

SEMI-MOBILE HF DIRECTION FINDING STATION "UKOL-RK"



- **Panoramic view with detection and direction-finding (DF) of signals in the frequency bands 1.5 - 30 MHz at the rate of up to 300 MHz/s**
- **Receiving and DF HF-signals of steeply dipping radio waves ($\beta > 60^\circ$)**
- **Automatic detection and direction-finding of sources of radio emissions of modern radio communication systems (Conventional & Frequency Hopping)**
- **Calculation of co-ordinates of radio emission sources with their imaging on a digital terrain map**
- **Classification of radio networks and signal parameter measurement**
- **Reception and digital recording of signals**
- **Aural and visual monitoring of detected signals**
- **Informational interaction in direction-finding network with time synchronization using GPS global positioning system**
- **Accumulation and processing of data about radio electronic environment**

GENERAL IDEA

The “Ukol-RK” semi-mobile radio monitoring station works in the automatic mode as a part of a complex or independently and is intended to solve tactical missions connected with obtaining data about a radio electronic environment in an area being monitored by means of observation of work and position of modern radio communication aids in the 1.5 – 30 MHz frequency band.

Station “Ukol-RK” based on two high utility vehicles (provided by Customer). The hardware of the “Ukol-RK” station is delivered in a standard shelter fitted with a life support system. Inside first vehicle there are two automatic operator workplaces, first workplace with high-speed panoramic HF band detectors-direction-finder equipment, second workplace with equipment of Master-Slave HF radio direction-finder (option), automated workstations of operators equipped with computers, tracking radio receivers, digital recording and classification equipment (W-CODE). In second vehicle deployed antenna-feeder system and supportive equipment.

The navigation equipment (GPS receiver) ensures a possibility of synchronous work of several “Ukol-RK” stations in a single direction-finding network in the mode of both slave and master station of the network. The interaction of the “Ukol-RK” stations is ensured through communication channels provided by a Customer.

Elements of the HF direction-finding antenna system are deployed around the station shelter at a radial distance of 25...50 m.

The omnidirectional HF monitoring V-shaped antenna-feeder system is mounted near the shelter side and secured on a flange of a hoisting-mast device (hoisting height: 12 m).

Two operators are necessary to ensure work of the “Ukol-RK” station, the first operator serves an HF radio monitoring post for searching RES, and the second operator serves a Master-Slave DF equipment (option). A crew consisting of 4 persons is necessary to deploy the antenna feeder systems. The station deployment time is 3 hours (including time of orientation antenna feeder system elements).

The station is powered from a diesel generator that forms 220 V 50 Hz industrial mains. The special hardware of the station is powered through uninterruptible power supply (UPS) sources, which ensure work of the station during 15 minutes after shut-down of the diesel generator.

The software of the “Ukol-RK” station is developed using modern computer technologies and functions under the control of OS Windows. Due to visual graphic interfaces GUI (virtual instrument panels), work with the station hardware does not require high skill and special knowledge of an operator, and a built-in diagnostics system enables him to easily find a fault in the hardware down to a replaceable unit during work.

The detectors-direction-finders of the “Ukol-RK” station pertain to the class of systems with spatial processing of signals and ensure detection of a signal by its spatial features together with evaluation of direction of a radio emission source using the vector-correlation method of calculation of direction-finding. The spatial processing of signals (including calculation of direction-finding) is made practically without stopping the frequency scanning due to use of high-performance servers based on crystals Intel Core I7 2.6 GHz.

Moreover, the decisive rule of detection of signals in the “Ukol-RK” station is based on the spectral-statistical signal detection algorithm that uses spatial FFT features of a group signal, which enables to detect newly appearing signals against the background of radio stations on the air.

The HF band direction-finding antenna-feeder system (AFS) is a circular antenna array 50...100 m in diameter, with 9 combine loop antenna elements, that overlaps the 1.5–30 MHz frequency band.

The HF band antenna elements are active loop antennas ($h = 4$ m), which are efficient for direction-finding of radio emission sources at distances of 100 - 500 km (the radio wave incidence elevation is $85^\circ \dots 60^\circ$ respectively).

