Palomar Amateur Radio Club – STEM Experimental Lab
KiwiSDR rev 2 Receiver located on Palomar Mountain

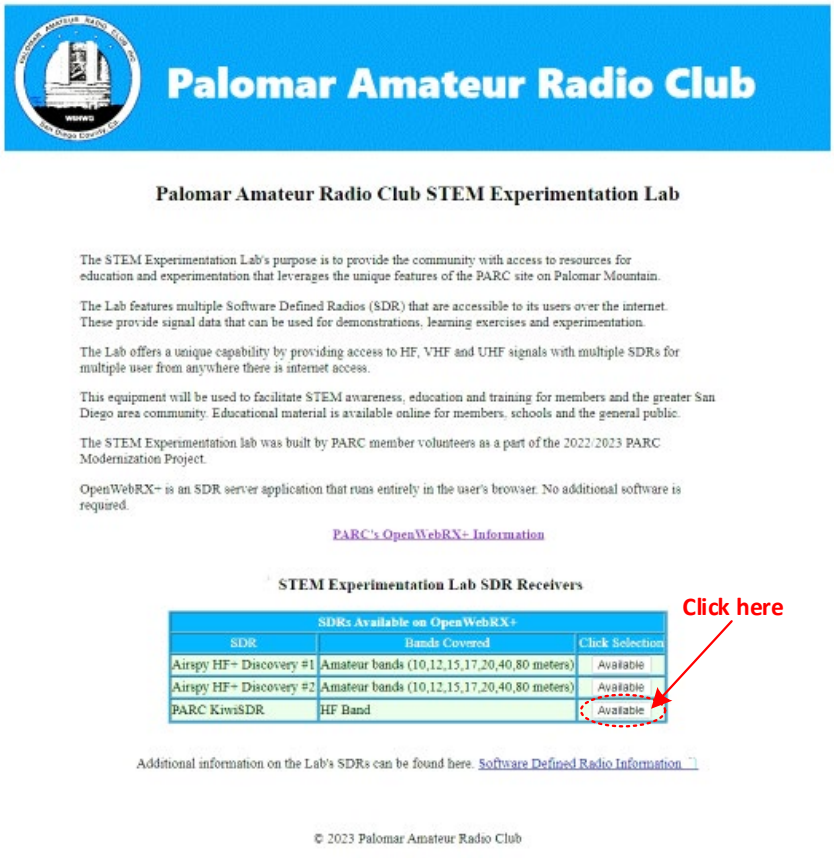
Rev A – 2024.11.26 by W4AFK

The STEM Experimentation Lab's purpose is to provide the community with access to resources for education and experimentation that leverages the unique features of the PARC site on Palomar Mountain.

The Lab features multiple Software Defined Radios (SDR) that are accessible to its users over the internet. This equipment will be used to facilitate STEM awareness, education and training for members and the greater San Diego area community. Educational material is available online for members, schools and the general public.

These provide signal data that can be used for demonstrations, learning exercises and experimentation. The Lab offers a unique capability by providing access to HF, VHF and UHF signals with multiple SDRs for multiple users from anywhere there is internet access.

This document addresses one of the SDR receivers, the “KiwiSDR”. It can be accessed via this hyperlink: https://services.palomararc.org/ then if available, click on PARC “available” on the KiwiSDR line



Introduction a Software Defined Radio (SDR)

Before we delve into the details of the receiver up on the mountain, here is some basic information on what a "SDR" is.

Traditional radios have been around for over a century. They were designed around separate components that worked together so that you can tune and receive news, listen to music and shows on your "radio". For decades, this technology remained essentially the same. Small improvements were made as technology improved. However, major changes required significant changes in the hardware, which increased the cost.

In the latter part of the 20th century, a new technology started to take shape. It was called "Software Defined Radio" (SDR). This was a paradigm shift on how radios were conceived. Today, most of the radio's functions are now done in software and not in hardware. Why is this so important? The main reason is that you can customize the radio, add new modes and capabilities, by simply changing the software. This also resulted in lower cost radios as SDR receivers require MUCH less components. Compare this image to the one on the next page. The KiwiSDR does more that this traditional receiver

The KiwiSDR you will be using is a perfect example of this SDR technology. This radio is loaded with features and capabilities, yet it is very small in size. Previous generation "traditional" radios which had some of the capabilities could easily fill a desk and even a rack. Other capabilities required thousands of dollars of external equipment

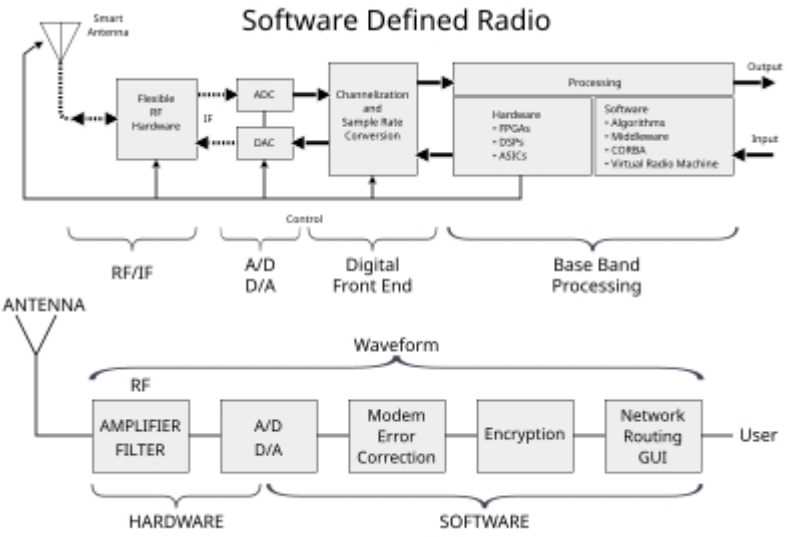
This image is of the circuit board gives you an example of the small number of components that are needed

Another example of this technology is your cell phone. If it wasn't for SDR, you would be lugging around a briefcase sized "cell phone" (I did many years ago).

