

MOBILE STATION OF COMINT AND DF SIGNALS VHF-UHF FREQUENCY «SCORPION-M»



*External view of station “Scorpion-M”
on vehicle Skoda Octavia A5 «Scout»*



*External view of station “Scorpion-M”
on vehicle Ford Transit 330*

MAIN FEATURES

- Panoramic scanning with signal detection and bearing taking in the frequency band from 25 MHz to 3000 MHz with a rate of up to **15 GHz/sec**
- Coverage range within radio visibility: **up to 20-30 km** in the frequency band 25 – 500 MHz and **up to 5-10 km** in the frequency band 500 – 3000 MHz
- **Simultaneous detection-direction finding of signals within the frequency band and executive direction finding on fixed frequencies**
- Automatic detection and direction finding of radio sources of state-of-art radio communication systems (satellite communication lines **Turaya** and **Iridium**) including FH (**V=10 – 2000 hopping/s**), basing on **correlation and vector method**
- Bandwidth of simultaneous frequency scanning for detection-direction finding **10 MHz**
- Coordinates computation of radio sources implementing **triangulation method** with coordinates display on the background of electronic map of the region
- Analysis and digital registration of IF (**with frequency bandwidth of 3 MHz**) and LF signals
- Audio and visual control of detected signals
- Informational interaction within direction finding network with work synchronization by signals coming from GPS navigation system
- **Direction finding of mobile telephones GSM 900/1800 MHz** under control of a Customer «catcher»

GENERAL INFORMATION

VHF-UHF mobile station of radiomonitoring “Scorpion-M” is designed for detection, direction finding, audio and visual control and for registration of radio sources signals in the frequency band 25 – 3000 MHz.

VHF-UHF station “Scorpion-M” provides scanning of preset frequency subbands or frequency lists, spatial search and position fix of radio sources by surface radiowaves with vertical polarization.

Equipment of “Scorpion-M” is installed inside a vehicle provided by a Customer (microbus or passenger vehicle). High-speed panoramic detector-direction finder of VHF-UHF frequency band, executive direction finder of VHF-UHF frequency band, operator’s workstation equipped with Notebook and communication equipment.

VHF-UHF antenna feeder system of detection, direction finding, tracking and communication is installed on the roof of the vehicle in radioparent automobile cargo box.

Navigation equipment (GPS-receiver) together with equipment of radio communication provides possibility of synchronous operation of mobile stations “Scorpion-M” within direction finding network both in slave and master modes and in the mode of operation under control of stationary network “Barvinok”.

System is powered from vehicle board electrical system or from accumulators in autonomous mode and from industrial one-phase AC line with voltage 220 V, frequency 50 Hz when operating on stationary position.

Station “Scorpion-M” is serviced by single operator. Software of the station is developed implementing state-of-the-art computing technologies and functions under OS Windows 7. Operating of equipment doesn’t involve high qualification and special knowledge of operator due to graphical interface (virtual board panels) and built-in diagnostics system allows determination of equipment failure up to replacement assembly.

Detector-direction finder of “Scorpion-M” station belongs to the class of systems with spatial signal processing and provides signal detection by its spatial features together with assessment of direction to signal source implementing vector and correlation method of bearing computation.

Station “Scorpion-M” provides **simultaneous implementation of detector-direction finder and executive direction** for successful **bearing taking of all sources** on detected frequency. Possibility of configuring detector-direction finder in power mode (for high scanning rate) or mode of spatial (detection with bearing measuring) detection of signal working frequency is also available.

Listening to the signal is done by operator via audio control section of executive direction finder of “Scorpion-M” station.

Antenna system of VHF-UHF band consists of two ring arrays each containing seven antennas covering frequency subbands: 25-1000 MHz and 1-3 GHz respectively. Frequency subband 1-3 GHz is converted into frequency subband 300 – 800 MHz using VHF-UHF converter for the following processing.

Receiving system of the station is based on 20-1000 MHz frequency band receiver with two independent two-channel sections of analogue and digital processing. Tasks of digital processing are solved by 4-channel section with 16-bit ADC, FPGA Cyclone 3 and DSP Analogue Devices under control of operational routine of Notebook.

In “Scorpion-M” station it is possible to configure detector-direction finder as a second post of executive direction finding for simultaneous operation in manual mode and command-executive mode within direction finding network. Final composition of station “Scorpion-M” is selected in conference with Customer.

