piHPSDR User's Manual

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Contents

Chapter 1

Introduction

piHPSDR is a program that can operate with software defined radios (SDRs). As a graphical user interface, it uses the GTK-3 toolkit, while the actual signal processing is done by Warren Pratt's WDSP library. Thus, piHPSDR organizes the transfer of digitized radio frequency (RF) data between the radio hardware and the WDSP library, the transfer of audio data (either from a microphone or to a headphone), as well as the processing of user input (either by mouse/touch-screen, keyboard, or external "knobs and buttons"), and the graphical display of the RF data. piHPSDR is intended to run on different variants of Unix. It runs on all sorts of Linux systems, including a Raspberry Pi (hence the name piHPSDR), but equally well on Linux desktop or laptop computers, and on Apple Macintosh (Mac OSX) computers which have a Unix variant under the hood. The present author is not aware of piHPSDR running under the Windows operating system, although with environments such as MinGW, this should be possible.

Although piHPSDR can be operated entirely by using mouse and keyboard as input devices, many users prefer to have physical push-buttons and/or knobs or dials. To this end, piHPSDR can control push-buttons and rotary encoders connected to the GPIO (general purpose input/output) lines of a Raspberry Pi. At least two generations of such controllers have been put on the market by Apache labs, and I know of several projects where home-brewn controllers have successfully been made. As an alternative, MIDI devices can be used for user interaction. For desktop/laptop computers that do not have GPIO lines, MIDI offers an easy-to-use possibility of having push-bottons and dials that control piHPSDR. Apart from homebrew projects in which a micro-controller such as an Arduino Micro controls the actual buttons/knobs and acts as a MIDI device to the computer to which it is connected via USB, there are low-cost so-called "DJ controllers" (DJ stands for disk jockey) from various brands which have successfully been used with piHPSDR. A third possibility to control piHPSDR is via a serial interface through CAT (computer aided transceiver) commands. The CAT model used by piHPSDR is based on the Kenwood TS-2000 command set with lots of PowerSDR extensions.

Using a touch-screen instead of a mouse offers the possiblity to put the actual radio hardware together with a Raspberry Pi running piHPSDR and an assortment of buttons/knobs into a single enclosure. This way, one can build an SDR radio which can be operated like a conventional analog one.

The piHPSDR program has been written by John Melton G0ORX/N6LYT. It is free software that is licensed under the GNU (free software foundation) general public license. Many other radio amateurs have contributed to the code. A lot of extensions and improvements have been added by myself, therefore this document refers to the version of piHPSDR that can be found on my github account `https://github.com/dl1ycf/pihpsdr`.

Because piHPSDR can be used on many different types of computers, and because operating systems change rather quickly over time, I generally do not recommend to have a ,,binary release" with files that you can just copy to your computer and then it runs. Instead, my personal recommendation is to build piHPSDR and WDSP from the sources, only this procedure guarantees compatibility of the final program with your operating system. A manual of how to compile piHPSDR from the sources is available separately, see `https://github.com/dl1ycf/pihpsdr-compile-from-sources`, so this will not be covered in the present manual. This manual starts with the first invocation of a freshly compiled piHPSDR.

Chapter 2

Starting piHPSDR for the first time

Let us assume you have an SDR (say, an ANAN-7000 or a HermesLite-II) powered up and connected to an antenna, and you have piHPSDR installed on a computer (say, a Raspberry Pi or an Apple Macintosh), the first thing to do is to establish a proper connection between the computer and the radio. Although advocated at many places, I do highly recommend against a WiFi connection. WiFi routers often use ,,optimizations" where they hold back data packets for a given client for a while, to be able to send a collection of them in a burst. While this certainly optimizes the through-put because it minimizes clear-channel arbritration events, such jitters are desastrous in SDR operation. The safest way of connecting the radio and the computer is to have a managed switch with a built-in DHCP server, and to connect both the computer and the radio with a suitable cable to the switch. If the computer has both a RJ45 jack for an ethernet cable, and a WiFi interface, my personal recommendation is to use WiFi to connect to the internet, and use a single ,,direct cable" plugged into the RJ45 jacks of the computer and of the radio. This is a little bit tricky since both the computer and the radio have to be set to a fixed IP address (e.g. computer: 192.168.1.50, radio: 192.168.1.51) with the same netmask. However, once this has been done, this is the safest connection with no perturbations from elsewhere.

If the piHPSDR program is started for the first time, it opens a window that looks like Fig. 2.1. Besides stating a version number and when piHPSDR

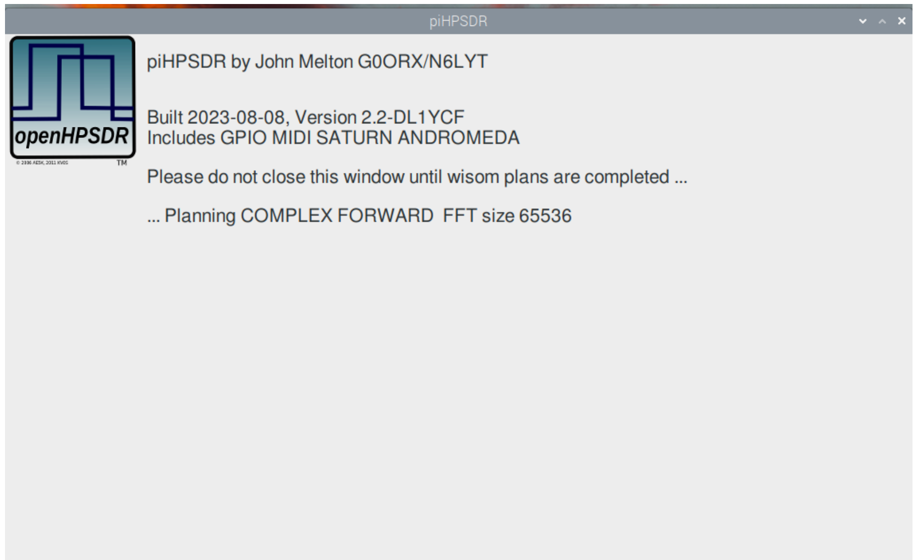


Fig. 2.1: piHPSDR screen while completing the ,,wisdom plans".

was built, a list of optional features (to be activated at compile time) is stated, in this case, GPIO, MIDI, SATURN, and ANDROMEDA. These options indicate that the program has GPIO support (this is only possible on Raspberry Pi or similar single board computers), that is has support for MIDI devices, that it can run natively on the compute module of the latest G2 (generation two) SDRs from Apache labs, and that is has support for Laurence Barker's ANDROMEDA controller. What is important here that you have to wait. This only applies to the very first time you start piHPSDR. On CPUs with a rather simple instruction set (like the ARM processor in the Raspberry Pi, or the Apple Silicon processor in recent Macintosh computers), this "planning" step is quite fast, on CPUs with very complex instruction sets like the Intel x86 processors, this step can last up to 15 minutes. When the "wisdom plans" are completed, piHPSDR tries to detect a radio on the network. If everything went well with the network connection, you then see a screen with a ,,discovery menu" (Fig. 2.2).

At this point, you can start the radio by clicking the `Start` button, but let us first explain the purpose of the other buttons! Easiest to explain is the `Exit` button, this will simply terminate the program. Most likely, you may want to go into the `Protocols` menu sooner or later. By default, piHPSDR tries

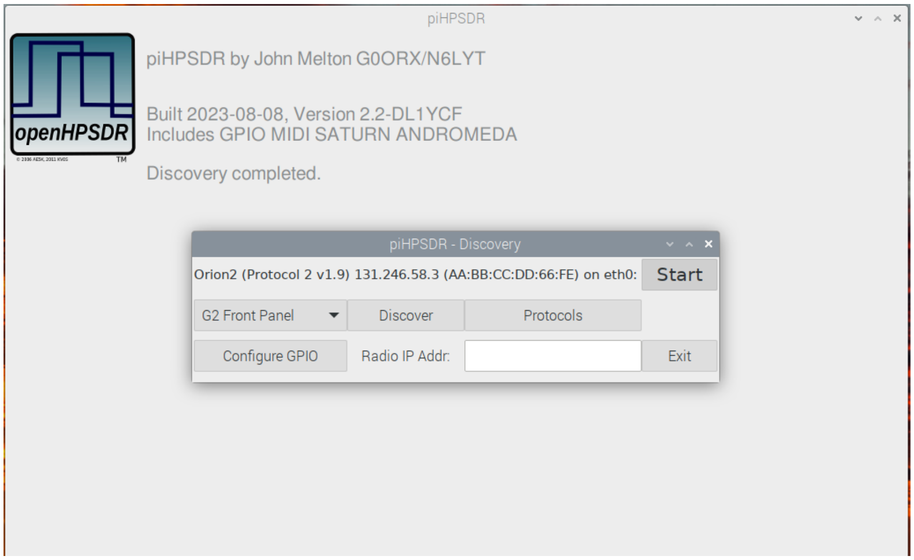


Fig. 2.2: A radio has been discoverd. You are ready to start it.

to discover the presence of a radio using all protocols known to piHPSDR. However, if you know that your radio, for example, uses Protocol 2, then trying to discover a Protocol-1 radio is just a waste of time. So if you know which types of radio you want to connect to, check these protocols. The available protocols are

`Protocol 1` This is the "original" HPSDR protocol.

`Protocol 2` This is the "new" HPSDR protocol.

`Saturn XDMA` This is used to talk to a Saturn FPGA through the internal XDMA interface. Only available if piHPSDR is compiled with the `SATURN` option.

`USB OZY` This is used to talk to a radio using the legacy USB OZY interface. Only available if piHPSDR is compiled with the `USBOZY` option.

`SoapySDR` This is used to talk to a radio through the SoapySDR library, for example to an AdalmPLUTO. Only available if piHPSDR is compiled with the `SOAPYSDR` option.

`STEMlab` This is used to connect to RedPitaya based SDRs through the WEB interface. Only available if piHPSDR is compiled with the `STEMLAB_DISCOVERY` option. Starting the radio using this protocol is a two-step process: first, the RedPitaya's WEB interface is located, and the `Start` button then starts the SDR app on the RedPitaya. Then, piHPSDR tries to connect to this SDR app and upon success offers a new `Start` button to start the radio. If the RedPitaya is exclusively used as a radio, it is recommended to auto-start the SDR app when the RedPitaya is powered up. In this case, the STEMlab protocol is not used, because the SDR app can be started through Protocol-2.

`Autostart` This is a very useful option. It indicates that if exactly one radio has been found, it is automatically started. So in normal operation, when starting piHPSDR subsequently, and all settings are still valid, the radio is started without user intervention. If this option is activated and one radio is present, you will not see this menu, so in order to make further changes here, you have to disconnect the radio from the ethernet cable, start piHPSDR until you see this menu, and reconnect the radio.

Sometimes piHPSDR needs to know the IP address of the radio. This is, for example, the case for the `STEMlab` discovery described above. In such a case the IP address in numerical form (xxx.xxx.xxx.xxx) can be entered in the box with the label `Radio IP Addr:`. If a legal IP address is contained in this box, protocol-1 and protocol-2 discoveries will also send, in addition to a broadcast discovery packet, such a packet to the IP address specified. This way one can connect to radios which are not on the same subnet as the computer, in principle you can connect to any radio on the world provided it is on the internet. However, the original HPSDR standard states that a broadcast packet must be used, so several radios won't reply. On the other hand, there are some radios such as a RedPitaya or a HermesLite-II which allow being discovered by such a routed packet.

The `Discover` button re-starts the discovery process. This is useful if the radio has been powered up too late and was not yet ready when piHPSDR was started. Simply press `Discover` to give another try.

The `Configure GPIO` button opens a menu that currently has no function, so it is not described here.

The combo-box (pop-down menu) to the left of the `Discover` button lets you choose which type of GPIO controller you have attached to the computer. This menu is only available if piHPSDR has been compiled with the `GPIO` option, which is not the case on desktop/laptop computers. The menu lets you choose between

`No Controller` Choose this if no GPIO controller is wired to your Raspberry Pi.

`Contoller1` Choose this if you have a "version 1" piHPSDR controller.

`Controller2 V1` This option is valid for some early prototypes of the "version 2" controller.

`Controller2 V2` Choose this if you have a "version 2" piHPSDR controller.

`G2 Front Panel` Choose this if you have an ANAN G2 radio with a built-in controller.

Attention. Be sure to choose a controller only if such a controller is actually connected to your Raspberry Pi. If you choose, for example, a controller which uses an I2C expander for the switches, but no I2C interface is present on your Raspberry Pi, the program my hang when trying to open the I2C connection.

All settings (protocols, controller, IP address) made in this menu are stored in the global (radio-indepentend) settings and are restored when piHPSDR is started the next time.

If all went well, a radio could be discovered and you hit the `Start` button, the radio is started, and if this succeeds, you see something like shown in Fig. 2.3.