For those who have some basic understanding of radios, the following is a simplified block diagram on an SDR. The simple explanation is if you look at the second section from the left. What's called "ADC", "DAC", "A/D" and "D/A"

Everything to the left is considered "analog" and its role is to filter and condition the signal that's received from the antenna.

All the "hard work" is done on the right side, which is called "digital", and that work is done in software.



ADC or A/D = Analog to Digital Converter; DAC or D/A = Digital to Analog Converter

So, what can you do with the KiwiSDR? Quite simply: "Play with IT" … it's "Your lab"!

You can …

- Receive Shortwave broadcasts from around the world
- Receive various data modes, those mysterious sounds that appear
- Listen to amateur radio stations from around the world
- Listen to aircraft flying overseas (yes, they still use HF)
- What else? (You tell us)

STEM Experimental Lab

The STEM Experimentation lab was built by PARC member volunteers as a part of the 2022/2023 PARC Modernization Project. If you have questions, feel free to ask anyone from the PARC Modernization program.

As this SDR receiver has many capabilities, this document will highlight the main functions. If you want to learn about all its capabilities, you are encouraged to visit this website: http://kiwisdr.com/quickstart/index.html#id-user. A higher-level introduction is located here: Introduction to using the KiwiSDR and a complete manual is here: http://kiwisdr.com/info/. An excellent YouTube introduction video is available here: https://www.youtube.com/watch?v=7rkSM4w2VY4

HF Coverage - This SDR receiver is connected to a "Cushcraft R8" Vertical antenna which was designed to cover the following amateur radio bands: 40m, 30m, 20m, 17m, 15m, 12m, and 10m. As such it can be used to receive from 7 MHz to 30 MHz … and even more with reduced performance.

We are using Revision 2 of the KiwiSDR, a wideband HF software defined radio. It's the newest iteration of the KiwiSDR family and was introduced in early 2024 and supports up to four (4) simultaneous users.

The KiwiSDR is a very sophisticated device with numerous options and functions and is well worth taking the time to understand. Many members of the KiwiSDR user community make their KiwiSDRs freely accessible online so that anyone can connect to and use them.

You might already be scratching your head asking about some of the acronyms you have seen. Let's see if we can explain some of these.

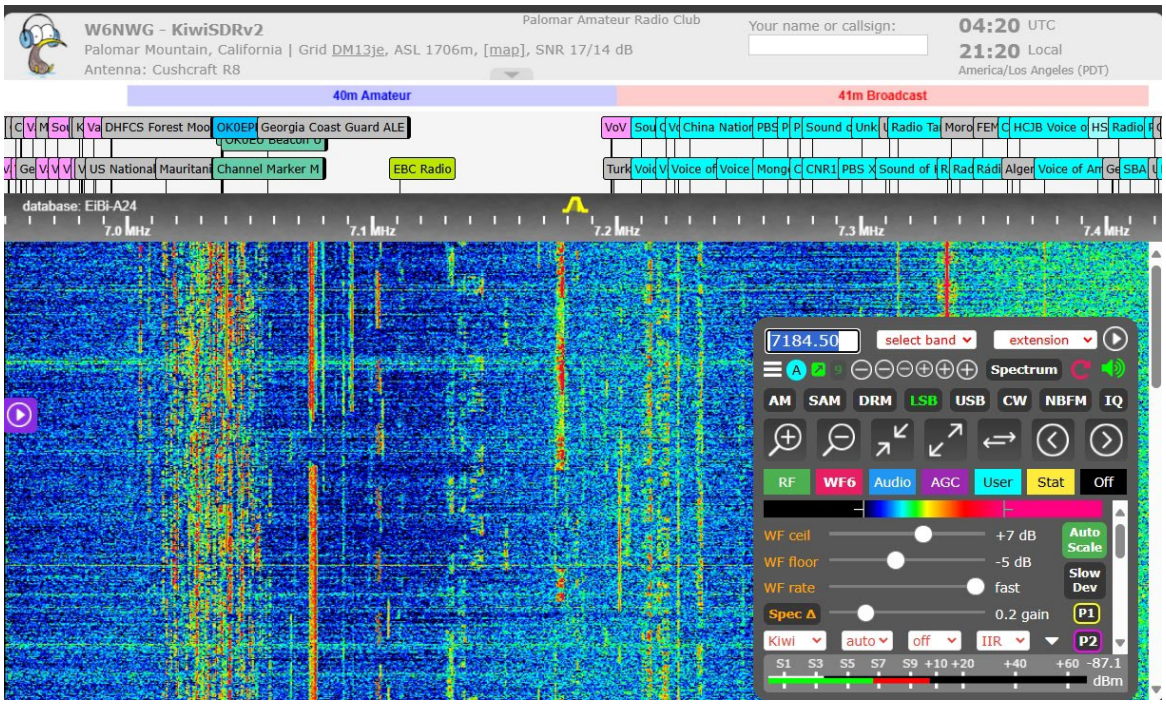
- 80m, 40m, 30m, 20m … 10m: These are designations used to identify ranges of frequencies on the HF spectrum (3 MHz to 30 MHz). We use "m" for "meter" as it designates the length of one wave at that frequency. For example, 80m means that a full wave is 80 meters in length. There is a simple formula to convert this into frequency, but I will let you discover it (Google is my friend). I'll just say that the 80m band is the frequency range between 3.5 MHz and 4 MHz. 40m is around 7 MHz, etc.
- "kHz" is Kilo Hertz, "MHz" is Mega Hertz (ex.: 7200 kHz = 7.200 MHz)
- MF (Medium Frequency) …This refers to frequencies between 300 kHz and 3 MHz
- HF (High Frequency) … is 3 MHz and 30 MHz
- VHF (Very High Frequency) … is 30-300 MHz
- UHF (Ultra High Frequency) …is 300-3000 MHz. There are many more for you to discover
- VFO … "Variable Frequency Oscillator" and old term which defines the "tuning knob". I say old as SDRs are different, but the terminology stays the same
- AM, SAM, LSB, USB, SSB, SRM, etc. … these are Modes: AM is Amplitude Modulation, SAM is Synchronous AM, USB is Upper Sideband, LSB is Lower Sideband, DRM is Digital Radio Mondiale, CW is Continuous Wave (Morse Code), NBFM is Narrow Band FM, etc. Look them up!

