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# ANALYSIS OF MAIN CHARACTERISTICS AND PARAMETERS OF TRANSMITTERS WITH AMPLITUDE MODULATION

Shorakhmatov Mukhammadsaid Jahongir o'gli
Tashkent State Transport University, Uzbekistan

Abidova Gulmira Shuxratovna
Tashkent State Transport University, Uzbekistan

**Abstract**

AM transmitters are used for telephone communications, radio broadcasting, and transmission of television images. AM transmitters are used in all radio frequency ranges. The method for obtaining amplitude modulation depends on the purpose, power, energy and quality characteristics of the transmitter. Amplitude modulation can be carried out in any of the amplifying stages of the transmitter, if, according to the law of the information signal, the modulation factor is changed. The energy and quality indicators of the transmitter depend on which of the supply voltages is changed during modulation. There are two main types of simple modulation: displacement Ed along the input circuit of the active element and the supply voltage of the collector circuit Ev (collector modulation).

Combined modulation is used, in which several supply voltages change simultaneously. Shift modulation transmitters have a low efficiency, which prevents their use in broadcasting, professional communication systems. Such modulation is used in television, in the image channel, where the video signal has a wide bandwidth (up to 6 MHz). Such a signal is easier to obtain in a low power modulator inherent in offset modulation. In this case, the efficiency of the transmitter is low. The desired modulation quality with the highest possible efficiency is obtained with combined modulation, although this requires a more complex and powerful modulator. This article is devoted to the analysis of the main characteristics of the modulation process, for further designing a transmitter with a high efficiency.

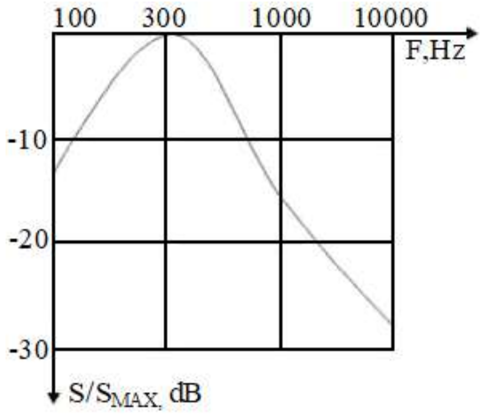
**Keywords:** modulation, transmitter, transmitter power, receiver.

## INTRODUCTION

Modulation is the process of changing one or more parameters of the carrier radio frequency wave in accordance with the change in the parameters of the transmitted signal. In the case of amplitude modulation, the variable parameter is the amplitude of the carrier harmonic oscillation.

At present, the main areas of application of amplitude modulation are: sound broadcasting in the LW, MW and HF bands, television broadcasting (image transmitters) in the meter and decimeter bands. For radio communications, AM is used in the ranges of 100-150 MHz (short range radio communications in aviation) [1].

The sound modulating signal is characterized by the bandwidth ($□_{min}$ - $□_{max}$) and intensity, and the signal power distribution in the audio frequency band - by the spectral density S(F). The spectrum of sound frequencies perceived by the human ear occupies the frequency band from 20 Hz to 20 kHz, but the spectral density of speech is very uneven (Fig. 1). The maximum sensitivity of the ear is near 1000 Hz, and the main energy of the voice is concentrated in a narrow band from 200 to 600 Hz [2].




Rice. 1. Spectrum of the speech signal

To ensure intelligible perception of speech during radiotelephone communications, it is sufficient to pass modulating frequencies of 300 - 3400 Hz through the transmitter with an allowable unevenness in this band of □(2□3) dB. To ensure high-quality radio transmission, a wider frequency band must be transmitted - up to 20□30 kHz [3]. The variance of the transmitted signal $□^2 u$, which characterizes its average power, is related to the spectral density by the relation

$$\sigma_u^2 = \frac{1}{2\pi} \int_{\Omega\min}^{\Omega\max} S(\Omega) d\Omega$$

When designing transmitters, it is important to know how much the real modulating signal U(t) differs from its RMS value □u. It depends on whether the transmitter will be “overloaded” by the signal and whether the nonlinear distortion of the signal in the transmitter will become unacceptably large or, conversely, the transmitter will be underused in terms of modulation depth. The difference between the real signal and □u is estimated by the crest factor P [4,5]:

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$P=U_{max}$□□$_u$ or $P(dB)=20\log(U_{max}$□□$_u)$.
For a speech signal, P =3,3(10,4 dB).
When designing transmitters, the peak factor is usually taken at the level of 3.4□4.
With amplitude modulation of the carrier by a signal of the form U□(t)=U□cos □t the first harmonic of the anode current of the generator changes according to the law
$i_{a1} = I_{a1T}$ (1 + m cos□t )cos □$_0$t =
= $I_{a1T}$ cos □$_0$t + ($mI_{a1T}$□2)cos(□$_0$+□)t+($mI_{a1T}$/2)cos(□$_0$-□)t.

