IRCOS JSC

ARGAMAK-M

PANORAMIC RADIO RECEIVER

ИРКОС

Fax: +7 (495) 615-7302, Phone: +7 (495) 615-0838, 615-0810

ARGAMAK-M

Panoramic Radio Receiver

(compact solution and great potential)

ARGAMAK-M Panoramic Radio Receiver

FEATURES AND ADVANTAGES

Optimized weight and dimensions:

- Volume: about 1 dm^3;
- Max. weight: 1.5 kg

Low energy consumption:

- 10 W, max.

High efficiency:

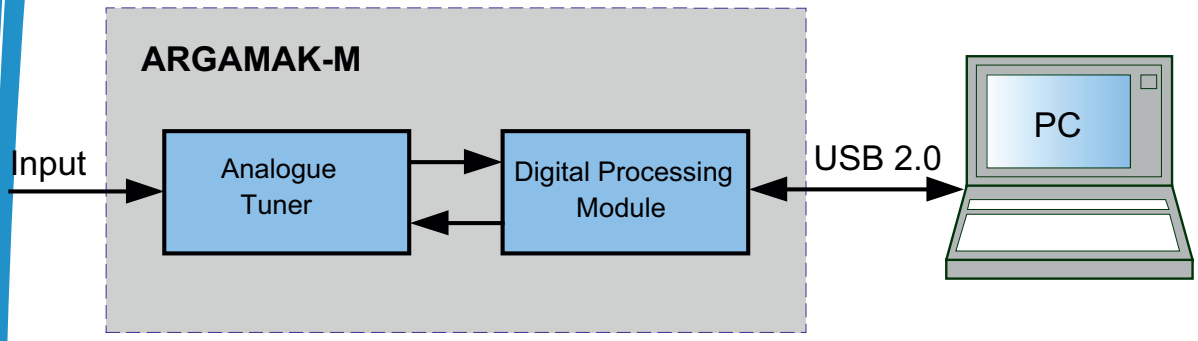
- MHz/s within the operating frequency range;
- Up to 200 GHz/s within 8 MHz processing band

Multifunctional performance, Software Defined Radio (SDR) design approach:

- Outdoor and indoor radio monitoring (9 kHz – 18 GHz)
- Manual direction finding incl. GSM / CDMA / TETRA / WiFi / WiMax (0.3 MHz…18 GHz)
- Analysis of wireless communication and data transmission system signals incl. GSM/CDMA/TETRA
- Analysis of DVB T/H digital TV signals
- Detection and position finding:
  - Standard UHF radio equipment,
  - GSM / CDMA / TETRA / WiFi / WiMax transmitters
  - VSAT C, VSAT Ku surface transmitters
- Radio signal recording and technical analysis.

DESIGN APPROACH, DETAILS AND PERFORMANCE FIGURES

Digital panoramic radio receivers (DPRR) are now becoming more and more popular in radio monitoring applications. The typical design approach for such receivers is Software Defined Radio (SDR). In this approach, the digitized radio signals are converted into a required format by digital signal processors or programmable logical integral circuits under a firmware control. A typical block diagram of such DPRR is shown on the picture below.