Palomar Amateur Radio Club

The following sections will help to set up the radio and listen to other amateur radio operators on the 40m amateur radio band and provide you with examples. It's designed to give you an idea of how to use the radio. A detailed KiwiSDR on-line manual is available here: http://kiwisdr.com/info/

Quick Start to get you on the air

The first time you connect to KiwiSDR *(screen shows what I have programmed so your initial one might be different)*

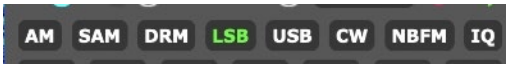


Setting the receiver to a 40m, LSB frequency 7184.50 kHz (7.1845 MHz)

1. "Select Band", scroll to "40m"

There are many bands that are preconfigured. Scroll down to "Amateur | 40m". You can ignore the "extension" for now. Note that the "A" in the circle refers to VFO "A". There are two VFOs in this radio

2. Select the Mode "LSB" (Lower Sideband)

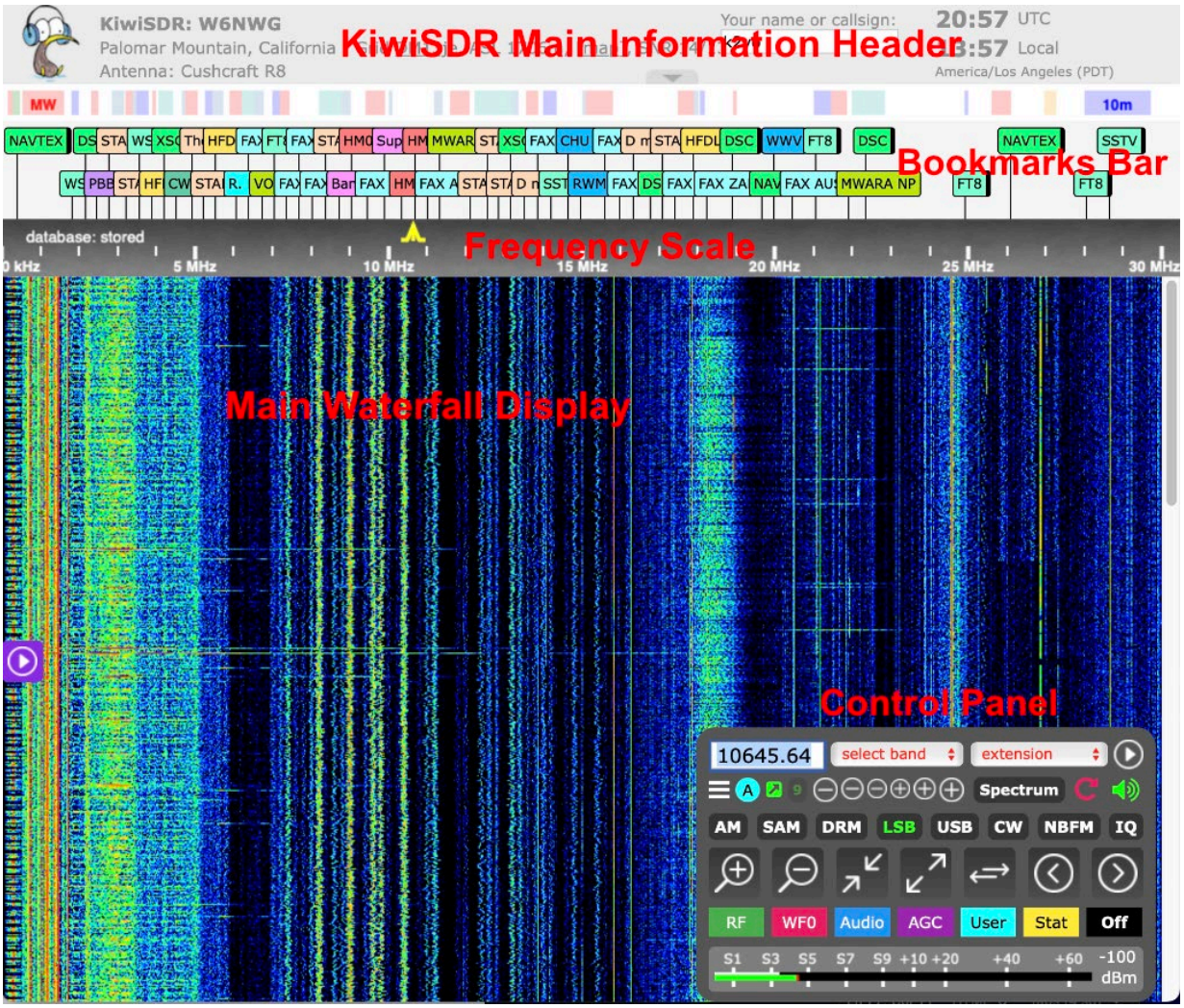


3. Enter Frequency 7184.50 kHz

To select the frequency, you can click on the frequency, and type it in. This entry needs to be in kHz, so 7184.50 then press the enter" key on your computer. If you don't hear audio, click on the blue "Audio" button and there is a volume slider

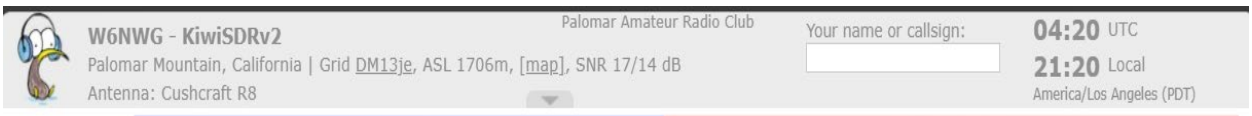
That's it! You are now listening on 7184.5 kHz in the 40m amateur radio band.

Explanations of the different parts of the main screen



Introduction to the KiwiSDR screens

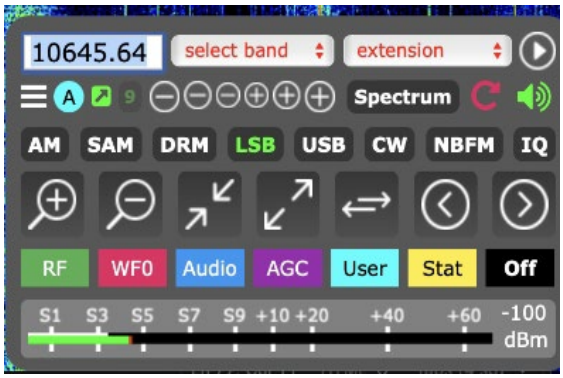
- **KiwiSDR Main Information Header** - Displays general information about the station
  - It includes the station name, location, the antenna in use the current local and UTC time.
  - Please insert your name or amateur radio callsign in the area shown below