It follows from this expression that the AM oscillation spectrum contains three components: carrier frequency oscillation □$_0$ with amplitude $I_{a1T}$ and two side oscillations with frequencies (□$_0$ + □) and (□$_0$- □) with amplitude 1□2$mI_{a1T}$.
The timing diagram of the AM oscillation and its spectrum are shown in Fig.2.

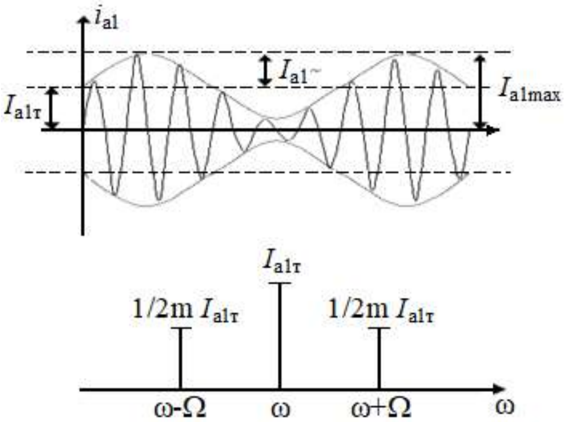


Fig.2. Timing Diagram and Spectrum of AM Signal

The change in the current amplitude is characterized by the modulation factor m=$I_{a1}$□□□ $I_{a1T}$.
Maximum and minimum current amplitude value
$I_{a1max} = I_{a1T}$ (1 + m)
$I_{a1min} = I_{a1T}$ (1 - m)
If the modulating voltage contains several harmonics, then the number of side harmonics in the spectrum will increase accordingly.
AM transmitter power in carrier mode (silent mode)
$P_{1T} = 0,5\ I^2_{a1T} R_e$
At the moment when the current amplitude passes through the maximum, the power
$P_{1max} = 0,5\ I^2_{a1max} R_э = 0,5\ I^2_{a1T} (1 + m)^2 R_э = P_{1T} (1 + m)^2$
The maximum power for which the transmitter must be rated is at
$m = m_{max} = 1$.
$P_{1max} = P_{1T} (1 + m_{max})^2 = 4P_{1T}$

With modulation, the power radiated by the antenna changes continuously. Power averaged over high frequency period

$P_{1P4}$ = 0,5 $I^2_{a1T}$ (1 + cos □t) ² $R_э$ = $P_{1T}$ ( 1 + mcos□t)²

The average value of the power over the period of the modulating signal is usually determined for the average modulation coefficients

$$P_{1av.} = \frac{1}{2\pi}\int_0^{2\pi} P_{1T}(1+m_{av.}\cos\Omega t)^2 d(\Omega t) = P_{1T} + \frac{m_{av.}}{2}P_{1T} = P_{1T}(1+\frac{m^2_{av.}}{2}).$$

The power during modulation increases compared to the power in the silent mode by 0,5$m^2_{av.}$$P_{1T}$ due to the power of the two side frequencies $P_{side}$ = 2□0,25 $m^2_{av.}$ $P_{1T}$.

Therefore, in order to obtain a long communication range and improve the signal-to-noise ratio at the reception point, it is necessary to increase the power of the side components, therefore, it is necessary to strive for a greater modulation depth [6]. AM transmitters are designed for $m_{max}$=1. If we assume that the peak is a factor P = 3,5□4, and

$m_{cp}$ □ $\frac{\sqrt{2m_{max}}}{P}$ ,

it turns out that $m_{av.}$= 0,35□0,4. This means that the proportion of sidebands at AM is (1,5□2,2)% of $P_{1max}$ and the rated power of electronic devices is used extremely inefficiently.

There are several ways to obtain AM oscillations in tube and transistor oscillators. Usually modulation is carried out by changing the voltage at some electrode of the lamp or transistor [7,8].

The suitability of an oscillator for AM can be judged by its static modulation characteristics, i.e. dependences of $I_{a1}$, $I_{ao}$, $P_1$, $P_o$, □ etc. on any one constant voltage $E_a$, $E_{e1}$. There is no modulating audio frequency voltage. To identify non-linearity factors, dynamic modulation characteristics are taken, i.e. dependence of the amplitude modulation coefficient or other indicators of the magnitude and quality of modulation on the voltage amplitude of the modulating signal voltage U□ (Fig. 3). Measurements are usually made at frequencies of 400 or 1000 Hz. Measurements of the modulation factor m or the coefficient of non-linear distortion (harmonic distortion) are made for both positive and negative half-cycles of the AM oscillation envelope. The coincidence of these dependences and their linearity indicate the symmetry of the modulation and small non-linear distortions. For broadcast transmitters with AM in the frequency band 100□4000 Hz and with a modulation depth m= 50%, the harmonic coefficient should not be more than 1%, and for m□90% - no more than 2%.

