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THE METHOD OF USING NOISE-LIKE SIGNALS FOR INFORMATION TRANSMIT VIA THE CABLE POWER LINE

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Abstract. *The modern methods of information transfer in the conditions of the mine have a row of essential shortcomings. In article the possibility of application of noise-type signals on the basis of the pseudorandom sequences of Hafmen for data transfer on local force distributive networks of the mine is researched.Establishment by practical consideration possibilities of application of noise-type signals on the basis of the pseudorandom sequences of Huffman for data transfer on local force distributive networks of the mine.The research is conducted by an actual path by means of laboratory installation (the device of transfer and reception of information on the basis of the pseudorandom sequences of Huffman). Synthesis of system is carried out. The analysis of the obtained experimental data is made. It is established by practical consideration that at a ratio a signal/hindrance equal 4V and time of integration of 3 ms the probability of wrong reception is equal to zero. An opportunity to carry faultless data transfer on force local distributive lines is confirmed.*

Key words: ***noise-like signal; pseudorandom sequence of Huffman; power distributive network; mine***

Introduction. Among the technological facilities of the mines, far from the underground electric substations, where equipment controlled by items of information (telemechanical) systems is usually placed, there are district drainage and ventilation systems and mine atmosphere means of control. For the exchange of information with such objects, you can use dedicated radio channels, wired and optical communication lines and power distribution networks. The use of radio channels limits the transmission distance because of the complex geometry of the mine workings, which is not sufficiently protected against unauthorized interception of information and different noises, and also causes a number of difficulties in connection with necessity of obtaining a license for its use. Other existing methods of information transfer such as the use of fiber optic cable or separately conducted electrical cable, can solve the above problems, but are economically costly and unreliable.

In this regard, it is proposed to use the mine precinct power distribution network as the communication lines. A clear advantage of this method use is the ability to use them throughout the extent of the mine at minimal cost.

Analysis of recent researches and publications. Choosing the solution of multi-channel data transmission based on either narrowing or expanding the range of communication channel, be aware that the characteristics of the spectrum of interference in the communication channel can change in time and depend on the structure of communication lines. In this regard, the use of narrowband transmission systems is quite challenging. The only successful solution was a subsystem of the PPT-1, designed to transmit TV signals from the mining combine. To realize the function of remote control, where the requirements for reliability of information transmission is significantly higher (for 2nd class telecomplex – three orders of magnitude), the narrowband solution seems a little promising.

Broadband information transmission system with noise-like signals(NLS)[1] was initially developed for the operating conditions of the channels with interference of an uncertain nature, including intentional one. The basis of action is the dispersion of the signal energy in the frequency band, which in some cases exceeds the bandwidth information (primary) message signal by 2 to 3 orders of magnitude. Receive-side signal "is being gathered" across the bandwidth of the channel with the method of correlation processing. For the transmission of information via power distribution networks broadband as an optimal solution to conditions of the mine is proposed.

In the scientific literature the noise-like signals by their properties are divided into these types: frequency modulated, multi-frequency, digital frequency, digital composite frequency, phase-shift keyed signals [2]. In connection with the presence of powerful jamming, affecting the communication line in mines, it is proposed to use frequency-modulated NLS, their advantages are: high noise immunity, more effective use of transmitter power, and comparative ease of obtaining modulated signals.

Frequency modulated signals are continuous signals whose frequency varies according to a given law.

Purpose. The aim of this work is the establishment by the method of electric modeling of the possibility of using NLS based on pseudorandom sequences(PRS) of Huffman to transfer data over the local power distribution grids of the mine.

Methods. At the moment there are two methods to study extensive power networks. The first method is analytical one, which makes it impossible to obtain all the necessary information about the physical phenomena occurring in the network, since with non-stationary objects the input resistance and the overall distribution of the signal level are continuously varied.

The second method is electrical simulation, which provides ample opportunities to explore the different modes of operation. This takes into account all the phenomena affecting the transmitted signal.

Under the electric modeling implies the creation of a set of active and reactive resistances of the equivalent cell line which is typed in the network diagram which is electrically equivalent to a real network located in the mine.

To achieve this goal it is necessary to develop a laboratory setting that allows to generate a modulated NLS based on the PRS of Huffman coding, which will be sent to the communication line, and then transmitted to the receiver for subsequent correlation and integration. The experimental data at different levels of noise in the communication line will be recorded for further statistical processing.

Theoretical implementation. Sequence of maximum length is obtained using recurrence relations, which are determined by the primitive generating polynomials of degree m [3].

