Prediction of Quality of Binary Message HF Transmission Using the Simulation Model of HF Channel

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A novel approach to predicting the quality of binary message transmission via a narrowband shortwave channel is described. This approach is based on the simulation model of HF channel, and makes it possible to account for actual mechanisms of short wave propagation in magneto-active spatially non-uniform ionosphere for specific helio- and geophysical conditions. Resultantly, the expected structure of HF field at a reception site is predicted, and the possibility of solution is provided for both long-term and real-time prediction problems.

The prediction procedure is implemented as the software package comprising five main blocks: (1) generator of a test digital sequence, (2) simulation model of a shortwave signal field, (3) noise (interference) generator, (4) model of a decision circuit, and (5) error detection block. Generator of a test sequence produces binary sequences of a given length with arbitrary duration of binary elements. Keying scheme can be selected arbitrarily. The test sequence is inputted to the simulation model of a HF signal field which is a simplified version of the deterministic simulation model of HF channel described in (B. G. Barabashov et al., *Radio Science*, 41, RS5S42, doi: 10.1029/2005RS003332, 2006). Next the channel pulse response is calculated. Distinctive property of a narrowband channel is that there is the possibility of neglecting frequency dispersion of partial rays within signal bandwidth. Due to this circumstance it is possible to have the model operate real time. Channel output signal is then obtained by taking the convolution of pulse response and input signal. Noise generator (generator of additive interference) produces a sequence of samples of narrowband noise with given correlation and probabilistic characteristics. Model of decision circuit implements the algorithm of processing a received message. In error detection block the initial (transmitted) test sequence is compared to the received one, and the number of errors is calculated.

The process of predicting the quality of reception is realized through the following steps. The samples of a test sequence are generated, and run through the model. Resultantly the samples are obtained of quadrature components of signal and noise for a given signal-to-noise ratio. Next, after processing in the decision circuit, the sequence of simulated samples enters the error detection block where it is compared to the initial test sequence. To obtain statistical characteristics, multiple runs of the test sequence are made for various parameters of channel model, and for two or three noise realizations. The result is obtained in the form of predicted distribution of errors in a message of a given length. In addition to error rate prediction, the algorithm allows for predicting other statistical characteristics like rate of code word distortion, distribution of intervals between errors, and others.

The results of experimental testing of the proposed approach are reported for mid-latitude single-hop sky-wave paths, and exhibit good performance of the algorithm with respect to prediction accuracy and number of predicted characteristics.