The bottom of the window looks different (more controls) if you have chosen `No Controller` in the preceeding menu. You see two receiver panels stacked vertically, both of them having a spectrum display and a waterfall area. At the top, just below the window title, you have the VFO bar which contains information on the frequencies of the two VFOs A and B, as well as lots of

Fig. 2.3: The radio with two RX. Sliders and Toolbar are not on display by default when using a controller.

further information, to be explained later. At the top right, there are two buttons `Hide` and `Menu` which will be explained in the next chapter. To the left of these two buttons, there is the meter bar which by default is a digital S-meter. At this point, you have started piHPSDR successfully for the first time.

Chapter 3

Main window layout

3.1 One or two receivers

At the end of the previous chapter (Fig. 2.3), there were two receiver panels in the piHPSDR window, stacked vertically, and both including a spectrum scope (the green-coloured noise floor) and a waterfall. The waterfall area is completely black in the above picture since there was no RF signal. piHPSDR can be switched between having one or two receivers in the `Radio` menu. If there are two receivers (called RX1 and RX2), one of the two is the *active receiver*. If you look closely at the above picture, you will note that the spectrum scope of the lower (RX2) panel is shaded, while it is in bright colour for RX1. This indicates that RX1 is currently the active receiver. By simply clicking into the panel of the other (inactive) receiver, either with a mouse or on a touch screen, the formely inactive receiver becomes active.

Many conventional rigs with two independent receivers discriminate between the "main" and the "sub" receiver. It is important that this is *not* the case for piHPSDR. Both receivers are largely equivalent. For example, if you start transmitting in normal (non-split) mode, the TX frequency matches the frequency of the active receiver, no matter whether this is RX1 or RX2. Likewise, in split mode, the TX frequency matches the frequency of the non-active receiver. Most of the receiver-specific controls, for example adjusting the AF volume or the AGC gain, refer to the current active receiver. If piHPSDR runs with two receivers, RX1 is always controlled by VFO-A while

RX2 is controlled by VFO-B. The VFO settings not only include the frequency but also the current mode (e.g. LSB or CWU), the filter setting, the band and bandstack setting, whether RIT is enabled or not, and the RIT offset. So changing the RIT value only changes it for the active receiver. If you want to change the RIT value for RX2 while RX1 is the active receiver, you have to make RX2 active, change the RIT value and then make RX1 active again.

RX1 and RX2 are largely independent. They can receive on different bands. They can receive from different antennas provided the radio has two RF frontend with two analog-to-digital converter4s (ADC, as most modern radios do. In this case, one usually assigns the first ADC (ADC0) to RX1 and the second ADC (ADC1) to RX2. This can be done in the `RX` menu.

By default, if there are two receivers, they are vertically stacked, with RX1 in the upper part and RX2 in the lower part of the display. This can be changed in the `Screen` menu to horizontal stacking, where RX1 is in the left half and RX2 in the right half of the display. Changing the stacking trades vertical against horizontal resolution, of course.

Fig. 3.1: piHPSDR with a single RX and all controls (Zoom/Pan, Sliders, Toolbar) at the bottom.

Fig. 3.1 picture shows, for demonstration purpose, a piHPSDR window with a single receiver. The RX panel only contains a spectrum scope with a white line and no waterfall (this can be changed in the `Display` menu. In addition, you see the toolbar with eight buttons at the lower edge of the window, and above it an area with sliders. Showing the sliders is the default (and necessary) if there is no GPIO or MIDI controller attached, since then these sliders are the only way to change, for example, the AF volume. If there is only one receiver, it is controlled by VFO-A. VFO-B then actually controls nothing (except the TX frequency in split mode), but the data stored in VFO-B can be quickly used, for example by copying VFO-B to VFO-A (the `A<B` command), or by swapping the two VFOs (the `A<>B` command).

3.2 Spectrum scope options

You have already seen two different spectrum scopes: in the first picture, the spectrum was a filled green area, while in the last picture, there only was a white line (this is similar to what you would see on a spectrum analyzer). This can be adjusted to your personal preference in the `Display` menu (see below). There are two options which you can enable or disable, such that there are four different outcomes. The first option is the ,,Filled" option which discriminates between a line spectrum and a spectrum which is filled below the line. In the picture below, the first and third example have no filling, while the second and fourth spectrum are filled:

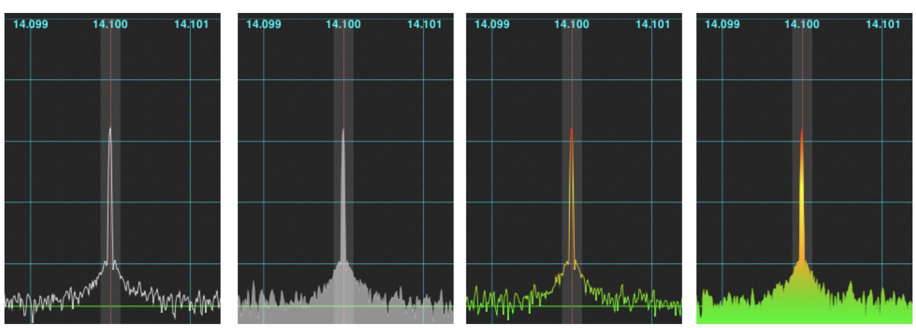


Fig. 3.2: Display options for the spectrum scope.

Then there is the ,,Gradient" option. Without this option, the spectrum is displayed in white colour. With the gradient option, the colour changes from green over yellow towards red depending on the signal strength (red colour is reached for S9). The above picture demonstrates the four possible combinations, and in the `Display` menu, you can make your choice. This setting refers to both receivers when there are two. Note that the TX spectrum can be a filled one or a line spectrum, but that the gradient option does not apply.

3.3 Zoom and Pan

Fig. 3.3: The spectrum scope of Fig. 3.1 with a large Zoom value.

The width of the RX spectrum equals the sample rate of the receiver. This means that if you use, say, a sample rate of 96 kHz for a receiver, its spectrum will be 96 kHz wide, which may encompass a larger part of the spectrum than you are interested in. As a drawback, the part which is relevant to you may look a little bit compressed. This is where the `Zoom` function comes in. The Zoom value can adopt integral values between 1 (no zoom) and 8. In the latter case, only 1/8 of the overall spectrum is displayed on the screen. In the picture below, you see that the RX scope is only 12 kHz wide (which is 1/8 of the RX sample rate, 96 kHz in our example). Note that what is displayed is in full resolution. Internally, a spectrum with 8 times the number of pixels of the screen width is created and only a part of it is displayed. The Zoom value can be changed using the Zoom slider (at the left edge below the RX panel).

When using a Zoom value larger than one, this means that a spectrum with more pixels than the actual screen width is produced. One can select which part of that area is displayed on the screen with the `Pan` slider (below the RX panel at the right side). Normally (Zoom=1), the VFO dial frequency is exactly in the middle of the RX scope, and marked with a thin red line. On the picture above, the dial frequency (14.100 MHz) is found in the RX panel close to the left edge, and this has been done by moving the `Pan` slider.

3.4 The `Hide` button

Fig. 3.4: piHPSDR window with the Toolbar/Sliders/Zoom area ,,hidden".

On small screens, space is scarce. This in in particular true for the vertical space if one used two RX panels and both with a spectrum scope and a waterfall. I this case, it may be hard to actually watch the signals if the screen is small. This is where the `Hide` button comes in. Clicking on this button ,,hides" the toolbar and slider area:

The text on the button then changes to `Show`, and clicking this button again will then return to the previous display.

3.5 Window areas

Look again at Fig. 3.1! Starting from the top, you see the title bar of the window. This bar is not visible in full screen mode, where the size of the piHPSDR window matches the display size. The title bar contains some basis information about the radio, e.g. its type, the protocol used, the IP and the hardware address of the radio. If you are really interested in this information, it is recommended to open the `About` menu.

Between the title bar and the RX spectrum scope, you see a small vertical area, most of which is taken by the VFO bar (containing the large frequency dials). At the rightmost end of this area, you see two buttons `Hide` (already discussed) and `Menu`. Clicking on the latter button opens the main menu, which will be discussed in detail in the following chapters. The `Menu` button is really important, since it enables access to one of the menus used for configuring piHPSDR. Between the VFO bar and the `Hide`/`Menu` buttons, you see the meter area where you find the S-meter (during RX) and information about output power, SWR, etc. during TX.

Below the RX spectrum scope, you see the Zoom/Pan area with the Zoom and Pan sliders, as already discussed. This area can be ,,hidden" with the `Display` menu to save some vertical space. Below the Zoom/Pan sliders you see a larger Sliders area containing several sliders for adjusting AF volume, TX drive leve, RX AGC threshold, etc. Although the Sliders area can also be hidden via the `Display` menu, you should not do so unless you have a GPIO or MIDI controller which knobs that you can asssign to the slider functions. This is so since for normal operation, having access to the sliders is vital. Remember that for temporarily enlarging the space for the RX panel, there is the `Hide` button!

If you have a GPIO or MIDI console, and, say, assigned a knob there to control the AF volume, then turning the knob will auto-magically also move the AF slider if its on display (that is, if the sliders area is not hidden). If you turn a knob for which function there is slider on display, either because the slider area is hidden or because this function does not have a slider in that area, then a graphical slider will temporarily pop up in the middle of

Fig. 3.5: A pop-up attenuation slider.

the window to inform you about the changes you have made. To give one example, a knob at a MIDI console has been assigned to the `ATTEN` function (see Appendix A), which controls the step attenuator in the RF front-end (if there is one). As long as the sliders are on display, the `ATT` slider in the left part of the slider area moves when turning the knob. But when the sliders are hidden, e.g. via the `Display` menu, then a slider image pops up on the middle of the screen, and the bar contained therein moves when turning the knob, and the numerical value is displayed as well (Fig. 3.5).

DESCRIBE THE SHORT CUT OPENING OF VFO, BAND, METER RX, TX menu.

3.6 VFO bar and status indicators

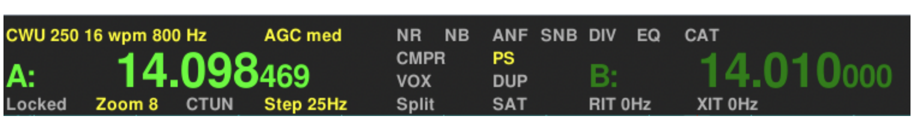


Fig. 3.6: The VFO bar

Fig. 3.6 shows the VFO bar layout in more detail. Note there are several VFO bar layouts coded into the program between which the user can choose (see the `Screen` menu), but the information content is the same for all those layouts.

The large dials indicating the frequencies of VFO-A and VFO-B are easily recognized. The number to the left of the decimal point is the MHz part of the frequency, the three large digits to the right of the decimal point is the kHz part, and the last three (smaller) digits offer sub-kHz resolution. You may wonder why there is so much space to the left of the frequencies. This is so because with the advent of the QO-100 satellite, frequencies above 10 GHz can be used (with the transverter bands) and therefore eleven digits are needed!

Apart from the frequencies, you see a lot of text, most in light grey colour. As a general rule, a text in grey colour indicates a feature that is currently disabled, while features currently active are normally shown in yellow and sometimes in red.

At the top left corner of the VFO bar, the mode and filter of the currently active receiver is displayed. In Fig. 3.6, you can see that the mode is CWU (upper side band CW) and the RX filter with designation "250" (it is easy to guess that this filter is 250 Hz wide, see the `Filter` menu). For CWU and CWL, the CW speed (in wpm) and the side tone frequency (in Hz) is stated as well.

Now we continue line by line, from left to right and find the string `AGC med` printed in yellow. This means that automatic gain control (AGC) is effective in the active receiver, and that the AGC time constant is intermediate. Possible values for the time constant are Long, Slow, Medium and Fast which can be selected in the `AGC` menu. Here one can also disable AGC, in this case the VFO bar shows `AGC off` in grey colour.

Continuing to the left, we see the noise reduction settings, all printed in grey (that is, they are not effective). This can be changed in the `Noise` menu. We have two different noise reduction capabilities `NR1` and `NR2`, these strings are printed in yellow instead of the grey `NR` if they are effective. There are also two different noise blankers `NB1` and `NB2`, the automatic notch filter `ANF` and the spectral noise blanker `SNB`. Besides enabling/disabling these functions, there are further parameters you can tweak in the `Noise` menu.

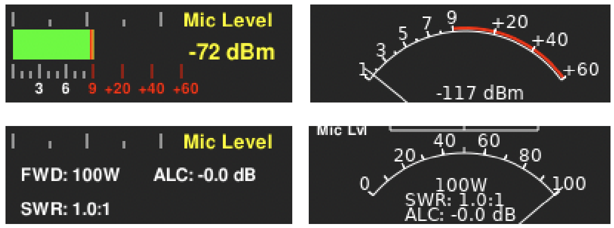
The next strings whether Diversity reception is enabled or disabled (`DIV`), or whether an equalizer is effective `EQ`. Since there is a separate equalizer for the RX and TX audio chain, the equalizer indicator, if it is effective, not only turns yellow but reads `RXEQ` while receiving and `TXEQ` while transmitting. This means, if only the TX equalizer is enabled, the indicator will show a grey `EQ` while receiving and a yellow `TXEQ` while transmitting.

