



# ARGAMAK-2K

## TWO-CHANNEL PANORAMIC RADIO RECEIVER





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handheld high-performance device  
with two coherent receiving channels



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### FEATURES AND ADVANTAGES

#### Optimized weight and dimensions:

- Volume: 12 dm<sup>3</sup>;
- Max. weight: 5.5 kg

#### Low energy consumption:

- 20 W, max.

#### High efficiency:

- 6 MHz/s within the operating frequency range,
- Up to 250 GHz/s within 10 MHz processing band

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

- Outdoor and indoor radio monitoring (9 kHz – 18 GHz)
- Automated direction finding (20 MHz ... 8 GHz)
- Detection and position finding:
  - Standard VHF/UHF radio equipment,
  - GSM / CDMA / TETRA / WiFi / WiMax transmitters
  - VSAT C, VSAT Ku surface transmitters
- Manual direction finding (0.3 MHz ... 18 GHz)
- Analysis of wireless communication and data transmission system signals incl. GSM/CDMA
- Analysis of DVB T/H digital TV signals
- Radio signal recording and technical analysis.

## DESIGN APPROACH, DETAILS AND PERFORMANCE FIGURES

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 equipment is based on panoramic digital receivers of ARGAMAK family. All receivers in the product line are based on SDR approach and are used in stationary, portable and handheld equipment.

ARGAMAK-2K digital panoramic receiver was designed as a portable digital radio receiver with two coherent receiving channels and self-contained power supply that can be used in handheld automatic correlative interferometer direction finders, cross-talks detectors and fast deployable data leaks detection systems. The main difficulties which our engineers were facing when they designed that receiver were to diminish the receivers' weight and dimensions, include self-contained power supply in the two-channel receiver, extend its operating temperature range and make it capable for work in high humidity and dust conditions.

ARGAMAK-2K specifications are given in the table below and the receiver itself is shown on the figure above.

### Specifications

<b>General</b>	
Operating frequency range for each channel:	
• basic configuration	9 kHz – 3000 MHz
• with AS-HP2 Antenna System	3 - 8 GHz
Frequency range, extended configuration (for one channel only)	9 kHz - 18 GHz
Frequency tuning discreteness	0.1 Hz
Noise figure:	
• within 25 - 465 MHz range	12 dB max.
• within 465 - 3000 MHz range	12 - 14 dB max.
Maximum allowable input voltage	23 dBm
Input attenuator	0 - 30 dB with 2 dB increment
Relative error of frequency tuning	$\pm 5 \times 10^{-7}$
Synthesizer tuning time	2 ms, max.
Heterodyne phase noise when mistuning at 10 kHz:	
• within 25 - 1000 MHz range	-95 dBs/Hz
• within 1000 - 3000 MHz range	-85 dBs/Hz
<b>Selectivity and Harmonic Distortions</b>	
IF rejection	70 dB, min
Image rejection	70 dB, min
Intermodulation free dynamic range (3rd and 2nd order)	75 dB
Input IP3:	
• attenuator is off	0 dBm, min
• attenuator is 30 dB	30 dBm, min
<b>Analog-Digital Processing Path</b>	
Detecting, modulation types	AM, FM, SSB, AT
AGC switching off	from digital demodulator output
Input signal level estimation range in a 250 kHz pass band (with automatic attenuators)	-20 ... +110 dB/ $\mu$ V
Input signal level estimation range in a 10 kHz pass band (with automatic attenuators)	-5 ... +110 dB/ $\mu$ V
Limit of allowable absolute error of signal level estimation	$\pm 3$ dB
Panoramic analysis rate (with 6.25 kHz spectrum discreteness)	6000 MHz/s min

<b>Radio Signal Recording, Technical Analysis and Parameter Measurement</b>	
Continuous radio signal recording bandwidth (Limited number of discontinuity is possible. The total length is less then 3 %)	up to 2 MHz
Processed frequency bandwidth	up to 10 MHz
<b>Input, Outputs, Remote Control and Data Transmission Interface</b>	
IF analogue signal frequency	41.6 MHz
Pass band before IF output	10 MHz
PC control interface	USB 2.0
IF signal output for connection of external equipment (option)	41.6 MHz
Headphones socket (controllable volume)	Yes
Optional equipment control interface	RS485
<b>Operating Temperature, Weight, Dimensions and Power Consumption</b>	
Operating temperature range	-20°C ... +55°C
Power supply:	
• AC network power supply *	90 - 250 V
• from external DC source	9 - 32 V
• from internal battery	12 V
Continuous receiver battery run-time	min. 4 hours
Power consumption (provided that battery is fully loaded), max.	20 W
Dimensions, max.	330 x 250 x 170 mm
Weight with battery	5.5 kg, max

\* when AC power supply unit is available.