PURPOSE

Mobile station of radio monitoring of VHF-UHF frequency band “Scorpion-M” is designed for solving the following tasks:

- Monitoring of radio electronic environment of the area within radio visibility of up to 20-30 km in the frequency band of 25-500 MHz and up to 5-10 km in the frequency band of 500-3000 MHz;
- Search, detection, direction finding of new sources within preset frequency subbands of VHF-UHF band (25–3000 MHz) (including signals of satellite communication lines Turaya, Iridium);
- Scanning of preset frequency channels by the list;
- Signal express-analysis and audio control of detected sources;
- Registration of signals in digital form on audio and intermediate frequencies;
- Automated processing and logging of radio electronic environment data;
- Coordinates determination of source position and displaying them on the map;
- Parameters and modes managing, information collection from slave stations of direction finding network;
- Informational interaction with stations from the composition of direction finding network via GSM radio channel ;
- Interaction with Customer “catcher” when searching mobile telephones GSM 900/1800 MHz.

COMPOSITION

- 1) VHF-UHF direction finding antenna-feeder system consisting of two antenna arrays, each containing seven elements (25-1000 MHz and 1-3 GHz);
- 2) Radioparent automobile cargo box of Thule Pacific 200 type;
- 3) Omnidirectional antenna by azimuth of VHF band of surveillance equipment (active monopole,
- 4) Two-channel converter of frequency band 1-3 GHz – 2 pcs;
- 5) Receiver (20-1000 MHz frequency band) with two independent two-channel sections of analogue and digital processing;
- 6) Operator’s board based on Notebook (Intel Core i7 or latest);
- 7) GPS-receiver with antenna;
- 8) Electronic compass;
- 9) Equipment of data receiving\transmitting (telecode communication modem, UHF-radiostation, antenna);
- 10) GSM-modem (3G/GPRS, 900/1800 MHz);
- 11) Power supply system consisting of:
 - Power distribution board;
 - Notebook adapter;
 - Station power supply unit;
 - Accumulators (2 pcs);
 - Cables of power supply system;
- 12) Complete set of connecting cables and RF-feeders;
- 13) Complete set of spare parts and accessories including field heterodyne DG-20M (30-1000 MHz), DG-33M (1-3 GHz);
- 14) Operational documentation (Operating Instruction and Special Instruction. User Guide);

Note. Vehicle must be selected by the Customer by agreement with Manufacturer. Size of the roof of the vehicle must not be less than 1.5x2.5m, there must be an access to rear section of the vehicle.

TECHNICAL PARAMETERS

Panoramic detector-direction finder:

- Operating frequency band 25-3000 MHz
- Bandwidth of simultaneous frequency scanning/look 2.5 / 10 MHz
- Instrumental frequency scanning rate with processing of detected signals:

Frequency resolution FFT, kHz	3.125	6.25	12.5	25	50	100
Instrumental detection rate with direction finding, GHz/sec	2.0	3.75	6.5	10.5	14.2	15.0
Instrumental detection rate without direction finding, GHz/sec	7.0	11.5	17.0	18.7	19.6	20.0

- Instrumental error of signal bearing taking*:
 - within 25-200 MHz frequency band 5.0° (RMS)
 - within 200-1000 MHz frequency band 2.0° (RMS)
 - within 1000-3000 MHz frequency band 2.0° (RMS)
- *- on vehicle Ford Transit 330
- Sensitivity by electromagnetic field (BW=12.5 kHz):
 - in the frequency band 25-200 MHz with 5.0° RMS 10-40 μV/m
 - in the frequency band 200-1000 MHz with 3.0° RMS 5-15 μV/m
 - in the frequency band 1-3 GHz with 3.0° RMS 10-30 μV/m
- Instrumental probability of detection and bearing taking of one-shot signal with 5 msec duration in BW 10 MHz > 0.9
- Minimal duration of signal to be detected and its bearing to be taken 2 msec
- Sensitivity of radio receiving sections (SNR=10 dB, BW=12.5 kHz) < 1.0 μV
- Dynamic range with respect to the third order intermodulation: > 75 dB
- Dynamic range of received signal levels > 120 dB
- Suppression of spurious receiving channels > 80 dB
- Relative frequency instability ±2·10⁻⁷
- Receiver frequency synthesizer tuning time <200 μsec
- Density of heterodyne spectral noise (with 25 kHz detuning) – 100 dBsec/Hz
- Quality assessment of direction finding and signal receiving RMS Θ/U dBμV

