KRAKENSDR

KRAKENRF INC

USERS MANUAL
BENUTZERHANDBUCH

PREFACE

Congratulations on receiving your new KrakenSDR!

KrakenSDR is a 5-channel coherent RTL-SDR system. With a coherent RTL-SDR you can expect to be able to setup interesting applications such as radio direction finding, passive radar and beamforming. Or it can be simply used as five individual radio systems.

This manual will explain the device, safety information, its design, and provide some information on its operation.

This paper manual is a regulatory requirement for the EU. Instead of consulting this manual we instead suggest consulting our online guide at krakenrf.com as we are constantly working on the software and adding new features.

SAFETY & ENVIRONMENT

HAZARDS

Before getting started with your KrakenSDR, please review these safety instructions.

Electrical shock: You could be **INJURED OR KILLED** if live electrical wires touch an antenna that is connected to a KrakenSDR. When dealing with external antennas, always ensure that your antennas are kept well away from power lines and any other live electrical wires.

EM leakage: The KrakenSDR **CANNOT TRANSMIT**, however it contains a built-in internal wideband noise source that is used for phase calibration purposes. Whilst this noise source is low power, isolated from the antennas via a high isolation silicon switch and enclosed within a metal faraday cage, there could be small amounts of wideband EM leakage that could interfere with highly sensitive radio equipment. This leakage has been measured to be well below regulatory compliance thresholds. However, should you remove the enclosure or make any modifications for any reason, noise source leakage may increase beyond compliance thresholds.

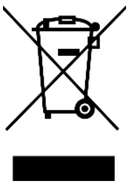
Enclosure temperature: The KrakenSDR metal enclosure may become warm or hot to the touch during operation.

Cooling fan blades The KrakenSDR contains a cooling fan on the enclosure that operates at high RPM. There is a finger guard, however small fingers and debris could get into the fan blades. Take care when handling, and always ensure that the fan area is clear of debris before powering the device.

Driving risks: A typical use-case for the KrakenSDR may be using it in a vehicle for radio direction finding. Please always pay attention to the road when using the device in a vehicle and have a passenger performing navigation tasks. Always ensure that antennas on the roof of your vehicle are attached securely and comply with local laws.

Regions of conflict/war or use in or near sensitive locations: Any radio receivers used in regions of conflict/war or when used around sensitive locations may not be seen by authorities favourably. Please consider your use of the KrakenSDR very carefully in these areas.

RECYCLING



The KrakenSDR is compliant with RoHs. However, as the KrakenSDR contains a PCB and electronic components, please do not throw it in the trash. Should you need to dispose of a KrakenSDR, please take it to an e-waste recycling plant, or ship it back to KrakenRF Inc.

AVOID DAMAGING YOUR KRAKENSDR

NEARBY TRANSMITTERS

The KrakenSDR is a sensitive radio receiver. Like most radio receivers, any antennas connected to the KrakenSDR MUST be kept away from powerful nearby transmitters.

The maximum input power allowed at the SMA port is +10dBm. Please take external measures to block or limit power if you know that you will be operating next to a powerful transmitter.

LIGHTNING/ESD DAMAGE

For protection, the KrakenSDR implements ESD diodes, gas discharge tubes, and diode clipping protection.

However, it will not withstand direct or nearby lightning events, or possibly huge ESD events from events like snow and dust storms.

Therefore we suggest that any outdoor connected antenna MUST have externally provided lightning and ESD protection measures in place.

OPERATING ENVIRONMENT

The KrakenSDR has been tested to operate in ambient environments up to 50C. However, for longevity it is recommended to keep it in a cool environment.