- Displays a collection of DX Labels (like **bookmarks**) each containing a set of saved tuning parameters. When clicked the KiwiSDR tunes to the saved frequency and sets the receiver mode, passband and decoding parameters. If specified it will start an extension as well

    - DX Labels provide a convenient way to remember and then quickly tune the KiwiSDR to favorite stations.
- A **frequency scale** is provided for the waterfall display. The selected frequency is denoted with a trapezoidal frequency icon:
- The frequency icon is centered on the currently selected frequency and its width indicates the bandwidth corresponding to the currently selected operating mode.

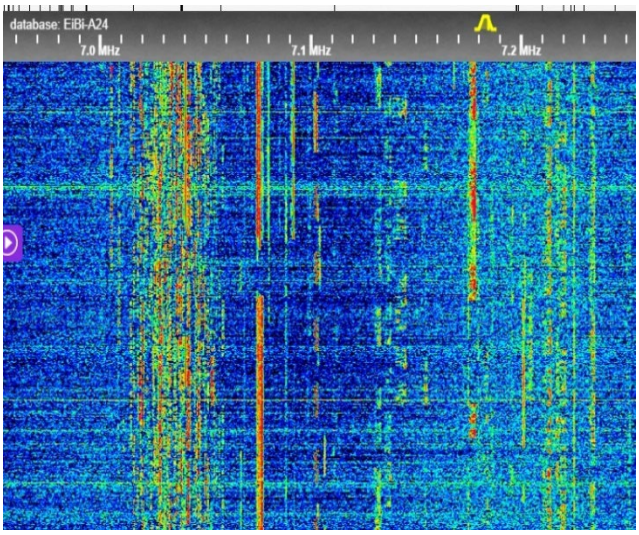
The **Control Panel** has most of the controls for operating the KiwiSDR including band selection, receiver operating modes and the waterfall display characteristics.



- A is VFO A. The KiwiSDR has two receivers, A and B
- + and – are to zoom in and out
- The diagonal upward and downward arrows denote maximum zoom out and zoom in
- The left-to-right arrows let you zoom out to the entire band.
- RF, WF0 Audio, AGC, User, Stat are buttons to let you customize functions. The OFF is to close any of the sub menus you selected. We recommend that you refer to the KiwiSDR manual for details on all these functions.
- The left < and > are used to scroll to a different page of the receiver. Up or down in frequency while listening to the same frequency you selected. This is useful to see the "waterfall" of other signals
- The – and + buttons let you scroll up and down the frequency. The steps are shown by the size of the symbols

The **Control Panel** has 6 rows of buttons and controls that are described below. Hovering the mouse cursor over a button or menu box will show some helpful text.

