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ФОРМИРОВАНИЕ СОВРЕМЕННОГО ИНФОРМАЦИОННОГО ОБЩЕСТВА – ПРОБЛЕМЫ, ПЕРСПЕКТИВЫ, ИННОВАЦИОННЫЕ ПОДХОДЫ

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1–5 июня 2015 года

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ISA District 12 (International Society of Automation) and SUAI (Saint-Petersburg State University of Aerospace Instrumentation) have organized the Eleventh ISA European students paper competition (ESPC-2015). Papers of professors and the best students were included into this volume of the proceedings of the XVI International Forum «Modern information society formation – problems, perspectives, innovation approaches». Papers can be interesting for students, post-graduated students, professors and specialists.

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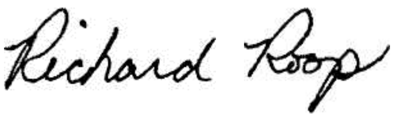
On behalf of ISA, I extend congratulations to the ISA Russia Section, ISA District 12, and the St. Petersburg State University of Aerospace Instrumentation (SUAI) on successfully completing the 11th ISA European Student Paper Competition.

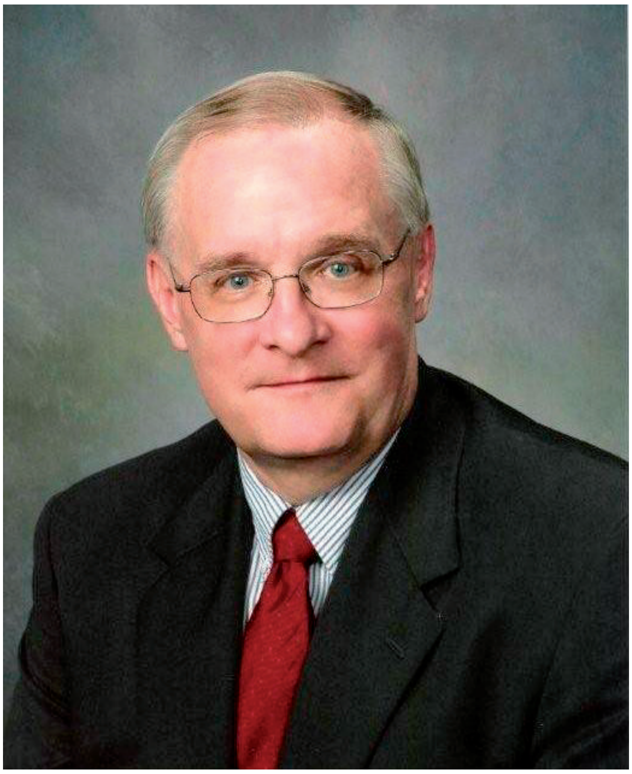
Students are the future for our Society. We are excited about the potential of these talented students who will help "set the standard for automation" and shape the processes that will secure, improve, and make our lives better in the years ahead. No matter which career path they choose, we hope ISA will have a place in their continuing education and professional development.

The papers published in this volume, selected by the advisory committee, represent the best contributions from among an excellent group of papers. I commend the students who committed their time to prepare a paper and on having their work selected for this publication.

Sincerely,

Richard W. Roop
2015 ISA President





I would like to extend congratulations to the ISA Russia Section, ISA District 12, Indiana State University (ISU), and the St. Petersburg State University of Aerospace Instrumentation (SUAI) for successfully organizing the Eleventh ISA European Student Paper Competition. This international forum has become one of the foremost conferences in the world.

As an education and member of ISA for almost 30 years, I continue to appreciate the sharing of technical information by students and faculty members. This global sharing will serve to help advance the technical knowledge base and help in the global collaboration of ideas. I always look forward to having the opportunity to share with students the amazing challenges and personal rewards that a life in automation can bring. ISA is honored to have the opportunity to nurture the next generation of automation professionals.

Indiana State University and the International Society of Automation look forward to our continued relationship between the Russia Section, District 12, and SUAI. Through distance learning classes on project management and ongoing international forums, we are developing new understandings in the technical, cultural, and personal arenas.

Congratulations to those who have developed papers for this volume and to the advisory committee who have the difficult task of making paper selections.

Sincerely,

Gerald W. Cockrell
ISA Former President (2009)
Professor Emeritus(ISU)

Gerald W. Cockrell

RESEARCH AND DEVELOPMENT SPECIAL AUTOMATED CONTROL SYSTEM OF PASSENGER TRAFFIC AT THE AIRPORT USING THE SIMULATION

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Abstract

Purpose of research: For quality and smooth operation of the airport need coordinated work of a plurality of units and services, which in the case of problematic situations must quickly take measures to eliminate them. To improve the quality of work should take decisions on the development of an automated control system of passenger traffic to increase efficiency in the use of existing airport infrastructure and improve the quality of passenger service. The aim is to research effective methods of determining weaknesses in the real processing of passengers and implement a unified representation of the concept of automated passenger traffic management system based on the analysis of video information and using accurate simulation model of the airport. Airport system simulation can be viewed as a set of methods and tools for automating the process of development of specialized management system.

Results of research: Schematic diagram of the automated control system of passenger traffic in airport the was submitted and developed a specialized simulation model airport, which takes into account the actual numerical characteristics of passenger flow. Simulation model of the airport implemented using agent-based modeling in AnyLogic and the model includes all units of the terminal with the geometrical factors of the terminal.

Practical significance: Schematic diagram of the automated control system allows to solve the traffic passenger flow as operational tasks in the terminal and could solve problems of prediction work services, depending on the passenger flow, was the presented . The simulation model takes into account the characteristics of all essential elements of the airport affecting on passenger traffic. Special feature of this system is the combination of video work with the identification of passengers and data transfer numeric values in a software environment simulation model.

Keywords: Airport, intensity, modeling, transportation, queuing system, agent-based modeling, simulation

I. INTRODUCTION

Increase in the intensity of flights and seasonal peak loads at the airport, the need for efficient air traffic management, strict requirements for optimizing the structure and functions of the airport complex – is the main trends in modern airports [1–3, 5, 6]. Existing infrastructure with increasing passenger traffic may not be able to provide quality services for passengers and related logistics in peak mode and as a result, requires a significant investment for the reorganization and reconstruction of both the airport and the surrounding regions. Airports now become the basis of large multimodal hubs, parts of which are extremely difficult because of the huge amount of their constituent elements, the multiple links between them, and a complex organization. The research problem of the airport complex is relevant as today in the study of airports particularly urgent question is: how will operate all systems in the complex, depending on the load changes, how to change the passenger flow, if one of the services will move to a new mode of operation, or will introduce new or what would happen if the passenger traffic increase in times? The answers to these questions can only be using specialized automated systems that can be based on specialized simulation models, which in turn will be able to predict the operation of the airport and its services.

