in 6dB steps for example.

4.4 Keyboard and Mouse Actions

The PC keyboard and mouse can be used to control the program.

In the main display, the mouse scroll wheel will move the tuned frequency up or down by one step. If the cursor is positioned over a digit in the VFO group, it will move that digit up or down by one step.

The keyboard functions can be configured in the Menu > Setup > Keyboard form. The initial settings are:

Q, A	Step up/down the MHz frequency digit
W, S	Step up/down the 100KHz frequency digit
E, D	Step up/down the 10KHz frequency digit
R, F	Step up/down the 1KHz frequency digit
T, G	Step up/down the 100Hz frequency digit
Y, H	Step up/down the 10Hz frequency digit
U, J	Step up/down the 1Hz frequency digit
M, N	Step up/down the current band
B, V	Step up/down the current selected filter bandwidth
X, Z	Step up/down the current mode
O, I	Step up/down the current RIT frequency offset
[, P	Step up/down the current XIT frequency offset
Space bar	Press-to-talk (MOX)

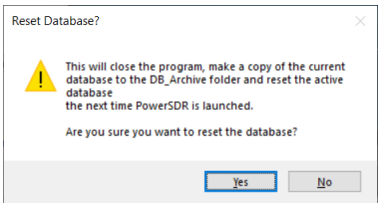
4.5 Database Reset

Occasionally it is recommended to carry out a database reset. This resets all settings to initial, “safe” values. There are two occasions when this could be needed: after a major update, which has changed too many settings to be individually described; and if you have edited settings in a way that turned out to be inappropriate, and you cannot recover.

To prepare for this consider the following actions to preserve changes that you want to reinstate:

- Make screenshots of important or complex settings, for instance amplifier calibration values.
- Use Menu > Setup > Transmit > Export Current Profile to export important and/or complex transmit profiles.
- Use Menu > Setup > CAT > Configure MIDI > Manage Mappings > Export Mappings to export MIDI settings.

You can now carry out the database reset. Open the Menu > Setup form and click the **Database Reset** button at bottom left. It will issue a warning; click **Yes** to proceed.

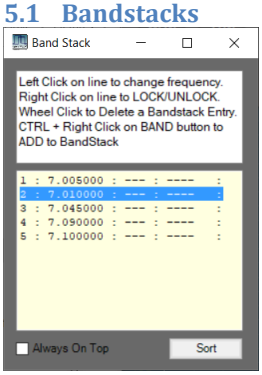


To restore any saved settings:

- For each transmit profile exported it can be imported using Menu > Setup **Import Database**. It will require a separate import cycle for each profile.
- MIDI settings can be imported using the “Import Mappings” function that was adjacent to the “Export Mappings” function referred to above.

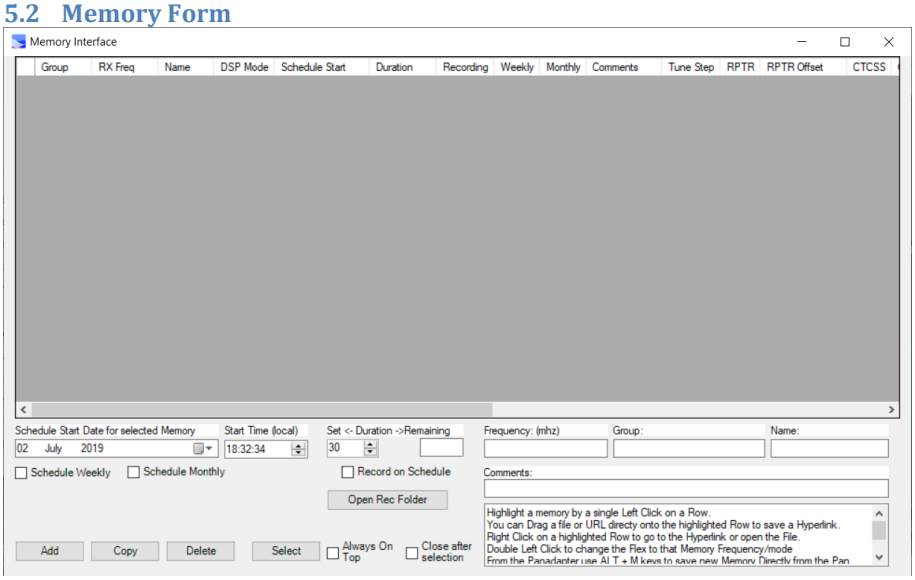
5 Other Forms

5.1 Bandstacks



This form allows bandstacks for each band to be edited. It provides instructions at the top of the form.

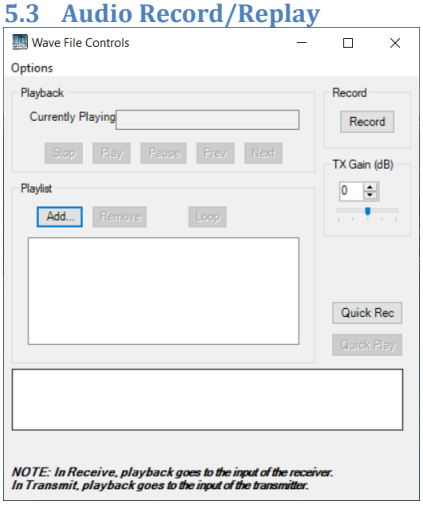
5.2 Memory Form



This form allows menu settings to be stored, edited and recalled. When **Add** is clicked the current console settings are copied to a new menu entry. Many of the settings are stored, and can subsequently be edited.

This is also used from the FM mode settings (see section 4.1.10.4) to select a new FM memory in the same way that a VHF/UHF FM transceiver would do the same. It is a good idea to set the tuning step size to the local channel step size (e.g. 12.5KHz for the 2m band in Europe) before creating the menu entry.

5.3 Audio Record/Replay

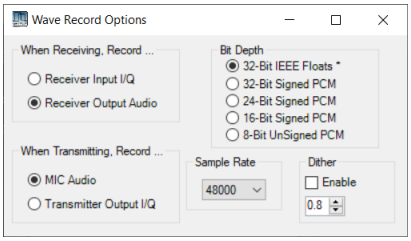


This form allows signals to be recorded, then replayed later. Signals can be received (off-air) signals or TX signals.

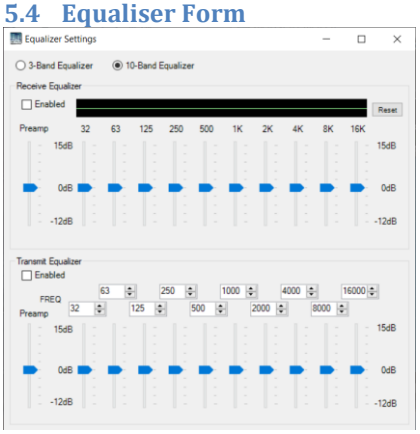
Received signals can be stored as receiver ADC samples; when replayed, they are replayed through the receiver processing chain. This could allow different DSP settings to be used to recover an unintelligible signal for example. Alternatively the processed RX audio can be recorded, consuming less disk space. Similarly, TX signals can be recorded as microphone audio or the result of the entire TX chain can be stored. They can then be replayed through the transmitter, as a voice keyer.

"Quick Record" and "Quick play" can be accessed as single button pressed from the expanded display form.

Options for waveform record & replay can be selected by clicking the form's **Options** menu item. This brings up the options form below:



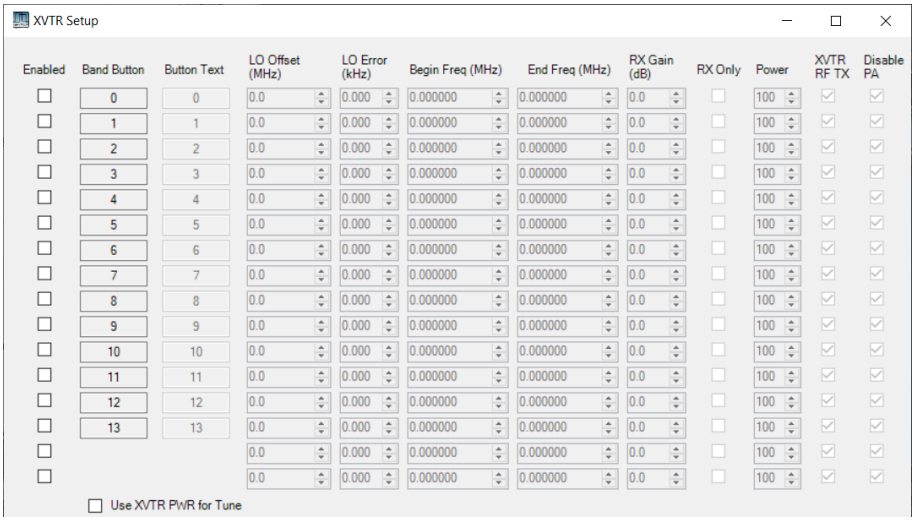
5.4 Equaliser Form



This form provides a 3 or 10 band graphic equaliser. It allows the RX and TX audio paths to be separately equalised (i.e. gain adjusted vs frequency). This is particularly important for TX, as different microphones have very different frequency response characteristics.

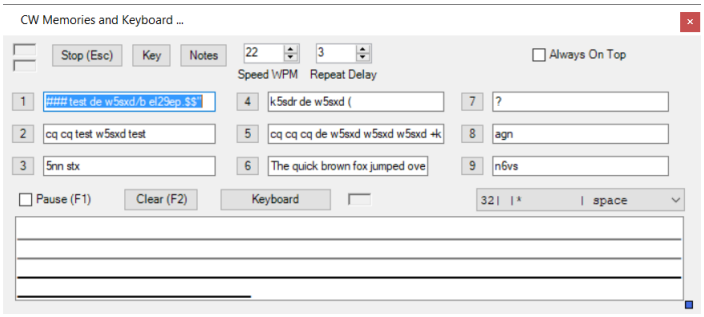
The equaliser interpolates between the amplitudes at each frequency point, to avoid sudden jumps at each new point. The amplitudes are not flat in between the frequency points.

5.5 Transverters



This form allows the radio to be used as an HF exciter to feed a transverter, which converts the signal to another band. When enabled, this form adds entries to the **VHF** band button panel so that transverters can be rapidly controlled.

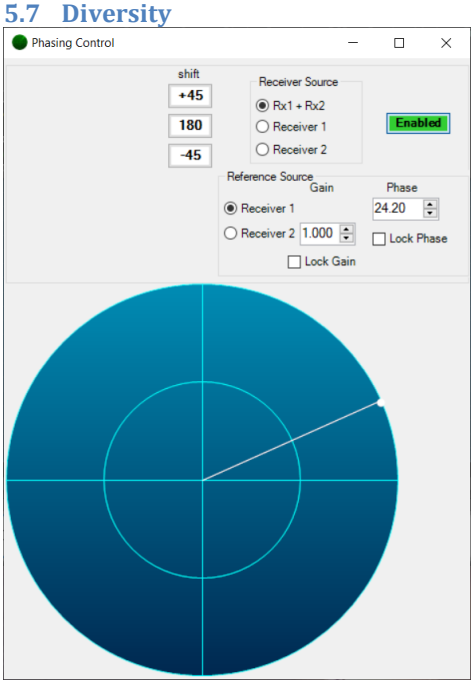
5.6 CW Transmit



This form allows commonly used messages to be recorded, then replayed as CW on demand. Also text can be typed in and transmitted.

The **Notes** button brings up a set of instructions.

5.7 Diversity

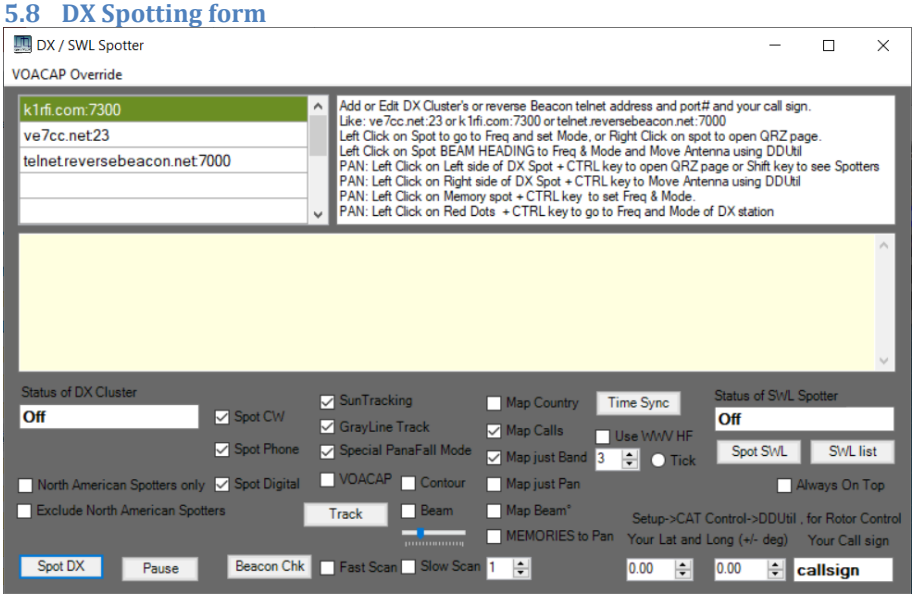


Diversity allows a receiver equipped with dual A-D converters to implement beamforming. This requires two fully independent inputs, one through each A-D converter, from two antennas. This can be used to enhance a weak signal, or to steer a null towards an interference source. Diversity improves the received signal for RX1, but is independent of the operation of RX2. RX2 can be used on a different band if desired; the only constraint is if it is on a different band, its RX filters will need to be disabled.

To use diversity:

1. Select the Menu > Diversity menu item to open the Diversity form.
2. Set **Receiver source** to RX1 + RX2
3. Set **reference Source** to RX1
4. To minimise interference:
    a. Use the mouse to select the “dot” on the display
    b. Click and hold the mouse, and drag the dot around the outer circle on the display
    c. You should see the panadapter noise floor move up and down as you drag
    d. Find the angle giving minimum noise floor
    e. Keeping the mouse at that angle, move in towards the centre until you get minimum noise
    f. If you aren’t able to get a minimum: Set **reference Source** to RX2 and try again
5. To maximise strength of one signal:
    a. Use the mouse to select the “dot” on the display
    b. Click and hold the mouse, and drag the dot around the outer circle on the display
    c. Find the angle giving maximum signal on the panadapter for the wanted signal
    d. Keeping the mouse at that angle, move in towards the centre until you get maximum signal
    e. If you aren’t able to get a maximum: Set **reference Source** to RX2 and try again
6. To turn diversity off, Click **Enabled** and it will turn to a red **Disabled** button.

5.8 DX Spotting form



This form is provided to allow the radio to be quickly set to the appropriate settings for a station identified in a DX Cluster. DX cluster websites can be accessed, and the frequency / mode / beam heading can be established automatically. The form has its own instructions.

5.9 Puresignal

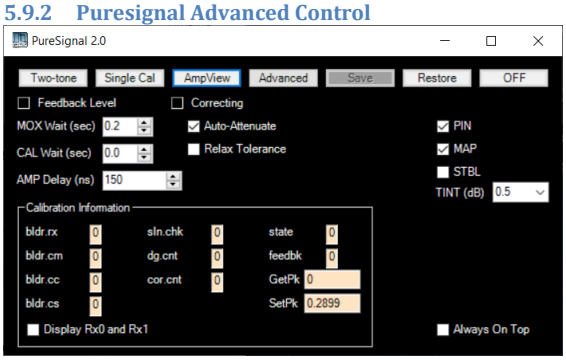
Puresignal is a technology to linearise the transmitter's power amplifier. When Puresignal is enabled, THETIS applies dynamic corrections to ensure that the output signal from the amplifier is as close as possible to that originated by the software. Puresignal has three possible display forms:

5.9.1 Puresignal Control

This is the standard display.

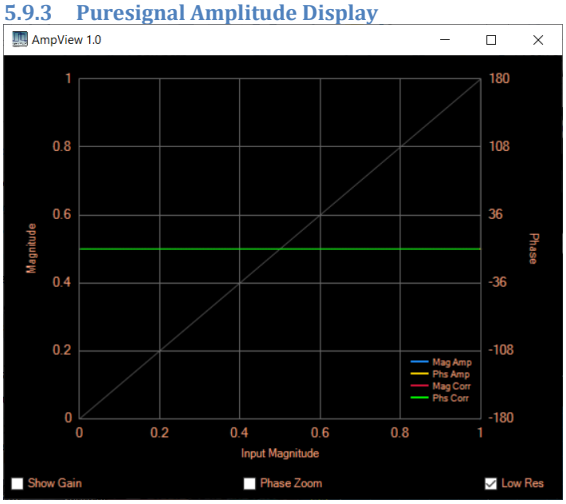
Two-tone	Perform a thorough two-tone test
Single Cal	Perform a quick single calibration
AmpView	Shows the Puresignal Amplitude display (section 5.9.3 below)
Advanced	Calls up the advanced display (below)
Save	Saves the current correction settings to a file
Restore	Restores correction settings from a previously saved file
Off	Turns Puresignal off
Feedback Level	Lights Green when a valid feedback signal has been received. If this is not green during a test or operation, sufficient signal is not been fed back via the coupler.
Correcting	Lights green when linearization corrections are being made

5.9.2 Puresignal Advanced Control



The advanced display provides more information and controls. It is recommended that these be left unchanged unless you know what you are changing!