THE KRAKENSDR

Hardware provided in package(s):

1. 1x KrakenSDR
2. (ANTENNA OPTION)
    a. 5x Magnetic Whip Antennas
    b. 5x SMA Tee's
    c. 5x 2M LLMR100 cable

Hardware you'll need to provide:

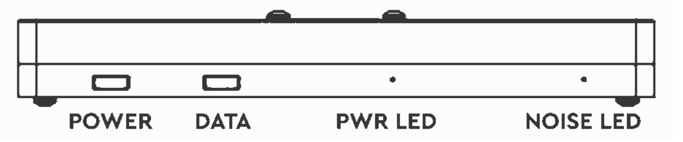
1. A computing device such as a Raspberry Pi 4, Linux Single Board Computer, or Linux PC.
2. A 5V 2.4A capable USB-C power pack. If you intend on using devices connected to the bias tees, we recommend a 3A capable power pack. The Raspberry Pi official USB-C power pack is a good choice.
3. A USB-C to USB-A data cable. For connecting the data port to your Raspberry Pi 4, Linux Single Board Computer, or Linux PC.
4. Antennas.
    a. A set of five identical antennas for use with the radio direction finding software.
    b. Two directional Yagi antennas for use with the passive radar software.

TECHNICAL SPECIFICATIONS

Dimensions: L: 177mm x W: 112.3mm x H: 25.86mm (+4.7mm height for fan finger guard) (See appendix for drawing)
Weight: 670g
Typical Power Draw: 5v, 2.2A (11W)
Radio Tuner: 5x R820T2
Radio ADC: 5x RTL2832U
ADC Bit Depth: 8-bits
Frequency Range: 24 MHz -1766 GHz
Bandwidth: 2.56 MHz

RX Ports: 5
Oscillator Stability: 1PPM

KRAKENSDR HARDWARE



KRAKENSDR POWER PORT

The KrakenSDR requires power from a 5V 2.4A capable USB-C power supply. It is also compatible with ‘PD’ type USB-C power packs that you might find used with laptops.

For use in vehicles, it is possible to use USB cigarette lighter adapters. Make sure that they can support at least 5V 2.4A out. Battery packs can also be used, as long as they support 2.4A or more output current.

Bias Tee Note: The KrakenSDR draws 2.2A under nominal operation. If you intend to use the bias tees to power external devices, please ensure that you use a power pack capable of providing the power required. For example, if you use a 3A power pack, you will have about 800 mA current margin.

Note that the KrakenSDR has no power connection on the data port.

KRAKENSDR DATA PORT

The KrakenSDR requires a USB-C cable to connect the computing device to the data port. Please note that this data port is not connected to power, so you cannot power the device from the data cable. You must use the data cable AND the power cable together.

Make sure that you use a high-quality USB-C cable.

KrakenSDR Cooling

The KrakenSDR is cooled by heatsink fins and a cooling fan. Internally the PCB is thermally connected to the cooled enclosure via a thermally conductive silicon.

KrakenSDR has been tested to operate normally in ambient temperatures of up to 50C / 122F.

We recommend keeping your KrakenSDR out of direct sunlight and in an area with sufficient air flow.

Large sudden temperature swings may cause issues with phase coherence calibration being lost. See information later on periodic software automatic recalibration.

SMA Ports

The KrakenSDR has 5 SMA RX IN ports for connecting antennas labelled from CH0 to CH4.

Bias Tee

The KrakenSDR can provide 4.5V out via a bias tee out on each of its SMA ports. This can be used for powering external RF components such as LNAs. As mentioned previously, your power pack will need to be able to provide sufficient current to support external devices.

STATUS LIGHTS

The KrakenSDR provides peep holes for several status lights.

PWR LED: If illuminated the white PWR LED to the right of the two USB-C ports indicates that the KrakenSDR is receiving power from the POWER USB-C port.

NOISE LED: If illuminated the white NOISE LED to the right of the PWR LED indicates that the noise source on the KrakenSDR is active. This LED may flash briefly every few minutes when running the software if calibration monitoring/auto recalibration is turned on.

CHANNEL LEDS: There are five blue CHANNEL LEDS next to each of the SMA ports. If illuminated, these LEDs indicate that that channel tuner has been enumerated by the computing device. It does not indicate if the drivers are installed, or if the DSP software has connected to the tuners.

KRAKENSDR DESIGN

The KrakenSDR coherent design consists of

- 5x RTL-SDR tuners (with R820T and RTL2832U chips)
- 1x single clock source for all RTL-SDRs
- 1x noise source
- 5x noise / antenna port switches
- 1x USB hub

The KrakenSDR is not a naturally coherent system just by its hardware alone, but the design with the single clock source and noise source with switches allows for coherence to be achieved in software through cross-correlation algorithms.