The last indicator in the top row is `CAT` which indicates if the CAT module (see the `RIGCTL` menu) has accepted at least one connection. In total, piHPSDR can be CAT-controlled simultaneously by five different sources, two of them using a serial line and three of them a TCP connection.

The indicators in the middle, between the VFO dials, are related to transmitting. `CMPR` indicates if a speech processor (compressor) is enabled, if so, it prints in yellow, followed by a number between 1 and 20 indicating the compression value in dB. `PS` indicates whether adaptive pre-distortion („PureSignal") is enabled, PS settings can be made in the `PS` menu. `VOX` indicates whether VOX (voice control) is enabled. VOX means that if the microphone delivers an amplitude above a certain threshold, the radio is automatically put into TX mode. Enabling/Disabling VOX and setting the correct threshold can be done in the `VOX` menu. Finally, `DUP` indicates whether duplex mode is active. In duplex mode, the receiver(s) continue to work during transmit. Duplex mode when using the same antenna for RX and TX is no fun: you not only hear your own signal with a delay (from the cross-talk at the TRX relay), but this cross-talk signal is usually so strong that it leads to „AGC pumping", so your receiver is virtually deaf during the first second after TX/RX transition. For satellite operation, on the other hand, duplex mode is very convenient. Here you usually have two separate and well-decoupled antennas for RX and TX.

The bottom line of the VFO bar indicators are related to the VFO status. If the `Locked` string is red, it indicates that the VFO is locked and will not accept changes. There is a LOCK action which toggles the LOCK status and which can be assigned to a toolbar button or a push-button on a GPIO or MIDI console, but the Lock status can also be set/unset via the `VFO menu`.