The length of Huffman PRS is equal to:

$$n = 2^m - 1,$$

where m is the number of elements in the initial phase of the PRS.[3,83] For the purposes of initial familiarization with the method of extended-spectrum suffices it is enough to use the value of m = 3 for which

$n = 2^3 - 1 = 7$, generating polynomials:

$$P(x)_1 = x^3 + x^2 + 1 \quad (1),$$

$$\text{or } P(x)_2 = x^3 + x + 1$$

and the corresponding recurrence relations:

$$\alpha_i = \alpha_{i-3} \oplus \alpha_{i-2}, \quad (2)$$

$$\alpha_i = \alpha_{i-3} \oplus \alpha_{i-1}. \quad (3)$$

The number of terms in the recurrence relations will always be even. PRS based on the amounts of (2.3) can be obtained by hardware implementation using a shift register and the adder by modulo 2, the block diagram of which is shown in figure 1.

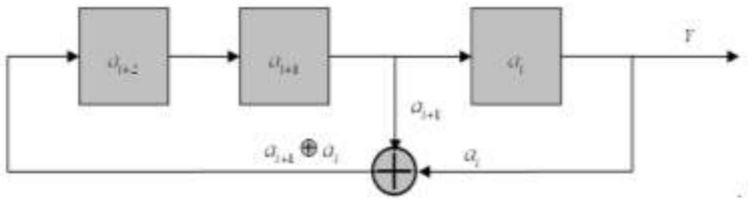

Figure 1. Structural scheme of hardware implementation using shift register and adder by modulo 2

In the general case the shift register consists of cells (storage elements). In each moment of time defined by the clock frequency, the contents of all cells are shifted one cell (discharge) to the right, and the contents of the cells corresponding to the members of the polynomial, are summed modulo 2 and fed into the leftmost cell. If in the described example, the case in time i contains numbers a_{i+2}, a_{i+1}, a_i, at the time moment $i+1$ it will contain the numbers of $a_{i+3} = a_{i+1} \oplus a_i, a_{i+2}, a_{i+1}$. In other words, the shift register with feedback generates an infinite sequence $a_0, a_1, a_2 .... a_i$, satisfying the recursive ratio $a_{i+3} = a_{i+1} \oplus a_i, i = 0,1,...$. To start the shift register it is necessary to set initial values $a_0, a_1, ..., a_{m-1}$. Table 1 shows the state of memory cells of the shift register to all seven cycles of the shear initial shear combination 010.

1. The state of the memory cells of the shift register with the initial shear combination 010

№	The state of registers			Shift (Y)
	a_{i+2}	a_{i+1}	a_i	
1	0	1	0	0
2	1	0	1	1
3	1	1	0	1
4	1	1	1	1
5	0	1	1	0
6	0	0	1	0
7	1	0	0	1

Hardware realization. Design of coal mine distribution network as a communication line varied. As a result of their analysis as a communication line it was established that despite its multi design, which is shown in figure 2, coal mine distribution network is similar to the single-wire line. As a direct line this line is the group of isolated from ground, but electrically connected wires, and as a reverse - rock and conductors lying on the ground, such as rails, pipes.

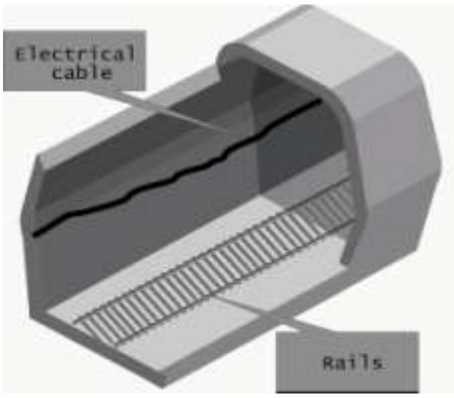

Figure 2. Wiring mine distribution network

Figure 3 shows a block diagram of the laboratory setup of the system transmission and receiving NLS based on the PRS Huffman. The signal source randomly generates a sequence of 999 bits. Further, the information signal supplied to the modulator where it is modulated by a pseudorandom sequence based on the polynomial (1) with the initial phase 010.

