

Chapter 2

Problems, Classification and Structure of ARM Equipment

Introduction

The fundamental purposes of radio monitoring (RM) equipment are:

- Permanent or intermittent monitoring of airwaves in the wide frequency range
- Detection and analysis of new emissions
- Determination of the emission sources location
- Evaluation its danger or value
- Detection of unintentional or specially-organized radio channels, for information leakage.

Each of these tasks is a complex, multistage one. Each can be solved under the conditions of the complex electromagnetic environment, and each requires the application of a wide range of radio electronic means (REM), which execute definite functions [1, 2]. These functions can be divided into the following main groups:

1. Universal functions, which, as a rule, are executed by modern, automated RM (ARM) systems
2. Additional functions for specific RM task solutions in the field
3. Additional functions for RM task solutions at one, separately-controlled location, or at a group of the most important premises of the controlled object
4. Additional functions for detecting compromising electromagnetic emanations (CEE).

Regarding the first RM functions group (universal functions) one can consider the following:

- Real-time panoramic spectral analysis with the maximum high rate, resolving capacity, and adaptation to the complex electromagnetic environment
- Fast search for new emissions, including wide-band, and emissions with the dynamic time-frequency structure, its parameters measurement, and comparison to the database, to determine its danger (value) for the user

- Creation of a signals database, its replenishment, and the registered data comparison with the references stored in the database
- Control of the radio emission sources (RES) with emission parameters estimation
- Radio signals recording, including digital signals, simultaneously with the service parameters (frequency, time, signal level, spectrum data, etc.) and its further play-back
- Real-time and post-processing technical analysis of radio signals.

The following functions can be classified to the second functional group:

- Field strength measurement
- RES direction finding with arbitrary types of modulation on azimuth and elevation angles
- Stationary and mobile RES location determination in the field and on extensive objects, and its representation in cartographic diagrams (digital object image).

The third group of tasks includes:

- Search and detection of the technical channels of information leakage, at the separate or combined premises
- RES identification as a radio microphone
- RES site location.

The compromising electromagnetic emanation (CEE) detection (the fourth group function) provides the following:

- Technical means emission parameters and electromagnetic field strength measurement in the receiving antenna near-field zone
- Confidential information immunity examination during the course of its processing and storing by the intended technical facilities
- Survey of confidential information immunity against leakage, due to the pick-up from the auxiliary technical facilities, systems, and its communication lines
- Allocated premises immunity analysis against speech information leakage through the acoustic and electric transformation channels
- Measures effectiveness control concerning information security against the CEE leakage.

Classification of Radio Monitoring Equipment

It is expedient to classify RM equipment based on specific signs, with further determination of the RM facilities' efficient structure within each group. These signs are:

- Size of the RM operation zone (territory)
- RM means application

- Executed functions
- Performance of RM means
- Design constraints.

Let us consider, in detail, the RM means categories, according to these signs.

Operation Zone Sizes

Based on operation zone size, all radio monitoring means can be grouped as follows [3]:

- Means for RM task solutions in the field and RES direction finding
- Means for information protection measures on the external boundaries of the controlled objects
- Means for RM task solutions within separate or several controlled premises of the object; these facilities will be referred to as eavesdropping detection means
- Facilities for CEE special investigations.

The first and second group means should be able to cover substantial territories with the possibility of RES detection at the exits, and at the external boundaries of the controlled objects.

The third group means should provide RM task solutions with maximum operating rate, to detect the RES location and to identify it as a radio microphone. These tasks should be solved at both the separate premise and the premises group, under control from one post. Control facilities are located inside the premises.

Special investigations of the technical means for CEE presence can be executed, as a rule, in specially-allocated premises, but investigations are possible directly at the place of the means location, as well.

Application

Based on the applications, RM means can be classified into three groups:

- For open operation at stationary or temporary posts, as well as when moving on different transport carriers
- For concealed operation with RM means carried in an attaché case, handbag, or on the operator's body. In this instance, appropriate measures for camouflaging the antenna system should be provided, as well as measures to conceal the technical means design, and, in several cases, in combination with fully-autonomous functioning during operator movement
- For combined (open or concealed) RM means application, with the possibility of carrier control, and the necessary measures for camouflaging the antenna systems and the appropriate, RM means design.

Equipment Performance

RM means performance can be characterized by the signal panoramic spectral analysis operating rate at the given resolution and the dynamic range. Typically, the following classifications are used:

- Low performance (10–100 MHz/s)
- Medium performance (100–1,000 MHz/s)
- High performance (1,000–10,000 MHz/s)
- Ultra-high performance (more than 10 GHz/s).

