Monitoring complex of UAVs of the Russian Federation
Self-production and operation

DISTRIBUTION RESTRICTIONS: There are no distribution restrictions.

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Currently, the Armed Forces of Ukraine and the National Guard of Ukraine are monitoring enemy UAVs by the forces of regular electronic warfare and electronic warfare units. Control is carried out by direction finding systems, which are relatively few and installed as far as possible from the front line in order to minimize the risks of fire damage. Also, in many areas of the front, information about enemy UAVs is transmitted with a delay or is not accurate.

This complex will help you monitor the enemy's UAVs and, most importantly, form the basic knowledge for your future development in the direction of UAV electronic warfare.

Purpose of the complex:
- control the flights of the main UAVs of the Russian Federation in order to minimize the risks of their use by the enemy.

Repeatability:
- This device (hereinafter referred to as the receiver, monitoring point, receiving device, reception point) is easy to manufacture and was personally tested by me during the year in different areas of the fronts

Application:
- fixing the types of UAVs, the distance to them, movement. Fixation of departures and movements of attack UAVs of the "Lancet" format. Monitoring of reconnaissance UAV flights in the Ukrainian rear (such activity is almost always a "harbinger" of an attack on rear facilities). Analysis of UAV activity (which is always a factor in the activity of Russian troops)

Implementation:
-monitoring point on a local computer at the reception point -remote monitoring point (receiver in one place, operator in another)

Optional application:
- control of the activity of electronic warfare equipment, control of FPV drones

Implementation option

Before purchasing components and assembling, you need to choose an option

Option 1 (easy, I recommend beginners start with it)

You buy an SDR receiver and connect it to your computer at your place of service. Install SDR# on your computer. Connect the LNA signal amplifier to the receiver. From the amplifier, you "pull" a cable 5-15 meters to the roof, where you put the antenna.

Option 2

You need to "watch" the signals from the "receiver" while being in a different location. To do this, you do everything in the same way as in option 1, but you install a remote control program (for example, TeamViewer) on your computer. You will mount everything in a remote place, and you will control the "receiver" from your computer.

Of course, in order for the receiver to be brought to zero, you need a computer of the smallest possible size, and it is necessary that its power is enough for the SDR# program for Windows. You also need a stable communication channel (Stralink, LTE modem). The computer should not "fall asleep", but always be ready to connect.

For those who are interested, I managed to successfully assemble a remote receiver based on a mini computer of this type.

MOREFINE M6S Mini PC Intel N100/N5105 8G 12G DDR5/DDR4 128GB/...

512GB SSD SATA, N100 DDR5 12G, EU

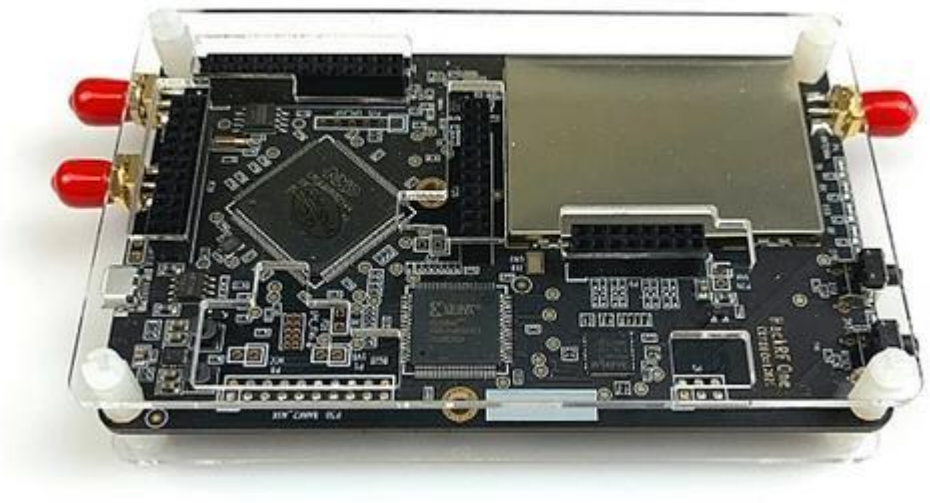
US $185.28 x1

If you are assembling a remote reception point in a building, remember the need for ventilation in this case. In hot weather, the computer and SDR receiver will get very hot.

Components and components

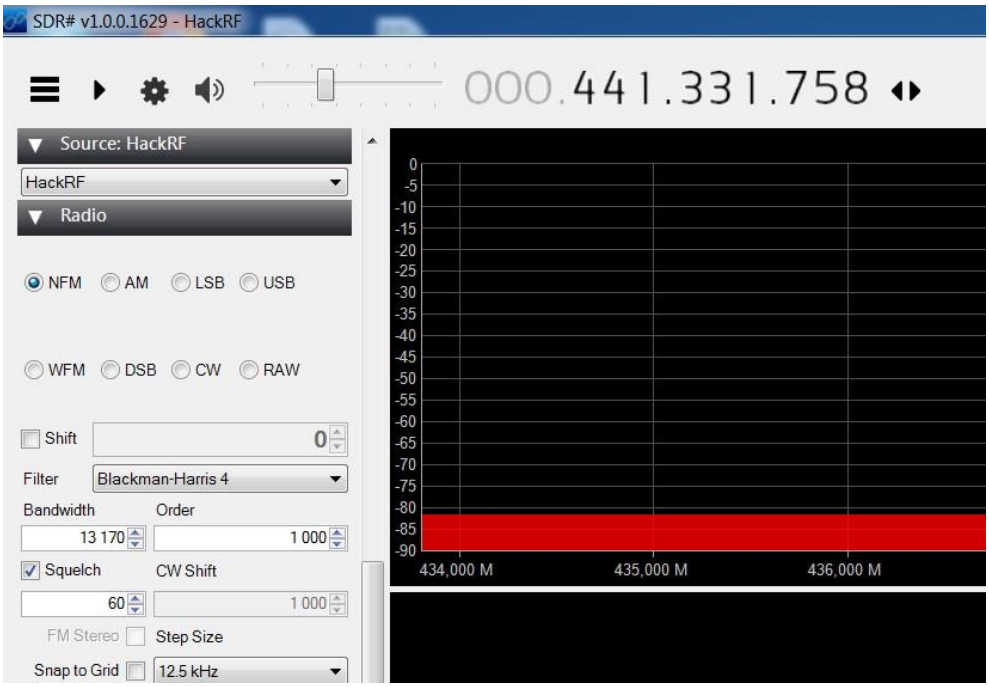
The main system is an SDR receiver.
We will use SDR HackRF, which can be bought in Ukraine (more expensive) or on "Ali" (cheaper than $80)

https://www.aliexpress.com/item/32972753170.html



Software

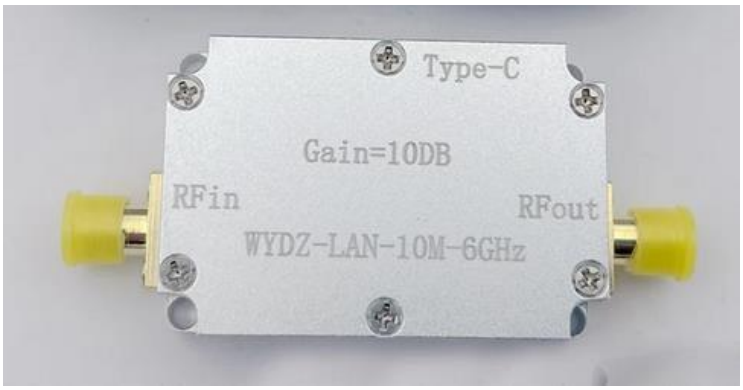
A free SDR# app that you can download from the company's AirSpy website or find elsewhere https://airspy.com/download



Low-noise amplifier

For better receiver sensitivity, I recommend using a low-noise amplifier with a gain of 20dB ($12).

