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ОРИГИНАЛЬНАЯ СТАТЬЯ

Радиотехнические средства передачи, приема и обработки сигналов
Radio electronic facilities for signal transmission, reception and processing

ORIGINAL ARTICLE

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Selection and Application of the Data Transfer Operating Protocol Software Architecture for the Software-Defined Radio

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Abstract
Introduction. Noise-proof coding is used in many communication systems to provide an acceptable level of performance. A particular feature of its use is the inclusion of redundant characters in a coded packet. It demands more transfer time and essentially better throughput of the channel than in the case of an uncoded packet transferring. A promising development is a software change in the configuration of radio communication system and the development of communication protocols. This is done to ensure the maximum load factor of the channel while ensuring an acceptable level of performance.
Objective. To improve radio system performance by updating communication protocols, in order to solve the problem of ensuring maximum channel load during signal formation and reception.
Materials and methods. The paper describes the structure of the protocol developed by the authors. It is applicable in software to control ionospheric radio communication system transceiver modules. The software was developed in LabView (VHDL language) cross-platform software environment and was studied by means of a radio interface simulation model.
Results. The study examined the corrective ability of codes in the case of a supplementary Gaussian channel with binary phase modulation (OFDM-modulation, 2PSK and 4PSK absolute phase manipulation) in the selection of an energy-efficient approach to the design of ionospheric radio communication system. The study developed the structure and the functional description of the protocol used in the software for the simulation model of software-configurable radio channel. The software operation can be carried out in Windows 7 and in later versions with bit depth x32/x64 under the MS VisualC++package. It was shown that the software thus developed can use the hardware and software controls of the transceiver module. SunSDR2 transceiver and antenna amplifier were included in the module.
Conclusion. The results obtained allow for the replacement of separately adjusted radio receivers and transceivers built on a complex super-heterodyne scheme. A limited number of hardware units operate under the control of the developed software. Further studies will be carried out to assess the passage of OFDM signals through multipath communication channels with Rician and Rayleigh fadings. The resulting model will allow for the assessment of noise immunity at different lengths of the cyclic prefix OFDM symbol and for observation of signal constellation behaviour under the influence of various instabilities.

Key words: coding schemes, decoding schemes, communication system, transfer channel, software, signal-code structures, broadcast protocol, half-duplex protocol

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ORIGINAL ARTICLE

Радиотехнические средства передачи, приема и обработки сигналов
Radio electronic facilities for signal transmission, reception and processing

Выбор и использование программной архитектуры действующего протокола передачи данных программно-конфигурируемого радиоканала

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Аннотация

Введение. Помехозащищенное кодирование используется во многих системах связи для обеспечения приемлемого уровня производительности. Особенность использования – во включении избыточных символов в закодированный пакет, что требует большего времени передачи и существенно большую пропускную способности канала, чем при передаче некодированного пакета. Перспективным здесь является программное изменение конфигурации системы радиосвязи и разработка протоколов связи для обеспечения максимального коэффициента загруженности канала при обеспечения приемлемого уровня производительности.

Цель работы. Повышение производительности радиосистемы путём совершенствования протоколов связи, решение вопроса обеспечения максимальной загруженности канала при формировании и приеме сигналов.

Материалы и методы. В работе приводится описание и структура протокола, разработанного авторами и применимого в части программного обеспечения (ПО) управления приемопередающего модуля системы ионосферной радиосвязи. ПО разрабатывается в кроссплатформенной программной среде LabView на языке VHDL и проходит исследования на имитационной модели радиоинтерфейса.

Результаты. Исследована корректирующая способность кодов, для случая аддитивного гауссовского канала с двоичной фазовой модуляцией (OFDM-модуляция совместно с абсолютной фазовой манипуляцией 2PSK и 4PSK) для выбора энергоэффективного подхода к проектированию системы ионосферной радиосвязи. Разработана структура и функциональное описание протокола, используемого в ПО для имитационной модели программно-конфигурируемого радиоканала. Работа ПО осуществляется в ОС Windows 7 и более поздних версиях с разрядностью x32/x64 под управлением пакета MS VisualC++. Показано, что разработанное ПО может задействовать аппаратные и программные средства управления приемопередающего модуля, включающего трансивер SunSDR2 и антенный усилитель.

Заключение. Полученные результаты позволяют заменить отдельно настраиваемые радиоприемники и трансиверы, построенные по сложной супергетеродинной схеме, на ограниченное число аппаратных блоков, работающих под управлением разработанного ПО. В дальнейшем планируется провести исследования по оценке прохождения сигналов OFDM через многолучевые каналы связи с замираниями Релея и Райса. Получаемая модель позволит оценить помехоустойчивость при различной длине циклического префикса OFDM символа и пронаблюдать за поведением сигнального созвездия при воздействии различных нестабильностей.

