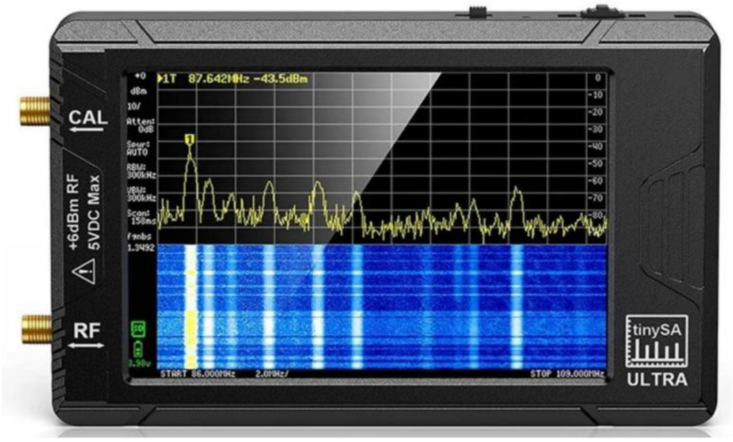
By order of the Ground Forces Training Command

Attitude

Practical application of the spectrum analyzer "TINY SA ULTRA" for combat missions



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Document content:

1. General information

The Tiny Sa Ultra spectrum analyzer (further referred to as the device) is a portable spectrum analyzer with a built-in battery that allows you to receive and examine radio signals in the frequency range up to 6 GHz.

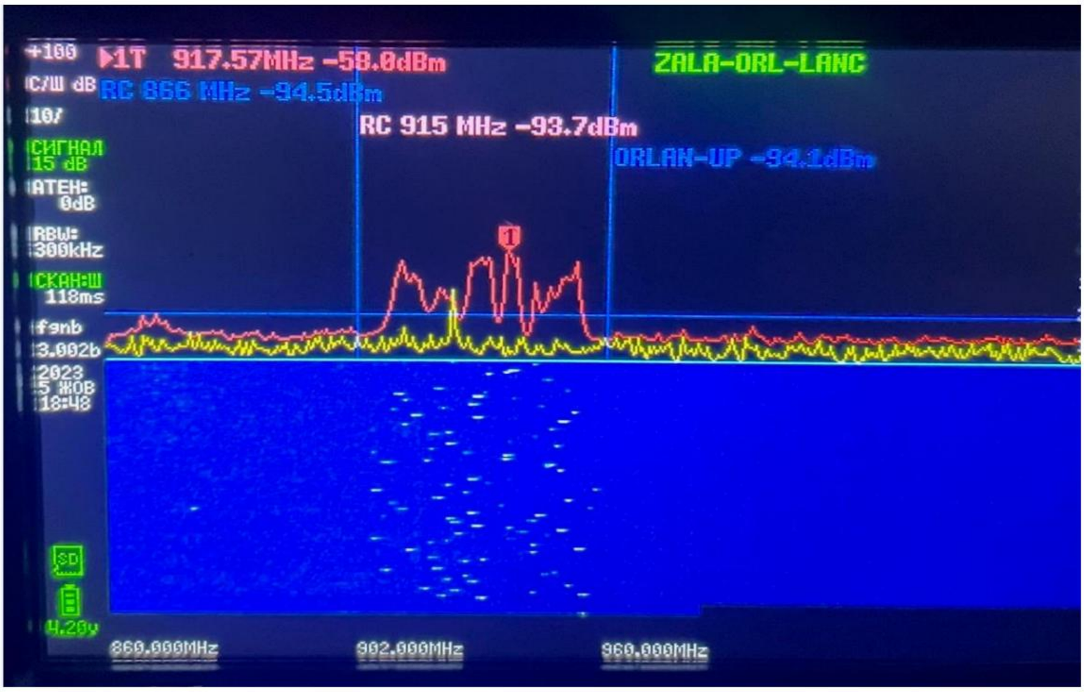
The device has many settings, but the general logic of working with it is simple: the vertical axis displays the signal level in decibels, and the horizontal frequency range.

Therefore, any signal will be displayed in "splashes" on the yellow line screen. The red line has been added to show the maximum "spike" values.

Since signals can appear and disappear very quickly (and modern digital signals are generally difficult to track by "bursts"), the device implements a solution called a "waterfall". Under the yellow line on a blue background, you can see signals "expanded in time" that the device caught, but you did not have time to notice with your eyes.

"Waterfall" is a downward-creeping tape on which signal marks are placed. You are familiar with this principle from the device that makes a cardiogram.

The stronger the signal, the higher the yellow splashes will be, and the dots on the waterfall will be bolder and change color to red.



Note: This guide can also be used to work with any SDR receivers and spectrum analyzers that have similar characteristics.

2. Recommendations for working with the device

The device is passive, does not emit anything, and is not fixed by the enemy's PEP.

1. For more convenient and simple use of the device, a special Ukrainian-language firmware with a full set of ready-made ranges and settings should be installed on it. The firmware and installation and configuration instructions can be obtained from the author at www.facebook.com/bkmit Please note that the author has protected the firmware from the enemy and you will need to give the author the serial number of your device and then enter the activation code into the device after installing the firmware.

2. A fully charged device works from the built-in battery for about 2 hours, for longer operation it should be connected via a "type C" wire to an external power source. Charging time of the built-in battery is 1 hour.

3. The device has a built-in signal amplifier (LNA, Ukrainian MSHP), if you use an external amplifier, then the internal one must be turned off,
by removing the check mark in the menu.

4. It is recommended to use an external amplifier with a gain of 20-30 dB. Be sure to pay attention to the range of the amplifier. If the 5.8 GHz band is important to you, then an external amplifier is a must. With an internal amplifier at 5.8 GHz, the device does not work well.

Signal amplifier

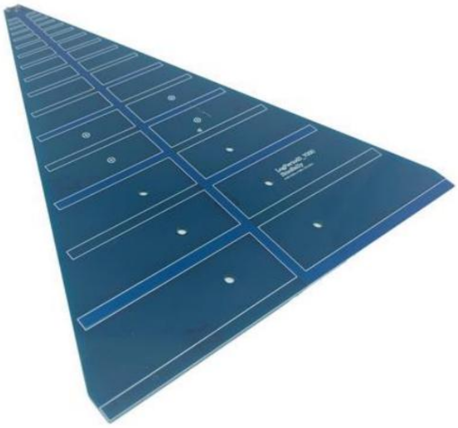
5. The device reflects very strongly in the sun, be sure to use protective visors and matte films as a protection option.

6. Do not bring the device closer than 3 meters to anti-drone guns and do not point the antenna directly at them.

7. Any antennas and feeders with a resistance of 50 Ohm can be connected to the device through a standard SMA connector. To locate signal sources and amplify weak signals, you need directional antennas (for example, a wave channel) that are tuned to the desired range. For example, 900 MHz antennas from mobile signal amplifiers are suitable for receiving Russian UAV and FPV signals. Directional antennas from WiFi are suitable for receiving drone signals at 2.4 GHz and 5.8 GHz.

Directional antenna wave channel

8. The well-known logoperiodic "triangle" antenna is a compromise. It works on all ranges, but has a weak gain and does not allow accurate direction finding of objects.



9. On Youtube you will find many video lessons on using the device.

10. Example of connection option Analyzer + Amplifier + Power bank + 2.4GHz antenna

11. Antennas of transmitters have a certain polarization. Therefore, when receiving signals by turning the antenna around the axis horizontally or vertically, you can achieve a significant improvement in the reception signal. You must first work with the antenna in a vertical position.

3. Practical combat application

The Tiiny SA Ultra portable spectrum analyzer can be used for the following areas of military activity:

A. Checking the frequency ranges for the presence of interference or the presence of EW activity (both own and others)

- by satellite navigation signals (suppression of GPS Starlink module)

- by communication frequencies and reception frequencies of UHF repeaters and VHF

- UAV control channels

- channels for receiving video signals from UAVs

B. Fixation and identification of winged reconnaissance UAVs with the possibility of their bearing

V. Fixation and identification of winged attack UAVs with the possibility of their bearing (Lancet, Zala)

G. Fixation with the possibility of direction finding of quadcopters, FPV drones, DJI, AUTEL

D. Fixation with the possibility of direction finding of WiFi points at enemy positions

E. Direction finding of signal sources by the method of triangulation

- satellite navigation signals

- communication frequencies and reception frequencies of UHF and VHF repeaters

- UAV control channels

- channels for receiving video signals from UAVs

3.1 Checking the frequency ranges for interference or the presence of EW activity

Checking the frequency range for the presence of interference or the presence of EW activity (both own and others) on communication frequencies and receiving frequencies of UHF and VHF repeaters

The adversary can set active interference in the 136-174 MHz and 420-470 MHz bands in order to interfere with radio communication. Since we use the digital form of communication of the DMR standard, we cannot recognize the presence of such interference without spectrum analysis. In analog communication, such activity could be recognized in the form of amplified noises and extraneous sounds. In digital format, we won't hear noises, but communication distances will be greatly reduced. Constant control of the ether will help us to record the enemy's EW activity and change the frequencies to spare ones in a timely manner.

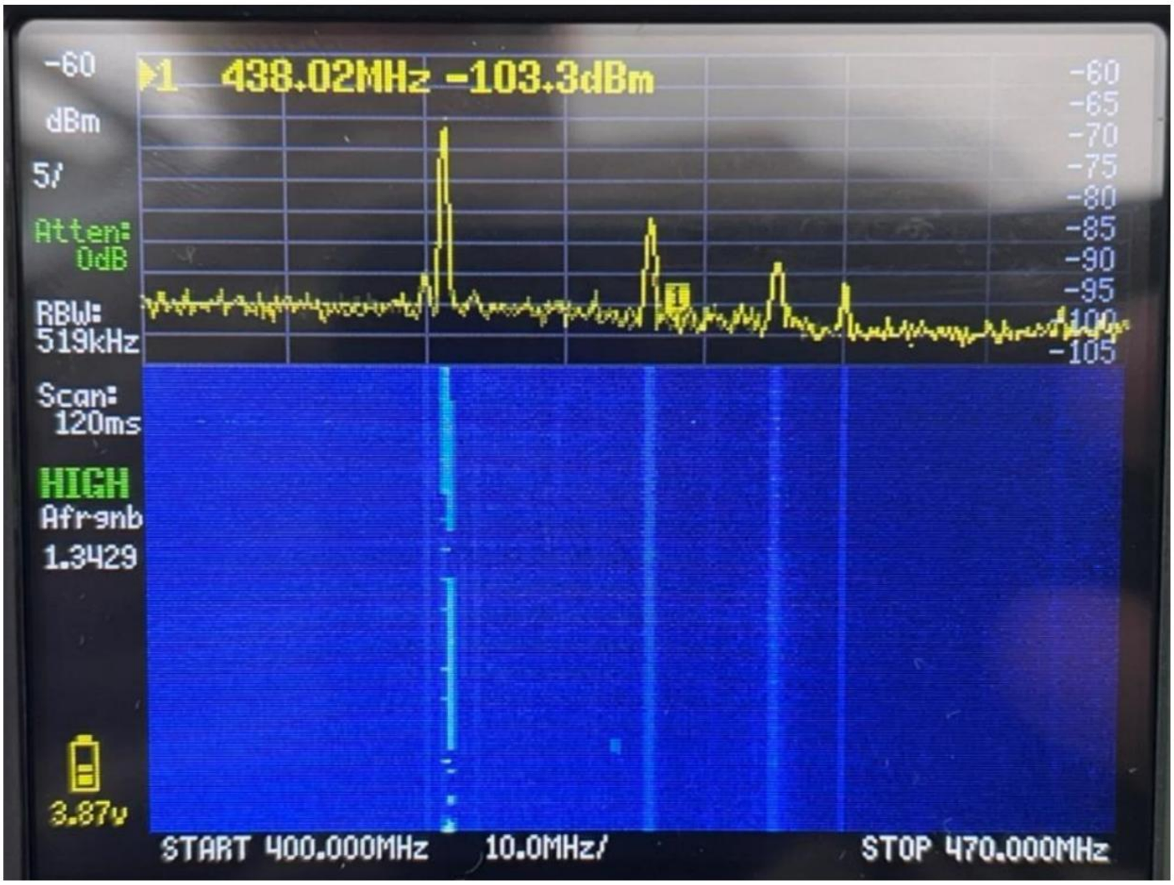
More difficult is the situation with the formation of interference by the enemy on the reception (input frequencies of the radio repeater). This will lead to the fact that the repeater will not hear distant stations, and possibly nearby ones. Without spectrum analysis, it will be difficult to quickly determine the cause.

Spectrum analysis also allows communicators to select the cleanest receiving frequency. Because on the active fronts, the airwaves are densely loaded, and you may be disturbed by the transmitters of neighboring units.

Application

It is necessary to set the desired range and find your frequency by turning the wheel and make sure that there are no obstacles on it. If there is an obstacle, it is necessary to change the frequency. It often happens that in the VHF and UHF range, powerful sources of interference (for example, the P-18 radar) periodically operate, which will not allow you to organize normal communication on a specific section of the front and you will have to select frequencies. That is, it is not enough to look at the frequency once, it should be monitored over time.

Example: state of the air in the UHF band. Obstacles and busyness are immediately visible
frequency



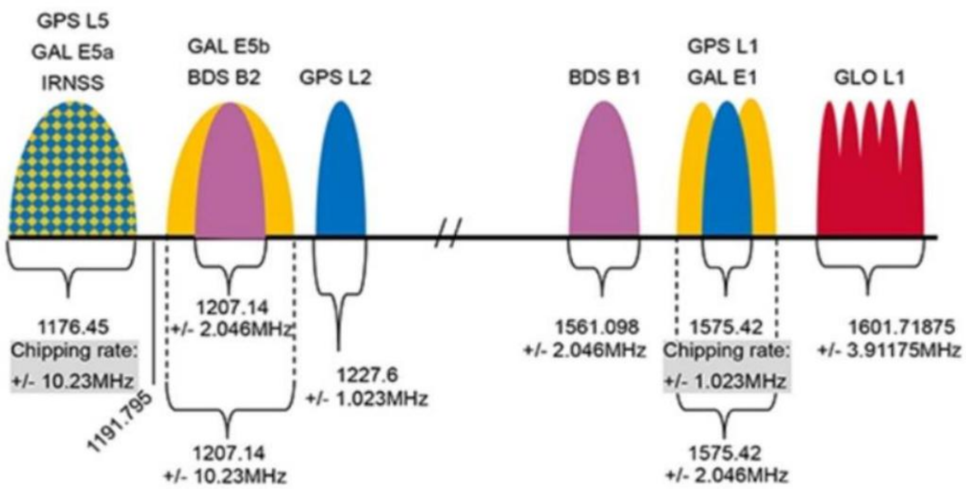
Example: state of the air in the UHF band.

Antennas

You can use any VHF or UHF antennas. To check the repeater reception frequency, the device must be connected to the repeater antenna cable through an adapter.