II. FEATURES OF DETERMINING THE NUMBER OF PASSENGERS IN THE AIRPORT TERMINALS

Airports designed to serve the departing and arriving passengers. Their main technical characteristic is capacity of terminal. Any failure causes a chain reaction in other services leading to the detention of flights. In the event of partial failure checking of certain airport services performed by attracting professional employee who makes measurements of time to process the passenger or luggage and after the analysis of the data suggests the causes of failures. In addition, to obtain objective and reliable information on the work of the study service facilities necessary to collect data simultaneously at several points in the survey, as the service works in close relationship and influence each other [1, 2, 5, 10, 11].

In practice, the airport study processes of passengers flow apply three basic ways to collect information [12, 13].

1. *Manual way*.

In manual mode the direct data collection carried out by fieldworkers transport. Data are collected during a certain time interval. At the end of the information from the worksheets specialist contributes to the control card. As a result of measurement in the control chart recorded data on the intensity of work, the service time of passengers or baggage, as well as on the distribution of passenger flows. These statistics should be introduced in automated software for further analysis.

2. *Semi-automatic*.

Semi-automatic method for collecting information is that the collection of information is carried out by special video equipment that allows you to take pictures, and processing the collected information is then performed manually. When this data is entered directly into the database, there is no step input certain data collected in the control map. Data collection for this method by using devices such as surveillance cameras (fig. 1). To collect information from all directions of movement inside the terminal using dome cameras.

Fig. 1. Example of dome camera

The disadvantages of such devices could be included that the location may not always be optimal for achieving this objective. The resulting video is processed by the operator PC using specialized software for accounting of passengers. Specialized software allows the operator to directly enter the number of passengers to carry with video recording and automatically populate the database survey intensity. Thus, the essential difference between the second methods of collecting data from the first is that the direct calculation of the intensity of passenger traffic flows is performed simultaneously with the input of information into the database. Such method allows obtaining more accurate information than the first.

3. *Automatic*.

In the third case is supposed to use automated software determines the number of passengers in the video information and apply the number directly into the database without going through the operator. In this case, there may be errors recognition exact number of passengers.

III. THE CONCEPT OF AUTOMATED CONTROL SYSTEM FOR PASSENGER TRAFFIC

Any airport in future faced with restrictions on further building its infrastructure, so you need to make decisions on the development of passenger traffic management system to increase efficiency in the use of existing space and improve the quality of passenger service. This problem could be solved by reducing the delay of passenger traffic. Established system of active control terminal which will provide an opportunity to control the flow of passengers at the airport. Control system terminal based on the measurement of the current passenger traffic flow and forecasting its changes. It is proposed to use all three methods to collect information. The central component of the methodology is forecasting simulation model of the terminal.

Schematic diagram, automated passenger traffic management system is shown on fig. 2. The model shows the passage of passengers to the airplane.

On fig. 2. П1 – service unit "1-st inspection" (check metal detector); П2 – service unit "Registration"; П3 – service unit "pre-flight inspection"; П4 – service unit "Departing passengers"; П5 – the service "Control landing", x (t) – the flow of passengers, Δt – delay the processing of the application, the delay in the processing of the passenger; Yi – numerical characteristics of passenger traffic.

The feature of this scheme is the simultaneous use of a simulation model of the terminal and automated analysis of a large amount of real work of video terminal. Based on the analysis of video information from the dome cameras are determined taking into account the numerical characteristics of passengers, their movements on the terminal and visually detected failures. But in this case the presence of a fault must be retained by the terminal agent. When the addition of such a scheme simulation model, and when transmission of the number of passengers in the simulation model, it is possible to solve the problem of prediction of failure in the system. In this case, the simulation model is to provide a high simulation accuracy, and ensure the highest performance of the system, which would allow for only a few minutes to get the forecast of passenger traffic for a few hours ahead [3, 4, 8, 9]. In addition, the system should take into account the specificities of all the essential elements of airport infrastructure affecting passenger traffic. For example: a large number of checkpoints, check-in counters, border controls, as well as many stairs and elevators. The movement pattern of passengers at Airport Terminal Pulkovo is shown in fig. 3. This is the basic foundation for the simulation model.

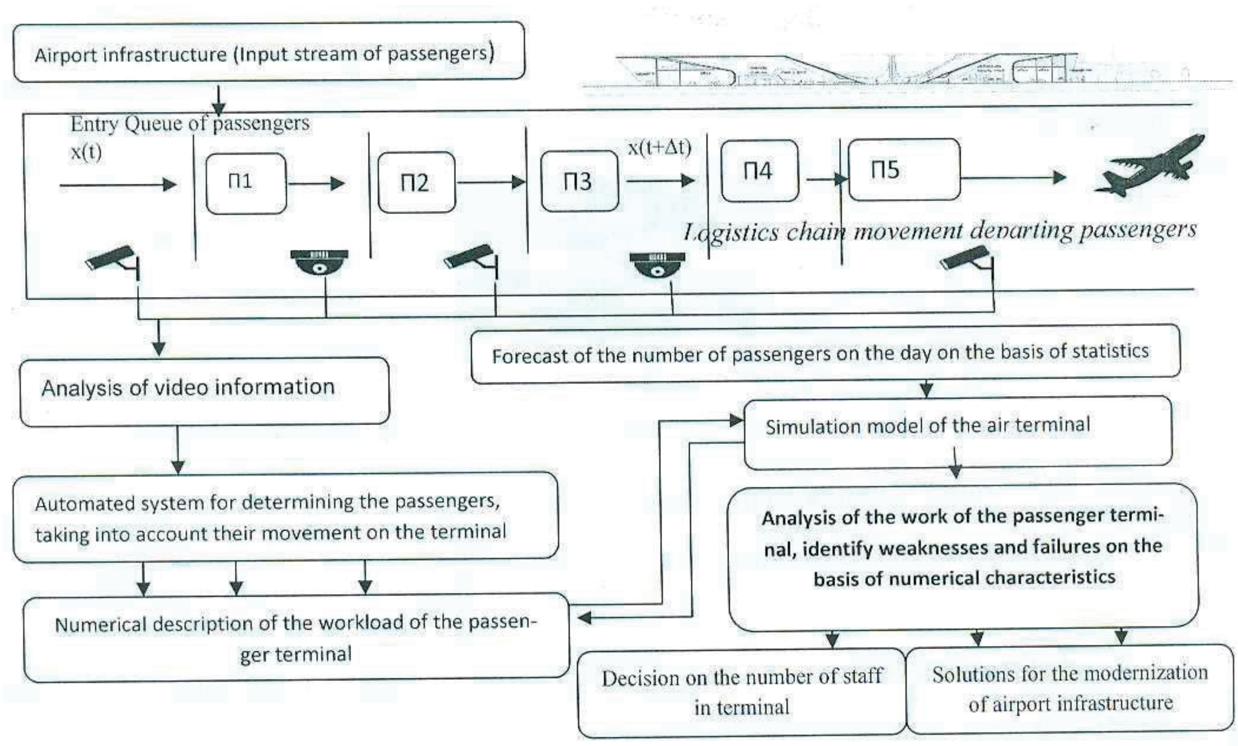

Fig. 2. Schematic diagram of the automated control system for passenger traffic, based on the analysis of video information and using the special simulation model

