Western European Journal of Modern Experiments and Scientific Methods
Volume 3, Issue 10, October 2025
https://westerneuropeanstudies.com/index.php/1
ISSN (E): 2942-1896 Open Access| Peer Reviewed

MULTIFUNCTIONALITY OF RADIO RECEIVING DEVICES

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Abstract: The article presents radio receiving devices that are designed to receive radio signals and convert them to a form that allows the use of the useful information contained in them.

Keywords: received signal decoding, frequency filtering, received signal processing

Any radio receiver consists of a receiving antenna and a radio receiver (or, more simply, a receiver). A radio receiver, in the broadest sense, is a system of components and units that perform the following operations:

- conversion of the electromagnetic field of a signal (interference) into a radio signal using a receiving antenna and ensuring spatial and polarization selectivity of the useful radio signal;
- selection (frequency filtering) of useful radio signals from a set of other (interfering) signals and interference acting at the output of the receiving antenna and not coinciding in frequency with the useful signal;
- conversion and amplification of received signals to ensure high-quality operation of the demodulator, decoder, receiver protection circuits against interference and the reverse EFPS (decisive or executive device);
- demodulation of the received signal in order to extract information (modulating function) contained in the useful radio signal;
- decoding the received signal;
- processing of received signals in order to reduce the interfering effects of artificial and natural interference.

Such an operation involves the introduction of interference protection means into the receiver and the effective processing of signals and interference, which achieves the best detection of signals or the evaluation of received information (messages) according to some criterion of receiver optimality in accordance with the target content of the practical problem being solved.

In all the radio engineering systems considered, useful information is embedded in the parameters of the radio signal at the input of the radio receiving device. Therefore, all the main operations related to the spatial and frequency selectivity of a radio signal, its amplification, demodulation and processing, can be solved on the basis of a unified theory of analysis and synthesis of receiver paths and the same principles of their circuit implementation.

Let's consider receiving devices from a classification perspective. Receivers are classified by purpose, the range of waves (frequencies) they receive, the type of modulation of the transmitted signals, and operating conditions. The quality indicators of radio receiving devices are determined by electrical, design, operational and economic characteristics.

Receivers are classified by purpose as professional and broadcast (household). Professional receivers include communications, radar, radio navigation, and other receivers. Household receivers provide reception of audio and television broadcasting programs. [1]

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The operating frequency range, i.e., the tuning frequency range within which all other electrical characteristics of the receiver are maintained. Modern radio receivers provide reliable reception of radio signals across a wide frequency range, within which radio systems can operate.

According to the type of signal modulation, radio receivers, like radio transmitters, are divided into devices with amplitude, balanced amplitude and single-sideband, frequency, phase, pulse, pulse-code (digital) and other types of modulation.

Depending on their operating conditions, receivers can be stationary, airborne (space, marine, aircraft, automotive), portable (handheld), or mobile.

The main characteristics of a receiver include sensitivity, selectivity, and interference immunity.

Noise immunity-is the ability of a radio receiver to maintain signal reception quality under the influence of various types of interference, such as electromagnetic noise, interference signals and other unwanted influences.

- Units of measurement: Noise immunity can be measured in decibels (dB), which reflects the ratio of the level of the useful signal to the level of interference (sometimes called the signal-to-interference ratio, SIR).

• Typical value: Values may vary depending on the type of interference and operating conditions, but a good indicator is an SIR level above 20-30 dB.

Parameters Affecting Noise Immunity:

• Automatic Gain Control (AGC) systems: Help maintain a stable signal level at the receiver output despite changes in the input signal level.

• Modulation and demodulation technologies: The use of more complex modulation schemes, such as QAM (Quadrature Amplitude Modulation), and coding techniques, such as error-correcting codes, improves noise immunity.

• Shielding and grounding: Physical methods of protecting the receiver from external electromagnetic influences.

A radio receiver's-sensitivity is the device's ability to detect weak signals. Technically, it is defined as the minimum input signal level at which the receiver can provide a certain level of reception quality, usually expressed as the signal-to-noise ratio (SNR).

• Units of measurement: Sensitivity is typically expressed in microvolts (μV) or decibels relative to a microvolt (dBμV) at the receiver input.

• Typical value: Modern radio receivers can have a sensitivity of about 0.5-1 μV with an SNR of 10 dB.

Parameters affecting sensitivity:

• Noise Figure (NF): The lower the noise figure, the higher the receiver sensitivity.

• Gain: Increasing the gain can increase sensitivity, but only up to a certain point, after which the receiver's internal noise begins to dominate.

Selectivity-is a radio receiver's ability to distinguish between signals of different frequencies while rejecting signals at frequencies close to the operating frequency. This is especially important for preventing interference from adjacent channels.

• Units: Selectivity is typically measured in decibels (dB), which represents the difference in

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gain between the desired signal and signals on adjacent frequencies.
• Typical value: High-quality receivers can have selectivity in the order of 60-80 dB.

Parameters Affecting Selectivity:

• Bandwidth: A narrower bandwidth improves selectivity but may limit throughput.

• Filters: Using high-quality filters (such as quartz or ceramic filters) helps improve selectivity.

Figure 1 shows the classification of radio receivers based on their intended use. This classification includes various categories, such as consumer receivers, professional receivers, and specialized receivers for aviation, maritime, and other specific applications.

– Now that we've covered the concept of radio receivers and their classifications, let's look at the characteristics of frequency converters:

The conversion ratio is the ratio of the output voltage amplitude to the input signal amplitude. It is determined by precise tuning of the local oscillator and equality of the frequency of the useful component and the average frequency of the passband of the load selective system. The higher the conversion factor, the better the intermediate frequency. The conversion factor can be either greater than zero in active frequency converters $U_{IF} > U_C$, or negative in passive converters $U_{IF} < U_C$ [1].