Control Panel Control Sets		
	**Frequency Tuning Controls** Current Frequency, Band Selection and extension dropdown menus	Most of the frequency band and extension selections are on these menus.
	**Frequency Tuning Buttons** There are several types of controls.	A/B VFO Selection, copy URL to clipboard, frequency tuning, record, spectrum and muting. ⓘ Frequency Tuning
	**Audio Mode Quick-Selection Buttons** Buttons.	Some of the most used audio modes. ⓘ KiwiSDR Audio Modes
	**Waterfall Controls** Scrolling and zooming the waterfall.	Waterfall buttons.
	**KiwiSDR Info Tab Selection Buttons** Shows various expanded info panels.	Info panels show different sets of information. ⓘ KiwiSDR Info Panels
	**S-meter** Signal level meter.	Shows the received signal strength.



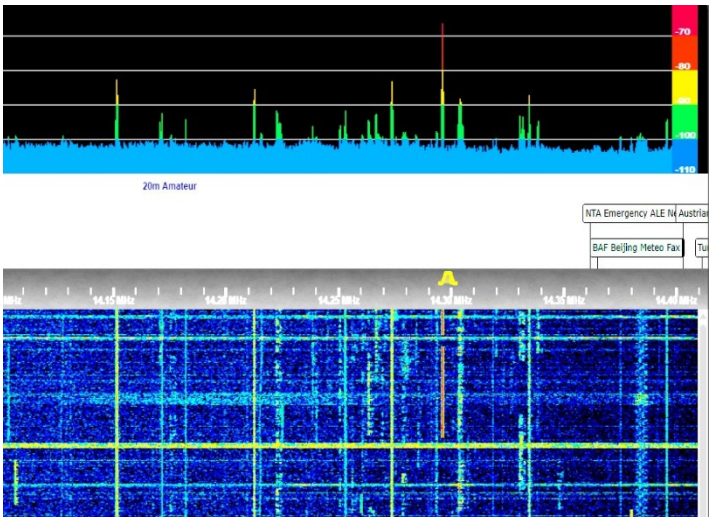
- The **Waterfall Display** is a means to display activity over time. Like a waterfall, on top is the current signal while the "falling" part is the past.

- The color of the waterfall lines indicates its strength. This is customizable and what we preconfigured shows stronger signals are brighter red. This is useful for you to see if there was any activity. Note that if you tune AM broadcast stations (like 1000 kHz (1 MHz), you will see the waterfall of a broadcast station.

- Prior to SDRs, only very expensive radios had this capability … and they were rare!

- If you click on "**SPECTRUM**" in the Control Panel, a new display appears on top of the waterfall. This shows the real time spectrum of the signal being received. I will let you learn about this. Look up "Spectrum Analyzer".

- The SPECTRUM display is complementary to the waterfall. It shows the real time signal while the waterfall shows it over time. The top of the waterfall is what is shown in the SPECTRUM display



Let's dive a bit deeper with some examples

Data mode: FT8

The screen on the next page shows the waterfall and decoding of FT8 signals on 20 meters. "FT8" is a very popular digital mode that is mainly used for contesting and logging contacts. Look up "Amateur Radio FT8" to learn more about this mode. This SDR supports many other digital modes. You can see their abbreviations in the "extension" pull down menu. Seach them on the Internet to learn about these other data modes used by amateur radio … and by others.

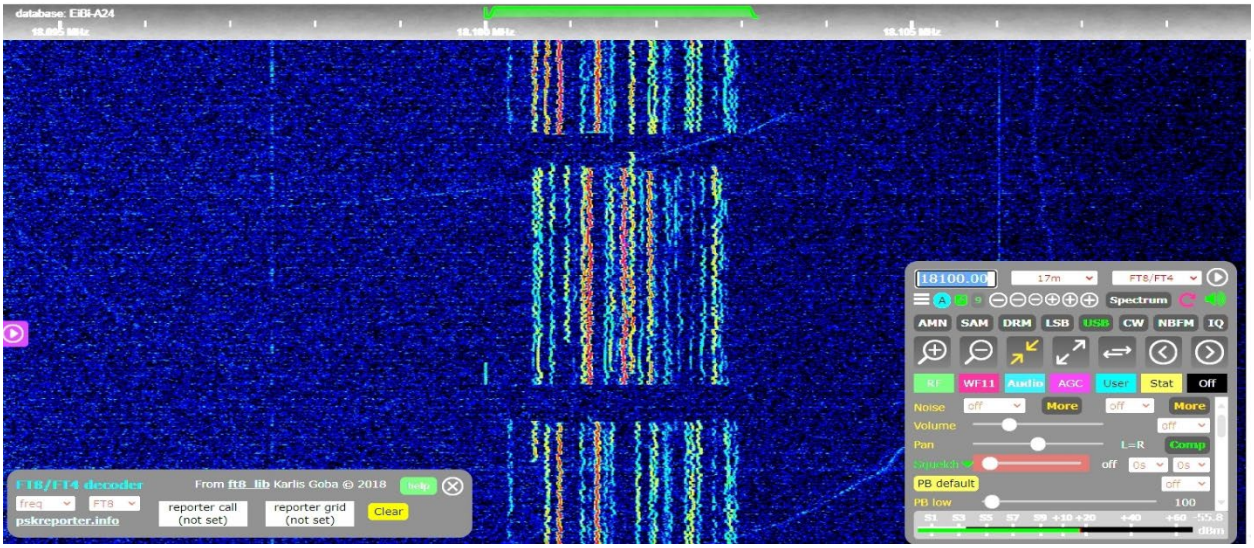
In Control Panel, select:

- FT8/FT4 in the EXTENSION pulldown
- Select 20m Amateur radio is Select Band pull down
- Enter **14074.00** in the Frequency box (in Blue)
- Select **USB** as the mode

You can use the same approach to select other modes and frequencies. As different modes use different frequencies, you will need to do a bit of research to find them. It's not hard as most of the WIKI pages for these modes list the currently used bands and frequencies.