5.9.3 Puresignal Amplitude Display



The AmpView Display shows the measured gain and phase characteristics of the analogue amplifier chain and the gain and phase correction being applied by PureSignal.

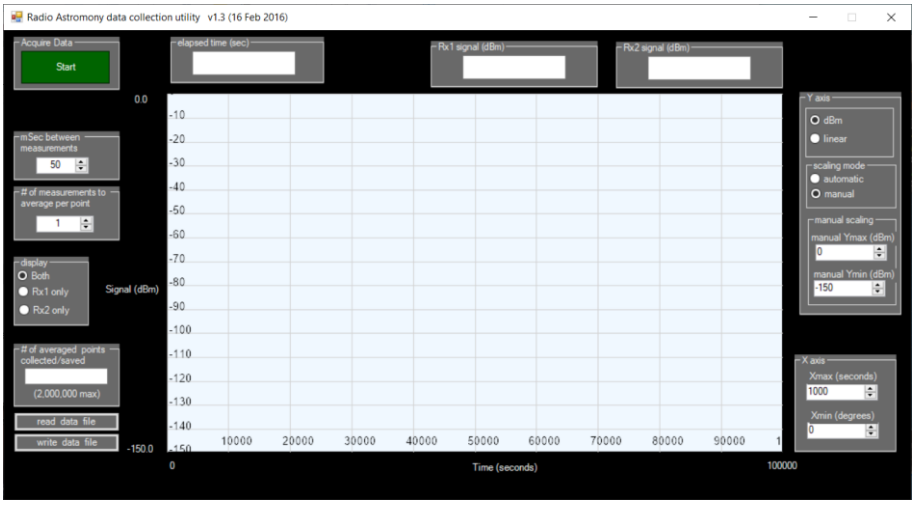
5.10 Radio Astronomy

(With thanks to Joe K5SO for this description)

The RA option is intended to operate essentially as a “strip chart recorder” function for those interested in observing and recording signals received by the HPSDR as a function of time.

The signals displayed are the signal-level values that PowerSDR/Thetis sends to the S-meter, not raw data from the radio. In particular, the signals shown in the RA option are not the instantaneous IQ values being received from the radio, they are instead signals that have been subjected to the digital signal processing routines of PowerSDR/Thetis that generate the S-meter readings shown on the main displays of those software programs.

There are several controls implemented that are similar to those you might find on conventional strip chart recorders and a few controls that you don’t find on them. These controls are described briefly below, referring to the attached JPEG image of the RA display that becomes visible when the RA option is selected in PowerSDR or Thetis. The RA display is shown below:



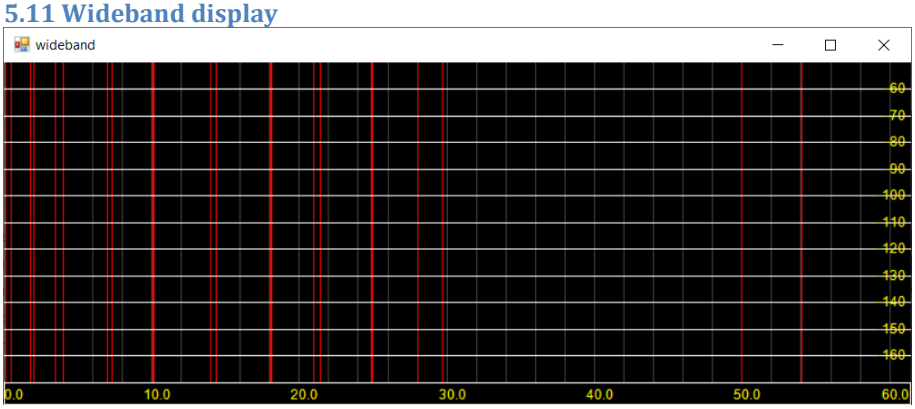
Start	This button in the Acquire data box of the display initiates and halts acquisition and display of data from the radio. Each time data is started old data is discarded and is lost unless it was saved earlier using the "write data file" button described later.
mSec between measurements	This allows the user to select a value of the number of milliseconds that should exist between signal-strength measurements, in the range 50-1000 in increments of 1 mSec.
# of measurements to average per point	This box allows the user to select how many points are to be used to average together for each point displayed. The range is 1-2000 points.
Display	This box allows the user to select what signals are to be plotted on the RA graph. Both plots signals independently from Rx 1 and Rx2 in different pen colors so they can be distinguished from each other Rx1 only plots only the signal from Rx1 Rx2 only plots only the signal from Rx2
# of averaged points collected / saved	This box shows the user how many data points have been written to file as the data acquisition proceeds.
read data file	Opens a dialog box in which the user may specify a data file to read and display using the RA option. The default filename is "RA_data.csv".
write data file	Opens a dialog box in which the user may specify a filename to use to write the data to disk, the default filename is "RA_data.csv".
elapsed time (secs)	Displays how long the current data acquisition has been running, in seconds. It resets to zero when a new "Start" is initiated
Rx1 signal (dBm)	Displays the instantaneous signal strength of RX1 in dBm
Rx2 signal (dBm)	Displays the instantaneous signal strength of RX2 in dBm

Y-axis	Contains controls to allow the user to set and/or select various modes and limits of the y-axis of the graphics plot including, mode of operation (logarithmic (dBm) or linear (arb. units)), automatic or manual scaling of the y-axis, and max/min limits for the display when in manual scaling mode. In dBm mode the max/min limits are -140 to 1000 for the Ymax limits and -150 to 1000 for the Ymin limits. Of course 1000 is a far greater level than is physically achievable with HPSDR but that is the Ymax limit for the graph.
X-axis	Contains controls to allow the user to specify an x-axis range for the graphic display with Xmin values ranging from 0-99999 seconds and Xmax values ranging from 1-100000 seconds.

Joe K5SO created this display and offers the following observations on its use:

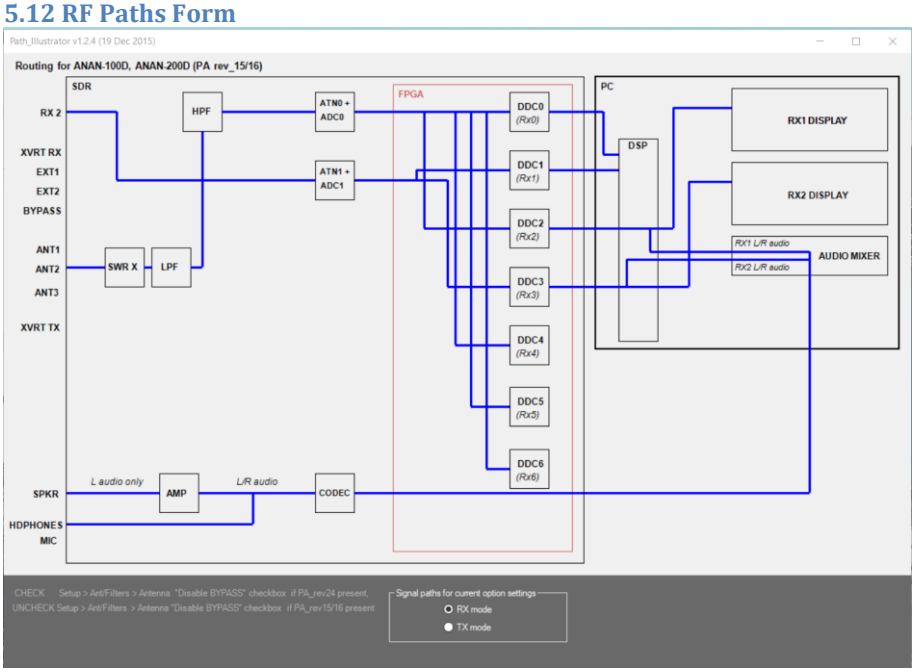
I have usefully employed the RA option personally in the past to measure sun noise, while using UHF/microwave to HF down converters, for system testing. Also, I have usefully employed the RA option during EME operations to monitor moon noise (thermal emission from the moon) to ensure my tracking is optimum during EME QSOs. Others might use the RA option to monitor signal levels directly on the HF bands. One could use the option to obtain a graphical display of the nulling effect of the Diversity option in PowerSDR/Thetis, although I've never actually done that personally. I'm sure there are numerous other uses for the RA option but these four are what come to my mind at the moment without thinking too hard about it.

5.11 Wideband display



This display provides an amplitude vs frequency display of the whole spectrum seen by the software defined radio. The amateur bands are marked by red vertical bands.

5.12 RF Paths Form

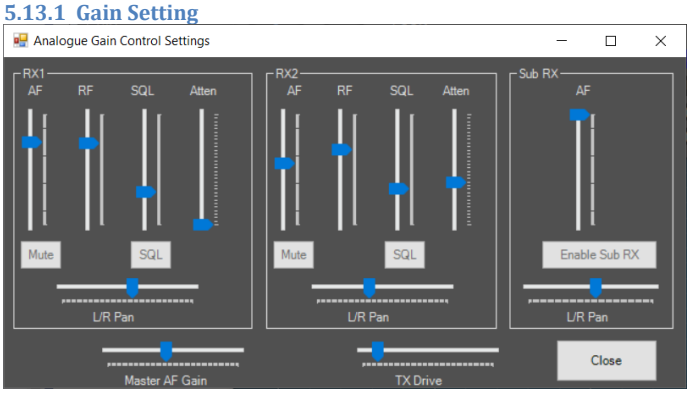


This form provides an illustration of the signal path in use for the current selected radio and operating mode.

5.13 Andromeda Popup Forms

This section lists the popup forms that have been created for the Andromeda mode. These are designed to allow settings to be activated while using a 7" touchscreen display. Most have larger controls than used elsewhere so they can be "touch" operated (although a mouse can of course still be used).

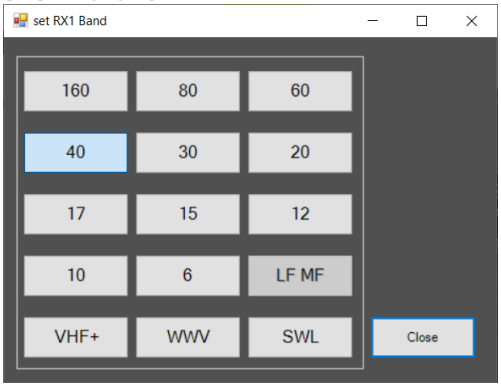
5.13.1 Gain Setting



This form is intended for use with the "Andromeda" collapsed view, where most of the controls are hidden. It duplicates several of the analogue settings available through the "expanded" display.

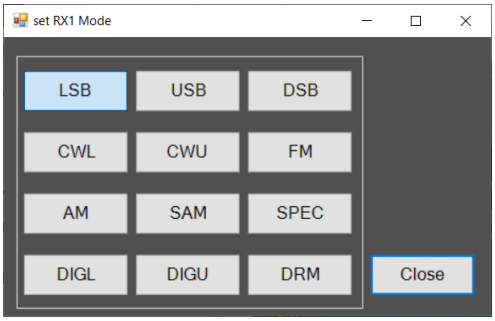
Many of these controls are available as physical controls on the Andromeda front panel; this form may be useful to see what position the control is set to.

5.13.2 Band Form



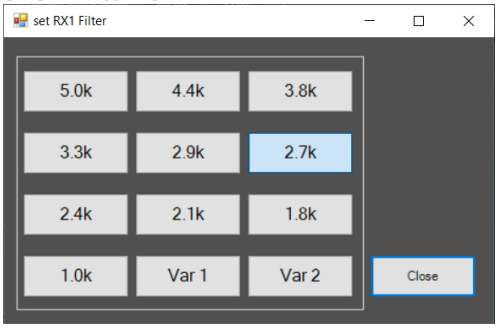
This form provides access to the full set of “band” buttons. They have the same functions as the console buttons described in section 4.1.3. The Andromeda front panel provides “band up” and “band down” for quick band changes.

5.13.3 Mode Form



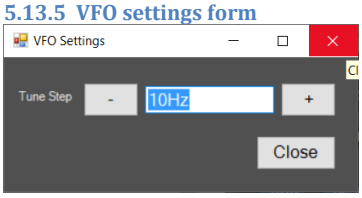
This form provides access to the full set of “mode” buttons. They have the same functions as the console buttons described in section 4.1.4. The Andromeda front panel provides “mode up” and “mode down” for quick mode changes.

5.13.4 Filter Form



This form provides access to the set of "filter" buttons. They have the same functions as the console buttons described in section 4.1.5. The Andromeda front panel provides "filter up" and "filter down" for quick filter changes. It also provides rotary controls for filter high cut and filter low cut: these select the **VAR 1** filter, then adjust the upper and lower edges of the audio passband respectively.

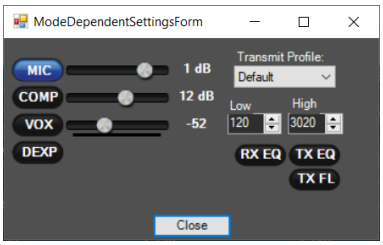
5.13.5 VFO settings form

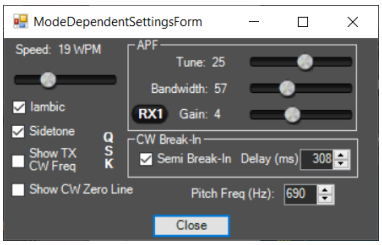


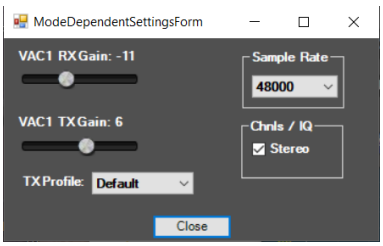
This form provides the "VFO Tune Step" setting. This sets the frequency increment used for mouse, keyboard or front panel tune operations; see section 4.1.2.

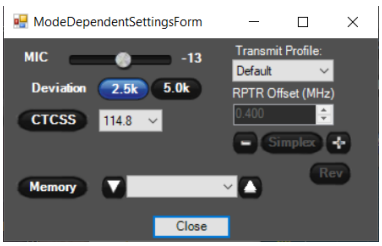
5.13.6 Mode Dependent Settings

Four forms can be shown under "mode dependent settings": depending on the kind of operating mode currently selected. They are identical to those on the expanded display (see section 4.1.10).







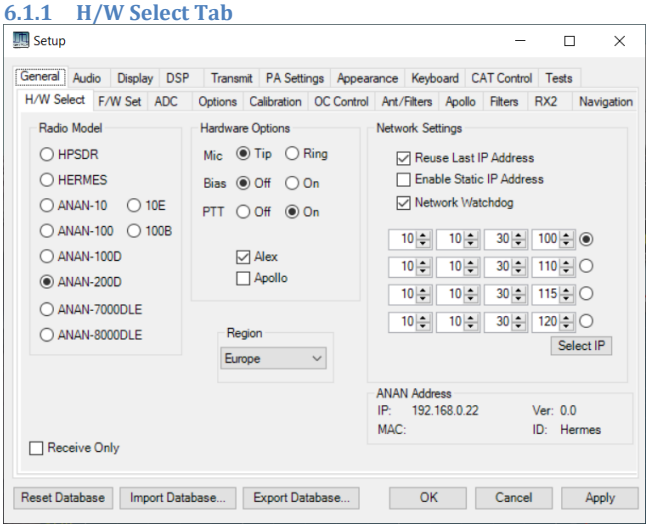


6 THETIS Setup Form

THETIS has a large number of user configurable settings, and many of these are located within a multi-tabbed SETUP form. For many PC programs, the Setup form isn't used much after initial settings have been established; with THETIS, you can expect to use this form often.

6.1 General settings Tabs

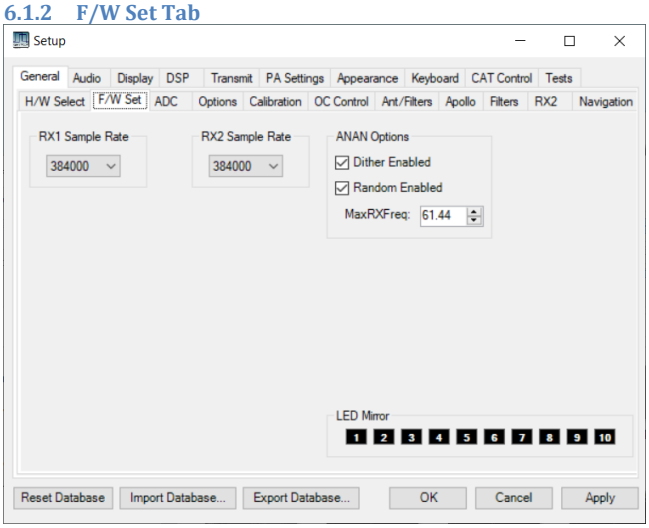
6.1.1 H/W Select Tab



This tab allows your radio hardware to be selected.

