G0ETP V2 SDR HF Receiver – User Guide

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This document describes the controls and functions of the V2 G0ETP HF receiver, along with some useful operating procedures and tips.

NV-SRAM Settings and Initial Power On

The radio uses battery backed-up SRAM to store various parameters when the power is off. If at any point corrupt values are detected in the SRAM they will be re-initialised with default values. You can forcibly reset the SRAM settings by holding the VFO button in while turning the power on. Once you have calibrated your radio's RSSI (amplitude) and TCXO (frequency) it is a good idea to write these down somewhere in case a reset occurs.

Primary Radio Controls

Push Buttons

- **VFO** Press this to toggle between VFO A and B
  Hold this to copy the current VFO into the other one**.**
- **Mode** Press this to cycle through the modes USB, LSB, CW and DATA or AM and FM modes.
  Hold this button to switch between SSB/CW and AM/FM groups.
- **Display** Press this to cycle through display modes that are appropriate to the current mode. In SSB, AM and FM this will be the FFT display and the waterfall display. In CW and DATA modes a text decode screen is also available.
  Hold this button in CW mode to view the amplitude slicer or in DATA mode to view the raw demodulator output.
- **Step** Press this to cycle through the tuning step sizes from 10Hz to 10kHz. Hold this to enter 100kHz tuning mode to move quickly between HF bands.
  If Freq Quantise is on, any VFO offset below the tuning step size gets zeroed when you tune. If Freq Quantise is off then any VFO offset smaller than the tuning step will remain when you tune.
  If Auto Step is enabled then this gets set to a suitable value on certain mode changes.

Push/Rotate Menu Knob

Pressing the menu knob will first bring up the menu display if it is hidden.

Pressing this while the menu is visible will toggle between menu item selection and menu item adjustment.

When a menu item is selected for adjustment, the rotation of the menu knob remains associated with that value, even after the menu display has disappeared.

Menu Items

The following items are stored on a per-VFO basis:

- **Max AGC Gain** This limits the maximum gain that will be applied to weak signals. It is used to control the volume of the *channel background noise*. This is functionally identical to 'AGC Threshold' available on some other radios. This also controls the CW slice threshold in CW mode, the bias level of the waterfall display and squelch in FM mode.
- **Attenuation** The V2 design has an RF attenuator before the RF preamplifier. This can be used to position the dynamic range of the ADC according to your local noise levels and any strong signals nearby. Use the highest attenuation setting that you can that does not result in the receiver noise being too high. (Rx noise 10 – 20 dB below the antenna noise will be fine.)
- **Bandwidth** Select Normal, Wide or Narrow bandwidth (the exact widths available are mode dependent).
- **Data mode** Select between RTTY45, BPSK31, 63 and 125 modes.
- **AGC Decay Time** The AGC has a logarithmic decay and (currently) no hold time. This controls the time needed for AGC to return to 90% of its full value.
- **Notch filters** These allow the notch filters to be turned on and off. When it is on the notch freq is displayed. Notch tuning if performed by the main tuning knob but *only* when the menu is visible.
- **IF Shift** This shifts the filter passband to help avoid adjacent channel interference.

- **Freq Quantise** When this is on, any VFO offset smaller than the tuning step will get zeroed when you tune (most radios behave like this). If Freq Quantise is off then any VFO offset smaller than the tuning step will remain when you tune; this is useful for offset channel grids, such as CB channels.
- **Auto step** When this is on the tuning step size is (re)set to a convenient value when certain mode changes occur.
- **Waterfall bias** This offsets the waterfall level (colours) *relative* to the current signal levels being received and the Max AGC setting.
- **FFT peak hold** FFT peak hold enables a line of dots that track the envelope of the FFT display.

The following items are global:

- **Pre-sel filter** If you have fitted an RF pre-selection filter you must select the correct type here. There is a bypass setting for every filter type, regardless of whether your particular filter hardware supports it.
- **Ref freq adjust** Used to calibrate the internal TCXO (see calibration procedure below).
- **RSSI Cal Adjust** Used to calibrate the dBm and S-Meter signal level reporting (see calibration procedure below).
- **W/fall Hscroll** When this is on the waterfall history will scroll sideways when the radio is tuned.
- **AGC spk mode** The AGC impulse-noise detector can either operate over the channel filter bandwidth or the whole ADC bandwidth.
- **AGC spk thresh** Adjusts the sensitivity of noise spike detection.
- **AGC spk delay** Changes the hold time before the 'normal' AGC level is restored.
- **Menu step div 2** This option can correct for using the wrong type of encoder for the menu control (1 full-cycle per detent).
- **Tun enc steps** The original design uses a 256 step/revolution encoder for tuning. This option can mostly correct for using an encoder with 128 steps.
- **Code version** Display only.