3.7 Meter section

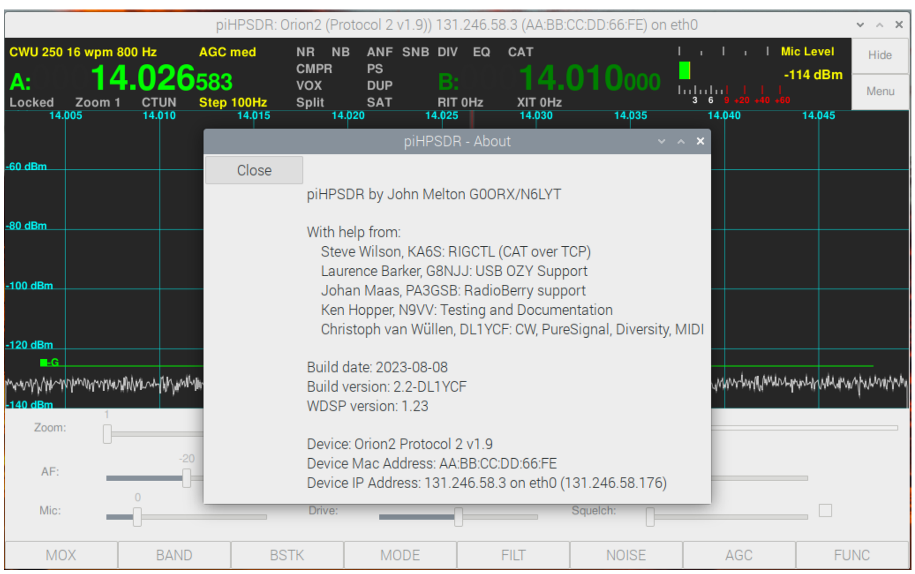


Chapter 4

The Main Menu: introduction

4.1 The Exit Menu

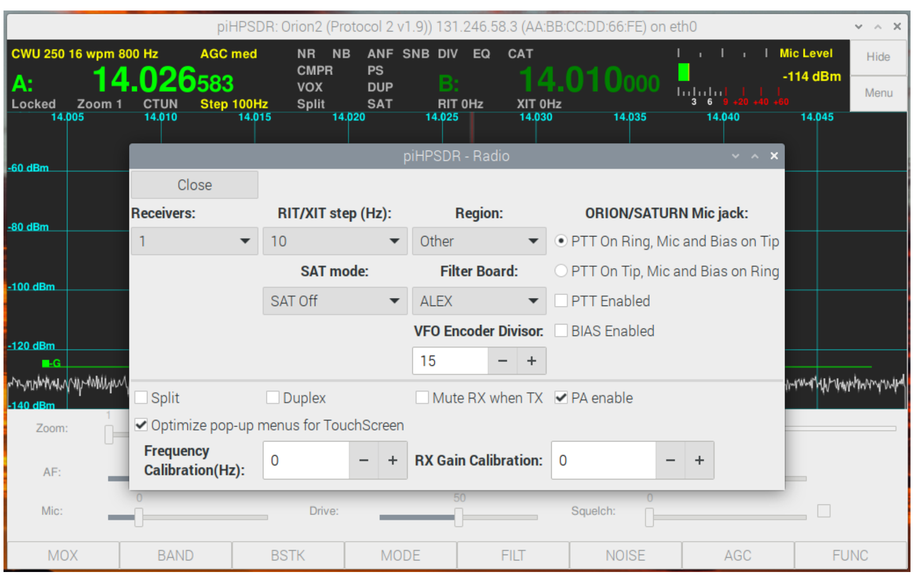
4.2 The About Menu



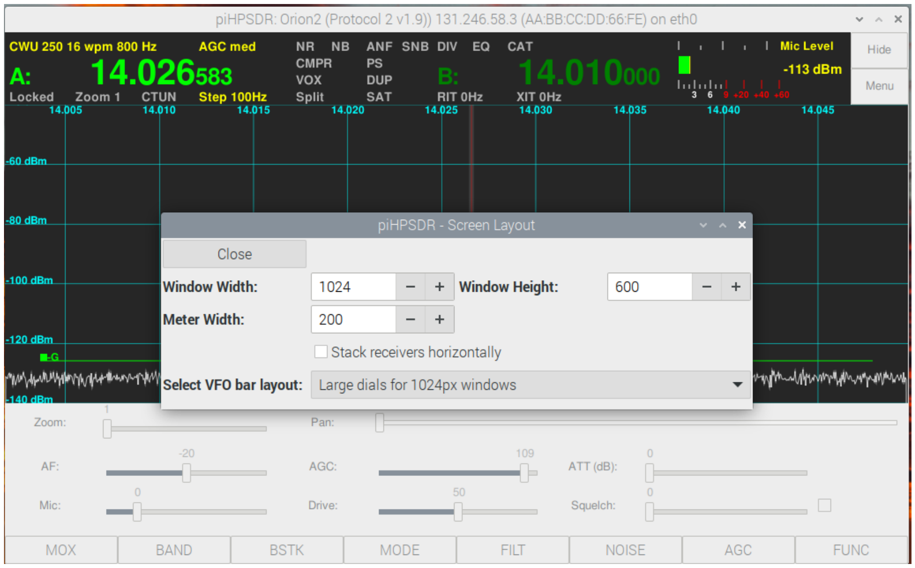
Chapter 5

The Main Menu: Radio-related menus

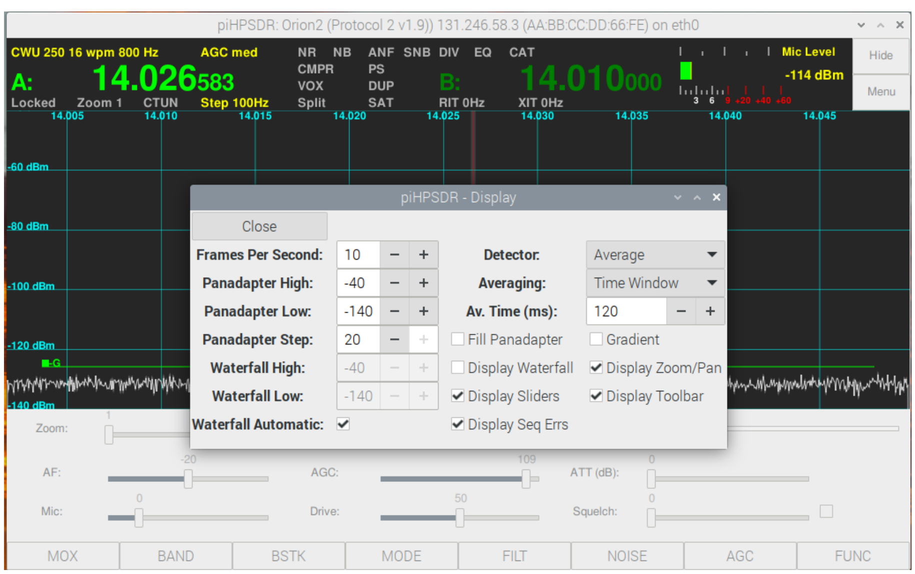
5.1 The Radio Menu



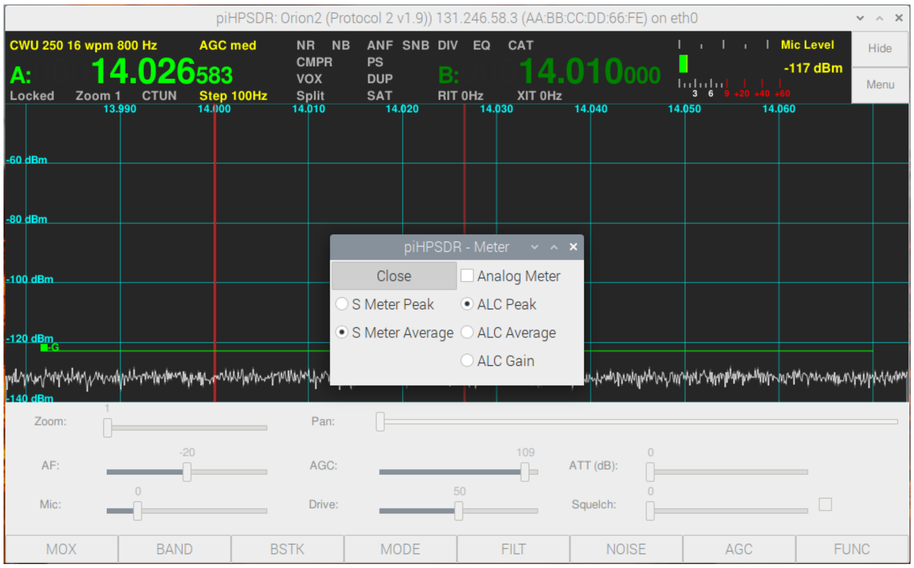
5.2 The Screen Menu



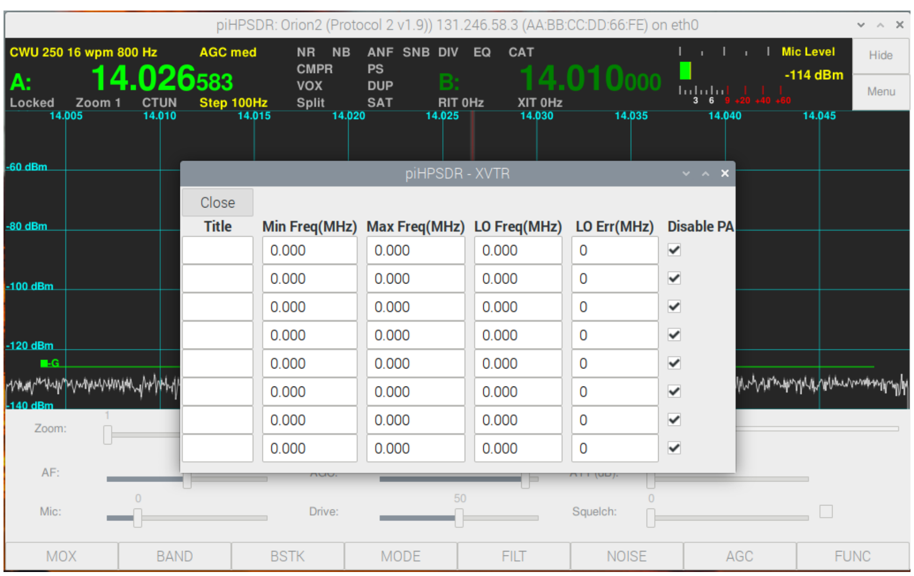
5.3 The Display Menu



5.4 The Meter menu



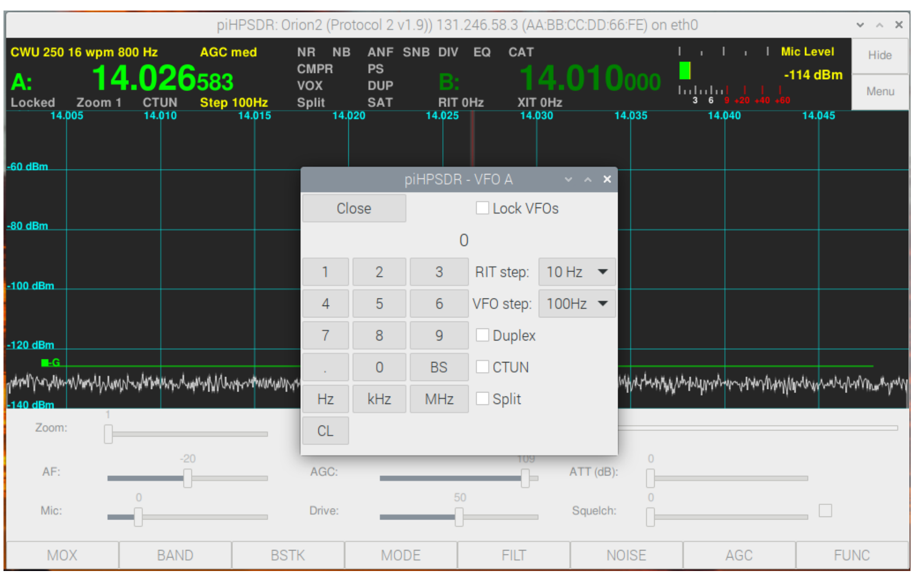
5.5 The XVTR (Transverter) Menu



Chapter 6

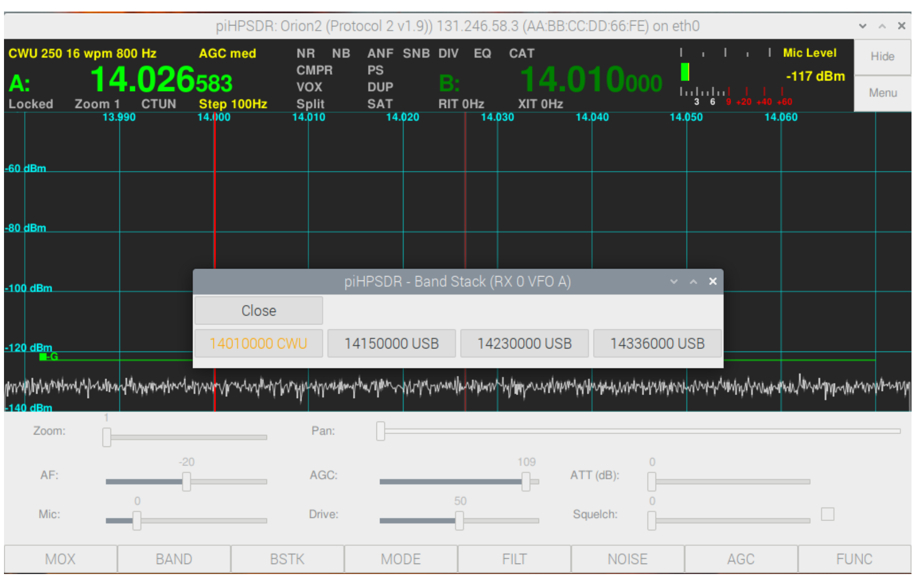
The Main Menu: VFO-related menus

6.1 The FREQ (VFO) menu

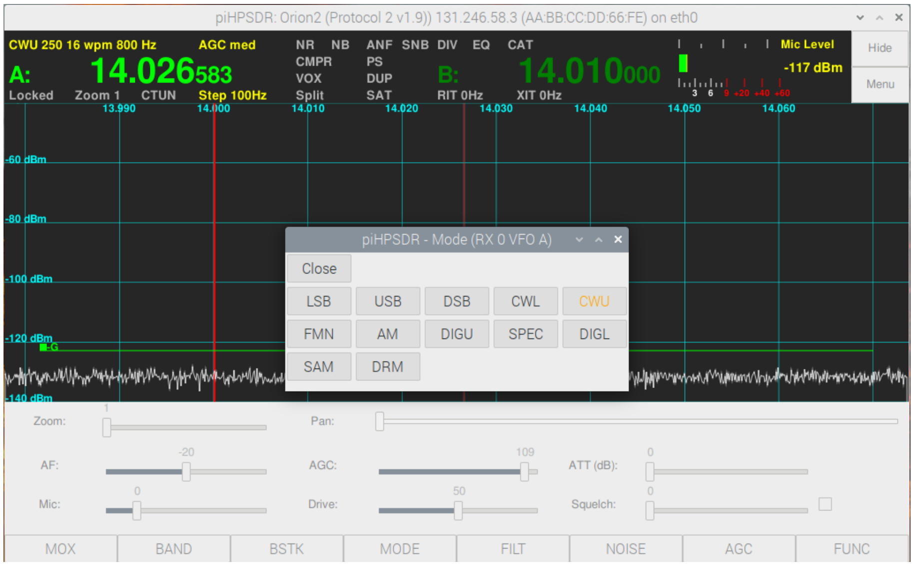


6.2 The Band menu

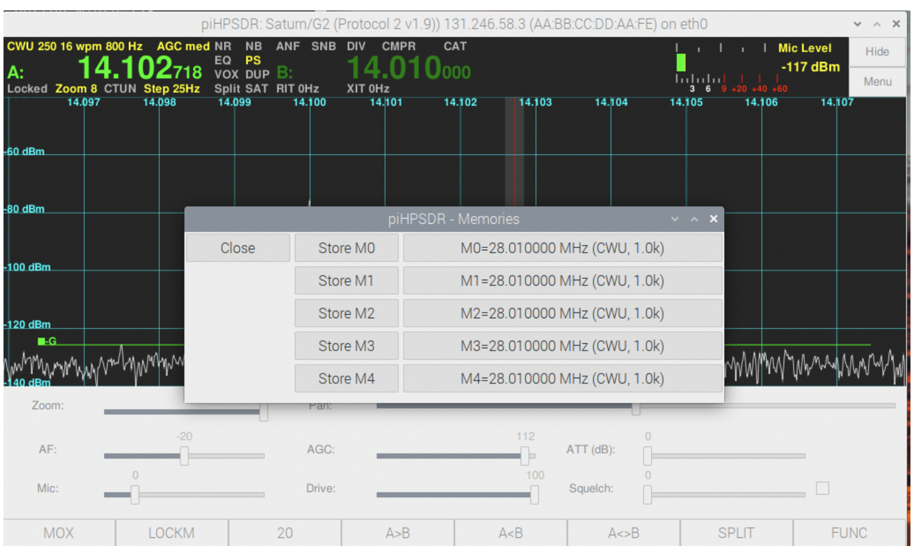
6.3 The BStack (Bandstack) menu



6.4 The Mode menu



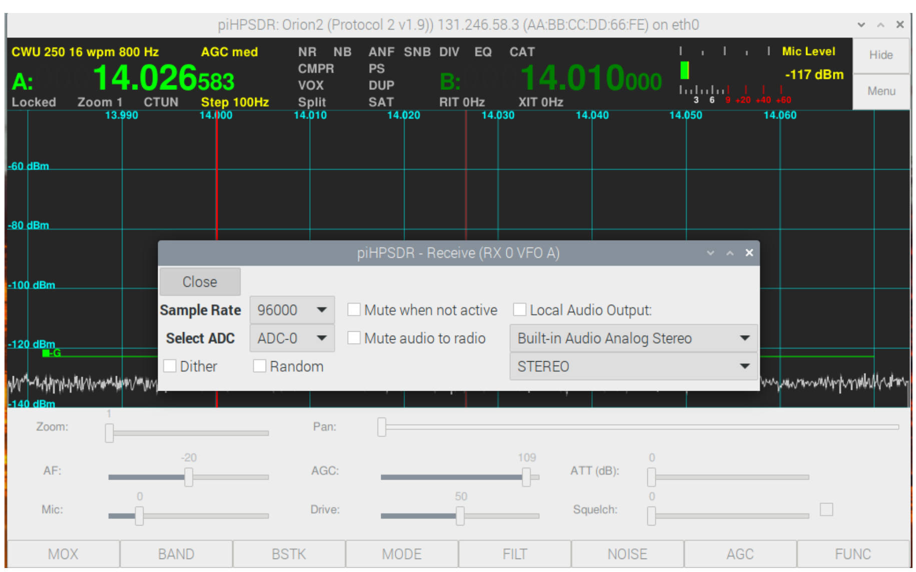
6.5 The MEM (Memory) menu



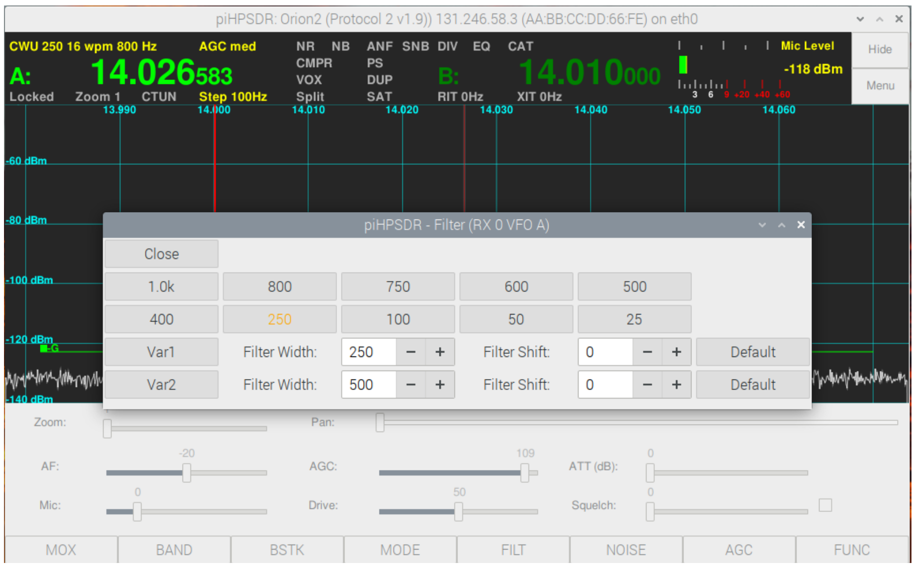
Chapter 7

The Main Menu: RX-related menus

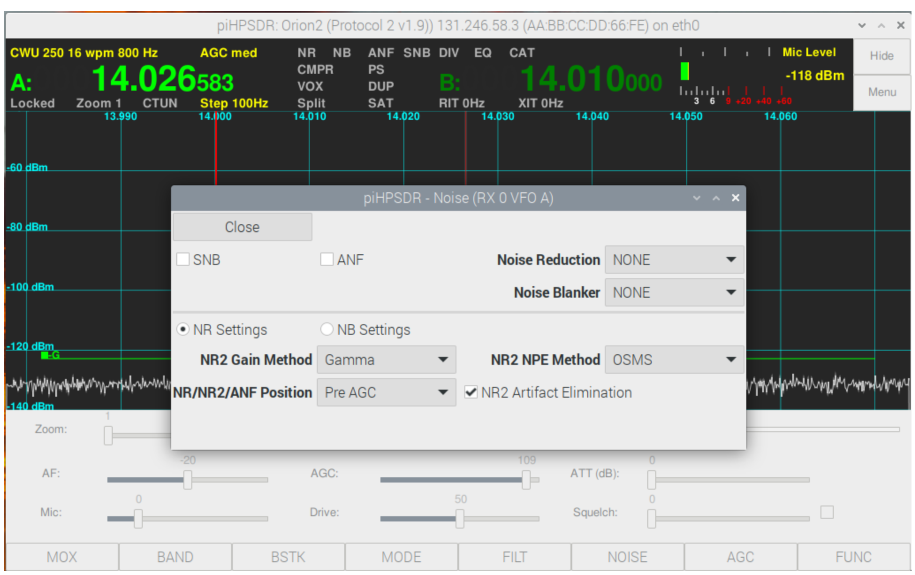
7.1 The RX Menu

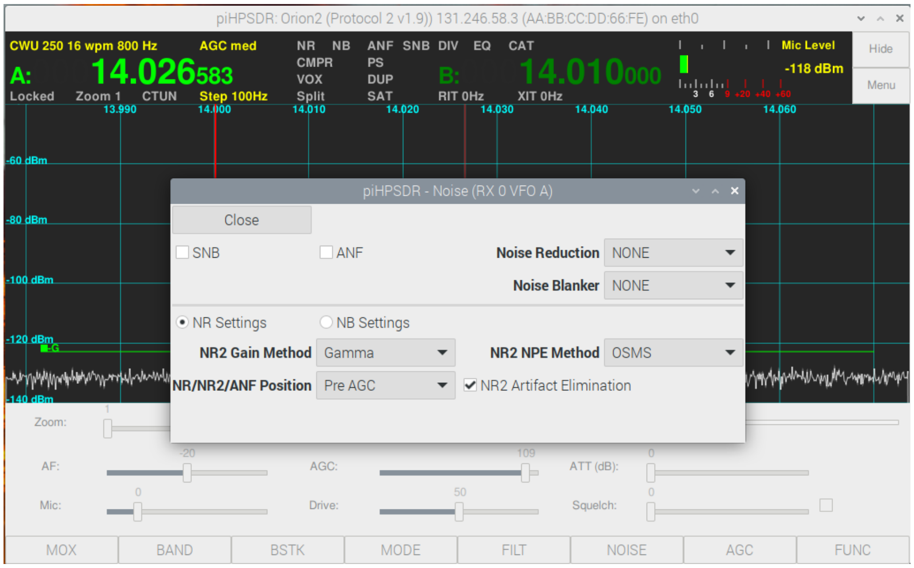