Ключевые слова: схемы кодирования, схемы декодирования, система связи, канал передачи, программное обеспечение, сигнально-кодовые конструкции, широковещательный протокол, полудуплексный протокол

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Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

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Introduction. The fact that ionised traces of meteors entering the Earth's atmosphere can reflect radio signals has been known since the early 1930s. Pickard observed that high-frequency radiation flashes occur during meteor showers [1]. In 1935, Skellet discovered that an ionised trail left by a meteor while burning up in the Earth's atmosphere can be used to reflect radio signals towards the Earth [2].

Previously, there was no way of detecting and utilising an ionised (meteor) trail before its scattering. A meteor burst communication was a rarity sometimes used by radio amateurs but had very little practical application. The emerging of modern low-cost technologies and high-speed digital equipment has led to dramatic changes in commercially available meteor burst communication technology. Unlike other transmission technology, it can provide communication "beyond the limits of direct visibility" otherwise known as the "Extend Line of Sight" method.

Typically, a meteor burst communication transceiver network consists of one or more base stations and a number of remote terminals. Base stations communicate with remote terminals and other base stations. The terminals only communicate with base stations. Communication between one terminal and another is possible through the base station. Part of the digitised data is transferred as a short pulse when the corresponding trail is detected and its "quality" is determined. Existence of the trail is determined by a test signal reception transferred by the base station or other network terminal. The terminal transmits confirmation to the base station when it receives the test signal, thus indicating that the trail exists and the terminal is ready for data exchange. Time spent on this exchange is sacrificed in favour of system reliability [3], [4].

In order to maintain communication in a situation of significantly changing signal propagation conditions associated with the rapid changes in meteor trail parameters, the parameters and encoding formats of transferred signals must also change rapidly. For this purpose, all the radio systems considered provide for configuration change by software, thus relating to software-defined radio systems.

The objective of the present work, the results of which are presented in this paper is the investigation of existing modulation/demodulation methods and subsequent digital signal processing. These factors impose requirements on network station equipment and system operation algorithms, in order to determine the most appropriate and efficient development way of technical means (including software (SW) capable of meeting the maximum number of possible applications of radio access channels.

The authors of this paper rely on OFDM modulation together with absolute phase shift keying (2PSK and 4PSK) in sub-channels. In addition to [5], the choice of this modulation method is influenced by the study of the popular standard digital network communication IEEE 802.11a working principle, which is part of the commercial Wi-Fi standard. In terms of proper scaling, the operating conditions of both systems are very similar despite the fact that their frequency ranges differ by several orders of magnitude. In addition, the study considers the existing standards [6], amateur systems such as WinLink, and marine digital and analogue information systems for the "physical" and "channel" levels. Other scientific and technical publications were also taking into consideration [3].

Let us consider the described software-defined radio by starting with a description of the modulation circuit used.

Modulation circuit. Frequency shift keying (FSK) signals for radio channel information transfer were used. The following requirements were imposed on designed software-defined communication channel operating in a "streaming" information transfer mode:

– peak factor equals 1 to allow maximum use of signal amplifiers;

– signal reception noise immunity is acceptable for estimated signal-to-noise ratio;

– low complexity implementation.

The FSK signal modulation circuit is shown in Fig. 1, and FSK signal modulation circuit with z-wave nodes is presented in Fig. 2. The information transfer rate lies within the range of $10^2 ... 10^4$ bps. The frequency band (in Hz) is numerically equal to twice the value of this parameter.

The quadrature components $x(n)$ and $q(n)$ (n is a time moment serial number) are in blocks of ad-