Radio Model	Select your radio hardware from the list available.
Hardware Options	Consult our radio manual regarding the options you have available. Mic — Selects the microphone audio connection to be the tip or ring connection of a 3.5mm stereo jack plug Bias — Enables a bias supply for "Electret" microphones on the mic connection PTT — Enables the other connector on the jack plug to be a PTT input; transmits when grounded. Alex — Selects whether a standard set of "Alex" filters are connected (normally an internal part of your radio) Apollo — Selects an alternative "Apollo" PA
Region	Selects the ITU region: used to display the correct band plans
Receive Only	If ticked, the radio will not enter TX mode
Network Settings	Selects IP addresses, if you have multiple radios available. Normally THETIS will find the radio on the network.
ANAN address	Displays the IP address for the radio it has most recently found on the network

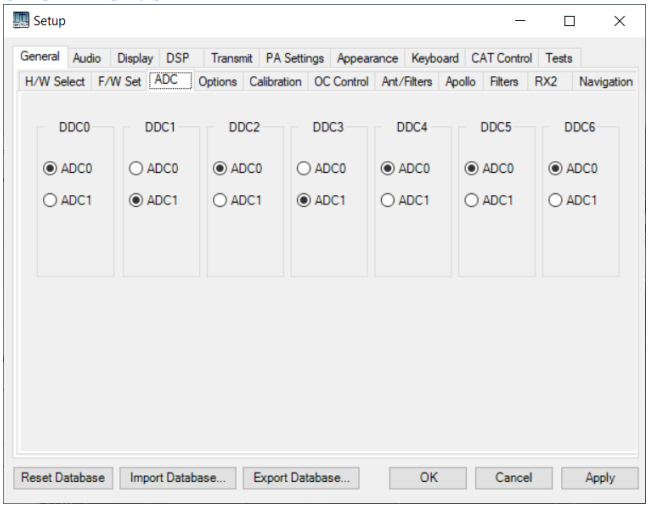
6.1.2 F/W Set Tab



This tab sets the sample rate used for each receiver, and consequently the bandwidth that will be available for the panadapter displays.

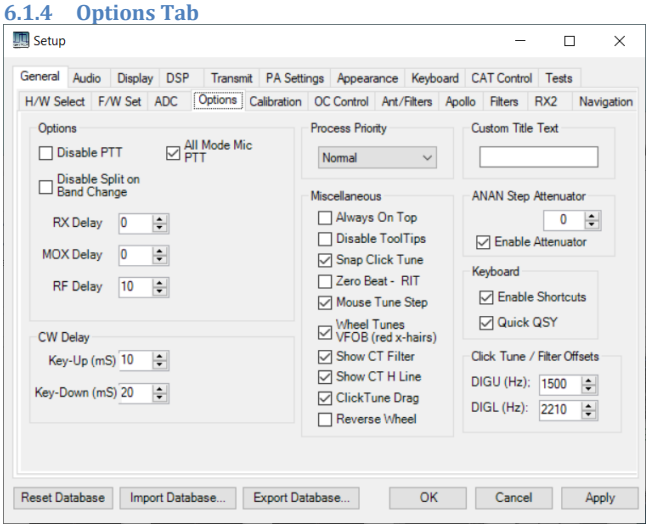
RX1 Sample Rate	Sets the sample rate for the first receiver. The larger the sample rate, the higher the PC CPU utilisation – you will need a reasonably modern PC to use rates above 384000.
RX2 Sample Rate	Sets the sample rate for the first receiver. The larger the sample rate, the higher the PC CPU utilisation – you will need a reasonably modern PC to use rates above 384000.
Dither enabled	When ticked, a small jitter in the sample clock is performed in the A-D converter. This will increase the noise floor slightly but reduce line spurious signal levels
Random enabled	When ticked, the data inside the ADC is “hashed” to reduce digital noise to the ADC. It is “unhashed” in the FPGA giving the same identical data. You may see a small noise reduction if this is ticked.
Max RX Freq	Sets the upper frequency to which the RX can be tuned.

6.1.3 ADC Tab



Sets which A-D converter is connected to which downconverter in the FPGA. The settings available will be dependent on radio model. Do not change this unless you know why you are doing it!

6.1.4 Options Tab

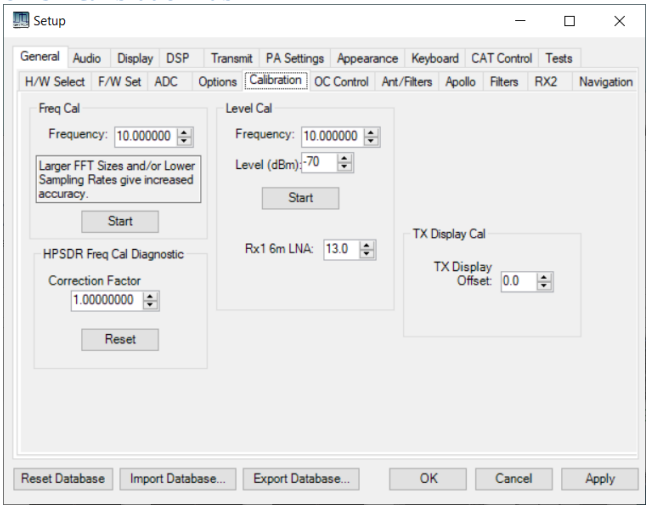


This form has many general options for THETIS

Disable PTT	Disables the PTT input pins to the radio MIC connector
All mode Pic PTT	If ticked, the PTT input on the MIC connector works for all modes. If unticked, it activates TX only when in voice modes.
Disable Split on band change	Disables a band SPLIT operation of the band is changed. (re-enable it after tuning to correct new frequency if required)
RX Delay	Delay (ms) before RX re-enabled after MOX released at end of TX

MOX delay	Delay (ms) after carrier has ramped to zero before MOX released at end of TX
RF Delay	Delay (ms) after TX initiated before carrier ramps up
CW key-up delay	Delay (ms) between CW carrier ramped down and MOX released
CW key-down delay	Delay (ms) after key down before carrier enabled for CW
Process Priority	Sets the process priority that THETIS runs at in Windows
Custom Title Text	Adds a custom string to the title bar
Always on top	If ticked, THETIS is always the topmost window
Disable ToolTips	Disable “helper” strings when the mouse hovers over controls
Snap click Tune	When ticked, Click tune is snapped to the nearest tune step
Zero beat-RIT	When clicked, zero beat uses RIT instead of moving the VFO tune frequency; leaving TX frequency unchanged.
Mouse Tune Step	When clicked the middle mouse button changes the tune step
Wheel Tunes – VFO B	When checked, the mouse wheel tunes VFO B when red cross-hairs active (when SPLIT or MultiRX are active)
Show CT Filter	Displays the receive filter as a grey vertical bar in Click Tune mode (this allows you to see exactly where the receiver will be placed)
Show CT H line	Displays horizontal line in click tune mode
Click Tune Drag	Enables Click Tune and Drag mode
Reverse Wheel	Reverses the direction of the mouse wheel
Anan Step Attenuator	When ticked, the 0-31dB step attenuator is enabled if available. The edit box sets the attenuation to be used. (double clicking in the **ATT** control in the main console also turns this on)
Keyboard Enable Shortcuts	If unticked, the local keyboard commands will be disabled
Keyboard Quick QSY	When enables, typing in a frequency will directly edit the VFO frequency
Click Tune / filter offsets DIGU DIGL	Enters a frequency offset for click tuning when in **DIG L** or **DIG U** modes.

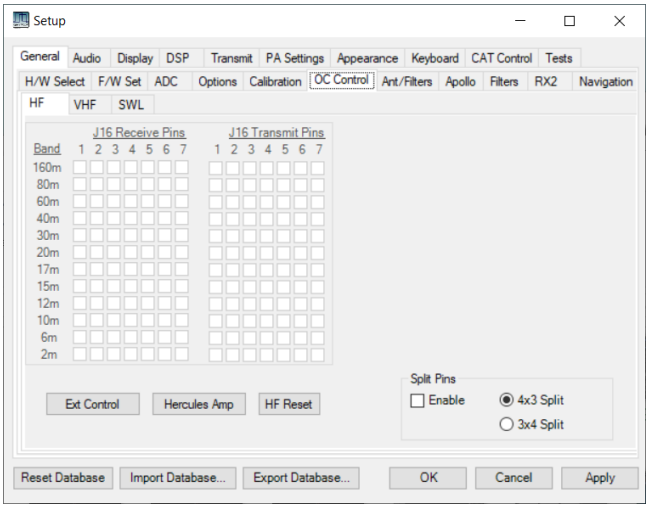
6.1.5 Calibration Tab



Allows calibration constants to be entered, and calibration processes initiated.

Frequency Cal	Allows the absolute frequencies displayed by Thetis to be calibrated against a high quality reference (e.g. a WWV transmission).	
	Frequency	Enter the Frequency (MHz) of the reference input
	Start	Start the calibration cycle
Level Cal	Allows the absolute amplitudes displayed by Thetis to be calibrated against a high quality reference (e.g. a signal generator).	
	Frequency	Enter the Frequency (MHz) of the reference input
	Start	Start the calibration cycle
	RX1 6m LNA	Sets the gain (dB) of the 6 metre band low noise preamp
HPSDR Freq Cal Diagnostic	Correction Factor	correction factor for frequency errors
	Reset	resets the correction factor to 1.0
TX Display Offset	Sets an offset in dB for TX level values	

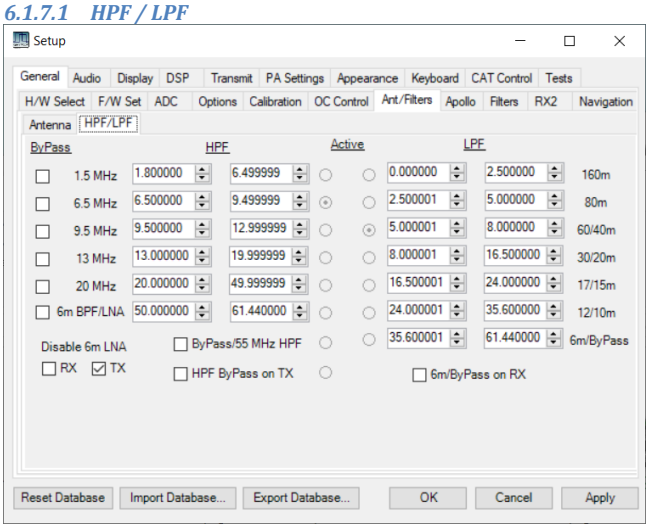
6.1.6 OC Control Tab



Controls the 7 open collector digital outputs. Where ticked, the output will be asserted (like a switch to ground) on a band-by-band basis. Different settings available for RX and TX. These can be used to control external devices: for example to indicate the frequency band to remote antennas, linear amplifiers or antenna tuners.

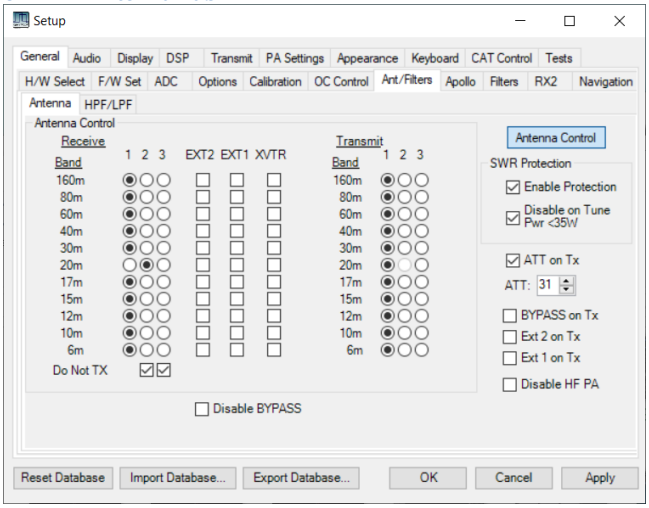
6.1.7 Ant/Filters Tab

6.1.7.1 HPF / LPF



The filters available depend on your radio model. THETIS is aware of the filter configurations, and if you have selected the correct radio type then the filters should be selected correctly for each band. The settings shown on the filters form will depend on the radio type.

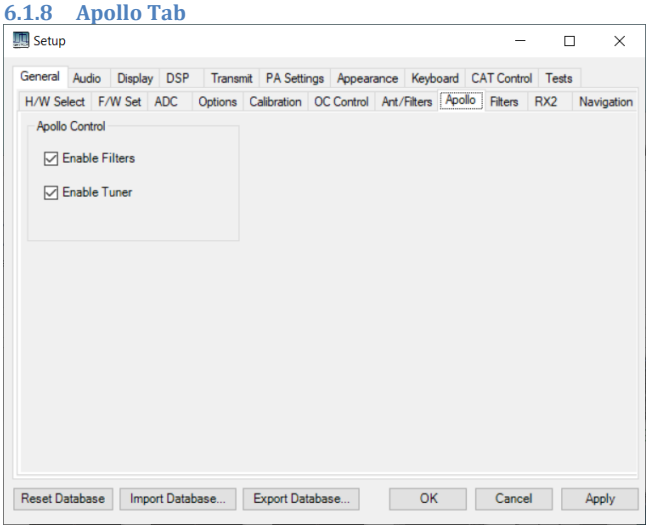
6.1.7.2 Antenna Tab



This form chooses which antenna is used for which band. Consult your radio manual for the exact paths available.

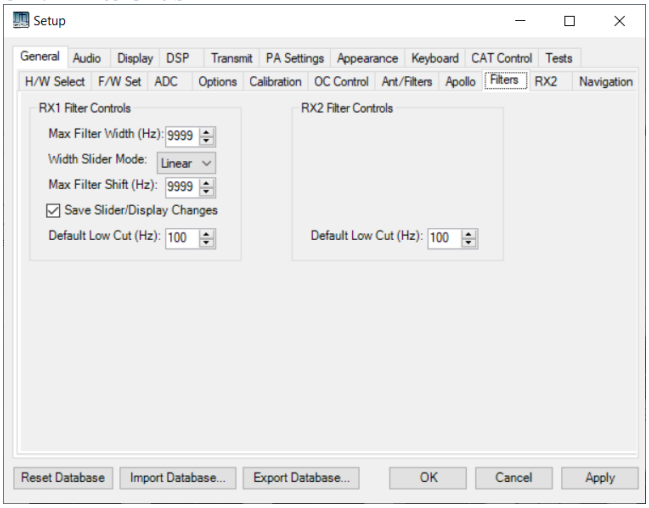
Antenna Control	If not selected, the antenna control section is greyed out and the radio will use RX1 for all bands.
Enable SWR protection	When enabled a high VSWR condition will cause the radio to cease transmitting
Disable on Tune pwr < 35W	Disables SWR protection during tuning, when the tune power level is less than 35W. In this condition a high VSWR is less likely to cause damage.
ATT on TX	Sets the attenuation applied to the receiver path during transmit.
BYPASS on TX	Select BYPASS during TX: to be used when an external PA feedback connection to the Bypass connector is used with ANAN100D/200D with rev24 PA board (This is radio specific)
Ext 2 on TX	Selects RX1 to use the Ext 2 input during TX (e.g. for a Puresignal coupler)
Ext 1 on TX	Selects RX1 to use the Ext 1 input during TX (e.g. for a Puresignal coupler)
Disable HF PA	Disables an external PA
Disable Bypass	Disables Bypass relay when Ext1, 2 , XVTR ports selected, when used with ANAN100D/200D with rev24 PA (This is radio specific)

6.1.8 Apollo Tab



Applies settings specific to the APOLLO linear amplifier unit.

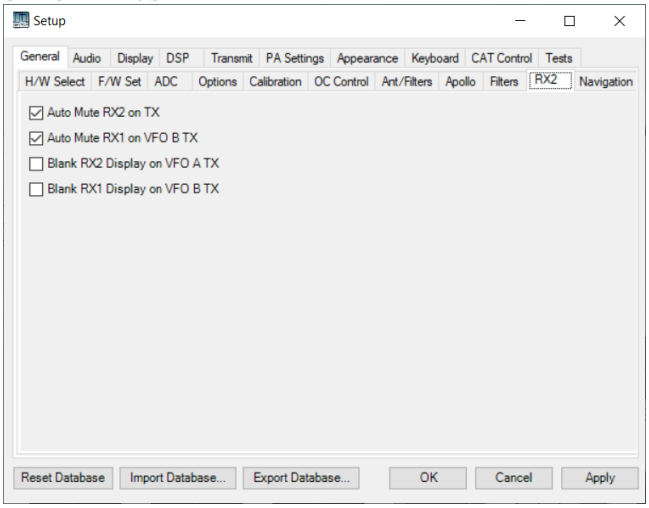
6.1.9 Filters Tab



Controls the min and max frequencies for the variable filter passband controls on the console.

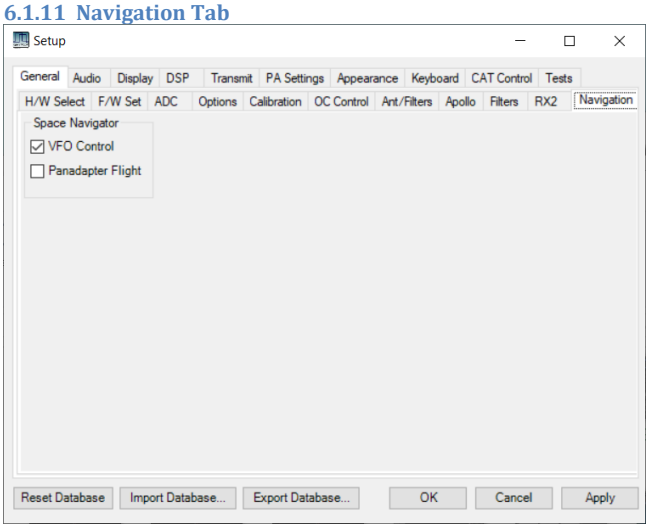
Max Filter Width (Hz)	Sets the maximum width available through the variable filter controls
Width Slider Mode	Sets the slider to have linear, Log or Log10 modes. The log modes will have better resolution for narrow (e.g. SW) filters.
Max Filter Shift (Hz)	Sets the maximum shift from centre available through the variable filter controls
Save Slider / Display Changes	If Checked, the settings for VAR1 and VAR2 filters will be updated by the changes made to the shift and width sliders. If not, the changes will be lost after a new filter setting is selected.
Default Low Cut (Hz)	Sets the default low frequency cut-off of USB or LSB filters.