Design Constraints

Modern RM equipment has been created based on a system approach: hardware-software means united by overall design. This approach provides the ability to link each separate means with its weight and size parameters, its electromagnetic compatibility, the decoupling of its power supply, and the development of its design implementation, all of which correspond to the used-carrier parameters.

Such problems can be solved by effective classification of the means into groups. Each of the groups shall fulfill each – or a number of – stated conditions. It is often suggested to divide all means into families: stationary, mobile, portable and hand-held means. When developing the means of each family, those technical solutions are preferable, which first of all comply with the set of main parameters, secondly, which comply with the minimal weight and size parameters, and, lastly, which cost the least.

For stationary RM means, weight and size constraints are practically absent, and therefore the best technical parameters can be achieved via RM means. Thus, to ensure a large operating area for stationary posts, an antenna system located on remote masts can be applied, which can then be mounted on high buildings or in elevated areas.

For mobile RM means, which are located on a vehicle or air transport carrier that is able to execute the main function while moving, it is important to take into consideration any constraints on weight, dimensions, and power consumption. This relates to the dimensions and carrying capacity of the carriers themselves, as well as the power capacity and the power of the sources located on the transport carriers.

Since the above-mentioned constraints are not very strict, in the mobile RM means family, similar to the stationary means family, one can use multi-channel digital panoramic receivers to obtain high values on the dynamic range, the rate of panoramic analysis, and on received-information processing.

Portable RM means are intended for transportation by one or a number of operators and are destined for further operation at stationary or temporary posts equipped or not equipped with power sources, and in the field. There is no requirement for these means to function during transport. Thus, serious constraints are formulated as to the weight, power consumption, and dimensions of the detection and

direction-finding antenna system. Moreover, for portable RM means, it is necessary to have an autonomous power source to provide for its function (e.g., accumulator charge, unfolding solar batteries, fuel supply for gasoline-electric generators, etc.).

Hand-held RM means are intended, first of all, for operation during operator movement when placed on the operator's body (or in his arms). Additionally, these means can be used to solve RM tasks at temporary or stationary posts. From the point of view their application, these means are universal and their usage is appropriate to detect RES locations in out-of-the-way places or where concealed operation is needed. Due to the serious constraints of energy consumption and weight and size parameters, such means parameters should be selected taking into account the unit's operating life with a single power source set.

Measuring radio-receiving devices and antenna systems are required for the measurement of regular radio electronic means (REM) parameters at the emission control of the officially-registered communications equipment, and also to estimate the effectiveness of information-leakage prevention measures at the boundaries of the controlled objects, and for SEE investigations. Usage of RM means for measurements can occur in the stationary, mobile, portable or hand-held versions. In Russia, the possibility of such usage for measurements must be approved by the respective certificates of Gosstandard and the Federal Service for Technical and Export Supervision of the Russian Federation.

Therefore, we formalize the classification of all RM means into the following groups:

- Stationary RM means family
- Mobile RM means family, mounted on vehicles, and on air and sea transport carriers
- Portable RM means family, operation of which is provided only after its deployment at the temporal location posts
- Hand-held RM means family, for concealed and open operation, intended for operation while the operator is moving (without operator participation in the mean control, or with partial or complete participation)
- Measuring means, to ensure effective control of the attempts made at information-leakage prevention, and also to measure the emission parameters for regular radio facilities.

In order to decrease the number of means, it is expedient to combine the first and second families (stationary and mobile) into one family, provided that the execution by mobile means equals all the functions of the stationary means, taking into account the constraints to the antenna systems and the electric power systems of mobile means.

Radio Monitoring Equipment Design Philosophy

The main purpose of RM equipment development is the creation of universal hardware-software systems, using the limited range of devices to carry out the

maximum possible RM task scope [4, 5]. The main requirements for RM equipment, aimed at the minimization and unification of the equipment and software, are the following:

- Universality and multifunctionality of basic RM equipment for each family
- Universality and multifunctionality of the additional means
- Provision for the combined operation of the family's basic equipment with the additional equipment, common for all families of RM equipment
- Unification of the different families' equipment
- Unification of software, using similar modules, data formats, and interface formats for the different families
- Unification of power supply
- Effective distribution of processing tasks between the hardware signal processors and the controlling computer
- Creation of code libraries for the basic set of each family's equipment
- End-to-end solutions for electromagnetic compatibility problems.

