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Development and Modern Areas of Application of Electronic Signal Amplifiers

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Abstract: This article provides a detailed study of the development of electronic signal amplifiers, their operating principles, and their role in modern technologies. It also analyzes the main types of electronic amplifiers and their technical characteristics, as well as their applications in radio communications, telecommunications, medicine, and industry. The article discusses the importance of signal amplifiers in modern electronic devices and their future development prospects.

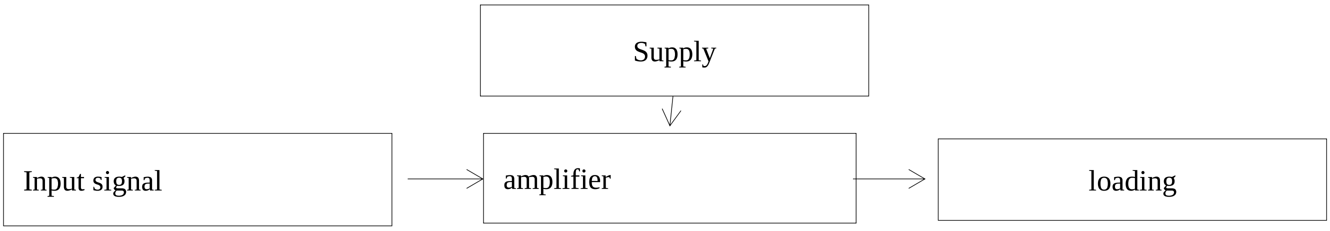
Keywords: Electronic signal amplifier, history of development, technical parameters, modern technologies, radio communications and telecommunications, applications in medicine and industry.

INTRODUCTION

The development of modern electronics and information technology has made electronic signal generators an important element. Electronic signal amplifiers amplify small or current signals, increasing the quality of loads in various equipment and devices. Signal power amplifiers are widely used in radio communications, telecommunications, audio and video equipment, medical diagnostic equipment, and industrial automation systems. Therefore, the history, principles of operation, and role of the enterprise in modern technologies are of great scientific importance.

An electronic amplifier is a device that converts a low-power electrical signal at the input into a high-power electrical signal without distorting its shape. Signal power is increased due to an additional power source. Accordingly, an amplifier is a device that converts the energy of the source supplied by the input signal into the energy of the output signal. A microphone, photocell, thermocouple, piezosensor, low-power amplifier, etc. can act as an input signal.

The signal at the output of the amplifier is fed to a device called a consumer or load. In many cases, the consumer is also called a load resistor. Devices such as telephones, loudspeakers, galvanometers, oscillographs, relays, electromotors, etc. can be consumers. The connection between the amplifier supply source, the input signal source, and the consumer is illustrated in Figure 1.1.



1.1-rasm Structural diagram of the amplifier.

Amplification coefficient. Linear and nonlinear distortions. The main parameter of an electronic amplifier is the amplification coefficient. The amplification coefficient is the main characteristic of an amplifier, determined by the ratio of the output signal power (voltage, current) to the input signal power (voltage, current).

In the absence of reactive elements, as well as in certain operating modes, that is, when reactive elements are not taken into account, the amplification coefficient is a real value and does not depend on frequency. At this time, the output signal repeats the shape of the input signal, but its amplitude differs by K times.

Variable signals are divided into amplification coefficients for power, voltage and current, depending on the requirements for the output parameters of amplifiers.