The loop antenna elements of the HF direction-finding AFS of the “Ukol-RK” station have three reception modes:

- loop with “left-hand” circular polarization;
- loop with “right-hand” circular polarization;
- wide-band monopole (“rod”) with vertical polarization.

A reception mode of the loop antennas is chosen by an operator depending on a polarization and an elevation angle of incident radio waves, radio emission sources subject to direction finding.

The reception systems of the detector-direction-finder and the HF band executive direction-finder are built on the basis of receivers consisting of 9 DDC paths for direct frequency conversion with digital signal processing. The capacity of the analog-digital converter in paths of the reception systems of the detectors-direction-finders is 16 bit.

PURPOSE

The “Ukol-RK” vehicle station for HF band radio monitoring is capable of solving the following tasks:

- monitoring of radioelectronic environment of an area up to 30-50 km (surface waves receiving), 100...150 – 2,000 km (ionosphere waves receiving) and more;
- search, detection and direction-finding of new radio emission sources (RES) in desired sections of HF (1.5–30 MHz) frequency band;
- master-slave direction finding of the redetected signals and getting commands for synchronize bearing from external complex (options);
- classification of radio networks and measurement of parameters of signals of detected RESs;
- monitoring of work of known RESs being observed;
- discovery of emission modes and composition of radio networks working at conventional and hopping frequencies, with selection of individual sources in terms of frequency-direction-finding panorama;
- recording of signals at audio and intermediate frequency outputs of tracking receiver;
- real-time rapid analysis of RES signals;
- determination of RES co-ordinates with imaging on a terrain map (including SSL-method when data of parameters ionosphere);
- control of parameters and operating modes, collection of information from slave stations of the direction-finding network through the Customer’s communication channels;
- sending commands for bearing to DF network (option);
- external complex radio intercept posts aiming (setting frequency for observation);
- automated processing and documentation of data about radio electronic environment.

GENERAL INFORMATION

- Maximum frequency scan speed: 300 MHz/s;
- Monopulse principle of bearing provides detection and bearing of impulse and frequency hopping signals with duration 3 ms;
- Parallel work of direction-finding and command-executive bearing systems (option);
- Automatically setting on synchronize bearing command, received from external complex;
- Classification of radio networks and setting parameters of signals;
- Automatically coordinate finding (triangulation and SSL methods);
- Throughout capacity of detector-direction finder > 1000 bearings/s;
- Automatic aiming of external radio interception posts.

COMPOSITION

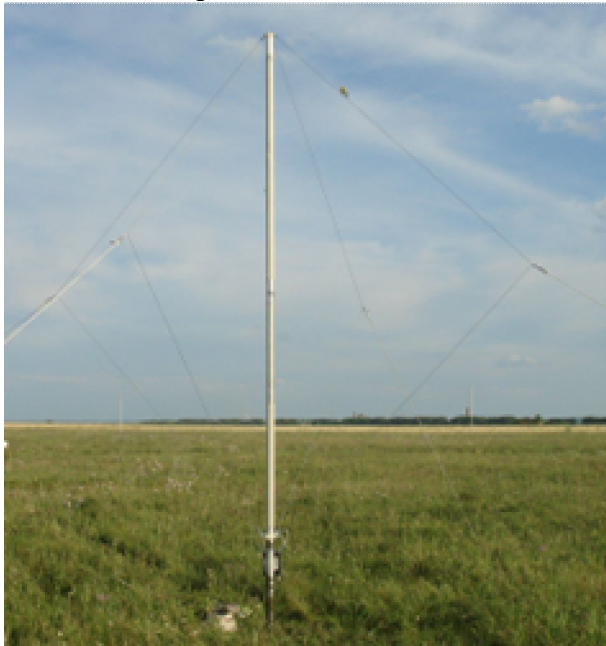
- 1) HF direction-finding antenna feeder system consisting of circular antenna array including 9 combine loop elements ($h=4$ m, $S=9$ m²);
 - 2) HF omnidirectional antenna (V-shaped antennas – 4 pieces);
 - 3) rack of wide-band input devices and switching of direction-finding AFS (option);
 - 4) antenna decoupling and omnidirectional antenna switchboard unit;
 - 5) rack of panoramic HF band detector-direction-finder based on 9-path wide-band digital receiver and signal processing unit;
 - 6) rack of measuring receiver of executive radio direction-finder based on 9-path narrow-band digital receiver and signal processing unit (option);
 - 7) “Galaktika-M” HF tracking radio receiver-2 pieces;
 - 8) two workstations of operator, who processes HF signals, based on a computer equipped with pushbutton board for operational control (second workstation - option);
 - 9) GPS receiver with antenna;
 - 10) two uninterruptible power supply sources UPS-2000 VA (second UPS - option);
 - 11) power supply board;
 - 12) manually-operated GPS receiver (for AFS orientation);
 - 13) set of connecting cables and HF feeders;
 - 14) 5 kW diesel electric power plant – 2 pieces;
 - 15) Two high utility vehicles;
 - 16) shelter equipped with tables, operators’ chairs, air conditioner, lighting and ventilation systems;
 - 17) accessories, including units of field heterodynes for checking of direction-finding systems;
 - 18) operational documentation (operation and use manual);
 - 19) special mathematical software for station (two copies of installation CDs, including W-CODE).
- Note.** Vehicular platform and powering system are provided by Customer.