A partial decrease the amount of necessary RM equipment can be achieved at the development stage of each family's equipment, based on the functionally-modular principle of combining each family's basic equipment with the additional means common for all RM families' equipment. Investigations of the various types of digital receiver structures with wide operating frequency ranges show that minimizing the number of means can be achieved by restricting the operating range of the family's basic equipment combined with the additional means common for all RM families. Implementation of this principle allows the selection of a fixed, basic equipment structure for each family. Another argument in favor of this principle is the consideration that, at present, technologically, the implementation of all or most of the functions mentioned in section "Introduction" into one constructively-completed mean would lead to an unreasonable increase of weight, dimensions, power consumption, and cost.

Realization of this multi-functionality principle assumes that it is possible to reduce the structure of RM equipment, based on hardware digital-unit usage, with the possibility of quick reprogramming to execute the various signal processing algorithms, to combine the functions of separately-manufactured devices, and to effectively distribute problems between two software layers, namely, those used in the hardware digital unit and in the controlling computer.

An end-to-end solution to the power supply problem assumes the unification of voltages supplied, including, in the equipment structure, any units that provide power supply from the AC network, from the onboard network of the mobile vehicle (car, helicopter, etc.), as well as from the battery with the charging device for autonomous operation, and for fail prevention at any supply interruption.

The following principles defining the RM equipment structure are:

- Unification of different families' equipment; possibility of combining the equipment of various families, for example, combining the radio signals analog-digital

converter (ADC) of the mobile unit with the double-channel or single-channel unit of the analog-digital processor of the portable family

- Unification of software packages, application of a similar data structure and format to achieve the possibility of using the same software package (with various drivers) within the different families
- End-to-end solution of the electromagnetic compatibility problem, accounting for the carrier's electric equipment.

Minimization of the total expenses spent on RM equipment development relates directly to the possibility of its modernization during duplication.

The open command library for each equipment type allows the possibility for the user himself to program and solve individual specific tasks, using the available RM equipment hardware.

RM equipment development and usage experience shows that the equipment structure should include:

- Single-channel or multi-channel (with coherently-related local oscillator) radio signal converter
- Single or multi-channel analog-digital processing unit
- Equipment for digital radio signals recording, at the intermediate frequency (IF), to magnetic or other storage devices
- Equipment for real-time signal technical analysis and post-processing
- Digital demodulation unit
- Equipment for recording the demodulated signal simultaneously with the service signals (current time in the record moment, current frequency, etc.)
- Power supply unit with reduced interference level
- Universal control equipment allowing for the possibility of fast replacement and changing of modes, based on special mathematical software (SMS) program selection
- Uniform SMS packages.

Measuring radio-monitoring devices should be certified by the authorized, state-standard agencies.

The additional equipment includes:

- Wide-range unidirectional antennas of various applications
- Antenna system sets for automated direction finding when moving, at stops, and for the stationary posts
- Antenna modules sets with directional properties for hand-held direction finders of open and concealed application
- Radio signals tuners, to widen the operating frequency ranges
- Digital signal recorders
- Equipment for positioning the RM means at the geographical coordinates.

Additionally, the following argument should be taken into account in favor of separate implementation of the basic equipment and the additional means. At the stationary and mobile RM posts, one can try, if possible, to move the receiving antenna to a very high place (on the roof, on the mast, etc.) in order to widen the post's area of operation. In that case, the RF cable from the antenna to the basic equipment may be rather long. The losses and noise generated in the cable increase with the frequency. If all units, for example, in up to the 18 GHz range are concentrated in one place (say, on the operator's desk), then this situation – even in the case of very good cable application – would lead to unjustifiable significant signal damping in the RF cable with receiving signal frequency increase and, hence, to a reduction in system sensitivity. Moreover, in this situation, the so-called antenna effect will reveal radio signal crosstalk to the RF cable and will distort the directional pattern of the antenna. Using an additional frequency converter, for example, in the 1–18 GHz range, provided that it is located near the antenna, essentially decreases the requirements for the upper boundary frequency of the RF cable, increases the sensitivity, and reduces the antenna effect.

Requirements for RM Equipment Technical Parameters

Quality Criterion Selection

It is nearly impossible to execute all the parameters necessary for complete optimization of all RM tasks, due to large number of parameters. Nevertheless, it is evident that, for most executed tasks, there is a common approach. This approach consists of estimating the necessary RM equipment using an “effectiveness-cost” criterion. Under this method, the area of possible decisions is restricted as follows:

- Minimal number of important parameters is defined for each task or group of tasks
- Permissible (or acceptable, in the absence of clear recommendations) limit for each parameter is fixed.

