Monitoring the radio frequency spectrum based on an integrated antenna system

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Abstract. Currently, the active use of the electromagnetic resource associated with the development of systems and means of radio communications and radio engineering, as well as various electronic and electromechanical systems, leads to a significant appearance of an additional electromagnetic background, complicating the already difficult state of the noise environment and exacerbating the problems of electromagnetic compatibility.

1. Introduction
A particularly difficult electromagnetic environment is taking shape in large cities, where the main sources of electromagnetic fields of the radio frequency range are television and radio transmitting centers, mobile base stations and a huge variety of other systems and devices that broadcast electromagnetic fields on air.

For optimal distribution of the radio frequency resource and avoiding collisions during the joint operation of radio and electronic devices, it is necessary to constantly monitor the radio air, effectively identifying interference problems of a local and general nature. From this point of view, it is necessary to use high-precision measuring equipment to solve the above problem.

One of the main elements of such measuring equipment is the antenna. To a large extent, it is the antenna that determines the accuracy of measurements and, accordingly, the reliability of their results.

2. Theoretical features of the material
There is a wide variety of measuring antennas included in the measuring systems used to monitor radio broadcasts. However, solutions are still being sought to create a universal antenna that allows measurements to be taken in a very wide frequency band with minimal errors. One of the possible solutions to this problem could be the creation of an antenna system consisting of several antennas operating in certain frequency ranges, but jointly covering the entire studied range of radio air.

This article proposes and considers an antenna system that can be used as part of measuring equipment for monitoring radio broadcasts. The main task of radio monitoring is to study the radio broadcast in the frequency band in which all the main radio systems and devices operate. Research means effective direction finding of radiation from various radio sources, measurement of their electromagnetic field levels and analysis of the radio frequency spectrum congestion.

The antenna, being the first and most important element of the measuring equipment, must have the following technical characteristics:
• wide band of working frequencies;
• high stability gain;
• high stability of the shape of the radiation pattern in the main planes in the entire frequency band;
• low level of lateral radiation;
• high value of the coefficient of protective action;
• high value of cross-polarization;
• ease of use and unification of the design.

As part of the measuring equipment are used:

• wideband omnidirectional antennas for various applications;
• sets of antenna systems for automatic direction finding in motion, in parking lots and for stationary posts;
• sets of antenna modules with directional properties for hand-held direction finders of open and secretive use.

As you can see, most often as a part of measuring equipment sets of antennas are used, each of which has its own range and directional properties. When monitoring the radio frequency spectrum of a particular band, the use of an antenna with an appropriate operating frequency band is required. Therefore, you have to use either universal broadband antennas or change antennas when moving from one band to another.

3. The experimental part of the material

We have developed an antenna system designed for operation as part of measuring equipment for monitoring radio broadcasts. The system consists of two antennas: log-periodic, operating in the frequency band 80 ... 1000 MHz, and horn, operating in the frequency band 1 ... 12 GHz.

A log-periodic antenna consists of twenty-one elements, with a calculated period of the structure \( \tau = 0.84 \) and a web angle \( \alpha = 450 \). The antenna assembly line is 1.57 meters long, the longest vibrator (one arm) is 0.83 meters long, and the shortest is 0.4 meters long.

Antenna studies have shown that its gain in the operating frequency band remains virtually unchanged at 12 dB, and the protective coefficient is 18 dB.

As the second antenna, the measuring horn antenna P6-23A is used, having the following technical characteristics:

• frequency range - 1 ... 12 GHz;
• effective area:
  • at a frequency of up to 6 GHz - 150 sm;
  • at a frequency of more than 6 GHz - 130 sm;
• RF path - 50 Om;
• the error of the effective area is 20%;
• SWR - 1.5;
• antenna input (section AA) - coaxial;
• input resistance - 50 Om;
• level:
  • side lobes - not more than 10 dB;
  • transverse polarization - not more than 20 dB.

Figure 1 shows a generalized diagram of the antenna system. Both antennas are mounted on a common traverse, which, in turn, is mounted on a vertical mast. The system has the ability to change
the direction of monitoring in the meridional (horizontal) plane, as well as change the polarization of the antennas.