Upon the start of the software, the noise source will be activated, and each channel correlated against the master channel (CH0 by default). Any sample timing and phase differences will be recorded, and each sample will be adjusted in software.

RADIO DIRECTION FINDING

For the latest updates on software, we recommend following our software setup guides online at www.krakenrf.com.

QUICKSTART WITH ANDROID APP

This quickstart guide aims to have you connected to the Android Direction Finding App as quickly as possible. However, please make sure you read the rest of the manual to understand how direction finding works.

The first step is to burn the KrakenSDR Direction Finding image to an SD Card.

1. Using a PC, download the “Etcher” software from balena.io/etcher.
2. Download the latest KrkeanSDR DF Image zip file from krakenrf.com.
3. Use Etcher to burn the SD Card.
4. Insert the card into your Raspberry Pi 4.

The next steps show how to run the software and connecting to the app.

1. Creating a WiFi hotspot with your Android device with username and password credentials krakensdr/krakensdr.
2. Plug in your KrakenSDR Power port to a 5V 2.4A capable supply and plug the Data port into the Raspberry Pi 4.
3. Boot up the Raspberry Pi 4 with the KrakenSDR DFing SD card image. Once booted, if the

KrakenSDR hotspot is detected, the Pi 4 will automatically connect to the hotspot.

4. Via your phone settings, determine the IP address of the connected Raspberry Pi 4.
5. Open a browser and connect to IP_ADDR:8080
6. Start the KrakenSDR by pressing the 'Start' button.
7. Set the desired frequency, antenna configuration, and other settings for the specific signal of interest.
8. Open the Android app and enter the IP_ADDR of the Pi 4 in the settings.
9. Create a log file by pressing on the save button.
10. Press the Start DOA button to begin logging data and generating the heatmap.
11. Drive with your KrakenSDR, either by using the built-in navigation feature in the Android App, or by having your navigator direct you so that you move in the direction of the bearing.

Alternatively, if you do not create a WiFi hotspot with your phone:

1. Plug in your KrakenSDR Power port to a 5V 2.4A capable supply and plug the Data port into the Raspberry Pi 4.
2. Boot up the Raspberry Pi 4 with the KrakenSDR DFing SD card image. The Pi 4 will create its own WiFi hotspot.

3. Open the KrakenSDR Android app, and use the download offline maps feature to download the maps for the region that you will be working in.
4. Connect to the krakensdr WiFi hotspot on your Android device.
5. In your Android WiFi settings find out the IP address of the Pi 4.
6. Enter the IP Address in the KrakenSDR Android App settings.
7. You can now continue from steps 5 onwards in the previous list of steps.

DIRECTION FINDING BACKGROUND

In a radio direction finding operation the goal is to determine the exact location of an RF transmitter. This may be an illegal or interfering transmitter, a foxhunt beacon, an asset/pet/wildlife tracking beacon, a search and rescue beacon, or maybe just a curious unknown signal.

To locate a transmitter, a bearing towards the transmitter needs to be determined from multiple locations via a radio direction finding device. The bearings should then be plotted, and where they intersect is the estimated location of the transmitter.

However, radio direction finding will always have several degrees of bearing noise inaccuracies, and there will often be poor results due to a phenomenon known as multipath. Multipath is when the signal may be reflecting off some objects such as terrain, buildings or vehicles, and the radio direction finding system may ‘see’ that reflection as the source. This can either skew the bearing away from the actual source, or simply provide a totally incorrect reading. The worst case is when the signal source does not have line of sight to the antennas, so only the reflections can be seen.

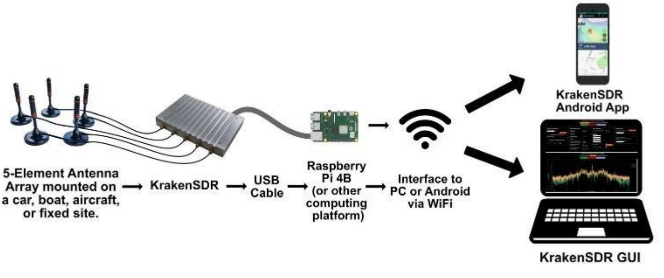
As an analogous example, you may be indoors looking at sunlight on the wall. If you couldn’t see the sun directly, and didn’t know any better, you might conclude that the source of light is the wall or window instead of the sun.

