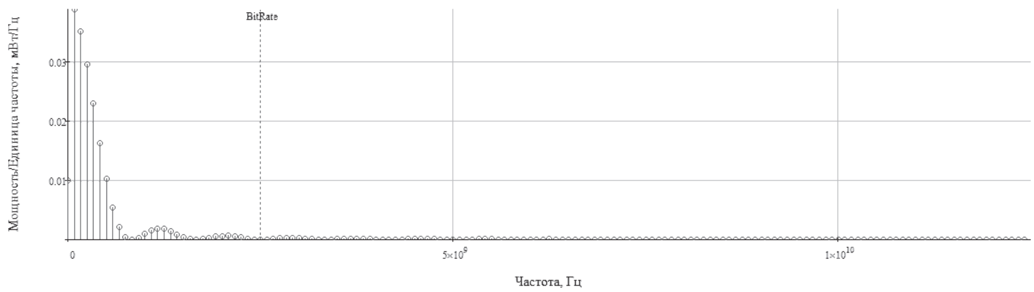

Рис. 8. Изображение СПМ тестового сигнала, заданного псевдослучайной тестовой последовательностью полинома вида $D^{28} + D^{31} = 0$.

Pic.8. PSD of test signal, specified by pseudo-random test sequence of polynomial of the form $D^{28} + D^{31} = 0$.

ного цифрового тестового сигнала. Аргументы представляют собой их начальные фазы. Совокупность амплитуд и значений частот становится амплитудным спектром сигнала, а совокупность значений начальных фаз и частотных – фазовым спектром сигнала [4].

Для расчета спектральной плотности мощности сигнала необходимо учитывать пиковые значения напряжений каждой спектральной составляющей и сопротивление входного интерфейса передатчика:

$$P(f_k) = \frac{S(f_k)^2}{R}, \quad k = 0, 1, 2, \ldots, N/2,$$

где R – сопротивление входного интерфейса передатчика.

Результаты расчета характеристик СПМ тестовых сигналов, заданных некоторыми фиксированными и псевдослучайными последовательностями, приведены на рис. 5–8.

В заключение следует отметить, что помимо прочего предложенная методика моделирования и расчета характеристик СПМ цифровых тестовых сигналов является аналитическим инструментом. Он дает возможность исследовать влияние методов линейного кодирования и форматов модуляции оптических сигналов на качество передачи данных по каналам и трактам высокоскоростных цифровых сетей. И это тоже немаловажная функция научного обеспечения техники связи.

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CALCULATION OF DIGITAL ELECTRICAL SIGNALS SPECTRUM

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ABSTRACT

In communications technology for testing of digital channels and links are widely used digital signals with fixed and pseudorandom structures. The author proposes a method for simulating and analyzing the characteristics of the power spectral density of standard test digital electrical signals for different methods of linear coding. As models of their initial (primary) formations are used standard binary sequences of fixed and pseudorandom structures. As an analytical tool the method is suitable for studying the effect of the linear coding and modulation formats on the quality of data transmission in high-speed networks of transport links.

ENGLISH SUMMARY

Background. *Representation in the analytical form the characteristics of power spectral density (PSD) of digital test signals allows solving many problems. This relates primarily to assess the quality of data transmission in channels and links of communication networks, depending on the selected methods of linear signal coding.*

For the mathematical description of their structure at the department a model of binary test signal generator has been developed.

Objective. *The author aims at describing a method for simulating and analyzing the characteristics of the power spectral density of standard test digital electrical signals for different methods of linear coding.*

Methods. *As main methods the author uses mathematical method, analysis and mathematical modeling.*

Analysis and results.

In test signals with a fixed structure (FS) of R form logical units / K bits of zeros on the structure of bit allocation for the transmission cycle is constant.

For example, test sequences of the form «a single logical unit of eight bits' has the structure 10000000 and sequence of «two logical units of eight bits' – 10001000.