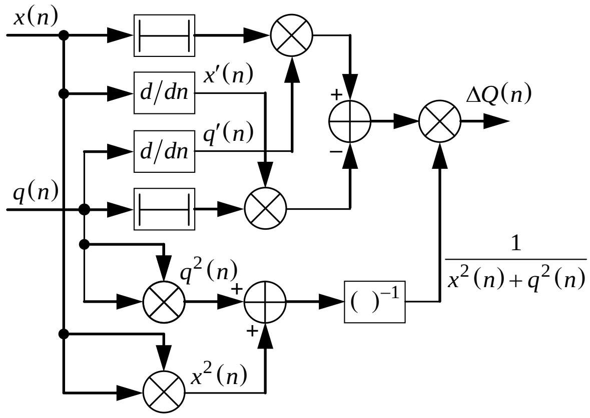

Fig. 1. FSK signals modulation circuit

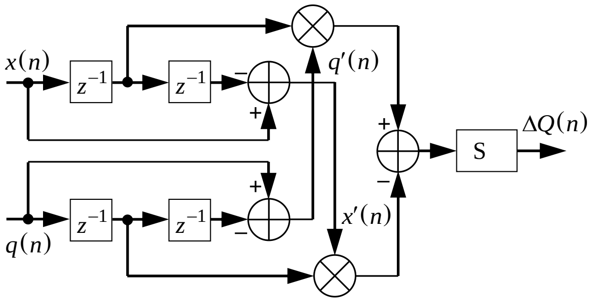

Fig. 2. FSK signals modulation circuit with z-wave nodes

dition, delay and multiplication. The result is transferred at the final stage to a solver (S) [6].

Signal processing is based on the optimum algorthym for adopted modulation and coding methods in the communication channel demodulator.

Coding scheme. Code structure. It is shown in [3] that output balanced channel without binary input memory is characterised by the conditional probability density $W(y|c)$ of the received signal *y* with the transferred symbol *c*, together with the transformation described by the matrix G_N, thus defining a family of *N* transmission sub-channels with conditional probability densities:

$$W\left(\mathbf{y}_0^{N-1},\ \mathbf{u}_0^{i-1}\middle|u_i\right)= =\frac{1}{2^{N-1}}\sum_{u_j\in\{0,\ 1\}} W\left[y_{\mathrm{s}}\middle|\left(\mathbf{u}_0^{N-1}G_N\right)_{\mathrm{s}}\right], \quad (1)$$

$$0\le i<N,\ i<j<N,$$

where $\mathbf{y}_0^{N-1}=(y_0,\ \mathrm{K}\ ,\ y_{N-1})$ is the received signal input vector; $\mathbf{u}_0^{N-1}=(u_0,\ \mathrm{K}\ ,\ u_{N-1})$ is the polarization transform input vector; u_i, u_j are information symbols; *i* is the channel number; *j* is the decoding phase; subscript s denotes the received signal.

Next, the indicated transfer with an example of a code structure with polar codes was considered. Polar codes [5] are codes with a generator matrix consisting of matrix rows

$$G_N=B_NF^{\otimes m}=F^{\otimes m}B_N,$$

where $N=2^m$; m is the base 2 logarithm of the not shortened polar code length with dynamic frozen symbols; B_N is the permutation matrix for bits with dimensions $2^m\times 2^m$;

$$F=\begin{pmatrix}1 & 0\\ 1 & 1\end{pmatrix};$$

$\otimes m$ denotes the *m*-fold Kronecker product of the matrix with itself. The predefined linear combinations of input symbols u_i at positions corresponding to dynamic frozen symbols are calculated. Bit reversal is then performed via multiplication using a matrix B_N. Inactive symbols are excluded from the resulting vector.

The code word for this code is $\mathbf{c}_0^{N-1}=\mathbf{u}_0^{N-1}G_N$. The information bits intended for transmission comprise *k* elements of the vector, and the remaining elements are calculated according to a procedure shown below. As *m* increases, these sub-channels become polarized, meaning their Bhattacharya parameters* Z_i converge to 0 and 1.

We are considering transfer of useful data without encoding through virtual sub-channels using $Z_i\approx 0$, and transfer of predefined values through sub-channels with $Z_i\approx 1$. The sub-channels with $Z_i\approx 1$ are referred to as frozen (as well as the corresponding symbols u_i) and in classical polar codes, zeros are transferred through them $(u_i=0)$. The generator matrix of the classical polar code is obtained by deleting lines corresponding to the frozen sub-channels from the matrix G_N. It should be noted that if the Bhattacharya parameter of the original information transfer channel is sufficiently small, then the estimation of $Z_i=0\left[Z^{wt(i)}\right]$, where $wt(i)$ is the number of non-zero bits in the binary representation of the number *i*, is valid.

Polar codes with dynamic frozen symbols (PCDFS) [6] where instead of zeros, the linear combinations of the previous characters are transferred via frozen sub-channels, are used for reliable data transfer through the channel. These codes have a larger minimum distance compared to classical ones. Expressions for linear combinations are called dynamic freezing constraints [6]:

$$\mathbf{u}_0^{N-1}G_NH^{\mathrm{T}}Q=\mathbf{u}_0^{N-1}V^{\mathrm{T}}=0,$$

* The Bhattacharya parameter of a channel with a binary input forms an upper bound for a double probability value of an error per bit when transmitting data through this channel without encoding.

where H is the verification matrix of the extended simple cyclic Bose–Chaudhuri–Hocquenghem code (BCH) with the following dimensions: $f \times n$; Q is the invertible matrix where the i-th row of the matrix V is placed in a column t_i, all t_i are different and $V_{i,\,t_i} = 1$, while $f \le n - k$ (n is the code length (number of code symbols); k is the code size (number of information symbols)); "т" denotes the transpose symbol. Thus, the symbol u_{t_i} can be calculated as a combination of linear symbols with lower numbers. It is therefore called a dynamic frozen symbol.

