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TRANSMISSION AND RECEPTION OF UWB SIGNALS BASED ON ANTENNA DECODING

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Background. A new idea for receiving and transmitting impulse radio ultrawideband signals with Pulse Position Coding (PPC) in transmitter station and antenna decoding in receiver station is proposed. A receiving station that allows decoding the ultrawideband signal with PPC only by receiver antenna due to its construction which is spatially matched with the subscriber’s PPC address sequence is described.

Objective. The aim of the paper is to present the idea of ultrawideband signals transmitting and receiving based on the application of antenna decoding method of subscriber’s PPC address sequence.

Methods. Computer simulation of impulse radio ultrawideband signal generator by using such computer-aided design as AWR Microwave Office was used. Also mathematical tool to describe ultrawideband signal at the outputs of antenna dipoles and in the receiver was used.

Results. The simulation results of the impulse radio ultrawideband signal generator with step recovery diode indicate the possibility of generating at its output a signal with a time duration less than 1 ns in 0.3 – 2.5 GHz frequency bandwidth and a pulse amplitude that doesn’t exceed 0.3...0.45 volts. A mathematical model and graphs of ultrawideband signals for PPC depict antenna decoding method of subscriber’s PPC address sequence in the receiver station.

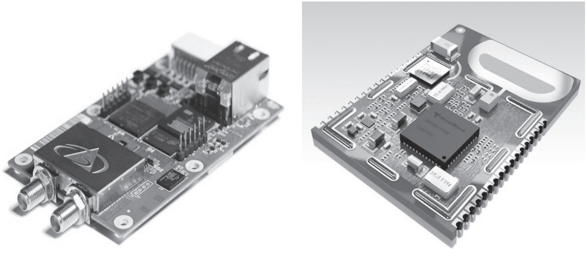
Conclusions. The proposed idea is conceptual. Its realization will give an opportunity to offer new technological solutions for the creation of next-generation radio telecommunication systems, particularly in the terahertz frequency band.

Keywords: ultrawideband; pulse; antenna; transmitter; receiver

Introduction

Today, ultrawideband (UWB) technology is one of the promising technologies of high-speed wireless data transmission. However, the action radius of wireless communication systems based on state-of-the-art UWB devices is small. This is due to limitations on the permissible spectral density of UWB signal radiation in 3.1–10.6 GHz frequency band introduced by the Federal Communication Commission of USA in order provide electromagnetic compatibility with radio electronic devices of other wireless communication systems. The UWB technology is divided into two main directions: UWB based on MB-OFDM (or Multiband UWB) (IEEE 802.15.4-2011 standard) and UWB based on impulse radio (IR-UWB).

Nowadays, UWB transceivers that use multiband UWB technology are commercially available. Such companies as Decawave Ltd. and Time Domain Inc. are developing such transceivers [1]. For example, in the world market for electronic components, commercially available DWM1001 UWB transceiver of Decawave Ltd and PulsON 440 (Fig.1) of Time Domain Inc. based on IEEE 802.15.4-2011 standard for location detection and wireless communication systems are available for sale [1,2]. The range of such UWB transceivers typically is not more than 300 m at a maximum transmission rate up to 6.8 Mbps.



a) b)

Fig.1 PulsON 440 (a) of Time Domain Inc. and DWM1001 (b) of Decawave Ltd. UWB transceivers photos

It is worthwhile to notice that there are also developments of military UWB tranceivers based on IR-UWB technology: MultiSpectral Solutions Inc. developed an UWB transceiver for packet data transmission at speeds of 9.6-128 kbps at distances up to tens of kilometers [3].

The transmission of data using impulse radio ultrawideband signals (IR-UWB) remains an attractive and promising method in communications due to many advantages over the transmission by continuous signals based on sinusoidal carriers.

Therefore, usually each bit of information (or a control command) is transmitted not by one but by n pulses. Their possible number in each bit is determined by the duration of the pulses themselves, their amplitude, duty cycle and the required information data rate.

By analogy with broadband signals, the base of the impulse signal B can be interpreted as the product of the pulse duration by the number of pulses in the signal. The base of the signal at a given pulse power determines the energy gain when the pulses accumulate when signals are received. The average duty cycle of the signal is determined by the necessary combination of possible number of UWB signals in the network with their mutual orthogonality or relative pauses between them in the pseudo-random coding of their position on the time axis. Also usage of UWB provides multiple access of a certain number of subscribers with absolute or quasi-orthogonality between their signals. This property can be interpreted as a large channel capacity, the possibility of parallel transmission of signals of a large alphabet and a number of other properties that make it possible to make channels or networks based on them efficient.

However, ultrashort impulses of practical power (units, tens of watts) carry a small energy equal to the pulse power P_i multiplied by its duration τ_i: $E_i = P_i \tau_i$. As a result, the signal-to-noise ratio E_i/N_0, which determines the probability of reception errors, is low. Therefore, data transmission is performed by a series of impulses, the group of which determines the transmitted symbol. This group of pulses T_s is encoded in accordance with a time code or subscriber's address sequence (Pulse Position Coding - PPC) orthogonal to codes of other symbols or signals of other transmission systems operating in the same frequency band. An example of such a signal is shown in Fig.2.