1 The amplification coefficient for voltage is determined by the ratio of the output signal voltage to the input signal voltage.

$$K_u=K_{ch}/K_{kr} \quad (1.1)$$

2 The current gain is determined by the ratio of the output signal current to the input signal current.

$$K_i=I_{ch}/I_{kr} \quad (1.2)$$

3. The power gain is characterized by the ratio of the output signal power to the input signal power.

$$K_p=P_{ch}/P_{kr}$$

Power:

$$P_{ch}=U_{ch.ef}I_{ch.ef}=\left(\frac{U_{ch}}{\sqrt{2}}\right)\left(\frac{I_{ch}}{\sqrt{2}}\right)=\frac{U_{ch}I_{ch}}{2}, P_{kr}=\frac{U_{kr}I_{kr}}{2}$$

Since the power amplification coefficient can be written as follows:

$$K_p=\frac{P_{ch}}{P_{kr}}=\frac{I_{ch}U_{ch}}{I_{kr}U_{kr}}=K_iK_u \quad (1.3)$$

When the reactive elements in the circuit are capacitors and inductances, the amplification factor should be considered as a complex quantity.

$$\dot{K}=m+jn=K(cos\varphi+jsin\varphi)=Ke^{j\varphi}$$

Here, m and n are the real and imaginary components of the amplification coefficient, which depend on the frequency of the input signal.

$$K=\sqrt{m^2+n^2\varphi}=arccos\frac{m}{\sqrt{m^2+n^2}}=arctg\frac{n}{m}$$

and a sinusoidal signal is fed to the amplifier input, then the output signal is also sinusoidal and differs in phase by an angle K times the amplitude of the input signal.

Complex periodic signals can be considered as a sum of a finite or infinite number of harmonics with different amplitudes, frequencies, and phases, according to Fourier's theorem.

Since the amplification factor is a complex quantity, the input signal consisting of harmonic components changes differently when passing through the amplifier, and the output signal differs in shape from the input signal.

If the distortions that occur when the signal passes through the amplifier occur due to the fact that the amplifier parameters depend on the frequency of the input signal, and do not depend on its amplitude, then the distortions are called linear. In turn, linear distortions can be frequency and phase. Frequency distortion characterizes the change in the modulus of the amplification coefficient in a given frequency range due to the influence of reactive elements in the amplifier. Phase distortion characterizes the frequency-dependent phase shift between the input and output signals due to the influence of reactive elements.

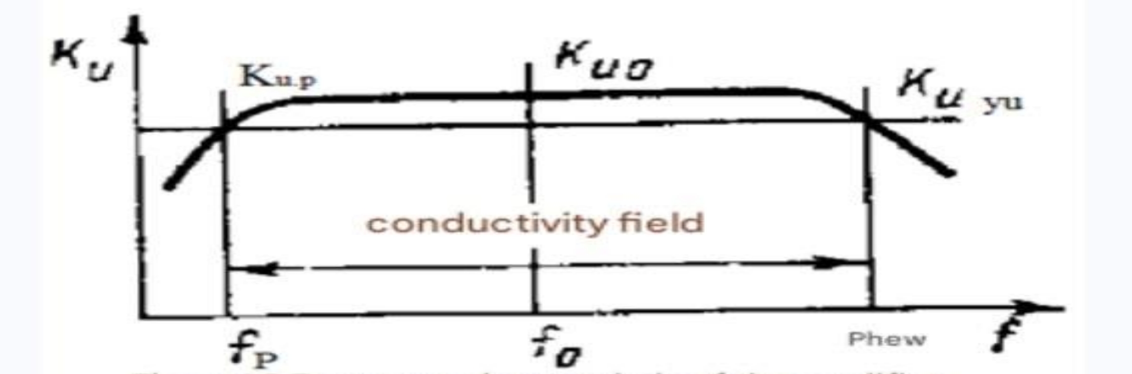


Figure 1.2 Frequency characteristic of the amplifier.

The frequency distortion of the signal can be estimated by the amplitude-frequency characteristic. The amplitude-frequency characteristic characterizes the dependence of the modulus of the gain coefficient on the voltage on the frequency (Fig. 1.2). The amplifier's threshold fp is considered to be constant in the range of low frequencies and fyu in the range of high frequencies, which is called the range of the amplifier's transition to this operating frequency range. The threshold frequencies are determined at frequencies below the maximum value of the gain coefficient Ku0, f0 at the mid-frequency range.