So, if we take a singular reading at a location where the multipath effect is strong due to a lack of line of sight, we may come to the wrong conclusion about the signal source bearing. Therefore, to obtain an accurate location, we need to take multiple readings at multiple locations to average out the incorrect or skewed readings we get from multipath. This can be achieved by either having multiple distributed sites with a KrakenSDRs and antenna array at each site, or by moving a single KrakenSDR around on a vehicle and taking many readings.

MOBILE VEHICULAR OPERATION THEORY

Many simple radio direction finding systems will have the user drive to different locations, take a manual reading and plot that bearing on a map. With the KrakenSDR system we make use of modern smart phone technologies such as mapping, GPS and compass sensors, to take hundreds of readings by automatically logging bearings from the KrakenSDR with the current location as the vehicle moves. The system over time generates an average intersection of these readings, essentially pinpointing the location of the transmitter. We make use of the smartphone mapping service MapBox to plot this data on a constantly updating map.

Advanced: The KrakenSDR app actually does something a little more clever than calculating simple intersections of bearing lines. It uses the full 360 degrees of data given by the correlative interferometry system. This 360 degrees of data includes multipath data too. It then overlays this data on a grid, activating each cell the bearing data lies on. Over time, the cell with the most activations is deemed to be the transmitter location.



KRAKENSDR DOA WEB INTERFACE

INTERFACE PAGES

Configuration: The configuration page contains all the settings to change centre frequency, gain, and to adjust DoA parameters such as array size and algorithm type.

Spectrum: The spectrum page displays an RF spectrum and waterfall graph of the currently tuned frequency.

DOA Estimation: The DOA Estimation page shows a graph of the currently estimated direction of arrival data.

CONFIGURATION PAGE SETTINGS

Centre Frequency: The frequency at the centre of the active bandwidth.

Receiver Gain: The gain setting for all 5 tuners. Check the SNR in the spectrum plot screen, and adjust the gain to achieve high SNR, and avoid the spectrum overloading.

Any changes to the centre frequency or receiver gain are only applied when the "Update Receiver Parameters" button is pressed.

Antenna Configuration: Choose what antenna array type you are using, either a linear "ULA" or circular "UCA" antenna configuration.

Antenna Radius/Interelement Spacing: Set the size of the array here (in meters)

Wavelength Multiplier: Shows the spacing multiplier based on the frequency and array sizing

Enable DoA Estimation: Enable the direction finding algorithms

DoA Algorithm: Choose between various direction finding algorithms. In almost all cases you will want to use MUSIC.

Enable F-B Averaging: When you use a linear ULA array, this can be enabled and may improve direction finding performance.

DoA Graph Type: Changes between a linear, polar or compass style graph for displaying DoA bearings. If you use the compass plot, you can set a compass offset, to compensate for where your array is pointing.

BASIC DAQ SETTINGS

The DAQ code can be controlled from the web interface too. However, we recommend that only advanced users change DAQ settings.

Preconfigured DAQ Files: Choose a DAQ file configuration from a preset.

Data Block Length: Integrated time of each processed block. Larger blocks provide more processing gain, at the expense of slow update rates.

Decimated Bandwidth: The bandwidth of the system after decimation. Decimation may be required to keep the update rate fast enough for intermittent signals.

Recalibration Interval: How many minutes the system waits before checking up on coherence calibration and performing recalibration if calibration was lost for any reason.

The advanced DAQ settings will not be described here. For those settings, please refer to the code technical documentation.

Any changes to the basic or advanced DAQ settings can be applied by pressing the “Reconfigure & Restart DAQ Chain” button. This restart process may take a couple of minutes to complete.

THE KRAKENSDR ANDROID APP

The KrakenSDR Android app can be downloaded from the Google Play store. Just search for ‘KrakenSDR’.

The app is free and can be installed on any modern Android device with an internet connection, and GPS. We recommend that you have a phone or tablet mount for your vehicle positioned so that you can see the map without compromising on driving safety.