In a number of cases, the probability $P(t \leq T_s)$ of appropriate RM task execution during the operating time interval, not exceeding the given value of signal time T_s , can be successfully used as the main index of ARM equipment effectiveness. In this instance, the important technical parameters of the equipment should not be worse than required. RM equipment can be considered optimal when it provides the greatest probability of task execution during the same time at the same cost.

At the same time, at the selection of the specific equipment by the user, other indexes can be the most important, for example, the accuracy of the current frequency measurement or the accuracy of the direction finding, as well as the equipment cost.

Let us use the probability criterion to estimate the performance of a variety of equipment, for the task of signal detection. We consider detection probability functions at the panoramic spectral analysis, under the assumption that the radio signal has the duration of, say, 3 s. This time interval is the typical average value at the radio interchange. The probability of single-frequency signal detection with T_s duration, under assumption that the signal/noise ratio (SNR) is high, is defined in Chapter 4. Let us assume that the scan range is equal to 1,800 MHz. The calculation results for the case of single-frequency REM detection are shown in Fig. 2.1. In Chapter 4, the suggested probability criterion is used for more complex cases of signal detection, for example, signals with programmable operating frequency tuning (POFT).

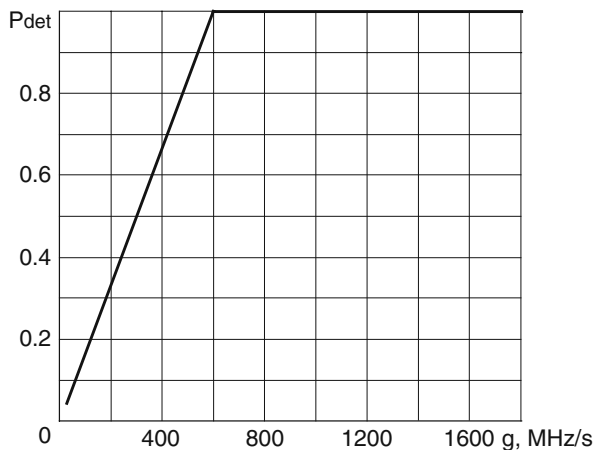


Fig. 2.1 Detection probability of single-frequency signal vs. a function of system performance during time interval $T=3$ s. Search range is 1,800 MHz at the analysis bandwidth 2 MHz

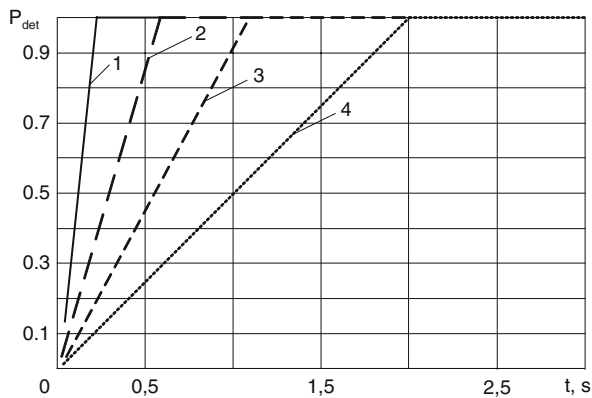
Fig. 2.1 shows that, at search range 1,800 MHz, the continuous wave (CW) signal with duration 3 s can be detected with the probability $P = 0.5$ at the system performance 300 MHz/s, and with unit probability beginning with the panoramic analysis speed 600 MHz/s.

Plots of the “new” signal detection for the panoramic analysis rate of 1,500 MHz for several values of the search range are shown in Fig. 2.2. At this given rate, the CW signal for the maximum search range of 3,000 MHz is positively detected in only 2 s.

Main Technical Parameters of RM Equipment

The basis of any RM equipment is the panoramic radio receiver, executing the functions of panoramic analysis and signal detection during its search.

Fig. 2.2 Detection probability of single-frequency signal vs. time at performance of 1,500 MHz/s, bandwidth 2 MHz at the various search range (1 – search range is 300 MHz; 2 – search range is 900 MHz; 3 – search range is 2000 MHz; 4 – search range is 3000 MHz)



As mentioned above, the probability $P(t \leq T_s)$ of the appropriate RM task during the definite signal time interval T_s can be used as the RM equipment performance index. At that time, the main parameter values of this equipment are fixed and recorded. At detection-problem solution, this probability depends mainly on panoramic spectral analysis speed, which is ensured by the radio receiver (RR). However, the analysis speed cannot be examined separately from the other receiver parameters: the dynamic range on the intermodulation of 2nd and 3rd order, the frequency resolution, the sensitivity, the operating frequency range, the simultaneous bandwidth, the frequency stability, and the spurious rejection. Thus, the needless increase of the resolution can essentially reduce the detection possibilities of a fast radio signal with the dynamic time-frequency distribution.