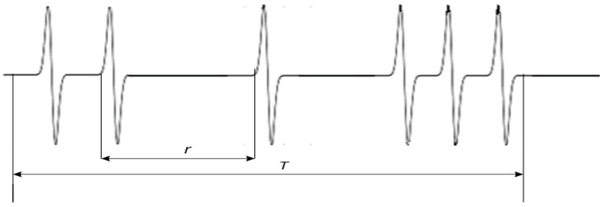


Fig.2 Pulse Position Coding

The information symbol must consist of enough impulses of sufficient amplitude to carry necessary energy to fulfil necessary bit error rate in a receiver. Usually impulse amplitudes are limited and the only way to fulfil energy requirements is to use as many impulses on bit as possible within necessary data rate. Big amount of impulses on bit make possible to generate big ensembles of orthogonal codes which mitigate mutual interference and increase number of addresses in multiple access networks.

To separate the signals at reception it is necessary to use the correlation method. The correlator can be an active device, selecting symbols by comparing the received impulse series with the reference signal structure (Fig.3). An active correlator requires the synchronization of the local reference code sequence with the received signal. Using impulses with ultrashort duration, it is practically impossible to make synchronization with acceptable accuracy and stability in receivers.

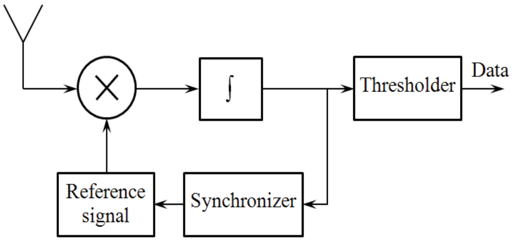


Fig.3 Active correlator receiver.

A passive correlator based, for example, on a delay line with taps (Fig.4) is independent of synchronization but requires ultrawideband throughput and high accuracy of taps positions.

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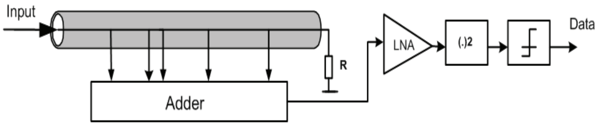


Fig.4 Passive correlator receiver

Thus, classical ultrashort impulse signal decoding becomes a difficult task.

Receiver passive and active correlators can be simplified by applying the "non-energy" receiver principles [4-6], in which the received ultrashort impulses are replaced by "standard" pulses of amplitude and duration suitable for processing by digital circuits and programs.

So, the aim of the paper is present the idea of IR-UWB transmitting and receiving based on the application of antenna decoding method of subscriber's PPC address sequence.

UWB signal generation

Typically, an IR-UWB signal generator is a significant part of any modern wireless communication transceiver that uses IR-UWB signal. The literature analysis [7-9] of IR-UWB signal generators shows that its generalized block diagram can be presented as a serial connection between the pulse sharpener and the Gaussian monocycle forming network, as shown in Fig.5.

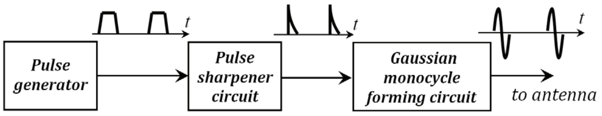


Fig.5 Block diagram of IR-UWB signal generator

In accordance with Fig.5, the pulse sharpener is designed to generate short-duration unipolar pulses, usually with duration of hundreds of picoseconds / units of nanoseconds, which are similar to Gaussian pulses in time domain. The input signal of pulse sharpener is single- or bipolar rectangular pulses of pulse generator.

As pulse sharpener of the pulse edges of the input signal from pulse generator, usually special semiconductor devices are used: an avalanche transistor, a tunnel diode, a step recovery diode (SRD), and a field-effect transistor. The avalanche transistor has the advantage because it allows to sharp edges of pulse of considerable power, but has limited pulse repetition frequency due to the significant level of dissipative losses in the transistor. Tunnel diodes have the smallest switching time which equals to several picoseconds, but with very low power at several milliwats. The SRD is a compromise variant since it has a low switching time of about 100 picoseconds, with an average power level ranging from hundreds of milliwats to tens of watts and with a high pulse repetition frequency. These properties make it relevant for usage in development of IR-UWB signal generators [7,9].

The SRD works as a controlled switch, which can very quickly change its resistance from small to large. This property of the SRD is used to sharp the long edges of pulse signals.

As SRD for the model of IR-UWB signal generator, we select the KD524A diode, which is available in Ukraine. Based on the parameters of the KD524A diode, the following values were set in the model STEPRD: IS = 2 microampere; TT = 30 ns; $CREF$ = 3 picofarads; BV = 24 volts; T = 25 degrees; $IMAX$ = 400 milliampere. The parameters RS, N, AFAC were unchanged.

Since the SRD has parasitic parameters, the equivalent electric circuit of the SRD which taking into account these parameters using AWR Microwave Office will looks like Fig.6.

