OVERVIEW OF RADIO RECEIVERS FOR COMMUNICATION SYSTEMS

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https://doi.org/10.5281/zenodo.14264071

Abstract: This article provides a comprehensive overview about radio receivers, focusing on their classification, operating principles and quality indicators. Radio receivers can be classified based on various criteria, including frequency range, modulation types, applications and etc. The operating principles are explored in detail, comprising the processes of signal reception, amplification, demodulation and others. In addition, key quality indicators such as sensitivity, selectivity, interference immunity are analyzed to evaluate performance and reliability of radio receivers. By understanding these aspects, users can make informed decisions when choosing radio receivers for a variety of applications, from personal use to professional broadcasting.

Keywords: radio receiver, classification, operating principles, quality indicators, sensitivity, selectivity, interference immunity.

I.INTRODUCTION.

A receiving device is an electronic or mechanical device designed to receive data, signal, or energy. Radio receivers are widely used in many fields such as telecommunications, radio broadcasting, television, radio relay and satellite communication systems. With the development of technology, the demand for the efficiency of radio receivers has increased, and different types of radio receivers have been created with different functions depending on the field of application. This article aims to classify radio receivers, elucidate their operating principles, and discuss the quality indicators that determine their performance.

II. RADIO RECEIVER CONCEPTS AND PERFORMANCE

Radio receiver – an electronic device that receives radio waves and converts them into a usable form. Radio receivers are mainly used to receive radio broadcasts, television signals and other types of radio waves. The main functions of the device are as follows:

- capturing the electromagnetic field energy that carries the useful information;
- amplifying the power of the useful radio signal;
- detecting the radio signal;
- amplifying the signal power and converting it into the message delivered to the receiver.

A. Classification of radio receivers

Radio receivers can be classified based on various criteria, including their design, functionality, and application. Below we explain in more detail the classification of radio receivers:

- According to the main functional task - professional and broadcasting radio receivers;
- Radio communication receivers - local technological, internal-zone, trunk, international and space communication receiving devices;
- According to received signal types - analog and digital signal receivers;
- By type of received information - radiotelephone, radiotelegraph, television, facsimile,

voice transmission, data transmission and other receivers;

- By modulation type - amplitude modulated (AM), frequency modulated (FM), phase modulated (PM), pulse modulated (PM) and other types of radio receivers;
- Depending on the wave range - myriametric waves (100...10 km), kilometer waves (10...1 km), hectometer waves (1000...100 m), decameter waves (100...10 m), meter waves (10…1 m), decimeter waves (100…10 cm), centimeter waves (10…1 cm), millimeter waves (10…1 mm), decimeter waves (1...0.1 mm) and other wave receivers. Receivers that have more than one of the above ranges are called multi-wave receivers.
- By installation location – stationary, mobile, portable radio receiver;
- By the method of supply – receivers which supplied from an alternating current network, accumulator, galvanic or solar batteries, with universal supply;
- According to the method of management and communication - manually controlled, partially or fully automated, remote, mixed-control receivers;
- According to the method of constructing the signal amplification tract before the detector - direct amplification, direct detection, single, double or multiple frequency conversion switchable super-heterodyne receivers.

B. Principles of operation

Figure 1 shows a diagram demonstrating the basic functions of a radio receiver. It consists of five functional parts. Below we will explore in detail the tasks that these functional parts perform:

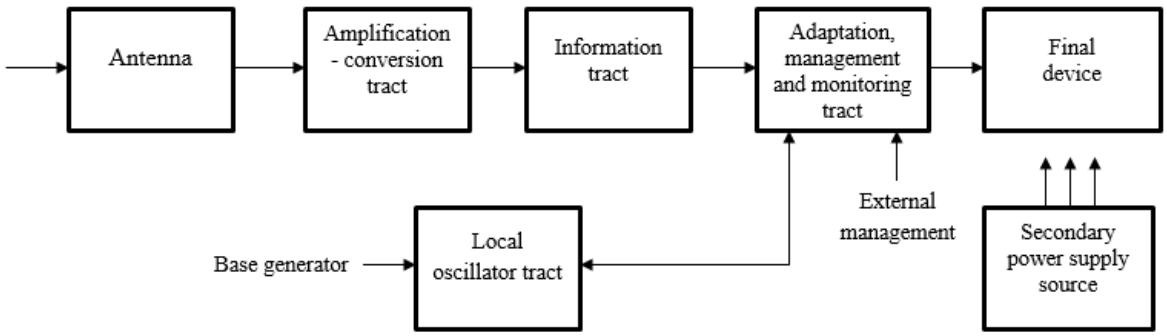

Fig. 1. A generalized scheme showing the functions of a radio receiver

In the **amplification-conversion tract**, useful signals are extracted from the mixture of signals coming from antenna A and interferences that do not match the useful signal in terms of frequency, and amplification of the useful signal necessary for the normal operation of subsequent cascades is performed.