[5] shows that any extended simple BCH code in some sense is a sub-code of a Reed–Muller code of the length $n = 2^m$ and order $r \le m$. The last condition can be considered as a polar code with indexes of frozen symbols constituting a set of values $i : wt(i) < m - r$. Thus, all sub-channels, where the Bhattacharya parameter decreases slowly with a Z-parameter decrease of the original data transmission channel, are frozen. This, however, is not enough to provide for the appropriate probability of decoding error. Therefore, the remaining n–k–f sub-channels with the highest error probability P_i are frozen statically, meaning that constraints $u_i = 0$ are imposed on them.

Based on the above, a condition that F is a set of static and dynamic frozen symbols is added, thus the resulting code is a sub-code of the extended BCH code.

The described polar codes have a length of 2^m that does not always meet practical requirements. Hence, codes with a length of $n \le 2^m$ are used for the further presentation of the algorithm. A necessary condition for unification is code shortening by reduction of its dimension and code lengthening by introducing additional constraints $c_i = 0$ on symbols of the original code word. The code words of the shortened code are obtained by excluding these "inactive" symbols.

We considered the description of the codes used in the form of a text file, where the first line contains space separated parameters m, k, d, n, where d is the minimum code distance.

If $n = 2^m$ (code is not shortened), then the next line is omitted. Otherwise, it lists the numbers of the "active" (i.e., potentially non-zero) symbols of the code word.

The following lines list the dynamic freezing constraints that specify the code. The number of symbols w included in the constraint is indicated at the beginning of each line. Then there is an indices list $i_0, i_0, \ldots, i_{w-1}$ of the symbols involved in the constraint:

$$\sum_{j=0}^{w-1} u_{i_j} = 0.$$

The symbol with the highest number i_j is considered as dynamic frozen. The bits intended for transmission are distributed according to an input vector of a polarising transformation $\mathbf{u}_0^{N-1}$. The linear combinations of input symbols u_i are calculated at positions corresponding to the dynamic frozen symbols. The bits permutation is produced on the basis of their multiplication using the matrix B_N. The resulting vector is multiplied by the matrix $F^{\otimes m}$. Inactive symbols are excluded from the resulting vector.

Fig. 3 illustrates error correction capability (ability of a code to detect and/or correct the maximum multiplicity error) of the PCDFS (256, 180, 14), built in accordance with the method described in [3] (line *1*). A comparison is made with the low-density parity-check code [7] (line *2*) for the additive Gaussian channel with binary phase modulation. It can be seen that the polar code provides an advantage of about 1 dB achieved due to the larger minimum distance of the PCDFS.

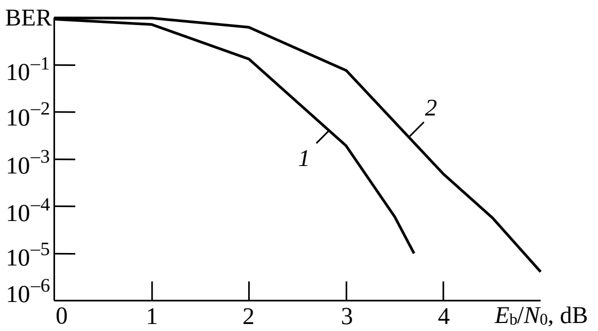

Fig. 3. Codes error correction capability: *1* – polar code with dynamic frozen symbols (256, 180, 14);
2 – low-density parity-check code

Decoding algorithm. In order to analyse the radio channel implementation, the decoding algorithm on the receiving side was considered.

The signal power received in an ionospheric communication channel varies significantly over time. Therefore, the transfer rate or transfer parameters, such as a ratio of information symbols (bits) and additional bits need to be adapted in the event of excessive noise immunity encoding. This task requires the following conditions:

1) quick and accurate estimation of channel characteristics;

2) affordable adaptability costs.

In order to build a code and, therefore, calculate control symbols by using known informational symbols, one of methods for defining a size k sub-space in a size n space can be used. Note, that space definition also implies a field specification that provides coefficients for the vector decomposition into basis components (vector coordinates). The previously considered codes, with the exception of the Reed-Solomon code, are defined for the binary field, and the latter is defined for the extended binary field with the number of elements matching the size of the vector $\mathbf{y}_0^{N-1}$.