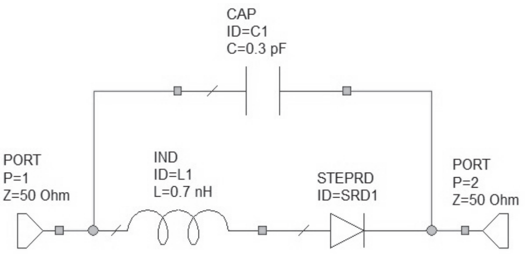


Fig.6 The electric model of the SRD which takes into account the parameters of its package

When using a short-circuit microstrip line, the electric circuit of the simplest IR-UWB generator in AWR Microwave Office will looks like as it is shown in Fig.7.

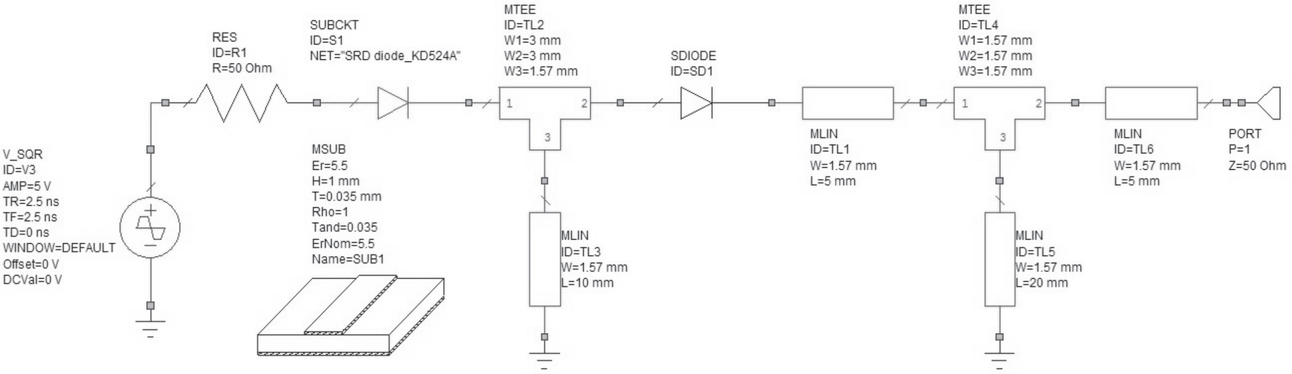


Fig.7 Electric circuit of simulated IR-UWB generator based on the SRD which generates Gaussian monocycle using a short-circuited microstrip line differentiating circle

The input signal of the IR-UWB generator (Fig.8) from the source V_SQR is the periodic sequence of bipolar pulses with pulse repetition frequency f = 10 MHz (period T = 100 ns), duty cycle σ = 50%, pulse duration τ = 50 ns, rising edge duration t_R = 2.5 ns, falling edge duration t_F = 2.5 ns, amplitude U_m = 5 volts.

Fig.9 shows time domain voltages presented at the output of the pulse sharpener and the Gaussian monocycle forming circuit output for the IR-UWB signal generator model shown on Fig.7 using the AWR Microwave Office. Analysis of Fig.9 shows that the duration of the monocycle does not exceed 1 ns, and the amplitude of Gaussian monocycle is Um ≈ 0.3 ... 0.45 volts.

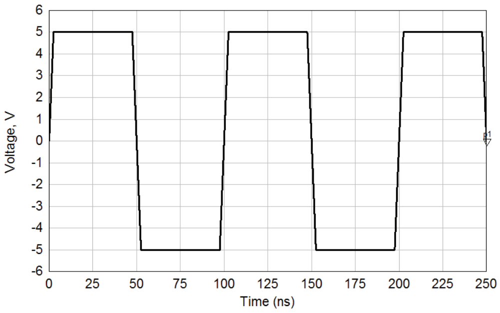


Fig. 8 Bipolar pulse signal applied to IR-UWB generator input

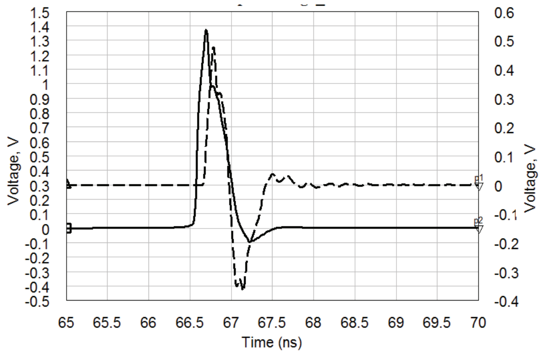


Fig.9 Pulse signal at the pulse sharpener output (solid line) and at the output of the Gaussian monocycle forming circuit (dashed line) of IR-UWB signal generator

The IR-UWB signal shown in Fig.9 can be approximated with sufficiently high accuracy as analytical formula

$$s(t) = -A_0 \frac{2t}{\tau_s^2} \exp\left(-\frac{t^2}{\tau_s^2}\right), \qquad (1)$$

here τ_s is duration of IR-UWB signal, A_0 its amplitude. The spectrum of the IR-UWB signal on Fig.9 (dashed line) is presented on Fig.10. Its bandwidth at -10 dB level is about 2.2 GHz, that is from 0.3 to 2.5 GHz.