At present, the panoramic digital RR's (DRR) have the widest application in the area of RM tasks. DRR is the combination of radio signal frequency converters with the fixed IF and the analog-digital processing unit, which provide the parallel signal processing within the simultaneous bandwidth with the necessary frequency resolution [6]. This implementation provides the maximum operating rate, however, it is necessary to take into account that the simultaneous bandwidth growth at high range load leads to ADC overloading, and the application of the attenuator leads to weak signal suppression, i.e., to reducing its electromagnetic accessibility zone. The solution for this situation is the usage of frequency selection sections (so-called "comb" sections) adjoined to each other. For example, to obtain the simultaneous bandwidth equal to 80 MHz one can use 8 sections of 10 MHz; however it essentially complicates signal processing and increases the cost. The methods for creating RM multi-channel panoramic DRR are discussed in Chapter 5.

The lowest frequency range boundary in RM applications is usually equal to 9 kHz for both Russian and foreign RM equipment. The upper frequency range boundary for the RR equipment base is equal to 3 GHz; it can be extended to 6, 8 or 18 GHz, with additional devices, and, at that point, the trend of upper range boundary growth is steady, as mentioned above. In any case, the implementation of the principle formulated above ensures minimum expenses on the existing equipment modernization. According to this principle, the basis DRR and the additional devices are provided in order to increase the upper boundary of the operating range.

Nowadays, the dynamic range of 70–80 dB and resolution of 6–25 kHz are considered sufficient for RM equipment. This corresponds to 3–12 kHz spectrum discretization. The spurious rejection should be not less than 70 dB, the relative frequency stability of the reference oscillator should be not worse than 10^{-6} – 10^{-7} . When necessary to obtain the better frequency stability, for example, for measuring equipment, it is possible to use the highly stable external or internal reference frequency oscillator in DRR.

Table 2.1 presents the typical tactical technical characteristics of stationary and mobile RM equipment, manufactured by one Russian company.¹

Table 2.1 Typical tactical and technical characteristics of stationary and mobile RM equipment

Characteristic	Stationary RM station with mast-mounted antenna system	Mobile station with antenna system	
		Vehicle-mounted	Mast-mounted
Panoramic spectral analysis (PSA)			
Operating range, MHz			
Basic equipment	25–3,000		25–3,000
With optional equipment		0.009–18,000	
PSA rate in the operating range, MHz/s			
For medium performance		100–1,000	
For high and ultra-high performance, MHz/s		More than 1,000	
Frequency sampling, kHz			
For medium performance		3	
For high performance, MHz/s		6–12	
Dynamic range, dB		75	
Sensitivity, μ V		Not worse than 3	
Direction finding			
Rate in the range, MHz/s			
For low radio range load		50–100	
For high load		More than 300	
Signal bandwidth, MHz		Arbitrary	
Sensitivity, μ V/m	1–12	2–15	3–15
Instrumental accuracy (RMS), degrees	1	1.5	1.5
Technical analysis			
Analysis bandwidth, kHz/resolution, Hz	2,000 (5,000)/15; 250/500, 120/240; 50/100; 9/20; 6/12		
Multi-channel radio monitoring			
No. of monitored channels:			
For low range load		2–4	
For high load		6–8	

¹IRCOS (www.ircos.ru)

Characteristics of RM Equipment Families

Radio Monitoring and RES Location Detection Systems

The required terrain coverage and RES location detection can be achieved using a system of distant RM and direction-finding (DF) stations (the central and several peripheral stations), which provide detection and signal-receiving by the central post and also the simultaneous (synchronous) direction finding by the central station command, as well as RES location calculation with representation on the map [7, 8]. The number of stations for the stationary system is defined by the relief, the possibility of using high-rise buildings for antenna mast-mounting, by the controlled RES power and the detection and DF equipment's sensitivity

For locations where it is difficult to receive signals via stationary stations, mobile RM stations shall be used as additional support for stationary RES detection and direction-finding systems. These mobile stations are intended for more accurate localization of the detected RES. Handheld direction-finding and manpack RM equipment shall be provided for RES localization inside of buildings and in places that are beyond the reach of mobile equipment.

The same regularities are true for the mobile system of detection-finding and RES location detection, with the only peculiarity being that the antenna system is mounted on the remote mast with less length, in the flat country, which leads to a reduction of the REM-monitoring operating zone. The antenna system dimensions (diameter) for the mobile equipment, evidently, will be less than the appropriate dimensions of the stationary system, due to application conditions, which leads to less direction-finding accuracy at the low section of the operating range (less than 100 MHz).

