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The analyses of plasma's influence factors on the satelite telecommunications noise immune

The analyses of plasma's influence factors on the satellite telecommunications noise immune with the spacecraft is carried, during its insertion on the orbit. The ways of telemetry with SC improvement is critically viewed, and possible prospects of noise immune systems of satellite telecommunications building are established. The energy efficient and high quality methods of ionized environment influence compensation on electromagnetic fluctuations are separated.

The development of satellite's telecommunications national segment and the Ukraine's entry into the global space community is an important conceptual task of implementing the state policy in the field of space activities for the period up to 2032 [1]. A key factor of telemetry with the spacecraft (SC) is an influence of ionized gas on the radio signal's energy. Theoretical and applied researches of plasma's effects on radio signals are relevant [2]. Countries- leaders of world community conduct studies of the ionospheric layer influence on the transmitted information quality through communication channels [3].

At an altitude of 50-60 km, the Earth's atmosphere represents plasma, i.e. gas which except of its neutral molecules has certain amount of ions and electrons due to the gases' ionization by ultraviolet and x-ray radiation of the Sun. The proportion of ionized molecules in the ionosphere is small and does not exceed 1% - is a faintly ionized gas. Only the lower part of atmosphere's plasma layer, which significantly affects on radio wave propagation is called ionosphere. In particular, plasma affects on the propagation of radio waves in the fact that electromagnetic wave sets the free electrons in motion. Therefore, an important characteristic of plasma is the electron concentration N (their number in m^3), Fig. 1.

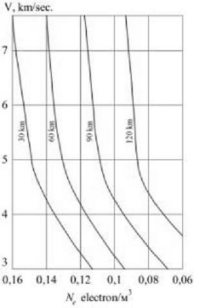

Fig. 1. The concentration of electrons according to its altitude and the SC entry's velocity to the atmosphere

The electrons concentration N_e in the space changes with the complicated way, induces the variety of radio waves trajectories shapes, and in point of each radio wave reception may come in several ways - rays. Their interference leads to the distortion and attenuation (fading) of the radio signal. If a group of electrons in the plasma move relatively to the ions, which can be considered as stationary, the electric force, which creates fluctuations in the space charge of the electrons relative to the ions is occurs.

A radio wave that is radiated vertically (in the growth direction N_e), reflected from the ionospheric plasma at the altitude where its frequency is close to critical. There as a result of the resonance, energy is transferred to the electrons and then emitted in the opposite direction. Therefore, the maximum frequency of radio waves that reflect from the ionosphere, corresponds to the maximum N_e. Quasi neutral plasma slows the radio waves down, and since the radio waves speed in the plasma depends on the frequency (dispersion), the complicated waveforms in the form of a harmonics sum with different frequencies are distorted.

The ionospheric plasma is a separate subject for excitation of plasma turbulence regularities studying, both in natural conditions and under various artificial influences (radiation of radio waves from the Earth and SC, the injection of charged particles beams and different reagents).

Analysis of available sources [4, 5] showed that in modern satellite telecommunications, it is a mistake to neglect the influence of ionospheric effects. You should consider such factors as the nonlinear heat source of electrons connected with the interaction of plasma's waves between themselves, the saturation of which is associated with spatial wave attenuation (abnormal weakening), multiple scattering of plasma waves by inhomogeneities, that lead to the plasma waves spreading of energy [6].

The most effectively reduction of the impact, resulting in quality of reception and transmitting signals increase is necessary.

The ascent phase (SC) to the orbit is designed to lift the SC above the Earth (planet) surface and disperse it to the proper speed. SC insertion into the Earth orbit is carried via space complex. During ground launch of space complex includes a carrier rocket and payload. In the case of air launch, the complex will include an aircraft carrier, rocket booster and payload. Payload is an SC. Part of the trajectory where the flight is carried out with a working missile carrier is the active site. For a single-stage rocket, the entire output area is active, whereas when using a multi-stage rocket launch trajectory can consist multiple active sites, separated from each other by segments of flight by inertia (in intervals of stage separation and engine start, the subsequent steps). The starting point of the trajectory in orbit insertion, during ground start, there is a point of carrier rocket start, whose position on the Earth's surface is pre-determined. At this point the rocket has a velocity due to the rotation of the planet. An active phase of orbital SC insertion is the most intensive of all phases of flight. At this stage, the SC construction is in the limit.

With the help of terrestrial and satellite radio communication systems the problem of information exchange between mobile objects is solving. Particularly acute this problem seems to be during the spacecraft insertion into the orbit, since

there are such extreme conditions as the trajectory of the flight, the aerodynamic resistance of the external gas environment, solar and geomagnetic activity and other factors that significantly affect the quality of communication with the spacecraft. To the limiting conditions the direction of the engine thrust at the start is included. During the air start in the number of boundary conditions that are included, in addition, altitude, velocity and direction of the aircraft flight at the time of separation media. The Earth also takes part in the orbital injection of a SC into Earth orbit. While sojourning on the surface, the carrier by its rotation before the start acquires a certain initial velocity.

In terms of SC reentry to the atmosphere at hypersonic speeds, due to aerodynamic resistance of external gaseous medium, their shell heats up. Such SC's include: manned space objects, space landers, space probes, warheads, intercontinental missiles, capsules with samples and objects that can or must be burned, for instance, satellites that have exhausted their resource and so on.

As a result of heating, massive amounts of heat releases, which leads to the formation of plasma around the aircraft. The plasma absorbs the radar radiation. As a consequence, a frequency selective fading environment, impervious to satellite telecommunication signals forms.