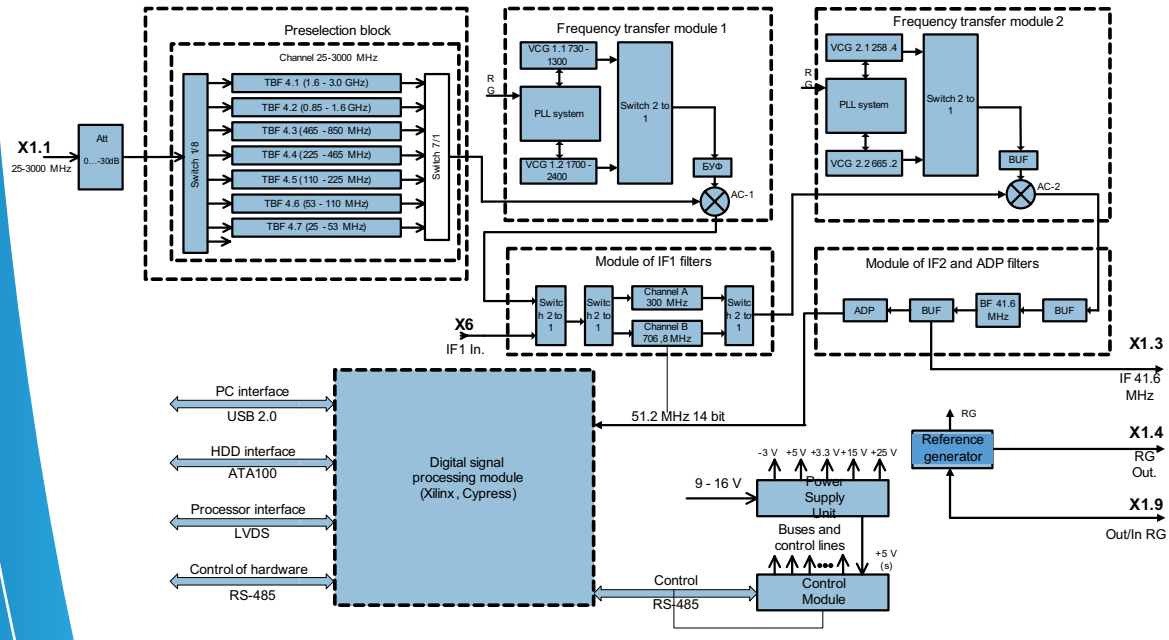


IRCOS, Russian Research & Production Company, is well-known both in Russia and abroad as a designer, developer and manufacturer of the digital radio receivers (DPRR) which ensure high performance at low energy consumption, light weight and small dimensions. The company products are intended for the following tasks and applications:

- Automated radio monitoring, direction finding and localization of radio emitters indoors and outdoors
- On-air measurement of radio equipment parameters and coverage areas
- Data leaks prevention monitoring
- Scanning of stray electromagnetic radiation and cross talks.

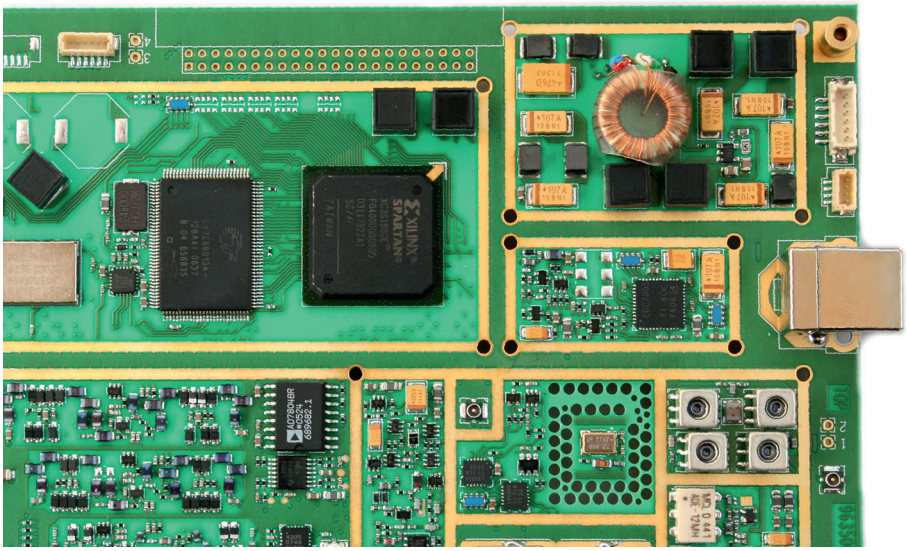
ARGAMAK-M is one of the latest models in our DPRR product line.

When ARGAMAK-M was being developed, the key target for our engineers was to reduce the weight and dimensions of that receiver and make it more convenient for handheld operations. All this should be achieved without prejudice to performance and efficiency typical for ARGAMAK product line: high rate of spectrum analysis,



ARC-CPS1 Structural Diagram

info@ircos.ru



ARC-CPS1 Printed Board

linear radio receiving path, suppression of interferences from spurious channels, demodulation quality.

To minimize ARGAMAK-M dimensions, it was decided to install the digital and analog components of the receiver on the same board. It was a difficult task and it took a lot of efforts to achieve electromagnetic compatibility of the analog and digital elements. Despite of all this, we succeeded in two tasks: we seriously improved equipment weight and dimensions and we ensured a very low level of spurious signal feedthrough – it was almost the same as in other receivers of that product line.