Pseudorandom structure (PS) is a conditional stochastic sequence of bit allocation for the transmission cycle formed by a given algorithm.

Standard polynomials defining the structure of PS are described in ITU-T Recommendations O.150-O.153. Main parameters and scope of the PS are summarized in Table 1 [1–3].

For example, when channels and links of digital communication networks are tested, which utilize Ethernet, short pseudorandom sequences of length 2^7-1 bits are applied, and for high –speed with length of up to $2^{23}-1$ bits.

PS structure is completely determined by the following parameters [1, 2]:

– The length of the transmission cycle L, bit (number of bits in the transmission cycle of PS);

– Generating polynomial of the form $D^M + D^i = 0$, describing the structure of the PS on the transmission cycle.

Transmission cycle length (number of bits) of PS is determined by:

$L = 2^M - 1$, *bit,*

where M – parameter of PS, characterizing the degree of the generating polynomial.

Pic. 1 illustrates an example of timing diagram of the digital test signal, predetermined by PS with the length L bits. Duration of transmission cycle of PS is $T_{ПСП}$ sec, with duration of one bit transmission – $T_{бит}$ s.

Pic. 2 shows developed simulation algorithm of PS. The result of the algorithm is the logical structure of PS formed on the transmission cycle.

Calculation of PSD for test signal is carried out by the discrete Fourier transform:

$$S(f_k) = \sum_{k=0}^{N-1} S(t_k) W^{kn}, \quad k = 0, 1, 2, \ldots, N-1,$$

where $W = \exp\left(\frac{-2\pi i}{N}\right)$, *$S(t_k)$ – an array of discrete values of the test signal,*

N-number of samples of the test signal, which is calculated by the formula:

$$N = \frac{L\,T_{бит}}{\Delta t},$$

where Δt – signal sampling step.

Sequence of computational operations is as follows:

– Transformation of the logical structure of the test sequence to temporary function using software MathCad;

– The formation of an array of values of simulated time $T = [T_0, T_1, T_2, \ldots, T_{M-1}]$ and an array of digital signal values $S = [S_0, S_1, S_2, \ldots, S_{M-1}]$, taken at time points $[0, \Delta t, 2 \cdot \Delta t, \ldots, (M-1) \cdot \Delta t]$;

– The sampling time of the test signal pulses and the formation of two-dimensional array of data (reports signal) of the form $[t_i; S_i]$;

– Calculation of the amplitude spectrum of the test signal using the data array $[t_i; S_i]$, and the discrete Fourier transform unit;

– Calculation of the power spectral density characteristics of the test signal.

These calculation steps are illustrated on Pic. 3.

In accordance with the steps of converting a digital test signal, an algorithm for calculating the parameters PSD signal has been developed (Pic. 4).

As a result of the computing operations -dimensional array of complex numbers is formed that are values corresponding to the amplitudes of the spectral components of the original digital test signal. Arguments are their initial phases. Set of amplitudes and frequencies becomes amplitude spectrum of the signal, and the set of values of the initial phase and frequency – phase spectrum of the signal [4].

For calculating the spectral density of signal power it is necessary to consider the peak voltage values of each spectral component and the input impedance of the transmitter interface:

$$P(f_k) = \frac{S(f_k)^2}{R}, \quad k = 0, 1, 2, \ldots, N/2,$$

where R – resistance of transmitter input interface.

The results of calculating the characteristics of PSD of test signals given by some fixed and pseudo-random sequences are shown on Pic. 5–8.

Conclusion. *In conclusion, it should be noted that among other things the proposed technique for modeling and calculation of the characteristics of PSD for digital test signals is an analytical tool. It gives the opportunity to explore the impact of the methods of linear coding and modulation formats of optical signals on the quality of data transmission channels and links of high-speed digital networks. And this is also an important function of scientific maintenance of communication technology.*

Keywords: communications technology, digital channels, test signals, test sequences, signal model, the power spectral density.

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