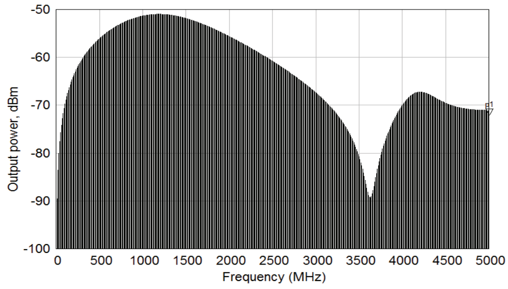


Fig.10 Monocycle spectrum at the output of the IR-UWB signal generator

UWB signals receiver with antenna decoder

The discrete nature of the IR-UWB signal with the encoding of information symbols by PPC allows to receive and decode signal at the input of the receiver by means of an antenna whose design is corresponds to the time structure of the signal. Fig.11 shows the receiver circuit with such antenna.

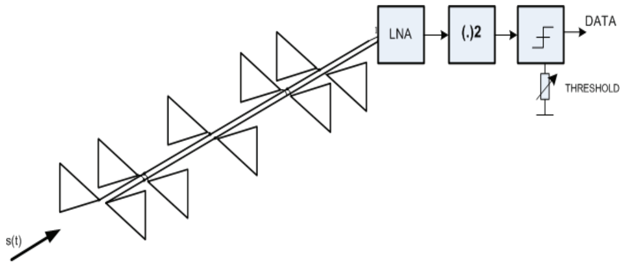


Fig.11 UWB receiver with decoding antenna

The received signal propagates along the antenna, which is a feeder line with ultrawideband vibrators forming dipoles connected to it. The feeder line plays the role of a combiner of the correlator, the vibrators are taps of long line, in this case – signal injecting.

In time, a signal of duration T can be represented as a pseudo-random sequence of *n* pulses α, coded in accordance with subscriber's PPC:

$$x(t) = \sum_{0}^{T} a(t - t_n), \qquad (2)$$

When the signal propagates in the free space, the distance between the pulses will be

$$r = c\left(\tau_n - \tau_{n-1}\right), \qquad (3)$$

where *c* is the speed of light. The distance between neighboring vibrators in the antenna also should be equal to these values. If the antenna is made in a medium with a dielectric constant ξ greater than 1, then the distances must be reduced by $\sqrt{\xi}$ because of the slowing of the signal propagation in this medium.

The position of the dipoles (distances between them) corresponds to inverse time domain position of impulses of the signal in the feeder, i.e. PPC, taking into account the propagation slowdown in the feeder. Thus, the antenna is a filter matched to the signal.

With a temporary mismatch, the antenna generates noise at the output of the feeder line, which reflects the separate excitation of the vibrators by the pulses of the signal. When the structure of the signal coincides with the antenna structure, a pulse appears at the output of the feeder line, corresponding to the sum of the voltages in the vibrators (correlation peak) caused by the coincidence in time of excitation of all or most of the vibrators. In a simplified form Fig.12 illustrates noise and the correlation peak at the output of feeder.

The signals at the output of the antenna feeder are amplified by a low-noise amplifier, squared to obtain an unipolar voltage, and fed to a decision device with a pre-set or adjustable threshold. Exceeding the threshold by the output of the squarer, causes a pulse at the output of the receiver, informing about the reception of a bit of the given antenna code.

The antenna in the horizontal plane has a one-way "information" direction in the form of a one-sided lobe of the dipole antenna, i.e. reception of the information with asymmetric PPC can be received only from one side. The energy pattern corresponds to the dipole pattern (Fig.13).

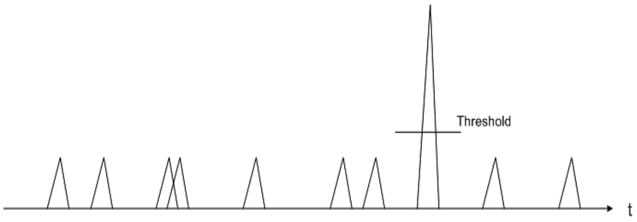
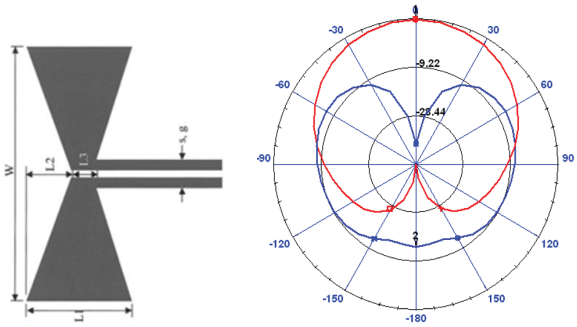


Fig.12 Signals at squarer output



a) b)

Fig.13 Bow-tie antenna (a) and its radiation pattern

Consider in details the principle of receiving the PPC address sequence of IR-UWB signals by a subscriber station, consisting of an antenna and a receiver. Let this sequence in the time domain consists of N = 10 time intervals of duration τ = 0.5 ns each, in which, depending on the subscriber's address, elementary IR-UWB signals in the shape of a Gaussian monocycle are located. The general graphic view of the PPC address sequence is shown in Fig.14.