6.1.10 RX2 Tab



Provides controls for a second receiver, where fitted.

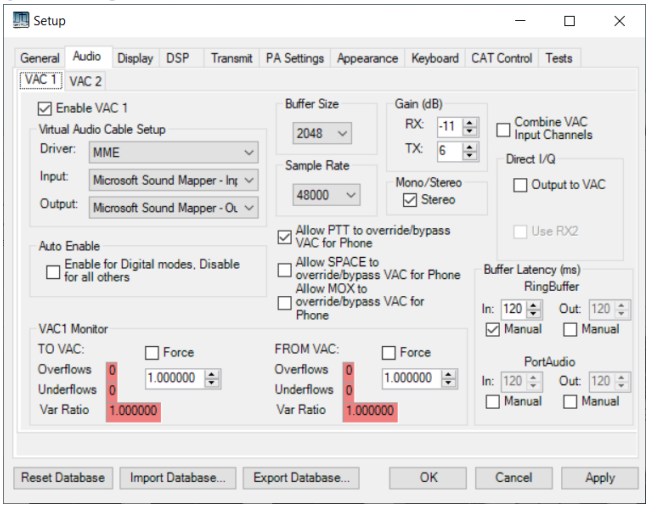
6.1.11 Navigation Tab



This form controls what a 3DConnexion SpaceMouse® interface device can adjust.

6.2 Audio Settings Tabs

6.2.1 VAC1

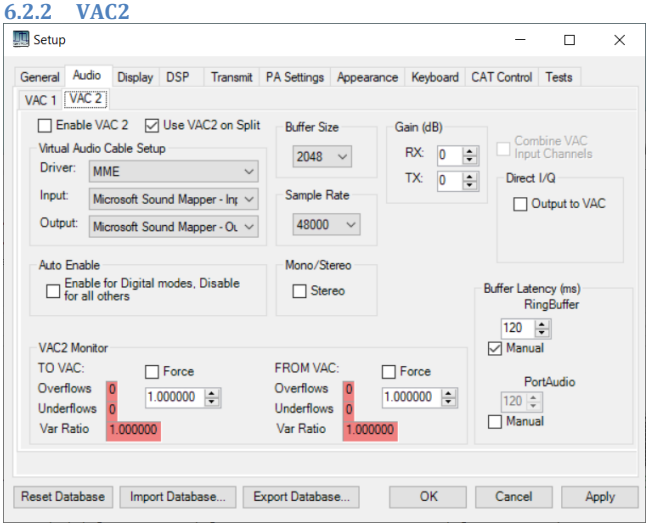


Controls for Versatile Audio Connection 1 (VAC1). This is used for PC audio (microphone, speaker) connections, and to connect to Virtual Audio Cable channels to connect audio to other programs within the same PC. See section 7.4 for more details of Virtual Audio Cable drivers.

Enable VAC1	Enables this channel. This has the same effect as clicking **VAC1** on the console.
Driver section	This section will be operating system and PC specific. The MME drivers seems to work well.
Auto enable	If ticked, **DIG L** and **DIG U** modes will activate VAC1
VAC1 Monitor	Monitors buffer under/overflows as a result of difference between the radio and PC clocks. The effect of this is removed by resampling filters in the DSP processing chain.
Buffer size	Leave alone unless you know why you are changing it!
Sample Rate	Leave at 48000 Hz unless you know why you are changing it!
Mono/Stereo	Tick for stereo audio. In general leave this on: THETIS uses stereo audio on RX and the **pan** sliders allow audio to be directed to left or right.
RX Gain	Sets the outgoing audio gain from the RX to other programs
TX Gain	Sets the incoming (e.g. microphone) audio gain to the TX
Combine VAC input channels	If ticked, stereo in (e.g. microphone) will be combined to one mono channel.
Direct I/Q output to VAC	When ticked sends pre-processed rather than post processed I/Q data to the VAC connection.
Allow PTT to override VAC for phone	When ticked, if the Mic PTT is pressed the microphone input will be selected instead of VAX
Allow space to override VAC for phone	When ticked, if the space bar is pressed the microphone input will be selected instead of VAX

Allow MOX to override VAC for phone	When ticked, if the **MOX** button is pressed the microphone input will be selected instead of VAX
Buffer Latency	Controls for the latency of the audio buffer. Leave alone if you don't know why you are changing this!

6.2.2 VAC2

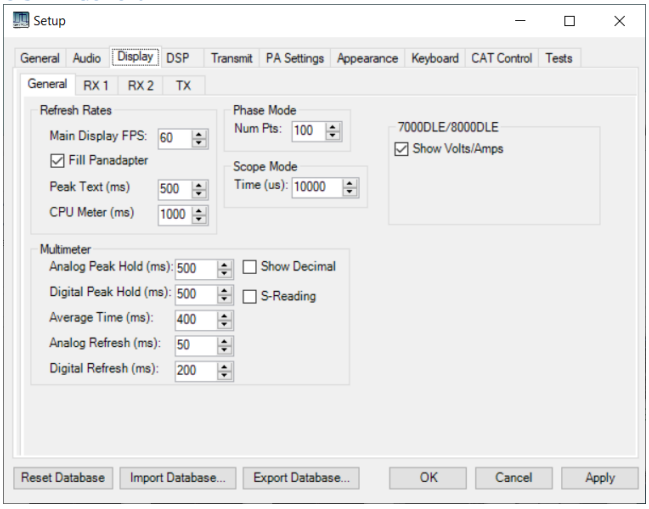


Similar controls for the VAC2 channel.

Use VAC2 on split	Selects use of VAC2 when band **Split** is active.

6.3 Display Settings Tabs

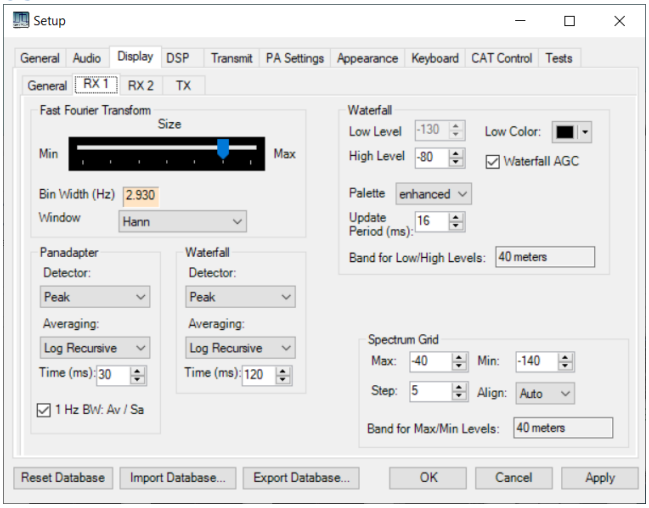
6.3.1 General



Refresh Rates	Main display FPS	Sets no. updates per second for the main display
	Fill Panadapter	When ticked, the panadapter area is filled below the trace
	Peak Text (ms)	Sets the rate at which the peak signal text is updated below the main display
	CPU meter (ms)	sets the rate at which CPU utilisation is updated
Multimeter	Analog Peak Hold	Time period for which peaks held on the analogue multimeter
	Digital Peak Hold	Time period to hold the digital meter for Fwd Pwr
	Average Time	Time period over which Sig Avg is averaged
	Analog Refresh	Update period for the analogue multimeter
	Digital Refresh	Update period for the digital multimeter
Phase Mode	Sets the number of points displayed per 360^0 cycle	
Scope Mode	Sets the horizontal timebase for Scope mode displays	
7000/8000DLE Show Volts/Amps	Enables additional displays for specific radio models showing PA voltage and PA current. Displayed in place of CPU utilisation to the bottom left.	

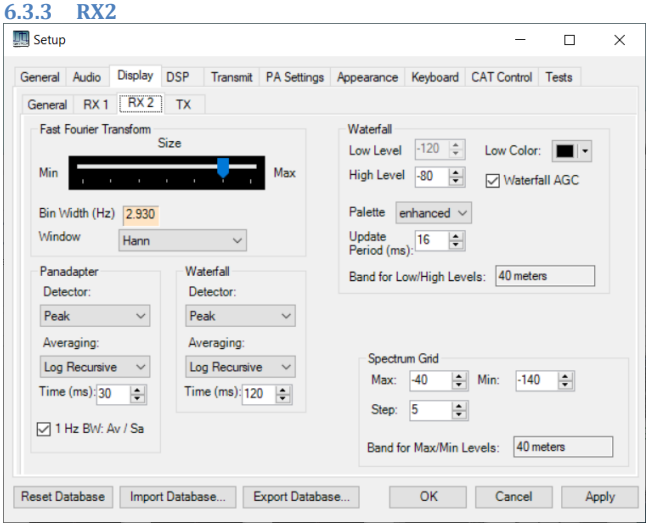
Be aware that setting faster updates will increase processor loading.

6.3.2 RX1



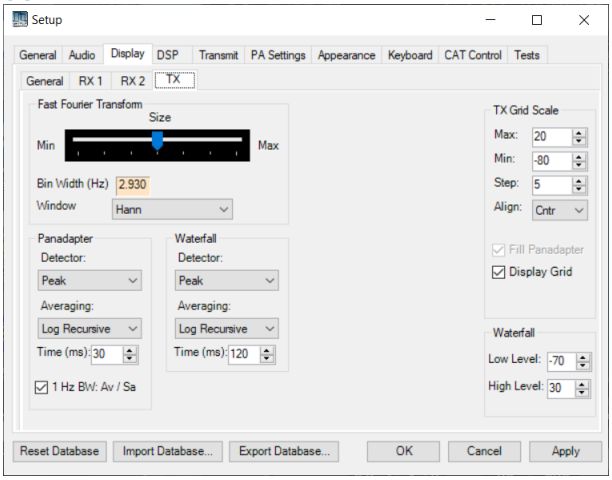
Fast Fourier Transform	Sets the FFT size and window function for spectrum based displays. The achieved resolution (Hz) is calculated and shown.	
Panadapter	Sets the detector mode and averaging used for the panadapter display	
Waterfall	Sets the detector mode and averaging used for the waterfall display	
Waterfall	Sets parameters for how spectrum amplitude is converted to coloured pixels for the waterfall display	
Spectrum Grid	Max	Level of top of display (dBm)
	Min	Level of bottom of display (dBm)
	Step	Vertical step size (dBm)
	Align	Sets where the vertical axis and legend is displayed

6.3.3 RX2



The same form, but for RX2 display

6.3.4 TX

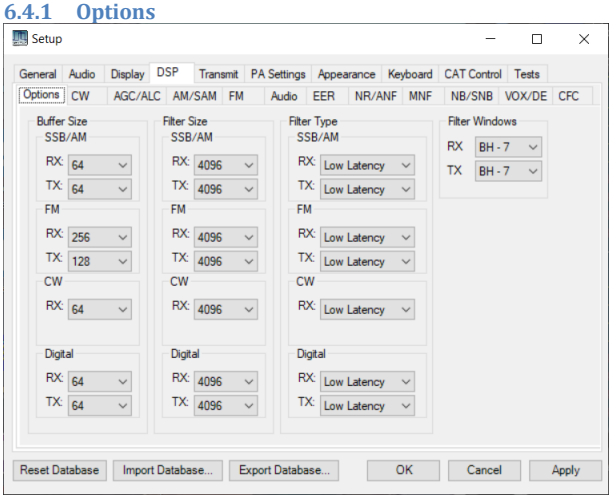


Fast Fourier Transform	Sets the FFT size and window function for spectrum based displays. The achieved resolution (Hz) is calculated and shown.	
Panadapter	Sets the detector mode and averaging used for the panadapter display	
Waterfall	Sets the detector mode and averaging used for the waterfall display	
TX Grid Scale	Max	Level of top of display (dBm)
	Min	Level of bottom of display (dBm)
	Step	Vertical step size (dBm)
	Align	Sets where the vertical axis and legend is displayed
	Display Grid	When ticked, the grid is drawn.
Waterfall	Sets the low and high levels for conversion to coloured pixels	

6.4 DSP Settings Tabs

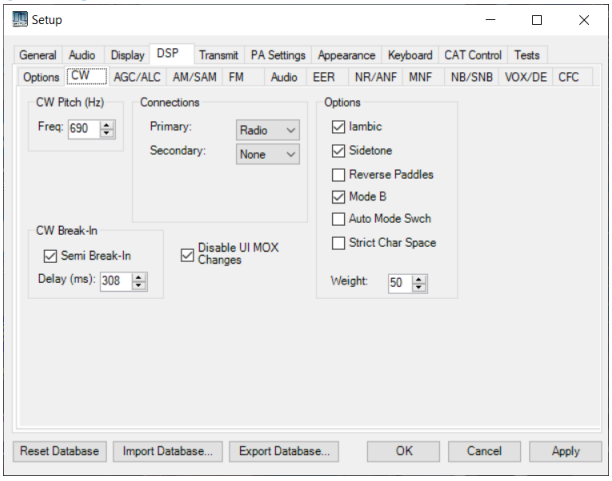
There are many tabs under this section. They provide in-depth settings for the underlying DSP operation within THETIS and are not intended for most users to adjust: if you know what to change you will know the meaning!

6.4.1 Options



This form selects buffer sizes for processing, filter lengths and types for different modes, and selects the window functions used for filtering.

6.4.2 CW

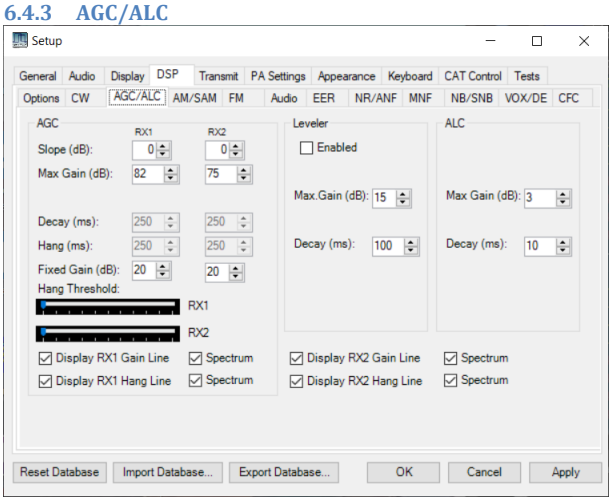


These controls affect CW operation and key type. Some of these settings are also available on the CW “mode specific” section of the console – see section 4.1.10.2.

CW Pitch freq	Sets the frequency expected for CW audio. This sets the offset from carrier for TX operation.
Semi break-in	If ticked, the RX will be re-enabled a short period after the keyer is released. The delay time (ms) is adjustable. The same controls are available on the console (section 4.1.10.2)

Connections	Sets whether the key is connected to the radio, or to the PC via a COM port. See section 7.7.1.2 for details on connecting a CW key to your PC
Disable UI MOX Changes	If ticked, changes to some console controls are disabled while in TX.
Iambic	When ticked, the keyer generates timed dots and dashes triggered by an Iambic keyer. When unticked a “straight” key is assumed.
Sidetone	Turns on/off audio sidetone for CW (either normal key or iambic keyer)
Reverse Paddles	Swaps the “dot” and “dash” paddle actions. Allows these to be changed without affecting wiring.
Mode B	When ticked, emulates iambic mode B; otherwise emulates mode A
Auto mode switch	If ticked, a CW mode will be automatically set when the key or paddles are activated.
Strict char space	
Weight	Sets the width ratio between dot and dash.

6.4.3 AGC/ALC

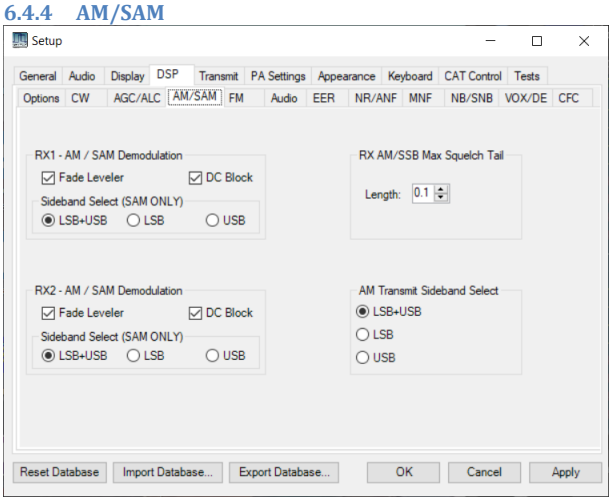


AGC operation is explained in the WDSP guide [6] pages 40-46.

AGC	Controls the RX AGC operation. This is critical to HF reception. This sets parameters for the AGC; there are also console controls for AGC (see section 4.1.6).	
	Slope (dB)	Sets a gain slope after the AGC has started to take effect. When 0dB, there is no further amplitude variation above the AGC threshold; with say 10dB there is a softer effect.
	Max Gain (dB)	The max AGC gain, set by the console AGC gain control (section 4.1.6). Should be set to just above the noise floor.