Executive direction finder:

- Operating frequency band 25-3000 MHz
- Instrumental error of signal bearing taking *:
 - within 25-200 MHz frequency band 3.0° (RMS)
 - within 200-1000 MHz frequency band 1.0° (RMS)
 - within 1000-3000 MHz frequency band 2.0° (RMS)

*- on vehicle Ford Transit 330

- Sensitivity by electromagnetic field (BW=12.5 kHz):
 - in the frequency band 25-200 MHz with 5.0° RMS 3-25 μV/m
 - in the frequency band 200-1000 MHz with 3.0° RMS 1-3 μV/m
 - in the frequency band 1-3 GHz with 3.0° RMS 2-5 μV/m
- Signal bearing taking in bandwidth 2.5...3000 kHz
- Signal demodulation for listening in frequency bandwidths:
 - SSB 2.5 kHz;
 - CW, AM 2.5; 6; 10; 12 kHz;
 - NFM 6; 10; 12; 18; 25 kHz;
 - WFM 100; 150; 280 kHz
- Receiving and signal registration in frequency bandwidth 2.5...3000 kHz
- Sensitivity of radio receiving channels (SNR=10 dB, BW=12.5 kHz) < 1.0 μV
- Dynamic range with respect to the third order intermodulation > 75 dB

- Dynamic range of received signal levels **> 120 dB**
- Suppression of spurious receiving channels **> 80 dB**
- Relative frequency instability **$\pm 2 \cdot 10^{-7}$**
- Receiver frequency synthesizer tuning time **< 200 μ sec**
- Density of heterodyne spectral noise (with 25 kHz detuning) **- 100 dBsec/Hz**
- Quality assessment of direction finding and signal receiving **RMS Θ/U dB μ V**
- Total duration of continuous signal record to HDD with frequency bandwidth 300 kHz **is defined by capacity HDD (300 Gb – 180 hours)**

Equipment of tracking and signal registration (optional):

- Number of receiving channels of tracking/receiving **1**
- Operating frequency band **20-3000 MHz**
- Sensitivity in audio section when receiving NFM signal (frequency of modulation 1 kHz, deviation 5 kHz, SNR=10 dB, BW=12 kHz):
 - within 25-100 MHz frequency band **15-25 μ V/m**
 - within 100-1000 MHz frequency band **3-15 μ V/m**
 - within 1000-3000 MHz frequency band **15-25 μ V/m**
- Sensitivity (SNR=10 dB, BW=12 kHz) **0.7 - 1 μ V**
- Dynamic range with respect to the third order intermodulation **> 60 dB**
- Dynamic range of received signal levels **> 100 dB**
- Automatic frequency tuning by commands coming from detector **available**
- Receiver frequency synthesizer tuning time **< 30 msec**
- Frequency tuning step **1-10 Hz**

General parameters

- Total power consumption from DC network **< 160 W**
- Duration of operation from completely charged accumulators **more than 8 hours**
- Operating temperature range for equipment:
 - installed inside a vehicle **+ 5° C ... + 40° C;**
 - antenna-feeder system **- 30° C ... + 60° C.**



Rear view of "SCORPION-M"



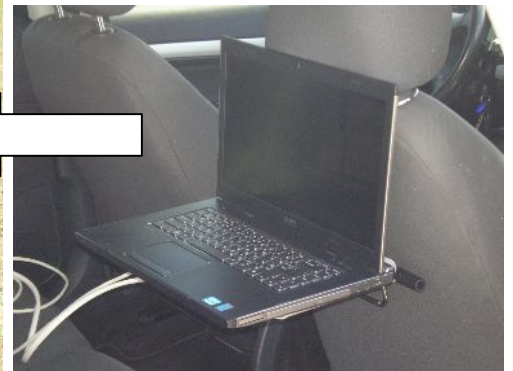
Arrangement of "SCORPION-M" equipment inside a vehicle