The Android app receives bearing data relative to the antenna from the KrakenSDR software via WiFi. We use the built in GPS and compass sensors in the Android device to determine our true direction of movement, and then the app calculates the true bearing to the transmitter. The true bearing is then plotted on a map from the current GPS position.

MAIN MAP PAGE BUTTONS

RIGHT EDGE BUTTONS

Save: Create a log file for recording bearing and GPS track data. If you logged data without first creating a log file, pressing save will create a log file with the temporary data saved in it.

Load: Load up a previously saved log file.

Close: Close any open log file or reset temporary data.

Navigation: Start the turn-by-turn navigation feature.

Start Logging: Connect to the KrakenSDR and begin logging data.

Centre Location: Centre the map to the current GPS location.

TOP BAR BUTTONS

Magnifier: Search for a location

Download: Download maps for the currently zoomed region

SETTINGS PAGE

Server Address: The IP address or hostname of the KrakenSDR server (the Pi 4, or computer running the KrakenSDR software)

Pause Data Collection When Stationary: If the GPS mode of bearing is used, you may wish to pause data collection when stationary to avoid bad vehicle bearing results.

Logging Period: How often the app polls the KrakenSDR server for data. Faster polling may give better results, but can end up with very large log files if the total logging time is long. There is no use polling faster than the update rate of the KrakenSDR server software.

Skip Every X Point: Skip every X log point. Useful if your Android device is a bit slow and struggles to plot many points.

Minimum Required Confidence: The confidence value is an estimation on how ‘good’ a bearing result was. Trial and error with this value may help reduce the data size by discarding the poorest results. But it is generally not required.

Minimum Required Power: Discard any values below a certain power level.

Total Grid Size: How far the direction finding grid should extend in total.

Number of Grids per Axis: Defines the size of each grid cell. More grids per axis results in smaller grids, and greater resolution. At the expense of possible computation time.

Grid Estimation Mode: Either choose to use the Full 360 degrees of data provided by the KrakenSDR with the grid system, use only a single bearing for the maximum bearing with the grid system, or use a single bearing with an intersection calculation algorithm. Generally the full 360 method yields the best results.

Trace Length: How long the displayed bearing traces should extend on the map.

Use Kalman Filter for Displayed Bearing: Direction finding is a noisy process, and the bearing can jump around a lot which can be difficult for a human to track. Here you can enable Kalman Filtering which will filter noise out of the bearing line.

Map Settings: Choose between a street or satellite map.

Camera Mode: Choose between free and auto camera modes. Free mode allows the user to position the map camera manually. Auto camera will automatically follow the vehicle location.

Zoom Mode: Choose between free and auto zoom modes. Free mode allows the zoom to be manually sent. Auto camera automatically zooms to the active area between the vehicle location and estimated location.

Bearing Mode: Whether the mapping system uses the GPS or Compass sensor for determining the direction of movement. Generally, the GPS sensor is the most accurate, as long as the device is moving. If compass mode is used you will need to be careful with the direction that the Android device points to. For fixed sites, the antenna array forward bearing, and coordinates can be manually set too.

Speedometer Units: Choose between metric and imperial speed units, or turn the speedometer off.

Antenna Array Type: Set in the app the type of antenna array that is used by the direction finding system. (May be depreciated soon in favour of reading this data from the KrakenSDR system)

Linear Array Plot Direction: If you are using a linear array, decide if you wish to plot bearings from the forward or backward direction, or both.

Anti-Clockwise Antenna: The standard convention is to arrange the antennas in order clockwise. If you arranged them anti-clockwise, select this to reverse the array in software.

ANTENNA SETUP

For standard direction finding you will need five identical omni-directional antennas. (You can use less antennas, but for best performance we recommend using the full five). These are typically magnet mount whip antennas, or dipoles.

Note that when mounting antennas, the convention is to mount them in a clockwise direction. So antenna one if the first antenna pointing towards bearing zero, antenna two is to the coordinate to the right of antenna one, and so on.

The explanations below provide a bit of detail as to the math behind the antenna spacing. However, in practise, you only need to decide what type of array you want to use, and then you can use an excel sheet calculator to calculate the spacing required. Please see krakenrf.com for the link to the excel sheet.