Subject to configuration, ARGAMAK-2K can have the following sockets:

- N-type general purpose RF power inputs rated for 9 kHz – 3 GHz or separate inputs for 25-3000 MHz and 9 kHz – 30 MHz.
- combined socket with RF inputs rated for 9 kHz – 3000 MHz together with power supply circuits and peripheral equipment control circuits. This feature allows to minimize the number of external connections (cables) and makes connection of peripheral equipment fast and convenient.
- IF inputs for processing of signals from external receivers. The central frequency of each IF channel is 41.6 MHz whereas the processed signal bandwidth is 10 MHz.
- Input for synchronization with external reference generator. The synchronization frequency may be 10 or 12.8 MHz (set up via software). For the internal reference generator, the frequency setting accuracy is  $\pm 5 \times 10^{-7}$  and for the external one it makes about  $\pm 1 \times 10^{-9}$ .
- IF analog outputs with 41.6 MHz central frequency and 10 MHz band pass for connection with accessory equipment.

Headphones socket to listen to the signals after digital demodulation.

The main components of ARGAMAK-2K digital receiver are two analog ARC-PS5 Tuning Modules and one two-channel ARC-CO10 Digital Processing Module. The receiver also includes charging/powering unit, battery module and interface module (IM).

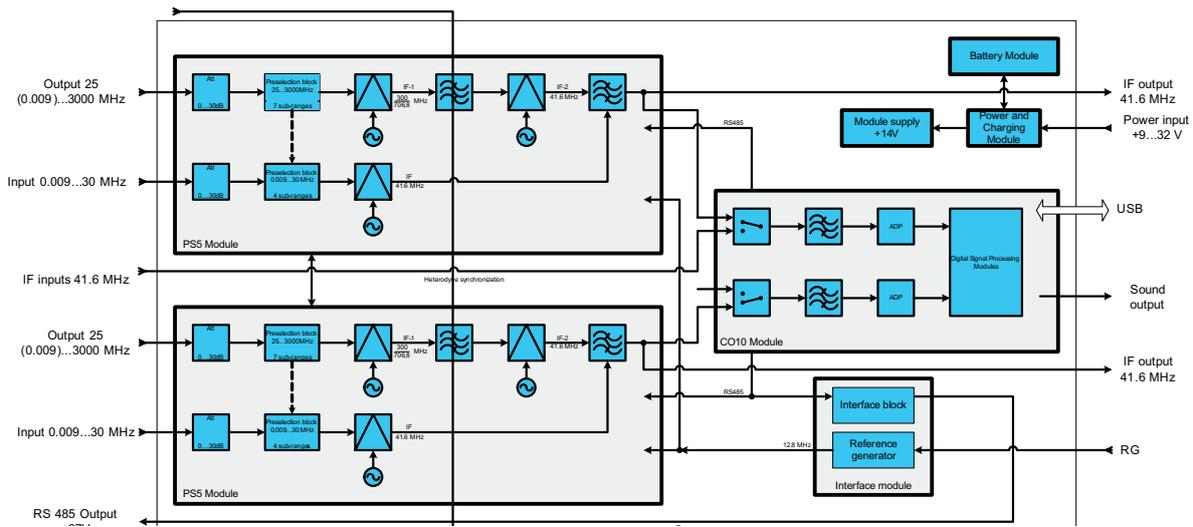
ARC-PC5 and ARC-CO10 modules are installed on separate Euro-boards and the board dimensions (incl. sockets) are 100x170x20 mm max.

To control the receiver from the PC, there is USB 2.0 interface which serves for transmission of commands and digital data streams (radio signals, spectra, demodulated signals, etc.)

RS-485 interface is used for connection with peripheral devices like automatic direction finding antenna systems (AS-PP07 and AC-MP07 rated for 20-1000 MHz, AS-HP1 rated for 110-3000 MHz and AS-HP2 rated for 3-8 GHz), ARC-PP control and display unit, ARC-KNV4 (3-18 GHz) converter, etc.