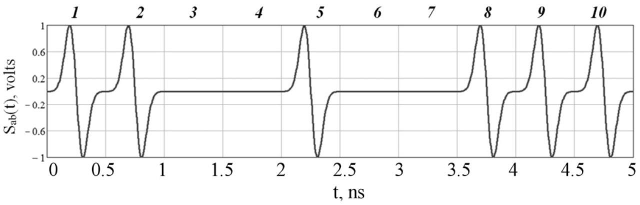


Fig.14 Waveform of PPC address sequence of an individual subscriber

Mathematically, the above PPC address sequence can be represented as formula

$$S_{ab}(t) = \sum_{i=0}^{9} a_i \mathrm{V}(t - i\tau), \tag{4}$$

where a_i are the coefficients of column vector **A**, which characterizes the position (presence or absence) of IR-UWB pulses in a particular time interval of the address sequence; V(t) is Gaussian monocycle formula in time domain, which can be represented as

$$\mathrm{V}(t) = -V_0 \frac{\sqrt{2e}}{\tau_0} \cdot (t - 0.5\tau) \cdot e^{-\left(\frac{t-0.5\tau}{\tau_0}\right)^2}, \tag{5}$$

where $V_0 = 1$ V is the amplitude of the monocycle; $\tau_0 = \tau/2\pi$ is a parameter that determines the duration of a monocycle.

The column vector A for the address sequence shown at Fig.14, can be expressed as:

$$\mathbf{A} = (1\ \ 1\ \ 0\ \ 0\ \ 1\ \ 0\ \ 0\ \ 1\ \ 1\ \ 1)^T, \tag{6}$$

In order to receive the address sequence shown in Fig.8, according to the proposed receiving principle, a traveling wave antenna should be used in which the spatial arrangement of individual dipoles (for example, a bow-tie antenna presented at Fig.13) corresponds to the inverse time arrangement of IR-UWB signals in the structure of address sequence. It means that the first antenna dipole (call it A_{10}) corresponds to the 10th IR-UWB (Fig.14), the second antenna dipole (A_9) corresponds to the 9th IR-UWB, the third antenna dipole (A_8) corresponds to 8th IR-UWB, the 4th antenna dipole (A_5) corresponds to the 5th IR-UWB, the 5th antenna dipole (A_2) corresponds to the 2nd IR-UWB, the 6th antenna dipole (A_1) corresponds to the 1st IR-UWB.

Note that the number of dipoles in the antenna corresponds to the number of active IR-UWB signals.

For the address sequence in Fig.14, the number of active IR-UWB signals is six, hence the antenna should also have six dipoles. The block diagram of radio link with address sequence decoding in the antenna (antenna decoder) shown at Fig.15.

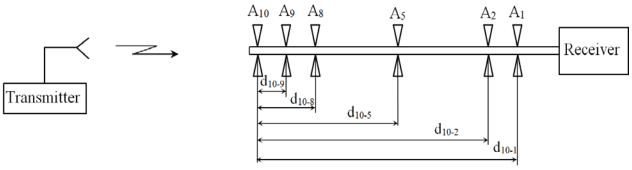


Fig.15 Block diagram of radio link with PPC address sequence decoding in the antenna

According to above mentioned, the spatial position of the dipoles can be calculated by the following formula:

$$d_{10-i} = c \cdot \Delta\tau_{10-i} / \sqrt{\varepsilon}\,, \tag{7}$$

where $i = \overline{1,9}$ is index; c = $3 \cdot 10^8$ m/s is velocity of electromagnetic waves, ε is the dielectric constant of the feeder material of antenna (for example, for polyethylene ε =2.3); $\Delta\tau_{10-i}$ is time delay between 10th and i-th IR-UWB signals in the address sequence. In this case, we get that $\Delta\tau_{10-9}=\tau=0.5$ns; $\Delta\tau_{10-8}=2\tau=1$ns; $\Delta\tau_{10-5}=5\tau=2.5$ns; $\Delta\tau_{10-2}=8\tau=4$ns; $\Delta\tau_{10-1}=9\tau=4.5$ns; $d_{10-9} \approx 10$ cm; $d_{10-8} \approx 20$ cm; $d_{10-5} \approx 50$ cm; $d_{10-2} \approx 80$ cm; $d_{10-1} \approx 90$ cm.

Then, mathematical formulae of signals at the outputs of respective dipoles of receiving antenna (ignoring propagation delay of the electromagnetic wave and losses in the free space between the transmitter antenna and the 10th (i.e. most closest dipole to antenna) dipole and without taking into account external noise) can be presented as:

$$\mathrm{S}_k(t) = \mathrm{S}_{\mathrm{ab}}(t - \Delta\tau_{10-k}) = \sum_{i=0}^{9} a_i \mathrm{V}(t - i \cdot \tau - (\mathrm{N} - k)\tau), \qquad \ldots(8)$$

where $k = \overline{1,10}$ is number of antenna dipole (in this case in accordance with Fig.15 k is equals to 10, 9, 8, 5, 2, 1).