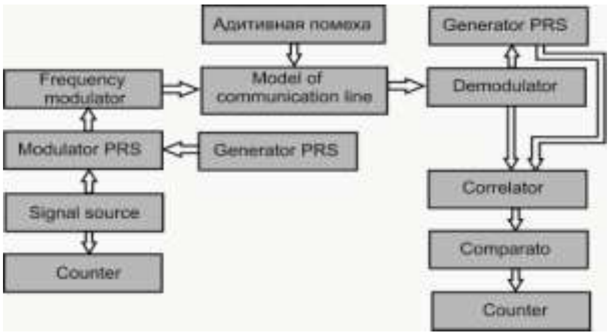

Figure 3. Structural scheme of the laboratory setup for the experiment

This happens in the following way: when transmitting a logical 0, the PRS is transmitted as inverted, and if 1 - as non-inverted. This signal is used as the modulating signal for frequency modulation. With the output of the frequency modulator signal is supplied to the communication line through a matching capacitor. In an electric model of a communication line [4,81] 40 u-shaped equivalent circuit of the line section with a length of 25 meters have been used. The total length of the model area was 1000 meters. Figure 4 shows the waveform of the information signal(B) and the PRS modulated information signal (A).

From communication lines modulated signal is supplied to the demodulator and then to the correlator. The demodulator produces the modulated signal PRS from the high frequency, which is supplied to full-wave pulse-phase detector performing the function of a correlator. For normal operation of the receiver PRS transmitter and receiver must be precisely synchronized.

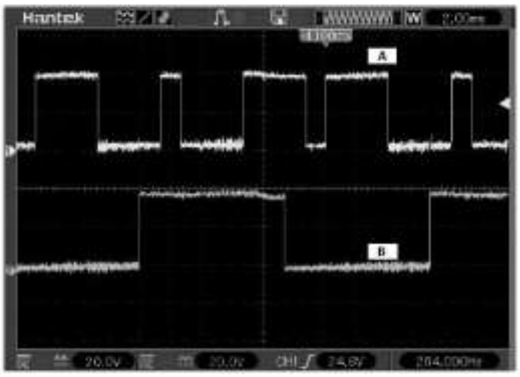

Figure 4. The waveform of the information signal and the modulated information signal of PRS

Synchronization of the PRS generator on the receiving side with a PRS generator at the transmitter side is carried out at the beginning of the session. Since the beginning of the communication session carrier frequency signal and its delay time is known at the receive side, the appearance of the pulse at given frequency runs a PRS generator at the receiving side. Since the speed of propagation of the radio signal is large, it can be argued that the PRS generator on the receiving side is started almost simultaneously with the generator on the transmitting side. At the output of correlator integrator is installed, which performs the role of lower frequencies filter as the simplest type of RC circuit.. The signal at the correlator output when the coincidence of the initial phases of PRS of receiver and transmitter is shown in figure 5(waveform C), relative to the information signal(waveform D) and in case of discrepancy in figure 6(waveform F) with respect to the information signal(waveform F). After the correlator signal is fed to a threshold element, assembled on the comparator. The counter on the transmission side counts the number of transmitted bits, and the counter at the receiver counts the number of bits taken correctly.

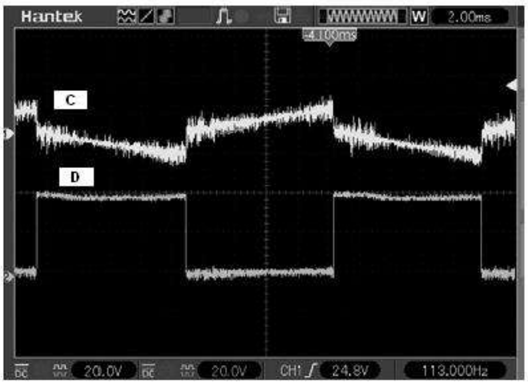

Figure 5. The signal at the coincidence of the initial phases of the PRS receiver and transmitter

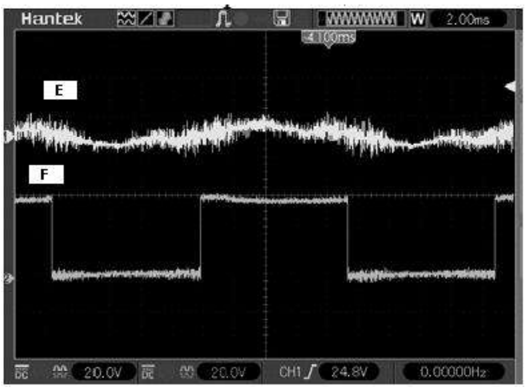

Figure 6. Signal in case of discrepancy of the initial phases of the PRS receiver and transmitter

Resalts. The developed laboratory setup allows to obtain data to evaluate the statistical parameters of the communication channel at different ratios of signal/noise and integration time of the signal, and also allows you to change the amplitude and frequency of signal, amplitude of noise and attenuation in the communication line.