Arrangement of "SCORPION-M" equipment

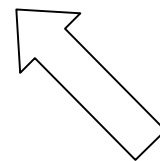
Direction finding AFS



Operator's work place



*Power station
HONDA (2.0 kBm)*



Two two-channel receivers of detector-direction finder and executive direction finder

MODES OF OPERATION

- **Initialization:** serviceability check of equipment after powering it, setting of initial parameters and tasks for searching: operating frequency subbands, sector by azimuth, list of prohibited segments and fixed frequencies, lists of priority and extra frequencies, FFT frequency resolution, and averaging parameters (scanning frame duration), adaptive threshold by levels of signal detection; selection of set frequency fragments using F-cursors for further work, minimal duration of signal to be detected, configuring of position fix system.
- **Autonomous:** automatic search, detection and bearing taking of radio sources signals; processing of requests queue of detector-direction finder by operator, audio control, direction finding and registration of detected signals, collecting and processing of bearing information coming from slave stations (when operating in the direction finding network).
- **Remote control:** automatic direction finding by commands coming from master station, sending of bearing information by request from master station.
- **Testing:** station serviceability check and automated search of faulty unit by the system of built-in control.

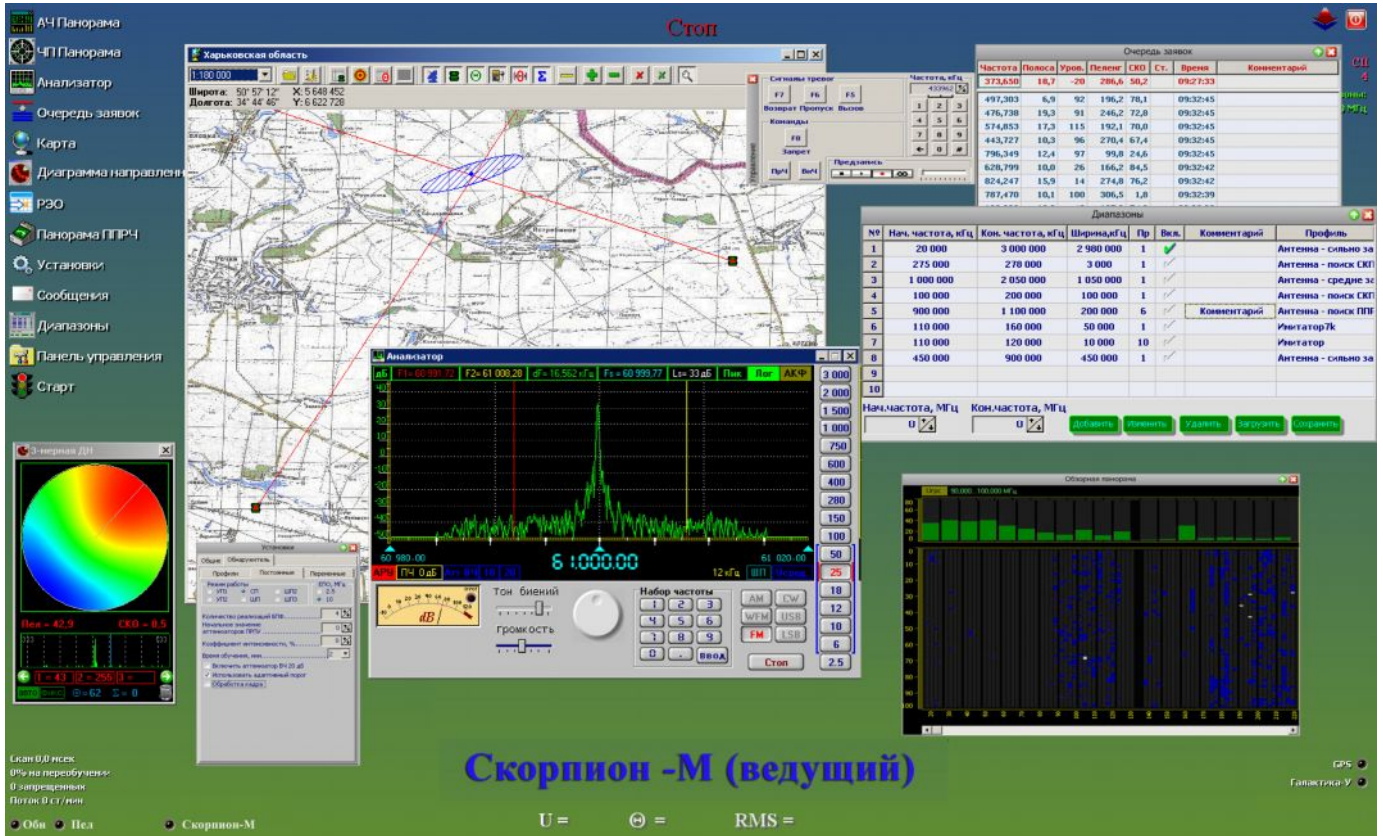
SYSTEM OF STATION CONTROL

- Generating and operational correction of the task by operator.
- Control over detector-direction finder, executive direction finder and tracking equipment in accordance with a task for providing radiomonitoring.
- Receiving and registration of panoramic analysis and direction finding results.
- Automatic processing of requests queue accounting for frequency priority and azimuth sector look.