Then, the total signal that goes to from antenna output to receiver input will be described by formula

$$\mathrm{S}_\Sigma(t) = \sum_{k=1}^{10} \mathrm{S}_k(t) = \sum_{k=1}^{10}\sum_{i=0}^{9} a_i \mathrm{V}(t - i \cdot \tau - (\mathrm{N} - k)\tau), \tag{9}$$

Fig.16 shows the waveforms calculated according to formula (9). Analysis of waveforms presented on Fig.16 shows that coherent accumulation of IR-UWB signals occurs in the antenna. As the result of accumulation, at certain instants we have a total signal with the maximum positive and negative peaks equal to 6 and -6 V at the receiver input respectively. Since the subscriber receiver has a squarer device, we get that the signal at the output of this device can be analytically represented in the form

$$\mathrm{S}_{\Sigma 2}(t) = \mathrm{S}_\Sigma^2(t)\,. \tag{10}$$

Fig.17 shows signal waveform at the output of the squarer device. As can be seen from Fig.17, there are two peaks with the amplitude of 36 volts^2, as well as side peaks with the amplitude of 9 volts^2. To smooth out the signal at the output of squarer, signal passed through a low-pass filter (LFP) with an impulse response *g(t)*, for example an RC filter. Then, the signal at the output of the LPF can be represented in the form

$$S_{\Sigma 3}(t) = -\int_0^t S_{\Sigma 3}(\tau)\, g(t - \tau) d\tau\,. \tag{11}$$

For RC filter, the impulse response has the form

$$g(t) = \left(1 - \frac{1}{\tau_{\mathrm{RC}}} e^{-\frac{t}{\tau_{\mathrm{RC}}}}\right)\sigma(t), \tag{12}$$

where $\tau_{RC} = RC$ is filter time constant; $\sigma(t)$ is Heaviside function

$$\sigma(t) = \begin{cases} 0, & t < 0 \\ 1, & t \geq 0 \end{cases}. \tag{13}$$

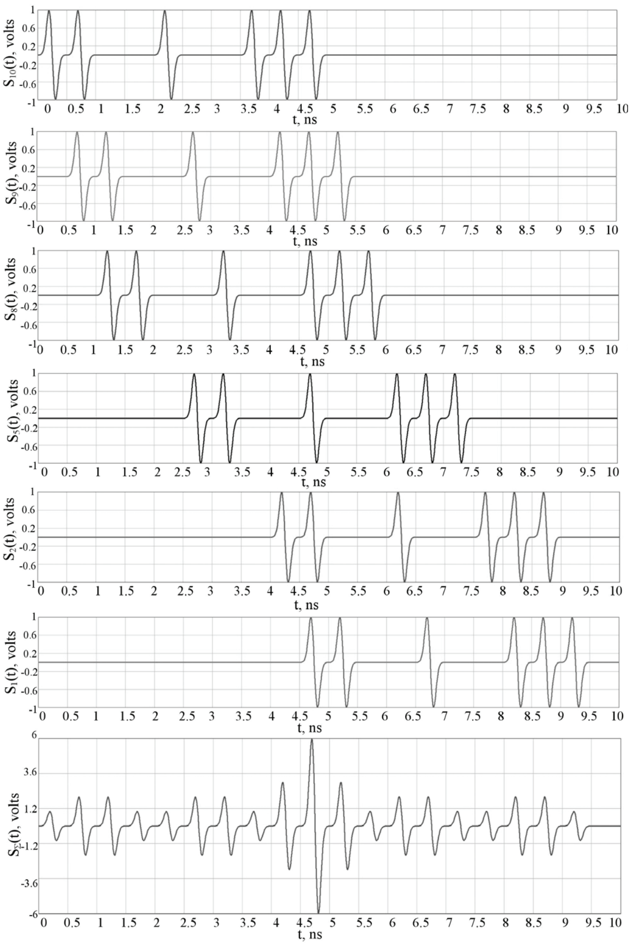


Fig.16 Waveforms of signal at the output of antenna dipoles and input of receiver

Fig.18 shows signal waveform at the output of the LPF at R = 200 ohms, C = 1 pF. According to Fig.18, having set the threshold level $U_{THR} = 12$ volts^2, we see a clearly expressed peak of signal that exceeds the preset level. Consequently, the receiver decision device for a given antenna configuration will register the PPC address sequence that is intended for this receiver.

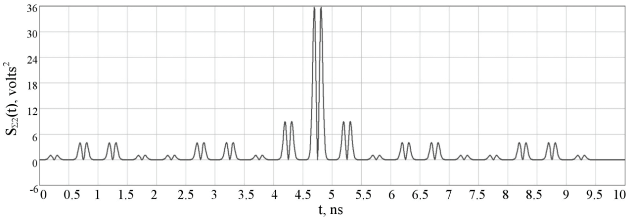


Fig.17 Signal waveform at the output of squarer device

It is interesting to research waveform of signal at the receiver decision device when receiving the subscriber's PPC address code, the structure of which is inconsistent with the antenna construction shown at Fig.15.