The decision on whether there is the noise at the receiver input at the moment or the signal has a threshold device, assembled on the comparator. If the voltage applied to the threshold device more than a threshold value, a decision is made that at the receiver input the signal is present, and if less than the reception threshold, it is considered that no signal is present. When receiving a single signal on the background of additive (added to the signal in the communication line) interference the following situations may arise: the correct reception signal, a pass signal, a correct identification signal, the false signal reception. The study is performed by measuring the number of accepted and missed when sending pulses of length 999 bits with 10 retransmissions and the change of integration time. Then the frequency of correct reception is calculated:

$$P_n = \frac{n}{999},$$

where is the number of correctly received pulses and incorrect $P_o = 1 - P_n$ receiving signals.

Figure 7 shows the experimental dependence of the frequency of erroneous reception from the ratio of signal/noise at different integration time of the signal. On the basis of the obtained experimental data it is shown that with increasing integration time, the probability of erroneous reception is reduced. The optimal integration time for this case is 3ms. With increasing integration time more than 3ms the opposite effect will be observed where the probability of incorrect reception will increase. This is because in this case, the integrator does not contain the chain of relief. The longer the integration time the greater the capacitance of the capacitor of the integrator. This means that the integrator capacitor accumulate more energy and not time runs out. This will distort the value of the following bits of data.

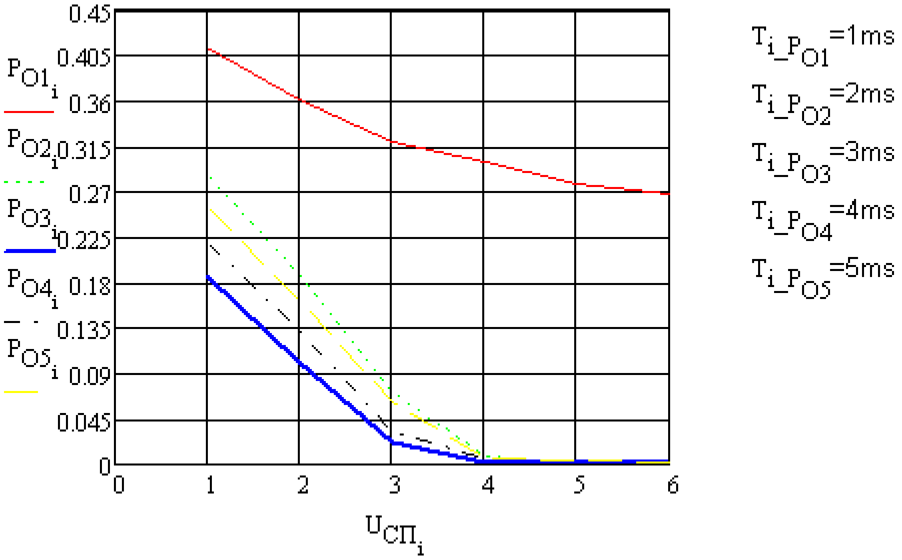

Figure 7. The experimental dependence of the frequency of erroneous reception from the ratio of signal/noise at different integration time of the signal

Discussion. The method of electrical modeling provides ample opportunities to explore the different modes of operation. In this regard, to investigate the possibility of data transmission via power grids in mines developed a laboratory setting. The length of the electric cable in this experiment was 1000 meters which is enough to confirm the possibility of transmission of information at the local mine grid.

The analysis of coal mine distribution network as a communication line was established that, despite its multi design, this network of mine like a single-line. As a direct line this line is the group isolated from ground, but connected the wires, and as a reverse - rock and conductors lying on the ground, such as rails, pipes. This method has the ease of connecting the receiving-transmitting equipment to the power cable.

The choice of a primitive irreducible polynomial of third degree allows to obtain a single maximum autocorrelation function, which would allow for independent transmission 7 channels of communication, which have noise-like signals based on a single generating polynomial with different initial phases.

This method of information transmission enables error-free reception when the ratio signal/noise is equal to 4, which confirms the study. If you use the pre-error-correcting-encoded and when the ratio signal/noise is equal to 1 (the noise level will be equal to the signal level) it is possible to receive signals.

In view of the above it can be concluded that it is possible to conduct error-free data transmission over power distribution lines as a district of the mine.