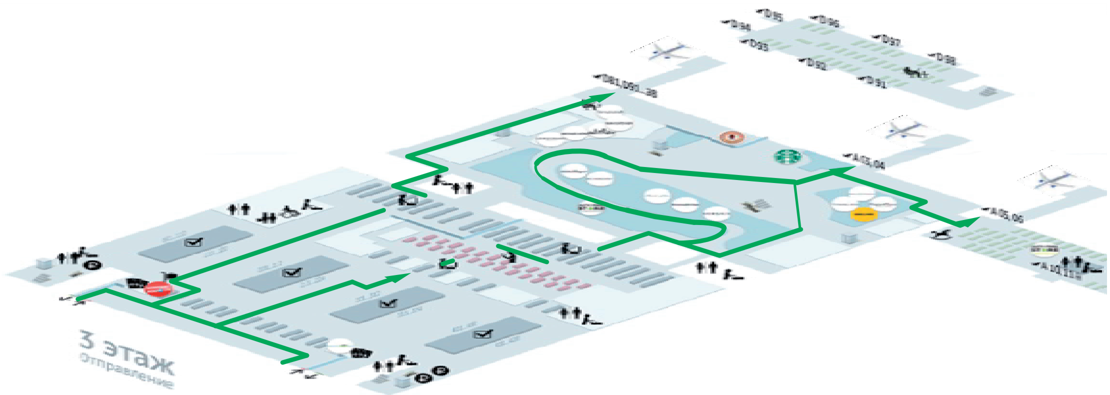

Fig. 3. Scheme of movement passengers on the 3-rd floor of the airport "Pulkovo" performing domestic or international flight

IV. PRACTICAL REALIZATION THE SIMULATION MODEL OF THE AIRPORT

The given fact that passengers have to go through a lot of places of service, it can be argued that the terminal is a multi-channel queuing system. In this system, the passenger should be treated as a request for service, and drives applications will be waiting rooms, where the service discipline must be maintained. When you create a simulation model is necessary to lay a choice of different laws of distribution [5, 6]. The throughput of the terminal as a probabilistic system, affects the intensity of each element of the service (service channel).

Total time passenger service [3] can be presented on a gross basis in the form of a linear sum of the variables:

$$T_{\text{passenger service}} = \sum_{i}^{N} t_i ,$$

where t_i – technological processing steps carriers, N – number of operations, t_1 – time to check at the entrance to the passenger terminal; t_2 – time to verify passenger's luggage when moving terminal; t_3 – time for inspection of passenger baggage at the entrance to the operating room; t_4 – time to receive and verify the reception of the passport of the passenger and luggage; t_5 – time to set/read data on a computer ticket passengers; t_6 – time to peel a receipt for hand luggage and luggage; t_7 – time installing luggage on a conveyor belt; t_8 – time consolidation of the coupon on the handle of the luggage; t_9 – time waiting for passport control; t_{10} – at passport control; t_{11} – time spent on rescreening of passengers and carry-on baggage; t_{12} – the time while waiting for permission to land in the plane; t_{13} – time it takes to receive your boarding pass; t_{14} – time to takes to pass through the passenger boarding bridge or board the bus sent to the aircraft. The most problematic areas in airport, where there are often queues, based on consideration of the supply chain are as follows [5, 8, 9]:

– the input control flow of passengers and luggage;
– the reception of passengers and luggage;
– place preflight inspection of passengers and carry-on baggage;
– lounges passengers;
– stand issuing boarding passes;
– stand customs control;
– free trade zones.

One of the main elements of the interaction with the employees airport passengers are reception, which checks the ticket and passport details, luggage and carry-on baggage. On the other hand, the capacity of the terminal depends on the movement of aircraft, aircraft size, free or busy passenger apron, weather conditions and other factors [9, 10]. To implement this portion of the simulation model is introduced in the schedule of aircraft movements over a given time interval.

The intensity of the filling of aircraft passenger traffic can be represented in the form of mathematical model:

$$M[Q]_{air} = \sum_{i=1}^{m} \lambda_i M[Q_i] f_m,$$

where λ_i – traffic of passengers in the aircraft; m – number of aircraft; f_m – frequency of approach of the aircraft to the platform; $M[Q_i]$ – the expectation of the number of passengers that fills a certain aircraft.

Expression of total passenger traffic through the airport terminal can be calculated

$$M[Q]_{air} =$$

$$= \sum_{i=1}^{m} (\sum_{i-1}^{k} \sum_{r=1}^{ni} n_{ir})(\frac{3600Knn}{M[Tserv]}) M (\sum_{i=1}^{k} \sum_{j=1}^{lj} n_{ij}) f_m,$$

where f_m – frequency of approach of the aircraft to the platform; *M[Tserv]* - the average time of duration of service per passenger; *Knn* – load factor stands at passenger service, *m* – number of aircraft; *k* – number of groups of different directions rack send passengers; n_i – number of columns of the *i*-th direction departing passengers; n_{ir} – passenger service of the *i*-th direction of traffic flow; n_{ij} – the number of passengers the *j*-th direction of the *i*-th carriage of passengers; *k* –passenger traffic shaping overall passenger traffic; l_j – general number of separate areas of transportation the *i*-th passenger.