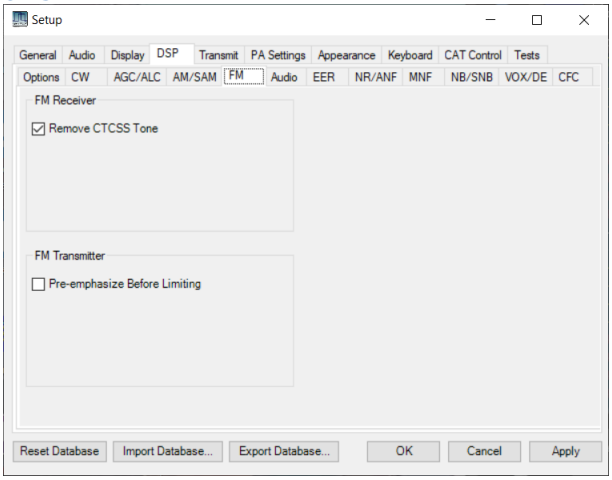
	Decay (ms)	sets a decay time if the console has selected custom AGC
	Hang (ms)	sets a hang time if the console has selected custom AGC
	Fixed Gain (dB)	sets the gain used if the console has selected Fixed AGC.
	Display gain line	If ticked shows the AGC gain on the panadapter
	Display hang line	If ticked shows the AGC hang level on the panadapter
	Spectrum	If ticked, shows a dotted line across the panadapter display. If not ticked shows the green or yellow square.
	Hang Threshold	Sets a threshold for AGC "hang". Available in Long, Slow and Custom AGC
Leveler	Controls the TX Leveler operation. The TX leveler provides a "slow time" amplitude adjustment intended to increase gain if you have momentarily moved away from the microphone for example.	
	Enabled	If ticked, the leveller is enabled.
	Max Gain	Sets the max gain the leveller can apply to "quiet" audio.
	Decay	sets a decay time constant: controls how quickly gain ramps back to the default 0dB value after a change.
ALC	Controls the TX Automatic Level Control operation. This operates much more quickly that the leveller and is responsible for making sure that the digital-to-analogue converter in the TX is never overdriven.	
	Max Gain	sets the max gain the ALC can apply (default = 0dB). The ALC will set gains below this value to attenuate larger audio signals.
	Decay	sets the time constant to ramp back after an over-range signal.

6.4.4 AM/SAM



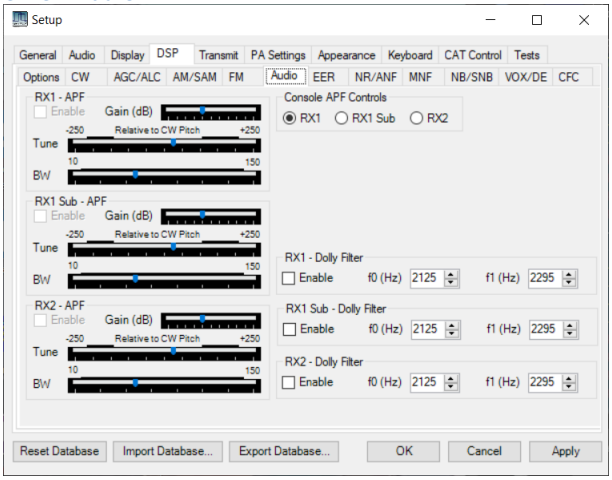
AM/SAM demodulation	Sideband select	for SAM, selects which sideband is used for demodulation. Useful if there is QRM one side but not the other.
	Fade leveller	This option has the effect of setting a constant level carrier. The original carrier is replaced with a locally generated constant amplitude one.
	DC Block	Selects the AM carrier block, to remove carrier (zero frequency) audio. If ticked, the carrier is removed post detection. This is useful for example of the signal is being recorded prior to retransmission.
RX AM/SSB max squelch tail	Sets the "tail" time i.e. how long squelch waits before gating off the audio.	
AM TX sideband select	Selects whether both sidebands, or just one sideband, are generated for AM	

6.4.5 FM



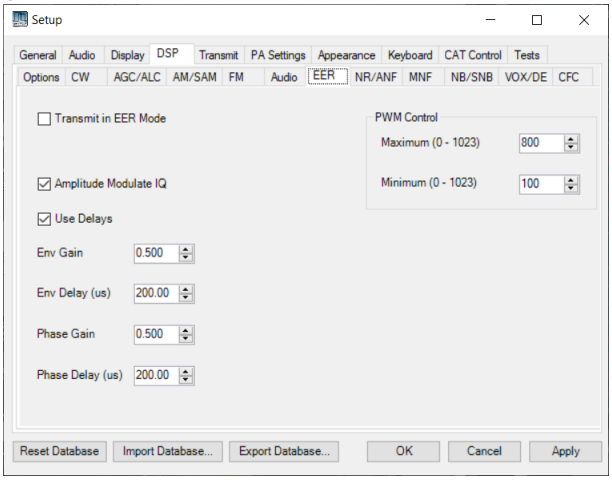
RX Remove CTCSS tone	Enables a filter to remove CTCSS tones from the RX audio
TX Pre-emphasise before limiting	Selects whether the audio pre-emphasis filter is before or after the limiter. Default: after the limiter. Putting this before the limiter may make the FM signal sound louder at the RX end.

6.4.6 Audio



APF	These settings are for three Audio Peaking Filters: one for each of RX1, RX2 and RX1 Sub-receiver. The controls are as described in section 4.1.10.2.
Console APF controls	Selects which APF is controlled by the console (see section 4.1.10.2)
RX1 Dolly filter RX1 Sub Dolly Filter RX2 Dolly filter	Twin bandpass filters for RTTY type modes. One filter is available for each of RX1, RX2 and RX1 sub-receiver. Enable Turns the filter on or off F_0 Selects the lower audio centre frequency F_1 Selects the upper audio centre frequency

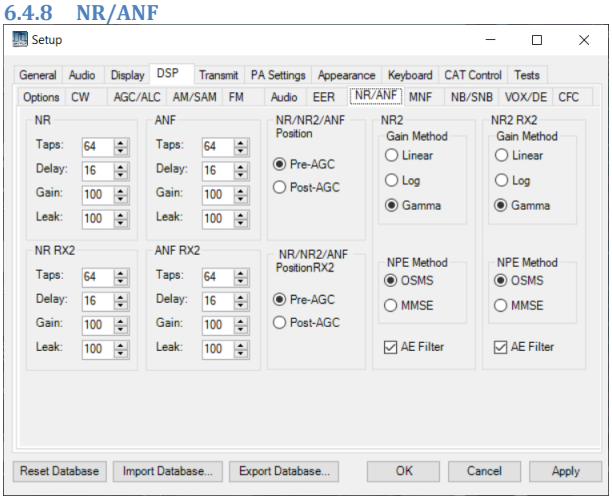
6.4.7 EER



This form controls the signals provided for external Envelope Elimination & Restoration (EER) type amplifiers. The settings are explained in the WDSP guide [6] p153-155.

Transmit in EER Mode	When ticked, the TX generates waveforms suitable for an EER mode amplifier. **You should have an appropriate amplifier and understand the settings required for this mode before using it, otherwise things may not go well!**
Amplitude Modulate I/Q	If unticked, phase information only (with amplitude = 1) is provided to the transmitter. If ticked, a normal I/Q carrier is provided to the amplifier.
Use Delays	If ticked, user adjustable delays for the RF path are implemented
Envelope Gain	Sets the algorithm envelope (mgain) value.
Envelope Delay	Sets the delay to be used for the envelope samples.
Phase Gain	Sets the algorithm phase (pgain) value.
Phase Delay	Sets the delay to be used for the phase (I/Q) samples.
PWM control	Sets the minimum and maximum values for the Pulse Width Modulated (PWM) envelope output (range 0-1023)

6.4.8 NR/ANF

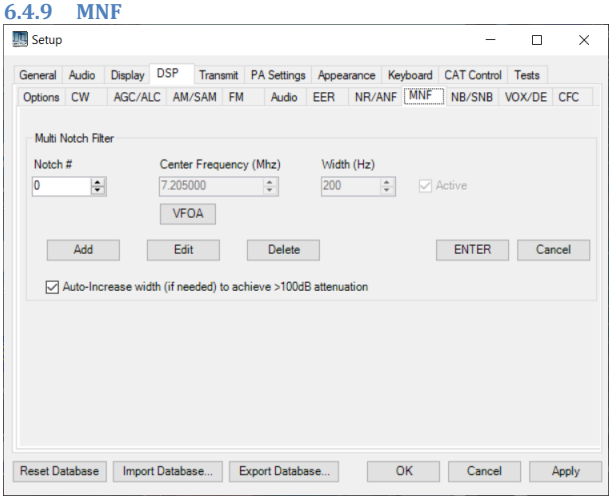


The relevant algorithms are described in the WDSP guide [4] pages 47-57.

NR	Control the LMS Noise Reduction algorithm. This uses an adaptive filter to estimate the signal content, removing noise content. Taps — Sets the number of taps in the LMS filter Delay — sets the signal delay, measured in samples Gain — sets the algorithm gain, in millionths of a unit: higher gain may more effective latch onto carriers, but may also distort speech. Typically 100 Leak — sets the algorithm “leak” value, in thousandths of a unit. Typically 100

ANF	Controls the Automatic Notch Filter. ANF uses an adaptive filter to select the energy belonging to continuous carriers; these are then subtracted from the input signal. Taps — Sets the number of taps in the LMS filter Delay — sets the signal delay, measured in samples Gain — sets the algorithm gain, in millionths of a unit: higher gain may more effective latch onto carriers, but may also distort speech. Typically 100 Leak — sets the algorithm "leak" value in thousandths of a unit. Typically 100
NR/NR2/ANF position	Selects where NR, NR2 and ANF are located in the processing chain. They can be applied before or after AGC. The default is to have NR, NR2 and ANF pre AGC. It is thought that there could be signal conditions where NR/NR2/ANF should be after AGC, so that the AGC can level out the signal amplitude first. If you find you get better reception by doing it, you can try having NR, NR2 and ANF post AGC.
NR2	Controls the NR2 filter. This applies gain to the frequency components of the signal containing speech and less gain to those containing noise. Gain Method — Sets the method used to set the gain per frequency bin. All are similar, but Gamma is preferred. NPE Method — Sets the method used to estimate noise power: OSMS — Optimum smoothing Minimum Statistics (normal conditions) MMSE — Minimum Mean Square Error: this has faster recovery (useful if the channel varies rapidly, eg static crashes caused by lightning) AE Filter — Selects the Artefact Elimination filter: this should normally be ticked.

6.4.9 MNF

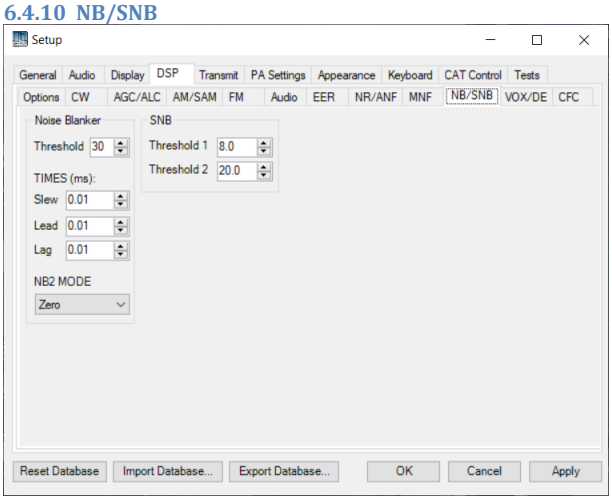


This form allows the notch frequencies for the **MNF** filter (selectable from the console) to be entered. The MNF notches are provided as a "last resort" to remove troublesome interference.

Notch #	Selects the notch being edited (1st notch is 0)
Centre Frequency (MHz)	Enters the notch centre frequency

Width (Hz)	Enters notch width in Hz. You will want as small a value as possible eg 100-200Hz
Active	Ticked when the notch is programmed and active
VFO A	When pressed, copies the current VFO A frequency into the centre frequency box
Add	Adds a new notch to the list
Edit	Edits the notch entry for the selected notch number
Delete	Deletes the currently selected notch entry
Auto Increase width	If ticked, the settings will be adjusted to achieve a minimum 100dB attenuation
Enter	Enters the notch being edited into the database
Cancel	Cancels the current edit

6.4.10 NB/SNB

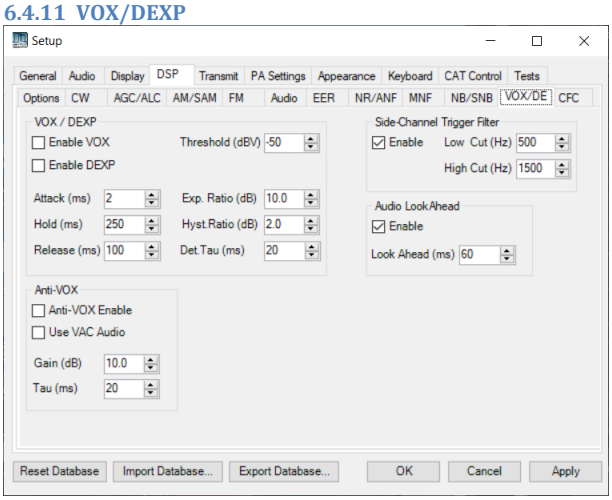


This form controls the operation of algorithms for NB, NB2 & SNB. The algorithms are described in the WDSP guide [4] p121, p128, p35.

Noise Blanker	The noise blanker detects narrow, high amplitude impulses and removes them before any other processing has been affected. NB ramps the signal to 0 during the impulse; NB2 estimates the original signal.	
	Threshold	Sets the threshold level at which a signal is considered an impulse. This is relative to mean power in the whole downconverted channel.
	Slew	Ramp “down” or “up” time, in ms.
	Lead	The time before the impulse where gain should reach zero
	Lag	The time after the impulse before gain should begin to ramp up.
		For each of the 3 times, suggest 0.01ms starting point.
	NB2 Mode	Sets the estimate used to replace the original signal.
	Zero	Sets signal to 0 (like NB)
	Sample & hold	Holds the value from before the impulse

	Mean-Hold	averages the signal before & after the impulse
	Hold & Sample	Holds the value from after the impulse
	Linear Interpolate	linearly interpolates across the blanked period
SNB	There are two adjustable thresholds for SNB. Their function is deeply embedded within the SNB algorithm and has no specific description. It is recommended that you leave these on their default positions. However if you are able to achieve better noise blanking by adjusting them, then try changes to them.	
	Threshold 1	(default 8.0)
	Threshold 2	(default 20.0)

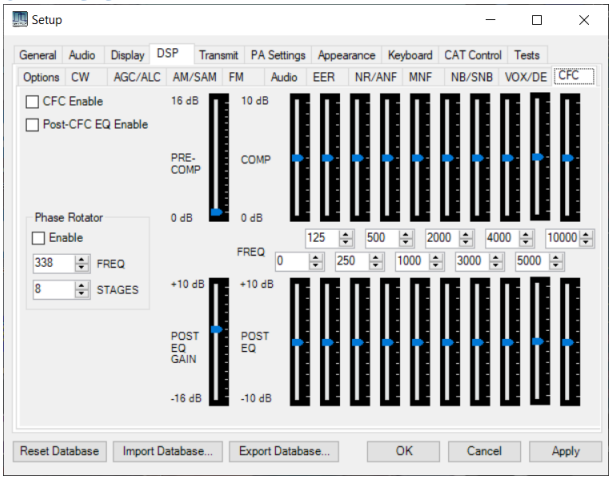
6.4.11 VOX/DEXP



This form provides controls for the VOX and Downward expander algorithms Scott WU2O contributed to the specification of this function. The algorithms are described in the WDSP guide [4] p156.

VOX/DEXP	Enable VOX	If ticked, VOX is enabled. Microphone audio above a threshold will initiate transmit.
	Enable DEXP	If ticked, enables the downward expander.
	Threshold	Sets the threshold on the mic input at which VOX is triggered and the DEXP is triggered.
	Attack	The time period over which the DEXP gain is increased after a threshold level has been reached.
	Hold	The time period over which the DEXP gain is held after the voice level drops below threshold before the gain begins to ramp down.
	Release	The time period over which DEXP gain ramps down after the hold time
	Exp. Ratio	The microphone gain is reduced by this amount when below the threshold level.
	Hysteresis	the ratio between trigger level and the (smaller) level used to count the hold time.
	Detector tau	Sets the time constant used for the VOX trigger detector
Anti-VOX	Anti-VOX enable	If ticked, anti-VOX is enabled to attempt to reject RX audio triggering VOX.
	Use VAC Audio	If ticked, uses VAC audio as the source for anti-VOX; if unticked, it will use the receiver audio path.
	Gain (dB)	Sets the gain (dB scale) for anti-VOX
	Tau (ms)	Sets the time constant used for smoothing anti-VOX data
Side-channel trigger filter	If ticked, selects an audio filter with user entered min/max frequency. This is used to select the frequency range used for VOX triggering.	
Auto Look-ahead	If ticked, this sets a duration in ms during which the algorithm looks ahead at as-yet un-transmitted audio to detect peaks and initiate TX before they occur. This avoid the first syllable being cut off, but increases TX latency.	