The basis of ARGAMAK-M receiver is ARC-CPS1 module which consists of a single board comprising both signal analog converter and digital part of the circuit. The signal analog converter is based on a superheterodyne with two frequency converters and tracking filters in a preliminary selection module. It ensures receipt of radio signals within the range from 9 kHz to 3000 MHz which can be extended up to 18 GHz if an external converter is connected. The analog converter produces the output signal at 41.6 MHz intermediate frequency. Pre-selection filters, synthesizers and other converter components are set up via RS-485 control bus.

The digital processing is also designed using SDR approach and is based on XILINX XC3S1600E field programmable logic devices and CYPRESS CY7C68013A control processor with USB 2.0 interface. Signal digital processing functions depend on the software loaded. Fully assembled ARC-CPS1 on the single board includes about 1500 elements.

Specifications

Operating frequency range, receiving mode:	
• Basic configuration	0,009 – 3000 MHz
• with ARC-KNV3M available	0,009 – 8 000 MHz
• with ARC-KNV4M available	0,009 – 18 000 MHz
Processed frequency bandwidth	up to 8 MHz
Panorama rate (with 6.25 kHz discreteness) within the operating frequency range	3.5 GHz/s, min
Minimal length of the detected signal within the simultaneous analysis band (w/o receiver re-tuning)	1 μs min.
Intermodulation free dynamic range (3rd and 2nd order)	75 dB, min
Receiver tuning resolution	0.1 Hz
Internal battery power supply	Yes
Vehicle power supply	10 - 32 V

AC network power supply	90 - 250 V
Continuous battery run-time for basic configuration, depending on total battery capacity	2 … 8 hours
Receiver weight (with batteries)	1.5 kg, max.
Receiver dimensions, max.	110 x 60 x 240 mm
Operating temperature range with control & display unit connected	-20°C … +55°C

Fast response time of the digital receiver component is achieved by up-to-date components and effective data processing algorithms.

In particular, when sampling frequency is 12.8 MHz and N (FFT) = 512 complex points, the spectrum frequency discreteness will be:

$$\Delta f = 12.8 \text{ MHz} / 512 = 25 \text{ kHz},$$

whereas the time sample length will be:

$$\Delta t = 512/12.8 \text{ MHz} = 40 \text{ μs}.$$

With this, within one second n = 1/Δt = 1/40 μs = 25000 spectra will be calculated. It means that when the band pass ΔF=8 , the spectrum analysis rate will be:

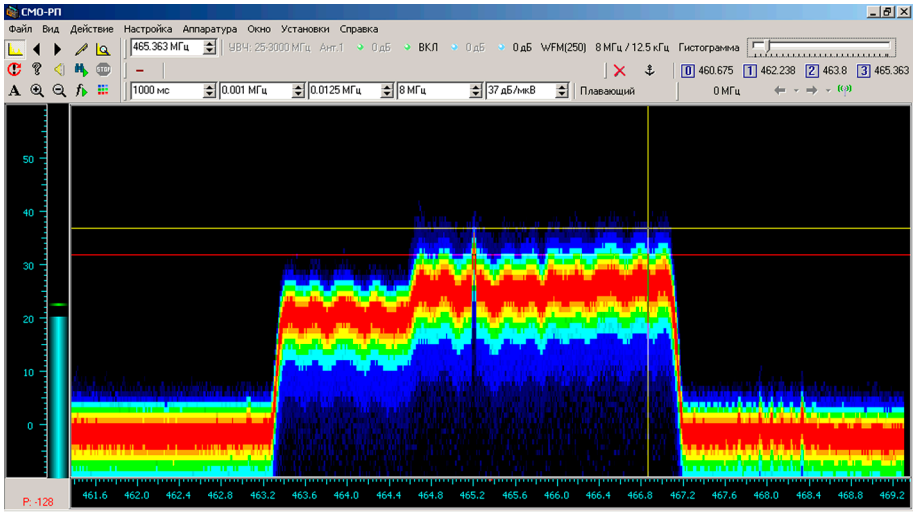
$$V = \Delta F*n = 8*25000 = 200 \text{ GHz/s}.$$

Operator physically cannot read the data with the rate of 25000 spectra per second. Therefore, all data received in the real time mode, should be statistically preprocessed (averaging, search for maximums, calculation of two-dimensional probability density). After such preparation, the radio environment data will enable displaying of the signals that were not visible in the typical spectrum viewing mode.