3.2 Checking frequency bands for interference or activity of EW (both own and others) based on satellite navigation signals

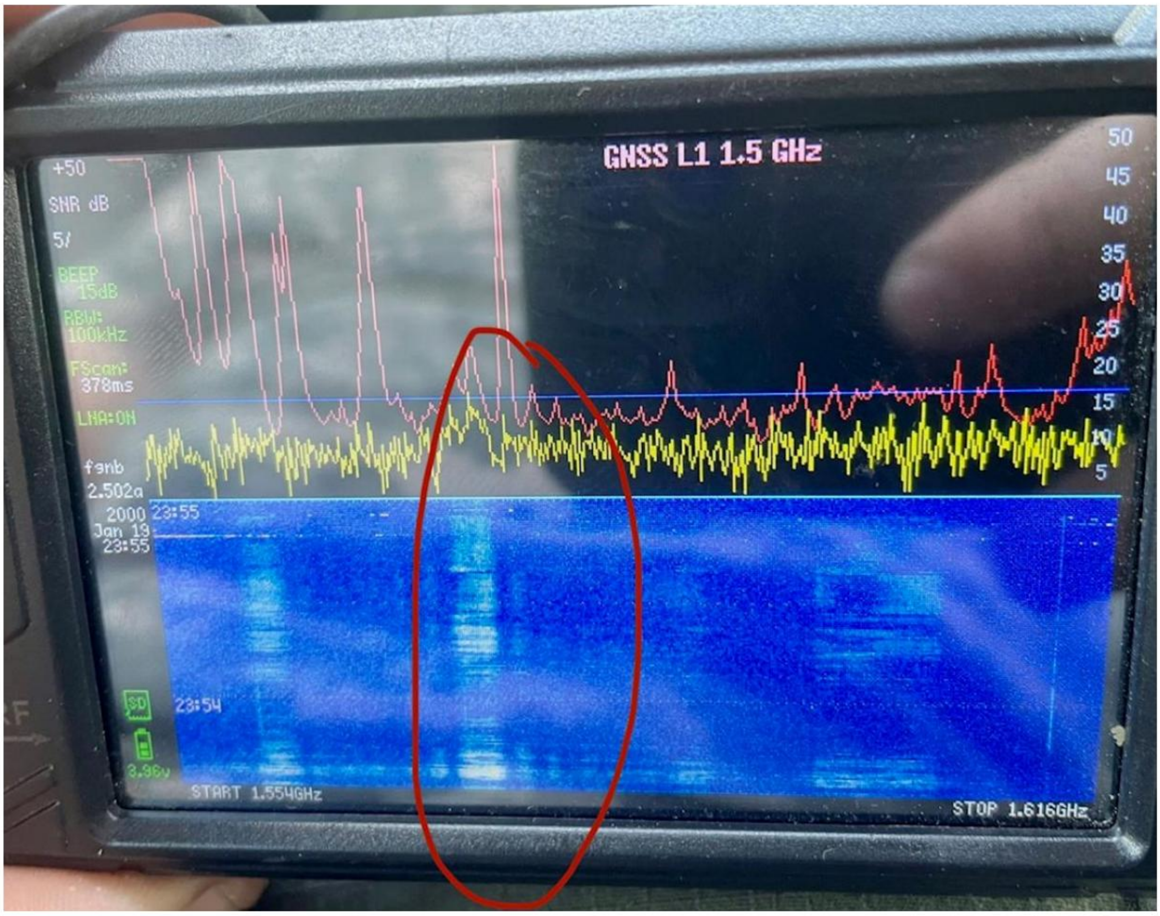
If you need to understand whether EW suppresses satellite navigation frequencies in your area, you need to "look" at the following frequencies:



Frequencies: GPS L1 1575 MHz GPS L2 1227 MHz GPS L5 1176 MHz GLONASS L1 1602 MHz GLONASS L2 1245 MHz

Example: EW on GPS and GLONASS navigation frequencies 1.54-1.64GHz

Example: EW on navigation frequencies



It should be taken into account that on the ground you will most likely not see an obstacle and you need to check the air at least 10 meters above ground level.

If right on the ground you see EW signals on navigation frequencies, this is it means that

- The RF electronic surveillance system is located somewhere nearby, most likely on a hill or on a building or on a mobile phone tower
- You will not be able to take off on a drone that is not prepared
- Your Starlink will not work well (in the Starlink menu, you need to select synchronization with your satellites)
- You can use the device to find a place with the minimum signal level from the EW

Application

Set the frequency range in which satellite navigation works on the device. Check for interference on navigation frequencies. You can also use the device to find a place with a minimum signal level from the EW

Antennas

A log-periodic antenna or a Vivaldi antenna can be used

3.3 Checking the frequency ranges for the presence of interference or the presence of EW activity (both own and others) on the channels UAV control and video signal reception channels

Before take-off, the UAV pilot must ensure that there is no EW operating near the take-off point, which jams control, telemetry and video channels. Otherwise, the UAV will fly some distance and its signal will be lost. It happens that our Ukrainian Internet of Things works.

Application

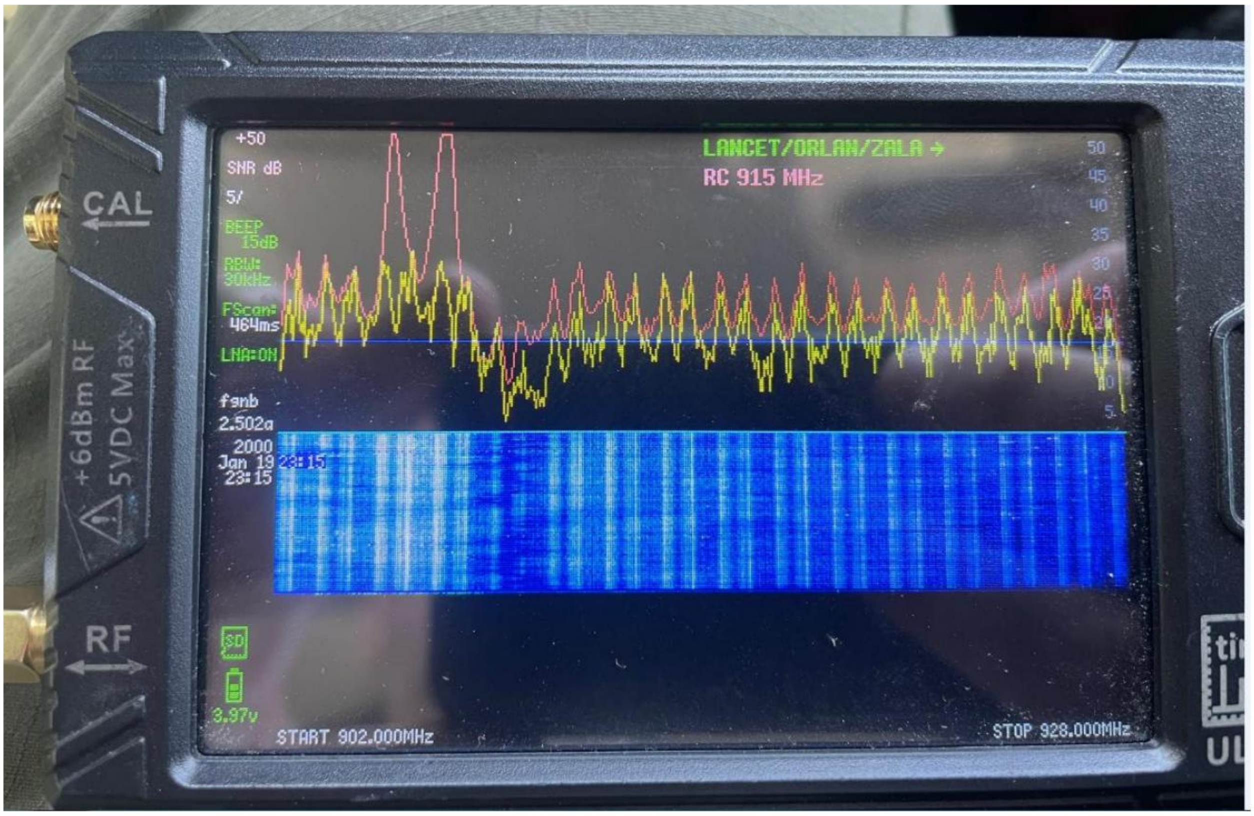
You need to know the frequency range in which your UAV operates (if it is a wing) and look at it on a spectrum analyzer. You will immediately see if there are signs of WB operation on the air. In practice, our EW usually uses the 900 MHz range (in addition to the RF UAVs, our FPVs and part of our wings fly there). Also, EW can press the 2.4 GHz, 5.8 GHz range, on which DJI flies, and the 5.8 GHz range, on which the video signal is transmitted from FPV.

The second part of the problem is the overloading of the 5.8 GHz band, which is bad for receiving video from FPV drones. Hundreds of drones fly around you, which you do not see, but they create an obstacle for your receiver. Look at the range and if there is interference on 5.8 GHz, choose a channel on which there is no interference.

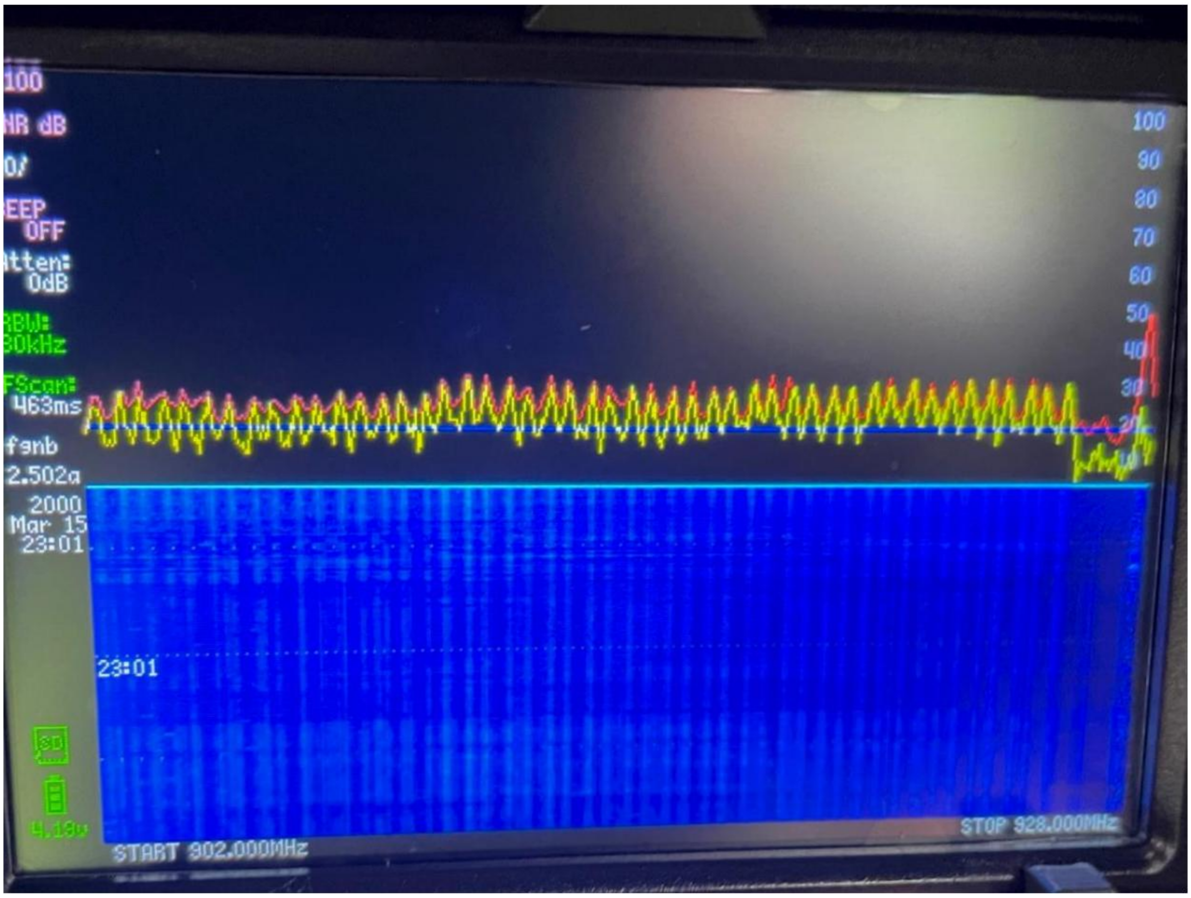
Antennas

You can use both a universal antenna and an antenna tuned to a specific range

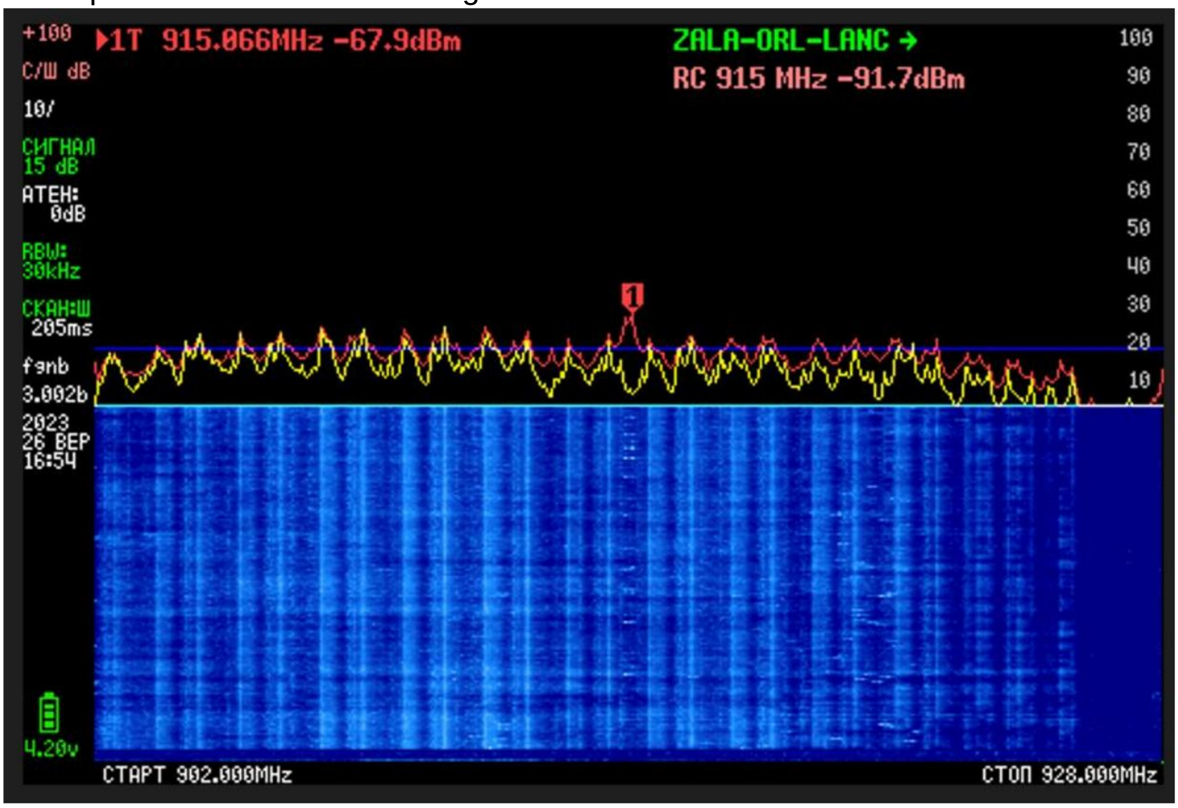
Example: REB for the entire range of 900-928MHz