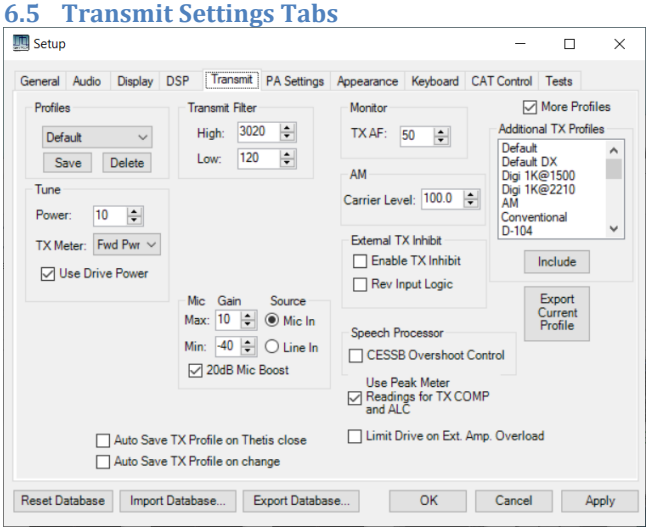
6.4.12 CFC



This form controls the continuous frequency compressor (CFC). The CFC provides audio compression, but with selectable compression levels for different audio frequencies. These are described in the WDSP guide [4] p86-87.

CFC Enable	When clicked the Continuous Frequency Compressor is enabled.
Pre Comp	Sets an overall compression level applied before CFC
Comp	Sliders set the compression level for each audio frequency band
Frequency boxes	Sets the centre frequency for each audio band
Post CFC EQ Enable	Enables a post CFC equaliser
Post EQ Gain	Overall gain setting after the CFC
Post EQ Frequency sliders	Sets frequency dependent gain for each frequency band post CFC
Phase rotator	Enables the phase rotator. The frequency and number of stages can be entered.

6.5 Transmit Settings Tabs

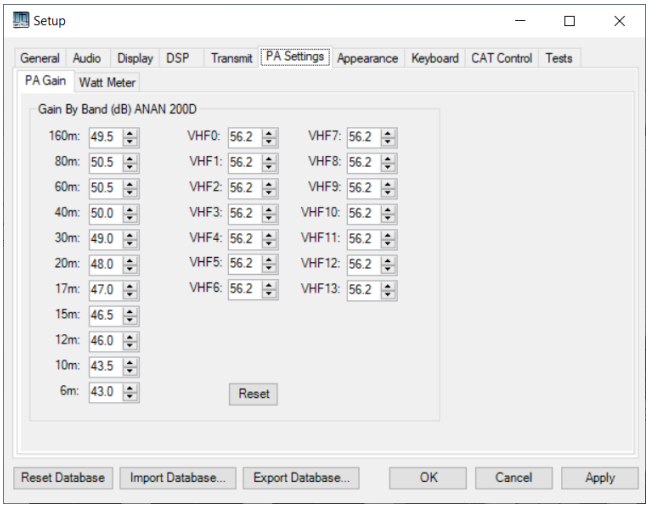


Profile	Allows a TX profile to be selected, saved or deleted. TX profiles allow all the TX settings to be stored so that can rapidly be set from the console (section 4.1.10.1). It may be appropriate to have a different profile for each mode, or each microphone.
Auto save profile on THETIS close	When ticked, the current TX profile will be stored when THETIS closes.
Auto save profile on change	When ticked, the current TX profile will be stored when a change to it is made.
More Profiles	Allows additional profiles to be loaded; when ticked, a list appears; The Include button causes the current item to be copied to the list of available profiles on the top left.
Export Current Profile	Exports the currently selected profile settings to a file.
Tune	This section controls the TX behaviour when **Tune** is selected. Power Sets a power level for the TX output during Tune.

	TX Meter Use Drive power	Sets the multimeter mode to be used during Tune. If ticked, the Drive control is used instead of the user entered Tune power.
Transmit Filter	Sets the low and high frequency edges of the TX filter passband. These are also accessible on the console (see section 4.1.10.1)	
Mic Gain	Controls the microphone gain settings. Min Gain Max Gain Source 20dB Boost	 Sets the min gain level for the console mic gain slider Sets the max gain level for the console mic gain slider Selects between the radio's front panel Mic connection and rear Line In signal When selected an analogue 20dB gain amplifier is used before any other processing.
Monitor	Sets the TX Audio monitor level (%) routed to the **Master AF** Control	
AM Carrier Level	Sets the modulation level for Full carrier AM. 100% is fully modulated.	
External TX inhibit	Enable TX Inhibit Rev. Input Logic	no idea! Inverts the input bit for TX inhibit
Speech Processor CESSB Overshoot control	Enables the Controlled Envelope SSB Audio Processing. This reduces the peak SSN=B level with little processing demand. See the WDSP manual [6] for details.	
Use peak readings for TX COMP and ALC	When ticked, peak readings are used for TX COMP and ALV values on the multimeter	
Limit Drive on Ext Amp Overload	No idea	

6.6 PA Settings Tabs

6.6.1 PA Gain

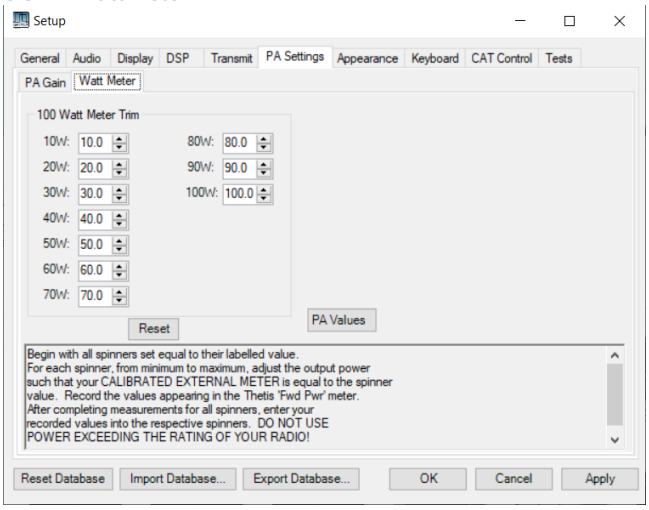


This form sets the gain of the TX on a per-band basis. It is used when calculating the drive level to achieve the expected power output.

These should be adjusted to optimise the TX power levels: the default figures will be approximate. Selected a required output level, measure the power out and adjust these settings until the desired power is achieved. To minimise excessive heat generation, it is suggested that 10W-20W max should be used.

A smaller number entered here will cause the power output to rise.

6.6.2 Watt Meter

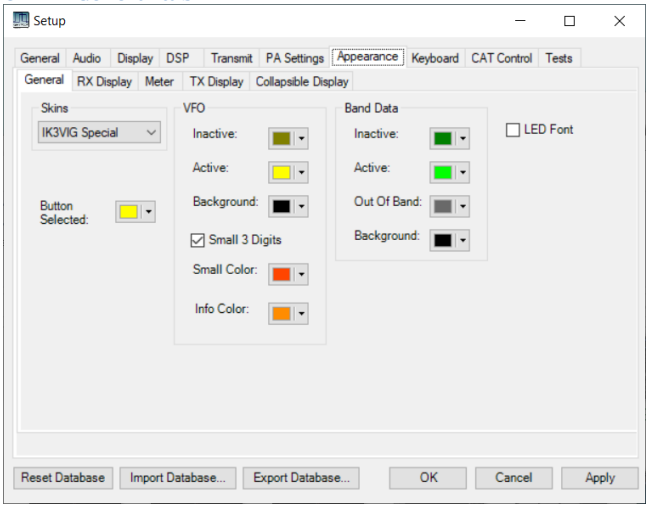


These settings allow the TX power reading multimeter to be calibrated for the output range 10W-100W. Instructions are provided on the form.

6.7 Appearance Settings Tabs

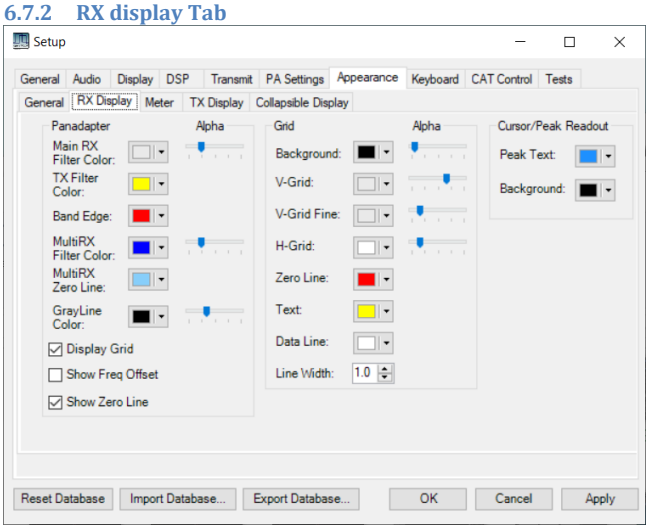
These tabs allow the colours for different parts of the console display to be changed, to personalise its appearance. These settings are generally self-explanatory.

6.7.1 General tab



Skins	"Skins" are sets of bitmap files which change the appearance of the background and buttons on the console. This selects which set is displayed.
Button selected	Sets the colour of selected / active buttons on the various forms
VFO	Changes the display of different elements in each VFO box.
Band Data	Changes the colour of text and background in the "band data" box below the VFO frequency.
LED Font	If ticked, uses a 7-segment-like font for VFO frequency (This seems to have been superseded in release 7.2.7 and now shows a larger font)

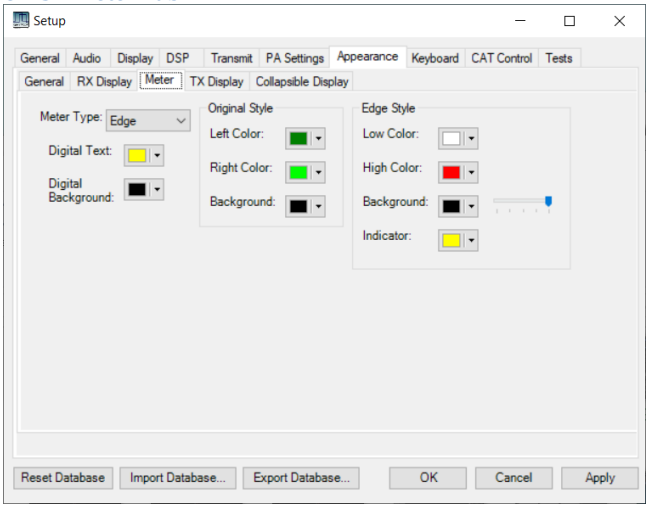
6.7.2 RX display Tab



This form controls the appearance of the main RX display.

Panadapter	Controls how the main panadapter display area is drawn. Colours for several items can be selected. Alpha — Sets transparency for an object – fully transparent to the left, fully opaque to the right. Display Grid — When ticked, the display grid is drawn; left blank if unticked. Show Freq Offset — When ticked, shows frequency offset from display centre rather than absolute frequency Show Zero Line — When ticked, shows the VFO frequency as a red vertical line
Grid	Controls how the grid is drawn.
Cursor/peak readout	Controls the colour of the readout text under the display. To the left, the frequency offset, amplitude and absolute frequency of the cursor position are shown. To the right, the same values for the current peak signal are shown.

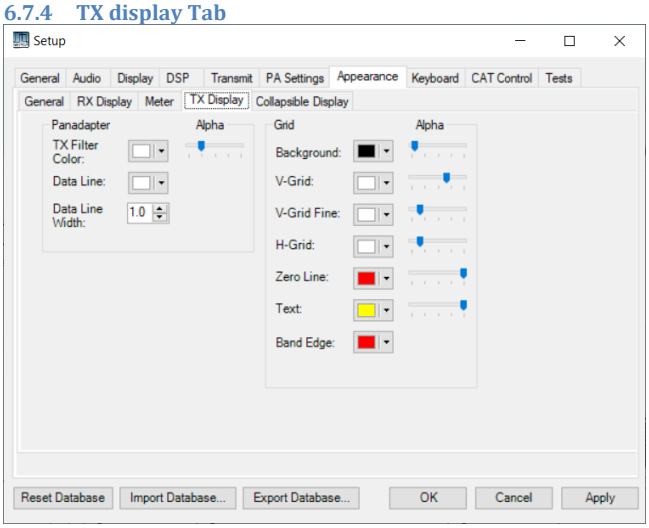
6.7.3 Meter Tab



This form displays how the multimeter is drawn.

Meter Type	Selects between two meter styles: Original Selects a bargraph type display. Edge Selects a moving needle type display
Digital Text	Sets the colour of text shown above the multimeter
Digital Background	Selects the background colour for the digital text box
Original Style	Selects how the original style meter is drawn. The colour of the bargraph segments can vary from left to right.
Edge Style	Selects how the Edge Style multimeter is drawn.

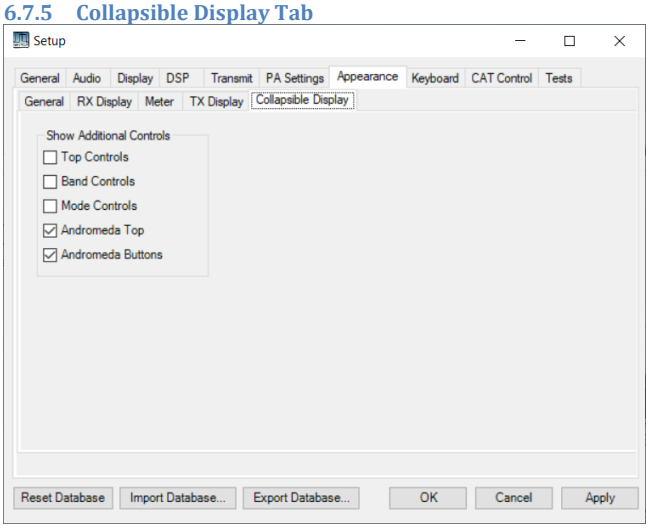
6.7.4 TX display Tab



Selects how the TX display is drawn.

Panadapter	Controls how the main panadapter display area is drawn. Colours for several items can be selected. TX Filter Colour — Shows the colour with which the TX filter width is shown; Alpha sets the transparency. Data Line — Sets the colour of the spectrum display trace showing peak TX envelope vs frequency Data line width — sets the line width for the TX envelope, in pixels
Grid	Controls how the grid is drawn.

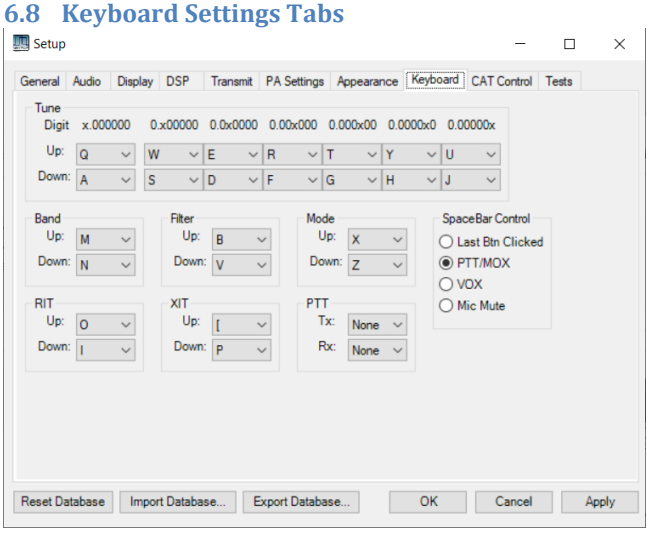
6.7.5 Collapsible Display Tab



This form controls the top/bottom bars in the “collapsed” displays

Top Controls	Shows the “classic” top display bar
Band controls	Shows the band buttons below the display
Mode controls	Shows the mode buttons below the display
Andromeda Top Controls	Shows the “Andromeda” top bar
Andromeda Button Bar	Shows the “Andromeda” menu button bar

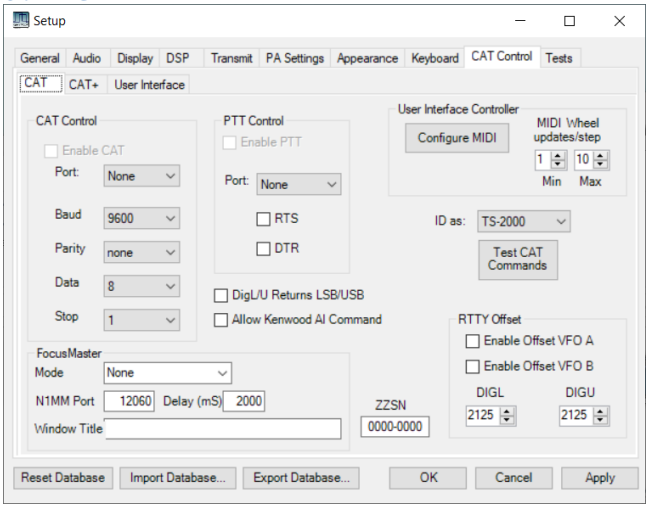
6.8 Keyboard Settings Tabs



This form allows the keyboard shortcuts to be edited. The functions available are described in section 4.4.