Analysis of spectrum in the real-time mode and presentation of data as spectrum components probability density (probability spectrum) allows to securely detect and differentiate between different packet signals (WiFi, BlueTooth) within a single band. Also, it enables finding non-system interferences in broadband data transmission signals

If the FFT is reduced by 32 complex points, the sampling duration will be reduced by 2.5 μs. It allows to detect radar stations pulse signals up to 1μs long when evaluating spectral density by means of periodograms with 50% overlapping.

For panoramic spectrum analysis in the frequency band above the simultaneous processing band, the analog radio signal converter will be re-tuned to the required frequency. When the average synthesizer re-tuning time is 2 μs and when the spectrum discreteness is 6.25 kHz, the panoramic receiver analysis rate is min. 3.5 GHz.



Narrow Bahd Interference with 465.2 MHz Frequency Appeared within CDMA Signal Band

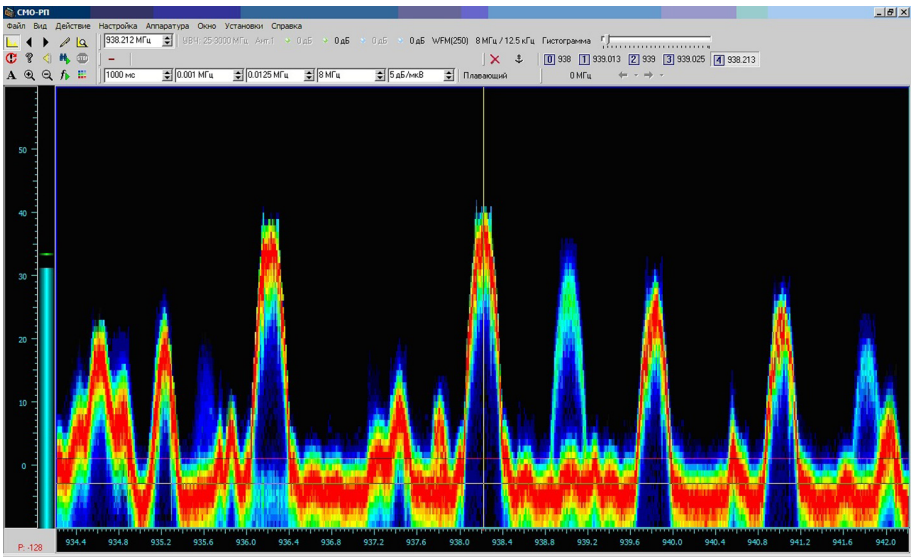
APPLICATION OF ARGAMAK-M DIGITAL RADIO RECEIVER

ARGAMAK-M digital panoramic receiver is a universal radio monitoring device that can be used as stationary, mobile and handheld equipment. ARGAMAK-M can receive spectra in the real time mode without any signal skipping and thus it can be used for detection and direction finding of the short signals up to several μs long including those at the same frequency. The application software included into supply package is developed for the following tasks:

- Radio monitoring and radio signal parameters measurement
- Field strength measurement
- Coverage area plotting
- Amplitude radio signals direction finding including wireless broadband radio signals
- Analysis of GSM and CDMA base stations
- Emitter coordinates finding
- Digital TV signal analysis
- Radio signal recording and technical analysis.

Radio Monitoring and Radio Signal Parameters Measurement

For radio monitoring applications, including radio signal parameters measurement and search of emitters, the following software is available: SMO-RP, SMO-PAI, SMO-ASPD, SMO-KN, SMO-BS1, SMO-BS2, SMO-BShRD, SMO-STA, SMO-STA2, SMO-DX. These programs enable operation both in the real-time mode and in the post-processing mode.