Uniform Circular Array

If you wish to determine radio sources from 360 degrees, the antennas should be arranged in a uniform circular array or UCA for short. The interelement spacing (the distance between the tip of each antenna element in the array) needs to be designed specifically for a range of interested frequencies.

You must design your array such that the interelement spacing I_e is less than half a wavelength λ of your highest frequency of interest

$$I_e = s\lambda$$

where s is the wavelength spacing multiplier that must be <= 0.5 and λ is the wavelength in meters.

An array with an interelement spacing larger than this will experience what's called 'ambiguity'. Put simply means that the system may see the signal source coming in from more than one direction, and we have no way to know which is the true direction. This is obviously not ideal, so always keep the multiplier below 0.5.

Using a spacing multiplier less than 0.5 can allow you to design a smaller array size, at the expense of some accuracy. Generally, down to s=0.2 is acceptable. However, it's important to note that the accuracy of the direction-finding result becomes much poorer with smaller spacing multipliers.

From this calculation you can see that the lower the frequency the larger the required array size. This shows that this type of radio direction finding method can be impractical for frequencies with large wavelengths as the arrays will take up a lot of space. For HF and VHF frequencies with large wavelengths, other radio direction methods like TDoA, Watson-Watt and Yagi based may be more appropriate.

It may be more useful to work with a radius vs interelement spacing. The formula for calculating radius for a given spacing multiplier and wavelength is given by:

$$r = \frac{s\lambda}{\sqrt{2\,(1 - cos(\frac{360}{n})}}$$

where s = spacing multiplier, λ = wavelength in meters and n = number of antenna elements

Uniform Linear Array

The other way to set up an array is to use a uniform linear array, which is just the antenna lined up in a straight line. The disadvantage to this arrangement is that you can only receive bearings from 180 degrees, and there is no way of knowing if the signal is coming from in front, or behind the array.

The advantage is much greater accuracy resolution due to a larger possible aperture. Like above, the interelement spacing calculation is the same formula

$$I_e = s\lambda$$

THEORY OF RESOLVING RESOLUTION

The resolving resolution of the system is effectively the accuracy. If the resolution is 10 degrees, we can say that the actual bearing is somewhere with a 10-degree arc.

If you are interested, we will briefly explain the theory behind what sort of resolution we can expect from this system. With a 5-element circular array spaced at 0.5 λ, we might roughly expect a resolution of about 8 degrees. With a 5-element linear array we could roughly expect about 3.4 degrees.

To estimate this, we used the Rayleigh resolution calculation from Physics. The Rayleigh formula states that resolving resolution is given by $\theta=1.22\lambda/D$, where D is the aperture of the antenna array. For a circular array the aperture is equivalent to the diameter, and for a linear array it's equal to the total length.

So, using the formula above to calculate radius, then multiplying by two to get diameter, we get for a n=5 element circular antenna array with s=0.5 spacing an aperture of D=0.85 λ . Therefore, the Rayleigh equation reduces to $\theta=1.22/0.85$ = 1.44rad = 83 degrees.

For a 5-element linear array its aperture is given by the total array length which is given by D = (n-1) * s λ. If we have n=5 elements and s=0.5 spacing, then $\theta=1.22/2$ = 0.61 rad = 34 degrees.

Because we use 'super-resolution' algorithms like MUSIC, we can improve on the Rayleigh resolution by a very approximate factor of 10. So, we end up with a resolution of 83/10 = 8.3 degrees for the circular array, and 34/10 = 3.4 degrees for the linear array.

Distributed Networked Direction Finding

At the time of writing this manual, our software to provide distributed networked direction finding services is not yet complete. Please check krakenrf.com for updates on the networked direction finding project.

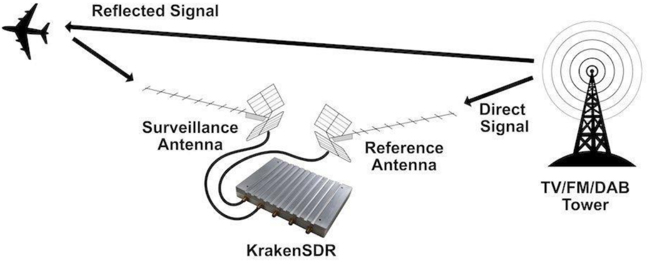
Once complete this software will allow the user to set up multiple KrakenSDR stations within a region and have them all upload bearing data to a central server. The central server will plot the data on a map, automatically combining the bearings into an estimated location of the transmitter.