6.9 CAT Control Settings Tabs

6.9.1 CAT

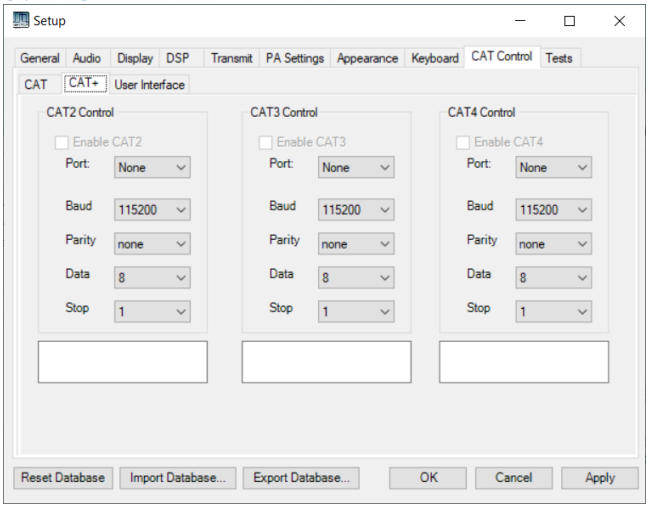


These settings allow external serial devices to communicate with THETIS. Devices of various types are available.

CAT Control	Sets the COM port, baud rate, parity, number of data bits and number of stop bits for a single CAT serial connection. When selected, click Enable. Note: DO NOT set a baud rate of 1200 for an "Arduino" based device – it will erase its code!
PTT control	Selects a COM port for which the strobe inputs can be used to initiate PTT. See section 7.7.1.1 for instructions on connecting a PTT switch.
User interface Controller	Controls a Midi device. I have no idea about this!
IS as	Sets the radio type that is reported as the CAT controller, in response to an "ID" CAT command
Test CAT commands	Opens the Test CAT commands form (see section 6.9.4)
Dig L/U returns LSB/USB	If ticked, the digital mode settings **DIGL** and **DIGU** are reported as **LSB** and **USB** respectively
Allow Kenwood AI command	When ticked, the "AI" CAT command is enabled. Thereafter the CAT port sends frequent unsolicited response messages
Focus Master	Relates to working with the N1MM contest logging program.
ZZSN	Sets the serial number reported in response to a ZZSN command. Useful if you have several radios.
RTTY Offset	Sets frequency offsets for the reported VFO frequency in RTTY modes. This can be separately enabled for each VFO.

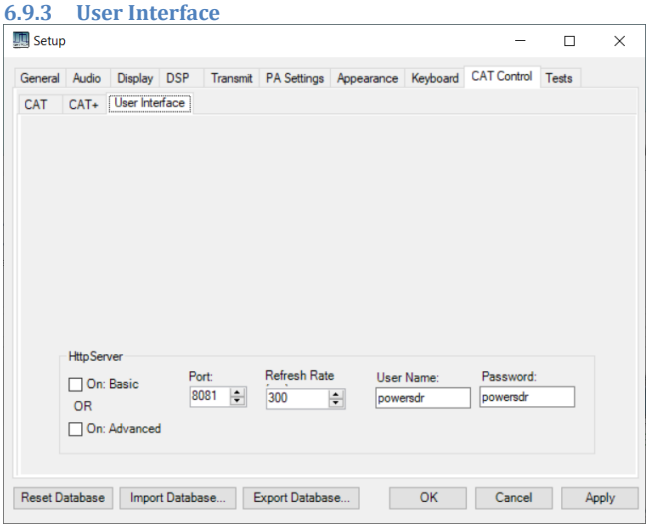
For Midi: Scott has a video, and it can be set with a midi phone app "Touchosc". See if that works?

6.9.2 CAT+



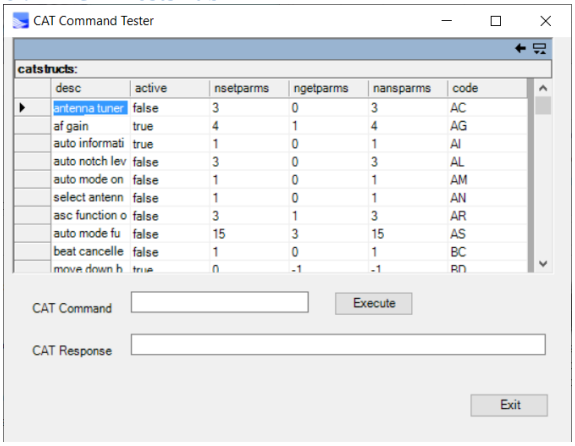
These settings allow THETIS to connect to three additional external devices using CAT commands. The serial port properties for these are identical to those on the main CAT form.

6.9.3 User Interface



These settings allow THETIS to accept CAT commands via a network connection. Http Server now streams live Display with no special commands or special setup. Setup->User Interface->Active. Open your web browser to http://localhost:8081/ to stream Display. Refresh rate sets the update time in msec.

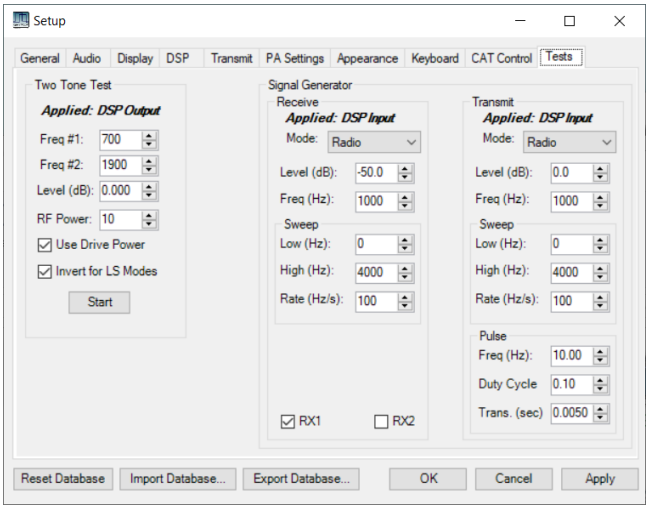
6.9.4 CAT Tests Tab



This form provides a method for developers to test the operation of CAT commands. The top half of the form lists the commands recognised by THETIS and the parameters they require.

A command can be typed into the **CAT command** box; when execute is pressed that command will be executed as if it had originated from an external device. The generated response it provided in the response box below.

6.10 Tests Tab



This form allows various tests to be carried out.

Two tone test	Injects a two-tone test source into the transmitter with specified tones and overall power level. Used for TX linearity testing. Start Initiates the 2 tone transmission.
Receive Signal Generator	Injects a CW tone, swept tone or noise into the receiver. The entered frequency is relative to the VFO frequency.

	Mode = Radio: no test tone Mode = Tone: single tone injected Mode = Sweep: sweeping tone injected Mode = Noise: noise waveform injected Mode=Silence: no receiver input
Transmit signal generator	Injects a signal source into the transmitter. The entered frequency is relative to the VFO frequency. Mode = Radio: no test tone Mode = Tone: single tone injected Mode = Sweep: sweeping tone injected Mode = Noise: noise waveform injected Mode = Sawtooth: Inject a sawtooth ramp, with instant "return to zero" Mode = Triangle: Inject a triangle signal with symmetrical ramp up and down Mode = Pulse: Inject a pulsed waveform Mode=Silence: no receiver input

6.11 Settings Database

The Setup form contains many settings for operation of THETIS. These are saved into a database when THETIS closes down. There are buttons at the bottom of the Setup for to control the database itself:

Reset Database	This resets the database to an initial list of known safe values. Essentially this brings THETIS bask to its state when installed.
Import Database	Import a new database from a named file. The default database is "database.xml" located in folder: C:\users*username*\AppData\Roaming\OpenHPSDR\Thetis
Export Database	Save the current settings to a named database file. This is useful to save a snapshot of updated settings for later use.
OK	Accept all current changes into the database and close the Setup form
Cancel	Cancels changes and re-loads the current database
Apply	Apply the current changes to the database but leave the form open.

7 Setting Up Thetis

7.1 Setting Up Microphone Levels

The TX audio chain contains a lot of features to control and enhance audio performance. It is very important to set these up in a logical order. This guide gets you "up to speed" with the basic settings. The more advanced settings, to enhance audio performance further, are covered in the next section.

Pay attention to the use of "TX profiles" below. They will avoid you having to repeat this every time!

1. Connect a suitably rated dummy load to your antenna connector.
2. Set the **Drive** level to a relatively low power (say 5-10, meaning 5-10W of RF)
3. Select an appropriate audio mode. Begin with USB or LSB depending on your band.
4. Connect a suitable microphone to your radio. (It is also possible to use microphones connected to your PC. See section 3.7).[2]
5. Depending on your radio: you may need to set the microphone connections on the Menu > Setup > Audio form, or may need to adjust jumpers accordingly. Consult your radio manual.
6. Reset all of the Tx audio path settings:
    a. Click the console **MIC** button to on
    b. Click the console **VOX**, **COMP**, **DEXP**, **TX EQ** buttons to off
    c. Untick **20dB Mic Boost** on the Menu > Setup > Transmit form
    d. Select **Mic In** as the input on that same form
    e. Untick **CESSB Overshoot Control** on the same form
    f. Tick **Use peak meter readings for TX COMP and ALC** on the same form
    g. Tick **Auto Save TX profile on THETIS close** on the same form
    h. Tick **Auto save TX profile on change** on the same form
    i. Click **Save** by profile name and give it a new name: eg "PC Headset"
    j. Untick **leveler** on the Menu > Setup > DSP >AGC/ALC form
    k. Set **ALC max gain** to 0 on that same form
    l. Untick **EER** on the Menu > Setup > DSP > EER form
    m. Untick **CFC enable**, **Post-CFC EQ enable**, **phase rotator enable** on the Menu > Setup > DSP > CFC form
7. Select the **TX meter mode** to MIC
8. Key the radio by pressing **MOX** on the console
9. Speak normally into the microphone
10. Adjust the console **MIC** gain slider until the TX meter consistently reads 0dB for speech peaks. (The meter is peak reading).
11. Return to RX mode by pressing **MOX** again.
12. If you were not able to reach 0dB: tick **20dB boost** in the Menu > Setup > Audio form and try again. (This may well be required for a dynamic microphone).
13. Assuming that has worked OK: you now have a working microphone connection.
14. Set the TX filter bandwidth appropriately. Min 200Hz, max 2800Hz suggested for SSB as a starting point.

[2] Note that some PC headset microphones will not work if simply plugged in. It is common for them to have the "tip" and "ring" contacts connected together. You may need to make an adapter which breaks the "ring" connection.

7.1.1 Adjusting the Equaliser

Different microphones have different characteristics, and the equaliser can adjust for them. For example a dynamic microphone may have enhanced low frequency response, while an "electret" type microphone may have better mid-range response. Good HF SSB audio should have a roughly flat response between 300Hz and around 2700Hz. To adjust:

1. Make sure your dummy load is still connected, and you have a low power level selected
2. Click the console **TX EQ** button to turn on the equaliser
3. Make sure the **MON** button on the console is not selected
4. Select the **TX meter** mode to EQ
5. Select the equaliser form using Menu > Equaliser
6. In the TX equaliser section: set all sliders to 0dB, and keep the form open.
7. Key the radio by pressing **MOX** on the console
8. Speak normally into your microphone, while watching the screen
9. You should see your TX audio displayed.
10. Use the equaliser sliders to get the audio response roughly flat from 300 to 2700Hz
11. Use the overall gain slider to make the TX meter show 0dB
12. Return to RX mode by pressing **MOX** again.
13. Save your TX profile.

7.1.2 Adjusting the Leveler

1. Make sure your dummy load is still connected, and you have a low power level selected
2. Tick **leveler** on the Menu > Setup form > DSP >AGC/ALC form
3. Select the **TX meter** mode to Leveler
4. Key the radio by pressing **MOX** on the console
5. Adjust **Max Gain (dB)** on the Menu > Setup > DSP > AGC/ALC form so that your voice peaks are reaching 0dB regularly.
6. Return to RX mode by pressing **MOX** again.
7. Save your TX profile.

7.1.3 Checking the Audio

1. Make sure your dummy load is still connected, and you have a low power level selected
2. Unselect the **Puresignal (PS-A)** button on the console
3. Click the **MON** button on the console to **on**
4. Preferably, connect headphones instead of speakers
5. Key the radio by pressing **MOX** on the console and speak normally
6. You should now hear your audio through speakers/headphone.
7. Return to RX mode by pressing **MOX** again.
8. Save your TX profile.

If you have problems: the likely cause is the microphone connection. Check with your radio's manual.

7.2 Speech Compression

The microphone level settings will have established a working microphone connection, but won't have optimised the audio. It is recognised that normal speech has a very high peak-to-average ratio, leading to low mean TX power. There are several compression algorithms available to enhance the

Commented [LB3]: Warren: Perhaps you have already taken advantage of this; however, I wanted to be sure you know that Rob, W1AEX, and Scott, WU2O, are real experts in setting up the CFC and related modules. I believe that Rob, W1AEX, has done an excellent write-up on this.

average power while keeping the peak unchanged, which will have the effect of enhancing communication range.

CFC Introduction: The CFC (Continuous Frequency Compression) components include the PREEQ, CFC, POST-EQ, and the PHASE ROTATOR. Note that all of the CFC settings are stored within the TX profile that they are saved in to allow unique settings within each TX profile that you create. The steps below are suggestions for establishing a starting point to allow you to use the components to optimize your transmit audio. To start out, if you have COMP enabled in the Console GUI, disable it for now. (Note that you may elect to enable that later if you wish to add a "hard limiting" wideband compression effect to your transmit profile. Enabling CESSB will significantly raise your average power output and further accentuate the hard limiting effect when COMP is enabled.) Also, if Pure Signal is enabled, temporarily disable it so that the audio you hear with MON enabled is not pre-distorted.

1. PRE-EQ: In step 2 of the basic audio chain adjustments above, you set the EQ sliders to produce a relatively flat response for the microphone or audio rack that you are using and have set the Preamp slider so that you do not exceed 0 dB on voice peaks while monitoring the EQ with the TX multimeter. Note that when the CFC option is enabled, the basic EQ will function as the Pre-EQ stage. If you are satisfied that your settings produce a relatively flat audio response, you can move on to the next step.
2. CONTINUOUS FREQUENCY COMPRESSOR: In the Menu > Setup > DSP > CFC form place a check in the **CFC Enable** and **Post-CFC EQ Enable** boxes. The CFC interface offers an over-all gain slider called PRE-COMP and 10 individual sliders that allow you to assign different levels of compression to each assigned frequency point. While listening to your transmit audio with **MON** enabled, adjust the frequency band sliders upward or downward to control the amount of "punch" you wish to add to your voice in each area of the voice spectrum. When you have established settings that produce the desired level of density for your voice, you can change the over-all compression level by adjusting the PRE-COMP slider upward or downward.
3. POST-EQ: While listening to your transmitted signal with MON enabled, use the Post-EQ form to tailor your transmit audio's frequency response. Again, you can assign custom frequency values to each of the 10 sliders but it is suggested that you use the defaults initially. The Post- EQ sliders give you complete control over the tonal quality of your signal to enhance clarity, brightness, and low-end response. As a last step, set your TX multimeter to ALC COMP and adjust the POST EQ GAIN slider so that you see several dB of ALC compression as you speak.
4. When you are satisfied with your CFC settings, go back to the Menu > Setup > Transmit form and save your profile.
5. Additional Adjustments: The TX multimeter has two new meter scales that can be very informative as you experiment with creating transmit profiles. The new CFC meter displays the output level of the CFC components from -30dB to +12dB and the new CFC Comp meter displays peak compression levels that exceed 0dB on a meter scale from 0dB to +25dB. As an example of how to use the new metering, try increasing the PRE-COMP gain slider and decreasing the POST EQ GAIN slider to create more punch and loudness in areas of your audio that you have emphasized with your CFC slider settings. As the PRE-COMP slider is advanced you will see the peak compression level of the multiband compressor increase in the CFC Comp meter. For a less aggressive sounding profile, try reducing the **PRE-COMP** slider until the CFC meter deflects to 0dB on voice peaks and then use the **POST EQ GAIN** slider to make up the difference in over-all gain. The two new meters give a nice visual indication of what is happening as you set the balance between the two CFC gain sliders.

6. PHASE ROTATOR: This feature can be used to improve the symmetry of your voice in your transmitted audio. It's a very individual adjustment as everyone's voice has very different symmetry characteristics. The steps below will get you started:

- Set the Panadapter in OpenHPSDR to display the Scope.
- Select a transmit profile that has a fairly wide response and set the mode to LSB or USB.
- While transmitting, enable the phase rotator, and as you speak observe your voice pattern on the Scope display.
- If your voice has more energy above the horizontal zero axis reduce the number of stages until better symmetry is observed.
- If your voice has more energy below the horizontal zero axis increase the number of stages until better symmetry is observed.
- Try setting the FREQ of the Phase Rotator to something other than 338 Hz if you believe most of the energy in your voice is higher or lower.
- When you have found a setting that is symmetrical with similar energy above and below the horizontal zero axis, save your TX profile.

Summary: Remember that while you are operating you can manually toggle COMP on or off to add a hard limiting effect to your transmit audio if desired. If you have enabled CESSB its hard limiting effect will also be present each time COMP is enabled. Remember, if COMP is enabled when you save your Transmit Profile these features will be on by default.
For those who wish to enable the console COMP button and CESSB, excessive output from the CFC components may make your transmitted audio sound somewhat harsh. To minimize this, try reducing the PRE-COMP slider so that the CFC meter displays maximum peaks of 0dB.
Note that when COMP and CESSB are enabled, the output is hard-limited at 0dB as shown with the "ALC Comp" meter. A new adjustment for COMP and CESSB users is available that allows you to exceed 0dB of ALC compression with COMP and CESSB enabled to make it possible to use the look-ahead algorithm at the ALC level to incorporate soft-limiting in the final stage. You can try this new feature by moving to the Menu > Setup > DSP > AGC/ALC form and using the new ALC **Max Gain** setting to increase **ALC Comp** in 1dB steps from 1dB to 10dB. Several dB of **ALC Comp** should increase your over-all loudness without added harshness.
Note that these CFC adjustment steps should be considered a starting point for optimizing your transmitted audio. When you have become comfortable with the interface, you might wish to experiment with changing the frequency points for the CFC sliders so they span the transmitted bandwidth of each transmit profile you are working on. As an example, for a 3.0k sideband profile try the following values: 50, 150, 300, 500, 750, 1250, 1750, 2000, 2500, 3000. There's nothing magical about those numbers so experiment with values that give you the best tonal control for your intended bandwidth.