GSM Base Station Spectrum Displayed in SMO-RP Software Package

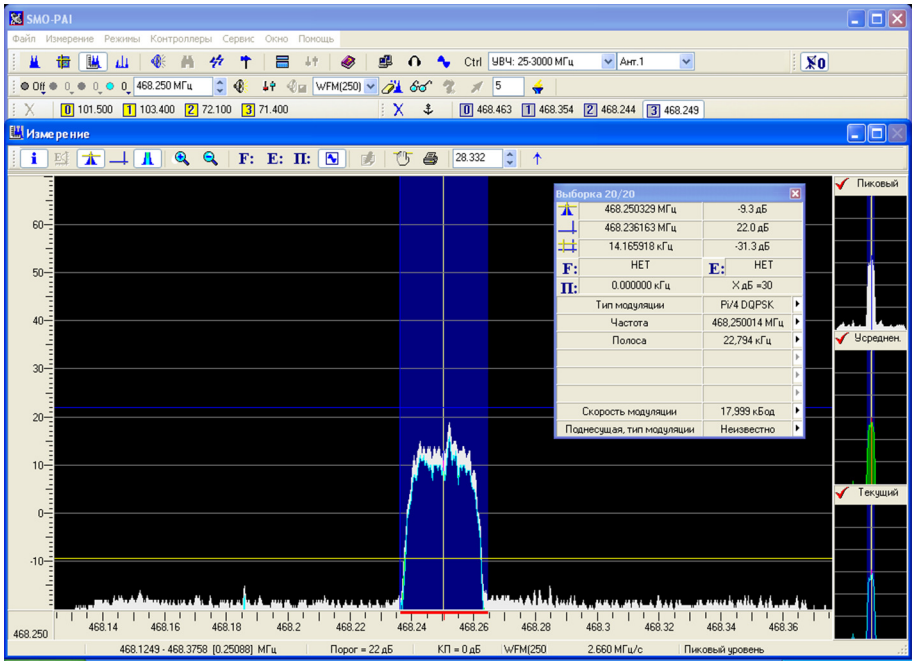
The programs ensure automated measurement of basic signal parameters with reference to the time and geographic coordinates including field strength measurement, signal frequency, definition of modulation types and parameters. Metrological data of ARGAMAK-M software and hardware are tabulated below.

Radio Signals Measurement Errors

Sinusoidal signal level, max.	3 dB 1.5 db with calibration
Non-modulated signal and AM-signal frequency, max.	5×10^{-7}; 1×10^{-9} with ext. reference generator
Frequency of signals with broadband frequency modulation (broadband stations), max.	220 Hz with ext. reference gene
Frequency of signals with narrow band modulation frequency, max.	5×10^{-7}; 1×10^{-8} with ext. reference generator
Frequency of digital signals with non-coherent modulation (MFn), max.	5×10^{-7}; 2×10^{-7} with ext. reference generator
Frequency of digital signals with coherent modulation (MMC, FMn), max.	5×10^{-7}; 1×10^{-8} with ext. reference generator
Frequency of digital signals without specific frequencies, band width up to 300 kHz	5 kHz, max.
Band width as per X method, dB, max.	5 %
Band width as per β/2 method, max.	10 %
AM factor, max.	10 %
Signal frequency deviations with frequency modulation, max.	5 %
FMn signal frequency distribution, max.	5 %

SMO-PAI supports automated recognition of the modulation type, measurement of carrier frequency, sub-carrier frequency, band width, modulation parameters (amplitude modulation factor, frequency deviation, angle modulation and data transmission rate for digital signals). The developed system is an open system, it allows adding new signal descriptions without prejudice to the general structure and system extension. On the figure you can see an example of definition of TETRA π/4 DQPSK signal type and modulation parameters (at 36 kbps rate).

ARGAMAK-M under SMO-DX program control ensures search of radio emitters indoors, enables prompt evaluation of radio environment, comparison with the reference panorama and detection of new emitters as well as real-time radio signal spectrum analysis, saving accumulated spectra to the database, review and operations with the accumulated spectrum panorama.