ARGAMAK-2K Receiver includes an integral power supply unit with 10 NiMH batteries rated for at least 4 hours of self-contained operation. For battery powering and charging, any 9-32V DC power supply can be used.

The receiver is enclosed in a heavy-duty IP64 case (dust proof, splash proof). For all external electrical connections, there are leakproof sockets on the side of the enclosure. The receiver weight with the battery set is 5.5 kg max. The max. dimensions are 330 x 250 x 170 mm.



ARGAMAK-2K Two-Channel DPRR Structural Diagram

Each receiver channel is rated for 9 kHz – 3000 MHz operating frequency range. The channels can function both in the coherent mode, when the two channels are tuned to the same central frequency and independently from each other. The coherent mode enables application of ARGAMAK-2K in automatic correlating/interferometric direction finders, in cross-talks detection systems and in data leaks control systems. At the same time, use of independent channels enables maximum scanning rate for frequency bands of 20 MHz and more. In that case, the receiving channels are tuned to bias by the simultaneous analysis band width. It allows boosting the panoramic analysis rate almost twofold in the wide frequency range.

ARC-PC5 analog tuning module is based on the super-heterodyne circuit with two VHF/UHF frequency converters and one HF converter. Pre-selection filters, synthesizer filters and other receiver parameters can be pre-set via the general control bus. The output signal for ARC-PS5 is the 41.6 MHz intermediate frequency signal.

ARC-CO10 Digital Processing Module is designed for receipt of 41.6 MHz intermediate frequency channels and LF-HF signals up to 30 MHz via two channels. In each channel IF or LF/HF signals from two coaxial inputs are switched to analog pre-filtration or amplification circuit, as appropriate. After that, the signal is digitized via AD9246 analog/digital receiver and then is sent to XC3S1600 field programmable logic device, passes through digital frequency selection, conversion and parallel digital processing. Further digital processing

including filtering, decimation and demodulation is performed by two AD6620 digital receivers and three ADSP2185 processors. The module is controlled via CY7C68013A controller.

Data processing algorithms in FPLD ensure continuous signal processing without any data losses. During regular time sampling, a spectrum of the previous sampling is determined.

For example, 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:

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

Thus, within one second, the receiver will calculate

$$n = 1 / \Delta t = 1 / 40 \text{ } \mu\text{s} = 25000 \text{ spectra}.$$

If band pass  $\Delta F = 10 \text{ MHz}$ , then spectrum analysis rate will be:

$$V = \Delta F * n = 10 * 25000 = 250 \text{ GHz/s}.$$

Operator physically cannot read the data with the rate of 25000 spectra per second. Therefore, all spectrum data received in the real time mode, should be statistically preprocessed (averaging, search for maximums, calculation of two-dimensional probability density). Such processing enables operator to display and view the signals that could not be viewed in the typical spectrum display 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 (Wi-Fi, BlueTooth, Dect, WiMAX) within a single band. Also, it enables finding non-system interferences in broadband data transmission signals. As an example, you can see CDMA probability spectrum with distinct narrow band interference at 465.2 MHz.

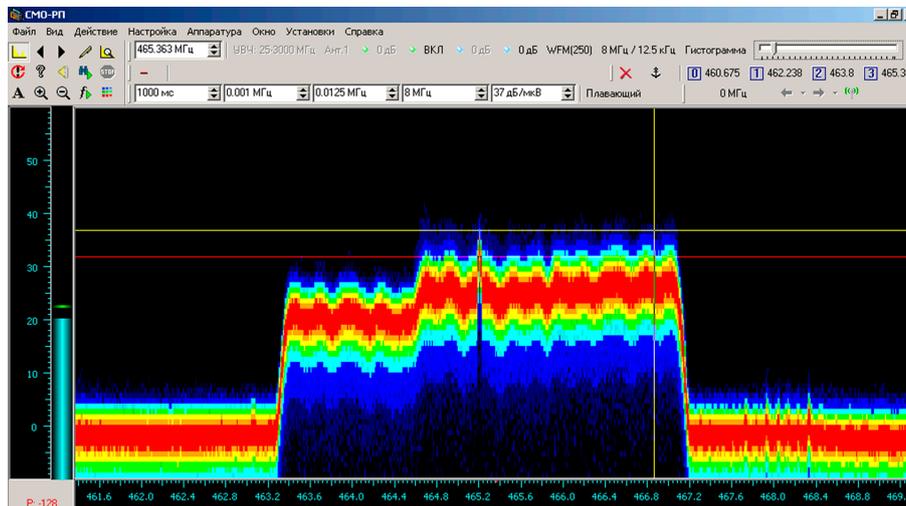
If the FFT is reduced by 32 complex points, the sampling duration will be reduced by 2.5  $\mu\text{s}$ . It allows detecting pulse signals with the length from 1  $\mu\text{s}$ .