Tuning

The main tuning knob is self explanatory. The tunable frequency range of the V2 design is 1.8MHz to 74MHz in 10Hz (or greater) steps. Note that mixer performance and balance becomes progressively worse above 30MHz and so frequencies above 30MHz are allowed only as a bonus; performance is not good.

FFT and Waterfall displays

These show signals in the range ±12.5kHz with 0 at the centre of the screen.

In FFT mode, the Y axis is logarithmic with a scale of 1dB per pixel, so it can display a range of 128dB.

The waterfall display uses a colour palette similar to that used in FLDIGI; this goes from black to blue to yellow to white to red. There is a blue 'plateau' just before yellow which can be used to separate stuff above (active signals) and stuff below (band noise). The Max AGC gain control (= AGC threshold) is linked to the waterfall colour offset so that the Max AGC gain setting can be adjusted to accommodate current band noise conditions for both the AGC and waterfall in one operation. If you need to offset the *relationship* between these two functions then adjust 'Waterfall bias' in the menu.

Pre-Selector Filter Selection

If you have fitted a pre-selector filter to your radio then you will need to select the correct filter within the radio menu. Failure to select the correct filter can result in little or no signal reception.

Check http://www.themadhowes.org.uk/g0etp/v2_sdr_rx/filters.html for an up to date list.

Distunguishing Real Signals from Images and Spurs

Signals that are 'really there' will move across the FFT and waterfall displays at the expected tuning rate, i.e. on the waterfall they will remain as vertical traces (when Waterfall Hscroll is enabled).

Signals that result from harmonic mixing in the radio QSD mixer will move at a multiple of the tuning rate or in a different direction; these will *not* stay still on the waterfall display and can therefore be recognised. To help avoid those that are caused by images of real signals, a bandpass pre-selection filter can be applied at the antenna input (e.g. the HA8LFK filter). An ATU can help a lot here too. If you are unlucky and have a persistent in-channel interferer then adding an external notch filter can help.

Other spurs, such as those coming from the ADC sample clock and the ARM board will tend to stay still as they are 'real signals'.

TCXO Frequency Calibration

The suggested method for calibrating the radio's internal TCXO frequency reference is to use an accurate off-air frequency standard, such as the Russian time and frequency reference RWM on 9996kHz (also 4996kHz and 14996kHz) Calibrate as follows:

- Select USB mode, 500Hz step size.
- Set IF shift to -700Hz (so we can hear 500Hz either side of 0).
- Tune to 9995.5kHz
- Set the tuning step to 1kHz.
- Turn off Freq Quantise
- Flip between 999**5**.5 and 999**6**.5 and alter the 'Ref freq adjust' menu option until you hear the *exact* same 500Hz tone either side of 9996kHz.

You can of course use a (very) accurate RF signal generator if you have one.

S-Meter (RSSI) Calibration

The gain of the receiver board should not vary drastically from one build to the next, so adjustment of the S meter is not essential. The addition of a preselector filter (along with an attenuator to stabilise the filter’s response) will have a significant effect on RSSI calibration. The procedure is as follows:

Put the radio in CW-W mode and inject a signal at an exactly known level from an RF generator at. I typically use 14MHz at a level of -60dBm. Using the RSSI calibration in the menu, find the min and max calibration point where the RSSI reads -60dBm. Set the RSSI calibration to the mid point of these 2 values.

Useful Operating Procedures

Max AGC Gain Setting

This menu setting limits the maximum gain that the AGC can apply. This will have a large impact on the background channel noise and will have no effect on the volume of signals unless this gain is reduced *too far*.

I aim to set the gain so that the channel background noise is at least 10dB lower than that of active signals; this makes for a pleasant listening experience and reduces fatigue.

When you are familiar with this control, this is easy. Otherwise, one way to do this is to tune to an empty channel and increase the gain from low to high. Remember the step at which the noise becomes no louder then back off by 9-12dB.

The default waterfall 'bias' has been set so that this setting coincides with the channel noise on the waterfall being a mid blue colour and not quite causing yellow to appear.