Hatps://vv.alixpress.com/item/1005006431241921.html Do not buy 4050dB, excessive gain will negatively affect the performance of the entire system.



Case

Of course, it will be aesthetically pleasing to collect all the elements in the case (and not on the table), which can be bought on the Internet for 400-500 hryvnia. For example, on Rozetka

Trivia

To connect the amplifier to the receiver, you need a cable (SMA maleSMA male), not everyone knows how to solder it themselves. You can buy it here for a couple of dollars Hatpas://vv.Alixpress.com/Item/2033874631

An adapter for a dollar to switch from SMA to a "thick cable" with an N type connector hatps://vv.alixpress.com/item/4001293689143.html

Remember that the amplifier needs to be connected to power via a TypeC to USB cable

Cable

Frequencies above 800 MHz attenuate strongly in the cable, so the cable from the receiver to the antenna should be as short and better as possible.

I recommend using an RG8 or LMR 400 cable with a length of no more than 10-20 meters. If you need a longer cable, you will have to move the amplifier to the antenna and power it through the cable using BIAS TEE technology. You can buy a cable on OLX or, for example, here https://selteq.com.ua

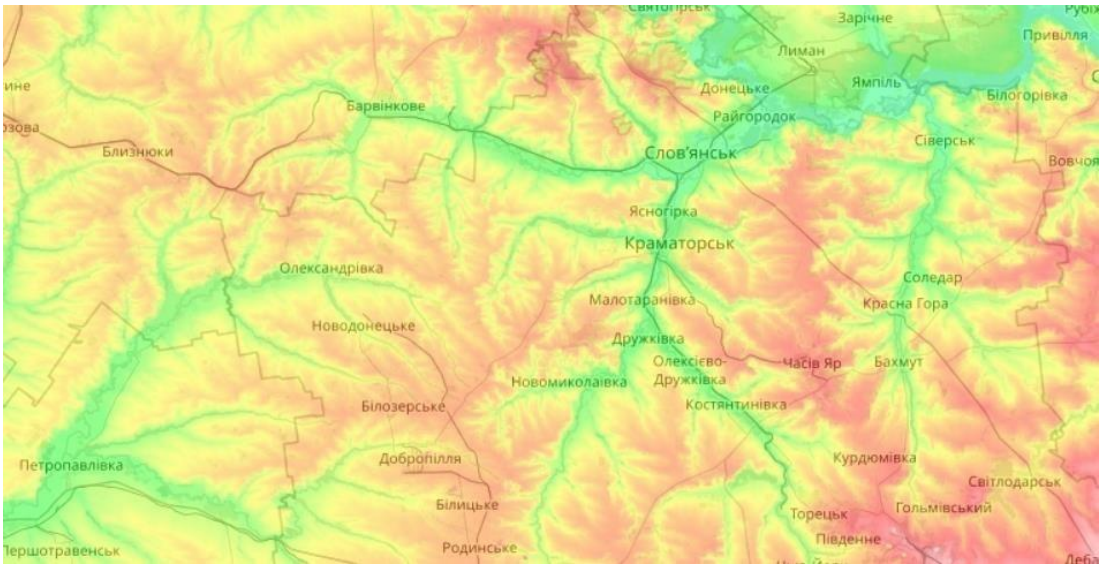
Choosing the Installation Location

Since you will be observing the UAV in the "sky", there is no need to raise the antenna very high. Rather, on the contrary, if you put the antenna high (for example, on an elevator), it will only get worse. You will receive all obstacles from the district and any electronic warfare tens of kilometers away will interfere with you.

When choosing an installation location, the main thing is:

1. Choose a place where the horizon is open towards the enemy. And not closed, for example, by a concrete building.

2. If you want to see a UAV at a distance of 40-50 kilometers, you need to choose the highest possible place on the altitude map (for example, in Kropyva)



When installing the antenna, remember that it is small and will not attract the attention of the enemy from the air. This type of antenna is used everywhere for mobile "amplifiers". The antenna can be spray-painted in green or black.

Remember that the receiver antenna and the receiver itself should be installed as far away from mobile antennas (especially the 900 MHz band). Also, the receiver should not be brought close to electronic warfare equipment and antennas of WIFI transmission systems. Do not place the receiver next to mobile phone amplifiers.

During the operation of the receiver, for example, on the roof of a private house, a soldier who at that moment is using the phone in the yard under the antenna will create obstacles for you.

Attention! The antenna of the SDR receiver does not emit anything and cannot be tracked.

Antenna

For the operation of the reception point, you can choose a directional antenna or a circular one. I usually choose the option with a directional antenna, which I orient in the direction of the enemy.
For on-air monitoring tasks, a cheap logoperiodic antenna from Chinese mobile phone amplifiers is ideal.

You can buy such an antenna on Ali or on olx. This antenna has less gain than a wave channel antenna, but it operates in a wide range of 700-3000 MHz and its radiation pattern is not as narrow. To monitor UAVs, the antenna should be placed vertically.

13 доларів hatps://www.elixpress.com/item/1005006055030100.html

It is also possible to use another type of sector-type directional antenna with the same wide bandwidth, a more open diagram along the horizon, but with less gain.

$9 https://www.aliexpress.com/item/1005003270061203.html

In some situations (for example, if you are right on the front line), it makes no sense to use a directional antenna. You may need an antenna with a circular pattern. This antenna receives the signal from all directions but has low gain. A high-gain circular antenna also exists, but will cost a lot more.

https://www.aliexpress.com/item/32837606167.html $10

If you are going not only to receive UAV signals, but also to try to determine the direction of flight by rotating the antenna around the horizon, then you need a wave channel antenna. For example, this one for $15.
Hatps://vv.Alixpress.com/item/32270674704.html

SDR Program#

The program has many features, and you can devote more than a dozen pages to it. I will write literally the most important things for you.

1. Select the HackRF device on the left in the Source field

2. Click the gear sign at the top left. There will be the receiver's SDR gain settings.

- if you are using an external amplifier, uncheck the Amp box

- Select the Sample rate of 20 MSPS so that the viewband is a maximum of 20 MHz.