PASSIVE RADAR

Active radar systems emit a radio pulse towards a target such as an aircraft and wait for the reflection of that pulse to return. In contrast, a passive radar system emits no signals. Instead, it makes use of already existing powerful transmitters, such as broadcast FM, TV and mobile phone towers.

In a basic two channel passive radar system, you have one ‘reference’ antenna pointing towards the illuminating transmitter which is used to receive the reference signal cleanly. The second ‘surveillance’ antenna points towards targets of interest, such as aircraft, cars or marine vessels. The reflections of the illuminating signal from these targets are received by the second antenna.

The reflections are then processed and correlated against the clean reference signal. The result is a ‘bistatic range-doppler’ graph that shows detected targets as dots. The position of the dot on the graph measures the velocity of the object, and the bistatic distance.



PASSIVE RADAR GEOMETRY

In a passive radar system, the geometry of the receiver, transmitter and targets of interest is very important for optimizing performance.

The targets and illuminator cannot be both in the same direction. The reason is that we want the reference antenna to receive only the direct reference signal, and most importantly we want the surveillance antenna to only receive the reflected signal. If the surveillance antenna is drowned out by the direct reference signal, it will be difficult to determine the reflections only.

PASSIVE RADAR ILLUMINATOR CHOICES

In the modern world there are several possible choices for illuminators. The best characteristics are

- **Wideband:** The wider the bandwidth, the greater our radar resolution (up until our max 2.56 MHz bandwidth limit)
- **Stable and 'noise-like':** HDTV digital signals such as ATSC/DVB-T as well as DAB stations appear noise like in the analogue domain. Purely analogue signals like broadcast FM are less desirable. If you must use broadcast FM, a trick is to use heavy metal stations, since heavy metal is close to white noise.
- **High power:** The higher the transmit power, generally the higher power the weak reflections will be.

With these characteristics in mind, we recommend using HDTV signals, or secondly DAB signals if they exist in your area. Mobile phone 3G/4G/5G signals can also work, but their transmit power is much lower, so they will work only over a smaller area. Broadcast FM is the least desirable due to its small bandwidth and least noise-like characteristics.

PASSIVE RADAR ANTENNAS

As per the chapter on geometry, it is desirable that the reference and surveillance signals are isolated from each other's antenna. To help with this requirement we can use directional antennas. Directional antennas are antennas that receive with high gain in one direction, but by design attenuate signals in all other directions.

For basic passive radar you will need two directional antennas, such as Yagi's. As HDTV signals are perfect for passive radar, it is possible and recommended to use cheap TV Yagi antennas from the local electronics store.

PASSIVE RADAR SOFTWARE

We have created software that can implement basic 2-channel passive radar. To install it please see our website at www.krakenrf.com for the most up to date instructions.

Like the direction finding software, the passive radar software has a configuration and spectrum display screen. The difference is the last page, which is the Passive Radar range-doppler display.

Passive Radar Configuration Settings

Enable Passive Radar: Enable the passive radar computations to be performed.

Clutter Cancellation: In most scenarios an algorithm to cancel out stationary 'clutter' will need to be used, otherwise stationary clutter returns will dominate, hiding the fainter returns from moving objects. At the time of writing this manual there is one clutter cancellation algorithm called "Wiener MRE" implemented.

Max Bistatic Range: How many kilometers of bi-static range to plot on the bi-static range-doppler graph. Depends on your setup.

Max Doppler: What is the max doppler (speed) reading that should be plotted on the range-doppler graph.

PR Persist: If enabled, the range doppler display will maintain a history of previous plots with some decay value.

Persist Decay: The amount to decay older plots each cycle.

Dynamic Range: Choose the plot thresholds for dynamic range. Adjust with trial and error depending on your specific setup until you get a good looking range-doppler graph that shows the moving objects clearly.