CW Decoder Slicer Level Adjustment

Like the colours in the waterfall, the threshold level used in the CW decoder key up/down decision is linked to the Max AGC gain control, so altering the Max AGC gain setting will adjust the CW decoder sensitivity.

The threshold needs to be set so that between transmissions, channel noise is just below the CW threshold and no 'crumbs' appear on the ticker-tape at the bottom of the CW decode screen. This threshold setting can limit sensitivity, however, particularly when there is a lot of channel fading. If more CW sensitivity is required, increase the Max AGC gain but accept the fact that noise will now cause false characters to appear.

RTTY Reception

The RTTY demodulator is configured for 2-FSK signals with a frequency shift of 170Hz. The MARK tone (logic 1) is the higher of the 2 RF frequencies and is indicated exactly by the VFO frequency display. The MARK tone has been set in this design to generate a 1000Hz audio tone. The SPACE tone (logic 0) is the lower of the 2 RF frequencies and produces an 830Hz audio tone. Tune the signal so that the signal energy shown in the data tuning indicator is centred. (You should be able to hear *both* tones of the RTTY signal.)

The RTTY decoder operates using the 5-bit Baudot / ITA-2 character set at 45.45 BAUD (22ms bit duration). There is an operating convention known as Un-shift On Space (UOS); this is enabled in this receiver.

PSK Reception

PSK reception is currently achieved using a single bandpass filter followed by a differential PSK demodulator. The current implementation is adequate for a casual look at PSK traffic but it should be noted that:

1. The Amateur PSK design is such that a *matched* filter cannot be used in the receiver, so any filter that is used will be sub-optimum in some way.
2. Differential demodulation is simple but provides sub-optimal performance at low signal to noise ratios.
3. There is no AFC, so very accurate manual tuning is required.

A PSK signal must be tuned to the nearest 10Hz step so that the energy in the data tuning indicator is centred. PSK31 is the most critical.

AM Reception

A feature of this zero-IF radio design and the particular ADC used means that there is a narrow notch at the 0 IF centre (where the green line is on the display). If an AM station is tuned exactly, the AM carrier can fall into this notch and result

in distorted audio. The workaround for this (for the time being) is to tune slightly to one side, e.g. set the VFO frequency 100Hz higher than the nominal AM carrier.

Whilst there is no synchronous AM detector, the accuracy of the VFO in this radio is so good that you can asynchronously decode AM in SSB mode. If the tuning error is < 5Hz this is even good enough for music.

When demodulating AM in SSB mode, the presence of the AM carrier can force the AGC up and lead to low audio output. If this is causing you grief, set the IF shift to +100Hz and this will bring the audio back to the expected volume but at the expense of a reduced bass response.

During AM reception I find that the FFT display is more useful than the waterfall display.

Notch Filter Tuning

In order to adjust the notch frequency you will need to press the menu knob and then tune the notch with the main tuning knob.

Hearing when the notch is in the best place to remove an interferer is easier if you wait until the wanted signal goes away.

Tuning the notch filter back-and-forth slightly can be used as a trick to stop the radio dropping back out of menu mode, allowing you more time to make the best adjustment.

V2 SDR Specifications

Tuning Range

1.8MHz to 74MHz in 10Hz (or greater) steps. Note that mixer performance and balance becomes progressively worse above 30MHz and so frequencies above 30MHz are allowed only as a bonus; performance is not good.

IF Filter Bandwidths

- SSB -6dB 2766Hz, -60dB 3314Hz (shape factor 1.2)
- SSB-W -6dB 4253Hz, -60dB 5066Hz (shape factor 1.2)
- SSB-N -6dB 2238Hz, -60dB 2685Hz (shape factor 1.2)
- CW -6dB 255Hz, -60dB 559Hz (shape factor 2.2)
- CW-W -6dB 508Hz, -60dB 1116Hz (shape factor 2.2)
- CW-N -6dB 86.3Hz, -60dB 188Hz (shape factor 2.2)
- AM -6dB 6510Hz
- AM-W -6dB 8650Hz
- FM -6dB 12880

In SSB mode the default BFO position (IF shift set to 0) is at the -6dB point on the filter skirt.

Sensitivity and Maximum Signal Handling

The receiver analogue gain is fixed to deliver a compromise between receiver sensitivity and strong signal handling. The 24bit ADC reaches saturation at an input signal level of around -TBDdBm, which is equivalent to S9+50dB. The noise figure (NF) of this receiver is around TBDdB.

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