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OPERATING PRINCIPLE OF THE STRUCTURAL AND CIRCUIT DIAGRAM OF A RADIO RECIEVER

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ABSTRACT	KEYWORDS
The article presents the design of a receiver where the signal in the path can undergo detection, multi-stage processing: filtering by frequency and amplitude, amplification, frequency conversion (spectrum shift), digitalization with subsequent software processing and conversion to analog form.	Preselector, radio frequency amplifiers (RFAs), heterodyne, mixer, bandpass filter.

Introduction

The structural diagram of a radio receiver depends largely on its purpose and modulation type. A general structural diagram of a radio receiver includes an antenna, a high-frequency path, a detector, an actuator, and a power supply (Fig. 1).

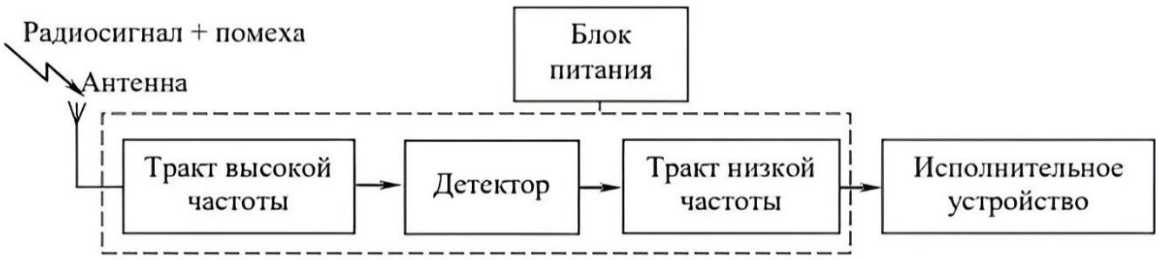

Fig.1. Generalized structural diagram of a radio receiving device.

The antenna is designed to convert electromagnetic field energy into high-frequency currents or voltages.[1].

The high-frequency path is designed to isolate useful signals and suppress interfering ones, and ensures frequency selectivity and sensitivity of the receiver.

The detector extracts the modulating signal—the useful message. The detector's circuit design depends on the modulation type.
The low frequency path is designed to amplify the received signal in order to ensure normal operation of the actuator.
The power supply is designed to provide operating modes for all components of the radio receiver.
The output device is a device that reproduces the transmitted message or further processes the received signal. It performs the important function of converting the processed signal into a form suitable for user perception. It includes detection, filtering, amplification, and signal reproduction. Proper design and configuration of all output device components ensures high-quality and reliable reproduction of received signals, a key aspect of the operation of any radio receiver [2].
The main processing of the received signal is carried out in the high-frequency (HF) path, the detector and the low-frequency path, and the circuit of the radio receiving device is determined by the general technical requirements.
Let us take as a clear example the structural diagram of a superheterodyne receiver as one of the most common examples (Fig. 2):

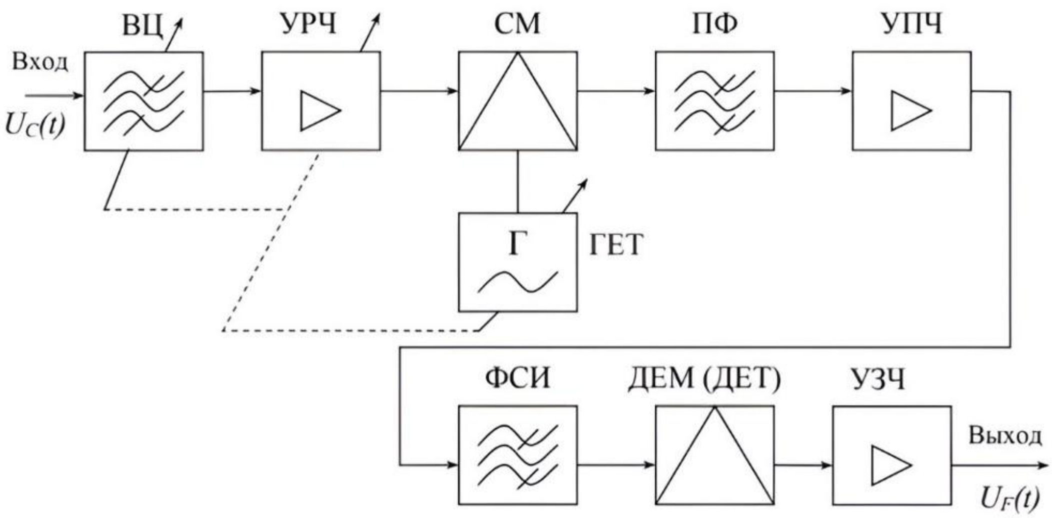

Fig.2. Structural diagram of a superheterodyne receiver.