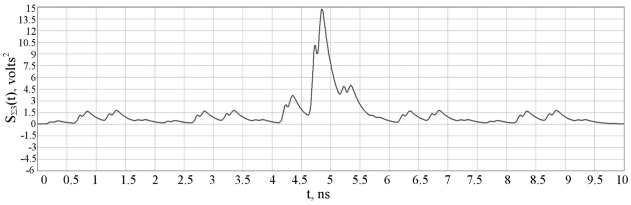


Fig.18 Signal waveform at the low pass filter output

Let the column vector A_2 of the coefficients is equals to

$$A_2 = \begin{pmatrix} 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 \end{pmatrix}^T \qquad (14)$$

Fig.19 shows waveform of this PPC address code, Fig.20 shows the total signal level at the receiver input, and Fig.21 shows signal level (after LPF) at the input of the decision device.

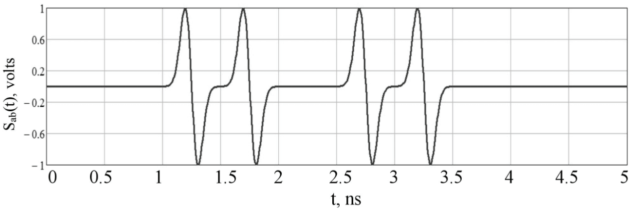


Fig.19 Waveform of the address code

Comparing Fig.21 with the threshold value $U_{THR} = 12$ volts^2, we see that the signal lies below this level, and therefore it is not registered by the receiver decision device, since it is intended for another subscriber.

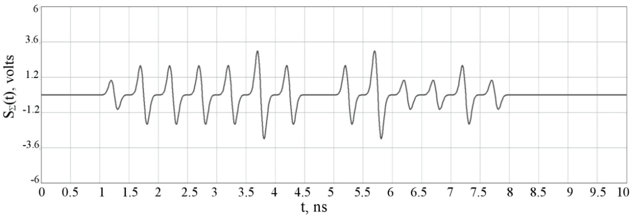


Fig.20 The total signal at the receiver input (antenna output)

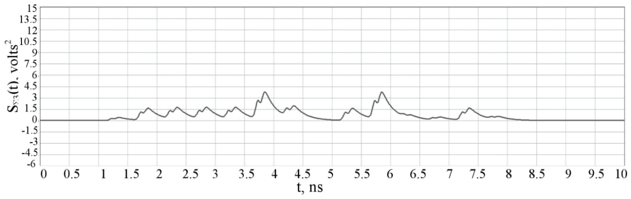


Fig.21 Signal at the input of the decision device

Let's take one more PPC address sequence. Let the column vector A_3 of the coefficients take the following form:

$$A_3 = \begin{pmatrix} 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \end{pmatrix}^T \qquad (15)$$

Fig.22 shows waveform of this address code according to (15), Fig.23 shows the total signal at the receiver input, and Fig.24 shows signal level (after LPF) at the input of the decision device

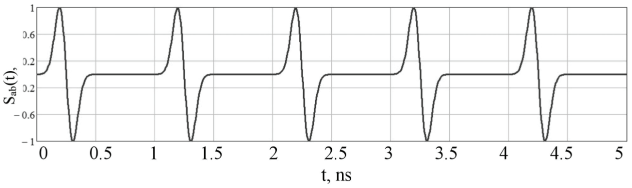


Fig.22 Waveform of the address code

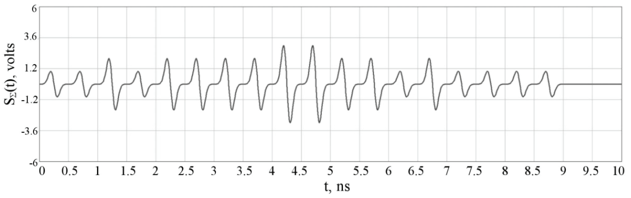


Fig.23 The total signal at the receiver input (antenna output)

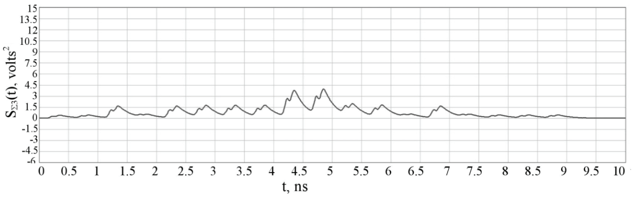


Fig.24 Signal at the input of the decision device

Comparing Fig.24 with the threshold value $U_{THR} = 12$ volts^2, we see that this signal also lies below this level, and therefore it will not be registered by the receiver decision device, since it is also intended for another subscriber.

It should be noted that all the results presented in this section are obtained for free space, that is, assuming the absence of multipath propagation of radio waves, the energy absorption of signals in the atmosphere, as well as the coincidence of the polarizations of the transmitting and receiving antennas.

Conclusion

A method for receiving, transmitting and retransmitting UWB impulse signals with Pulse Position Coding is proposed. The discrete nature of these signals allows them to be decoded directly by the receiver antenna, which design matched to the signal.

Also, the example of IR-UWB signal generator simulation with usage of AWR Microwave Office CAD was considered.

The transmission of IR-UWB signals with its simultaneous PPC coding can be accomplished by impulse excitation of a multi-element antenna with a predetermined arrangement of vibrators from the output of IR-UWB signal generator. The combination of the receiver and the transmitter allows implementing a repeater with or without changing the signal code.