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  $\mu\text{s}$  and when the spectrum discreteness is 6.25 kHz, the panoramic receiver analysis rate is min. 6 GHz.

## APPLICATION OF ARGAMAK-2K DIGITAL PANORAMIC RECEIVER

ARGAMAK-2K Digital Panoramic Receiver in its stationary, portable and handheld versions can be effectively used for the following tasks:

- Radio signal spectrum analysis and parameters measurement.
- Field strength measurement
- Coverage area plotting
- Automatic direction finding of active radio signal sources
- Manual direction finding
- Search of intermodulation interferences
- Analysis of GSM and CDMA base stations
- Finding emitter coordinates based on the field strength measuring
- Radio signal recording and technical analysis
- Digital TV Signal Analysis.



Probability Spectrum Display

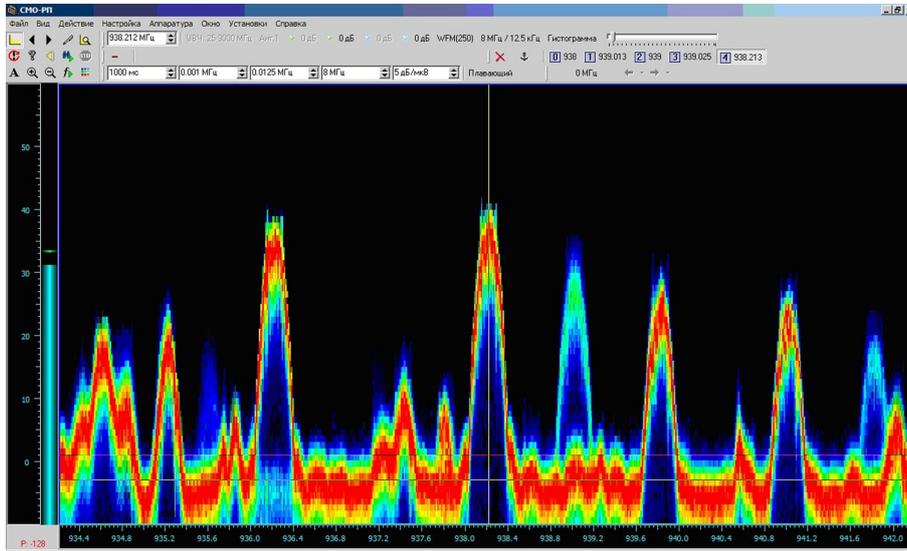
## Radio Signal Spectrum Analysis and Parameters Measurement

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-DH that enable operation of ARGAMAK-2K both in the real-time and in the post-processing mode. The programs ensure automated analysis and measurement of signal parameters with reference to the time and geographic coordinates including field strength measurement, signal frequency, definition of modulation types and parameters. Main signal parameters measurement errors 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.	$5 \times 10^{-7}$ ; $1 \times 10^{-9}$ with ext. reference generator
Frequency of signals with broadband frequency modulation (broadband stations), max.	20 Hz with ext. reference generator
Frequency of signals with narrow band modulation frequency, max.	$5 \times 10^{-7}$ ; $1 \times 10^{-8}$ with ext. reference generator
Frequency of digital signals with non-coherent modulation (MFn), max.	$5 \times 10^{-7}$ ; $2 \times 10^{-7}$ with ext. reference generator
Frequency of digital signals with coherent modulation (MMC, FMn), max.	$5 \times 10^{-7}$ ; $1 \times 10^{-8}$ with ext. reference generator
Frequency of digital signals without specific frequencies, band width up to 300 kHz	5 kHz
Band width as per X method, dB, max.	5 %
Band width as per $\beta/2$ 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 and parameter changes: carrier frequency, sub-carrier frequency, bandwidth, other parameters (amplitude modulation factor, frequency deviation, angle modulation and data transmission rate for digital signals). On the figure you can see an example of



GSM Base Station Spectrum Displayed in SMO-RP Software Package

definition of TETRA  $\pi/4$  DQPSK signal type and modulation parameters (at 36 kbps rate).