- It is better to set VGA gain a little higher than the minimum

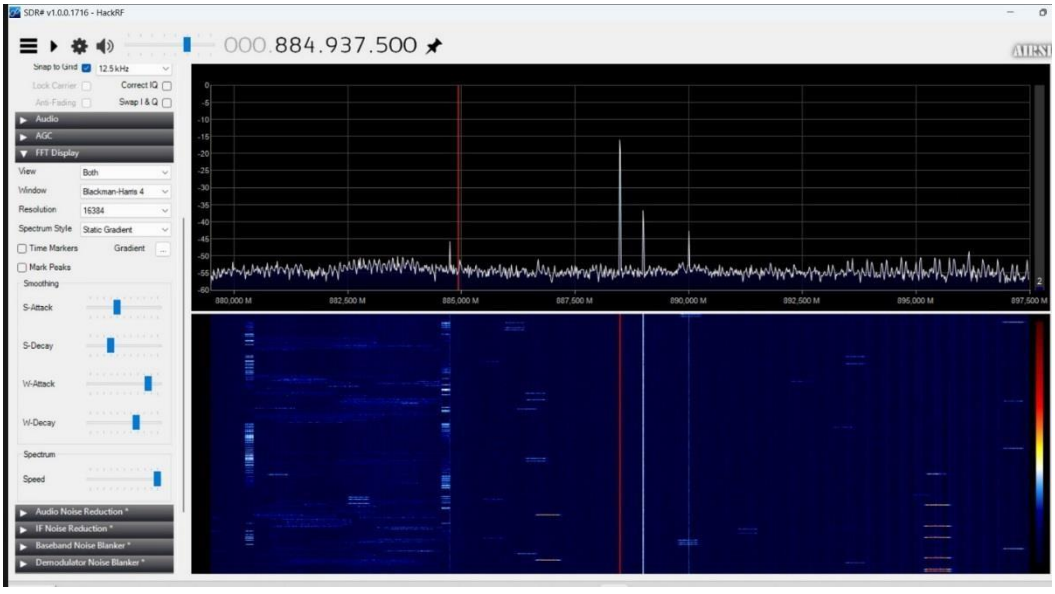
- LNA gain can be set from average to maximum. This is the amplification of the signal in the receiver's input stage.

3. On the top right, the Zoom knob adjusts the receive band. First, hold it in the down position to watch the maximum 20MHz band.

4. Use the Range knob to adjust the visibility of the noise level at the bottom of the screen

5. Use the Contrast knob to adjust the visibility of signals against a contrasting background

As a result, you should observe clear signals in the background.



6. You can adjust the speed of the blue screen here: left side of the screen, FFT display, Speed control. To begin with, put it as far to the right as possible so that the blue screen moves quickly.

Signals and types of UAVs

Any UAV can emit telemetry (control) signals and video transmission signals. The video signal is always wide and has a width of 410 MHz.

All Russian reconnaissance and strike UAVs transmit telemetry in the following bands.

860-870MHz

902-928 MHz

960-1020 MHz

Video signals from the UAV are transmitted in the following areas

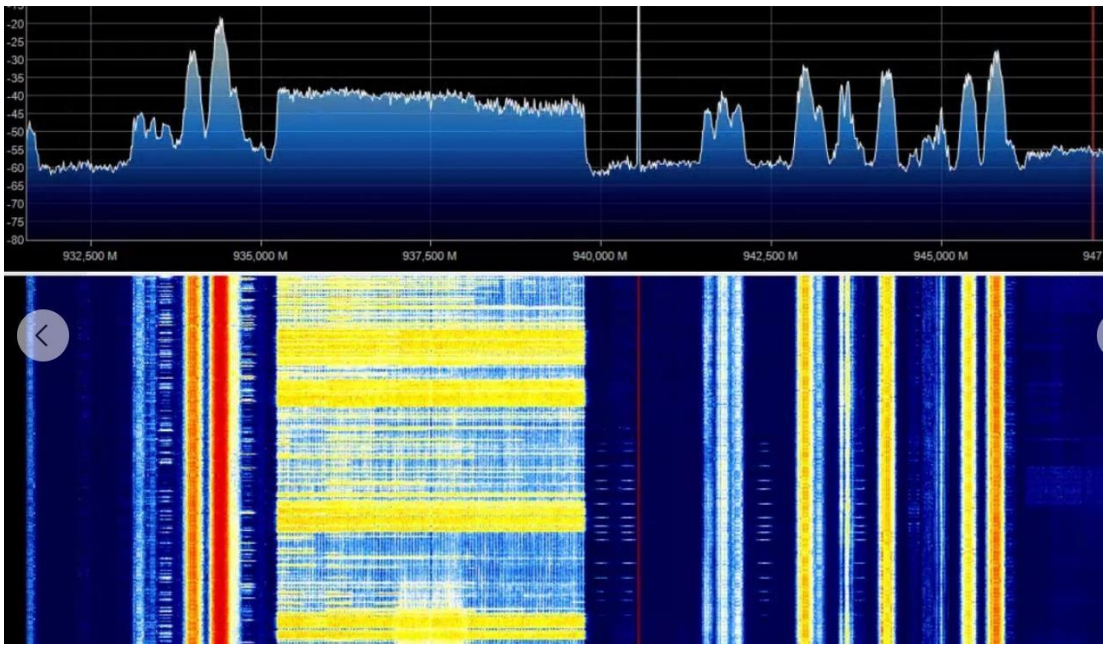
2.2-2.6 GHz

1.3 GHz

90% of Russian UAVs in all directions are Orlan, Supercam, Zala, Lancet

The first thing you need to know is that mobile base stations operate at 930-960 MHz frequencies in Ukraine. The signals from them are powerful and are observed everywhere. And of course, all beginners confuse them with UAVs. By the way, the same band is used for mobile communications in the Russian Federation, so neither Russian nor Russian UAVs (including FPVs) "fly" at frequencies of 928960 MHz.

Here's what cell phone signals look like. A wide signal is LTE.



Zala, Lancet

Both UAVs are produced at the same plant and have the same radio modules, so it is impossible to distinguish them by signal.

The signal from Zala, Lancet is unique and easy to recognize. Two vertical bars of dots on a blue background of the spectrum (waterfall). The dots go very close, between them 150-200 kHz. On the spectrogram at the top of the screen, it looks like two bursts side by side.