The portable system can be characterized by the more strict limitations on weight, dimensions, and power consumption, which inevitably adversely affect the performance and the functions. The necessity of operation under field conditions requires autonomous power-supply means in the system structure. Similar system creation tasks are discussed in detail in Chapter 9.

Stationary and Mobile RM Stations

Possible organization of the stationary and mobile RM stations includes the following posts, along with the handheld direction finder or the manpack RM unit.

- Post No.1. The direction finder with the stationary (Fig. 2.3a) antenna system or with the mast-mounted and vehicle-mounted antenna system (Fig. 2.3b).
- Post No.2. Panoramic radio receiver.
- Post No.3. Multi-channel panoramic radio receiver.
- Post No.4. The cartographic and RES location-calculation equipment.

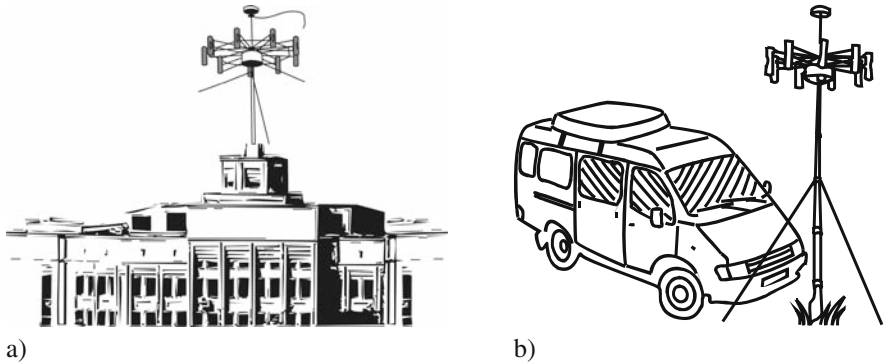


Fig. 2.3 Stationary (a) and mobile (b) RM stations

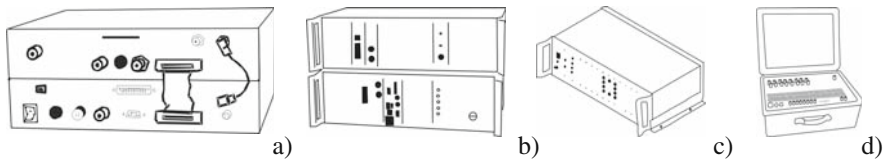


Fig. 2.4 Single-channel (a), double-channel (b) and multi-channel (c, d) DRR

The single-channel DRR structure used in RM stations (Fig. 2.4a,b) is:

- Wide-band RM antenna
- Tuner
- Analog-digital processing unit
- Control system with customized software package
- Power supply from the vehicle's on-board power or from the AC net
- Additionally, the measuring antennas set and the frequency converter for the frequency range extension.

The multi-channel DRR structure (Fig. 2.4c,d) is:

- Wide-band RM antenna
- Multi-channel panoramic DRR with remote control
- Control system with customized software package
- Power supply from the vehicle's on-board power or from the AC net
- Additionally, the frequency converter for the frequency range extension.

The parameters, the structural diagrams, and DRR examples are considered in Chapter 3, and the examples of multi-channel DRR are given in Chapter 5.

Portable RM Equipment

As previously mentioned, portable equipment is mainly purposed for radio monitoring at temporary and stationary posts, as well as in open terrain and in out-of-the-way places, where mobile and stationary equipment usage is impossible. The portable equipment functions for executing RM tasks in the field should correspond, if possible, to the functions of the stationary or mobile RM stations. It is clear that the direction-finding antenna system of the portable equipment will never be completely equivalent to the stationary or mobile antenna system. Taking into account the restrictions on power consumption and the strict weight requirements, the portable, automated, direction finders are developed, which are described in Chapter 8.

RM system structure for RES location detection, consisting of portable stations, (Fig. 2.5) is:

- Three or more portable stations (central and several peripheral)
- Handheld direction-finding equipment of open or concealed application
- Manpack RM unit.

In order to achieve multi-functionality, additional tasks related to CEE, may be entrusted to portable RM equipment. Possible versions of such units are described in Chapter 11.

The family of CEE detection equipment (Fig. 2.6) should include the following: control equipment for one or several premises and mobile RM, direction-finding and emission parameters measurement stations for the controlled zone boundaries. The problems of CEE detection are discussed in Chapter 11.