“Ukol-RK” station deployed on position



HF antenna elements of "Ukol-RK" station:

Loop active antenna of DF



Wide-band system of V-shaped antennas



Rack of HF band detector-direction-finder



View of operator workplace of "Ukol-RK" station



SPECIFICATIONS

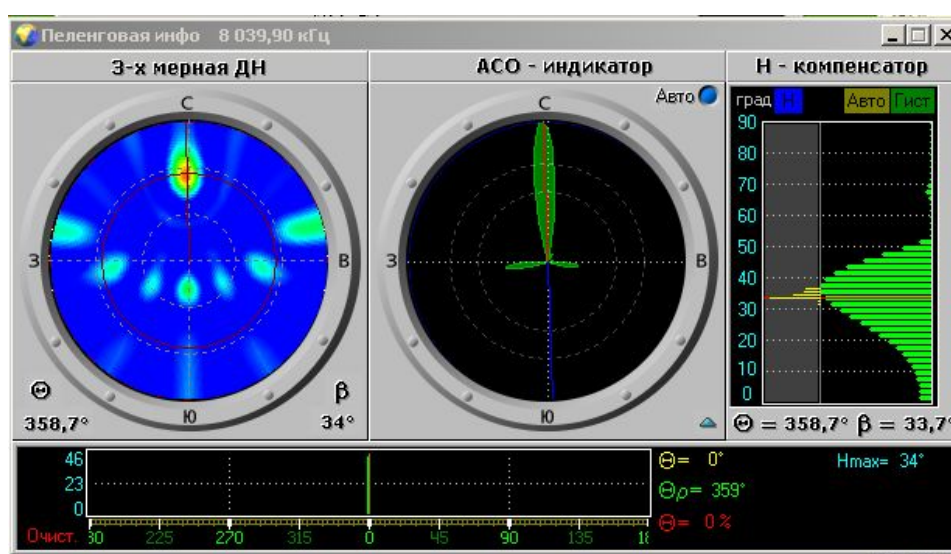
HF panoramic signal Detector–Direction Finder:

- Frequency band **1.5 - 30 MHz**
- Signal detection probability ($T=1$ s, $\Delta F_{scan}=10$ MHz, $SNR=10$ dB) **> 0.98**
- Probability of detection and direction finding of the following radio signals: with frequency hopping ($V=20\dots300$ jumps/s) while operating in frame mode of scanning **> 0.9**
- Scanning speed taking into account the spectral-statistical and spatial processing of signals detected (set by the operator):

Scanning speed, MHz/s	300	150	75	35	10
Frequency resolution, Hz	1,000	500	250	125	62.5
Averaging	3	3	3	3	2