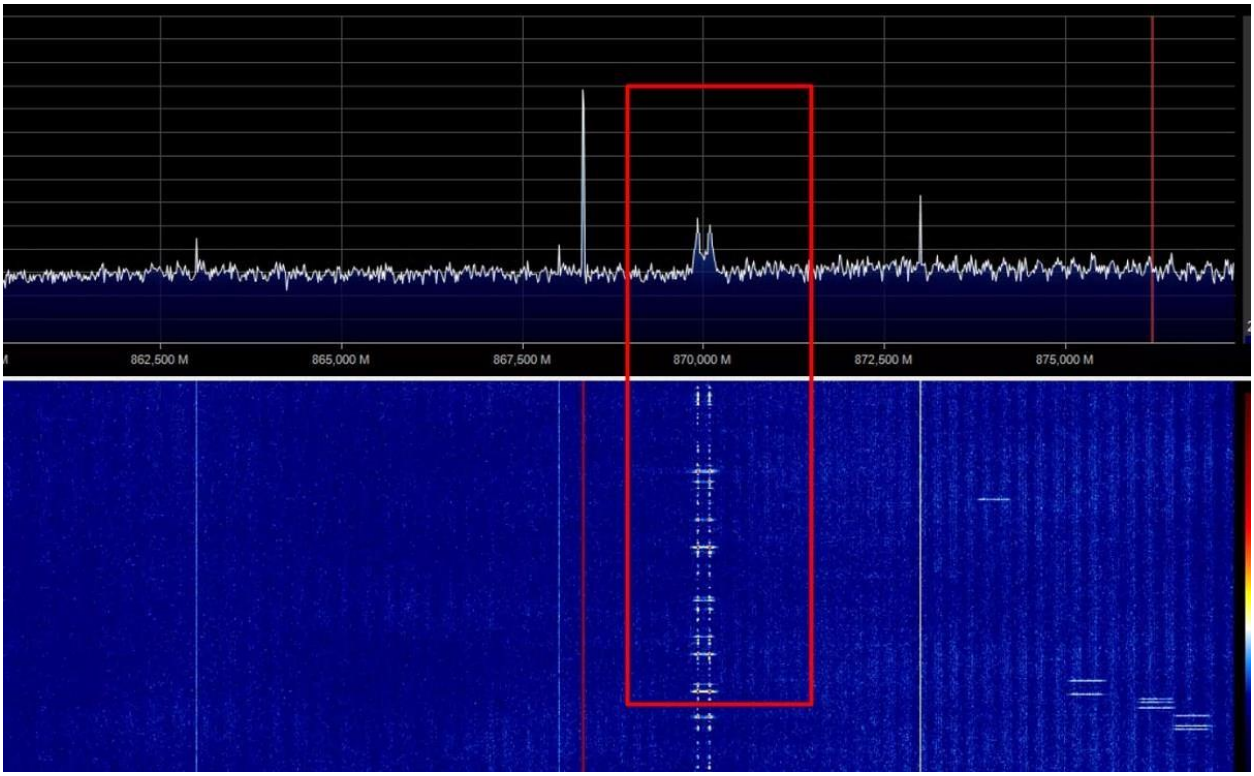
The signal is observed at frequencies of 868 MHz, 870 MHz, 915 MHz. Very rarely in my practice there have been cases of observation of a signal of other frequencies in the region of 902-920 MHz.

My observations:

The Lancet is more often at 868 MHz

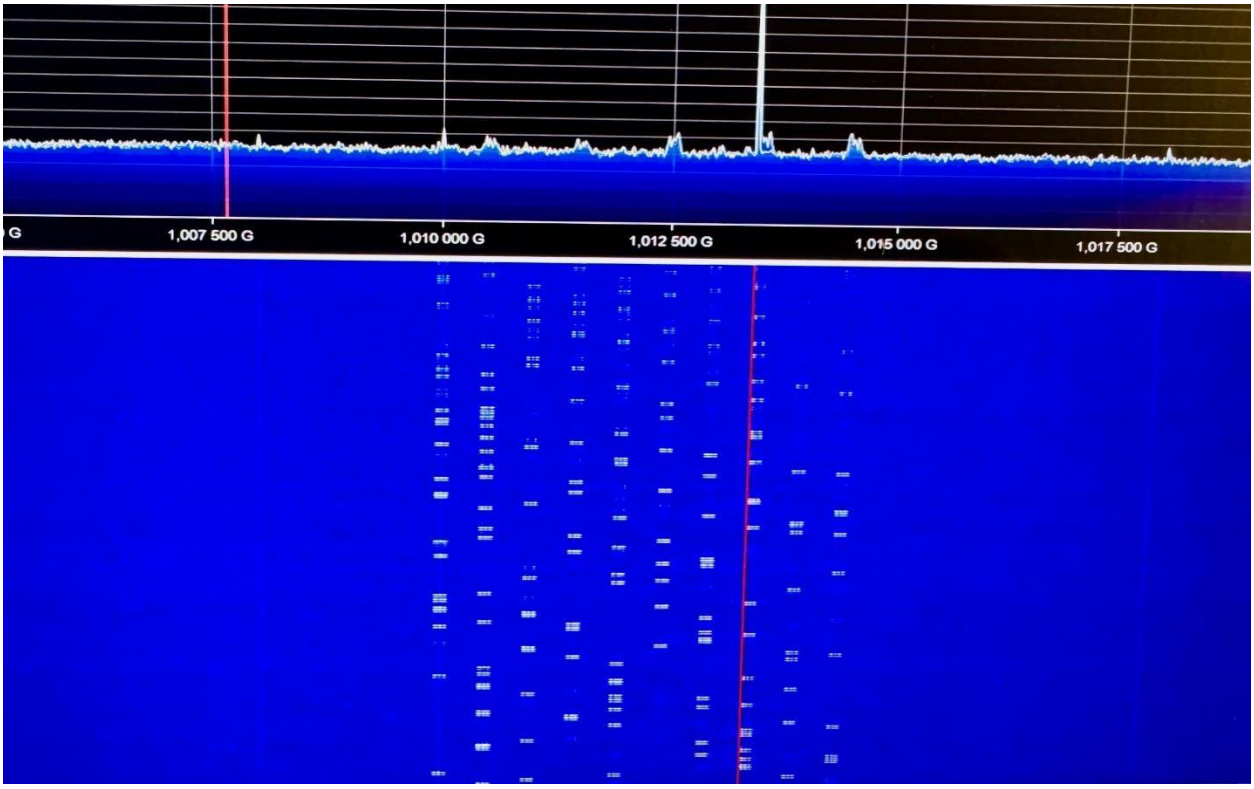
The Lancet doesn't fly for more than 40 minutes (if more, it's definitely Zala)

If you see a stable signal strength, this Zala "circles" in one position. The lancet flies in a straight line towards you or to the side and the signal from it usually rises or falls linearly.