Список використаних джерел

1. Варакин Л. Е. Системы связи с шумоподобными сигналами / Л. Е. Варанин. –М.: Радио и связь, 1985. – 384 с.

2. Барабашов Б.Г. Широкополосные системы связи и сигналы: учбное пособие / М. М. Анишин, Б.Г. Барабашов. – Ростов-на-Дону, 2008. – 86 с.

3. Кожевніков В.Л. Теорія інформації та кодування / В.Л. Кожевніков, А. В.Кожевніков. – Д.: Національний гірничий університет, 2013. – 144 с.

4. Ильин А. А. Разветвленные силовые сети как каналы связи для телемеханики / А. А. Ильин. – М.-Л., Госэнергоиздат, 1961. – 103 с.

References

1. Varakin, L. E. (1985). Sistemy svyazi s sh·chmopodobnymi signalami [Communication Systems with noise-like signals]. Moskow: Radio i svyaz’, 384.

2. Barabashov, B.G., Anishin, M. M. (2008). Shirokopolosnyye sistemy svyazi i signaly [Broadband communication systems and signals]. Rostov-na-Donu, 86.

3. Kozhevnikov, V. L., Kozhevnikov, A. V. (2013). Teoriia informatsii ta koduvannia [Theory information and coding]. Donetsk: Natsionalnyi hirnychyi universytet, 144. 4. Il’in, A. A. (1961). Razvetvlennyye silovyye seti kak kanaly svyazi dlya telemekhaniki [Branched power line as the communication channels for remote control]. Moskow - Leningrad., Gos·energoizdat, 103.

МЕТОДИКА ВИКОРИСТАННЯ ШУМОПОДІБНИХ СИГНАЛІВ ДЛЯ ПЕРЕДАЧІ ІНФОРМАЦІЇ ПО КАБЕЛЬНІЙ ЛІНІЇ ЕЛЕКТРОМЕРЕЖІ

Д. С. Зибалов

Анотація. *Сучасні способи передачі інформації в умовах шахти мають низку суттєвих недоліків. У статті досліджується можливість застосовання* *шумоподібних сигналів на основі псевдовипадкових послідовностей Хаффмана для передачі даних по ділянковим силовим розподільчим мережам шахти. Метою дослідження являється встановлення дослідним шляхом можливості застосування шумоподібних сигналів на основі псевдовипадкових послідовностей Хаффмана для передачі даних по ділянковим силовим розподільчим мережам шахти. Дослід проводиться фізичним шляхом за допомогою лабораторної установки(приладу передачі та прийому інформації на основі псевдовипадкових послідовностей Хаффмана). Проведено синтез системи. Проведено аналіз даних, що одержані в результаті експерименту. З'ясовано шляхом проведення досліду, що при співвідношенні сигнал/завада, яке дорівнює 4В та часу інтегрування 3мс імовірність помилкового прийому дорівнює нулю. Доведено можливість вести безпомилкову передачу даних по силовим ділянковим розподільчим лініям шахти.*

Ключові слова: ***шумоподібний сигнал, псевдовипадкова послідовність Хаффмана, розподільчі мережі шахти***

МЕТОДИКА ИСПОЛЬЗОВАНИЯ ШУМОПОДОБНЫХ СИГНАЛОВ ДЛЯ ПЕРЕДАЧИ ИНФОРМАЦИИ ПО КАБЕЛЬНОЙ ЛИНИИ ЭЛЕКТРОСЕТИ

Д. С. Зибалов

Аннотация. *Современные способы передачи информации в условиях шахты имеют ряд существенных недостатков. В статье исследуется возможность применения шумоподобных сигналов на основе псевдослучайных последовательностей Хаффмана для передачи данных по участковым силовым распределительным сетям шахты. Целью исследования является установление опытным путем возможности применения шумоподобных сигналов на основе псевдослучайных последовательностей Хаффмана для передачи данных по участковым силовым распределительным сетям шахты. Опыт проводится физическим путем с помощью лабораторной установки (прибора передачи и приема информации на основе псевдослучайных последовательностей Хаффмана). Проведен синтез системы. Проведен анализ данных, полученных в результате эксперимента. Выяснено путем проведения опыта, что при соотношении сигнал/помеха, равное 4В и времени интегрирования 3мс вероятность ошибочного приема равна нулю. Доказана возможность вести безошибочную передачу данных по силовым участковым распределительным линиям шахты.*

Ключевые слова: ***шумоподобный сигнал, псевдослучайная последовательность Хаффмана, распределительные сети шахты***