The above mentioned theoretical results of antenna decoder operation simulation for PPC address sequence detection, which consists of the set of IR-UWB signals, show the possibility of PPC sequence registering in the subscriber's receiver decision device only in the case of a clearly defined number and position of antenna dipoles in the receiving antenna design. Thus, it is possible to detect the PPC address codes of different subscribers only by changing the design (mutual position and quantity) of the antenna dipoles without changing the receiver structure (that is, all subscribers use the same type of receivers, which is an advantage of this method of signal reception).

The issue of sending and receiving signals of log. “1” and log.”0” for each of the subscribers remains open, if each of them is coded by its set of IR-UWB signals. The authors suppose that in this case each subscriber needs to send two address codes: one for log.”1” and the second for log.”0”. However, in this case, the antenna of each of the subscribers must consists of two antennas (or one combined), each of which is configured to receive its PPC address code corresponding to either log.”1” or log.”0”. Obviously, there will also be two independent processing paths with their amplifiers, squarer devices, filters, etc.

With increasing the numbers of subscribers, it is necessary to increase the length of the PPC subscriber address code. This leads to antenna decoder design complication of and enlargement of its linear dimensions for each subscriber.

Unlike the case with one subscriber considered here is further interest to conduct theoretical studies and simulate the operation of the antenna decoder of a particular subscriber in the presence of electromagnetic fields intended for other subscribers, in other words, under the influence of other subscriber signals on the receiving antenna decoder.

The proposed idea is conceptual. Its realization will give an opportunity to offer new technological solutions for the creation of next-generation radio telecommunication systems, particularly in the terahertz frequency band. The paper does not reflect issues related with signal distortions due to the non-ideality of the characteristics of circuit elements in ultrawideband signal processing path.

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Передавання та приймання надширокосмугових сигналів, що засновані на декодуванні з використанням антени

Проблематика. Запропоновано нову ідею з передавання та приймання надширокосмугових сигналів імпульсного радіо із застосуванням кодування положення імпульсу (PPC) в передавальній станції і декодування за допомогою антени в приймальні станції. Описано приймальну станцію, яка забезпечує декодування надширокосмугового сигналу у вигляді PPC тільки з використанням приймальної антени, що здійснюється за рахунок просторового узгодження її конструкції з PPC адресним кодом окремо обраного абонента.

Мета досліджень. Розкрити ідею передавання та приймання надширокосмугових сигналів на основі застосування методу антенного декодування PPC адресного коду окремо взятого абонента.

Методика реалізації. Проведено комп'ютерне моделювання генератора надширокосмугового сигналу імпульсного радіо з використанням САПР AWR Microwave Office. Для опису часових форм надширокосмугового сигналу на виході антенних диполів і в приймачі використаний математичний апарат.

Результати досліджень. Результати комп'ютерного моделювання генератора надширокосмугового сигналу імпульсного радіо на базі діода з накопиченням заряду показують можливість генерування на його виході сигналу з тривалістю меншою за 1 нс в смузі частот 0,3 - 2,5 ГГц і амплітудою, що не перевищує 0,3..0,45 В. Математична модель та графіки функцій надширокосмугового сигналу у вигляді PPC пояснюють метод антенного декодування PPC адресного коду окремо взятого абонента в приймальні станції.

Висновки. Запропонована ідея є концептуальною. Її реалізація надасть можливість запропонувати нові технологічні рішення для створення бездротових телекомунікаційних систем наступного покоління, зокрема в терагерцевому діапазоні.

Ключові слова: надширокосмуговий; імпульс; передавач; приймач

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Передача и прием сверхширокополосных сигналов, основанные на декодировании с использованием антенны

Проблематика. Предложена новая идея по передаче и приему сверхширокополосных сигналов импульсного радио с применением кодирования положения импульса (PPC) в передающей станции и декодировании с помощью антенны в приемной станции. Описана приемная станция, которая обеспечивает декодирование сверхширокополосного сигнала в виде PPC только с использованием приемной антенны, осуществляемого за счет пространственного согласования её конструкции с PPC адресным кодом отдельно взятого абонента.

Цель исследований. Раскрыть идею передачи и приема сверхширокополосных сигналов на основе применения метода антенного декодирования PPC адресного кода отдельно взятого абонента.

Методика реализации. Проведено компьютерное моделирования генератора сверхширокополосного сигнала импульсного радио с использованием САПР AWR Microwave Office. Для описания временных форм сверхширокополосного сигнала на выходе антенных диполей и в приемнике использован математический аппарат.

Результаты исследований. Результаты компьютерного моделирования генератора сверхширокополосного сигнала импульсного радио на базе диода с накоплением заряда показывают возможность генерирования на его выходе сигнала с длительнотью менее 1 нс в полосе частот 0,3 – 2,5 ГГц и амплитудой, не превыщающей 0,3..0,45 В. Математическая модель и графики функций сверхширокополосного сигнала в виде PPC поясняют метод антенного декодирования PPC адресного кода отдельно взятого абонента в приемной станции.

Выводы. Предложенная идея является концептуальной. Ее реализация дать возможность предложить новые технологические решения для создания беспроводных телекоммуникационных систем следующего поколения, в особенности в терагерцовом диапазоне.

Ключевые слова: сверхширокополосный; импульс; передатчик; приемник