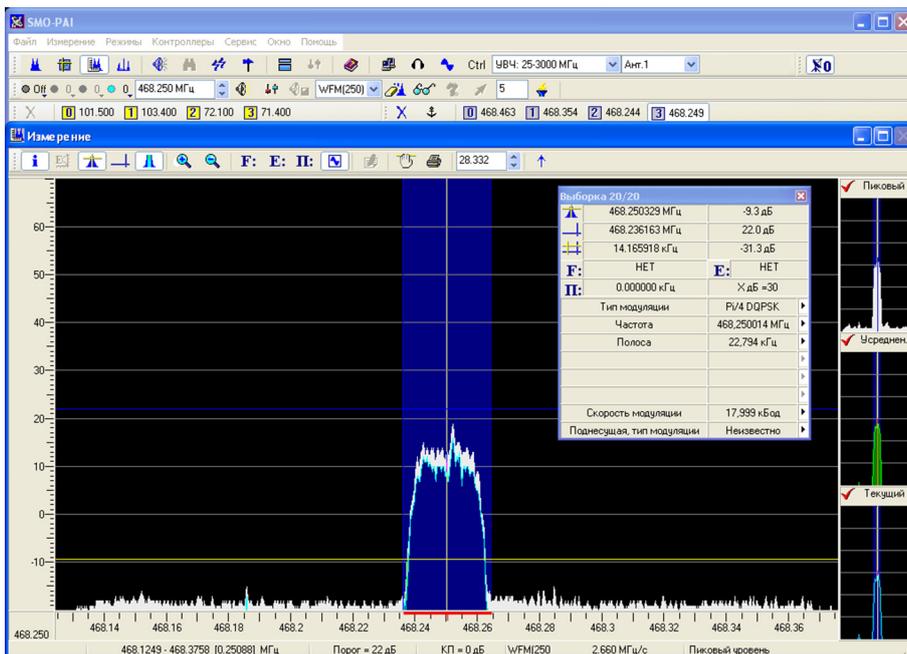
ARGAMAK-2K under SMO-DX program control ensures search of radio emitters indoors, enables prompt evaluation of radio environment, comparison with the reference panorama and detection of new emitters as well as real-time radio signal spectrum analysis. Two coherent receiving channels enable faster and more reliable detection of signals and emitters within the premise under monitoring.

### Field Strength Measurement

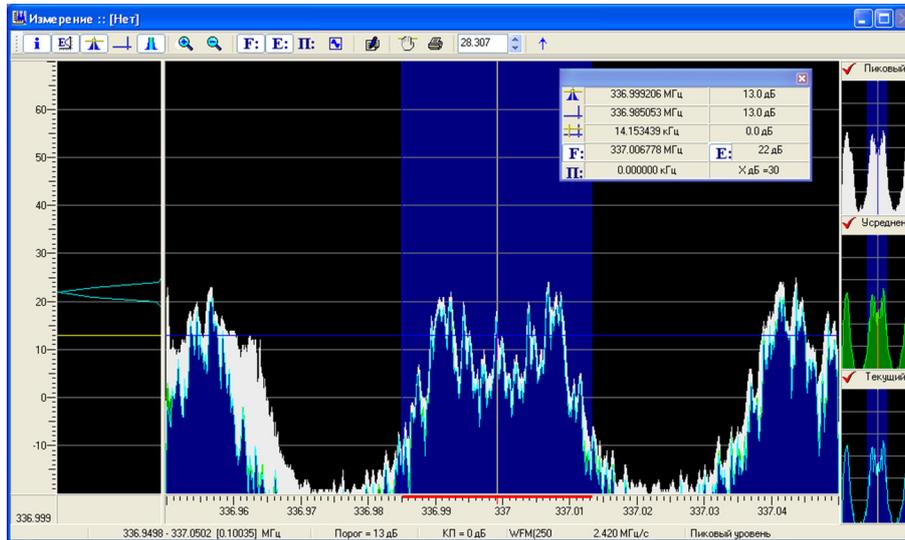
To measure field strength and to plot coverage areas, SMO-PAI and SMO-KN programs are used.

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.

