Application of radio wave reflections from meteor showers falling into the near-Earth space for organizing communications in the subpolar regions of the Earth

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Abstract

In this article we consider the possibilities of using organization of meteor-burst communication system in the subpolar regions of the Earth. Orthogonal frequency-division multiplexing (OFDM) signals as a general form of multi-frequency signals with amplitude limitation were applied. Optimal values of Peak-to-average power ratio (PAPR) reduction were found.

Keywords: *meteors, OFDM, multi-frequency signals, meteor trails*

1. Introduction

Meteors constantly fly into the Earth's atmosphere. Meteors burn up and meteor trails form in the upper atmosphere. Therefore, the meteor trail is an ionized region with a high initial linear electron density (see fig.1 on the left). There are uncompacted and overcompacted meteor trails, depending on the initial linear electron density. When a radio wave falls on a meteor trail, a mirror reflection occurs. We can use meteor trail to create communication system in polar regions.

The amplitude of the radio signal at the receiving point changes in time according to an exponential law when reflecting an uncompacted meteor trail (see fig.1 on the right). The lifetime of such a channel is on average 0.2÷0.5 s. The lifetime of a supersaturated meteor trail is already up to 10 seconds. In this case, multipath propagation of the reflected signal can be observed, leading to its deep fading at the receiving point, which does not allow analytically predicting changes in the value of the received signal over time. It follows from the practice of meteor communications that the transmission of information can be provided at a distance of up to 2000 kilometers.

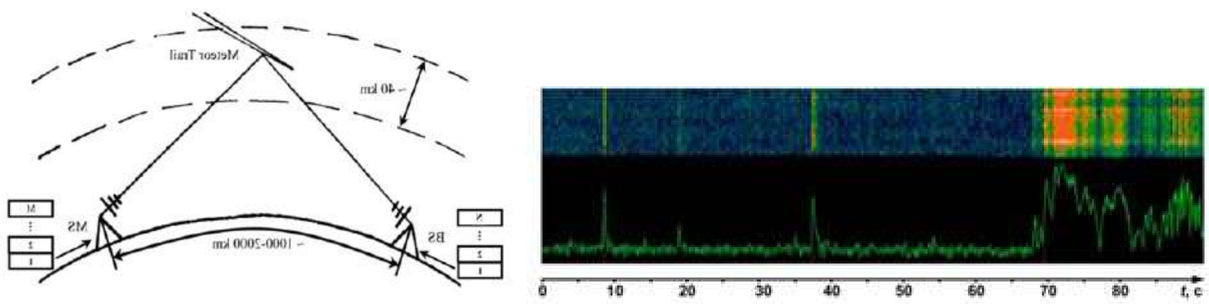

Figure 1. Meteor trails.

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2. Formation and reception of signals.

In this project, we propose to use multi-frequency signals for organizing communications in the subpolar regions of the Earth. We consider Orthogonal frequency-division multiplexing (OFDM) signals as a general form of multi-frequency signals. Simulation model for formation and reception of OFDM signals and corresponding amplitude limiter are shown on fig. 2.