– The operating frequency range of the intermediate frequency must correspond to that of the receiver. In today's congested radio bands, this is the dynamic range (DR) of the mixer. This parameter has several varieties, the main ones being: dynamic range for blocking and dynamic range for second- and third-order intermodulation distortion.

- The dynamic blocking range is the largest of those listed and determines the upper limit of conversion linearity. The dependence of the conversion coefficient K_{pr} on the received signal power P_c can be considered a linear function only within certain limits.

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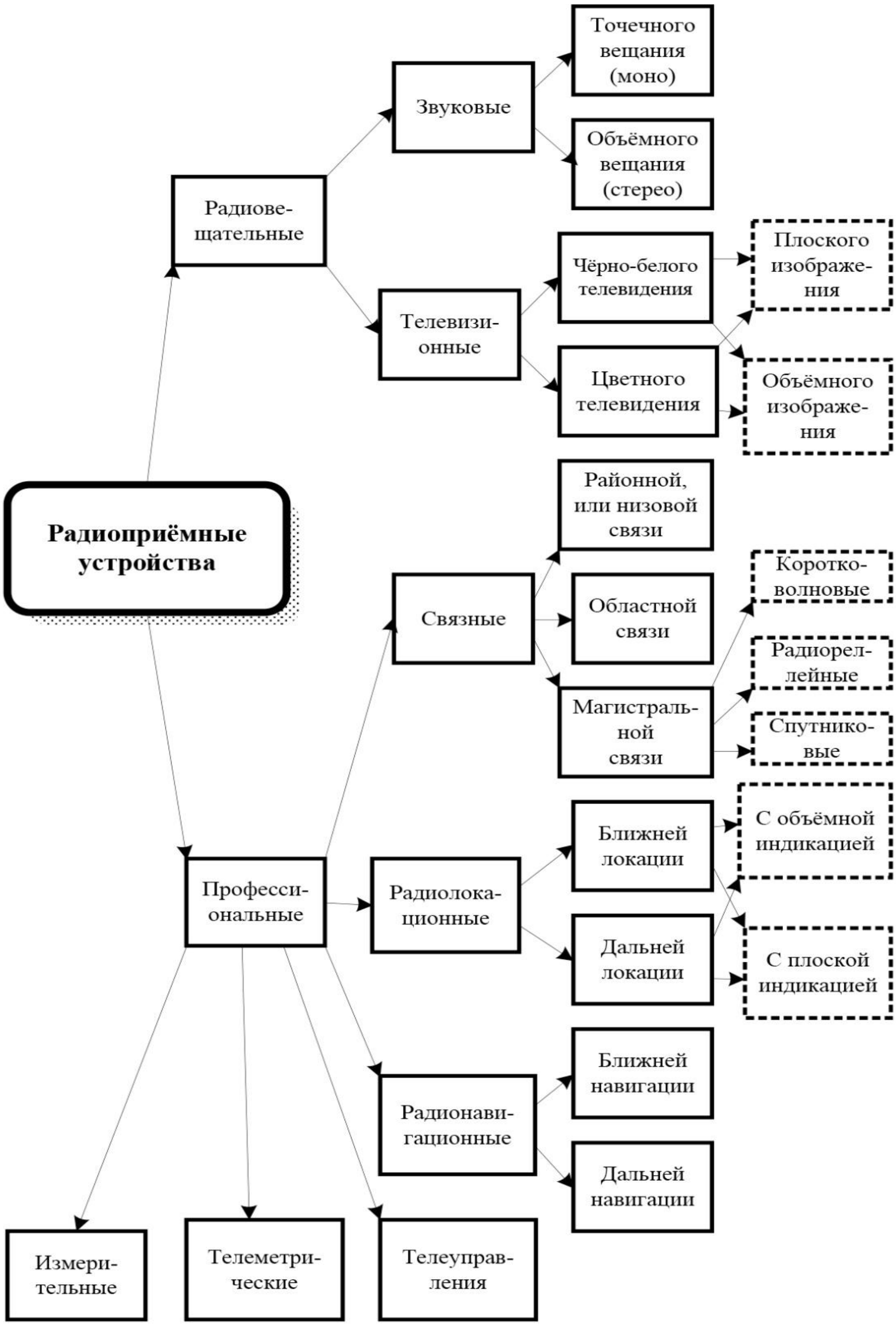

Figure.1 - Classification of radio receiving devices.

Starting from a certain critical value of the signal $P_{(s.cr)}$, saturation of the transformation function begins to appear, i.e. K_{pr} begins to decrease.[2]

Along with the weak useful signal, the preselector's passband usually also includes signals from other powerful radiation sources, which reduce the conversion efficiency, thus

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weakening the useful signal. At the same time, the out-of-band interference itself is not audible at the receiver output, since it is effectively suppressed by the concentrated selection filter (CSF).

The selectivity of the intermediate frequency is determined by the shape of the selectivity curve, which is understood as the dependence of the amplitude of the output voltage of the intermediate frequency on the frequency of the input signal with the amplitude and frequency of the local oscillator remaining unchanged[3].

– The intermediate frequency noise figure is estimated using the same methodology as for the amplifier stage. It determines the amplifier's noise properties. Special high-frequency amplifier circuits are used to reduce the noise figure.

– The level of intermediate frequency distortion is made up of amplitude-frequency, phase-frequency and nonlinear distortions.

-The stability of the intermediate frequency is characterized by the constancy of its parameters and the reliability of its operation. Since the input and output resonant systems of the intermediate frequency are tuned to significantly different frequencies, it is more stable.[4]

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