7.2 The Filter menu

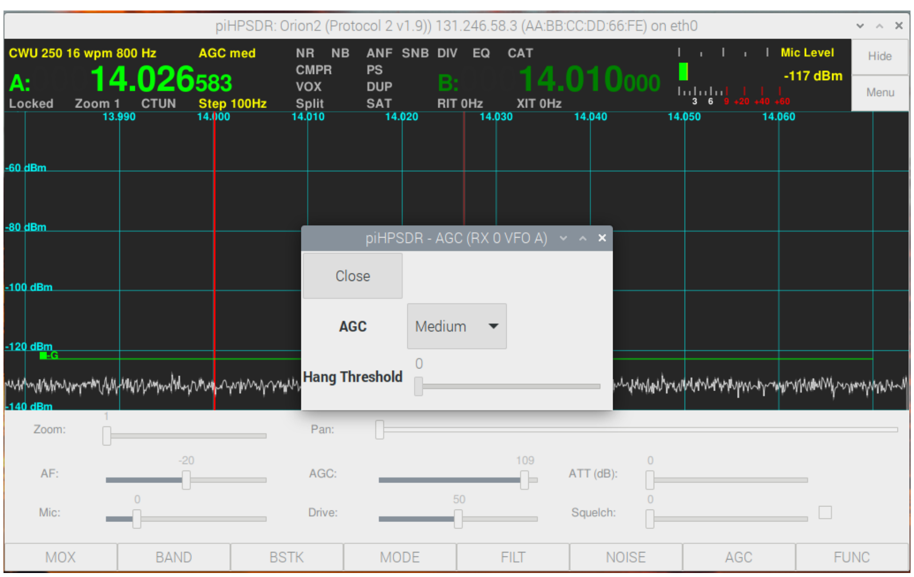


7.3 The Noise Menu

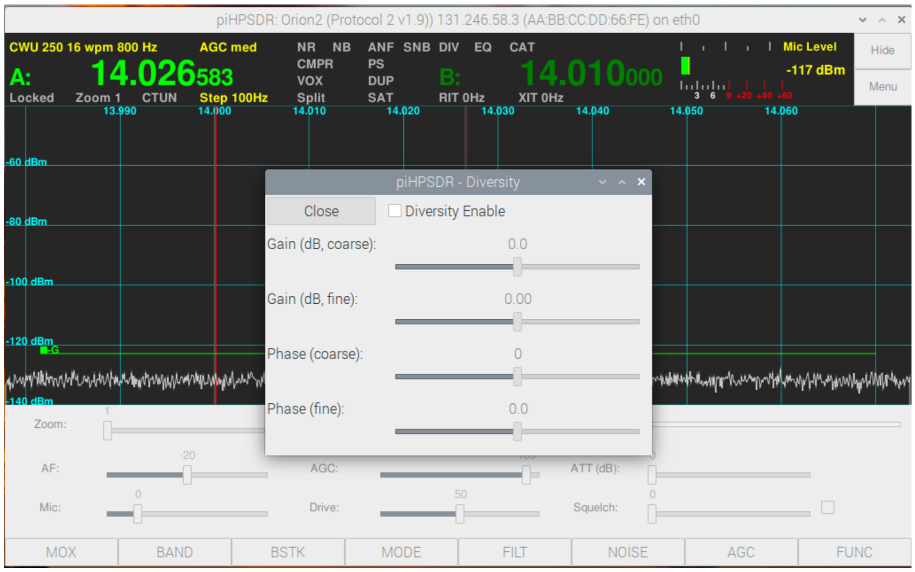




7.4 The AGC Menu



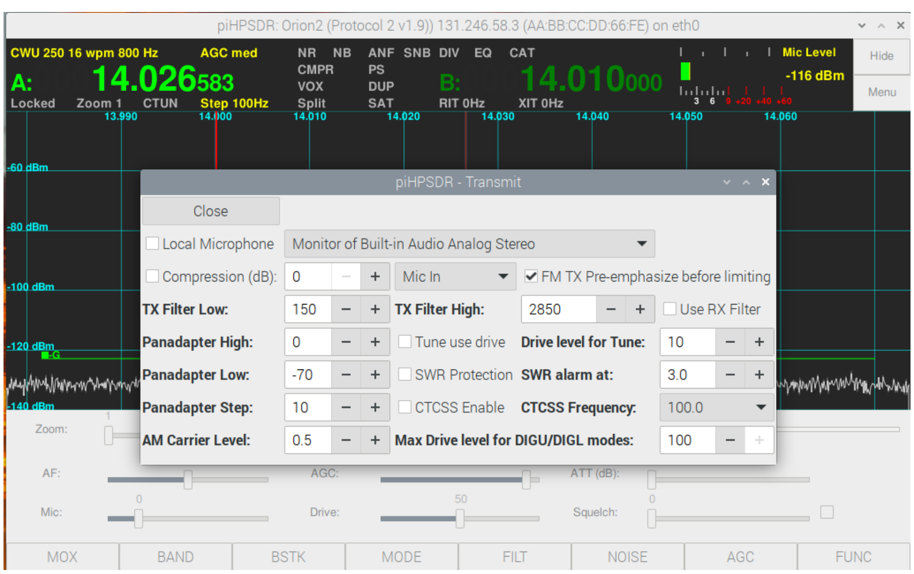
7.5 The Diversity Menu



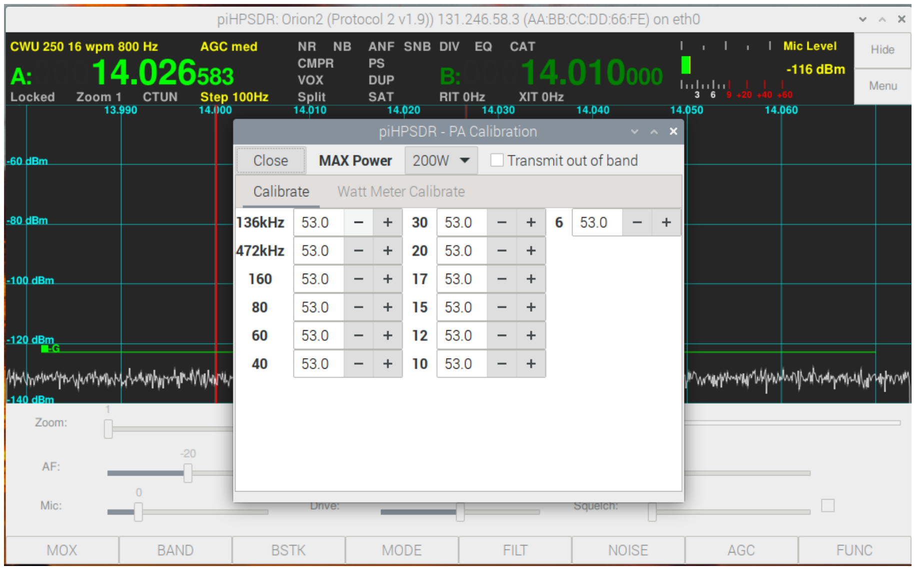
Chapter 8

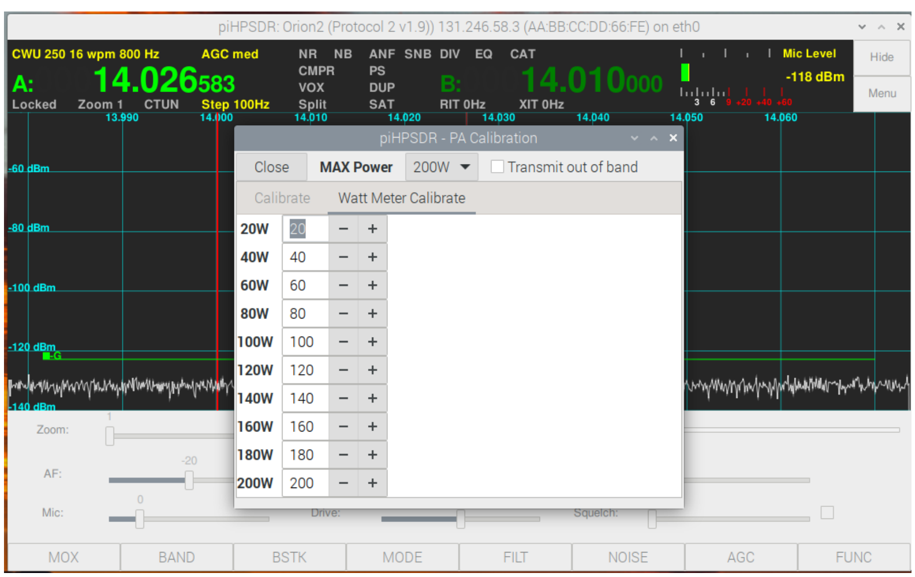
The Main Menu: TX-related menus

8.1 The TX Menu

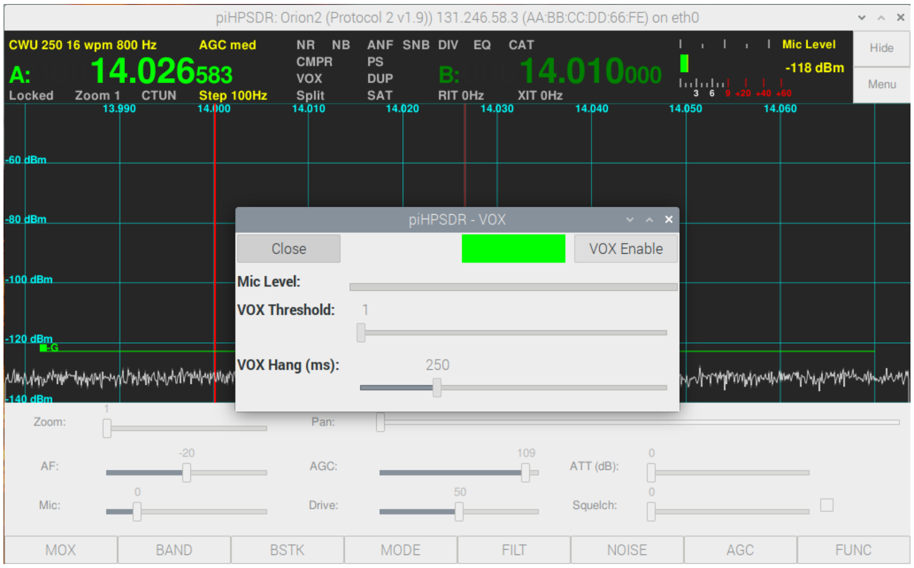


8.2 The PA Menu

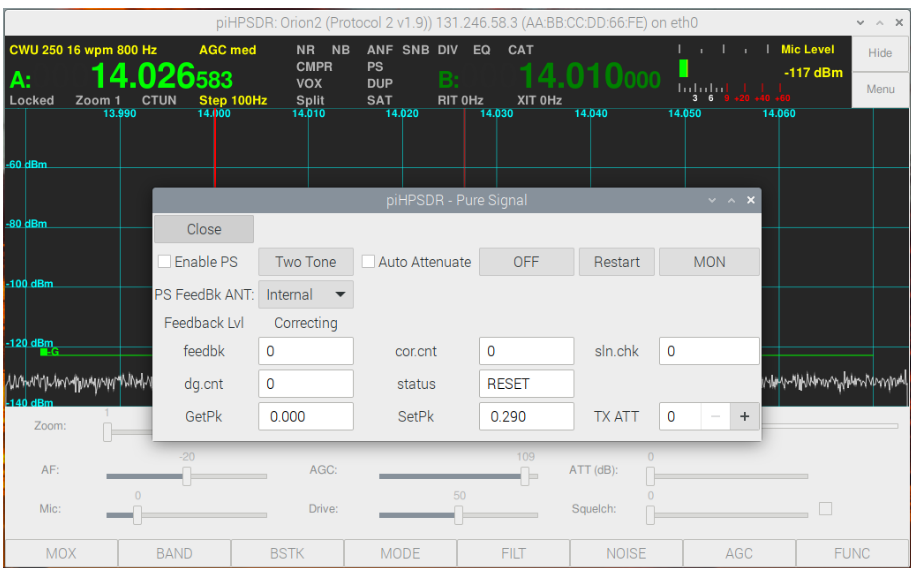




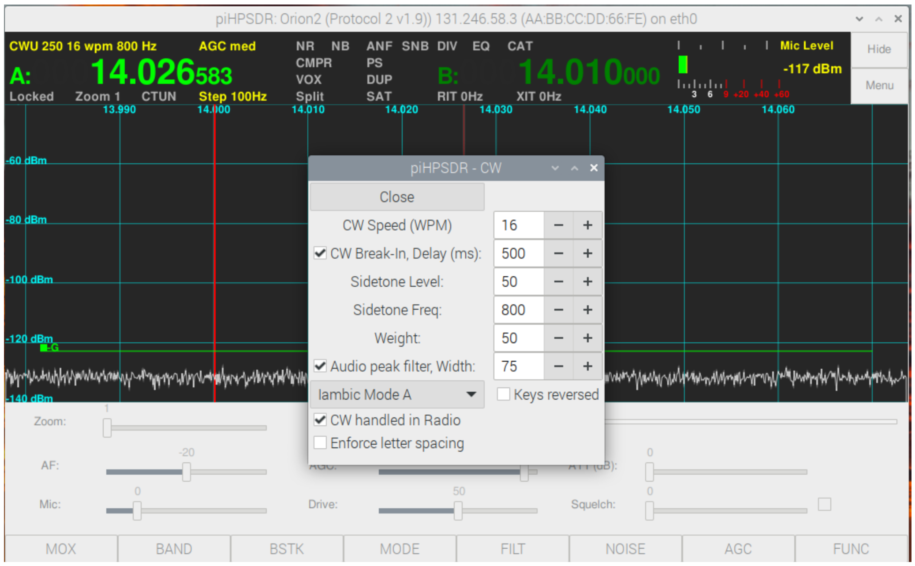
8.3 The VOX Menu



8.4 The PS (PureSignal) Menu



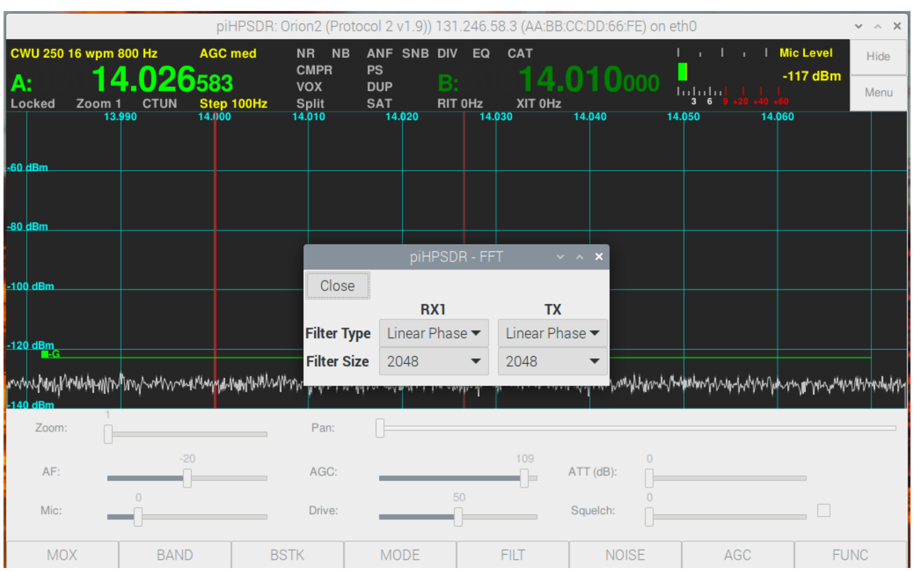
8.5 The `CW` Menu



Chapter 9

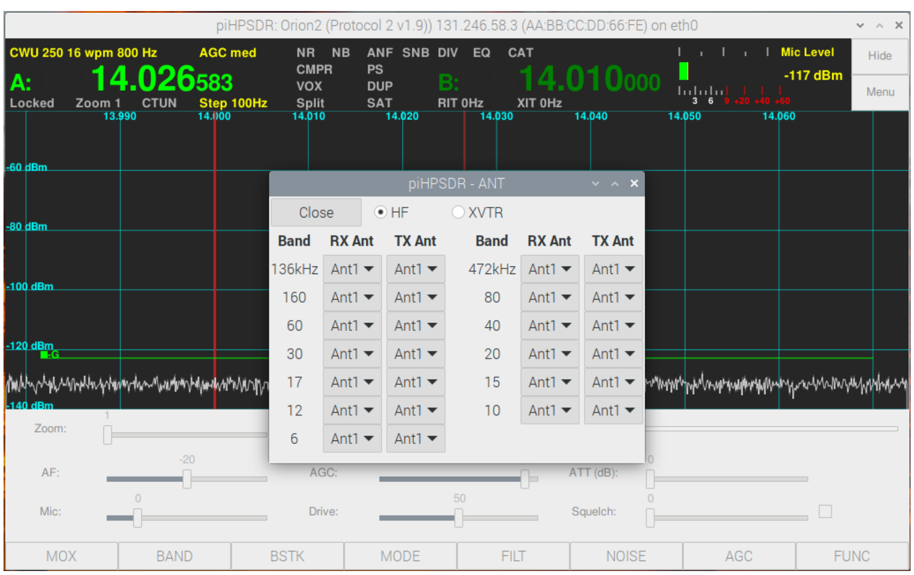
The Main Menu: menus for RX and TX

9.1 The FFT (Signal Processing) Menu

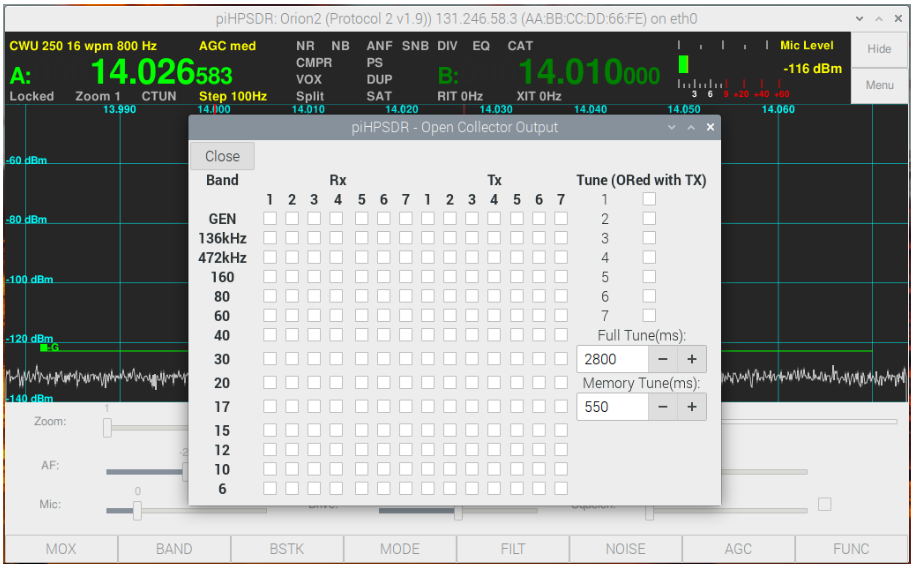


9.2 The Equalizer Menu

9.3 The Ant (Antenna) Menu



9.4 The `OC` (OpenCollector) Menu



Chapter 10

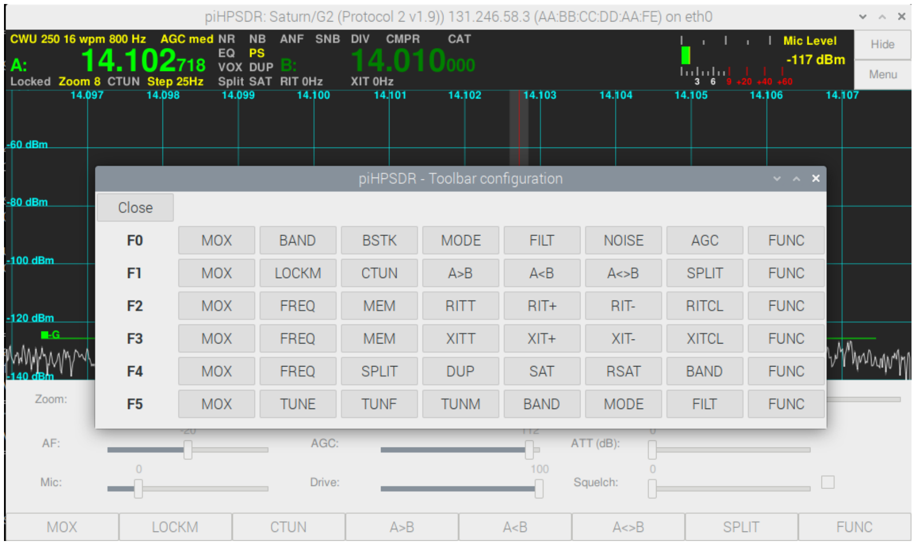
The Main Menu: controlling piHPSDR