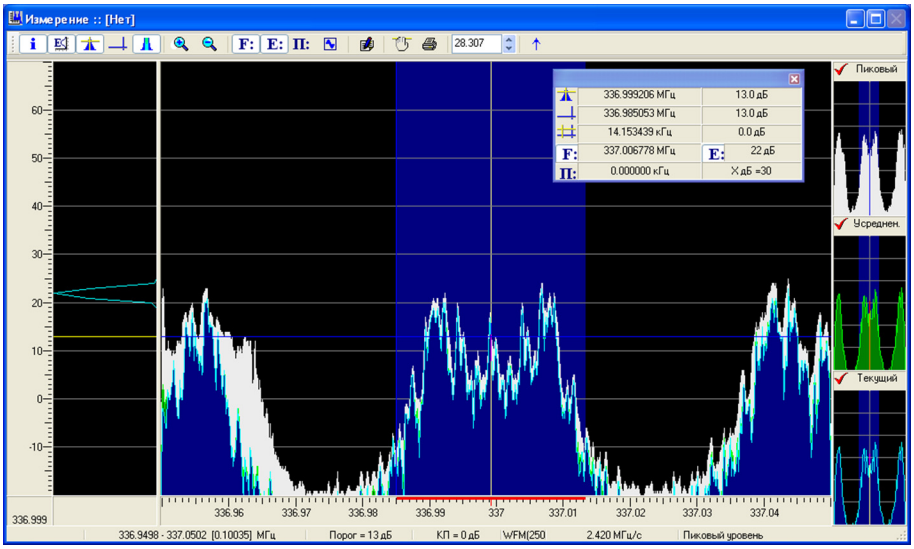


Autiomated Recognition of Modulation Type and Parameters

Field Strength Measurement

To measure field strength and to plot coverage areas, SMO-PAI and SMO-KN programs are used.

The field strength is measured subject to the measuring antenna calibration, losses in the lead in cable and antenna switch. The calibration tables for measuring antennae are stored in special file.



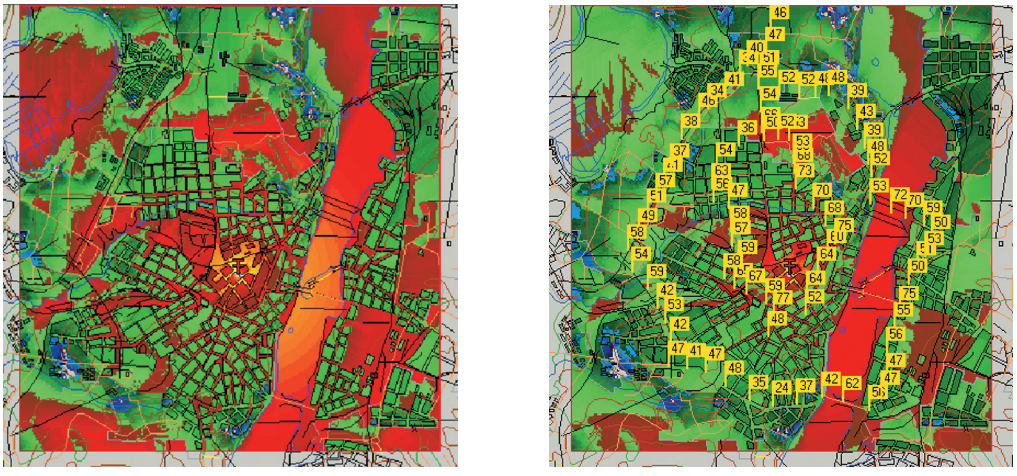
Field Strength Measurement in SMO-PAI Software Package

When measuring the field strength, SMO-PAI will log the measurement time and geographical coordinates.

Based on the field measurement strength, SMO-KN can perform the following operations:

- Transmitter coverage area definition
- Finding positions of emitters
- Check of reported transmitter parameters
- Calculation of emitters electromagnetic compatibility.

It includes the terrain, buildings, trees and bushes around, antenna directional pattern and hanging height. On the figures there is theoretically calculated emitters field and the field measured by the receiver.



Field Strength Diagram
(Teoretical Evalution and Based on Measurement Results)

Manual Direction Finding

ARGAMAK-M Panoramic Radio Receiver is a hardware basis for ARC-RP3M Handheld Direction Finder. Operating pack for manual direction finding can include handle and ARC-A3A - replaceable directional active antennae for frequency range from 0.3 to 3000 MHz and SMO-RP Software Package for manual direction finding. The antennae can be used both in active and passive mode. The operating pack includes four antennae:

- ARC-A3-KV (0.3 - 30 MHz)
- ARC-A3-1A (25 - 500 MHz)
- ARC-A3-2A (400 - 850 MHz)
- ARC-A3-3A (800 - 3000 MHz).

The pack also includes ARC-PP Control and Display Module. It has panoramic LCD with backlight and buttons to control the direction finder. During operation, the unit is fixed on the operator's hand by means of a special wristband.