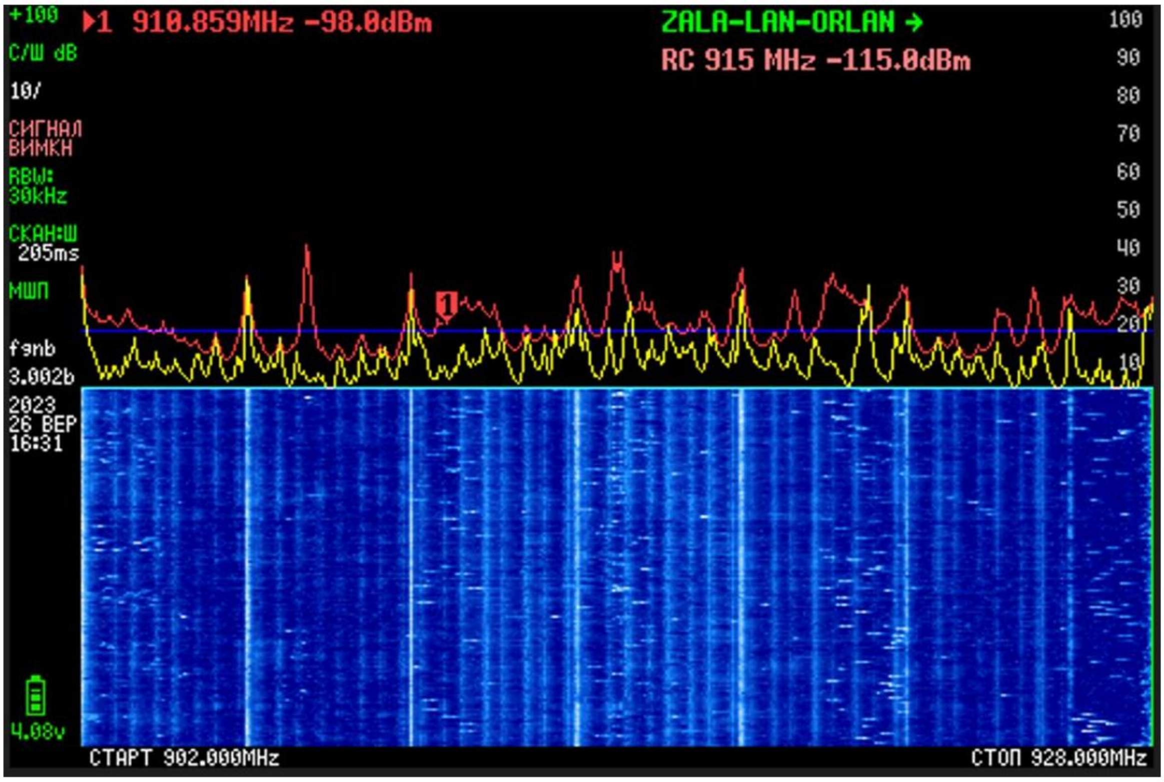
Example: REB for the entire range of 900-928MHz



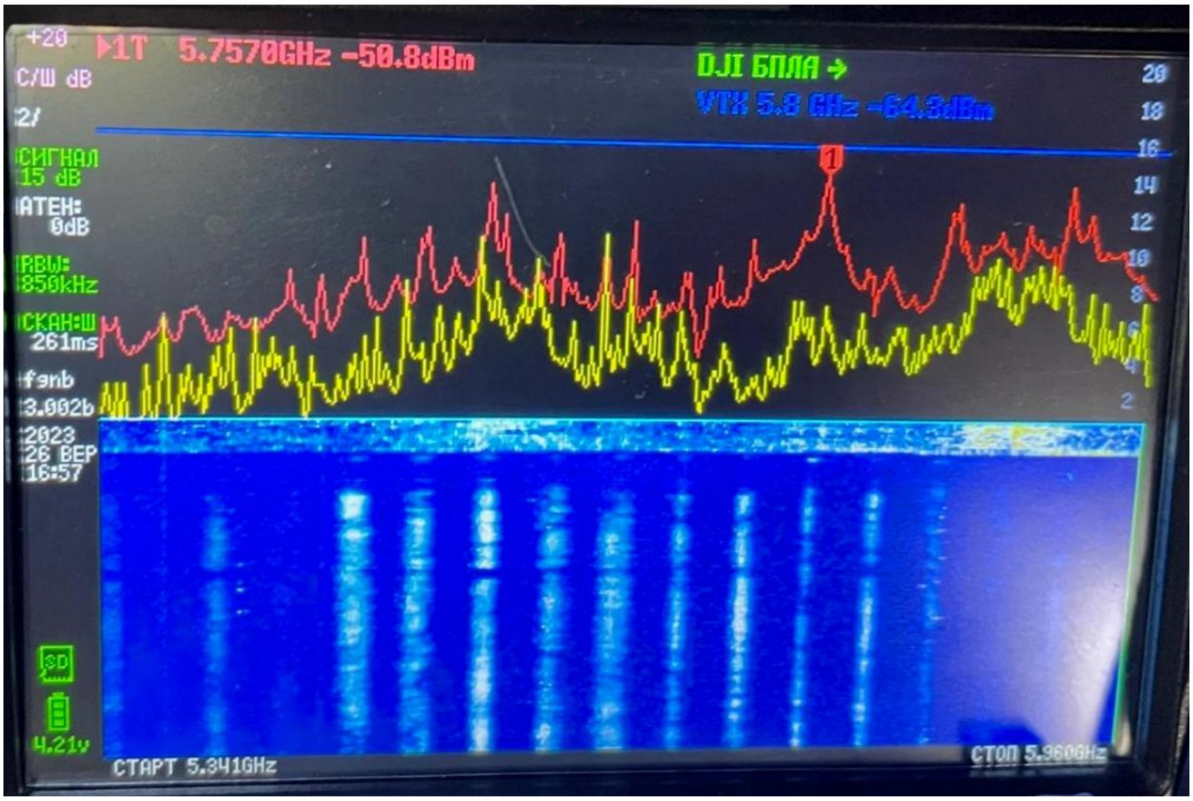
Example: REB for the entire range of 900-928MHz



Example: EW on the entire range of 900-928 MHz "through which" the UAVs of the Russian Federation are trying to work



Example: EW all video range 5.5-5.9 GHz



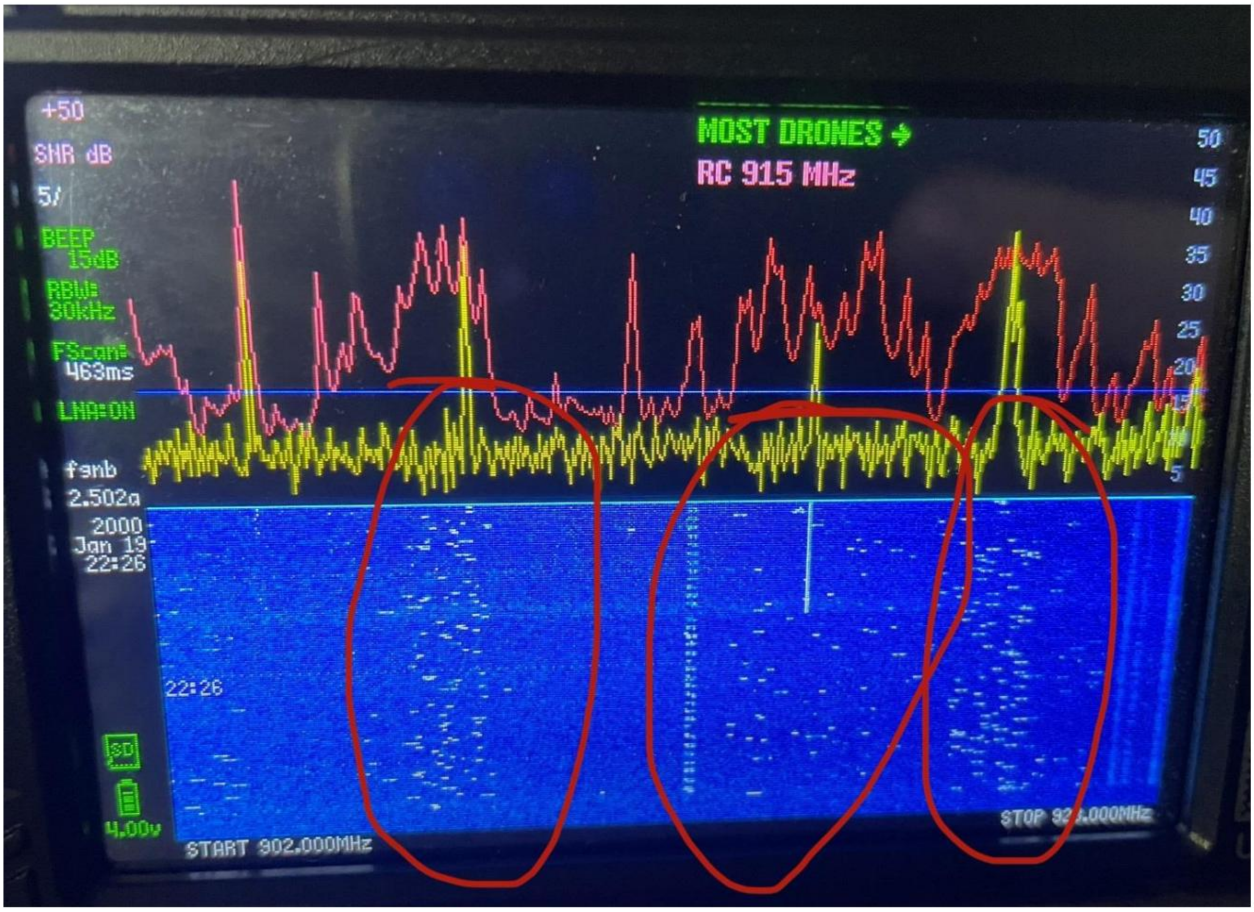
3.4 Fixation and identification of "winged" UAVs

Almost all 100% of enemy UAVs transmit telemetry signals in the 900 MHz range, or rather 868-870 MHz, 902-928 MHz, 960-1020 MHz

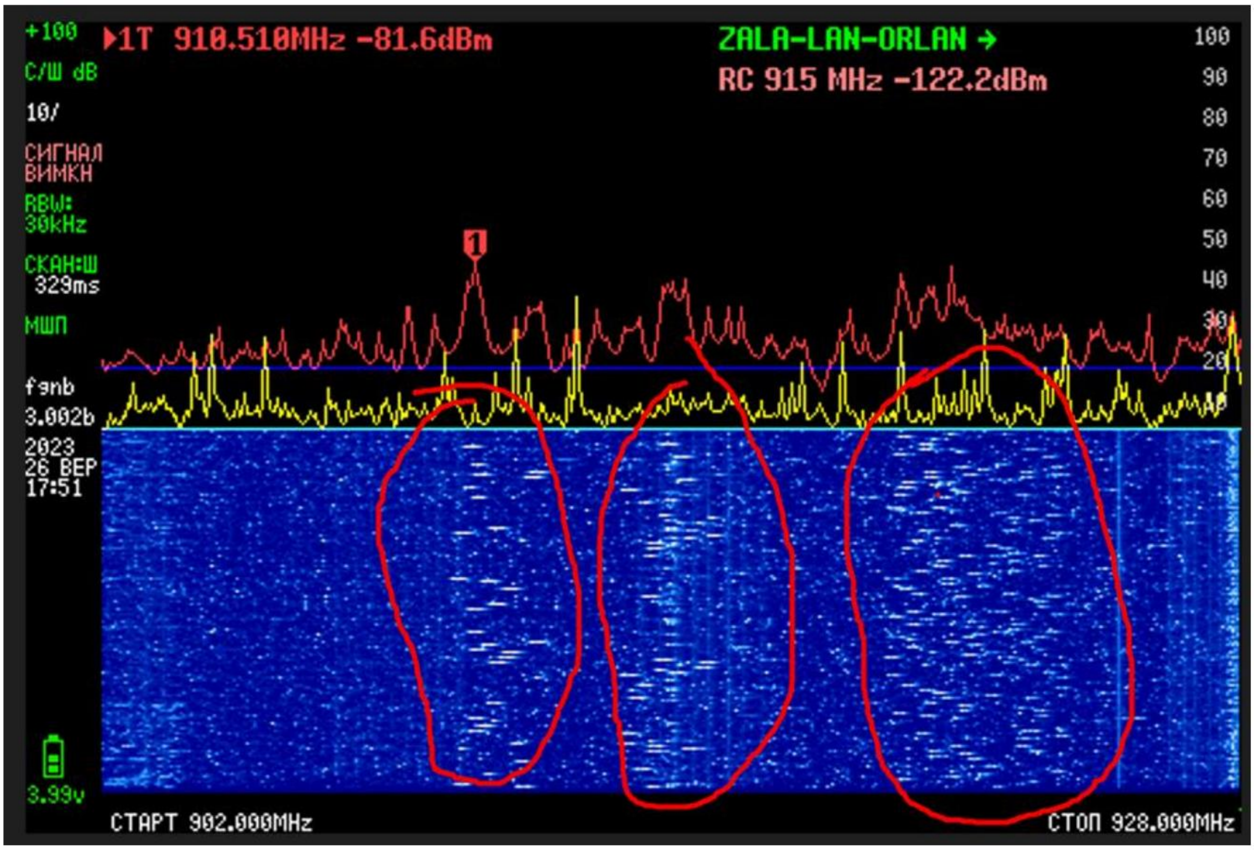
They can be distinguished by frequencies and waveforms.

Orlan is found most often on the fronts, works in the range 902-928 MHz (new models 960-1020 MHz). The signal looks like a set of dashes on a spectrum waterfall in the band usually 2 MHz or 4 MHz. Streaks are frequency jumps (FPR).

