



STATIONARY RADIO DIRECTION FINDING STATION OF HF FREQUENCY BAND “VOSTOK-RP”

Stationary direction finder “Vostok-RP” is designed for direction measuring to the source of radio emission operating in the frequency band 1 MHz – 30 MHz at the distance of up to 2000 km and more. Radio direction finder “Vostok-RP” provides measurement of azimuth and angle of signal radiowave arrival, it also can be used for position fixing of the source which bearing is being taken by SSL method (Single Station Location) by ionospheric radiowaves propagation.

Radio direction finding station “Vostok-RP”, that is currently produced, comparing to similar stations of previous generation provides the following additional functions:

- Receiving and efficient bearing taking of signals of steeply falling waves ($\beta > 60^\circ$) with left and right circular polarization due to implementing of multimode loop antenna elements;
- Continuous registration of signal I/Q-components over all direction finding channels for specifying bearing to the source in postponed mode;
- Possibility of remote control via LAN-channel and operatorless direction finding;
- Possess one additional reserve receiving section.

COMPOSITION

- Direction finding antenna feeder system (AFS), consisting of two circular antenna arrays (CAA) with diameters 120 m and 50 m, provides signal receiving in two frequency subbands: 1.0 MHz – 12 MHz and 12 MHz – 30 MHz. Each CAA contains 9 antenna elements:
 - vertical nonsymmetrical wideband monopoles of 12 m and 8 m height in the first and second subbands respectively;
 - symmetrical loop antennas (with quadrature HF-equipment and amplifiers with $K_u = 6$ dB) with height 8 m and 4 m in first and second subbands respectively;
- Unit of wideband input equipment and antenna switches;
- Multicircuit digital HF band receiver (10 channels) with unit of digital signal processing on the base of industrial computer Intel Core i7 ADLINK – rack of receiving and measuring device;
- Control and indicator board on the base of computer with two LCD-monitors;
- Operating control board;
- Equipment of data transceiving (supplied by Customer);
- System of time synchronization based on navigation receiver GPS-18;
- Unit of field heterodyne generating discrete frequency grid (0.5 MHz and 1 MHz) of supervisory signal is used for measuring instrumental accuracy of radio direction finder;
- Power supply system (power distribution board, UPS, line regulator 220 V),
- Complete set of HF feeders, connecting cables and accessories;
- Complete set of operational and maintenance documentation.

Notes:

1. Type of direction finding AFS (loop and monopole) is selected by Customer.
2. Radio direction finder is connected to communication channel of Customer.

MAIN PECULIARITIES

Unit of wideband input devices and switching

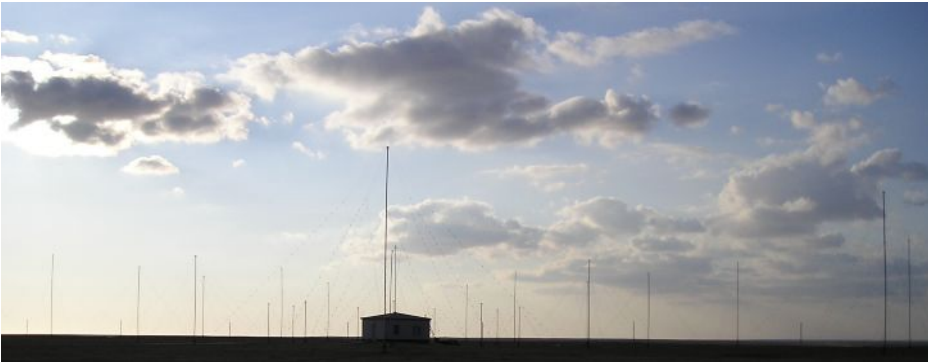


Rack of receiving and measuring device



- Widebase antenna system of radio direction finder provides its high performance in interferential fades of signals.
- Reception and bearing taking of signals with vertical and elliptical polarization with left and right rotation of field vector.
- Simultaneous azimuth and angle of radiowave arrival measurement makes it possible to fix source position from single point (SSL method) with indication on the map.
- Distance fixing to radio emission source by SSL method implementing ionosphere forecast (error of distance fixing comprises $\Delta D \leq 20\%$)
- Easy training and operating by attending personnel.
- Modular composition of station equipment.
- Built-in control system and failure diagnostics.
- Computer-aided station control by the interface presented by virtual panels.
- Continuous signal registration to computer HDD provides a possibility of playback and direction finding in unreal time mode for short-term signals and signals with low quality of reception.

General view of RDF “Vostok-RP” station deployment



WS of operator



External view of monopoles of DF AFS of “Vostok-RP” station



Additional HF-circuits are provided in the equipment of RDF station in order to double efficiency of processing commands for bearing taking; second receiving and measuring device with a possibility of independent control over frequency subbands of AFS can be connected to them.

In RDF station “Vostok-RP” bearing samples obtained by operator are always marked with time markers coming from channel of precise time second markers of GPS system, this significantly increases direction finding data validity and provides a possibility to automate source coordinates computation within integrated network.

External view of loop antenna elements of direction AFS of “Vostok-RP” product (I and II frequency subbands)



Antenna elements type selection of direction finding arrays depends on radio paths of sources those bearings are to be taken, for example:

1) to take bearings of source with radio path of 60° elevation angle (distance more than 400-500 km) it is recommended to use vertical wideband monopoles with the height 12 m and 8 m for frequency bands 1.0 MHz – 12 MHz and 12 MHz – 30 MHz respectively.