Let's consider the purpose of each element of the circuit.
The input circuit is the part of the radio receiver circuit between the connection points of the antenna and the first active element of the receiver, i.e. it is a frequency-selective system that can be adjusted in range.
The input circuit is designed to efficiently transmit the signal from the antenna to the first stage of the receiver and perform its preliminary frequency selectivity. It performs primary frequency selection of the desired signal, attenuates strong out-of-band interference, providing linear gain for subsequent receiver stages, and, in conjunction with the RF amplifier, provides selectivity for side channels. It is shown more clearly in Figure 3:

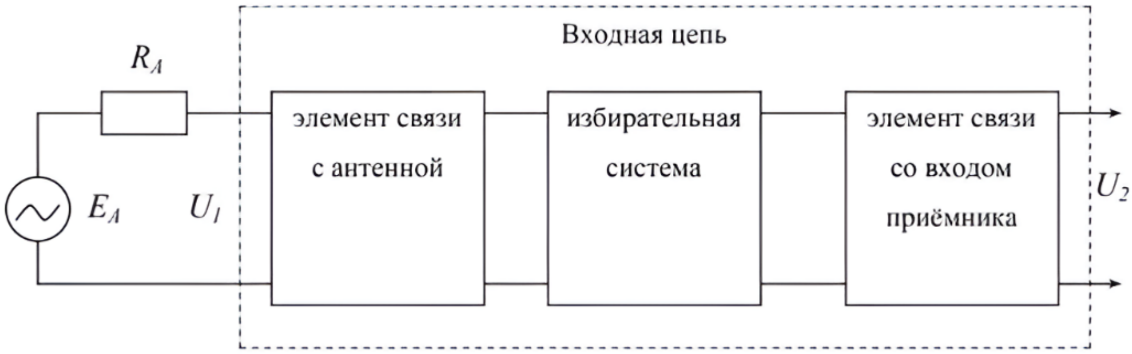

Fig.3. Generalized block diagram of the receiver input circuit.

The input circuit performs the following functions:
• ensures selectivity for side-channel reception;
• attenuates out-of-band interference, thereby ensuring the operation of the receiver's amplifier stages in linear mode and increasing the receiver's actual selectivity;
• matches the receiver input with the antenna-feeder device, thereby increasing the gain of the input circuit and, accordingly, the receiver's sensitivity [3].
The operational reliability of an input circuit determines its ability to operate for a specified period of time with a given probability of failure.
In addition, it is often required that the input circuit allows the use of different antennas with different parameters while maintaining the basic receiver performance unchanged.
Radio frequency amplifiers (RFAs) are the stages of radio receivers in which signal amplification occurs at the carrier (received) frequency.
The radio frequency amplifier is connected directly after the input circuit, and its output is connected either to a detector (in a direct-amplification receiver) or to a frequency converter (in a superheterodyne receiver). An example of a generalized structural diagram is shown in Fig. 4:

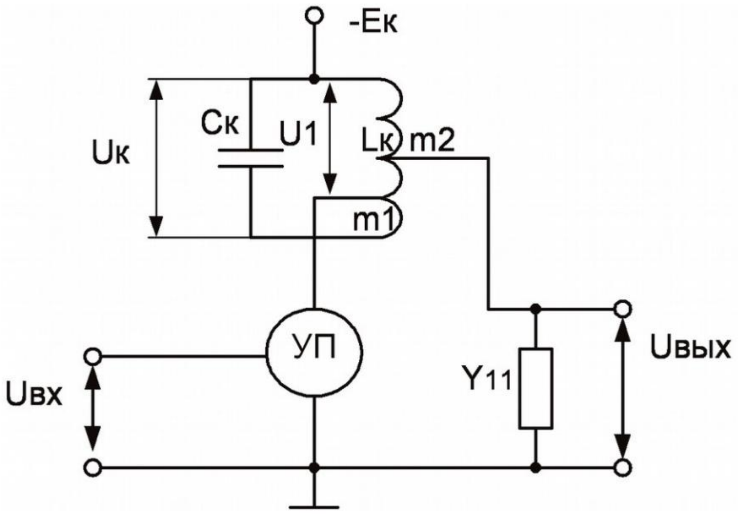

Fig.4. Structural diagram of a radio frequency amplifier.