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



Automated Recognition of Modulation Type and Parameters



Field Strength Measurement in SMO-PAI Software Package

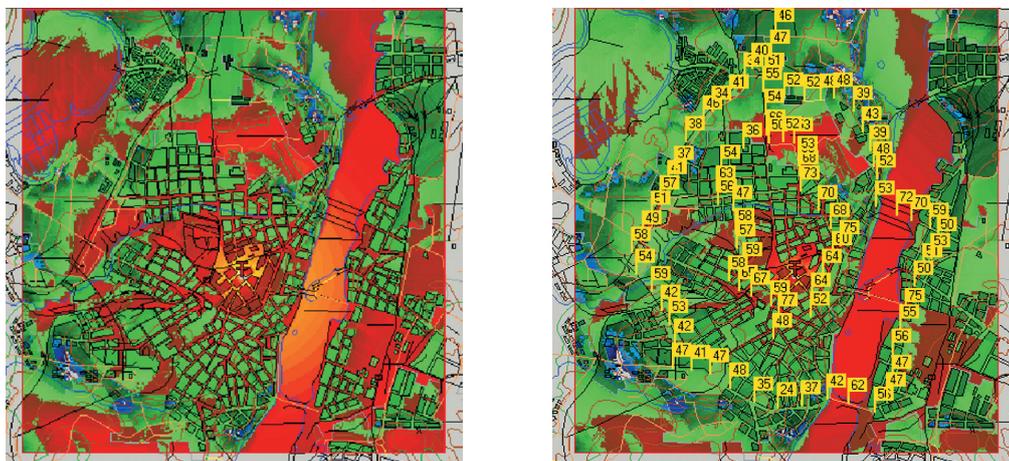
Based on the field measurement strength, SMO-KN can perform the following operations:

- 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.

### Automatic Direction Finding of Active Radio Signal Sources

With additional AS-HP1 or AS-HP2 Antenna System, ARGAMAK-2K can automatically take radio signal bearings. With AS-HP1 Antenna System, it can search and detect signals within 25-3000 MHz range as well as take their bearings within 110-3000 MHz range. Besides, with AS-HP2 Antenna System, it can search, detect and take bearings of signals within 3000-8000 MHz range. The automatic direction finding within 20-1000 MHz range can be achieved with AS-MP07 antenna system mounted on a vehicle. Main direction finding parameters are tabulated below.



Field Strength Diagram  
(Theoretical Evolution and Based on Measurement Results)

<b>General</b>	
Max. operating pack weight (as a handheld version with one AS-HP1 or AS-HP2 Antenna)	15 kg
Internal battery power supply	Yes
Vehicle power supply	10 ... 32 V
AC network power supply	90 ... 250 V
Continuous battery run-time, min.	3 h

<b>Single Channel and Multi-Channel Direction Finding</b>	
Direction finding within 20-8000 MHz frequency range	Correlative interferometer
Field sensitivity within 20-8000 MHz frequency range	1 - 15 $\mu$ V/m
Instrument accuracy (RMS) within 20-8000 MHz frequency range	2° - 5°

For portable operations the operating pack includes a light frame with shoulder slings and belt; and the direction finder is controlled via ARC-PP control unit or a sub-notebook (PC). The equipment with AS-HP1 or AS-HP2 antenna system is max. 15 kg.

The equipment can be also used in its mobile version. In this case, the antenna system is mounted on a vehicle roof by means of a magnetic pad.

For operations in the stationary mode, the antenna system is mounted on a portable mast to extend the direction finding coverage.

The portable, mobile and stationary versions of the direction finding equipment are shown on the figures.

During automated direction finding and search of emitters, the equipment is controlled via SMO-PPK and SMO-KN applications installed on a single sub-notebook or PC. With this, for localization of emitters, the following methods can be used:

- Homing method
- Quasi-stationary method
- On-the-run direction finding.

The homing method is based on movement of operator with (mobile) direction finder towards the emitter. The closer the emitter, the larger signal amplitude is and this is an additional witness that the operator is moving in the true direction.

The quasi-stationary method is based on receiving several individual bearing measurements from fixed points located at a significant distance from the object.

When bearings are taken from the mobile mode on the run, there appear some additional options for quick emitters locating using just one direction finder. In manpack operation mode, bearings can be taken also on the move because AS-HP1 and AS-HP2 antenna systems include an integrated navigation system.