- Automatic control of tracking section according to priority of frequency processing, analysis band selection and duration of signal registration.
- Display on the background of the map of detection and direction finding results.
- Display of registered signal spectrum in coordinates: amplitude-frequency and time-amplitude frequency in real time mode.
- Time fixing of signal detection and registration in the common timing network of navigation system GPS.
- Generating of databases of detected and registered source signals.
- Interface of interaction with receiver – LAN (1 Gbps).
- Interface of interaction with tracking receiver – USB 2.0.
- Interface of interaction with mobile stations “Scorpion-M”– GSM (9.6 kbps) or FM (1200 or 4800 kbps) via radio channel.

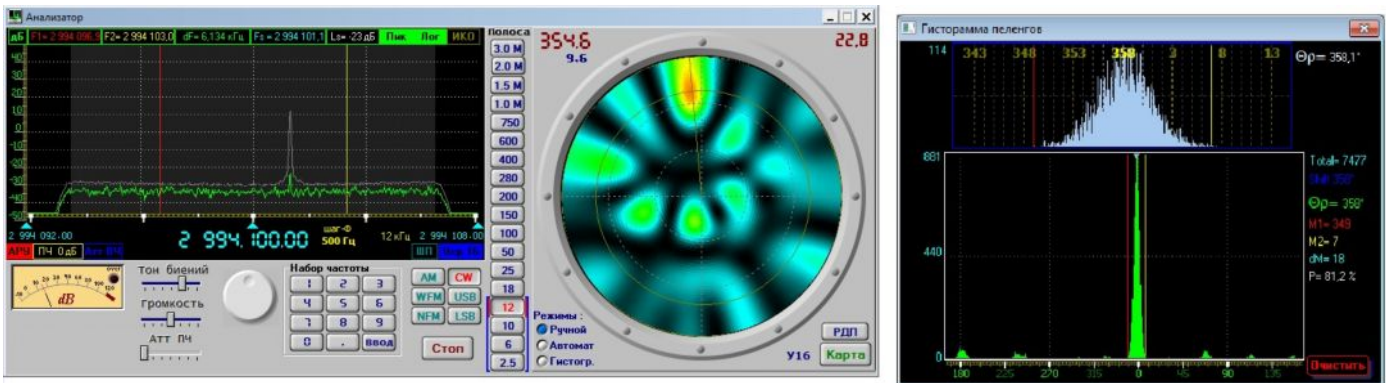
MODES OF INDICATION

- Indication of load panorama of undercontrolled frequency band in coordinates: “azimuth-frequency” (in polar or Cartesian coordinates), “amplitude-frequency” and “time-amplitude-frequency”.
- Indication of spectrum shape and autocorrelation function of analyzed signal.
- Digital indication of requests queue and parameters of detected radio sources and radio networks.
- Display of results of technical signal parameters measurement.
- Display of the map of undercontrolled area with coordinates of detected radio sources and lines of bearings of stations from the composition of direction finding network.

Operator's board of "Scorpion-M" station



Example of measuring the sensitivity of an effective direction finding



«Scientific-Engineering Center of Radio Engineering System of Applied Radioelectronics Academy of Science» Ltd.

7/8, sq. Zashchynkiv of Ukraine, Kharkov City, Ukraine, 61001

+38 (057) 732-25-53, +38 (057) 732-68-63

E-mail: ntcrts@kharkiv.com www.ntcrts.com