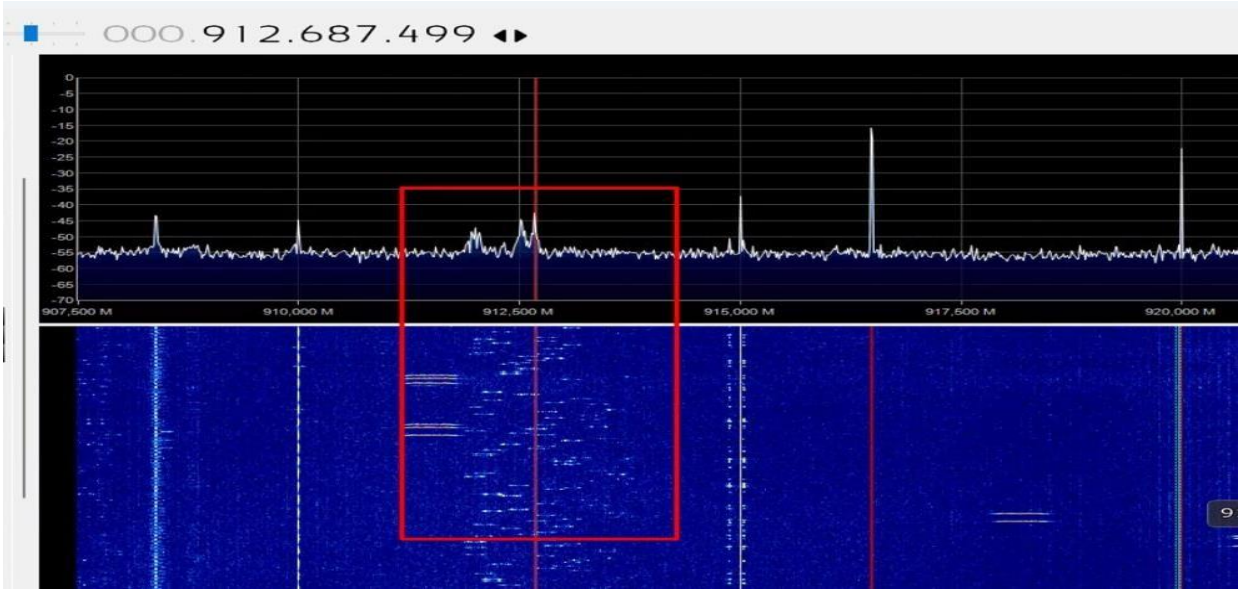
Superkam

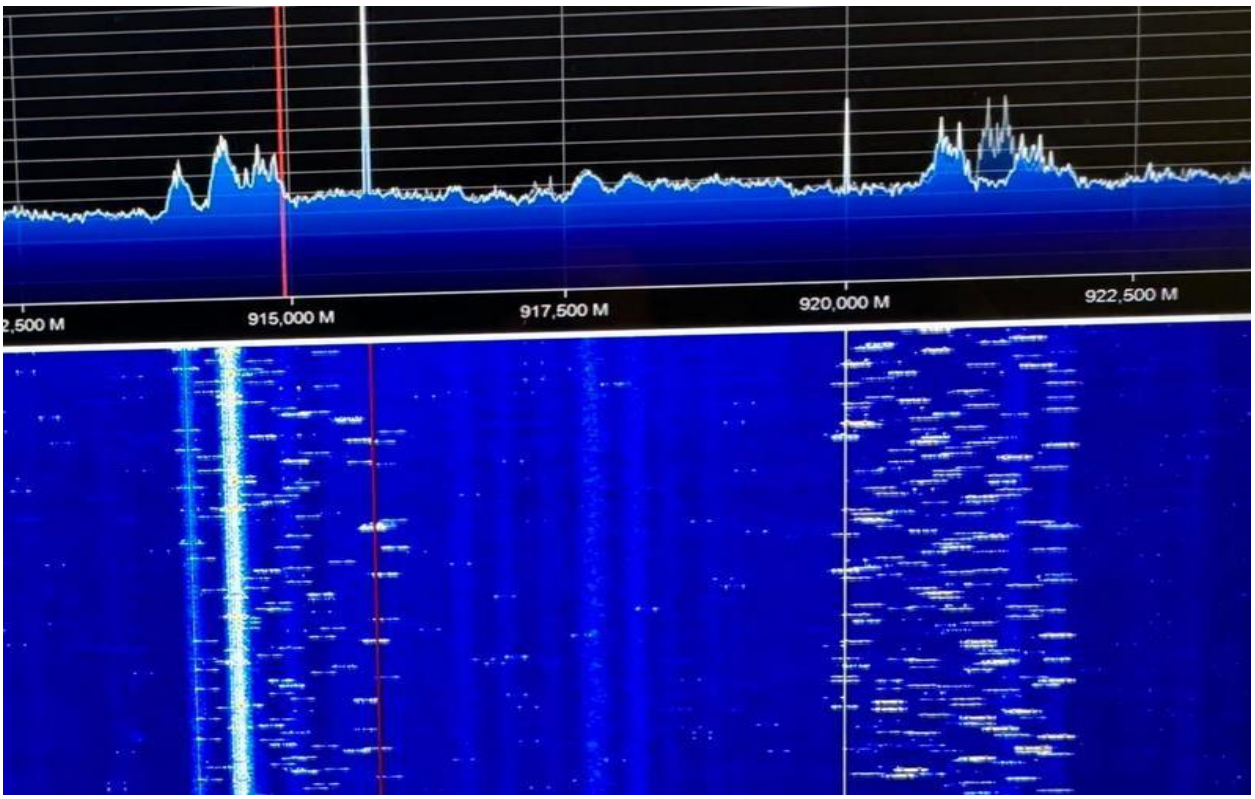
The signal looks like 10 vertical bars of dashes with a total width of 5 MHz Each strip is 150 kHz wide. The signal can be observed in the range of 856-1020 MHz.



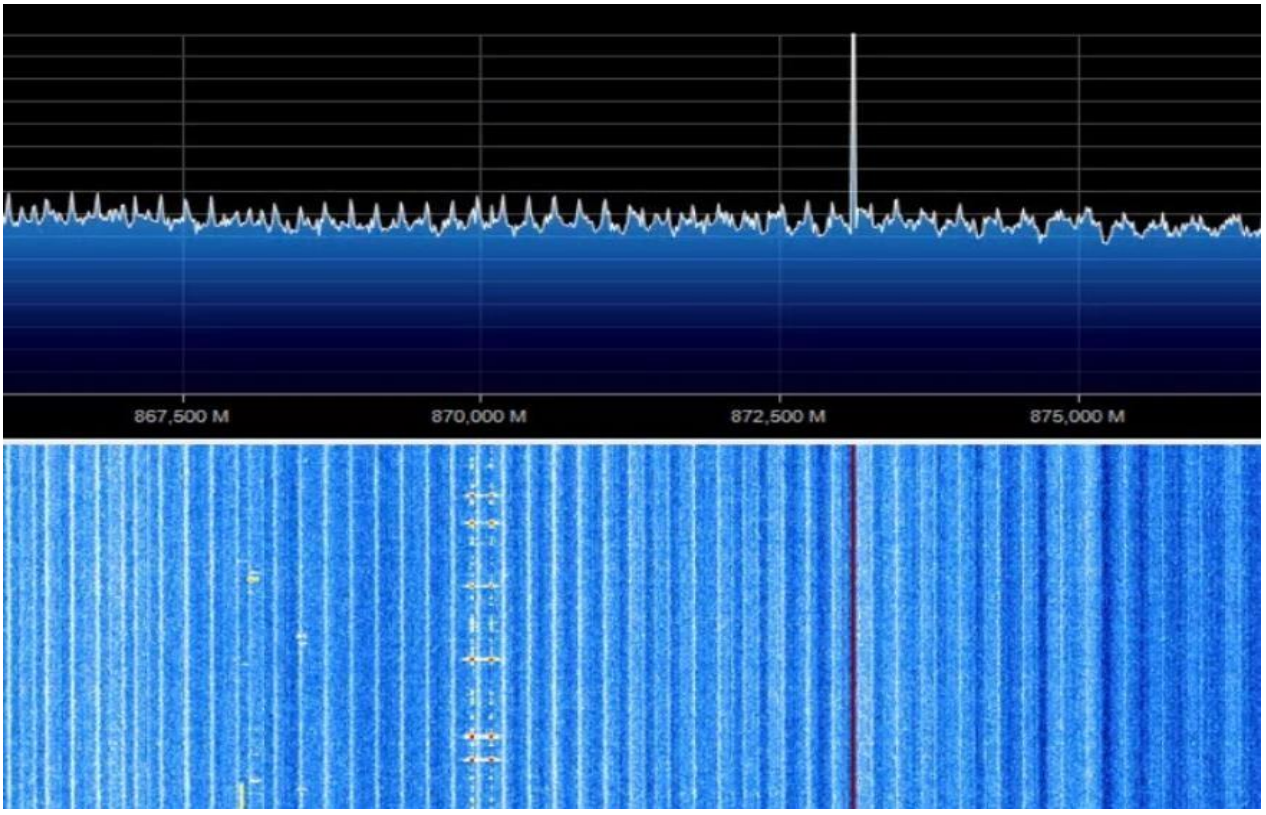
Orlan

Old versions "fly" in the range of 902-928 MHz, new ones can be found in the range of 960-1020 MHz. The eagle transmits a 2 or 4 MHz UHF signal. The ORLAN signal looks like a chaotic set of horizontal lines.