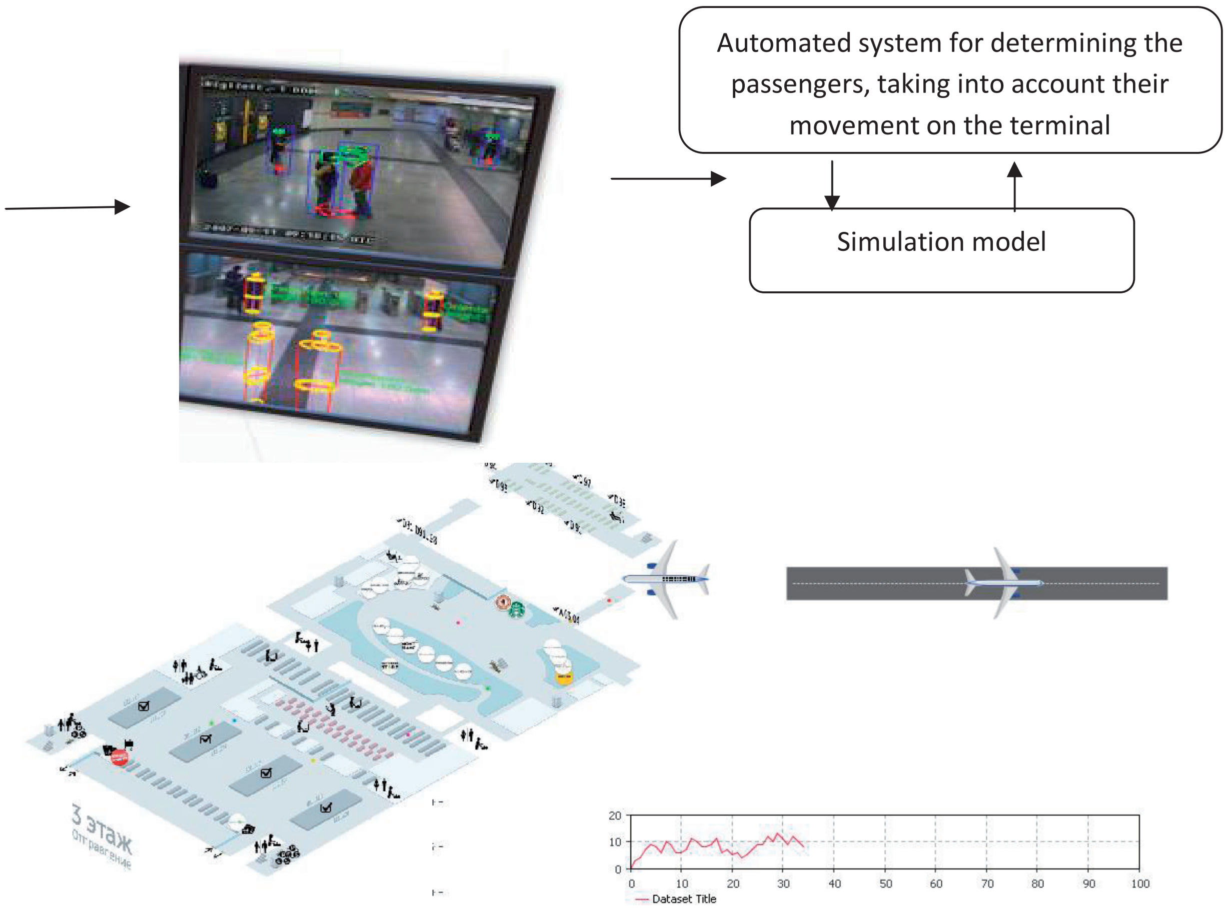

Fig. 4. Window form simulation model to obtain statistics on the number of vessels in the intensity and passenger flows inside the terminal

The agent-based modeling was made as mechanism for simulation. Practical implementation of the simulation model was chosen software Any-Logic [7]. Agent-based modeling is just a tool, using which it is possible the successful simulation of complex adaptive systems, which can be attributed to the airport. Agent-based modeling allows to simulate not aggregate system components, such as, for example, it makes the system dynamics [7] with the flow system and storage, but instead is based on the idea of modeling the processes of "bottom-up" approach: a model based on a set of basic elements of interaction which is born the general behavior of the system. "Emerging" behavior (in this case the airport) is the result of interaction of the elements of the system. Accordingly, in the framework of this modeling approach is necessary to correctly display the mechanism of behavior and interaction of the elements of the system – "agents". Agents, in this case, are the passengers going to land the aircraft. On the scheme of one floor of a new airport terminal was based. The fig. 4 displayed window form of the one module simulation model of the movement of passengers inside the terminal based on the location of the airport and the window shape of your camcorder to recognize number passengers.

As a result of this simulation model, based on real data obtained parameters such as statistics serviced passenger traffic, congestion as individual units, and the entire airport and several others needed to optimize performance. The simulation should run a certain number of times per day, at the same time will generate a large amount of data that must be analyzed by software solve problems and tasks for forecast for any time interval.

V. CONCLUSION

With the implementation of automated control system of passenger traffic at the airport with the simulation and identification of passengers on the basis of the video information from the cameras at times improves the quality of work and in practice we can to solve the problem of optimization of passenger traffic. The mathematical model and the agent-based modeling method allowed to realize accurate simulation model works airport. The simulation model of traffic at airports differs many advantages, among which are:

– easy to use with agent-based simulation;

– visualization tools, allowing to visualize passenger processes at the terminal;

– ability to support a hierarchy of models, ranging from single operations to the airport complex as whole terminal;

– possibility of introducing in the model of random factors (equipment failure rate, service time, deviations in the schedule, etc.);

– analysis tools intensive passenger traffic, that allowing you to quickly identify the system bottleneck and take steps to eliminate it;

– universal instruments to optimize the parameters and schedules.

Develop such system will improve the safety of the transport of the object, due to the continuous analysis of video information and will be operational decision management tasks and forecast passenger processes at the airport.

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RESEARCH OF METHODS OF ADAPTIVE FILTERING OF NARROWBAND INTERFERENCE IN SPEECH PROCESSING SYSTEM

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Abstracts

This article compares the classic approach and the new adaptive filtering of narrowband interference in systems of speech signal processing. We investigated four methods of adaptive filtering. The good quality of the new approach is the lack of requirements of the reference signal. The results of the comparison showed that the efficacy is comparable with the classical method.

I. INTRODUCTION

Speech signals, which have to deal with in practice, always more or some extent noisy. In cases where the intensity of the noise is significant, its presence can significantly distort the results of the processing, analysis or recognition of the speech signal. To date, developed a lot of different methods of digital processing of speech signal.

II. THEORETICAL INFORMATION

The basis of most of the algorithms of speech signal processing [3], the idea of adaptation, the essence of which is the use of current information about the signal to automatically adjust its mode of treatment. Such methods are a class of adaptive interference canceller. The classic version of the block diagram of the adaptive interference canceller is shown in fig. 1.

This class of methods for processing a noisy digital signals based on the use, the actual noisy signal which is to be filtered, and the one or more reference signals – signals which are correlated with the noise signal and uncorrelated (or weakly correlated) with the useful signal to be extracted. This signal is then subtracted from the noisy signal and the result of this operation is considered as an estimate not noisy signal. Adaptive interference canceller well enough to improve the quality of noisy signals, but the requirement for the reference signal is a disadvantage, significantly narrowing the scope of this method as an explicit reference signal often not available. In many cases, the reference signal can be received by using the information about the characteristics of the interference directly from the mixture signal interference.

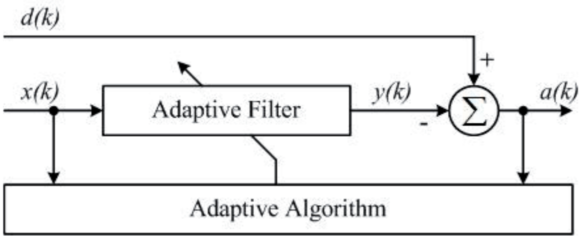

Fig. 1. Adaptive interference canceller ($x(k)$ – input signal, $d(k)$ – reference signal, $y(k)$ – output signal, $a(k)=d(k)–y(k)$ – error signal, k – index of discrete time signal to be processed)

Fig. 2 shows the proposed scheme of adaptive filtering a noisy speech signal, does not require a reference signal, in contrast to the classical adaptive interference canceller (fig. 1).

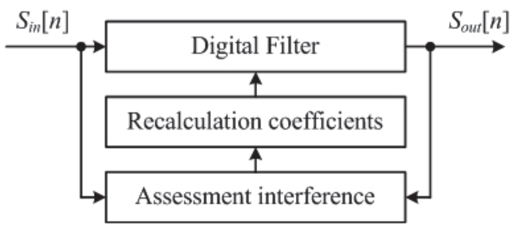

Fig. 2. Adaptive filtering scheme ($S_{in}[n]$ – input signal, $S_{out}[n]$ – output signal)

An input signal representing a mixture of the desired signal and interference is input to the blocks «digital filter» and the « assessment interference». Based on the result of the algorithm assessment the interference occurs and stored digital filter coefficients, in turn, the digital filter processes the input signal.