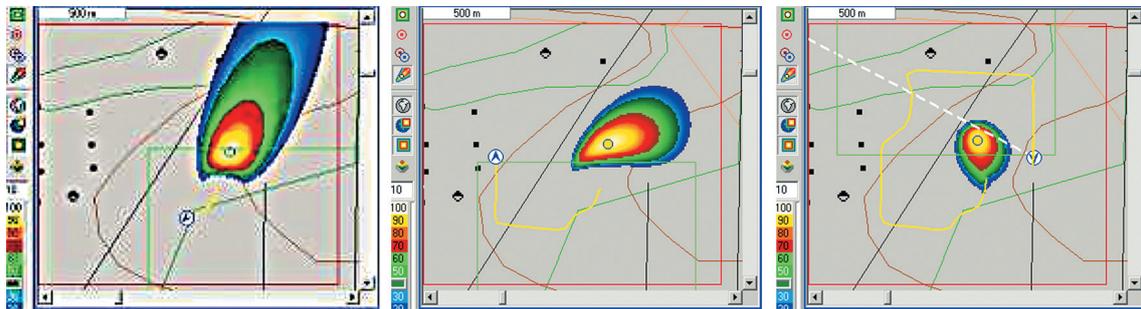
For taking bearings on the run, the most effective emitter localization method is the method based on the use of both amplitude and bearing data (amplitude-



Manpacked, Mobile and Stationary Operation Mode

goniometrical method). In SMO-KN application, you can also view the area where the emitter could be located (see figures below).

Use of the amplitude-goniometrical algorithm together with multi-channel direction finding enables simultaneously localization and displaying of several individual emitters located in different places on the map.



## Manual Direction Finding

Together with replaceable directional antennae, ARGAMAK-2K can be used for manual direction finding within the range of 0.3 – 3000 MHz. 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).

Besides antennae, the equipment can also include ARC-PP - control console with a panoramic LCD and backlight for the direction control button. 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.



Directional Antenna Set for 25-3000 MHz and ARC-PP Control Module

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-2K 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.

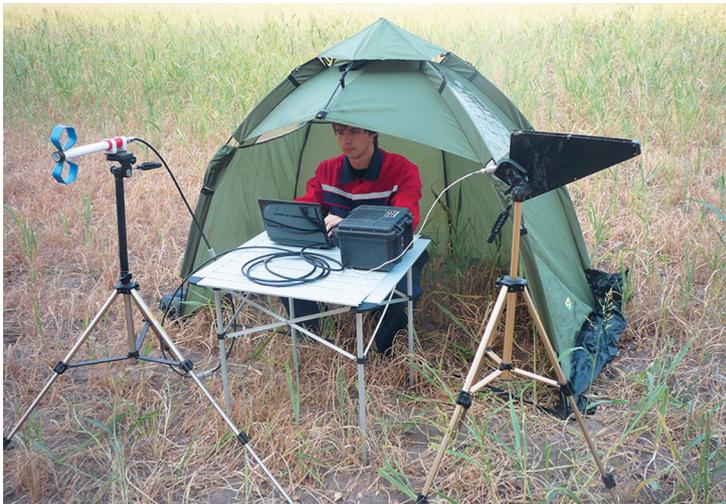
To extend the operating frequency range, operating pack may include ARC-KNV3M Frequency Down-Converter (3-8 GHz) or ARC-KNV4M converter (3-18 GHz), each of them has its own built-in directional antenna.

If the receiver is controlled via SMO-RP application installed on a portable PC, then the PC is used with a special carrying frame fixed on the operator's breast.

## Search for Intermodulation Interferences

One of actual radio monitoring tasks is to identify sources of intermodulation interferences caused by non-linear properties of radio receiving and transmitting equipment and wave distribution media.

The intermodulation interferences are caused by interaction of two or more signals at different frequencies on a non-linear element. Besides intermodulation interferences there are also interferences caused by harmonic sources and signals ingressing via secondary receiving channels.



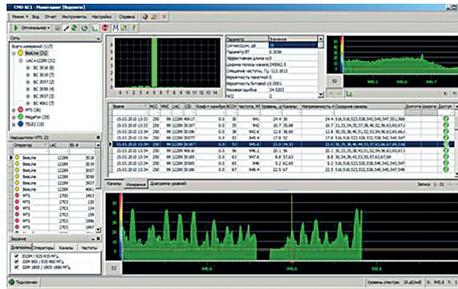
For detection of the intermodulation interferences, ARGAMAK-2K is controlled via SMO-PVP cross-talks detection application. The interference detection algorithm uses two coherent receiving channels and is based on calculation of cross-correlation function between demodulated signal at the  $F_c$  frequency affected by the interference and the signal assumed as a source of that interference from the list of suspected frequencies.