If electronic warfare is operating at the frequencies of the UAV, it will look like this on the spectrogram

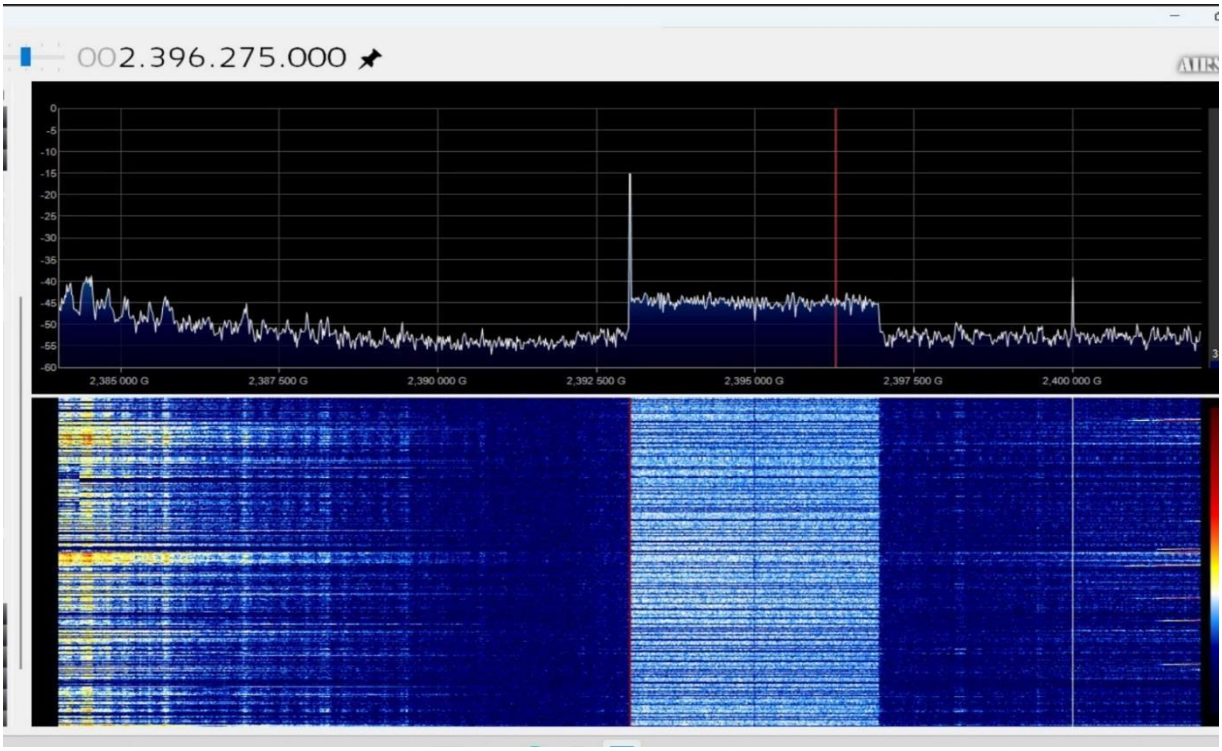


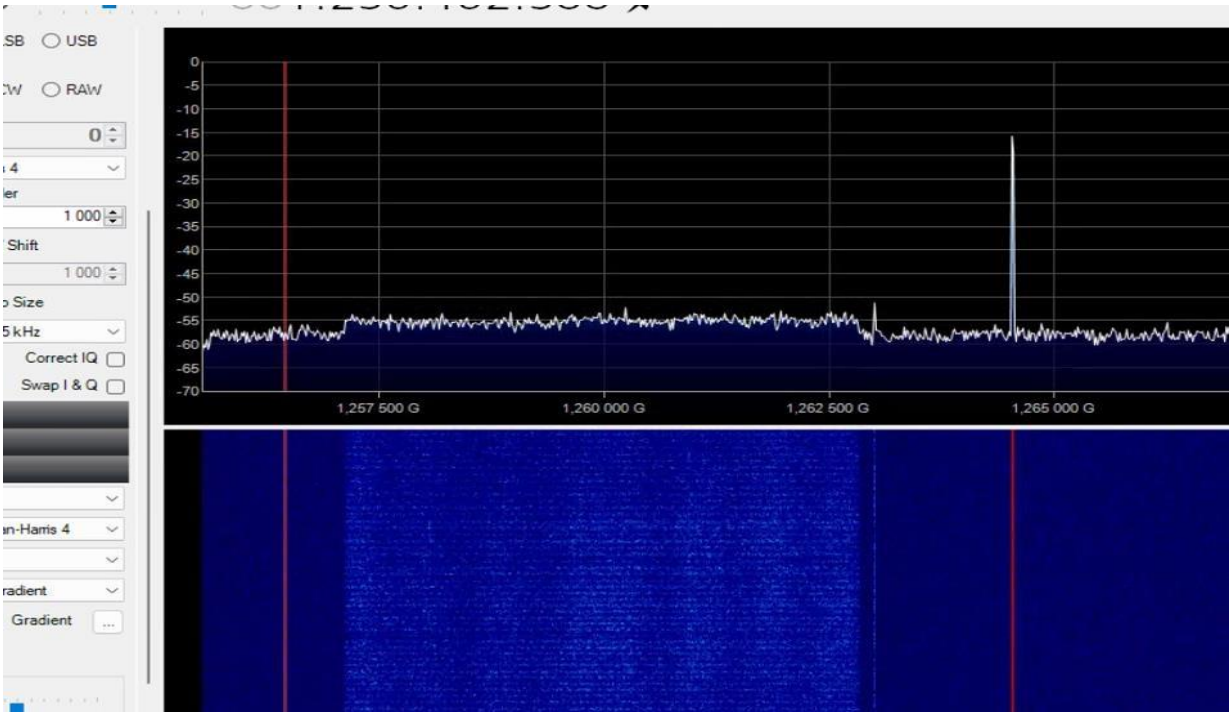
Video Signals

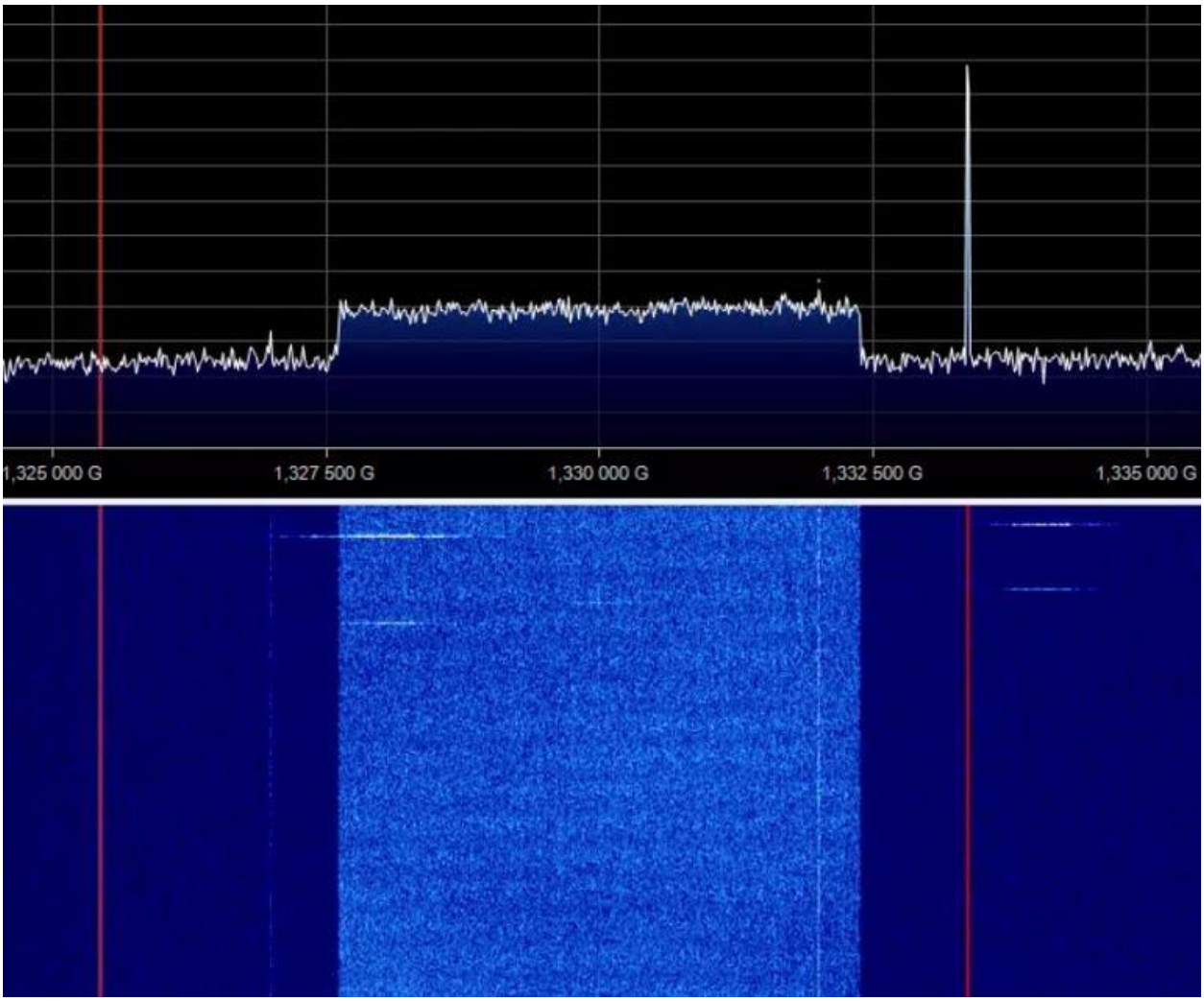
Any reconnaissance UAV can broadcast a real-time picture for reconnaissance or fire adjustment.

Any video signal has a distinctive appearance. This is a wide shelf on the spectrogram and a white stripe on the waterfall. The line width can be from 3 to 10 MHz.

If the video signal from FPV is analog and open, then winged UAVs encrypt the video transmission channel.







UAV designers can change the video transmission modules and the frequencies will also change, but for the "base" I will give information on video channels