Passive Radar DAQ Data Block Length /CPI Size Setting Guide

The data block length (aka CPI Size) specifies the length of time radio data is collected. This block of data is then forwarded onwards for DSP processing.

For passive radar the data block length is an important parameter. Longer data block lengths result in more processing gain (weaker signal detections), and better range-resolution. This comes at the expense of a slower update rate and more CPU processing time. If you run on a fast machine, the update rate will be equal to the data block length time.

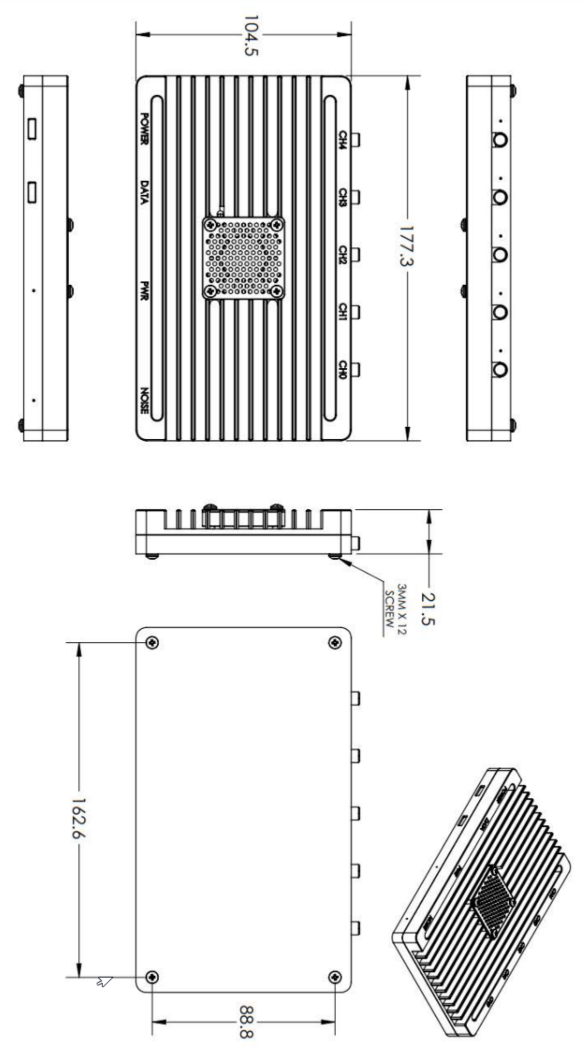
Another expense is that fast moving objects could spread their energy out over multiple range-doppler cells if the data block length is too long.

We have included three preconfigured DAQ files that can be used which set optimized data block lengths. They are “pr_2ch_2pow20”, “pr_2ch_2pow21” and “pr_2ch_2pow22”. The latter files have higher data block lengths, but update the display slower.

The optimal preconfig file will depend on the specific passive radar implementation. So we recommend experimenting with each type.

APPENDIX

ENCLOSURE DRAWING


104.5
177.3
POWER
DATA
PWR
NOISE
CH4
CH3
CH2
CH1
CH0
21.5
3MM X 12
SCREW
162.6
88.8

CONNECTING TO AN ESTABLISHED WIFI NETWORK

If you are using either the Kraken DF or Kraken PR software on a fixed WiFi network, instead of via hotspots, you will need to add your WiFi network details. To do so you will need to temporarily connect your Pi 4 to a monitor and keyboard, or connect your Pi 4 via Ethernet and SSH into it.

The default login credentials for the terminal and SSH are pi/krakensdr.

To add your network edit the file wpa_supplicant.conf

```
sudo nano
/etc/wpa_supplicant/wpa_supplicant.conf
```

Add your own network by adding the following text

```
network={
	ssid="MY_WIFI_SSID"
	psk="MY_WIFI_PASSWORD"
}
```

Then Press “CTRL+X”, “Y” to close and save the file. Now when you reboot the Pi 4 should automatically connect to your network.

SUPPORT

Please consult our website at krakenrf.com for support options.

WARRANTY

The KrakenSDR has a one-year warranty from manufacturing defects.

Please keep in mind the warranty will not cover damage from external events such as lightning or ESD.

REGISTRATION INFORMATION

Please register your KrakenSDR at krakenrf.com.