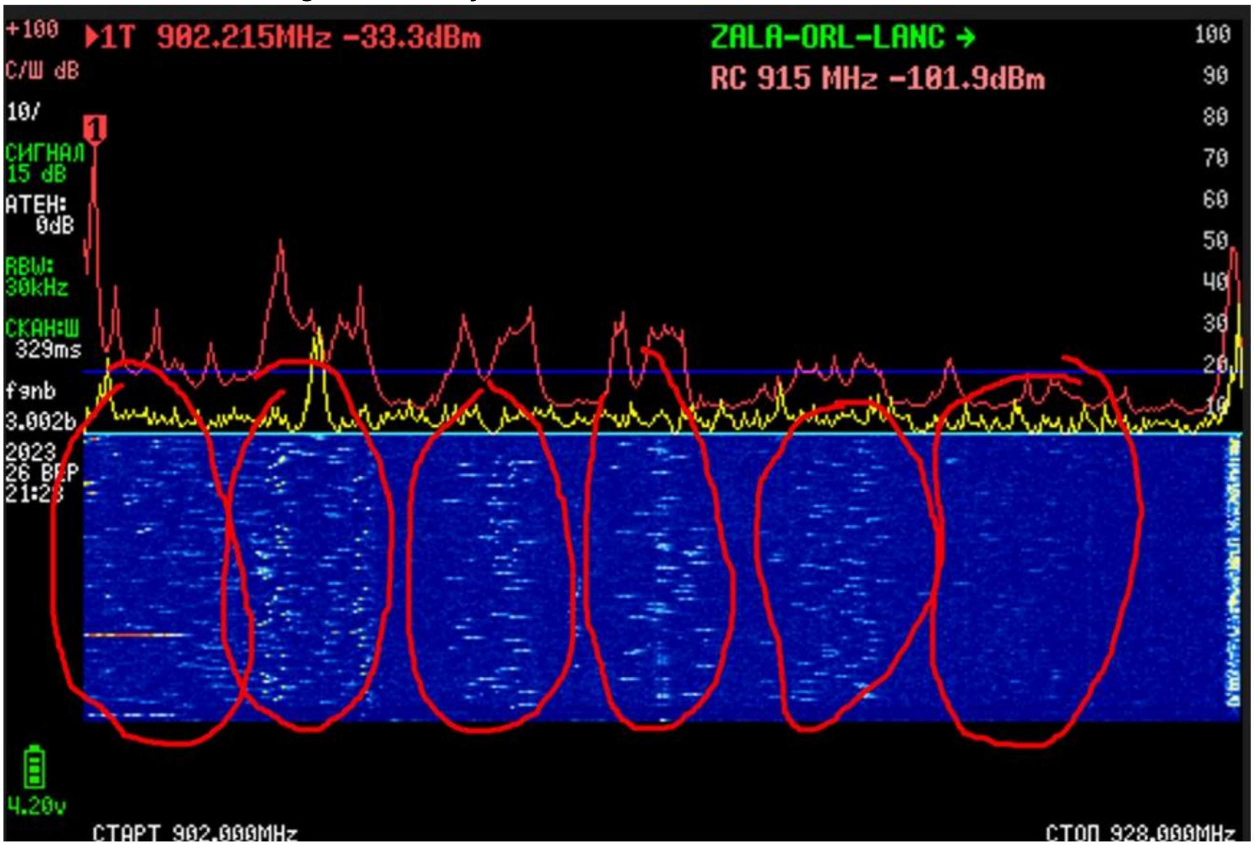
Example: three Orlans are marked in red. The average band has 4 MHz, the other 2 MHz. The analyzer also shows a signal from Hall or Lancet at 915 MHz in the form of a thin double line



Example: three Orlans are marked in red. On the right is a 4 MHz RFC band



Example: there are six Eagles in the sky (marked in red). The right one is the farthest. The signal is barely visible. The distance to it is about 40 kilometers



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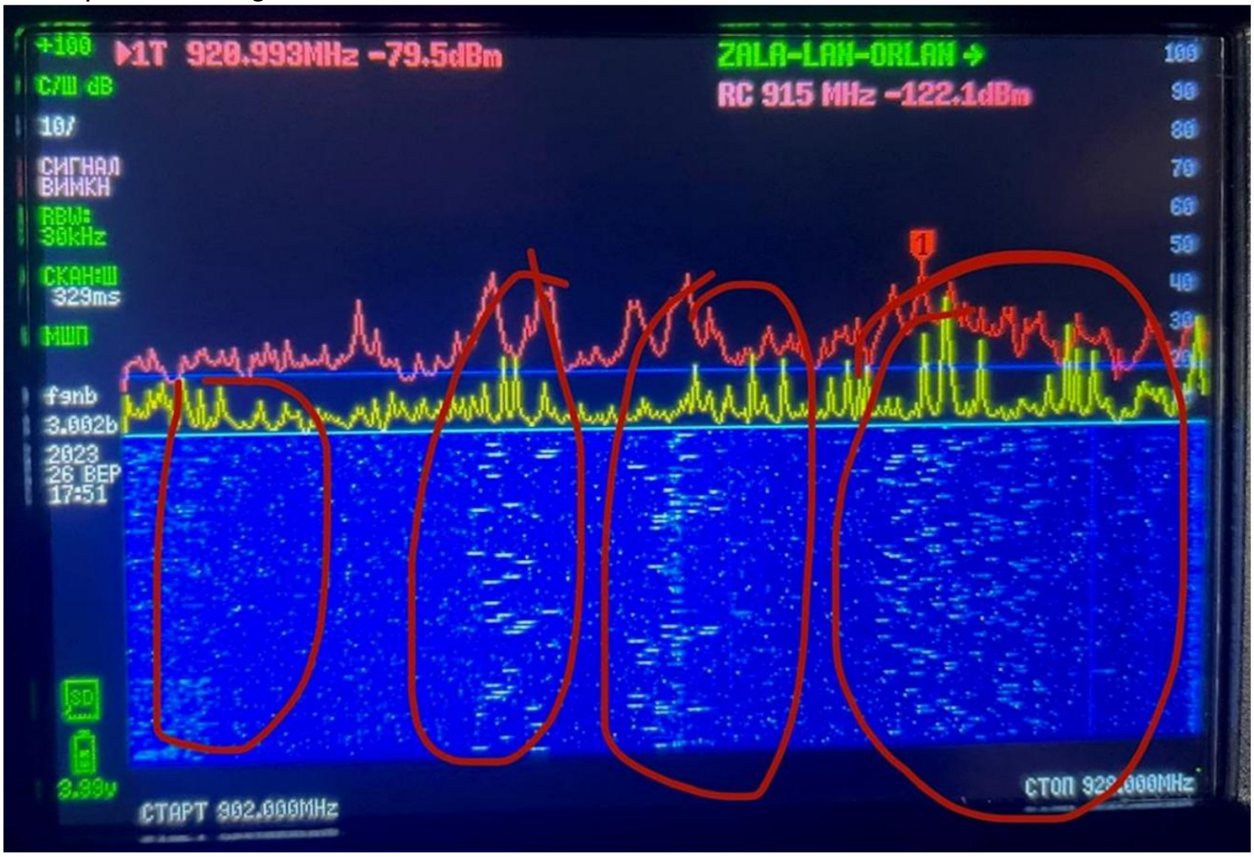
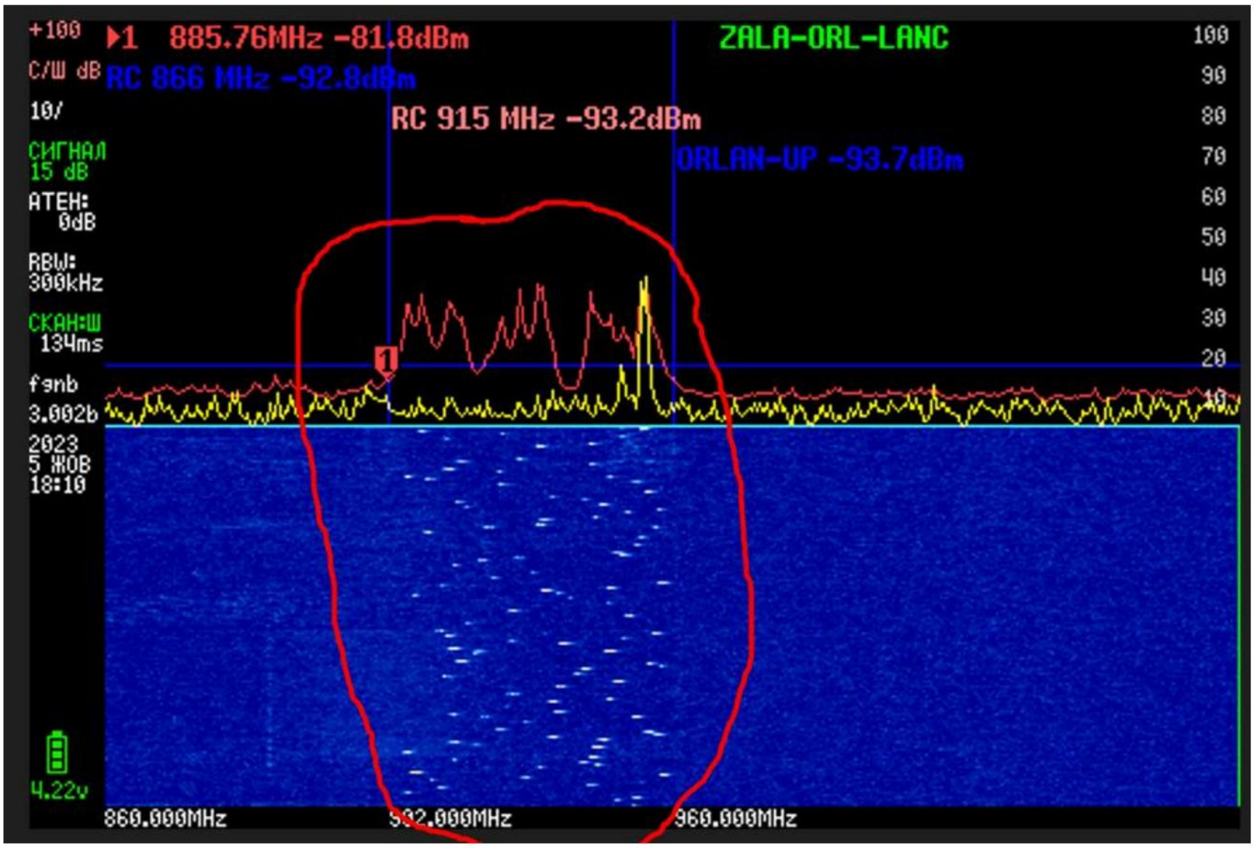
Example: four Eagles



Example: Two Orlans are very far (30 km)

Example: a good Orlan signal, to which 20 kilometers



SUPERCAM

UAV Supercam is 10 continuous bands on one band usually around 1000 MHz. The signal is specific and cannot be confused with other UAVs.

Суперкам
выявленные частоты:

865-870	10 каналов
880-885	10 каналов
890-895	10 каналов
960-965	10 каналов
965-970	10 каналов
990-995	10-11 каналов
995-1000	10-11 каналов
1000-1005	11 каналов
1005-1010	11 каналов
1015-1020	11 каналов

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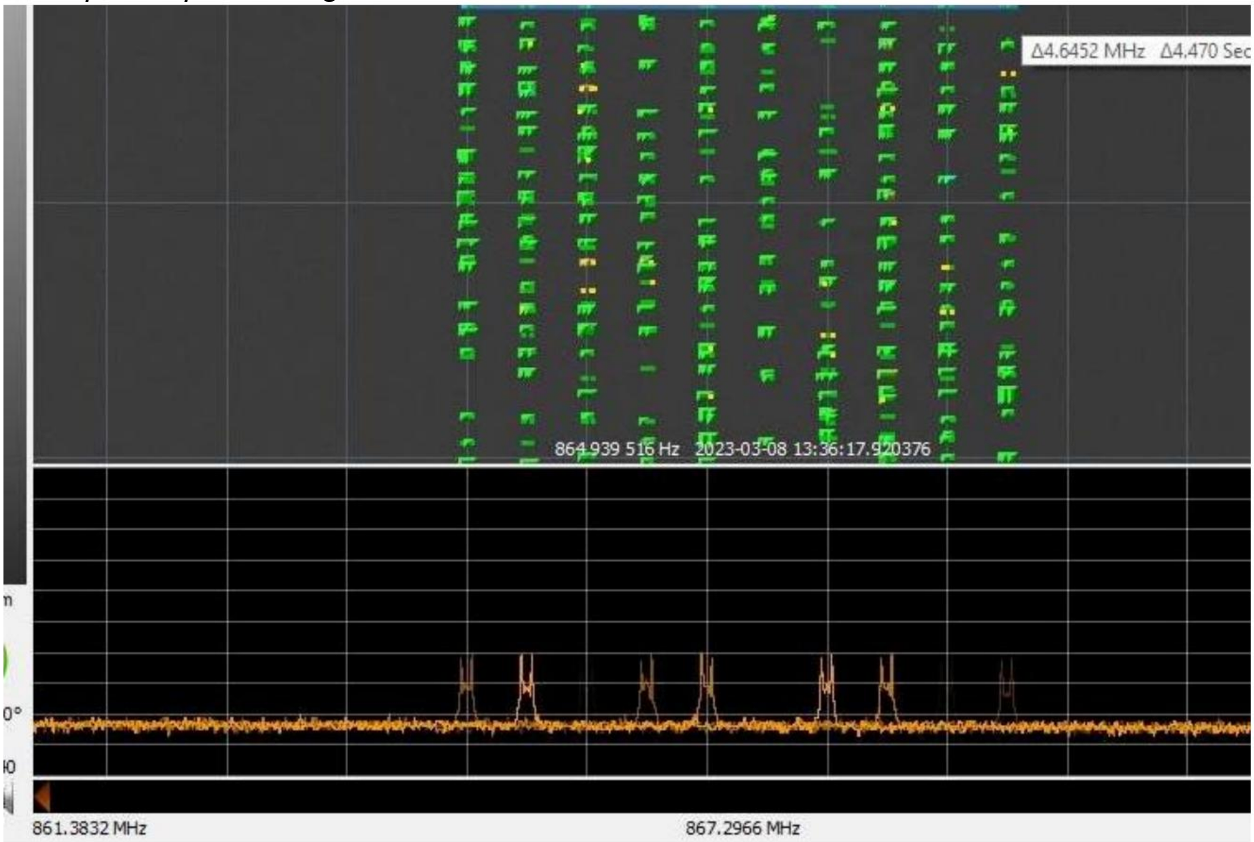
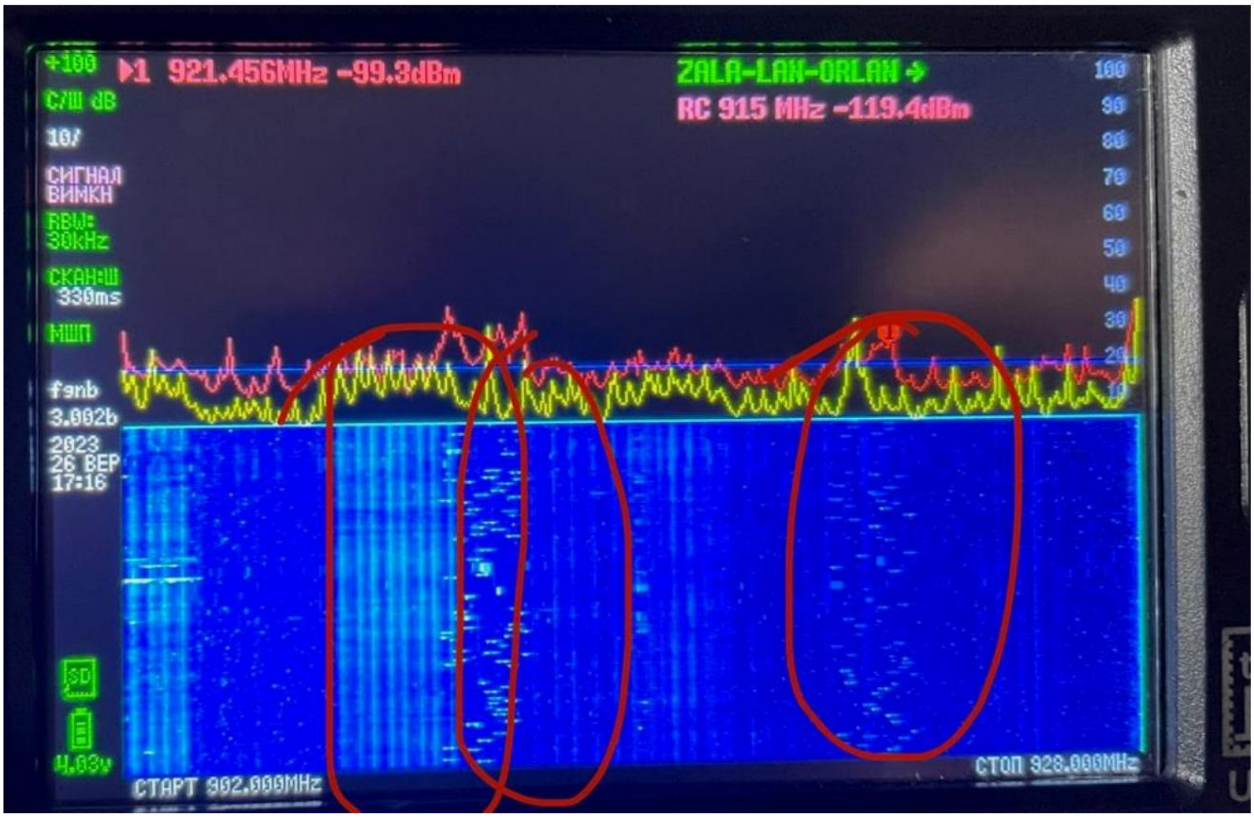
Example: Supercam signal

Example: Supercam signal



Example: several Eagles and a clear signal similar to Supercam, but band 8, not 10. And the frequencies are different. This is our "Poseidon".