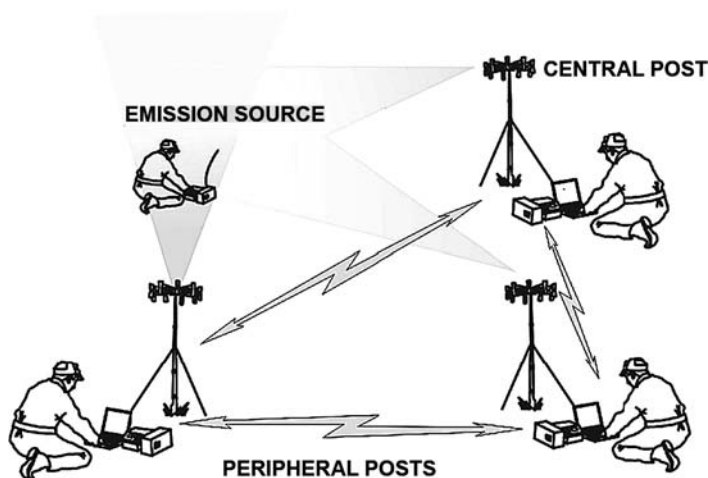


Fig. 2.5 System comprising the portable stations

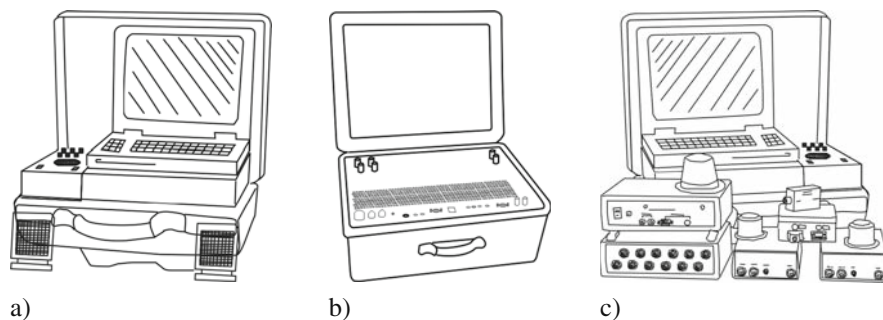


Fig. 2.6 Portable ARM units, with: single-channel panoramic DRR (a); double-channel DRR (b); and multi-channel panoramic DRR (c)

Certified RM equipment with measuring antennas and additional facilities can be used together with the appropriate customized mathematical software for special CEE investigations. Chapter 12 is devoted to these applications.

Manpack ARM Equipment

Implementation options for open and concealed RM applications relate mainly to manpack equipment. On the basis of our experience with communications surveillance services in Russia, we can affirm that the following manpack equipment-implementation options are desirable [9]: in the document-case, in the handbag (rucksack) or in the multi-pocket vest (Fig. 2.7).

If possible, manpack equipment should have the functions of stationary or mobile RM equipment.

Taking into consideration the need to minimize equipment weight and dimensions, as well as the variety of application conditions and the absence of strict requirements for direction-finding accuracy, it is reasonable to use the amplitude

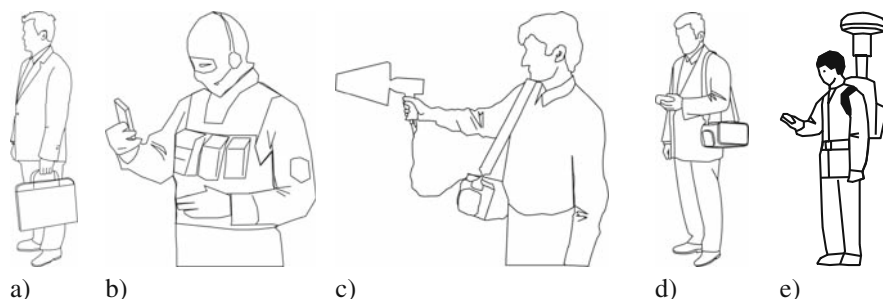


Fig. 2.7 The implementation options of RM manpack equipment: RM equipment in the document-case (a); in the multi-pocket vest (b); RM handheld equipment for open applications (c); concealed direction finder (d); automatic direction finder (e)

method of direction finding, based on the directional antennas in the manpack equipment. The manpack direction finders may have both open and concealed application options.

The RES search process using manpack automatic direction finders differs from the similar process using mobile facilities, by convenience mostly, since it is possible to use manpack automatic direction finders in places that are inaccessible for portable and mobile facilities. In such instances, the fundamental method for RES position determination – the “homing” method – is based on operator motion, with the manpack direction finder in the RES position area, along the bearing direction. When the distance to the RES decreases, the direction-finding signal amplitude increases, an additional sign that the direction finder is moving in the right direction. The structure of the manpack automatic direction finder is close to the portable facility structure.