## Analysis of GSM and CDMA Base Stations

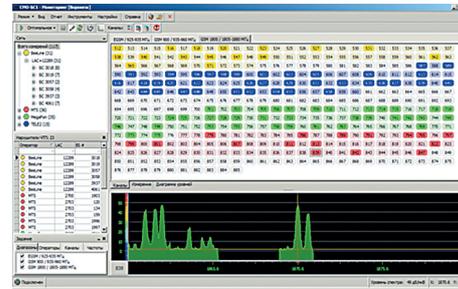
To analyze wireless communication and data transmission signal parameters, SMO-BS application is used. It supports

- 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

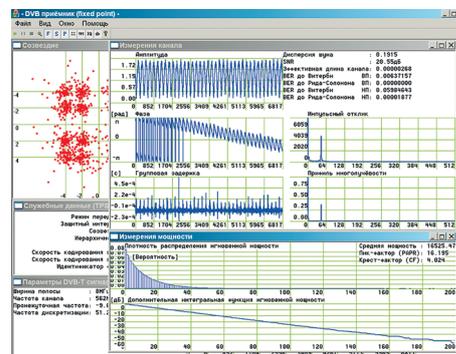
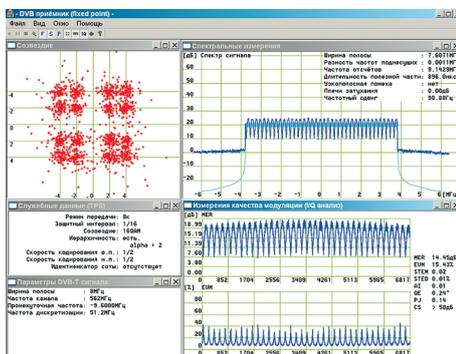
## Finding Emitter Coordinates Based on the Field Strength

ARGAMAK-2K, together with its equipment package (namely ARC-A7A-3 broadband vehicle-mounted antenna, ARC-KN1 Navigation Equipment and SMO-KN application) can be used for emitter position finding and calculation based on field strength measuring. 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. The time for coordinates calculation usually depends on the moving track but as a rule the error does not exceed 100 m.

## Digital TV Signal Analysis

The performance parameters of ARGAMAK-2K digital panoramic receivers are high. Thus, its band pass is 10 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.



## Radio Signal Recording & Technical Analysis

ARGAMAK-2K 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 10 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.

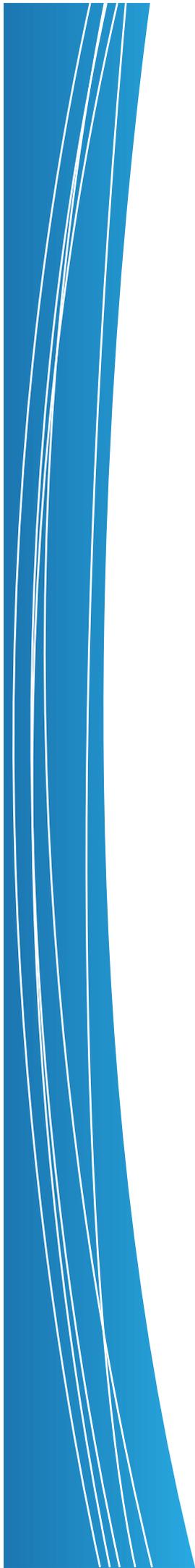
## RESUME

ARGAMAK-2K digital panoramic receiver is designed for real-time digital processing of signals within the 10 MHz band, enables detection of radio emissions with the length from 1  $\mu$ s and spectrum panoramic analysis with the rate min. 6 GHz/s. Two coherent receiving channels enable its application in correlation-interferometric direction finders, in intermodulation interferences detection system and in fast-response data leaks detection systems.

Optional equipment extends the receiving frequency range up to 18 GHz, enables automatic and manual direction finding, localization of emitters by amplitude-goniometrical method and plotting field strength distribution / coverage area diagrams.

The application software supports a great number of radio monitoring tasks including panoramic spectrum analysis and signal parameters measurement, automatic and manual direction finding, detection of intermodulation interferences and data leaks channels, finding emitters coordinates and technical analysis of radio signals.

ARGAMAK-2K is enclosed in IP64 heavy duty case, is rated for a wide temperature range, is lightweight, compact, and ensures high sensitivity, selectiveness and fast response time, what makes it convenient for manpack and mobile radio monitoring equipment.







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