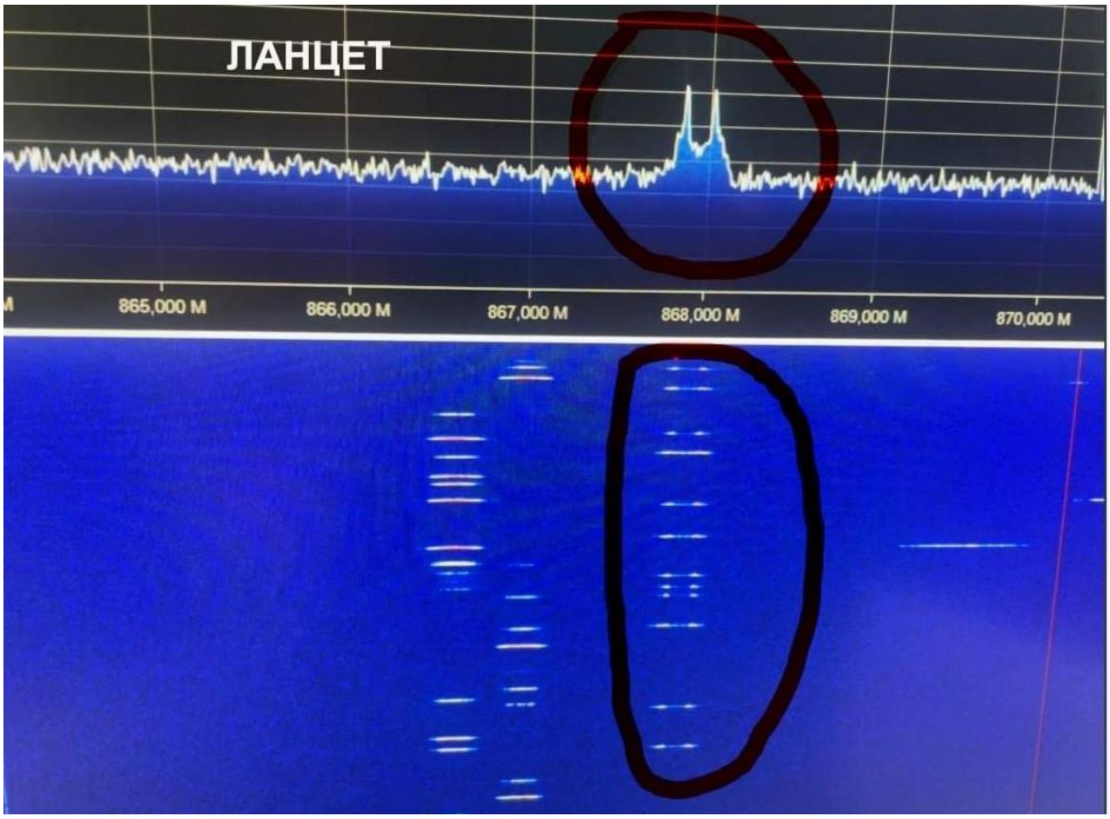
3.5 Fixation and identification of "winged" attack UAVs with the possibility of their direction finding (Lancet, Zala)

The Zala signal is of the same type as the Lancet, but the Zala usually operates at a frequency of 870 MHz. The signal on the waterfall looks like two intermittent bands that are very close (150-170 kHz)

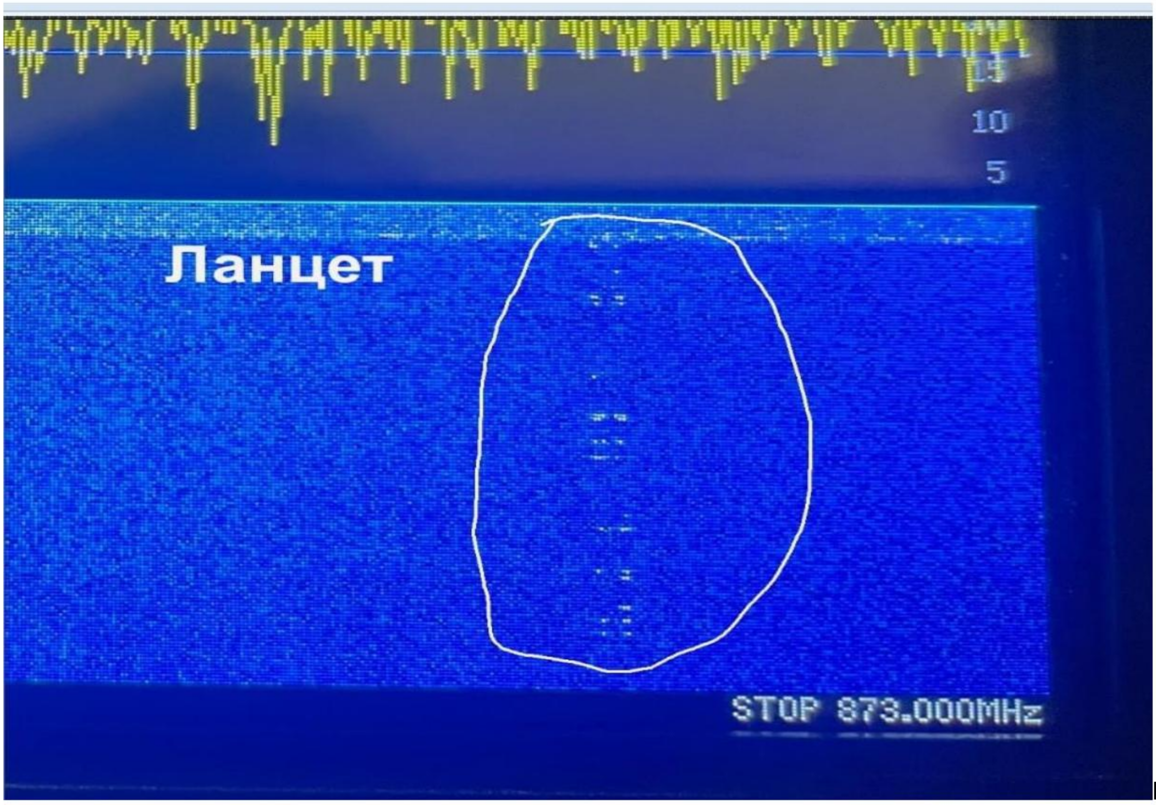
The Lancet has the same signal as the Zala, but usually operates at 868 MHz.

Machine Translated by Google

Example: a clear Lancet signal at 868 MHz. The sign is double horns. The distance is 10 km.

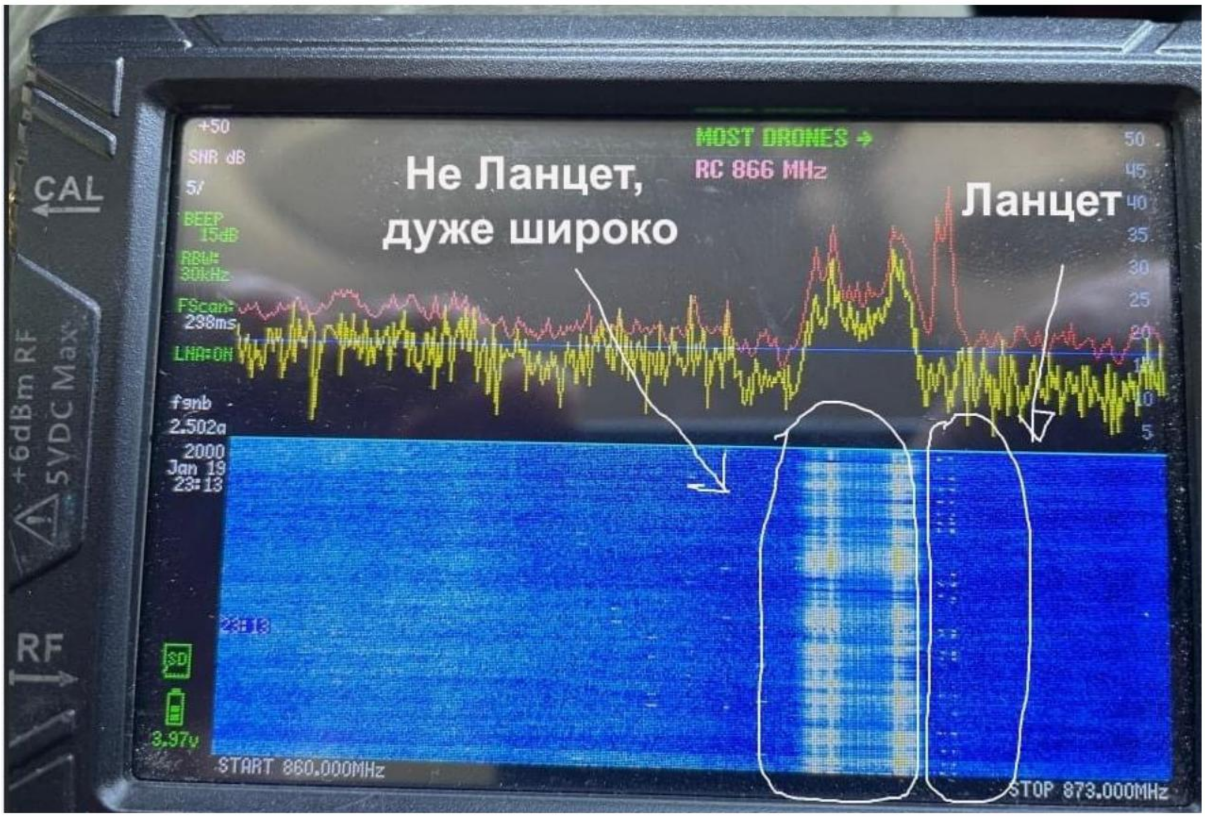


Example: Lancet's weak signal at 868 MHz. The distance is 15-20 km.

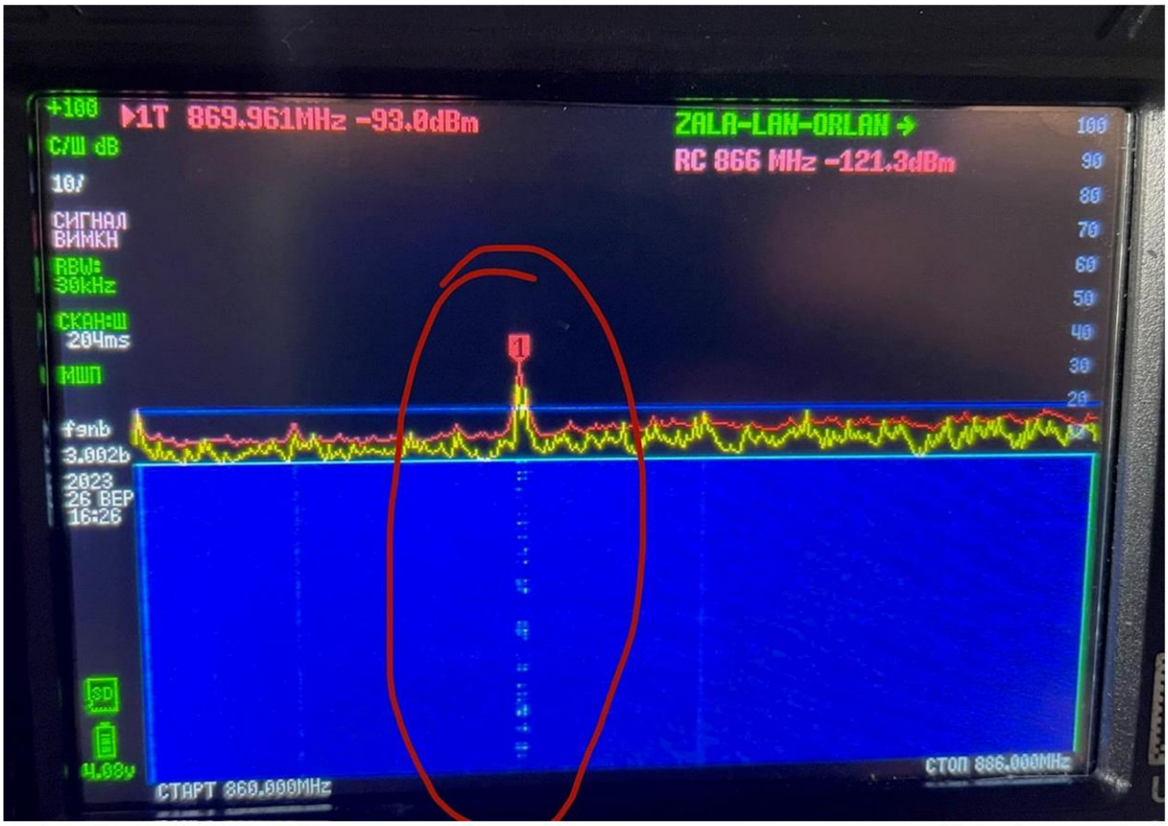


Example: very weak Lancet signal at 868 MHz. The distance is 20-30 km.