2) to take bearings of source with radio path of elevation angle exceeding 60° (distance less than 400-500 km) or up to 85° (distance up to 100 km) it is recommended to implement active crossed loops with three modes of reception:

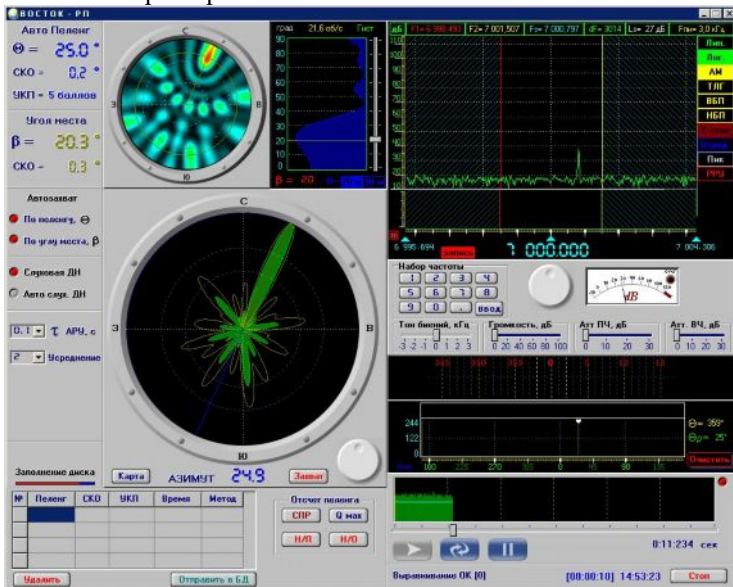
- loop with left polarization,
- loop with right polarization,
- wideband monopole (“monopole”).

Research revealed efficiency of variation of polarization modes in the loop especially in the case of receiving steeply falling radiowaves, correctly chosen polarization increases signal level at receivers input up to 20 dB and provides stable direction finding even at the distance of 30 km by ionosphere radiowave ($\beta=85^\circ$). Possibility of selecting “monopole” mode in loop antenna is efficient in case of receiving remote stations at the same time loss in efficiency comparing to full size monopole (height 8...12 m) is insignificant as far as loop elements are actively balanced with lead-in feeder.

RDF station “Vostok-RP” along with a mode of automatic bearing sampling involving spectrum and correlation processing of spatial channels reception has also traditional indication mode of ASL patterns (amplitude sector look), that was used for bearing measuring at RDF stations of previous generations.

Implementation of spatial FFT signal processing provides a possibility to take bearings of several radio emission sources signals of those are in the receiving band with overlapped spectra.

Desktop of operator’s board of RDF station “Vostok-RP”



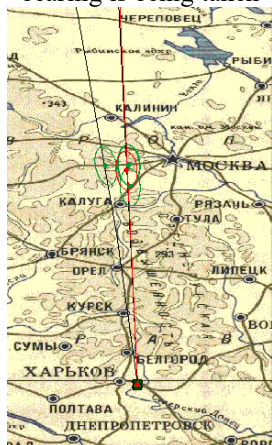
Modes of indication:

- Signal amplitude spectrum
- ASL pattern (two-dimensional)
- 3D ASL pattern
- H-histogram (antenna pattern in elevation plane)
- Polyphase raster of correlation interferometer (divides signals with overlapped spectra)
- Histograms of bearing samples (“coarse”: -180°...+180°; “accurate”: -15°... Θ_{RES} ...+15°)
- Oscillogram of RES signal by time
- Map with bearing lines to RES and results of position fixing by SSL method with ionosphere forecast

TECHNICAL PARAMETERS

Operating frequency band	1.0 MHz – 30 MHz
Polarization	vertical, circular (“left”/“right”)
Method of automatic bearing taking	correlation interferometer
Method of diagrammatic (visual) direction finding:	Amplitude sector look
Error of bearing measurement Θ from 0° to 360°:	
in the frequency band 1 MHz – 3 MHz	< 2° (RMS)
in the frequency band 3 MHz – 30 MHz	< 1° (RMS)
Error of elevation angle measurement β within 20°...85° boundaries:	
in the frequency band 1 MHz – 3 MHz	< 5° (RMS)
in the frequency band 3 MHz – 30 MHz	< 3° (RMS)
Error of position fixing implementing SSL method (when $K_v = \sigma$)	20% from distance to RES
Sensitivity (depending on frequency):	
monopole antenna array	0.2 - 3 μV/m
loop antenna array	0.3 - 5 μV/m
Spatial selectivity of interference stations signals	10...15 dB
Sensitivity radio circuits (SNR=10 dB)	0.3 μV
Dynamic range by third order intermodulation	> 85 dB
Resolution of digital ADC circuits	16 bit
Relative frequency instability	$0.5 \cdot 10^{-7}$
Digital resolution of signals	10 and 20 Hz
Minimal duration of signals those bearings are being taken	5 ms
Dynamic range	not less than 120 dB
Frequency bandwidth (20 Hz adjustment)	0.03...8.0 kHz
Accuracy of bearing sample timing	± 10 ms
Continuous signals recording, HDD space consumption	4 Mb/hour
Data throughput rate (depending on transmission type)	2...5 RES/min
Visual bearing indication by numbers of radionet correspondents	present
Remote control	LAN (FOCL channel)
	Main HF channel
	not more 800 VA
Consumed power	
Operating temperature range:	
equipment and operator board	+5 °C ...+ 40 °C
antenna system	- 40 °C...+ 65 °C

Coordinates indication (using SSL method) of the source which bearing is being taken



RDF station “Vostok-RP” along with the mode of automatic bearing sampling implementing spectral and correlation processing of spatial receiving channels has traditional mode of indication ASL patterns (automatic sector look) used for bearing measuring at the station of previous generation.

Implementation of different direction finding methods (amplitude and correlation interferometer) and also combination of data pickup methods (automatic, visual, audio) validates direction finding information about signal under the most difficult conditions of HF band receiving.

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