In the **information tract**, basic signal processing (demodulation) and interference reduction is performed in order to extract the information from the signal. At the same time, it is important to have high reliability of the allocated information. For this, an optimal filter, post-detector processing circuits, frequency and phase automatic adjustment systems (FAS and PAS) play a key role in the information tract structure. The task of FAS and PAS systems is to demodulate the signal, as well as search for it by frequency and phase.

Local oscillator tract changes its frequency or the frequency of the external base generator and forms the type of frequency required for frequency conversion in the amplification-conversion tract, signal processing devices in the information tract, and subsequent systems.

Adaptation, management and monitoring tract performs manual, remote and automated control of the receiver's operation mode and the display of its work quality in appropriate indicators.

In the **final device**, the energy of the isolated signal is used to create the required output, that is, an acoustic, optical, mechanical effect.

The secondary power supply source transforms the primary energy source into a convenient form and path suitable for use in the radio receiver. This functional part allows for voltage transformation, rectification, smoothing and stabilization to be carried out.

The considered structure scheme is general. Sometimes, some tracts may not be available in radio receivers or perform a limited set of tasks. In this case, the simplified structure of the receiving device and the limitation of the functions of individual tracts – reduces the capabilities of the radio receiver. The greatest efficiency of receiving is achieved by combining several radio receivers controlled on the basis of adaptive algorithms into a radio receiving system. In such systems, each radio receiver receives the same signal in different modes, and through computer control, processing of all received signals or selecting the better received signal.

C. Quality indicators

Several indicators that characterize the quality of radio receiver are available. From these indicators, sensitivity, selectivity and interference immunity determine the electromagnetic compatibility characteristic (EMC).

One of the main indicators of radio receiver is sensitivity, which measures the receiver's ability to receive weak signals normally. The sensitivity of the radio receiver is quantified by the minimum value E_A of the electromotive force (EMF) in the antenna:

$$E_A = 2\sqrt{kT\Delta F_R N q^2 r_A} = 2q\sqrt{kT\Delta F_R N q^2 r_A}$$

where, $k=1.38 \cdot 10^{-23}$ J/K – Boltzmann's constant; T - absolute temperature; ΔF_R is the bandwidth of the receiver; N is the noise coefficient of the receiver linear path; r_A is the resistance of the antenna.

The selectivity of a radio receiver is the ability of the radio receiver to distinguish the useful signal from interfering signals. It depends on the direction of arrival and the time of impact of the useful and interfering signals, their polarization, amplitude, frequency, and phase. The selectivity of a single signal is evaluated by the ratio of the level of the test signal at the frequency of the interference to its value at the frequency of the useful signal, that is, through the ratio of the corresponding gain coefficients, under constant tuning and the same output voltage at the frequency of the interference:

$$S_e = K_0 / K(f)$$

where, K_0 is the gain of the receiver at the resonance frequency f_0; K(f) is the modulus of the gain of the amplification-conversion tract over the voltage at an optional frequency f.

Interference immunity refers to the ability of a radio receiver to maintain the quality of performance under conditions affected by interferences. When receiving discrete signals, the resilience of the signal against interference is determined by the ratio of the number of correctly received elementary signals M to the total number of transmitted elementary signals N, expressed as $P_u = M/N$.

An increase in the number of radio stations leads to a high rate of interference between

radio stations. This interference leads to poor quality of the receiver. Research shows that the use of wrong components and poor integrated circuits are the causes of this interference and other receiver system deficiencies. As a result of modeling with the right components, drawbacks are eliminated and quality indicators such as sensitivity and selectivity are improved.

III. CONCLUSION

In conclusion, radio receivers play a pivotal role in modern communication systems, offering a diverse range of functionalities and applications across various fields. The classification of receivers based on frequency range, modulation type, and application enables a better understanding of their capabilities and suitability for different purposes. By exploring the operating principles, it becomes clear how these receivers convert electromagnetic waves into usable audio or data signals, ensuring effective reception and processing. Additionally, the quality indicators of radio receivers such as sensitivity, selectivity, and interference immunity – are essential factors that determine the overall performance and user experience. As technology continues to advance, radio receivers will remain integral to communication, with ongoing innovations aimed at improving their efficiency and adaptability to new transmission standards.

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