A vector $\mathbf{y}_0^{N-1}$, received by the receiving side was considered. This vector is characterised by an informational message. For the accurate decoding of the received informational message, a sequential decoding algorithm consisting of the following steps can be used:

Step 1. A path of zero length with probability $\Omega(0)$ is added to a priority queue.** The function

$$\Omega(i) \approx \prod_{\substack{j<i,\\ j\in F}} \left(1 - P_j\right)$$

characterises the probability of an error decision regarding a symbol u_i with known values of previously defined symbols (P_j is the probability of the error when receiving the previously transferred j-th symbol $(j < i,\ j \in F)$). Values P_j are calculated by using the Gaussian approximation method [5].

Step 2. The path in the code tree $\mathbf{u}_0^{N-1}$ with the highest probability estimate $W\left(\mathbf{u}_0^{i-1}\middle|\mathbf{y}_0^{N-1}\right)$. is selected from the priority queue. If the length of this path equals N, then the corresponding code word is considered generated and decoder terminates.

If the symbol u_i is dynamic frozen, then its value is calculated according to (1). Otherwise, cases $u_i = 0$, $u_i = 1$ are considered separately below. The probability estimates of the most probable code word $\mathbf{u}B_m G_N$ of the polar code defined by the vector $\mathbf{u}$ with the prefix $\mathbf{u}_0^i$ are calculated as follows:

$$W\left(\mathbf{u}_0^{i-1}\middle|\mathbf{y}_0^{N-1}\right) = P\left(\mathbf{u}_0^{i-1}\middle|\mathbf{y}_0^{N-1}\right)\Omega(i).$$

Vectors $\mathbf{u}_0^i$ are placed in the priority queue.

Step 3. If the number of paths $\mathbf{u}_0^{i-1}$ of the length i, extracted by the decoder, exceeds the predefined threshold L, then all paths of the length i or less are deleted from the priority queue. If the number of paths in the priority queue exceeds a parameter Θ, then all paths with the smallest values of $W\left(\mathbf{u}_0^{i-1}\middle|\mathbf{y}_0^{N-1}\right)$ are deleted, and then return to step 2 takes place.

Error probability decreases simultaneously with an increase in decoding complexity when L and Θ parameters values increase. The decoding is implemented at almost maximum likelihood when these parameters are sufficiently large.

In some cases, the code word returned by the algorithm is not the most probable. Typically, this is due to rejecting the correct path during step 3, and it is accompanied by a sharp increase in the number of iterations performed by the decoder. This can be used to detect decoding errors. Thus, the decoder returns an error flag, if the number of iterations of the considered algorithm exceeds a certain threshold value, which depends on the code.

The algorithm described herein provides for decision-making based on the high-quality use of the channel resource with a sufficient level of information transfer certainty and reliability, as contained in the described code structure. Further, we consider the software that implements the described algorithm.

Transfer protocols. Let us consider existing transfer protocols required for the correct operation of the designed radio system and software-defined radio. The radio system thus designed has two transfer protocols, namely broadcast and half-duplex protocols, described below from the point of view of their application in the radio system software.

Broadcast protocol. This protocol is designed for one-way communication and guaranteed message delivery implemented by message multiple repetition by a transmitter. It is characterised by periods of in-

** Priority queue is a data structure where each element is given a priority.

Table 1. Data frame structure

Header		Code word		
Preamble, byte	Code ID, byte	CRC, byte	Package ID, byte	Data field
6	2	2	1	Variable length

Table 2. Possible coding specifications and data field sizes

Specification	Size of the code word, bit	Size of the encoding data, bit	Size of the data field, bit (byte)
1024_896_6_4.spec	1024	896	872 (109)
1024_768_12_5.spec	1024	768	744 (93)
1024_512_32_5.spec	1024	512	488 (61)
1024_512_28_5.spec	1024	512	488 (61)
1024_256_44_2.spec	1024	256	232 (29)
256_204_12_4.spec	256	204	180 (22)
256_180_14_4.spec	256	180	156 (19)
128_90_12_4.spec	128	90	66 (8)
64_45_8_4.spec	64	45	21 (2)

formation reception and transmission. The protocol provides for message encoding; thus, the data is transferred as data frames. The data frame structure is presented in Table 1.

The frame header contains a preamble. The receiver synchronises with received clock signals upon the preamble reception. The double-byte field "Code ID" contains a recipient address. The code word consists of the double-byte checksum field, sender address in the single-byte field "Package ID" and data field of a variable length. The checksum field value is calculated by using specific algorithm (CRC-32 polynomial). A variety of coding specifications, which differ in data field and code word sizes and depend on the message size, are applied (Table 2). The specification indicates separated parameters such as the code word size, size of the encoding data, transfer rate and sender address.