III. TYPES OF INTERFERENCE FOR THE SELECTED RESEARCH

In this article we consider a class of narrowband interference defined by mathematical formulas:

1. Harmonic interference (HI):

$$d[n] = A_d sin(2\pi F_d nT_\Delta), \quad (1)$$

where n – index of discrete time signal to be processed $n=0, 1, ..., N-1$.

2. Harmonic interference with frequency varies jump wise (HIVJ):

$$d[n] = \begin{cases} A_d sin(2\pi F1_d nT_\Delta), n<\frac{N}{2} \\ 2A_d sin(2\pi F2_d nT_\Delta), n\geq\frac{N}{2} \end{cases} \quad (2)$$

3. Polyharmonic interference (PI):

$$d[n] = A_d sin(2\pi F1_d nT_\Delta) + +A_d sin(2\pi F2_d nT_\Delta) \quad (3)$$

Fig. 3 is a view of the implementation of the species interference.

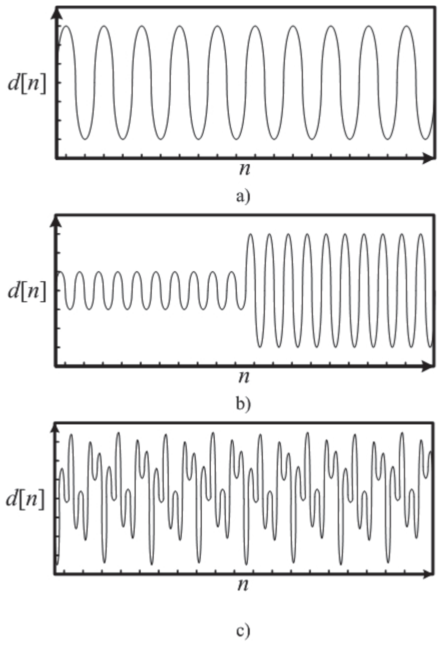

Fig. 3. View realization interference
(a – HI, b – HIVJ, c –PI)

IV. ALGORITHM FOR ASSESSMENT INTERFERENCE

For the evaluation of the frequency of the interference is advisable to use a fast Fourier transform, as it allows to evaluate the relative distribution of the amplitudes of the various harmonic components of the signal. The algorithm is based the fact that, if the signal is valid intense harmonic interference on the same frequency, in an array of samples of the amplitude spectrum is expected to peak at this frequency. In the case of harmonic noise somewhat, it seems likely that there will be maximum values at the corresponding frequencies in the amplitude spectrum.

A mathematical model of the signal $S_{in}[n]$ is represented as an additive mixture of "clean" speech signal $S[n]$, and $d[n]$, harmonic or polyharmonic interference interval $n=0, 1, ..., N-1$, where N – the length of the signal.

$$S_{in}[n] = S[n] + d[n] \quad (4)$$

To account for possible changes in the nature of the interference in time the algorithm is performed in a sliding window: the input signal is split into a number of windows of length M samples, each window mathematical transformations performed, resulting in the array of samples by computing the spectral fast Fourier transform (FFT):

$$SP[k] = \sum_{n=0}^{M-1} S_{in}[n] exp\left(-j\frac{2\pi}{M}nk\right), \quad (5)$$

where $k=0, 1, ..., N-1$.

The resulting array of samples of the spectrum $SP[k]$ is searched for the maximum modulus values and as a result the formation of the index assessment the frequency at which the interference acting:

$$k_{interference} = \arg_k(max(|SP[k]|)) \quad (6)$$

If necessary, several estimation frequency according to the method, the identification number is made by the largest magnitude values of $|SP[k]|$, using the decision rule (6). Illustration of the algorithm estimating interference is shown in fig. 4.

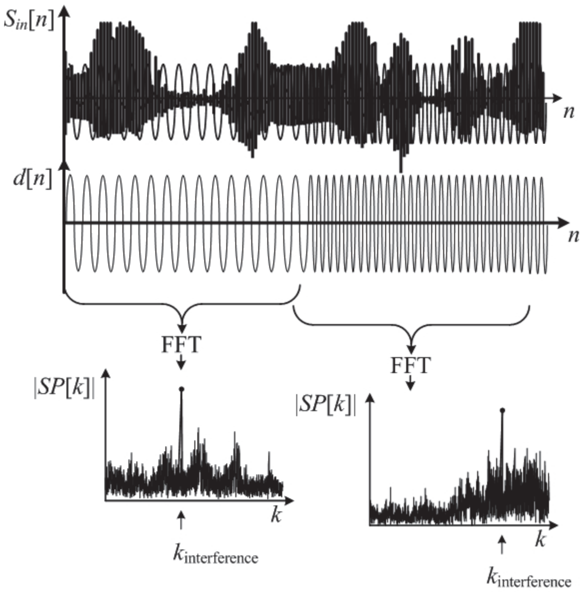

Fig. 4. Illustration of the algorithm assessment interference

V. METHODS OF ADAPTIVE NOISE FILTERING

In this article presents the results of research of four methods for adaptive noise filtering:

1. Classic adaptive notch filter (CANF) [3] (fig. 1).

2. Adaptive filter (AF) based on the amplitude spectral subtraction algorithm (ASSA) [4]. The idea of constructing a filter is to calculate the spectrum of the signal for each position of the window with a direct Fourier transform. The spectrum signal is multiplied by the transfer function of the notch filter and the result of this product is taken inverse Fourier transform. In this approach, processing is performed on the basis of the overlap with the accumulation.

3. Adaptive notch IIR-filter (ANIIRF). The idea is to design the digital notch filter using the generalized method of the bilinear z-transform of the transfer function of the analog low pass prototype filter may be obtained by the transfer function of a digital notch filter:

$$H(z) = \frac{B_0 + B_1 z^{-1} + ... + B_q z^{-q}}{1 + A_1 z^{-1} + ... + A_p z^{-p}}, \quad (7)$$

where *H(z)* – the transfer function of the digital notch filter; $B_0, B_1, \ldots, B_q, A_1, \ldots, A_p$ – filter coefficients, which are used to construct the difference equation IIR filter:

$$S_{out}[m] = \sum_{i=0}^{q} \left(\frac{B_i}{A_0} \right) S_{in}[m-i] - \sum_{i=1}^{p} \left(\frac{A_j}{A_0} \right) S_{out}[m-j], \quad (8)$$

where $m=4, 5, ..., N-1$. The filter coefficients are updated each time in accordance with the operation noise estimation algorithm.