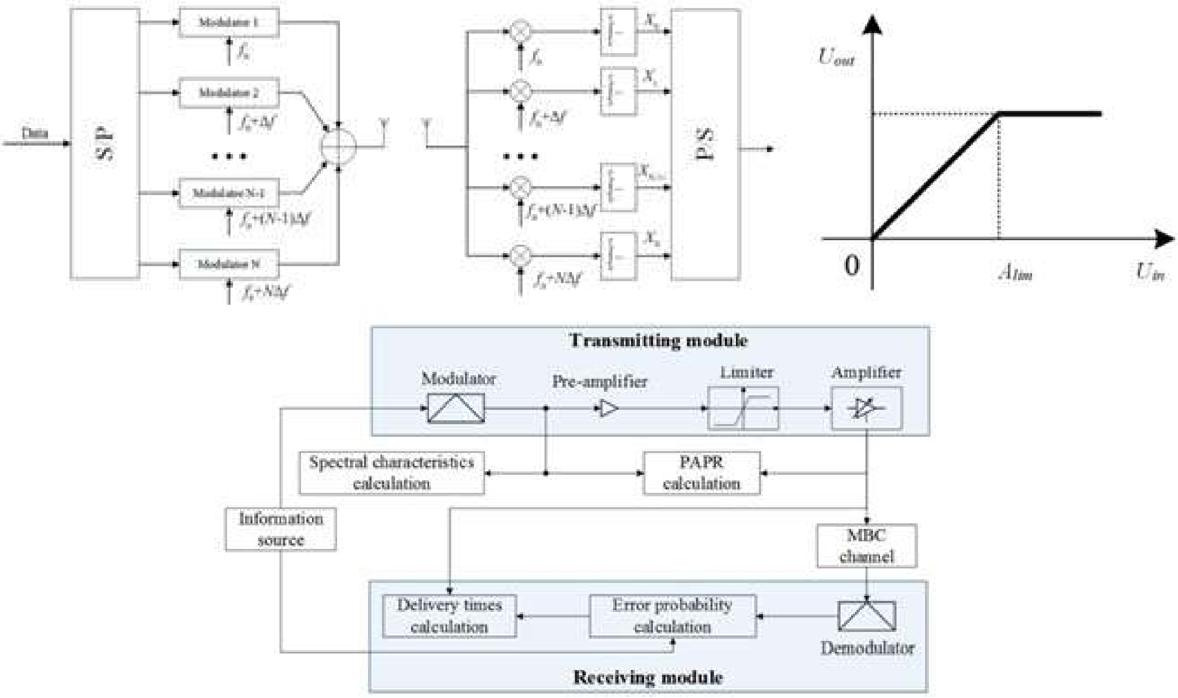

Figure 2. Formation and reception of OFDM signals (on the left), Characteristic of the limiter (on the right), Simulation model (on the bottom).

Parameters of simulation model: the number of frequency subcarriers of the OFDM signal is selected equal to 8; duration of one OFDM symbol equal to 0.1 ms; number of symbols in one packet: 100, 200, 300; duration of the package 0.01, 0.02 or 0.03 s; modulation scheme: quadrature phase shift keying (QPSK); sampling frequency $F_s = 10$ MHz.

The ratio of the Peak-to-average power ratio (PAPR) of the received signal at the output of the modulator (PAPR_{orig}) to the PAPR of the signal received at the output of the power amplifier (PAPR_{red}) is defined as the value of PAPR reduction (PR):

$$\text{PR} = \text{PAPR}_{orig}(\text{dB}) - \text{PAPR}_{red}(\text{dB}).$$

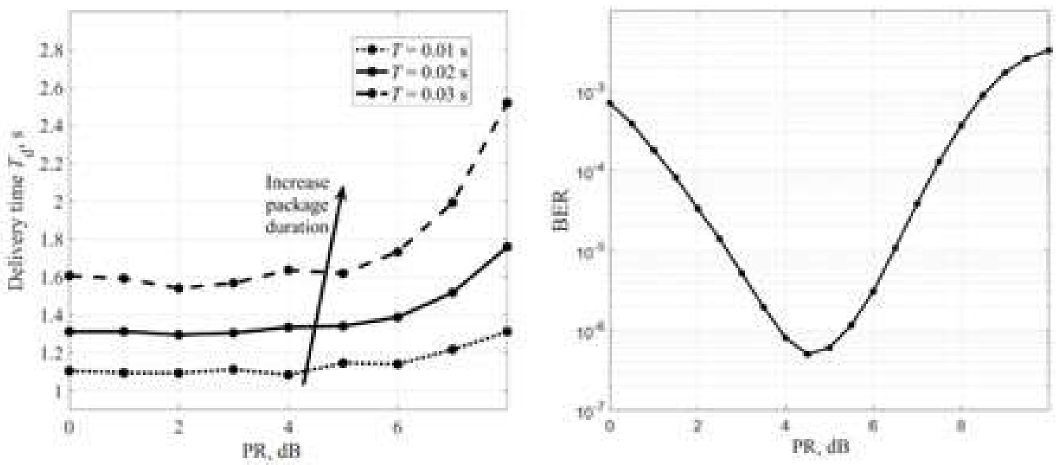

Figure 3. Dependence of delivery time on the level of PR.

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Fig. 3 on the left shows the dependence of the delivery time on the level of the PR values for various values of the packet duration T. We can conclude that with a decrease in PAPR by 5 dB, the delivery time is almost the same for OFDM signals.

In the considered scheme of the transmitting module there is both a limiter and an amplifier (see fig. 3). When limiting the value of the PAPR, the average power of the emitted oscillations increases, which reduces the error probability value for fixed signal-to-noise ratio values. However, with a further increase in the level of limitation, the signals from neighboring subcarrier frequencies start mutually affecting each other, which ultimately leads to an increase in the probability of error.

3. Conclusion.

The features of the organization of meteor radio communication systems are shown, the possibilities of application are considered.

The possibilities of using multi-frequency signals for the organization of meteor-burst communication are demonstrated.

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