7.3 VOX

7.3.1 Modes of operation:

- VOX OFF, DEXP OFF—no PTT action, no gating or downward expansion.
- VOX ON, DEXP OFF—PTT action, all gating functions operating except for Expander Ratio (Exp. Ratio), which is effectively set to infinity (a pure gate, no downward expansion).
- VOX OFF, DEXP ON—no PTT action, all gating and expander functions operating.
- VOX ON, DEXP ON—PTT action, all gating and expander functions operating.

7.3.2 Basic gate adjustments:

VOX threshold is adjusted with the slider control on the main console user interface in the same manner as previous versions of Thetis. Approximately 15 to 20 dB above normal background noise levels is a good starting point (not including receiver audio; see "Anti-VOX" below).

The remaining controls are found in Setup > DSP > VOX/DE:

- Attack time—after being triggered open the gate gain increases from fully closed to fully open in this amount of time. This adjustment can help soften the start of audio for a more natural sounding result, it is typically kept short for radio applications. 2 ms is a good starting point.
- Hold time—after being triggered closed the gate gain will stay fully open for this amount of time. This is most closely analogous to the old VOX hold time. If re-triggered open this timer resets. Adjust as desired, typical values range around 250ms, which is also a good starting point.
- Release time—after the hold time expires the gate gain decreases from fully open to fully closed in this amount of time. With VOX enabled, PTT releases after this time expires. It can be made longer for a more natural sound, especially when not using VOX, or made shorter for contest or VOX work. Typical values range from 10ms to 250ms. 100ms is a good starting point.
- Det. (detector) Tau—the amount of time the input audio must be over threshold before the gate is triggered open and, with VOX activated, PTT asserted. Making this longer can help filter out extraneous background noises from triggering the gate, such as typing on a keyboard, but it does increase gate latency. 10-20ms is a good starting point.
- Anti-VOX—this feature raises the VOX threshold in real time in concert with receiver audio levels in order to prevent receiver audio emanating from speakers from tripping the VOX threshold. Anti-VOX is not required when using headphones, of course. Note: this is not “noise cancellation”, only an adjustment based on sound level.
- Anti-VOX Gain—this is the gain factor used to cause VOX threshold adjustments in concert with receiver audio volume emanating from the radio speaker(s). This value can be positive or negative. Set the value as low as possible but high enough to prevent receiver audio from triggering VOX. It generally helps to set it very low, say -40dB, then work up from there. For average listening levels and RX1 AF or RX2 AF set to 100, a value of -20dB is typical. If the VOX threshold is set using a quiet room (fans and other equipment, but no receiver audio), adjustment in this manner should still allow triggering VOX even when receiver audio is active, e.g. when trying to break into a DX pile-up.
- Anti-VOX Tau—this sets the time constant of the low pass filter applied to the Anti-VOX gain algorithm. Smaller numbers make Anti-VOX more responsive to receiver audio at the expense of making the Anti-VOX gain setting more sensitive (aka “touchy”). 20ms is a good starting place.
- Use VAC Audio—when not checked, Anti-VOX will use both RX1 and RX2 audio (nominally for people using speakers attached to radio hardware). When checked, Anti-VOX will use the audio present on active VAC outputs (nominally for users who are fully “virtualized” i.e. remoted from the hardware).

7.3.3 Advanced gate adjustments:

- Side-channel Trigger Filter—when enabled, the actual audio used by the gate trigger detector will be filtered by the combination of the low and high cut filter adjustments. This does NOT affect the audio passed through the gate and sent out over the air, which remains unfiltered. Along with the Det. Tau adjustment, the side-channel filter can be extremely helpful in eliminating false triggers caused by keyboarding, bumping or moving the microphone around, cats jumping on the desk, etc. Adjust this to match up with the dominant frequencies of your voice. A low cut of 500Hz and a high cut of 1500Hz is a good starting point.
- Audio look-ahead—this adjusts a delay line such that the VOX/gate trigger decision can be made on a first syllable but that first syllable will not be lost because the gate acts on the audio coming out of the delay line. For best results this setting should be greater than the

sum of the Det. Tau setting AND the RF Delay setting (in Setup > General > Options) PLUS 10ms. Used properly, people may not even realize you are using VOX. The downside is that there is some latency so it may not be the optimum choice for contesting or the like. Proper adjustment depends on how quickly you speak, but a good starting place is 60ms.

- Hyst. (hysteresis) Ratio—to prevent rapid triggering/un-triggering of the gate this is the difference between the threshold for triggering the gate open or closed. 2dB is a good starting point.

7.3.4 Expander adjustment:

Exp. Ratio—this is the only expander adjustment, and this is the slope of the audio gain line from the gate threshold to fully closed. For a hard, "pure" gate, this can be made equal to 30dB. A more typical value would be 10dB which results in a 10:1 slope (fairly steep). For those who prefer a softer, more gradual transition (usually those who are not using VOX, maybe someone who just wants to suppress background fan noise), this can be made very gradual. For example a value of 3dB will provide a 2:1 gain slope.
In an “ideal” transmitter your linear amplifier would be exactly that: linear. Unfortunately no real amplifier ever is, and Intermodulation Distortion (IMD) to the transmitted signal is inevitable. If uncorrected (as with almost all amateur band transceivers) this will lead to unintended emissions above and below your TX signal which could easily be only 25- 30dB below your signal. In a crowded band those could cause real problems.

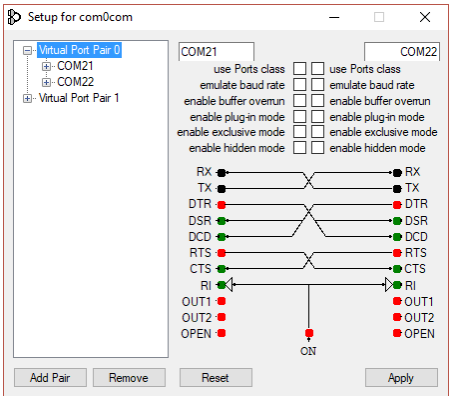
7.4 Setting Up Virtual Audio and COM Ports

To use data mode software, drivers are needed to provide an audio and a serial connection between two programs running on the same computer. We need two kinds of driver:

1. A virtual serial port – there are several program that do this; the strongly recommended ones are “Virtual Serial Port Driver” by Eltima software (paid for) or “Com0Com” which is free. In this case we will use Com0Com, but both are similar. Visit the download website https://sourceforge.net/projects/com0com/, download the code and install it. Documentation is available at http://com0com.sourceforge.net/
2. A Virtual Audio Cable. For this one option is to purchase this program – visit https://vac.muzychenko.net/en/purchase.htm & purchase the software. You will receive an email with a link to download the full version. Download and install it: you will probably need the 64 bit version for windows 10. There is also newer software available eg Voicemeeter Banana https://www.vb-audio.com/Voicemeeter/banana.htm

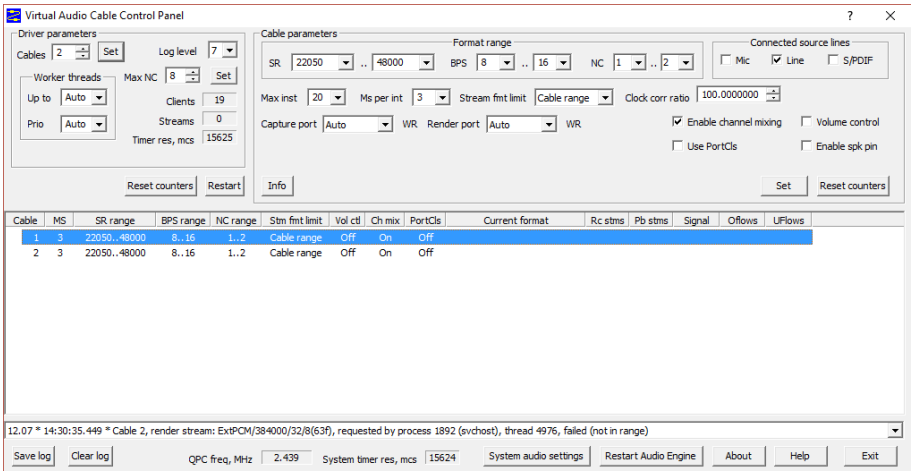
7.4.1 Virtual COM

1. Run the Com0Com setup utility from your windows menu. That will open a form showing the connection available.
2. By default the program will have created two pairs of ports: for example “CNCA0 & CNCB0” and “COM6 & COM4”. Delete one pair; rename the other two to COM21 and COM22 to make sure they are different from any real COM ports. Leave the other settings unchanged.
3. That’s it! PC programs will now see COM21 and COM22 as usable serial ports.



7.4.2 Setting up VAC

1. Find the "VAC Control panel" on your windows menu, right click and "run as administrator". The configuration window opens. There is a box at top left marked **cables**: set that to 2 and press **Set**.
2. You now have a pair of audio cables; we will use one for audio in, and one for audio out.
3. Exit the program using the button at the bottom right.
4. You need to restart your PC for these changes to take effect.



A guide to setting up Voicemeeter Banana software, as an alternative solution, has been written by Scott W2UO: http://wu2o.dyndns.org/wu2o_vac_tutorial_2.html

7.5 Interfacing to a Linear Amplifier

The manual for your radio will have important instructions on connecting an external linear amplifier to your radio.

7.5.1 Setting the Operating Band

Your linear will need to know which band is in use. If it provides a parallel hardwired connection it should be possible to use the 7 Open Collector outputs appropriately configured to indicate the band in a binary word. See section 6.1.6.

If your linear amplifier supports CAT commands, then it may be able to interrogate THETIS directly.

7.5.2 Keying

Your linear will need a signal to control when it enters TX mode. Your radio will provided appropriate control outputs; follow the radio manual instructions.

7.5.3 ALC

THETIS and the HPSDR radios do not support an ALC signal from a linear amplifier. ALC is operated internally within THETIS and your radio, to ensure an optimum drive signal is generated. Thereafter it is your responsibility to set the **Drive** level so that your linear operates in its linear region.

7.5.4 Puresignal

It is possible to use Puresignal to provide adaptive pre-distortion to the transmit signal through a linear amplifier in just the same way as when it linearises its own internal amplifier. It requires an RF coupler after the linear amplifier so that a sample of the TX signal can be coupled back to the receiver. Consult your radio manual for details.

7.6 Software Maintenance

7.6.1 Installing Software Updates

Installing updates is simply the same process as a clean install. However at the end of the process, THETIS will not need to re-run the FFT tests. You will get a message saying that the database will be updated to a new version; let this run to completion, then re-run THETIS.

7.6.2 Building THETIS from Source Code

It is possible to download the source code for THETIS [8], make proprietary changes then execute the code. To be able to do this, you will need to download Microsoft Visual Studio "Community Edition". Currently the correct version is the 2019 version. You will need a Microsoft account for continued use, but it is free for non-commercial use. Visual Studio can be downloaded from: https://visualstudio.microsoft.com/vs/

If you wish to make changes to THETIS that others can benefit from, you are recommended to contact Doug W5WC in the first instance.

7.7 CAT Control

Computer Aided Transceiver (CAT) commands were created to allow PCs to control radios. They allow most of the settings of a radio to be accessed using simple serial commands. Many different kinds of program use them, and many external devices are available (e.g. auto tuners) that use them.

THETIS supports CAT commands, and can have 4 connections open at any time. These are accessed through the Setup form, CAT Control tab (see section 6.9).

Establishing a connection is simple:

1. Connect an external device, if you have one.
2. If you are connecting to another program on the same PC, you will need a virtual COM port program (see section 7.4.1)

3. Choose the CAT connection on THETIS (THETIS has one CAT connection on the primary tab, and three more on the "CAT+" form. They are all the same).
4. Set the **port** to the port number of your device or VAC cable
5. Set the **baud** rate, **parity**, **data** and **stop** bits appropriately (there should be documentation for the product you are connecting to)
6. Click **Enable**
7. And that's it – connection will be established.

The list of CAT commands used by THETIS and PowerSDR mrx ps can be downloaded from the TAPS HPSDR github repository [9]. That document explains the format of the commands.

Take care if your remote device includes an "Arduino" based processor: **NEVER** open the connection with the baud rate set to 1200. That will cause the device to erase its firmware, requiring it to be reprogrammed.

7.7.1 Connecting Hardwired Inputs

THETIS allows you to connect PTT switches and CW keys to COM put inputs of the PC. In both cases begin by getting a USB to serial converter. These general have a 9 pin D male connector; you will need a 9 pin female connector to mate with it. Plug the converter into your PC; use windows control panel device manager to find out which COM part number has been assigned to it.

Note than when **DTR** is selected you should wire to pin 6 (DSR); when **RTS** is selected you should wire to pin 8 (CTS). In both cases the other end of the PTT or key switch goes to pin 7.

7.7.1.1 Connecting a PTT Switch

1. Connect your PTT between pin 7 and pin 6 on the 9 pin D female connector.
2. Plug the connector into your USB to Serial converter.
3. Select the Menu > Setup > CAT Control form.
4. In the PTT section:
    a. Select the COM port for your converter in the **Port** box
    b. Select **DTR**
    c. Click **Enable PTT**. The controls get greyed out.
5. Now when you press your PTT switch, and the radio will be keyed to TX.

7.7.1.2 Connecting a CW Key

1. Connect your key between pin 7 and pin 8 on the 9 pin D female connector.
2. Plug the connector into your USB to Serial converter.
3. Select the Menu > Setup > DSP > CW form.
4. In the Connections section:
    a. Select **Primary** = Radio
    b. Select **Secondary** = (your COM port)
    c. Select **Key** = RTS
5. Select a CW mode eg **CWL**
6. Tick **Semi Break-In**
7. Now when you press your key, your radio will be keyed to TX.

7.8 Control Panel Operation

THETIS supports at least three ways to have a physical “front panel” with controls on it to operate your radio.

7.8.1 Andromeda

Andromeda is (will be) a radio with an integral front panel with pushbuttons and rotary controls alongside a 7” touchscreen display. Its front panel is controlled by an Arduino module, and all commands and messages are exchanged using CAT commands.

7.8.2 Odin

Odin is a “front panel” type accessory device designed by Laurence Barker G8NJJ and Kjell Karlsen LA2NI. It has rotary controls and pushbuttons, and a small touchscreen display which can access more settings. The design for Odin is in the public domain published on github [15].

Odin connects to THETIS or PowerSDR mrx ps using CAT commands. It allows tuning with a tuning action comparable to that of the FT1000 with no “lag” evident even when turned at high speeds. A prototype, fully working Odin is shown below.

To connect Odin:

1. Open the Menu > Setup > CAT control form
2. In the **CAT control** area, click the **Port** combo box and select the correct com port
3. Set **Baud** = 9600, **Parity**=none, **Data**=8, **Stop**=1
4. (Do NOT select baud rate = 1200)
5. Click **Enable CAT**
6. And Odin will now be working. Its display will change to something similar to that above and the controls will operate.

You can even have two Odins – one for each receiver, if you have a dual receiver system. Set one to operate VFO A and the other to operate VFO B and each can, quite separately, operate its channel. To connect a second Odin, use the Menu > Setup > CAT Control > CAT+ form.

7.8.3 Midi

I have no idea how or where to start on this!

7.9 Connecting Other Devices

It is possible to connect a PTT button and a CW key to your PS, using serial port "strobe" signals.
more

8 References

[1] Open HPSDR Project Website: http://openhpsdr.org/
[2] Original PowerSDR manual: https://www.flexradio.com/downloads/flex-3000-owners-manual/#
[3] W1AEX skins - http://www.w1aex.com/hpsdr/hpsdr.html
[4] WDSP Guide: https://github.com/TAPR/OpenHPSDR-wdsp
[5] Protocol 3 documentation: https://github.com/TAPR/OpenHPSDR-Firmware/tree/master/Protocol%202/Documentation
[6] WDSP Documentation: https://github.com/TAPR/OpenHPSDR-wdsp
[7] Thetis releases - https://github.com/TAPR/OpenHPSDR-Thetis/releases
[8] Thetis source code repository: https://github.com/w5wc/Thetis
[9] Thetis And PowerSDR™ 3.x CAT Command Reference Guide: https://github.com/TAPR/OpenHPSDR-PowerSDR/blob/master/Documentation/Radio/PowerSDR-CAT-Command-Reference-Guide-V3.docx
[10] PowerSDR mrx ps release: https://github.com/TAPR/OpenHPSDR-PowerSDR
[11] SDR Console website: https://www.sdr-radio.com/
[12] LinHPSDR: https://github.com/g0orx/linhpsdr
[13] Pihpsdr: https://github.com/g0orx/pihpsdr
[14] WDSP port to Linux: https://github.com/g0orx/wdsp
[15] Odin can be found at: https://github.com/laurencebarker/odin-SDR-console