4. Adaptive notch FIR-filter (ANFIRF). The idea of constructing a notch FIR filter is to use a standard methodology for designing FIR filter frequency sampling method. An array of filter coefficients used for the difference equation FIR filter:

$$S_{out}[m] = \sum_{i=0}^{q} C_i S_{in}[m-i], \quad (9)$$

where $m=0, 1, ..., N-1$. An array of filter coefficients C_i, updated every time in accordance with the operation noise estimation algorithm.

VI. METHODS OF RESEARCH ON THE EFFECTIVENESS OF ADAPTIVE FILTERS

The research of adaptive noise filtering systems for processing speech signals produced by methods of mathematical modeling. The main objective is to compare the proposed processing algorithms, with a classic version of the adaptive filter.

Indicators of quality of treatment depend strongly on the signal-to-noise ratio (SNR):

$$q = \frac{\sigma_s}{A_d}, \quad (10)$$

where q – SNR, A_d – the amplitude of the interference, σ_s – the value of the standard deviation:

$$\sigma_s = \sqrt{\frac{1}{N} \sum_{i=0}^{N-1} \left(S[i] - \frac{1}{N} \sum_{j=0}^{N-1} S[j] \right)^2}. \quad (11)$$

The main objective of the work is to model algorithms for different types of noise and different values of the signal-to-noise ratio. To formulate the conclusion that the practical effectiveness of research methods of filtration, it is advisable to carry out their testing on any real signal and build a family of curves describing the dependence of the mean square error filtering of the signal/noise ratio for various types of interference. Mean square error filtering is an objective quantitative criterion:

$$E = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} \left(S[k] - S_{out}[k] \right)^2} \quad (12)$$

VII. RESULTS OF RESEARCH

To test the noise estimation algorithm proposed real impediment to the speech signal of each kind. Fig. 5 shows the graphs with the results of the proposed estimation algorithm interference.

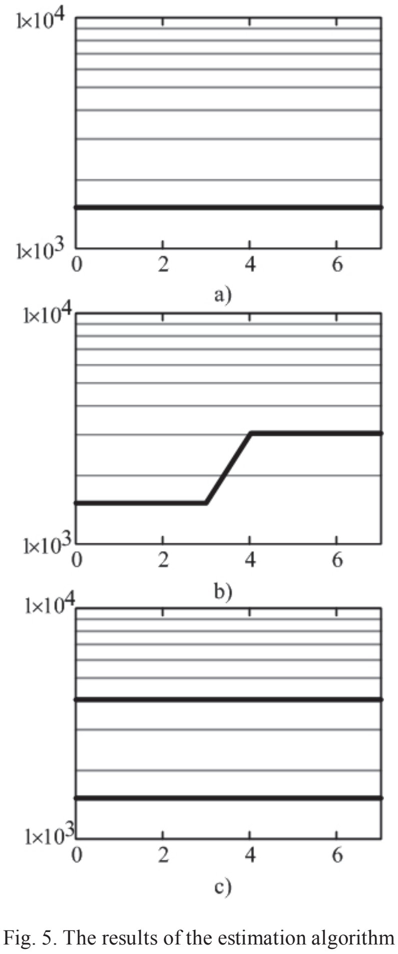

Fig. 5. The results of the estimation algorithm examined types of interference (a – HI F_d= 1,5 kHz, b – HIVJ $F1_d$= 1,5 kHz, $F2_d$= 3 kHz, c – PI $F1_d$=1,5 kHz, $F2_d$= 4 kHz).

In fig. 5 shows that the algorithm specifies the frequency at which the interference signal acting.

Of the four adaptive filtering algorithms, which have been investigated, only the classical adaptive notch filter and an adaptive notch FIR filter results showed that in the future it makes sense to analyze and compare with each other. Fig. 6 shows a family of curves mean square error for different noise reduction signal-to-noise ratio.

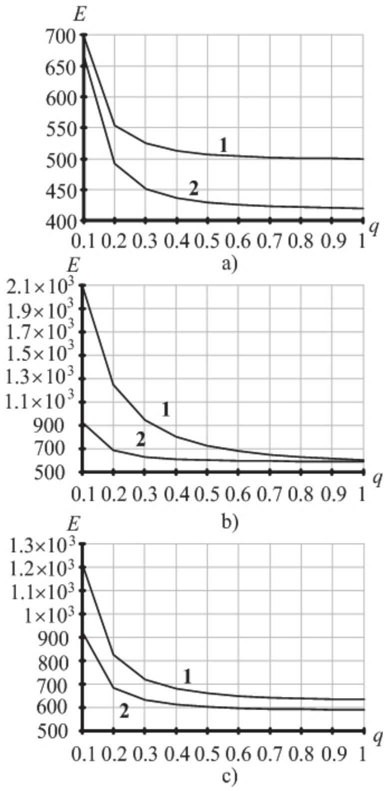

Fig. 6. Family of curves mean square error for different noise filtering: a – HI, b –HIVJ, в – PI (1 –ANFIRF, 2 – CANF)

Family of curves shown in fig. 6, allow us to conclude on the effectiveness of the algorithms rely on quantitative evaluation criteria, but there is also a quality criterion. Qualitative evaluation of noise reduction is listening and comparing the original "clean" speech signal and the filtered speech signal. This assessment, of course, is subjective. Table 1 shows the results of comparing the effectiveness of the algorithms. The efficiency of the algorithm is expressed on a scale from 1 to 4, the efficiency decreases with the increase. A quantitative estimation of efficiency, and (in parentheses), a qualitative assessment.

Table 1

Research methods	Types of interference		
	HI	HIVJ	PI
CANF	1(2)	1(2)	1(2)
AF based on the ASSA	2(4)	2(4)	2(4)
ANIIRF	3(3)	3(3)	3(3)
ANFIRF	2(1)	1(1)	1(1)

According to Table 1 shows that quality is the most efficient algorithm for adaptive FIR notch filter. To quantify, classical adaptive notch filter and an adaptive FIR notch filter about equally effective (fig. 6).

VIII. CONCLUSION

As a result, the task was quantitatively and qualitatively evaluate the results of algorithms of adaptive narrowband interference suppression for speech signal processing systems. Given informative illustrations of practical application of algorithms. Adaptive interference canceller quantitative criteria to cope better with treatment than those offered as an alternative to adaptive processing algorithms. But despite this, the developed adaptive processing algorithms do not require a reference signal, as required by the classical algorithm of adaptive interference canceller; interference characteristics assessed directly by signal processing the mixture signal interference. According to the analysis of the benefits and results of the qualitative and quantitative assessment filtering algorithms, a final conclusion: developed adaptive FIR notch filter is an excellent alternative to the classical method of adaptive suppression of narrowband interference.

In general, the development of software based on the use of adaptive filtering of narrowband interference, it is desirable to implement filtering using a variety of different algorithms for adaptive noise cancellation. Such an approach would provide a more effective solution to the problem of adaptive filtering of narrowband interference in the processing of speech signals.

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UWB PULSE SIGNAL DETECTION METHODS

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Abstract

UWB pulse of duration 1-2 ns detection methods are considered in the given work. The UWB signal receiver and detector flowcharts targeted for short pulse processing are proposed supplemented with accompanying probability calculation algorithms. In conclusion the math model and detection probability plots are presented.