RF amplifiers perform crucial functions in a receiver:
First, the RF amplifier must amplify received radio signals with only a small amount of added noise. This improves the receiver's effective sensitivity. To improve this, it is necessary to use stages at the receiver's input that have low noise and the highest possible power gain.
Secondly, together with the input circuits, they provide selectivity for out-of-band reception channels and protection of the antenna circuit from the penetration of its own local oscillator signal, which can create interference for neighboring radio receiving devices.
Radio frequency amplifiers selectively amplify a weak useful signal and increase the sensitivity of the receiver by reducing its noise figure.
Since a radio frequency amplifier must have frequency-selective properties, oscillatory circuits are used as loads in its stages, meaning that radio frequency amplifiers are resonant amplifiers. The selectivity of radio frequency amplifiers must be sufficiently high, as the receiver's input circuit, which in most cases contains only a single oscillatory circuit, is unable to provide the necessary selectivity.
In a receiver operating in a frequency range, the resonant amplifier circuits must be tuned. This tuning is usually accomplished using variable capacitors. To reduce the number of capacitors, modern radio receivers typically use one, or at most two, single-circuit amplifier stages.
Radio frequency amplifiers can be classified by a number of characteristics: the type of active element (vacuum tube, transistor, parametric, etc.), the number of stages, and the circuit type. The following are used as amplifying devices in RF amplifiers: transistors (bipolar and field-effect), TWTs, tunnel diodes, parametric diodes.
Due to the fact that some amplifying devices (bipolar transistors) have high input and output conductivity, their direct connection to the selective circuit would lead to strong shunting and deterioration of the amplifying and selective properties of the amplifier [4].
To weaken the shunting effect of these conductivities, partial inclusion of the selective circuit to the output of the amplifying device and to the input of the next cascade is carried out (Fig. 5).

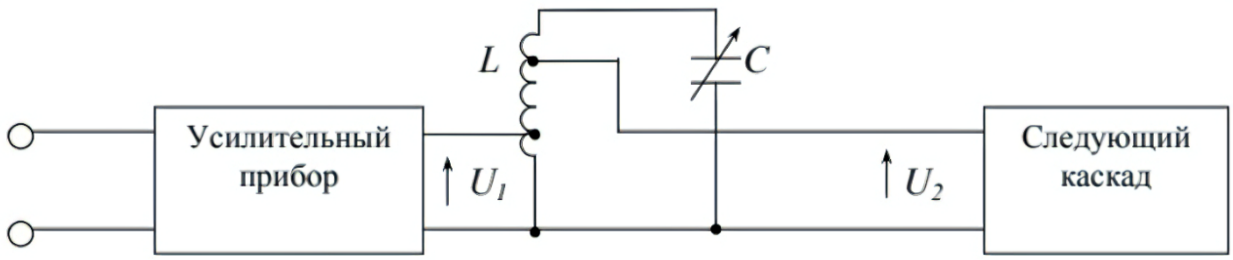

Fig.5. Schematic representation of partial inclusion of a selective circuit.

In the VHF range, the receiver's own noise plays a major role, and to reduce the receiver's noise figure, as noted, special low-noise amplifiers are used.
In superheterodyne receivers, the radio frequency amplifier is followed by a frequency converter, which converts the variable frequency of the input radio signal into a constant intermediate frequency for a given receiver without changing the type and nature of modulation.
The frequency converter consists of a mixer CM, a local oscillator HET and a bandpass filter PF and is designed to convert a radio frequency signal into a signal of constant intermediate frequency f_IF.

The constant f_IF allows the use of non-tunable multi-circuit selective systems in subsequent elements of the receiving path, ensuring high selectivity of the receiver for adjacent receiving channels.
In addition, the relatively low f_IF allows for a high gain of the receiving path, which improves the sensitivity of the receiver [3].
A mixer is a component that mixes an input radio frequency (RF) signal with a local oscillator signal, creating new frequencies: the sum and difference of the input and local oscillator frequencies.
The heterodyne (local oscillator) generates a stable signal at a frequency that differs from the frequency of the input RF signal by the value of the intermediate frequency(IF).
A bandpass filter selects the intermediate frequency (IF) signal from the signal mixture obtained at the mixer output and suppresses other frequencies.
The intermediate frequency amplifier (IFA) is one of the components of a superheterodyne receiver that provides the main amplification of high-frequency signals.
The intermediate frequency amplifier (IFA) is designed to amplify the radio signal to a level sufficient for the demodulator (detector) to function properly. The IFA performs the primary amplification of the radio signal, creates a frequency bandwidth determined by the spectrum of the received signal, and performs primary adjacent channel selectivity.
It should be noted that IF amplifiers, like RF amplifiers, are selective amplifiers. However, intermediate frequency amplifiers operate under conditions significantly different from RF amplifiers. Essentially, IF amplifiers differ from RF amplifiers in that they amplify radio signals at a constant, lower frequency.
Intermediate frequency amplifiers operate at a fixed frequency, and their basic circuits are bandpass amplifiers. The tuning frequency of a bandpass amplifier can be selected close to the optimal frequency for a given receiver. This allows for the use of complex oscillatory systems, which create a well-defined amplitude-frequency response that ensures high selectivity and, in addition, a high stable gain.
The IF amplifiers of modern superheterodyne receivers operate at fixed frequencies from 110 kHz to 200 MHz, have a gain from 10^2 to 10^8 (80 ÷ 100 dB) with a bandwidth from hundreds of Hz to tens of MHz and contain up to ten amplification stages.
Since the main selectivity and amplification of radio signals is performed at a constant intermediate frequency, the selectivity and sensitivity of the receiver does not change over the frequency range.
Currently, amplifiers with multi-link concentrated selection filters (CSF) are widely used in IF amplifiers, as shown in Fig. 1.14, which make it possible to obtain a narrow bandwidth.