The directional antenna package for 25-3000 MHz range as well as handle and ARC-PP control console are shown on the figures.

ARC-RP3M Handheld Direction Finder

The design of the handle and antenna elements enables detection of emitters with vertical and horizontal polarization.

The handle is optimized for operation in the field conditions. The weight of the handle with the antenna is 700 gram max., the center of gravity is located below the palm level thus enabling to work longer without getting tired.

One more advantage of the antenna system is that the most actively used frequency range (25-500 MHz) is covered by a single antenna.

Both ARC-PP and ARGAMAK-M is rated for the temperature from minus 20 to plus 55 deg. C and is protected from precipitations and dust (IP64). The panoramic display ensures high contrast presentation of graphical data even if exposed to direct sunlight.

Laptop Controlled Operation

Self-contained power supply from 9 standard Ni-Mh batteries (AA size) ensures continuous operation during at least two hours. An additional battery set can essentially extend the continuous operation time.

To extend the operating frequency range, direction finding pack may include ARC-KNV3M Frequency Down-Converter (3-8 GHz) or ARC-KNV4M converter (3-18 GHz), each of them has its own built-in directional antenna.

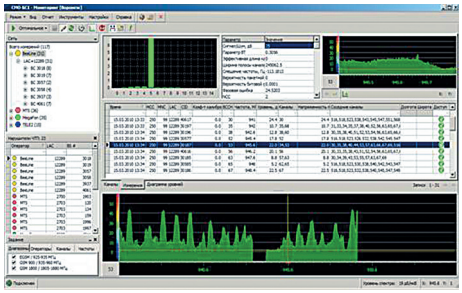
If the receiver is controlled with a portable PC, then the PC is used with a special carrying frame fixed on the operator's breast The pad design provides for adjustment of position and angularity for comfortable work under different conditions considering operator's individual differences.

Analysis of GSM and CDMA Base Stations

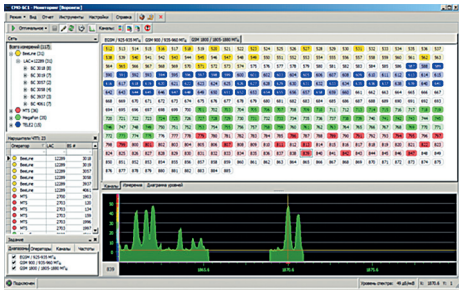
To analyze wireless communication and data transmission signal parameters, SMO-BS application is used. It supports:

- Acquisition of service data,
- Coverage area plotting
- Signal power definition
- Definition of conflicting frequency channels
- Finding base station positions
- Check against frequency/area plan
- Report generation based on operation results.

Screenshots showing program operations during base station signal analysis are given as an example below.



GSM BTS Signal Analysis



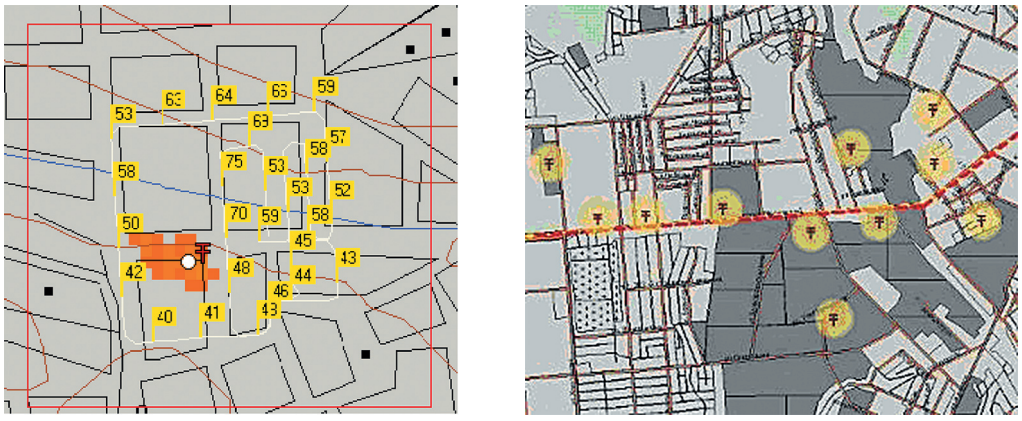
CDMA BTS Signal Analysis

Emitter Position Finding

ARGAMAK-M, together with its equipment package (namely ARC-A7A-3 broadband vehicle-mounted antenna, ARC-KN1 accessories and SMO-KN application) can be used for emitter position finding and calculation. All equipment should be mounted on a vehicle. The solution is based on the amplitude algorithm of coordinates calculation, namely on the dependencies between the emitter field amplitude and the distance to that emitter. The initial data for the calculations were field strength measured values, measurement point coordinates and transmission antenna directional pattern.