2.2-2.6 ГГц

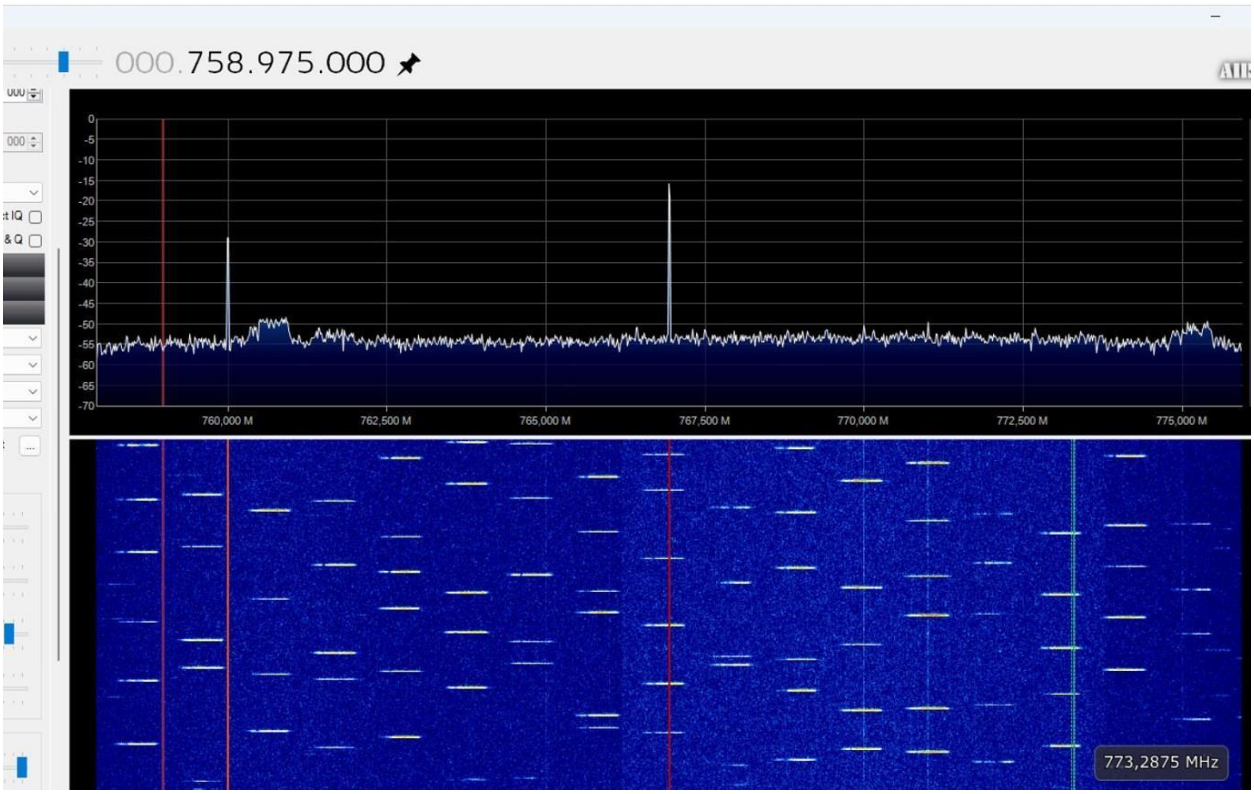
Supercam 1.3ГГц

Yeleron 1.2GHz

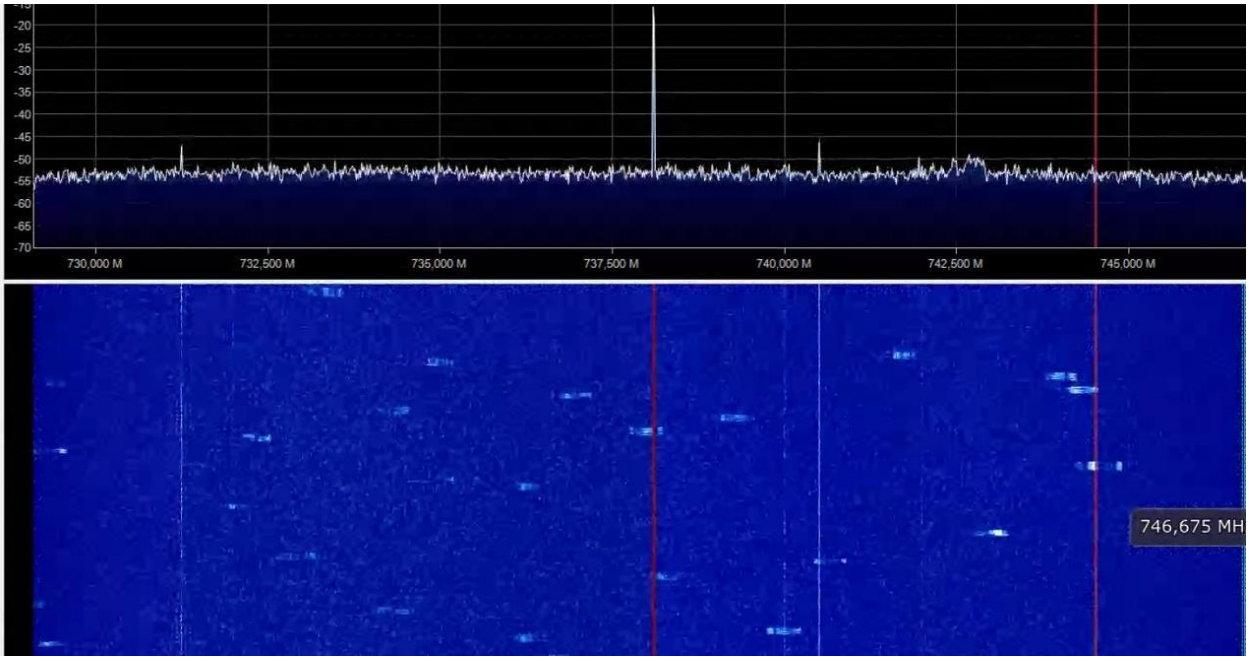
Orlan 2.2-2.5GHz

FPV

Almost all FPV drone pilots turn off telemetry, so the drone flies without emitting anything other than video. But for a general understanding, the signal looks like this. The IFRF, which is stretched much wider than winged UAVs along the 30-40 MHz band and can be found in the 700-1020 MHz area



This is what the signal from FPV looks like at 720-760 MHz (presumably the Hermes module)

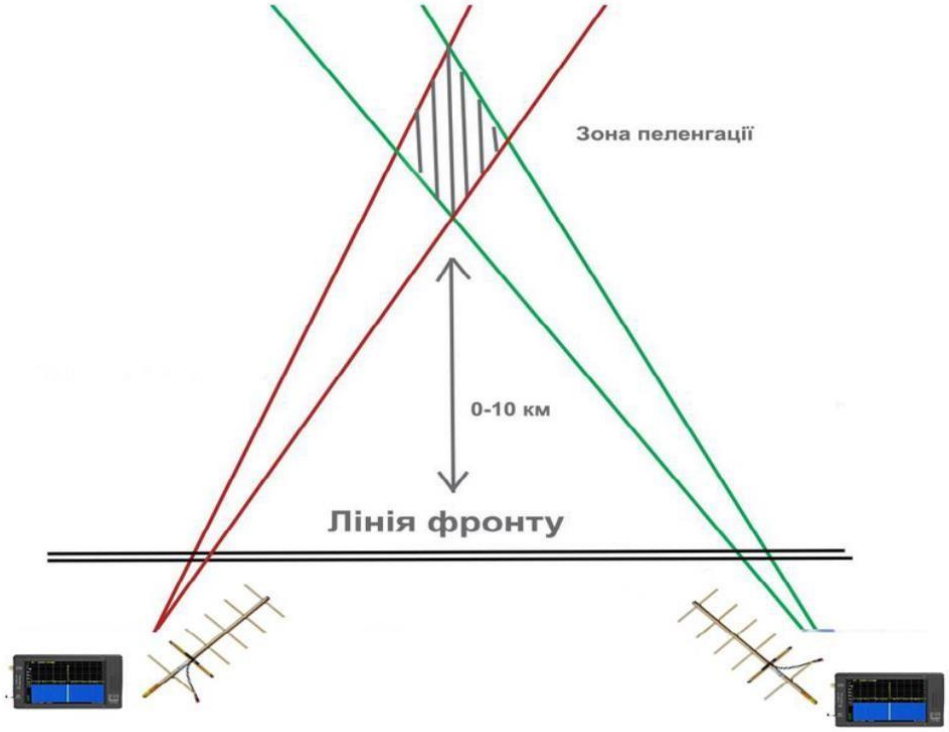


4. Direction finding of signal sources

Direction finding of an interference source or signal can be carried out by the classical triangulation method. To do this, you need to adjust the SDR to the desired range and by rotating the directional antenna in a circle, choose the direction with the strongest signal. Mark the bearing (azimuth) on the map or in Nettle.

Repeat the same process at another point, driving a few kilometers. The intersection of the two bearings will give you the location of the object. It is also better to take not two, but three bearings to increase accuracy.

For direction finding accuracy, you need an antenna with a narrow radiation pattern. A wave channel antenna (Yagi) is well suited for this. Of course, the accuracy of direction finding will be low (compared to Plastun or TCI direction finders), but it is quite sufficient to determine the approximate zone of the signal source. Direction finding should be carried out at a distance of several meters from large metal or reinforced concrete objects.



5. Determining the distance to the target
You can determine the distance to the signal source by the signal strength. This will only be an approximate understanding of the distance.

The signal strength will be affected by the type of antenna, the presence of a cable between the antenna and the instrument, the gain of the low-noise amplifier, the reception location, and the power of the transmitter. Therefore, in fact, you will be able to understand the distance from your experience after some time, but only approximately.
-When the signal is barely noticeable on the waterfall, then the level is very weak and the source is far away.
-When the signal became clear, the distance to the object decreased.
-When the signal on the waterfall is yellow or red, then the level is very strong. At the same time, the peaks of bursts go off scale in full screen. This means that the source is literally within a kilometer from you.

These ratios of signal levels and distances are different for different purposes. It's one thing for the Mavics, it's another for the Eagles. Therefore, only personal experience will help you here.