In this chapter, the customization of the toolbar (at the bottom of the piHPSDR window), as well as how to configure GPIO and MIDI controllers, is described. Furthermore, in this chapter we discuss the RIGCTL menu which allows controlling piHPSDR by some external program such as a logbook or contest program, via standardized CAT commands that can be sent to piHPSDR either over a serial line or via TCP.

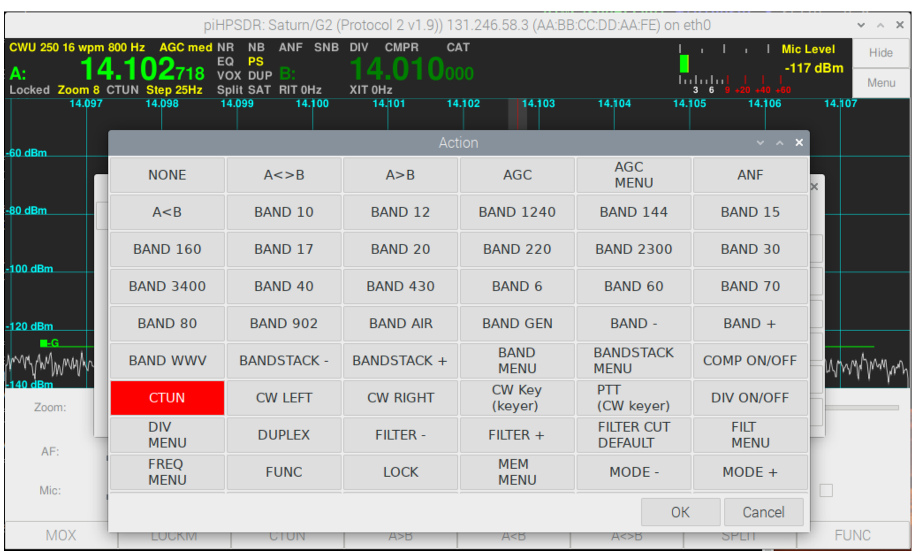
Note for Controller1 owners: The eight switches (push-buttons) of the controller, that a positioned below the screen, are bound to the eight toolbar buttons on the screen. Therefore, there is no "Switches" menu for this controller, and the switches are implicitly configured via the Toolbar menu.

10.1 The `Toolbar` Menu

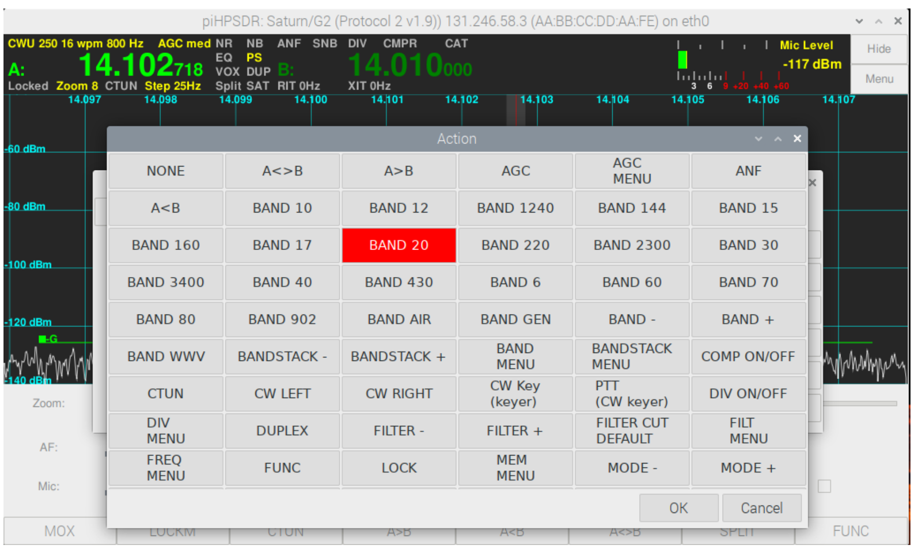
We start with the "Toolbar" menu, that can be found at the top of the rightmost column in the main menu. The toolbar consists of eight buttons that can be assigned to a set of eight functions. There are six such sets, and pressing the FUNC button cycles through these six sets. If you click the Toolbar button, a menu pops up and you see the following:



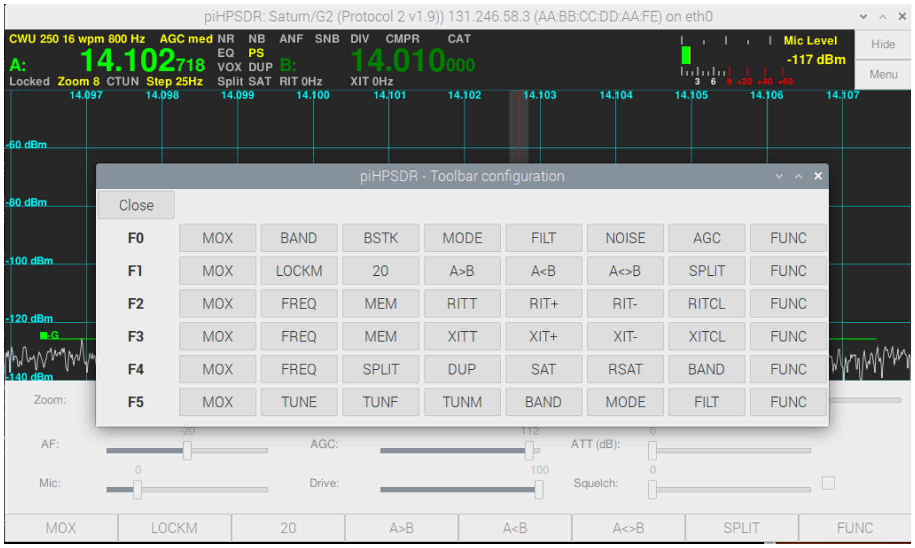
The six lines denoted `F0` through `F5` indicate the six different sets. If you look closely, you will discover that the set `F1` is the one that is currently active, since the labels in this line exactly match the labels in the toolbar. In this menu, the possible actions (that can be bound to a button) are written with the short text (see Appendix A), since this is the text that is printed on the toolbar buttons. If one now clicks (just an example) the `CTUN` button in the line `F1`, an ,,action dialog" pops up that looks as follows:



The current action selected (CTUN) is high-lighted. Lists of possible actions can be rather long, so it might be necessary that you have to scroll up or down in such an action dialog until you have found what you were looking for. Now (again just an example) the button Band 20 has been clicked in the action dialog, such that it gets high-lighted:



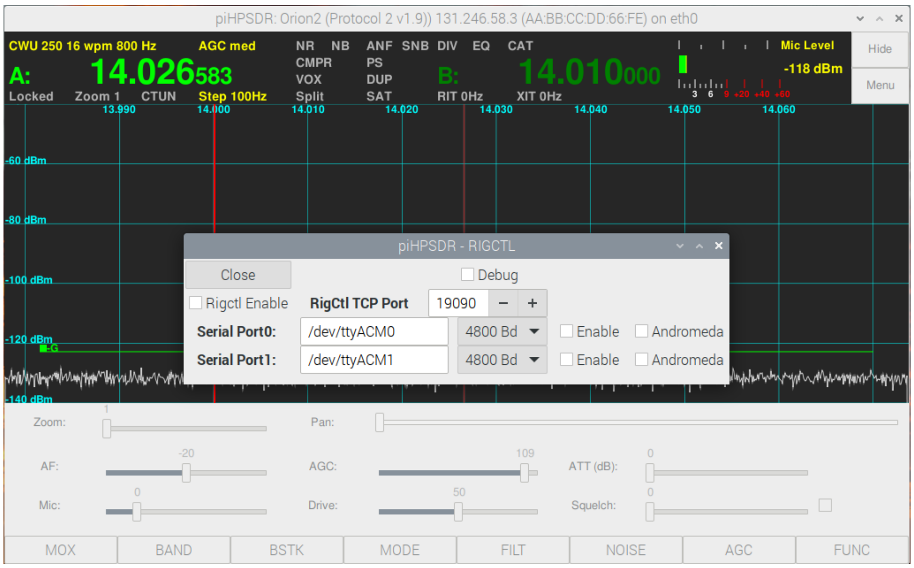
If one now closes the action dialog by clicking the OK button, the third button in the F1 line of the toolbar menu has changed, it now gives the short text (20) of the action, which will switch the active receiver to the 20m band (see the explanation of all the actions in Appendix A).



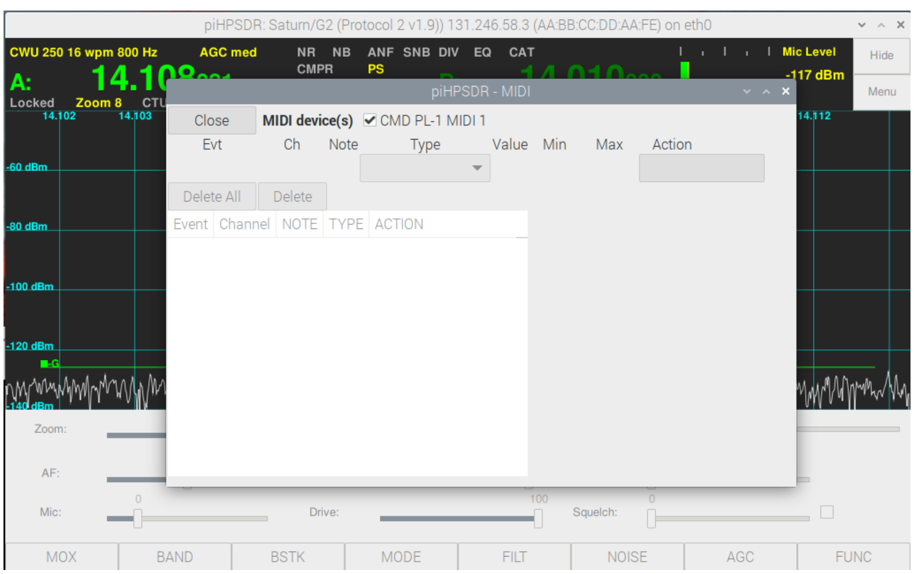
You also see that the toolbar has changed, now reading `20` on the third button from the left. Note that you can likewise change the functions of the toolbar sets that are currently not active, for example, we can change the behaviour of a toolbar button in set `F5`, no matter whether this set is currently active or not. Note futher that nothing happens if you press the `FUNC` buttons in the toolbar menu, since the rightmost button is hard-wired to that function. This is so because if in one set, you do not have the `FUNC` functions at hand, you are trapped and can no longer cycle through the sets.

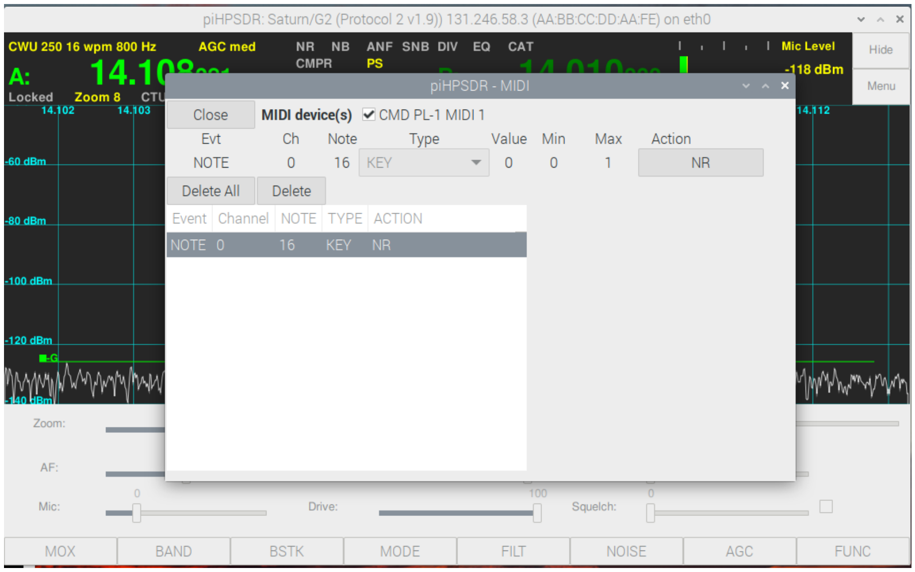
Assigning actions to buttons, as done here in the ,,action dialog" also works, exactly as described here, in the MIDI, the Encoders, and the Switches menus.

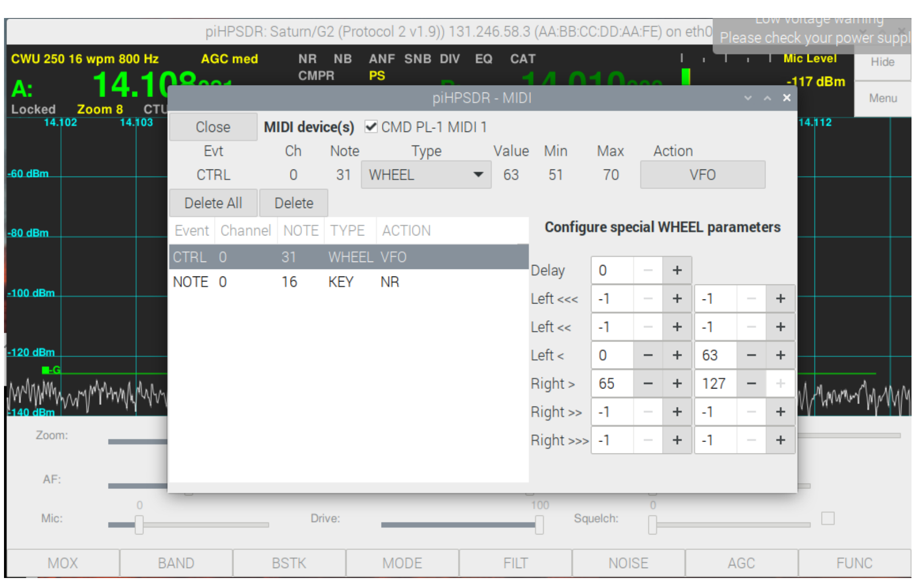
10.2 The RIGCTL (CAT control) Menu



10.3 The MIDI Menu

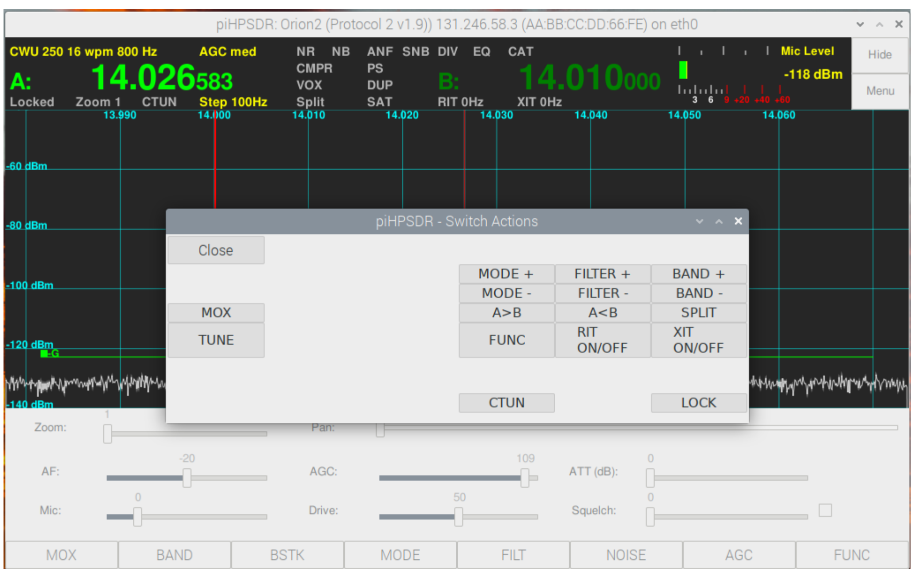



piHPSDR: Saturn/G2 (Protocol 2 v1.9)) 131.246.58.3 (AA:BB:CC:DD:AA:FE) on eth0
CWU 250 16 wpm 800 Hz
AGC med
NR NB ANF SNB DIV EQ CAT
CMPR PS
Mic Level
-118 dBm
Hide
Menu
A:
Locked
Zoom 8
piHPSDR - MIDI
Close
MIDI device(s)
CMD PL-1 MIDI 1
Evt Ch Note Type Value Min Max Action
NOTE 0 16 KEY 0 0 1 NR
Delete All
Delete
Event Channel NOTE TYPE ACTION
NOTE 0 16 KEY NR
Zoom:
AF:
Mic:
Drive:
Squelch:
MOX BAND BSTK MODE FILT NOISE AGC FUNC


piHPSDR: Saturn/G2 (Protocol 2 v1.9)) 131.246.58.3 (AA:BB:CC:DD:AA:FE) on eth0
Please check your power suppl
CWU 250 16 wpm 800 Hz
AGC med
NR NB ANF SNB DIV EQ CAT
CMPR PS
Mic Level
-117 dBm
Hide
Menu
A:
Locked
Zoom 8
piHPSDR - MIDI
Close
MIDI device(s)
CMD PL-1 MIDI 1
Evt Ch Note Type Value Min Max Action
CTRL 0 31 WHEEL 63 51 70 VFO
Delete All
Delete
Event Channel NOTE TYPE ACTION
CTRL 0 31 WHEEL VFO
NOTE 0 16 KEY NR
Configure special WHEEL parameters
Delay 0
Left <<< -1 -1
Left << -1 -1
Left < 0 63
Right > 65 127
Right >> -1 -1
Right >>> -1 -1
Zoom:
AF:
Mic:
Drive:
Squelch:
MOX BAND BSTK MODE FILT NOISE AGC FUNC

10.4 The Encoders Menu

10.5 The Switches Menu



Appendix A

List of piHPSDR ,,Actions”

In this chapter, we give a list of ,,actions” implemented in the piHPSDR program. These actions can be assigned to toolbar buttons on the screen, or pushbuttons/encoders of a GPIO-connected or MIDI controller. Not all actions can be assigned to all control elements. Changing the AF volume, for example, can only be assigned to a knob which you can turn, while switching RIT on/off can only be assigned to a button that you can push. For each action in the following table, there is a long and a short string assigned. The long string will be used when there is enough space, while the short string is used for small buttons and to store actions in preference files (therefore the short strings never contain a blank character or a line break). Then, for each action we give the type of control element allowed for this action as a combination of the letters B, P, E, which stand for

`B` ”Button”: A button in the toolbar, or a push-button or switch on a GPIO or MIDI connected console

`P` ”Potentiometer”: A potentiometer or a slider on a MIDI connected console

`E` ”Encoder”: A rotary encoder on a GPIO or MIDI connected console

The main difference between a ”potentiometer” and an ”encoder” is, that the former has a min and max position, while an encoder can be turned in either direction without stopping. This means that a potentiometer reports a value between min and max, while an encoder reports an increment, that is, whether it has been turned clock wise or counter clock wise. The existing GPIO consoles do not have potentiometers (most likely because of the lack of analog inputs), but many MIDI consoles do have, and Arduino-based MIDI controllers might have it because there analog inputs to read out potentiometers are available.