- Signal minimum duration ($\Delta F_{scan}=2400$ kHz) **3 ms**
- DF accuracy (RMS)
 - Circular antenna array (9 elements) **1.0° RMS**
 - 2-coordinate linear array **1.5° RMS**
- Sensitivity by EM-field (3-30 MHz) **0.5...5 μ V/m**
- Radio channels sensitivity, $SNR=10$ dB **0.4 μ V**
- Real time BW of DF-detector **2400 kHz**
- Dynamic band for 3rd order intermodulation **> 85 dB**
- Capacity of digital channels ADC **16 bit**
- Dynamic range of received signal levels **> 120 dB**
- Side channel reception suppression **> 90 dB**
- Frequency relative non-stability **$0.5 \cdot 10^{-7}$**
- Duration of receiver synthesizer frequency tuning **0.2 ms**
- Frequency retuning step **100 kHz**
- Oscillator noises Fourier distribution (at 1 kHz tune-out) **-115 dBc/Hz**
- Received signal quality evaluation **RMS Θ / U dB μ V**
- Remote control **LAN Ethernet**

“Ukol-RK” station antenna pattern obtained from HF circular antenna array:



Master-Slave Direction Finder (option):

- Frequency band **1.5-30 MHz**
- Quantity of receiving channels **9 channel of direction finding**
1 channel of monitoring and registration

• Signal minimum duration	5 ms
• DF accuracy (RMS) (option)	1.0°
• DF sensitivity by EM-field (3-30 МГц)	0.5..3 μV/m
• Radio channels sensitivity, SNR=10 dB	0.4 μV
• Bandwidth of direction finding frequencies	8 kHz
• Dynamic band for 3 rd order intermodulation	> 85 dB
• Frequency resolution of signals detected	10 / 20 Hz
• Bearing diagram updating rate with Master-Slave DF	25 frames/s
• Bearing diagram updating rate with DF detector	1...5 frames/s
• Capacity of direction finder digital channels ADC	16 bit
• Dynamic range of received signal levels	> 120 dB
• Frequency relative non-stability	0.5·10⁻⁷
• Duration of receiver synthesizer frequency tuning and equalizing	60 ms
• Frequency retuning step	1 Hz
• Oscillator noises Fourier distribution (at 1 kHz tune-out)	-115 dBc/Hz
• Received signal quality evaluation	RMS Θ/U dB μV

HF equipment of detecting signals monitoring and registration:

• Frequency band	1.5-30 MHz
• Quantity of receiving channels:	1 channel of main receiver 1 channel of additional receiver
• Monitoring sensitivity by EM-field (3-30 МГц)	10..20 μV/m
• Radio channels sensitivity, SNR=10 dB	0.4 μV
• Direction pattern update rate (without executive direction finder)	1-5 frames/s
• Bandwidth	0.1 ... 8 kHz
• Relative frequency instability	0.5·10⁻⁷
• Dynamic band for 3 rd order intermodulation	> 90 dB
• Capacity of monitoring receiver digital channel ADC	16 bit
• Dynamic range of received signal levels	> 120 dB
• Side channel reception suppression	> 90 dB
• Frequency relative non-stability	0.5·10⁻⁷
• Duration of receiver synthesizer frequency tuning	3 ms
• Frequency retuning step	1 Hz
• Oscillator noises Fourier distribution (at 1 kHz tune-out)	-115 dBc/Hz
• Probability of signal automatic classification (SNR=10 dB)	> 0.9
• Duration of signal automatic classification	0.3 - 1.2 s
• Signal alphabet classifier	8 types of modulation
• Automated measuring of technical parameters (central frequency, bandwidth, FM/FCK frequency deviation, manipulation speed)	
• Manual measuring of technical parameters and demodulation *.wav signals	W-CODE