Transmission uses standard-length code words. Considering the variable length of the data field, its size can be slightly reduced to comply with the length (see the right column in Table 2).

Half-duplex protocol. This protocol can be used in a software-defined radio. The protocol provides an information exchange between the transmitter and receiver in the data frames form.

Let us consider the structure and data of the frame (Fig. 4). At the initial time moment, the base station sends probe signals (P) which define the beginning of the ionised trail [6]. The probe signal duration is 0.8 ms with a 50 ms delay between them. This is a result of the minimum possible switching delay of antenna switches. The probe signal is fed to the peripheral station input in the case of the ionised (meteor) trail formation (line 1 in Fig. 4 depicts the intensity of the reflected from this trail signal). The peripheral station receives the probe signal, evaluates the possibility to transfer information, switches the antenna switch from the reception to transmission mode and transfers the ASK channel formation confirmation signal (ionised (meteor) trail formation) to the base station. After the base station receives the ASK signal, then the channel formation is recorded and data transmission through it is performed.

Confirmation of correct reception is sent as the ASK signal from the peripheral station to the base station upon each data frame reception. The number of the next expected data frame is transferred as a

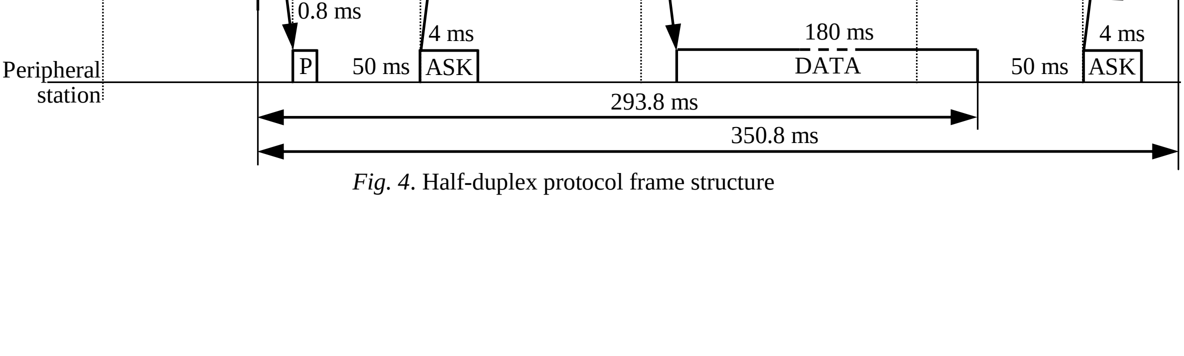

Fig. 4. Half-duplex protocol frame structure

Table 3. Confirmation frame structure

Frame header	
Frame field	
Name	Size, byte
Preamble	6
CRC	2
Flags	1
Package ID	1

part of the signal. The number of the frame 0 in the ASK signal which confirms the ionised channel formation, is then transferred.

The confirmation frame structure is given in Table 3.

The half-duplex protocol frame structure content for each signal needs to be described in detail. The system signals (probe, illumination, request, response, observed object intrinsic radio emission, reflected signal, etc.) are electromagnetic fields characterised by temporal and spatial structures [8]. The group signal demultiplexing equipment utilises the cyclic synchronisation mode, in order to ensure channel recognition and separation at the reception. The cyclic synchronisation mode is the identification procedure of the meteor signal appearance among signals received in the operating frequency range. The "Flag" field is used to indicate the digital information package beginning. The binary content example of this field: 11110000_2 means there is no data to transfer; 00001111_2 means that the data frame is transferred after the confirmation frame.

Table 4. Data frame structure with single code word

Frame field: Frame header	
Name	Size, byte
Preamble	6
Code ID	2
Frame field: Code word	
Name	Size, byte
CRC	2
Package ID	1
Data field	Variable length

Table 5. Data frame structure with several code words

Frame field: Frame header	
Name	Size, byte
Preamble	6
Code ID	2
Frame field: Code words	
Name	Size, byte
CRC	2
Package ID	1
Data field of the code word # 1	Variable length
...	
Data field of the code word # 7	Variable length

In the case under consideration, the coding is used for each message, and its specification depends on the message size [9].

The structure of a single code word data frame is presented in Table 4. An operating mode, where several code words are combined, is provided. In this case, only one header is used (Table 5), and code words are identified by the "Flags" fields presence.