The bottom left gives you more details.

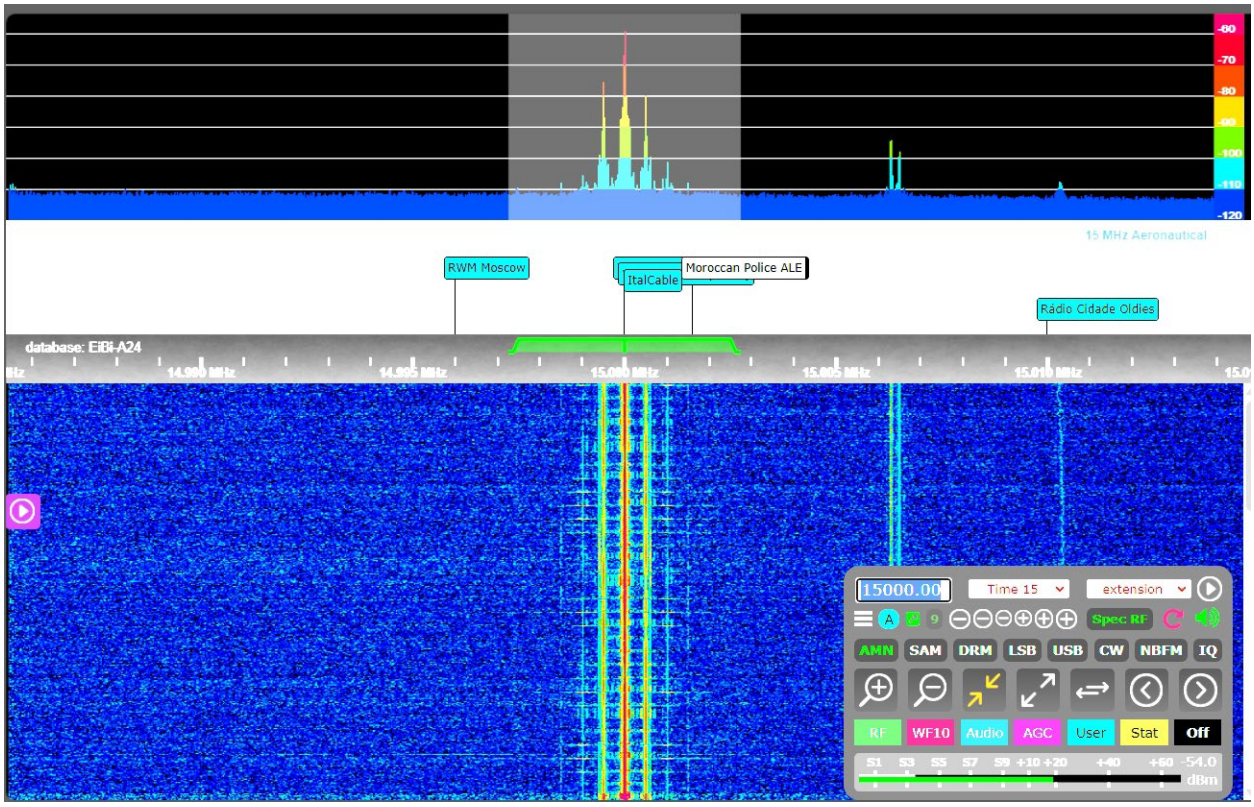
- If you select the "freq" pull down, you will see frequencies associated with mode you selected. In this case, FT8. So, this example shows that I selected 14074 kHz



OK, so what are we seeing on this screen?

- **Bottom right**: The control panel as shown on the previous page
- **Lower half**: This is the waterfall of FT8 signals being received. Each exchange lasts 15 seconds which is why you see the break.
- **Upper Half:** This is where the SDR receiver is decoding what has been received
- <u>Look at the line before the last one:</u>
    - **02:42:15** is the time in UTC (look this up … it's a way for all hams to share the same time)
    - **-15.5** is the signal to noise ratio (SNR) of that signal. That's -15.5 dB below noise (look this up as it's a bit tricky for FT8)
    - **-0.68** is the time differential between the stations clock and UTC. This means that it was 0.68 second late
    - **2400** is the offset frequency from 14074.00. It means that it was 2400 Hz above 14074.00 (which is: 14074 + 2.4 = 14076.4 kHz)
    - **Msg** This was the first one we received
    - **CQ K8USN EM90**
        - **CQ** "Calling All Stations"
        - **K8USN** the amateur radio station's call sign
        - **EM90** is its location. EM90 refers to the Maidenhead Grid Location (look it up). Our SDR on Palomar Mountain is at grid DM13je (the "je" suffix is simply a smaller sub-square) https://en.wikipedia.org/wiki/Maidenhead_Locator_System