The horizontal spacing between the antennas is 1.5 meters, which allows us to solve the problem of the mutual influence of the antennas on each other.

Figure 2 shows the complete structural diagram of the system, which consists of the developed antenna system, switching system, stationary radio monitoring system Rohde & Schwarz UMS100, with the ability to connect a portable Rohde & Schwarz PR100 receiver, antenna control unit, computer terminal.

Consider the design features of the developed antenna system. The system has the ability to change the polarization of both antennas using an electric motor that can be controlled remotely by issuing commands through a computer terminal. The polarization can be set separately for each antenna, or the same for both antennas.

The mast, on which the antennas are mounted, changes its position with the help of a second engine, which can also be controlled remotely by issuing commands through the same computer terminal. Thus, it is possible to quickly, in real time, control the direction of monitoring by changing the angle of
observation of the antenna system to the point of arrival of the signal under investigation from zero to three hundred and sixty degrees. The rotary system uses a selsyn-sensor-receiver, which synchronously, with an accuracy of 0.1 degrees, sets the angle of rotation of the antennas, set by the operator on the computer terminal.

Using the developed antenna system, measurements were made of the electric field generated by various sources of radio emission in different areas of the terrain.

Table 1 shows the measurement results obtained using the developed antenna system and standard antennas that are part of the Rohde & Schwarz UMS100 measuring equipment.

**Table 1.** The results of measurements of the electric field.

| №   | Frequency, MHz (type of system) | Field strength values measured using the developed antennas system (dBμV/m) | Field strengths measured using standard antennas UMS-100 (dBμV/m) |
|-----|--------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------|
|     |                                | Position 1 vertical | Position 2 horizontal | Position 1 vertical | Position 2 horizontal |
| 1.  | 100.5 (radio station FM)        | 87.0                | -                    | 80.0               | -                    |
| 2.  | 101.0 (radio station FM)        | 95.2                | -                    | 84.1               | -                    |
| 3.  | 554 (broadcasting standard DVB, 31TVK) | 78.4              | -                    | 70.0               | -                    |
| 4.  | 569 (broadcasting standard DVB, 33TVK) | -                 | 79.1/74.0            | 74.0/68.3          | -                    |
| 5.  | 465,850 (CDMA450 mobile communication) | 95.5              | -                    | 90.5               | -                    |
| 6.  | 872,500 (mobile communication standard LTE800) | 99.8              | -                    | 85.4               | -                    |
| 7.  | 886,5 (mobile communication standard GSM900) | 103.7             | -                    | 91.7               | -                    |
| 8.  | 946 (mobile communication standard GSM900) | 101.7             | -                    | 88.4               | -                    |

Analysis of the measurement results shows that the difference between the results obtained using the developed antenna system and standard antennas is from 5 dBμV/m to 26 dBμV/m. For example:

- at a frequency of 465.850 MHz, the difference is 5 dBμV/m,
- at a frequency of 100.5 MHz, the difference is 7 dBμV/m,
- at a frequency of 872.500 MHz, the difference is 14.4 dBμV/m,
- at a frequency of 2117.5 MHz, the difference is 16 dBμV/m,
- at a frequency of 2670 MHz, the difference is 13.2 dBμV/m,
- at a frequency of 1877.4 MHz, the difference is 26 dBμV/m.
Thus, we can state the fact that the developed antenna system gives more accurate results than when using standard antennas that are part of the measuring equipment.

In addition, due to the possibility of remote control (in manual or automatic modes) of the antenna system, the measurement process is greatly simplified, which is very important for difficult field conditions in the hot regions of the Republic of Uzbekistan.

4. Conclusion
In our study, the developed electronic mechanical antenna system, which can be used as a part of modern measuring equipment for conducting radio monitoring studies is described. The advantage of the development is that it greatly simplifies the measurement work, since during the measurement process it is often necessary to change the height of the suspension of the measuring antennas, their orientation in the horizontal plane and polarization. The use of selsyn sensors and engines in conjunction with a computer control system can improve the accuracy of measurements and reduce physical stress on the operators taking measurements. This is especially important when conducting long-term studies in difficult field conditions at high or low ambient temperatures and other climatic influences on a mobile radio monitoring terminal.

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