This environment completely blocks radio signals and as a result that SC is not able to implement a telemetry link with their communication stations within a few minutes. This period is the most dangerous from the reliability's and safety's of the SC flight point of view.

Not less actual problem in the military aspect: radar signals are blocked by hypersonic homing missiles and warheads of intercontinental ballistic missiles, which could lead to unintended consequences.

The problem of stable radio communication ensuring with the SC is very serious.

The latest technology has changed the ideology of radio communication systems noise immunity construction, have made the application of sophisticated tools that improve and lower the cost of supporting communication functions, and simultaneously open up almost unlimited possibilities of satellite SC telecommunications possible.

However, the capital cost of the creation and introduction of new telecommunication systems quickly compensate, for instance, the reduction of losses from accidents during failure through timely and accurate response.

Noise immunity of radio communication with SC can be improved by such approaches:

– organizational;

– energy;

– signals.

The organizational approach involves the arrangement of sources and radio signals receivers, and the specific frequencies choice. This approach is not very effective, because there is the complexity of hardware implementation and electromagnetic incompatibility between a large number of sources and receivers of radio signals.

Energy approach provides the increase in transmitter power to a level that exceeds the potential barriers. It is widely used in special and military satellite communication systems, but its use is in contradiction with the need of electromagnetic ensure compatibility, regulatory restrictions, and, in addition, is energetically and financially disadvantageous

With the purpose of noise immune radio communicational channel creation, the strengthening of the signal, that can be created by resonance, or agreed by electromagnetic oscillations between plasma shell, especially created by agreed layer and motion object are proposed. Chinese researchers proposed to add this layer for the creation of necessary resonance conditions during their motion at the hyper speed. It is believed, that the agreed layer will perform the functions of the capacitor in the normal electrical circuit. Plasma's shell, on the other side, will act as an inductor which prevents the change of electric current passage through it. When a capacitor and an inductor are connected, they can form a resonant circuit.

Once resonance is reached, the energy begins to flow stably between the plasma and artificially created impedance matching layer, similar to a conventional condenser and coil in an electric circuit. As a result, the radio signal that comes from the radar device may extend through the matching layer and the plasma membrane freely.

But for the effective work of this approach, the thickness of the matching layer and the plasma membrane must be less than the length of electromagnetic waves, which are used to communicate with a movable object. Therefore, the proposed method will not work if the frequency range of the antenna becomes too high, what takes place at present time.

Thanks to the development of digital technology the signal methods to the protection of interference are realized, they based on a digital signal processing, which reduces interference influences. The use of pseudo-random, multi-frequency and broadband signals and methods of noise immune signal coding, are used in modern satellite communication systems with a satisfactory efficiency. Their disadvantage is the need to enhance (sometimes very substantially) radio frequency spectrum. In the conditions of limited frequency resource, this drawback reduces the effectiveness of such approaches, especially in high-speed systems. The application of the signal approaches leads to a reduction in the rate immunity in parallel with the increasing speed of information flow.

During the last years, the noticeable progress in unstable state of the plasma environment that surrounds the SC was reached [6, 7]. Quasineutral plasma consists of both charged (positive ions and negative electrons) and neutral particles, since such particles are moving, plasma can conduct the electrical current.

To prevent the loss of communication with the SC, scientists have proposed several approaches [8].

For instance, using of antennas with the thermal protection, the construction of which owns a reduced sensitivity to its radio transparency for the interaction with the ionized gas of aerodynamic heating. Since plasma shell has changeable thickness a few centimeters, which depends on the velocity of SC, often proposed for the using heat resistant antenna, which are presented for the tape of the plasma sheath.

These approaches, purposed at improving noise immunity of a radio signal

passage, but they significantly impair the aerodynamics of the movable object. At the same time, the available sources do not provide information about creating a noise immune environment, without compromising the aerodynamics of the SC and energy-efficient methods of influence on the plasma membrane.

An alternative approach to improve the noise immunity of satellite telecommunications is the way to effect on plasma's radio impervious shell. It is used to facilitate the passage of radio electromagnetic waves.

This approach is based on the artificial environment creation around slit SC antenna that compensates the influence of the external ionized gas in radio waves [8]. This environment that is created in the middle of SC does not absorb and distort the radio signals. It allows signal passage due to the interaction on the electro-ion level with the external plasma.

Low-temperature precatory, artificially generated plasma interacts with the ionized flow of external ionospheric plasma (ions and electrons), pushing the external plasma flow. As a result, a «window» in the plasma sheath opens for telemetry. Generation of artificial plasma is implemented by relatively simple hardware and fairly energy efficient, without interference into the external SC design. But this approach has a drawback: since the plasma's high temperature film is non-stationary regarding to SC, through the variable environment density, the thermo-gas-dynamic processes and the motion SC velocity, the telemetry «window» will also be unstable. Due to the interaction of positive ions and electrons with artificial plasma, the telemetry signals will be distorted, or even absorbed.

For the noise immune telemetric communication creation, the generation of artificial plasma pulse, for several mc is proposed. Firstly, it requires minimum energy consumption. Secondly, that is enough for the radio signal passage, but not enough for the internal plasma to the external absorption. Low-temperature plasma emitter is situated in the middle of SC, and it does not impair the aerodynamic properties, has small size and low power consumption.

Conclusions

To create noise immune telemetric communication the generation of artificial plasma, which provides unobstructed passage of radio signal are proposed. Artificially created low-temperature plasma emitter does not degrade aerodynamic performance, has small dimensions and economical power consumption.

Using the proposed approach will improve the noise immunity of information transmission in the system of communication with the SC.

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