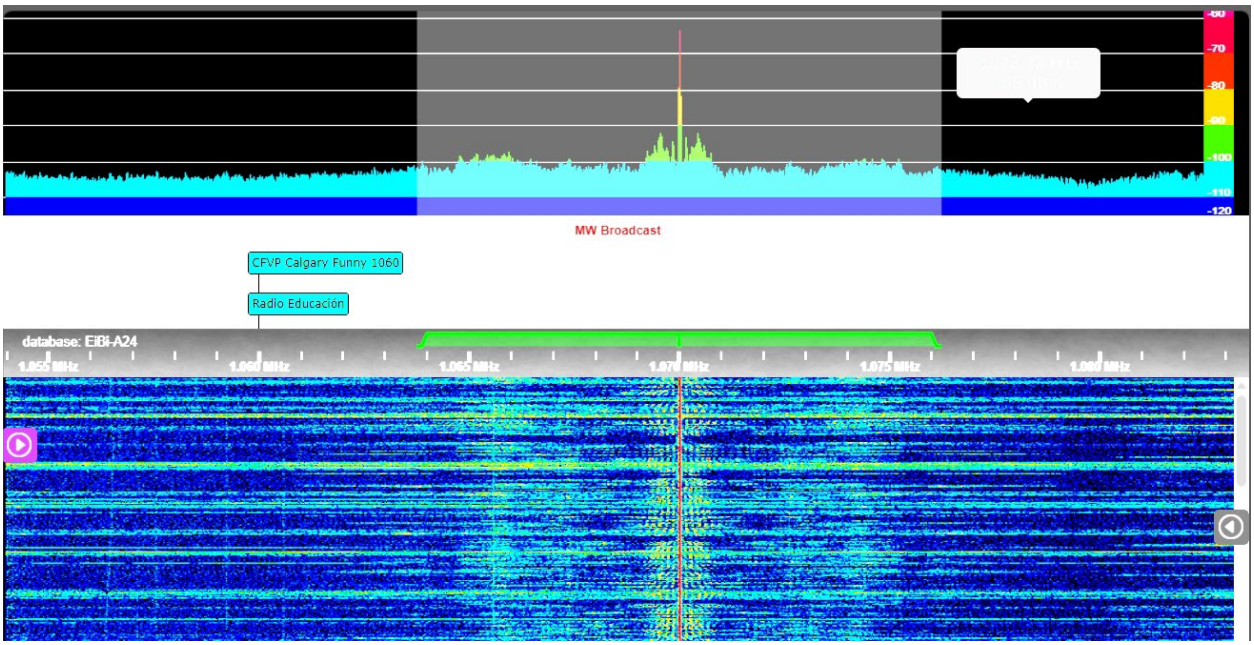
Time Broadcast



- Select Band: Time 15
- Mode: AMN (Click on AM and it will change between AM, AMN and AMW. AMN is Narrow band AM)

The above is a screen capture the spectrum and waterfall displays of the 15 MHz WWV transmission. This station is located in Fort Collins, Colorado, and it broadcasts standardized time and other information on 2.5 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz. Another station, WWVH, broadcasts on 2.5 MHz, 5 MHz, 10 MHz and 15 MHz from Kauai, Hawaii and at times, you can hear it stronger when HF propagation is enhanced towards the Pacific. Look up WWV and WWVH.

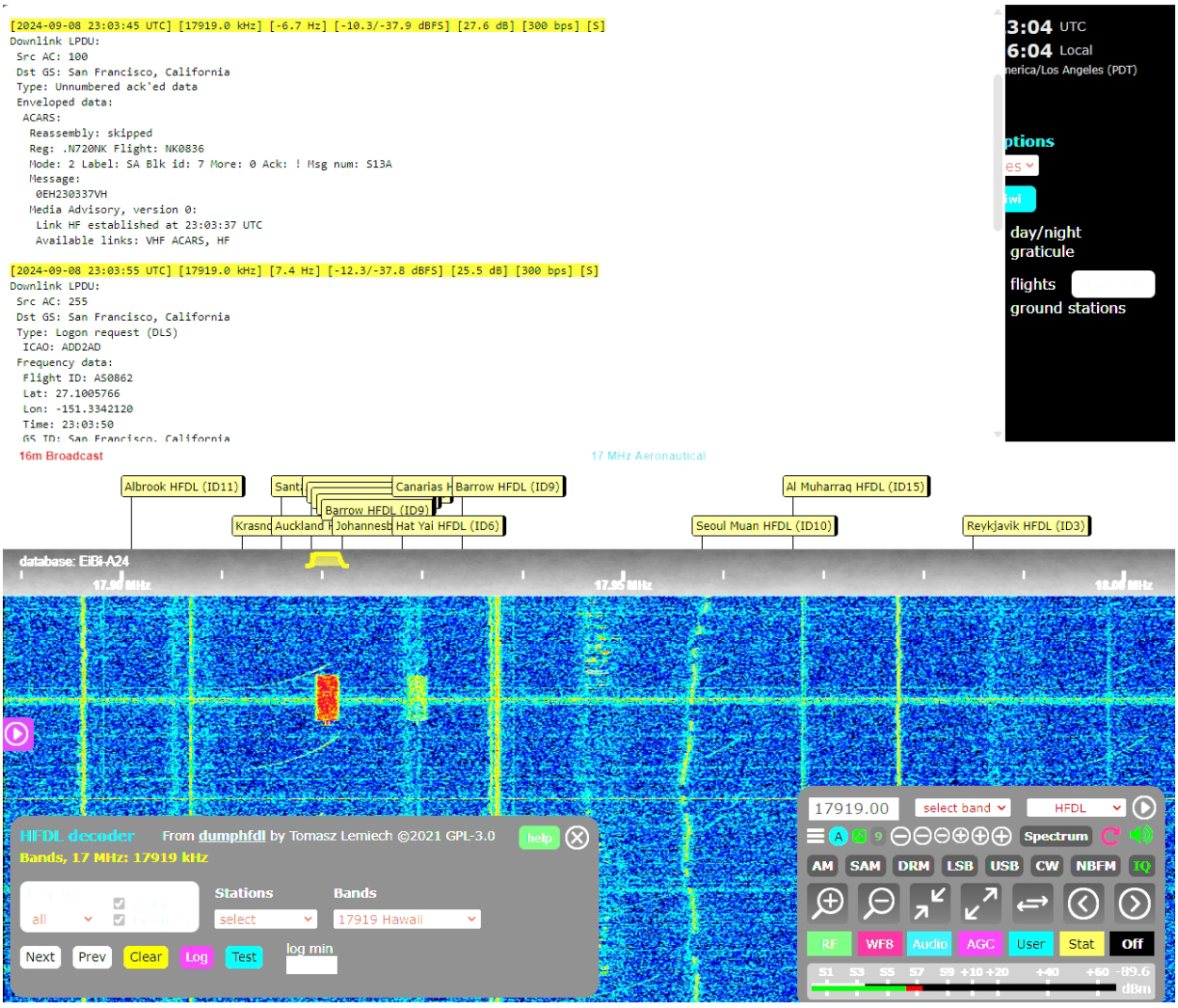
AM Broadcast – KNX 1070 kHz, Los Angeles