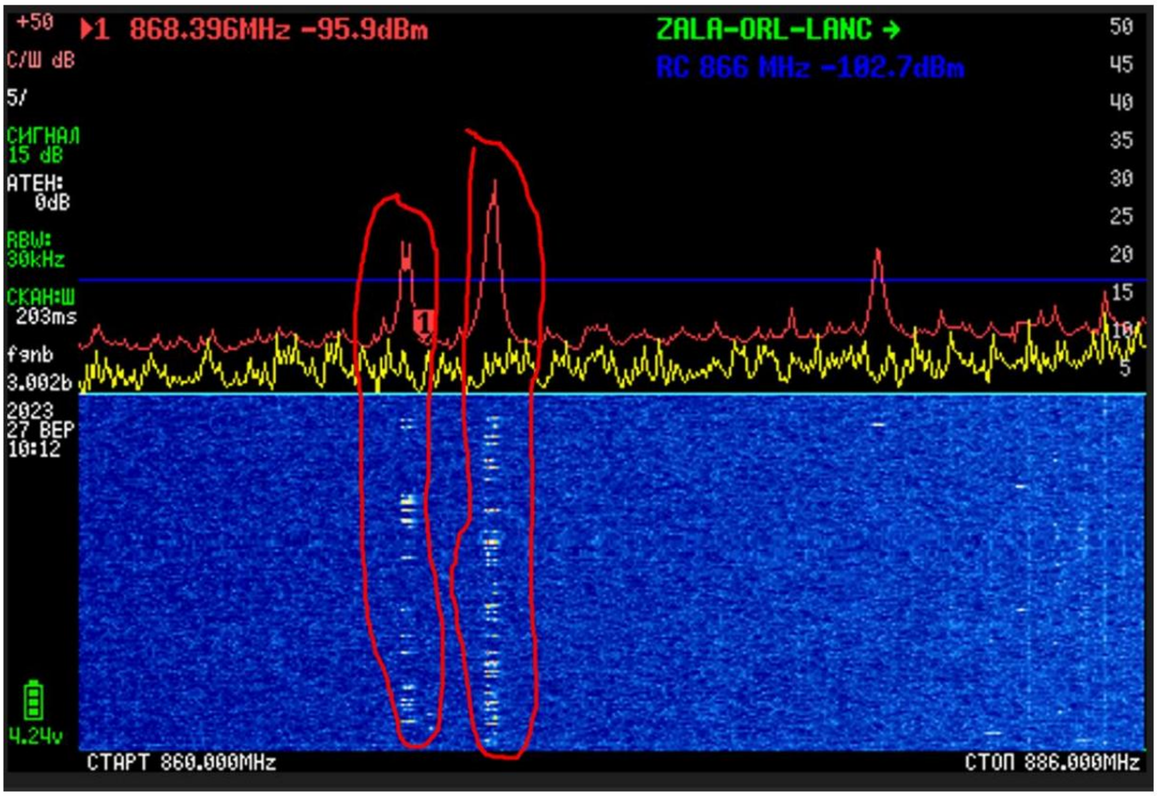
Example: average Lancet signal at 868 MHz Distance 15 km



Example: very weak Zala signal on 870 MHz Distance 20 Km

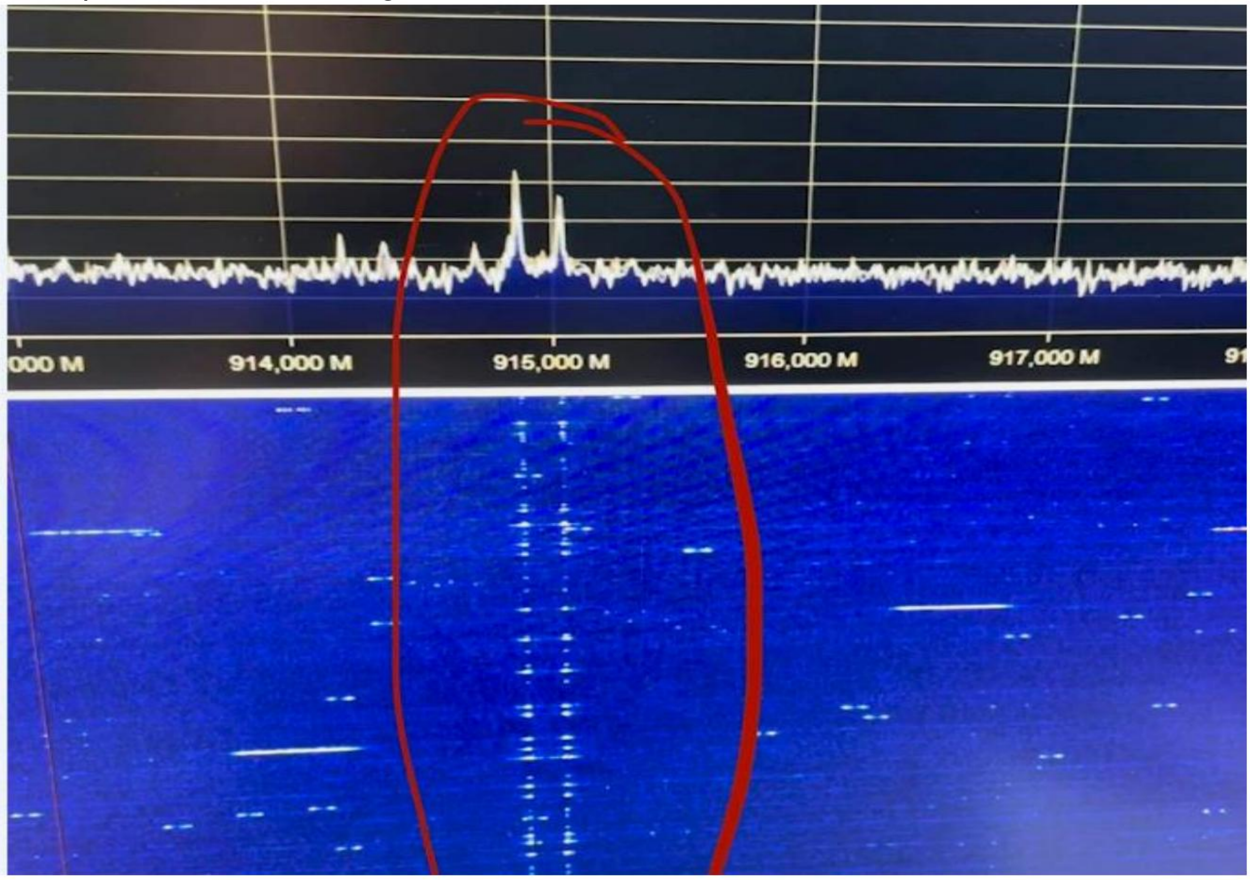


Example: Lancet signal at 868 MHz and Zala at 870 MHz, which Lancet guides

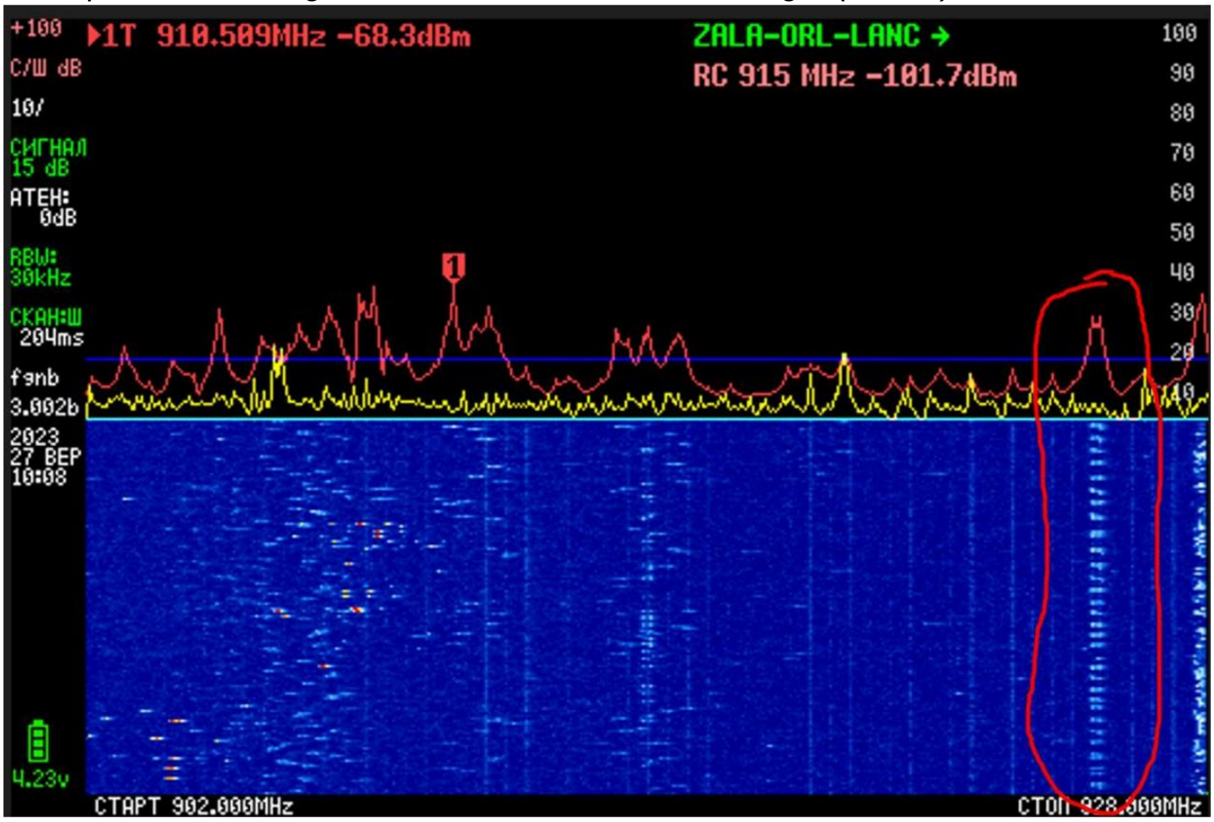


Lancet and Zala can also operate at 915 MHz

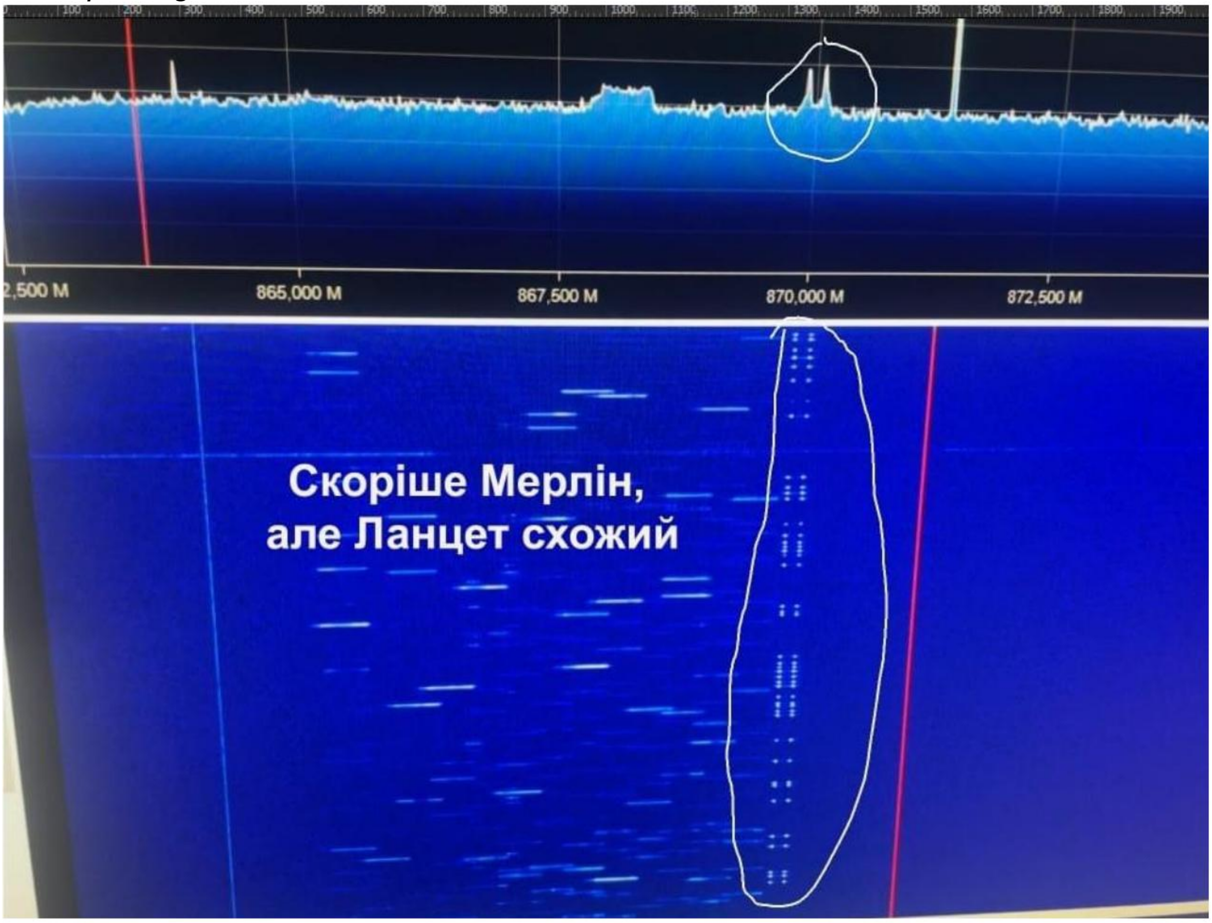
Example: Lancet or Hall signal at 915 MHz



Example: several Eagles on the left and Zala on the right (circled).