With the help of handheld direction finders, the RES search process is provided by means of some basic stages, which are as follows [10]:

- Fast panoramic spectral analysis in the given (operating) range and the detection of “new” signals
- Qualitative or quantitative estimation of the detected emission parameters
- Obtained parameters comparison with the database and the determination of RES value (danger)
- RES location detection is an iterative process of operator-executed RES direction-finding stages, where the estimate of each stage’s level, its comparison with the previous iteration level, and the operator’s choice of movement direction, with the equipment, for the next iteration, are fulfilled.

The handheld direction finder consists of:

- Exchangeable directional antennas for open application and the indicator
- Exchangeable directional antennas for concealed application and the control panel
- Panoramic digital radio receiver
- Additional facilities providing the signal level indication, level variation, signal demodulation and audition, and (when necessary) the operating frequency range extension
- Power source from the autonomous accumulators, car power net and AC net, as well as the accumulator re-charge.

The problem of field strength measurement using manpack equipment can be solved by using the measuring antennas only, and including required masts or tripods for their mounting, as part of the equipment structure, if necessary. To reduce the equipment range, and to provide the unification of high-quality radio monitoring, the main technical requirements for all types of equipment, including the portable and manpack ones, should not differ greatly from the appropriate requirements for the stationary and mobile equipment. The requirements for weight, dimensions and

power consumption may be the exception to this rule. Therefore, it is expedient to compile the single-channel and multi-channel DRR from the unified modules, to put them in cases, in keeping with the main requirements for the tactical technical characteristics – and for multi-functionality – and to provide a power supply from various power sources (AC net, car on-board supply, and accumulators). Moreover, it is desirable to provide full-scale radio monitoring, with the manpack equipment in operation at the temporary or stationary posts. Such an approach to RM equipment development allows for a lightening of the workload, with regard to the interaction between the technical facilities for the various families, and provides for unified database formation, as well as for electrical and informational compatibility.

Sensitivity and direction-finding accuracy are also the main parameters of the manpack equipment. Moreover, its weight and operation duration from the single power supply set are also important.

For the manpack equipment, expert estimates concerning the needed accuracy of RES direction finding show that, for practical purposes, it is enough to have the angle error 10^0 – 15^0 . Equipment sensitivity (across the field) defines the action zone size, which can sometimes influence the ability to safely execute the operation. With this aim in mind, it can be recognized as necessary to have the option of concealed equipment application. The sensitivity (across the field) of modern handheld direction finders, for open application, is equal to 5–25 $\mu\text{V/m}$ in the frequency range of 25–3,000 MHz. In the opinion of the professional experts, this solves most of the problems. The weight of the equipment set should not exceed 5–10 kg, and the operating duration from the single power source set should be not less than 3–5 h.

Conclusion

In the present chapter, ARM technical means are classified by territorial coverage zone, by application, by the character of the function, by the equipment performance, and by the construction constraints. It is expedient to divide the equipment range into the following families:

- Stationary equipment
- Mobile equipment
- Portable equipment
- Handheld equipment for open and concealed application.

ARM equipment can be used for CEE measurements and investigations, in the presence of the authorized organization certificates and the additional facilities.

This chapter proves the rationality of the approach that, in each equipment family, there is basic ARM equipment, the possibilities of which can be improved by the additional facilities that are mutual for all families. To reduce the ARM equipment set, it is necessary to use the programmable units of digital-signals processing, to share efficiently the problems that exists among the hardware and software means. It is desirable to have unified customized mathematical software packages and the

usage of the similar data structure and format to be able to use the same package (with various drivers) in all ARM equipment families.

A unified set of hardware-software facilities is offered. It includes:

- Single-channel or multi-channel frequency converter
- Single-channel and double-channel unit of analog-digital processing
- Multi-channel equipment for the radio signal digital record in the bandwidth of simultaneous analysis
- Equipment for the real-time and post-processing of signal technical analysis. Digital demodulators unit
- Equipment for recording the demodulated signal simultaneously with the service signals
- Means for RM equipment localization, as per geographical coordinates
- Power supply
- Customized mathematical software for the solution of RM problems, suitable for all families.

As the general estimation index for ARM equipment, the criterion “effectiveness-cost” can be chosen as the most convenient criterion. At this time, equipment effectiveness is the best of all criteria at characterizing the probability of executing the appropriate RM problem solution during the fixed-time interval, under the condition of the presence of the essential additional parameters for the given equipment.

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