To give an example, controlling the TX drive can be down both with a slider and with an encoder. While for a slider/potentiometer, the values from min to max are simple mapped to the TX drive values from 0 to 100, the signals from an encoder will just increase or decrease the value until one of a limits has been reached.

In the following, the actions are alphabetically sorted by their long name, with the ”empty” action listed first.

<table>
<tr><td>NONE</td><td>NONE</td><td>BPE</td></tr>
<tr><td colspan="3">This is an action which does nothing. It can be assigned to buttons or encoders that are often accidentally operated. Some MIDI consoles, for example, report a button press event if the VFO knob is touched, and this we want to ignore.</td></tr>
</table>

<table>
<tr><td>A<>B</td><td>A<>B</td><td>B</td></tr>
<tr><td colspan="3">Swap VFOs A and B. This will not only swap the frequencies, but also all other settings associated with that VFO, such as mode, filter, CTUN, and RIT settings.</td></tr>
</table>

<table>
<tr><td>A<B</td><td>A<B</td><td>B</td></tr>
<tr><td colspan="3">Copy VFO B to VFO A.</td></tr>
</table>

<table>
<tr><td>A>B</td><td>A>B</td><td>B</td></tr>
<tr><td colspan="3">Copy VFO A to VFO B.</td></tr>
</table>

<table>
<tr><td>AF GAIN</td><td>AFGAIN</td><td>PE</td></tr>
<tr><td colspan="3">Change the AF gain (headphone volume) of the active receiver.</td></tr>
</table>

AF GAIN RX1	AFGAIN1	PE
Change the AF gain (headphone volume) of the RX1 receiver.		

AF GAIN RX2	AFGAIN2	PE
Change the AF gain (headphone volume) of the RX2 receiver.		

AGC MENU	AGC	B
Opens the AGC menu.		

ANF	ANF	B
Toggels the state (on/off) of the automatic notch filter for the active receiver.		

ATTEN	ATTEN	PE
Changes the value (0-31 dB) of the step attenuator of the active receiver. This funciton is only available for radios that have such an attenuator.		

BAND 10	10	B
Change band of the active receiver to the 10m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 12	12	B
Change band of the active receiver to the 12m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 1240	1240	B
Change band of the active receiver to the 1240 MHz (23 cm) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 144	144	B
Change band of the active receiver to the 144 MHz (2m) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 15	15	B
Change band of the active receiver to the 15m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 160	160	B
Change band of the active receiver to the 160m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 17	17	B
Change band of the active receiver to the 15m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 20	20	B
Change band of the active receiver to the 15m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 220	220	B
Change band of the active receiver to the 220 MHz (1.25 m) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

`BAND 2300`	`2300`	`B`
Change band of the active receiver to the 2300MHz (13 cm) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

`BAND 30`	`30`	`B`
Change band of the active receiver to the 30m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

`BAND 3400`	`3400`	`B`
Change band of the active receiver to the 3400 Mhz (9 cm) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

`BAND 40`	`40`	`B`
Change band of the active receiver to the 40m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

`BAND 430`	`430`	`B`
Change band of the active receiver to the 430 MHz (70 cm) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

`BAND 6`	`6`	`B`
Change band of the active receiver to the 6m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 60	60	B
Change band of the active receiver to the 60m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 70	70	B
Change band of the active receiver to the 70 MHz (4m) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 80	80	B
Change band of the active receiver to the 80m band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND 902	902	B
Change band of the active receiver to the 902 MHz (33 cm) band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND AIR	AIR	B
Change band of the active receiver to the 108 MHz band, used for aircraft communication. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND GEN	GEN	B
Change band of the active receiver to the current bandstack entry of the ”general” band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BAND -	BND-	B
Change band of the active receiver to the next lower band in the list of bands. If already at the lowest band, switch to the highest band (including transverter bands which have been defined) whose frequency is with the radio's frequency range.		

BAND +	BND+	B
Change band of the active receiver to the next higher band in the list of bands (including transverter bands that have been defined). If already at the highest band, switch to the lowest band whose frequency is with the radio's frequency range.		

BAND WWV	WWV	B
Change band of the active receiver to the current bandstack entry of the WWV band. If already on that band, move to the next bandstack entry. This action is a no-op if the frequency of the band falls outside the frequency range of the radio.		

BANDSTACK -	BSTK-	B
Cylcle backward through the bandstack entries of the active receiver.		

BANDSTACK +	BSTK+	B
Cylcle forward through the bandstack entries of the active receiver.		

BAND MENU	BAND	B
Open the `BAND` menu.		

BANDSTACK MENU	BSTK	B
Open the `BANDSTACK` menu.		

COMP ON/OFF	COMP	B
Toggle the state (on/off) of the compressor used in the TX audio input.		

COMPRESSION	COMPVAL	PE
Change the value of the compressor (0-20 dB) used in the TX audio input. The compressor is automaticall switched on (off) if the ”new” value of the compressor is larger then (equal to) zero.		

CTUN	CTUN	B
Toggle the state (on/off) of the CTUN state of the active receiver. CTUN stands for ”click to tune”. In CTUN mode, you can move the RX frequency over the whole spectrum scope, whose center then remains at a fixed frequency.		

CW FREQUENCY	CWFREQ	PE
Change the CW side tone frequency in the range 300-1000 Hz. This also changes the BFO frequency upon receive.		

CW LEFT	CWL	B
This action indicates the closure/opening of the left paddle of a CW key. It is usually assigned to a GPIO line or a MIDI controller to which a Morse paddle is attached, and works with the iambic keyer that is built into piHPSDR. This keyer is only active if CW is *not* handled in the radio (see CW menu).		

CW RIGHT	CWR	B
This action indicates the closure/opening of the right paddle of a CW key. It is usually assigned to a GPIO line or a MIDI controller to which a Morse paddle is attached, and works with the iambic keyer that is built into piHPSDR. This keyer is only active if CW is *not* handled in the radio (see CW menu).		

CW SPEED	CWSPD	PE
Change the CW side tone frequency in the range 1-60 wpm. This affect the built-in iambic keyer or the keyer inside the radio, depending on whether CW is handled in the radio or not (see CW menu).		

CW Key (keyer)	CWKy	B
Straith key key-down or key-up event. Usually assigned to a GPIO line of MIDI controller to which a straight key or an external keyer is attached. Note that this action does not automatically switch to TX, so it must be used together with either manual RX/TX switching, or with the "`PTT (CW Keyer)`" action.		

PTT (keyer)	CWKyPTT	B
This is the PTT button. Unlike MOX, which toggles the PTT status, a button press means "PTT on" and a button release means "PTT off". This action is usually connected to a GPIO line or a MIDI controller, which then either connect to the PTT button of a microphone or the PTT output of an external CW keyer.		

DIV ON/OFF	DIVT	B
Toggles (enabled/disabled) DIVERSITY reception.		

DIV GAIN	DIVG	E
Adjust DIVERSITY gain. One tick of the encoder increments of decrements the gain by an amount of 0.5		

DIV GAIN COARSE	DIVGC	E
Adjust DIVERSITY gain (coarse adjustment). One tick of the encoder increments of decrements the gain by an amount of 2.5		

DIV GAIN FINE	DIVGF	E
Adjust DIVERSITY gain (fine adjustment). One tick of the encoder increments of decrements the gain by an amount of 0.1. Since adjusting the DIVERSITY gain (or phase) is sometimes difficult, assigning one encoder to a coarse and another encoder to a fine adjustment may help in locating the ,,sweet spot”.		

DIV PHASE	DIVP	E
Adjust DIVERSITY phase (fine adjustment). One tick of the encoder increments of decrements the gain by an amount of 0.5		

DIV PHASE COARSE	DIVPC	E
Adjust DIVERSITY gain (coarse adjustment). One tick of the encoder increments of decrements the gain by an amount of 2.5		

DIV PHASE FINE	DIVPF	E
Adjust DIVERSITY gain (coarse adjustment). One tick of the encoder increments of decrements the gain by an amount of 20.1		

DIV MENU	DIV	B
Open the DIVERSITY menu.		

DUPLEX	DUP	B
Toggle (on/off) DUPLEX status. IN the DUPLEX mode, the receivers continue to work during TX, and the RX panels are not removed during TX. Instead, a separate TX window opens during transmitting. Generally, DUPLEX only make sense when using different and well decoupled RX and TX antennas.		

FILTER -	FL-	B
Cycle forward (!) through the list of filters for the current mode of the active receiver. Normally, this means switching to a narrower filter (hence the name `FILTER -`). When reaching the last filter in the list, further cycling switches to the first (widest) filter.		

FILTER +	FL+	B
Cycle backward (!) through the list of filters for the current mode of the active receiver. Normally, this means switching to a wider filter (hence the name `FILTER +`). When reaching the first filter in the list, further cycling switches to the last filter which is the variable `Var2` filter.		

FILTER CUT LOW	FCUTL	E
Adjust the low-cut of the current filter. Note that the notion of ,,low" edge of the filter refers to audio frequencies for the single side band modes LSB, CWL, DIGL. This action is a no-op unless the current filter is one of the two variable filters `Var1` or `Var2`.		

FILTER CUT HIGH	FCUTL	E
Adjust the high-cut of the current filter. Note that the notion of ,,high" edge of the filter refers to audio frequencies for the single side band modes LSB, CWL, DIGL. This action is a no-op unless the current filter is one of the two variable filters `Var1` or `Var2`.		

FILTER CUT DEFAULT	FCUTDEF	B
Reset the low and high cut of the current filter to the default values. This action is a no-op unless the current filter is one of the two variable filters `Var1` or `Var2`.		

FILT MENU	FILT	B
This opens the `Filter` menu.		

FREQ MENU	FREQ	B

This opens the FREQ (VFO) menu.

FUNC	FUNC	B

Cycle through the six toolbar sets. For the piHPSDR GPIO controller V1, where the eight switches follow the toolbar buttons, this also affects the function of the switches. Note that this action is *always* connected with the right-most toolbar button.

IF SHIFT	IFSHFT	E

This command is effective only if one of the variable filters Var1 or Var2 is currently used in the active receiver, and shifts the filter, that is, it affects the low and high cut in the same way.

IF SHIFT RX1	IFSHFT1	E

This command is effective only if one of the variable filters Var1 or Var2 is currently used in VFO-A, and shifts the filter, that is, it affects the low and high cut in the same way.

IF SHIFT RX2	IFSHFT2	E

This command is effective only if one of the variable filters Var1 or Var2 is currently used in VFO-B, and shifts the filter, that is, it affects the low and high cut in the same way.

IF WIDTH	IFWIDTH	E

This command is effective only if one of the variable filters Var1 or Var2 is currently used in the active receiver, and changes the filter width, that is, it affects the low and high cut in an opposite way.

IF WIDTH RX1	IFWIDTH1	E

This command is effective only if one of the variable filters Var1 or Var2 is currently used in VFO-A, and changes the filter width, that is, it affects the low and high cut in an opposite way.

IF WIDTH RX2	IFWIDTH2	E
This command is effective only if one of the variable filters Var1 or Var2 is currently used in VFO-B, and changes the filter width, that is, it affects the low and high cut in an opposite way.		

LINEIN GAIN	LIGAIN	PE
Change the line-in gain of the radio. If the radio does not have a line-in input, this control has no effect.		

LOCK	LOCK	B
Lock the VFOs. A locked VFO will not accept VFO frequency steps in either direction, and cannot be moved by dragging with the mouse. Band changes etc. are still possible, though. The command is intended to guard against accidentally moving the VFO dial.		

MEM MENU	MEM	B
Open the `MEM` (Memory) menu.		

MIC GAIN	MICGAIN	PE
Change the mic gain (from -12 to 50 dB). The amplification of the microphone audio data is done in software, and applies both to microphone samples from the radio and to any audio source connected to the computer. (See the discussion of local microphones in the `TX` menu.		

Appendix B

piHPSDR CAT commands