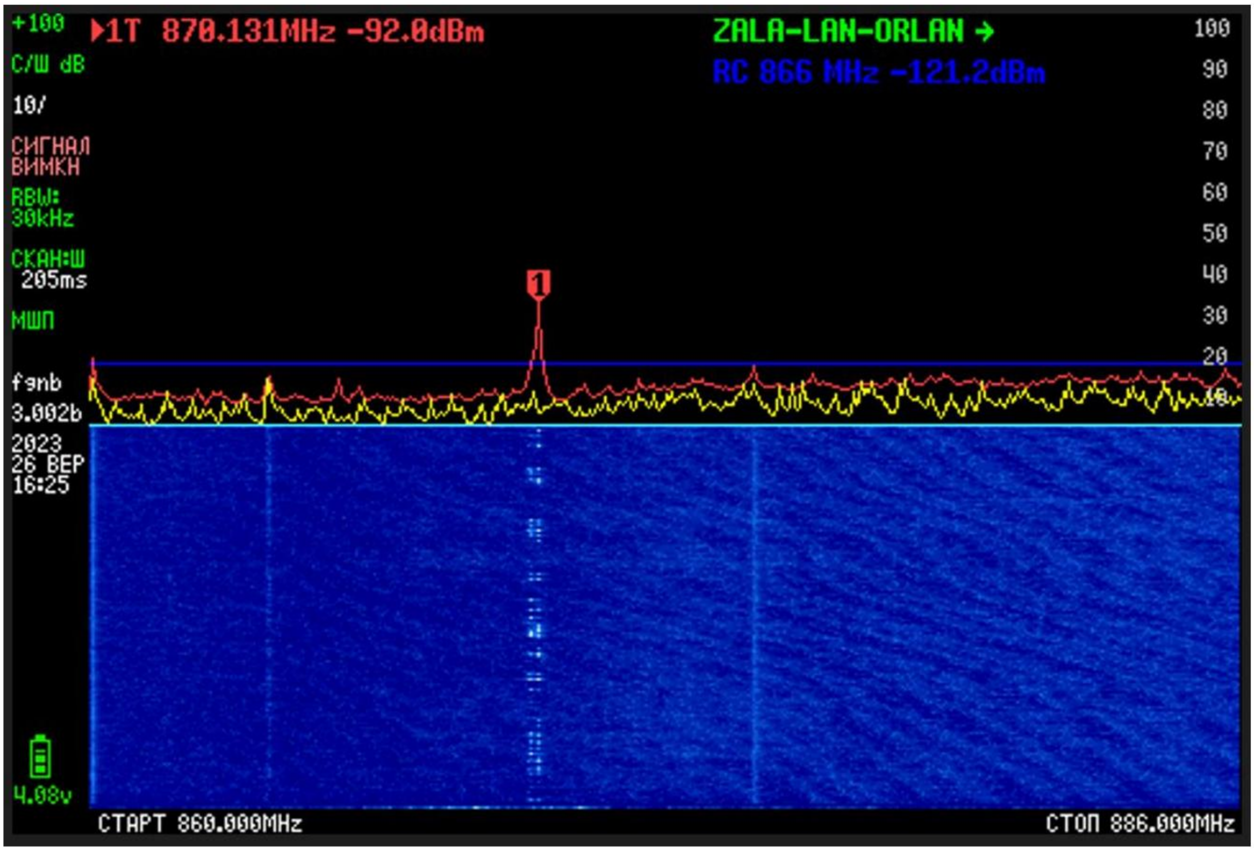


Example: signal from Merlin or Zala 870 MHz Distance 15 km

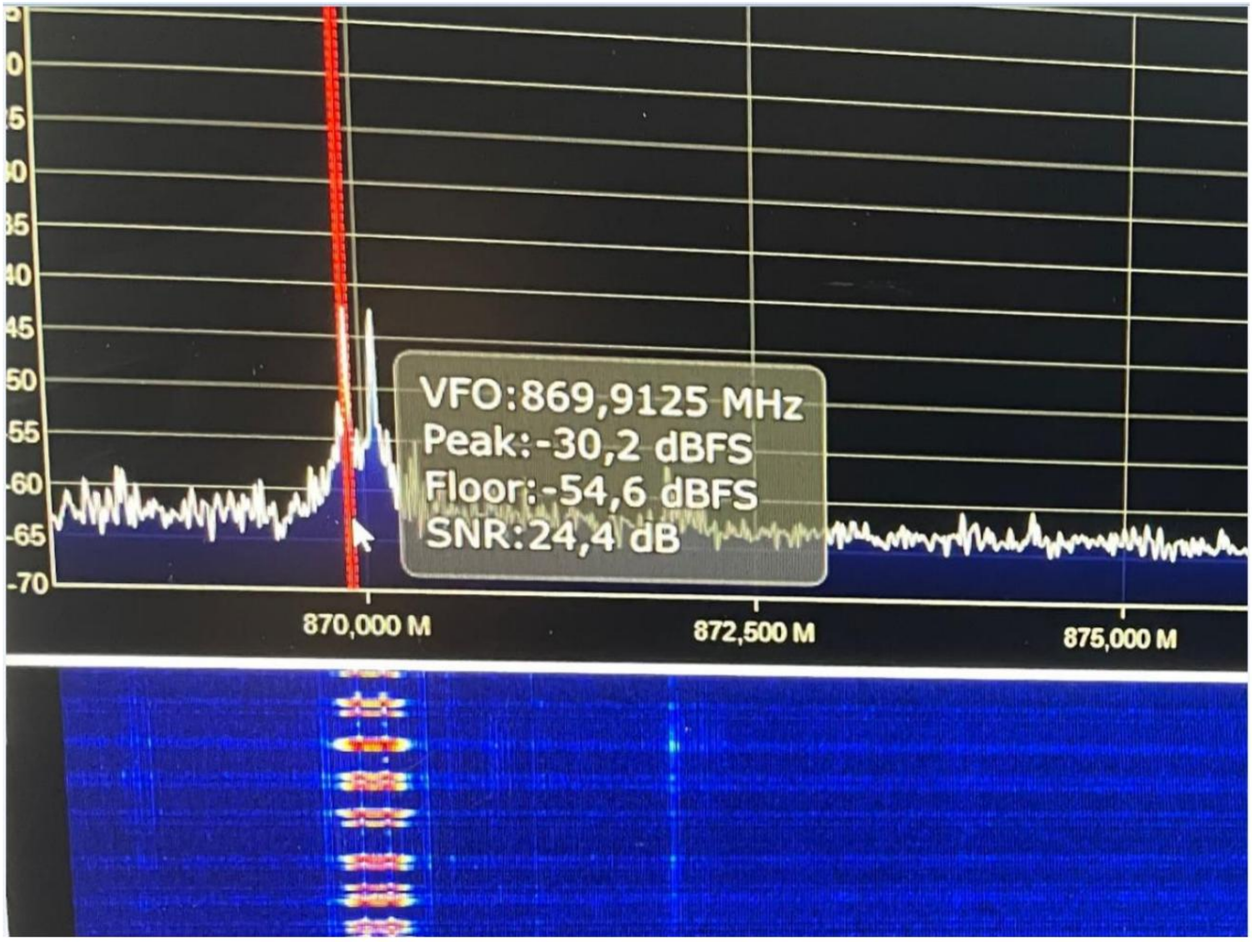


Example: signal from Merlin or Zala 870 MHz Distance 15 km

Example: signal from Merlin or Hall 870 MHz. The distance is 20 km.



Example: signal from Merlin or Hall 870 MHz. The distance is 5 km.

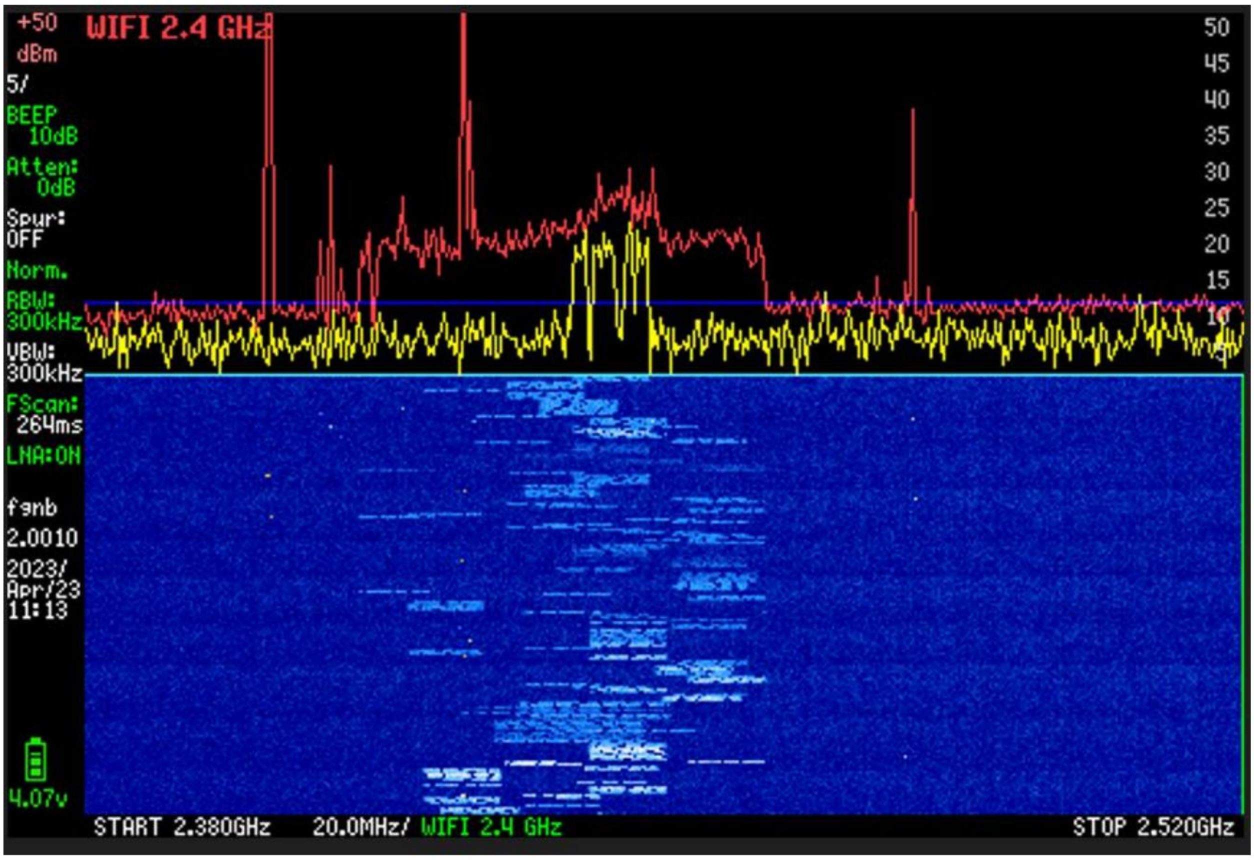


3.6 Fixation with the possibility of direction finding of quadcopters DJI, AUTEL

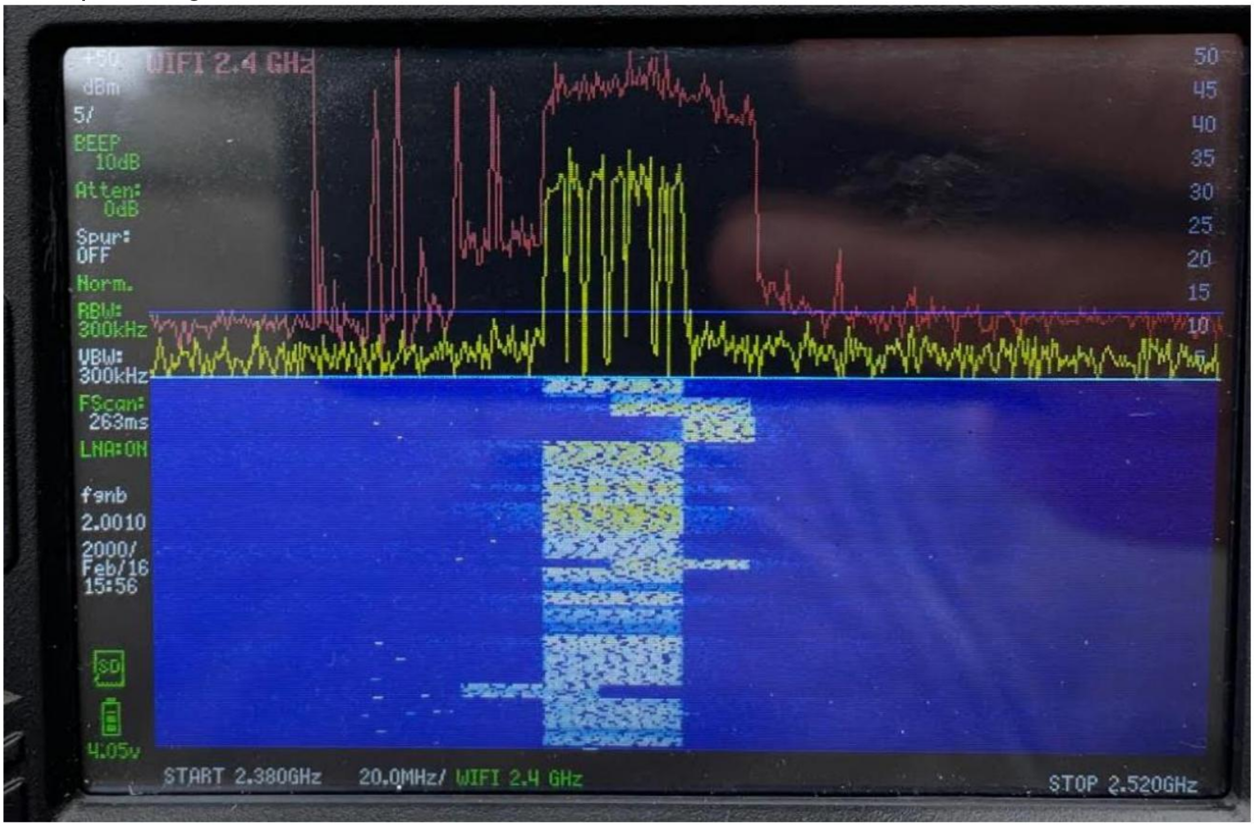
Almost all quadcopters fly with control in the frequency range of 2.4 GHz, 5.2 GHz, 5.8 GHz. At the same time, it is worth noting that long-distance flights are carried out only in the 2.4 GHz range. An exception is the Autel4T drone, which can be controlled in the 900 MHz range.

The drone in flight is fixed by the device at a distance of up to 3 kilometers and can be easily pinpointed. Modern drones use PPRC technology and during the flight, the range of the drone can move left and right, as can be seen in the figure below.

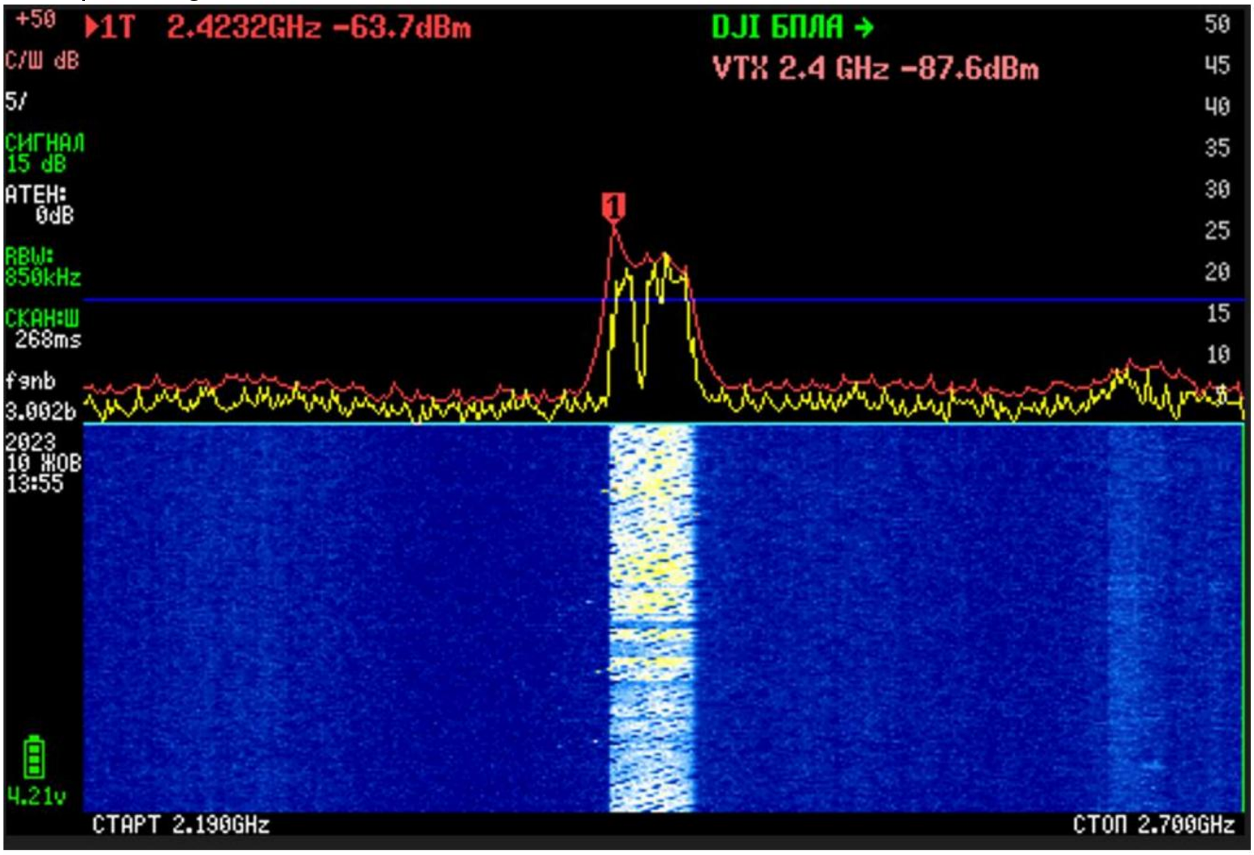
Example: signal from a DJI Mavic at a distance of 2 km. The drone moves through the spectrum, choosing the best frequencies.