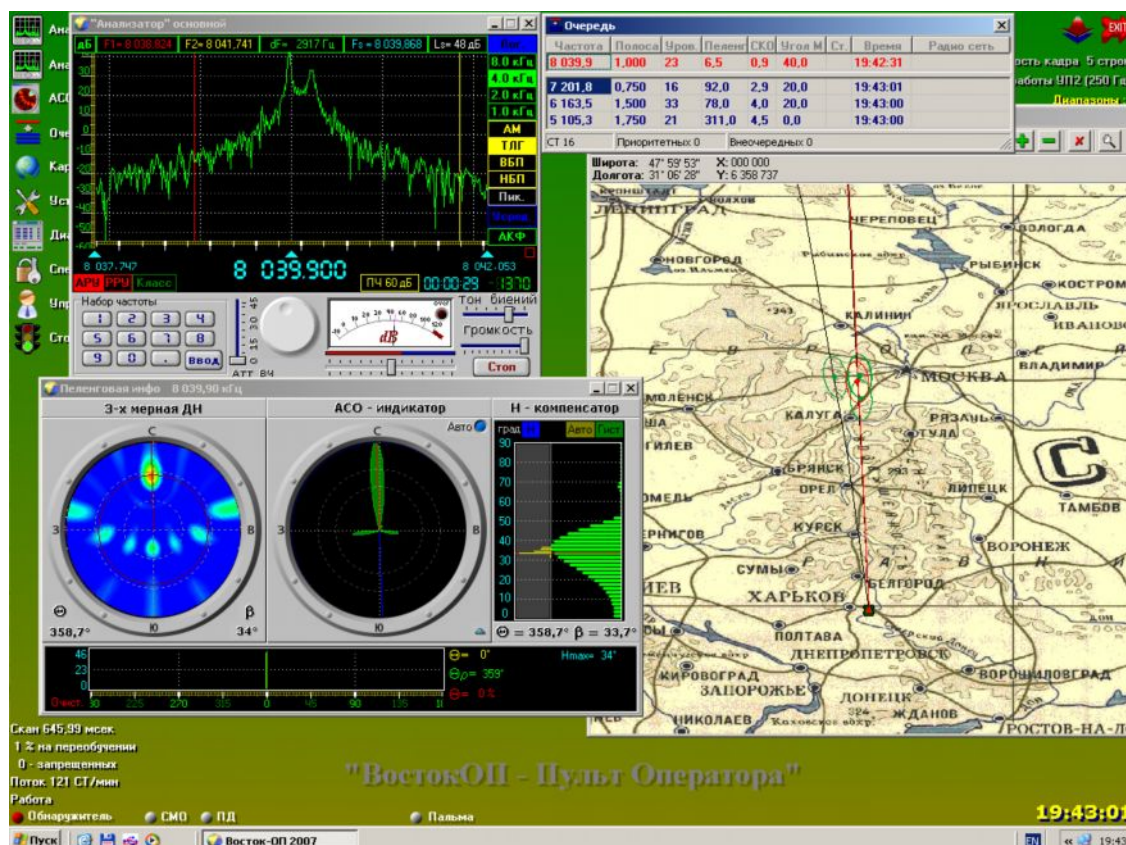
Main control functions:

- 1) Setting of operating frequency bands and list of priority frequencies,
- 2) Input and editing of lists of prohibited areas and fixed frequencies,
- 3) Selection of frequency resolution and averaging parameters (duration of scanning frame),
- 4) Input of parameters, according to which flow of requisitions are thinned out,
- 5) Handling of flow of requisitions (RESET/CALL, RESTORE, LOCATION, RECORDING),
- 6) Selection of preset fragments of a signal (interference) by means of F-cursors,
- 7) Control of station components through interfaces of instrument panels.

Main modes of display:

- 1) Display of downloaded panorama of controlled frequency band in co-ordinates: “azimuth – frequency” (in polar or rectangular co-ordinates), “amplitude – frequency”,
- 2) Display of spectrum shape and self-correlation function of analyzed signal,
- 3) Digital display of requisitions queue and parameters of detected RES and radio networks,
- 4) Display of results of automatic classification of signals and results of measurement of their parameters,
- 5) Display of monitoring area map with co-ordinates of detected RES and azimuth “fixes” of radars in direction finding network.

Desktop of HF operator’s panel of “Ukol-RK” station



GENERAL SPECIFICATIONS

- Power supply **single-phase 220V+15%, 50Hz**
- Station total power consumption (without consideration of life support systems):
 - without Master-Slave DF equipment **not more than 1,000 W**
 - with Master-Slave DF equipment **not more than 1,700 W**
- Duration of uninterrupted operation while power supply disappearance **not more than 10 min**
- Station total weight **not more than 700 kg**
- Operating temperatures range:
 - control board **+ 5° C ... + 40° C**
 - direction finder equipment **+ 5° C ... + 50° C**
 - antenna-feeder systems **- 40° C ... + 60° C**

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