Receive/transmit software. The information receive/transmit software utilises meteor reflections and has been developed to verify the operability of the proposed algorithm and transfer protocol. The software supports hardware and software to control the transceiver module including the antenna amplifier and SunSDR2 transceiver ensuring hardware operation in half-duplex mode*** [2].

The following hardware is required for the stable software operation [10]:

– computer with x86 architecture processor, at least 2 GB RAM, hard disk capacity of at least 100 GB, monitor with a screen resolution of at least 1024×768 pixels;

– antenna feeder devices;

– SunSDR2 transceiver.

The software runs in x32/x64 bit versions of Windows 7 (and higher) with Microsoft Visual C ++ 2010.

The block diagram of the developed software is shown in Fig. 5. The software is built on client-

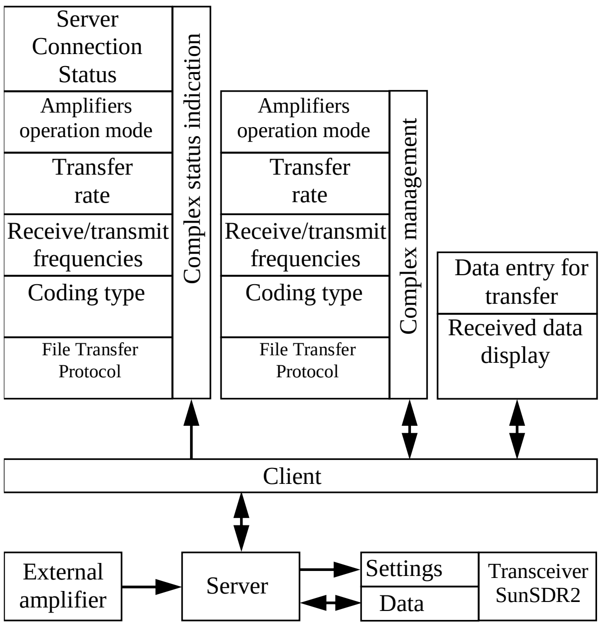

Fig. 5. Block diagram of the receive/transmit software

*** SunSDR2 also provides full-duplex mode, but it is not used in the present system.

server architecture [11]. The client part (located in the figure above the "Client") performs the functions of indicating, setting and managing the complex, data transfer, and transferred/received data display on the module. The resulting parameters and client part data are transferred to the server part to control the SunSDR2 transceiver and data transfer [12].

Fig. 6 shows the programme interface when running the server part with settings for the address and protocol information of the base station [13]. According to Fig. 6, the software input data (depending on the station) are:

– server part port ****;
– radio channel trace *2*;
– transceiver IP address and port *3*;
– transceiver transmitter power****;
– transfer rate *5*;
– transmitter frequency *6*;
– receiver frequency *7*;
– protocol type *8*;
– coding type (specification) *9*;
– amplifiers settings *10*;
– messages for transmission *11*;
– number of message repetitions for transmission through the broadcast protocol *12*.

The input data is alphanumeric and entered interactively.

The output data is alphanumeric or digital and displayed on a monitor screen or saved in files.

Conclusion. At the present time, software-defined radio systems are of great theoretical and practical interest, since they can perform a significant part of digital signal processing on a conventional PC or PLD. This purpose is a radio receiver or radio transmitter which can be modified by software reconfiguration. The traditional analogue receiver, where ADC converts signals from the analogue quadrature channels output, has the following disadvantages: a need for fine tuning; sensitivity to temperature and component parameters variation; non-