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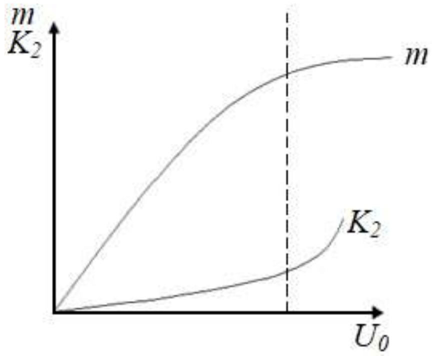
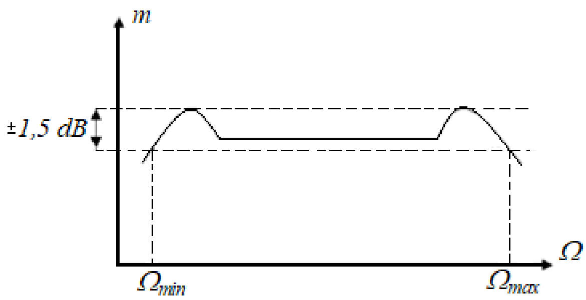



Fig. 3. Graphs of the dependence of the depth of modulation and coefficient and non-linear distortion on the magnitude of the modulating voltage

The presence and magnitude of frequency distortion in the range of modulating frequencies □$_{min}$-□$_{max}$, is judged by the uneven amplitude-frequency characteristic (AFC) of the transmitter, which is built at a constant amplitude of the modulating voltage U□ (Fig. 4).




Rice. 4. Frequency response

Amplitude modulation can be performed in any of the amplifier stages of the transmitter. The cascade in which the signal from the information source is converted into a radio signal is called a modulator. To ensure the operation of the modulator, as a rule, preliminary amplification of the modulating signal (for example, the signal from a microphone) is required. As a result, the block diagram of the transmitter with AM will take the form shown in Fig.5.

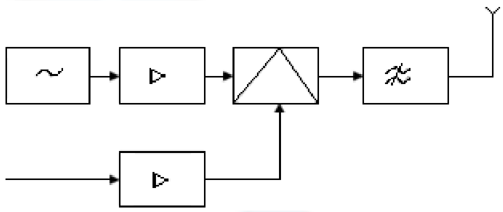


Fig. 5. Structural diagram of the transmitter with AM

The frequency spectrum of the transmitter radiation at the operating frequency formed during the modulation process consists of the main and out-of-band radiation. The main radiation contains useful information and occupies the necessary frequency band sufficient to ensure the transmission of messages with the required speed and quality. Out-of-band is the emission of a transmitter at frequencies directly adjacent to the required frequency band. Out-of-band radiation interferes with communication systems operating at frequencies adjacent to the frequency band of this transmitter. Such radiations arise when the carrier oscillation of the transmitter is modulated with an excessively wide spectrum, due to higher harmonics that occur during amplification, over modulation, etc.

## REFERENCES


1. Zikiy, A. N. Z-601 Ustroystva telekommunikasionnix sistem. Usiliteli moshnosti: Uchebnoe posobie / A. N. Zikiy, A. V. Pomazanov; Yujniy federalniy universitet. – Rostov-na-Donu; Taganrog: Izdatel'stvo Yujnogo federalnogo universiteta, 2019. – 138 s.
2. Shaxgildyan V.V. Proektirovanie radioperedatchikov. Uchebnoe posobie dlya studentov vuzov svyazi, obuchayushixsya po spesialnosti «Radiosvyaz, radioveshanie i televidenie». Pod redaksiey V.V. Shaxgildyana. 4-e izdanie, pererabotannoe i dopolnennoe. -Moskva: Izdatelstvo «Radio i svyaz», 2000.
3. Hua Wang, Kaushik Sengupta, in RF and Mm-Wave Power Generation in Silicon, 2016.
4. Matthew T. Cole, ... William I. Milne, in Emerging Nanotechnologies for Manufacturing (Second Edition), 2015.
5. Abidova G.Sh. Osnovnie parametri effektivnosti i nadejnosti ustroystva avtomaticheskogo vibora koeffisienta usileniya izmeritel'nogo usilitelya // Sbornik statey Mejdunarodnoy nauchno-prakticheskoy konferensii «Vnedrenie rezul'tatov innovasionnix razrabotok: Problemi i perspektivi», g. Yekaterinburg, 2019 g. s. 146-149.
6. Abidova G.Sh. Peredacha sifrovoy informasii na bol'shie rasstoyaniya s uvelichennoy pomexoustoychivost'yu // Respublikanskaya nauchno-texnicheskaya konferensiya, filial TUIT g. Karshi, 2018 g, s. 619-621.
7. Zaripov O.O., Abidova G.Sh. Calculation and development of the measuring amplifier with self-scaling, International Journal of Advanced Research in Science, Engineering and Technology. Vol. 3, Issue 8, August 2016, p.2469-2474.
8. Zaripov O.O., Abidova G.Sh., Aminov Sh.U. Razrabotka ustroystva preobrazovaniya parallel'nogo sifrovogo koda v posledovatel'niy kod dlya peredachi informasii na bol'shie rasstoyaniya // LXXII Mejdunarodnie nauchnie chteniya (pamyati N.G. Basova) Sbornik statey Mejdunarodnoy nauchno-prakticheskoy konferensii. - Moskva: Efir, 2020g.- s. 17-19.