Impact Factor: 9.2 ISSN-L: 2544-980X

Amplitude Characteristics and Directional Patterns

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Abstract: First, the feeder and the antenna are a load in relation to the radio transmitter. Therefore, the value of this load should be such that an effective mode of operation of the radio transmitter is ensured. Secondly, the range of the radio communication line, among other factors, depends on the value of the radiated antenna power. In some cases, the power at the antenna input is so high that there is a real threat of mechanical destruction of individual elements of the antenna or feeder due to electrical breakdown or thermal overheating.

Keywords: antenna radio transmitter, factors, radiated, antenna, radio power.

In the process of organizing communications, sound and television broadcasting, radio equipment is widely used to provide radiation and reception of radio waves. The simplest block diagram of a radio communication line is given. The elements of the circuit are: a radio transmitter, a feeder of the transmitting antenna, a transmitting antenna, a receiving antenna, a feeder of the receiving antenna and a radio receiver.

Let's take a general look at the operation of a radio communication line. The initial (primary) telecommunication signal $C(t)$ displaying the transmitted message is received at the input of the radio transmitter. The radio transmitter converts it into a radio frequency signal $S(t)$. This signal is connected via a special electrical circuit called a feeder to a transmitting antenna, a device designed for radio emission.

A very small part of the energy of the radio waves emitted by the transmitting antenna reaches the receiving antenna and excites a weak radio frequency signal in it. This signal is fed through the feeder of the receiving antenna to the input of the radio receiver, where it is processed until a copy of the original telecommunication signal is formed. The real process of radio reception is much more complicated — this is due to the fact that the radio receiver solves the problem of allocating a useful radio signal under conditions of interference of various nature. Radio communication is fundamentally impossible without the use of radio waves and, consequently, devices that would provide their radiation and reception. These functions are performed by antennas. A transmitting antenna is a device designed to emit electromagnetic waves, and a receiving antenna is a device used to receive electromagnetic waves.

A feeder is defined as an electrical circuit and auxiliary devices (they are not shown in Fig.1) by which the energy of a radio frequency signal is supplied from a radio transmitter to an antenna or from an antenna to a radio receiver. At the same time, attention is drawn to the inadmissibility of using synonyms instead of the certified term "feeder": "feeder line", "transmission line", "waveguide path".

In feeders, radio frequency signals propagate in the form of guided electromagnetic waves that are associated with charges and currents. In open space, the emitted electromagnetic waves become free — radio waves. Thus, on the transmitting side of the radio communication line, the transmitting antenna converts bound electromagnetic waves into free electromagnetic waves — radio waves. The reverse process takes place on the receiving side of the radio communication line. The receiving antenna converts radio waves into coupled electromagnetic waves, which are fed through a feeder to the input of the radio receiver.

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Almost all the energy of the radio waves emitted by the transmitting antenna is absorbed by the medium in which it propagates, as well as by various obstacles. The receiving antenna manages to capture from the environment an insignificant part of the energy that is emitted by the transmitting antenna. Nevertheless, in a properly designed radio communication line, the energy received by the antenna is quite enough for high-quality operation of the radio receiver.

Based on the principles of operation of the radio communication line considered, it is possible to formulate general requirements for feeders and antennas. Following the diagram shown in Fig.1, we will sequentially consider the feeder of the transmitting antenna, the transmitting antenna, the receiving antenna and the feeder of the receiving antenna. The obvious requirement for the feeder of the transmitting antenna is the transfer of energy from the output of the radio transmitter to the input of the antenna with minimal losses. A specific requirement is that the feeder should not have a noticeable antenna effect. The antenna effect of the transmitting antenna feeder is understood as its ability to generate unwanted radio emission, which can worsen the parameters of the transmitting antenna.

Let's formulate the basic requirements for the transmitting antenna. The first is to convert the electromagnetic energy coming to its input into the energy of radio waves with minimal losses. The second is to provide the necessary spatial concentration of radiated energy, that is, orientation. The third is to provide (together with the radio transmitter) at the receiving point the required value of the electromagnetic field strength. The fourth is to provide a given spatial and temporal orientation (polarization) of the electromagnetic field intensity vectors of radio waves.

It is necessary to pay attention to the not quite obvious, but nevertheless very important requirements that are directly related to both the feeder and the antenna. First, the feeder and the antenna are a load in relation to the radio transmitter. Therefore, the value of this load should be such that an effective mode of operation of the radio transmitter is ensured. Secondly, the range of the radio communication line, among other factors, depends on the value of the radiated antenna power. In some cases, the power at the antenna input is so high that there is a real threat of mechanical destruction of individual elements of the antenna or feeder due to electrical breakdown or thermal overheating. To avoid such damage, both the feeder and the antenna must have a certain electrical strength. Third, the feeder and antenna must function normally in a given frequency or wavelength range.

Along with the technical requirements listed above, requirements of a different plan are imposed on transmitting antennas and feeders: manufacturability, convenience and safety of operation, electromagnetic safety (environmental cleanliness). Next, consider the requirements for the receiving antenna and its feeder. The main requirements for the receiving antenna are as follows. The first is to provide the necessary spatial selectivity (directivity), that is, the ability to preferentially receive radio waves coming from certain directions. Directional receiving antennas, in comparison with non-directional ones, generally provide a higher ratio of radio signal power to interference power at the receiver input. The latter is the most important condition for a high-quality radio reception. The second requirement for the receiving antenna is to provide preferential response to radio waves of a certain type of polarization.

The main requirements for the receiving antenna feeder are as follows. Firstly, the energy transfer between the antenna and the input of the radio receiver should be carried out with low losses. Secondly, the feeder should not have a noticeable antenna effect. The antenna effect of the receiving antenna feeder is understood as its ability to receive a radio signal, which can worsen the parameters of the receiving antenna itself. The requirement for the degree of manifestation of the antenna effect in the feeders of receiving antennas is more stringent than in the feeders of transmitting antennas.

It is important to understand that the receiving antenna in relation to the radio receiver acts as an equivalent generator, the load of which is the input impedance of the feeder connected to the input circuits of the radio receiver. Therefore, another requirement, both for the receiving antenna and its feeder, is that the conditions for allocating the maximum power radio signal are met in the input circuits of the radio receiver.

The receiving antenna and its feeder must ensure the normal operation of the radio communication line in a given frequency range or wavelengths.

Along with the technical requirements for receiving antennas and feeders, certain requirements of a different plan are imposed — manufacturability, protection from lightning discharges, convenience and safety of operation, etc. There are no requirements for electrical strength and environmental cleanliness, since the signal strength in the receiving antenna and its feeder is very insignificant.

The considered requirements for antennas and feeders are basic for most radio equipment used in radio communications, radio broadcasting and television broadcasting. Almost every class of antennas and feeders, in relation to their purpose, is characterized by a number of additional requirements, which are introduced later in the process of studying the relevant sections of the full course on antenna-feeder devices.

Let's turn to the radio line diagram shown in Fig. 1. On the transmitting side, point 1 of the circuit corresponds to the output of the transmitter (input of the feeder). After $P1$, the power of the radio frequency signal at the output of the transmitter (input of the feeder) is indicated. Point 1' corresponds to the output of the feeder (the input of the transmitting antenna). The power of the RF signal at the output of the feeder (input of the transmitting antenna) is indicated by P'. Real antennas are made of wires or metal surfaces with finite conductivity or a dielectric with losses. Therefore, not all the power of the RF signal P' supplied to the antenna is converted into radiation power $P\Sigma$. Part of the supplied power is released as heat in the antenna.

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