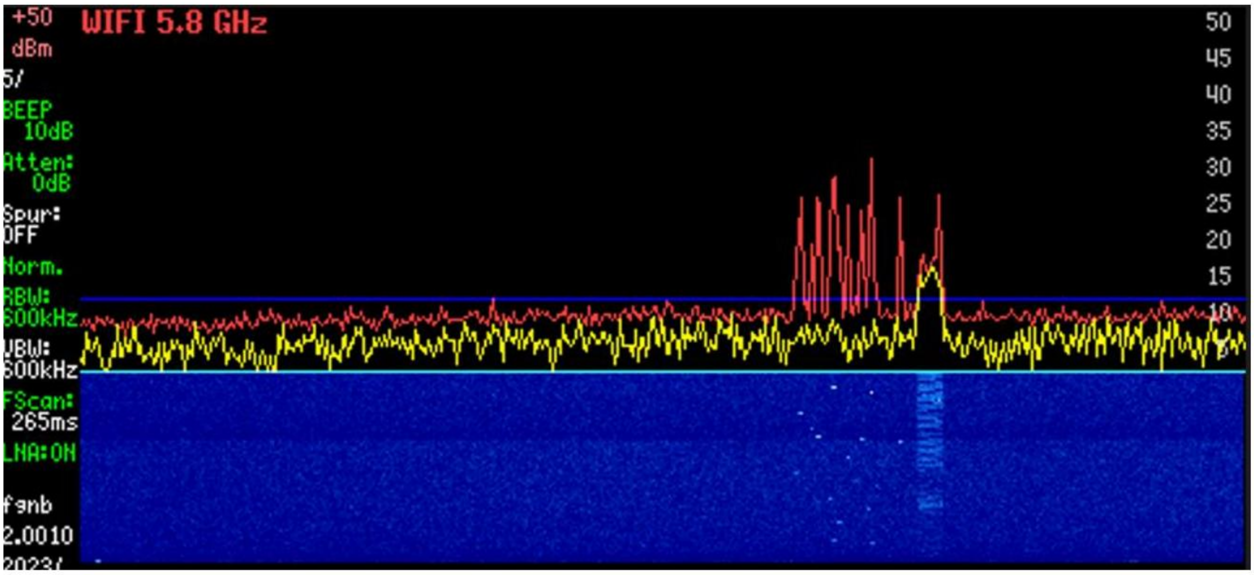
Example: a signal from a DJI Mavic at a distance of a kilometer



Example: a signal from a DJI Mavic at a distance of 500m

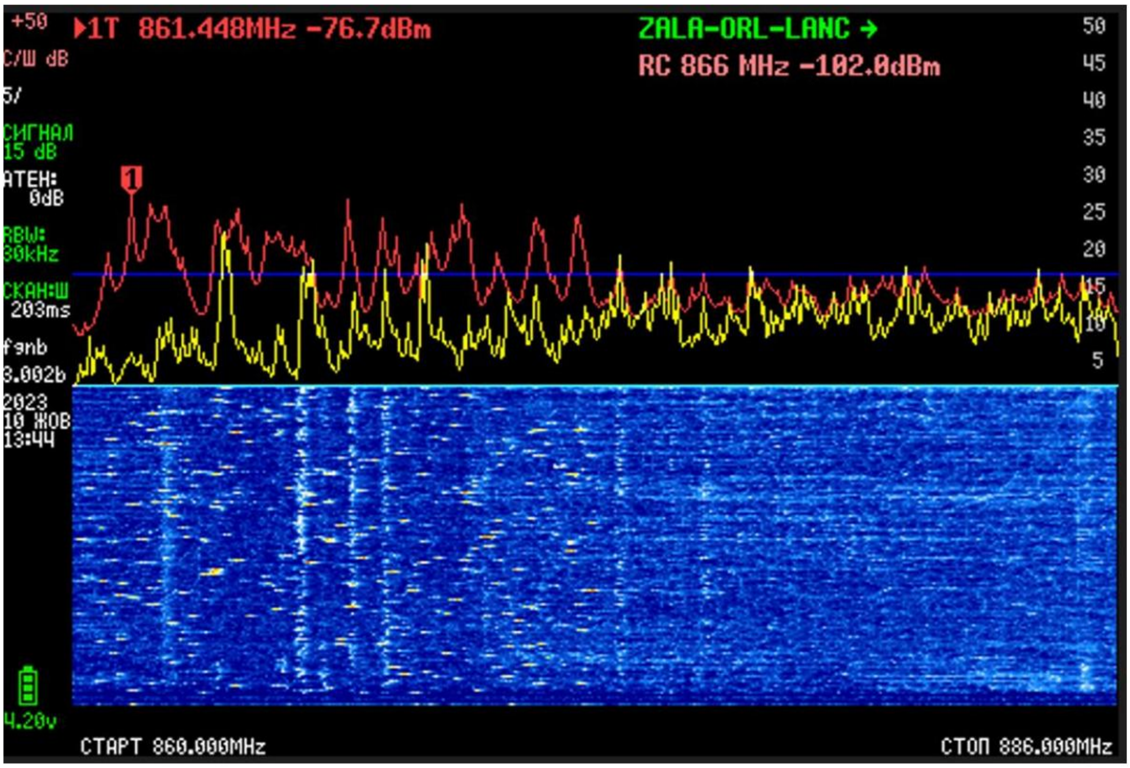


Example: a signal from a DJI Mavic at a distance of 2 kilometers in the 5.8 GHz range

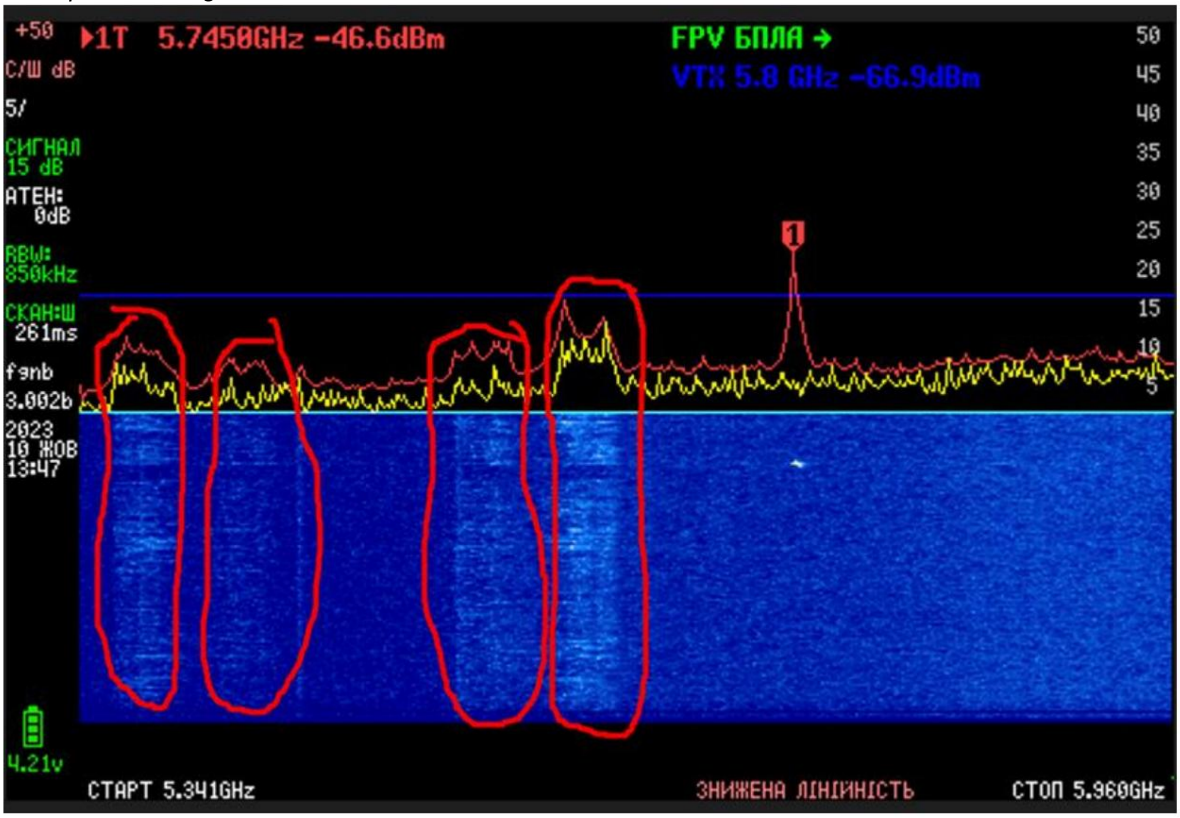


3.7 Fixation with the possibility of direction finding of FPV quadcopters

FPV drone control channel FPV drones
of the ELRS and TBS CROSSFIRE protocols work: - "band 868"
PPRF in the area of 860-886 MHz - "band 915" PPRF
in the area 902-928 MHz At these frequencies the
remote control emits and the drone transmits telemetry. If telemetry is disabled, the
drone only transmits a video signal on 5.8, 1.3 or another band *Example: several FPVs in the air at*
the same time on 860-886 MHz



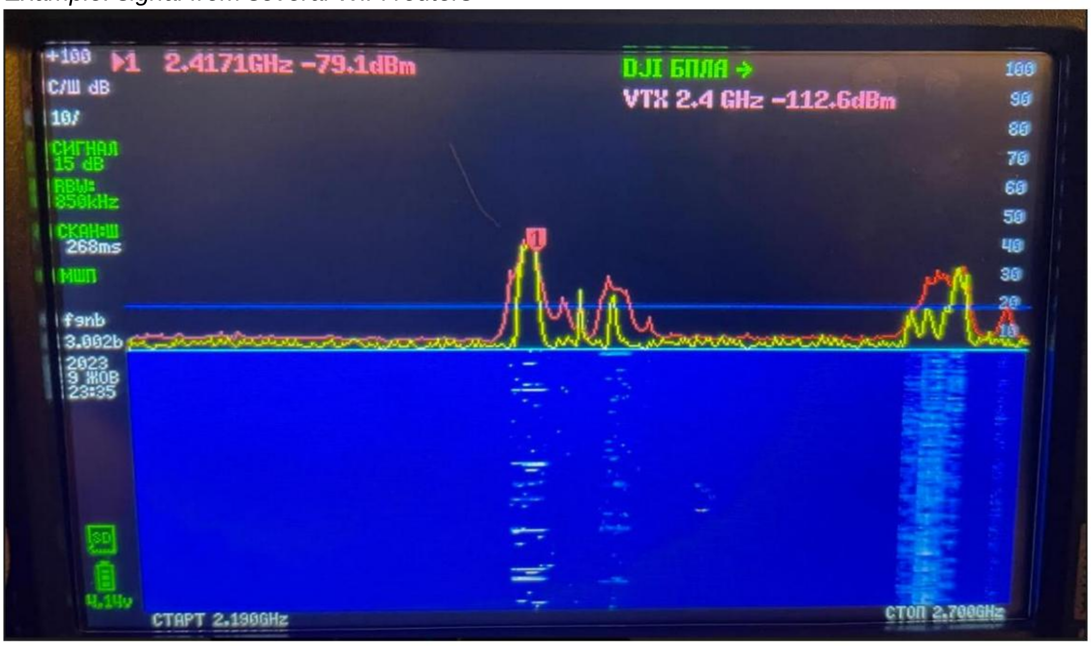
Example: video signals from 4 FPVs in the air at 5.8 GHz



3.8 Fixation with the possibility of direction finding of WiFi points at enemy positions

The device allows you to fix WiFi signal sources at enemy positions. These sources are most likely located at command posts and ROPs of the enemy. WiFi sources are detected quite far, but the presence of a large number of UAVs in active areas of the front will interfere with the detection of WiFi points

Example: signal from several WiFi routers



3.9 Other options for use

The device can be used to perform other tasks regarding
detection:

- Radio stations on enemy armored vehicles in the range of 30-70 MHz

- satellite phones

- checking the range of operation of anti-drone guns

- bookmarks and beacons on equipment and "volunteer" loads

- inspections of hidden broadcasting of trophy radio stations

- checking the frequency ranges in which mobile communication works and adjusting the antennas of mobile communication amplifiers to operators' towers

4. Direction finding of signal sources

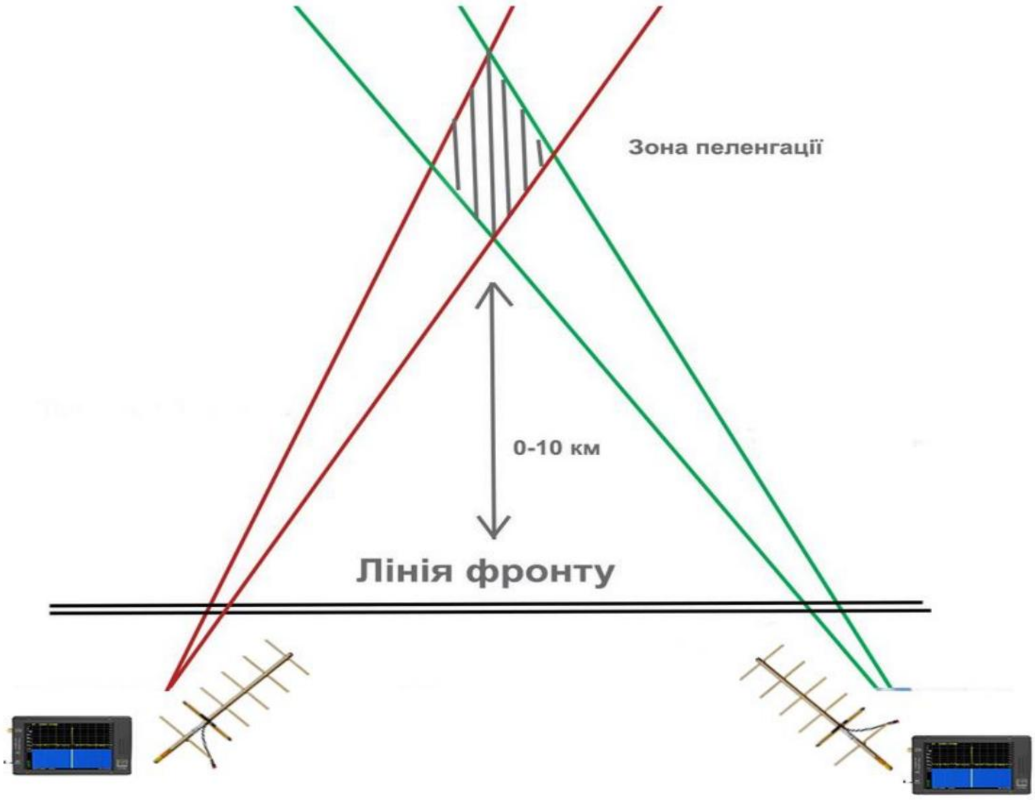
Direction finding of a source of interference or a signal can be carried out by the classical method of triangulation.

To do this, you need to set the analyzer to the desired range and, rotating the directional antenna in a circle, choose the direction with the strongest signal. Mark the bearing (azimuth) on the map or in Krapyv. Repeat the same process at another point, driving a few kilometers away. The intersection of two bearings will give you the location of the object. Ideally, direction finding should be done from a height so that the signal is strong enough. It is also better to take not two, but three bearings to increase t

eye contact

For accurate bearing, you need an antenna with a narrow directional pattern. A wave channel antenna is well suited for this
(Yagi). 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 area of the signal source and "reconnaissance" it with artillery or UAV fire.

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 level. This will only be an approximate understanding of the distance.

The signal level will be affected by the type of antenna, the presence of a cable between the antenna and the device, 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 based on your experience after some time, but only approximately.

When the signal is barely visible at the waterfall, 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, the level is very strong. At the same time, the peaks of the bursts are scaled to the entire 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.
One thing for the Maviks, another for the Orlans. Therefore, only personal experience will help you here.