- Select the Band: MW (Medium Wave, our AM broadcast band)
- Select the mode: AMW (Click on AM and it will change between AM, AMN and AMW. AMW is Wide band AM)
- Frequency: Enter 1070, which is KNX Los Angeles

On top, you can see the spectrum display of the broadcasting station. On the bottom, you can see the waterfall of that signal.

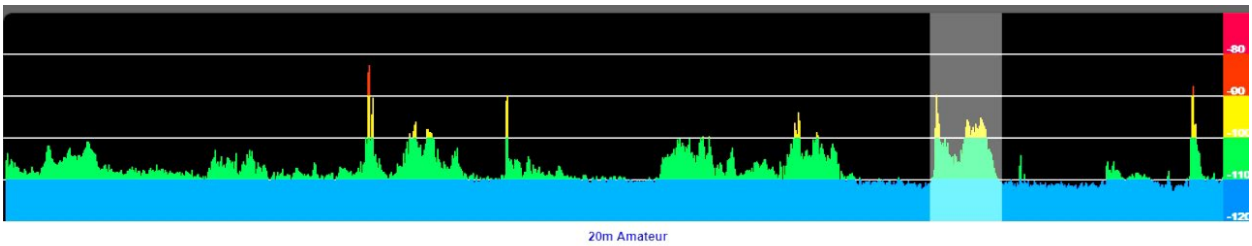
HFDL – High Frequency Datalink from commercial aircraft

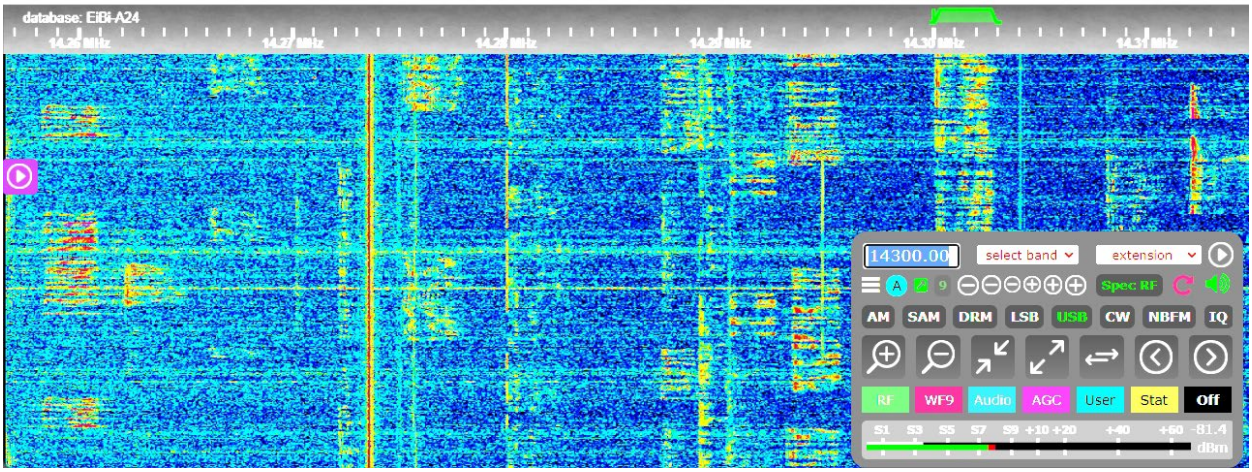


- Select the Band: AERO 17 MHz
- Select the Mode: HFDL

What you are seeing are “squitters”. These are digital exchanges between commercial aircraft flying over the ocean and ground stations. It contains core information like the flight number, the aircraft callsign, and technical information. The above was received from the San Francisco ground station but there are ground stations all around the world. You can try to receive from far away stations at night. If propagation is good, you will be able to receive these. Look up **HFDL** for more information

20m Amateur Radio – 14300 kHz Maritime Mobile Service Network





- Select the Band: Amateur 20m
- Select the Mode: USB

This is the amateur radio “Maritime Mobile Service Network”. This is a net that caters to boaters and covers the Atlantic, the Pacific, and the Gulf of Mexico. They provide support to boaters who need to contact ground stations. https://mmsn.org/

What else is there?

There are many more features and areas for you to experiment with. This document is only a means to introduce you to the KiwiSDR. As you experiment and uncover new items tied to your projects, share them with the modernization team and we will add them to this document.

The rest is in your court!