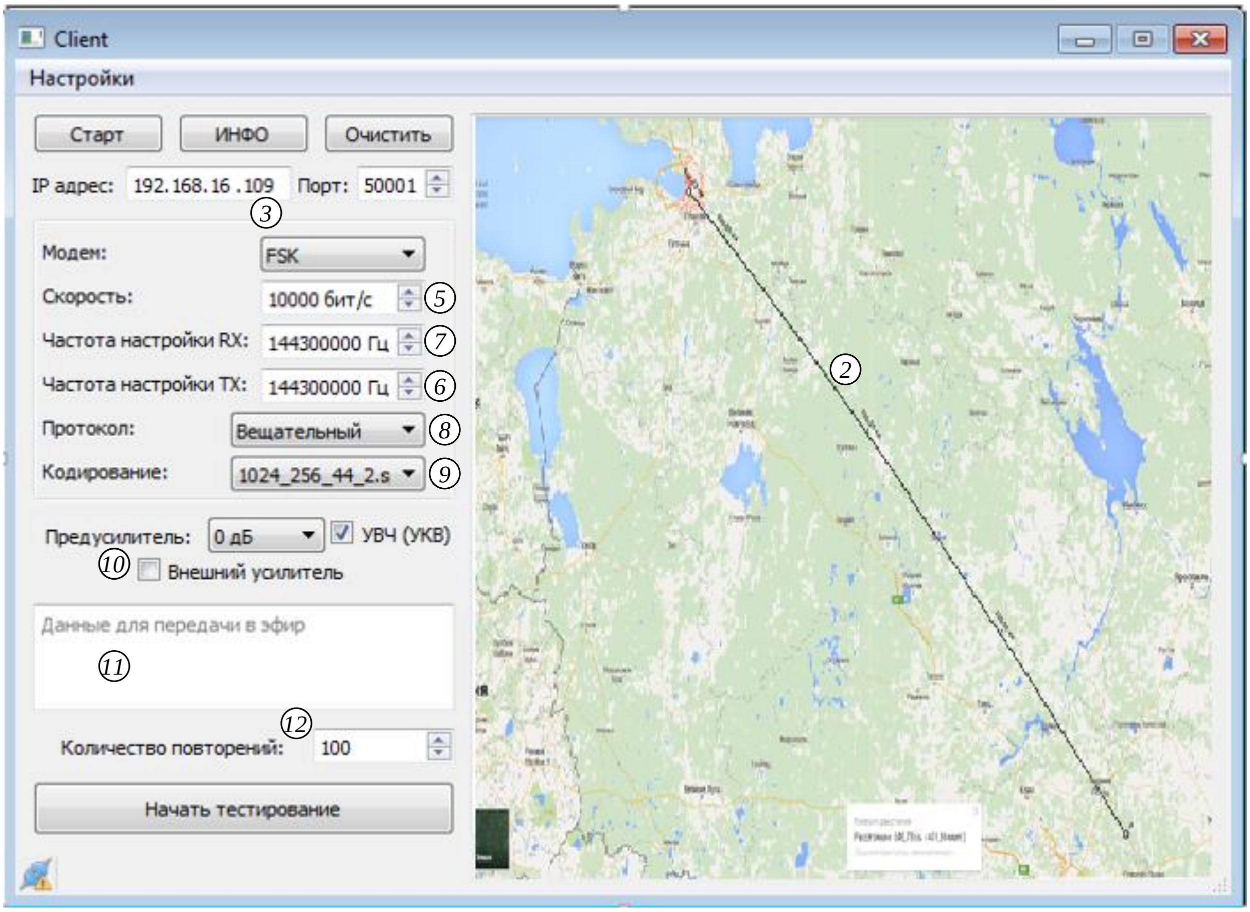

Fig. 6. The program interface when running the server part of the transmission channel

**** It is indicated on another page of the interface.

linear distortions; the design complexity of tuneable filters and filters with suppression of more than 60 dB. However, it is now possible to convert a signal directly from an intermediate frequency output due to the rapid development of a modern semiconductor element base, especially ADC and DAC [14].

The technology allows for the replacement of a variety of existing radios and transceivers, both serial and amateur built according to a complex – circuit, with a limited number of available hardware units running under developed software. This leads to both simplification and cheaper construction, significant improvement in characteristics, all types of modulation support, the emergence of a large number of service functions. It also enables rapid development, since the software can be improved by the entire community simultaneously [15]. This has become possible due to the affordable fast DACs and ADCs availability and cheapening of PCs and DSPs.

By analysing such an important technical characteristic of radio systems as noise immunity, we can conclude that radio systems with a two-way data exchange protocol possess a number of significant technical advantages in comparison with radio systems with the one-way data exchange protocol. Thus, radio systems with a two-way data exchange protocol are currently the only reliable alternative to wired systems. In the event that communication cannot be restored even after a number of actions such as changing the frequency channels, changing the radiation power, changing the on-air period, then this is evidence of intentional technical sabotage of the system operation, namely setting broadband interference in the entire allowed frequency range.

This paper presents the structure and functional description of software-defined radio and investigates the simulation radio interface model. By studying the structure and functional description of the developed software, it can be concluded that software developed for studying the reliability and operability of the proposed algorithm and transfer protocol can be used to receive and transmit information by utilising ionospheric reflections. The potential for this work consists in the review and analysis of the architecture of the software-defined radio in the LabView [16] in order to evaluate operational stability during the data transfer in multipath conditions.

Studies of OFDM signal passage through multipath communication channels with Rician and Rayleigh fadings are also planned. The resulting model allows for the evaluation of noise immunity at the different lengths of the OFDM symbol cyclic prefix; the various powers of the Rice model main beam and observation of signal constellation behaviour under the influence of various instabilities.

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