To get a more accurate evaluation of transmitter power, electromagnetic field strength is measured in a number of spots (about several tens). This is usually achieved by discrete searching of values through the range set by the operator. The object of the search is the value whose power maximally coincides with actual measurement results and theoretical calculations. With this, area terrain, local buildings and structures and vegetation are also taken into account. The time for coordinates calculation usually depends on the moving track but as a rule the error does not exceed 100 m.

Besides emitter location finding, SMO-KN is also used for area coverage plotting and correction of transmitter power.

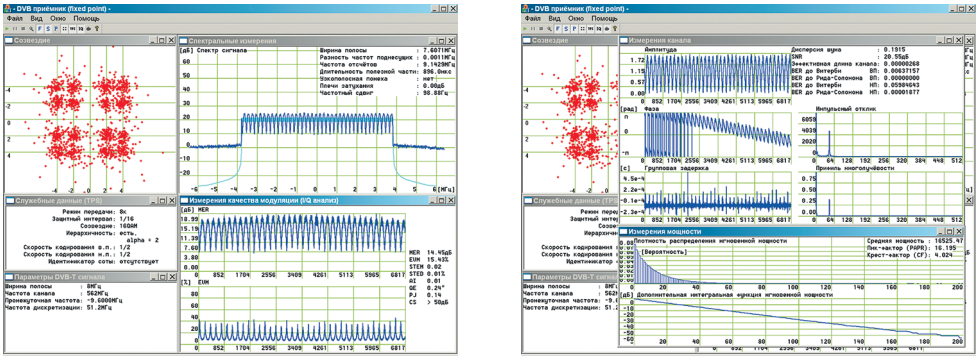


BTS Localization while Moving of Vehicle

Digital TV Signal Analysis

The performance parameters of ARGAMAK-M digital panoramic receivers are high. Thus, its band pass is 8 MHz which is sufficient for acquisition and analysis of digital TV signals with ARC-ACO-CT analyzer. SMO-CT Software Package, which we have been testing now, is designed for search of DVB-T/H digital TV signals, signal parameter estimation, control data acquisition, decoding and analysis of traffic stream, separating of different channel substreams and their viewing.

The program is designed in accordance with ETSI and NorDig requirements applicable for DVB-T signal measurement. It allows to detect digital TV station signals, receive service data, make required measurements of signal parameters and traffic stream, decode traffic stream and separate different programs for further viewing. SMO-CT program screenshots are shown on the figures.



SMO-CT Software Screenshots

Radio Signal Recording & Technical Analysis

ARGAMAK-M receiver supports recording of radio signals to a PC disk. The frequency band for the signal recording depends on the receiver digital filter pass band and makes up from just some kHz to 8 MHz. Continuous signal recording is possible when the band pass does not exceed 2 MHz. Record length depends on the free space on the PC disk.

SMO-STA technical analysis software ensures recognition of more than 70 types of radio emissions on the carrier and subcarrier frequencies, demodulation, time and structure analysis and digital stream processing.

RESUME

ARGAMAK-M digital panoramic receiver is a light-weight, compact and low-power device. In conjunction with high performance, it can be effectively used as a handheld radio monitoring equipment in the field conditions including subzero temperatures and bright sunshine. Moreover, this receiver can be also used on stationary and mobile radio monitoring posts.

The receiver is based on SDR approach, ensures a high processing rate, real-time digital signal processing within max. 8 MHz band and can detect signals with the length from 1 μs and more.

The software packages designed for that receiver are designed for a great number of radio monitoring tasks. When using accessories, the operating frequency range can be extended to 18 GHz. The device can find directions and localization of radio emitters including wireless broadband radio emitters and radar stations.

19, Zviezdny bul., Moscow, Russia
Phone: +7 (495) 615-08-38, 615-08-10
Fax: +7 (495) 615-73-02
info@ircos.ru
www.ircos.ru