I. INTRODUCTION

The performance improvement of radio equipment is a relevant problem in the current conditions. One of the possible solutions to that problem could be the study of brand new types of information carrying signals. In the papers [1, 2] the detailed description of nanosecond and sub-nanosecond ultra wide band (UWB) pulses is given. These signals can be utilized in order to improve the interference immunity, electromagnetic compatibility, communication security etc.

In the recent years UWB signals were successfully implemented in such fields of applications as:

- communication – the high speed UWB data transmission devices for indoor and outdoor communication [3];
- radiolocation – radars utilizing UWB technology can detect objects hidden behind the solid barrier such as concrete wall or soil thereby realizing the through-wall imaging feature [4];
- positioning – UWB technology can provide very fine positioning possibility due to short duration of pulse [5, 6].

The listed fields of application are very comprehensive, whereas in the current work the consideration is given to the particular problem of UWB pulse train detection. The UWB signals detection issues and detection probability calculation algorithms are discussed, as the denoted problems are essential when it comes to practical realization of UWB system referred to any of the abovementioned fields of application.

II. UWB PULSE RECEIVER FLOWCHART

The flowchart of the proposed receiver is given in fig 1. The receiver structure is based on a plain idea: the short pulse has wide spectrum. The frequency domain statistical correlation method is proposed in [7]. The received signal is splitted in several narrow bands and in case when the energy level increases simultaneously in every band of interest the UWB signal is considered to be detected.

The receiver consists of several identical channels. Each channel comprises a bandpass filter, amplitude detector, analog comparator, counter, 1st digital comparator, adder and 2nd digital comparator. The channels differ with central frequencies $f_1, f_2, f_3, \ldots, f_m$ of bandpass filters. As the filter bandwidths are chosen equal, the noise powers are considered to be equal in each channel as well. Current system is investigated in no interference conditions. In practice the automatic gain control (AGC) circuit could help to neutralize any interference.

The abovementioned method is not optimal. As shown in [8] the most optimal method in that case is signal accumulation without frequency processing, but the task of accumulation of nanosecond pulses requires very expensive sophisticated electronic equipment, whereas proposed structure could be implemented with standard performance and widespread analog and digital integrated circuits. Indeed the amplitude detector output could be captured with an analog comparator or ADC of a moderate speed. This feature allows to simplify the structure of detector as well as make it rather cost-effective.

While using ADC after amplitude detector, further signal processing might consist in “accumulating and voting” technique implementing the mathematical “k of n” criterion , but it is shown in [6] that in such kind of algorithms ADC gives just 1,5–2,0 dB of additional sound to noise ratio (SNR) versus binary quantizing using a comparator. Thereby “k of n” criterion seems to be rather effective in current application. Moreover, it is also suitable for inter-channel signal processing in the proposed system as well.

The mathematical modeling results are presented in fig. 2. Fig 2a depicts the original 1 ns duration pulses. Fig. 2b depicts the bandpass filter output and 2c depicts the amplitude detector output.