By introducing a frequency distortion coefficient at a given frequency f,

$$M = \frac{K_{uo}}{K_{u.f}} \quad (1.4)$$

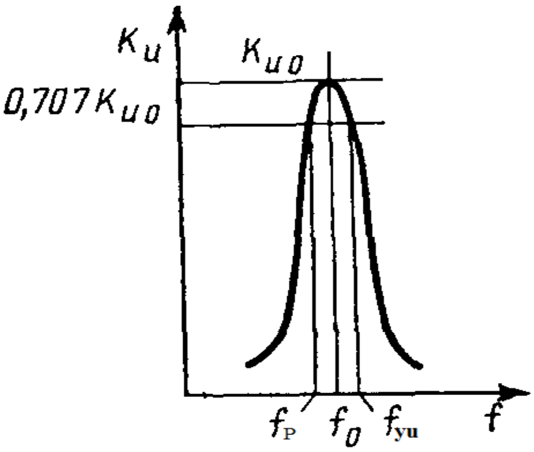
where Kuf is the amplification coefficient for the voltage at a given frequency, and using the amplitude-frequency characteristic, it is possible to determine the frequency distortions in any frequency range. Since the largest frequency distortions occur at the boundary frequencies, when designing amplifiers, the frequency distortion coefficients at the lower and upper boundary frequencies are given in advance, i.e.

$$M_p = \frac{K_{u0}}{K_{up}}$$

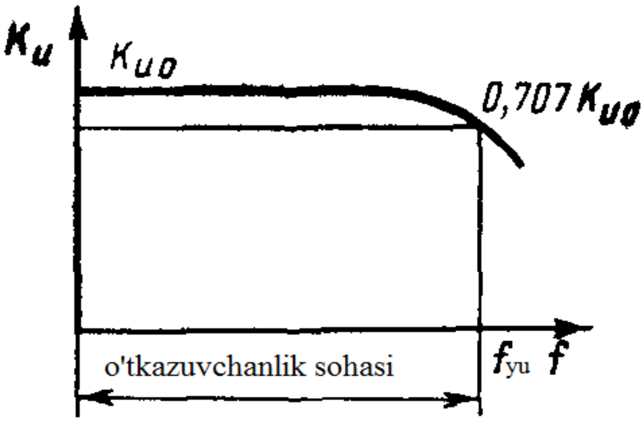
$$M_{yu} = \frac{K_{uo}}{K_{u.yu}} \quad (1.5)$$

where $M_p = M_{yu} = \sqrt{2}$ are the voltage gain coefficients of the amplifier at the upper and lower limit frequencies, respectively.

It is assumed that in practice, that is, at the limit frequencies, the gain coefficient of the amplifier decreases by 0.707 from that at the middle frequency. Based on these conditions, the frequency range of amplifiers at the audio frequency is in the range of 20-20000 Hz, and that of wide-band amplifiers is from a few fractions of Hz to several MHz.



1.3-rasm



1.4-rasm

When assessing the quality of an amplifier, an evaluation indicator is introduced with the following expression.

$$D \approx 2\pi K_{u0}(f_{yu} - f_p)$$

- In wideband amplifiers $f_{yu} >> f_p$ Since this indicator can be written as follows. (Figure 1.4)

$$D \approx 2\pi K_{u0} f_{yu}$$

- The opposite of wide-band amplifiers is a selective amplifier, their frequency response is narrow. (Figure 1.3).

Amplifiers called constant current amplifiers are designed to amplify signals with as low a frequency as possible, the lower limit of the frequency response of such amplifiers is zero. The amplitude-frequency characteristic of such amplifiers is shown in Figure 1.4.

Electronic signal amplifiers are an integral part of modern electronics. Their development is closely related to the technology. Modern amplifiers are characterized by high efficiency, small size and energy efficiency. In the future, electronic signal amplifiers will be further improved and will be widely used in various technological fields.

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