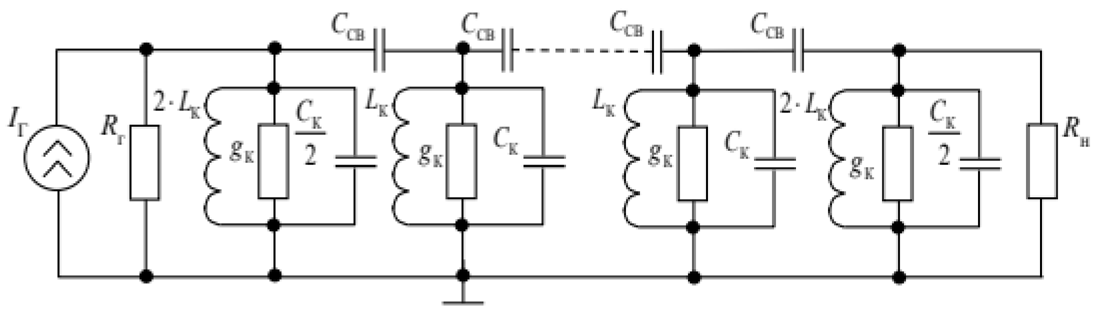

Fig.6. Equivalent circuit of n-link FSS.

IF amplifiers for professional mid-high-frequency receivers employ lumped-selectivity filters built around amplifiers and RC circuits. While passive, these circuits do not provide the required selectivity, using them in conjunction with an amplifier not only increases the filter's Q factor but also combines both selectivity and amplification functions in a single device [4].

The received signal, amplified in the high-frequency path (in the cascades of the RF amplifier of a direct amplification receiver or in the cascades of the RF amplifier and IF amplifier of a superheterodyne receiver), is fed to the detector. [1]

The demodulator (detector) is designed to convert received radio signals into a primary electrical signal (Fig. 7).

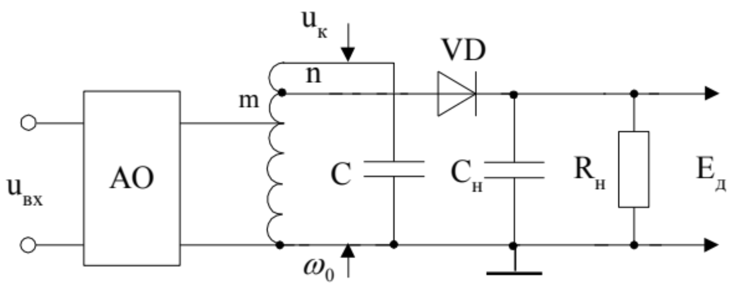

Fig.7. Generalized circuit of a single-circuit frequency detector.

The detector converts the modulated high-frequency oscillation into a low-frequency oscillation corresponding to changes in the modulated high-frequency oscillation parameter. Depending on the type of modulation, detectors are classified as amplitude, frequency, phase, and pulse detectors.

After demodulating the signal, the audio amplifier receives the low frequency audio signal, which is then amplified to a level sufficient to reproduce sound [2].

An audio amplifier is designed to amplify primary electrical signals to a level sufficient for the proper operation of receiving equipment. Its purpose is to amplify a weak audio signal to a level sufficient to drive a speaker and reproduce sound. The amplifier's function also includes filtering out unwanted noise and interference, and may also include gain control for adjusting sound volume.[4]

Thus, the advantage of a superheterodyne receiver is its high sensitivity and selectivity, which are constant throughout the entire frequency range of reception.

The disadvantage of a superheterodyne receiver is the presence of side reception channels that arise at the output of the frequency converter.

Another disadvantage of superheterodyne receivers is the possibility of constantly receiving interference with a frequency equal to or close to the intermediate frequency f_IF. If such interference is present at the input of the frequency converter, it can pass through it without frequency conversion and be further amplified in the IF amplifier. This interference reception occurs via a direct amplification circuit, regardless of the local oscillator frequency.

References

1. Design of microwave devices for radar receivers, Mironov 2023.
2. Development of a structural diagram of a radio receiver: A tutorial on course design. Sidorov V. M., 2018.
3. Design of radio receiving devices: A textbook for universities edited by A.P. Sivers, 2023.
4. Radio Receivers: A Textbook for Universities edited by N.N. Fomin, 2016.