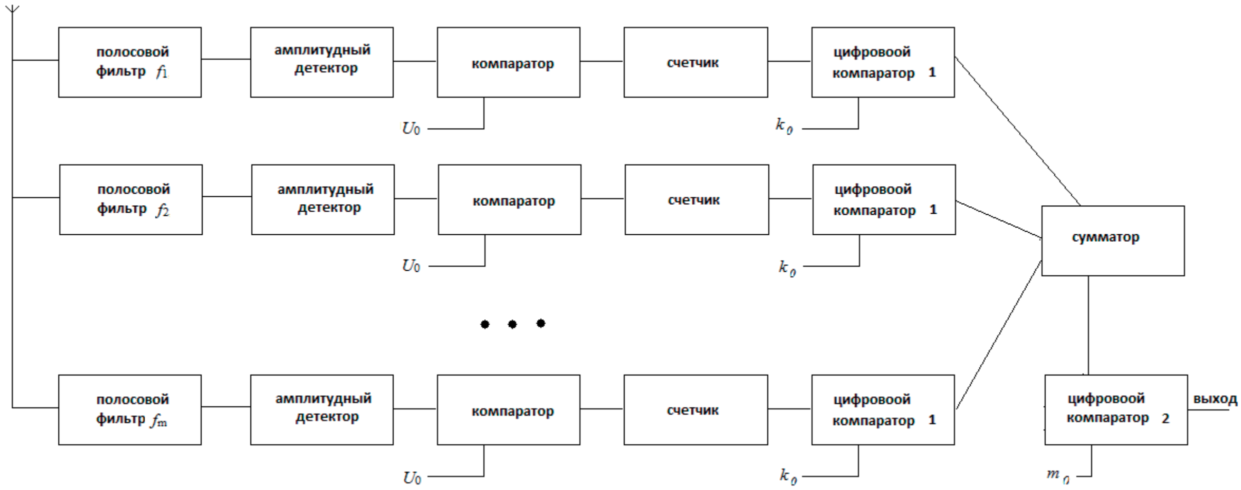


Fig. 1. Receiver flowchart

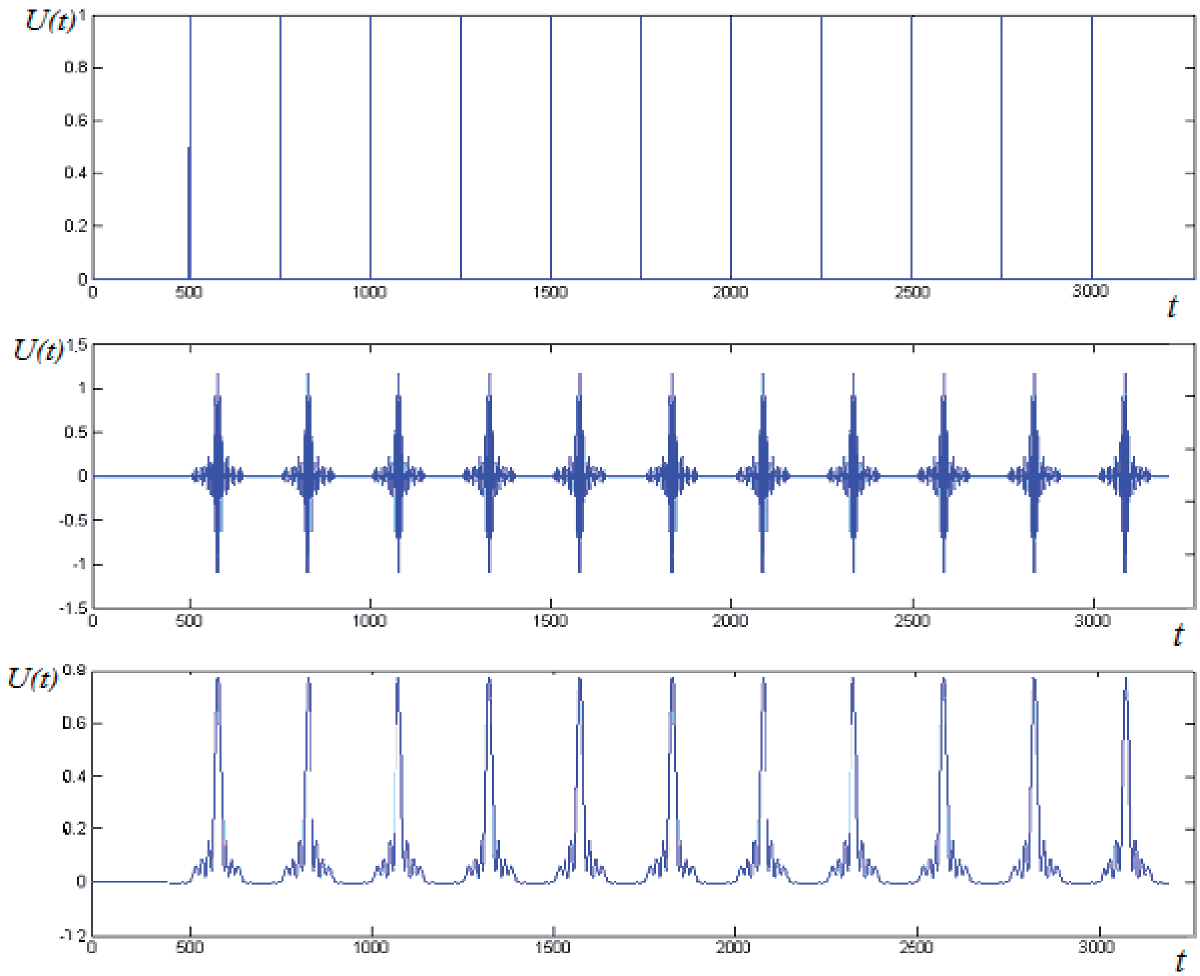


Fig. 2. Modeling with ideal conditions

Fig. 3a depicts the original nanosecond pulses with the additive white noise. 3b presents the amplitude detector output in conditions of additive signal and noise mix on the receiver input. It is clear that the received pulse amplitude is fluctuating. Analog comparator with a properly set threshold could equalize the pulses. Referring to the flowchart in fig. 1, one could investigate further signal processing algorithm. After comparator the binary pulse train is fed into the count input of the binary counter. The number of counted pulses is then applied to the digital comparator input. Its threshold is set to k. In other words, if "k" or more pulses are received, the digital comparator forms a 1 on its output, otherwise it forms 0. That digit is considered further as a channel output. On the next stage the outputs of all channels are summed and the result number is fed to a second digital comparator. Once again the "k of n" criterion is applied (m is a threshold in this case) and the system forms a binary output: 1 – the signal is most likely present, 0 – there is no signal detected.

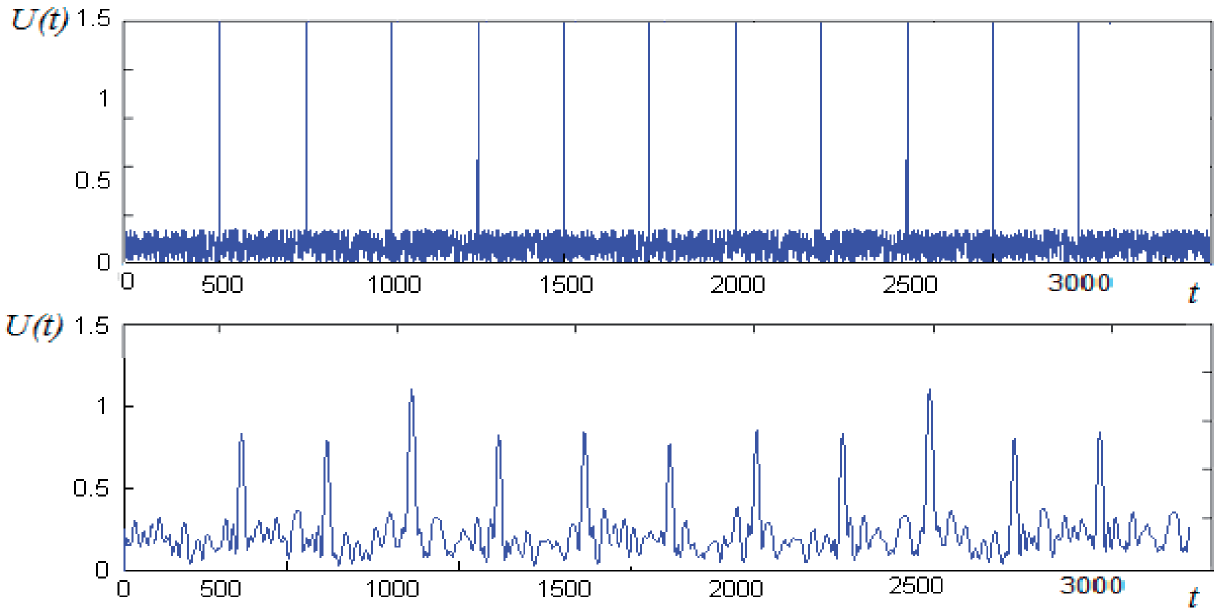


Fig. 3. Modeling with conditions of white additive noise

III. THE PROBABILITIES OF DETECTION AND FALSE ALARM CALCULATION

In order to describe the receiver system mathematically one should calculate the probabilities of detection P and false alarm F. In order to calculate the probabilities the "k of n" criterion was used, regarding the system frequency domain response.

So the pulse train of n pulses is supposed to be detected. The proposed receiver comprises m frequency channels. The traditional calculating methods imply the known white noise spectral density N and amplitude A_s. probability density function.

While calculating the filter bandwidth Δf is considered equal for each channel and therefore the noise powers in each channel will be equal to $\sigma_n^2 = N\Delta f$.

For the given model the probability distribution of noise after amplitude detector is described with the following equation [6]

$$f_n(U) = \frac{U}{\sigma_n^2} \cdot e^{-\frac{U^2}{2\sigma_n^2}}, U \geq 0. \quad (1)$$

As a consequence of (1) the probability of false alarm P_n in analog comparator is described with equation

$$P_n = \int_{U_0}^{\infty} f_n(U) \cdot dU = \int_{U_0}^{\infty} \frac{U}{\sigma_n^2} \cdot e^{-\frac{U^2}{2\sigma_n^2}} dU = e^{-\frac{U_0^2}{2\sigma_n^2}}, \quad (2)$$

where U_0 –analog comparator threshold.

In conditions of signal receiving the signal and noise additive mix with a probability distribution $f_{s+n}(U)$ is applied to the amplitude detector input. It is calculated via the convolution integral of the corresponding probability distributions. So the probability of true detection P_s in analog comparator with a signal and noise additive mix on its input is

$$P_s = \int_{U_0}^{\infty} f_{s+n}(U) \cdot dU. \quad (3)$$

The probability distributions of noise and signal and noise additive mix after amplitude detector are given in the fig. 4 Probabilities P_n and P_s pare equal to the areas beneath the corresponding curves, while $P_n < P_s$.

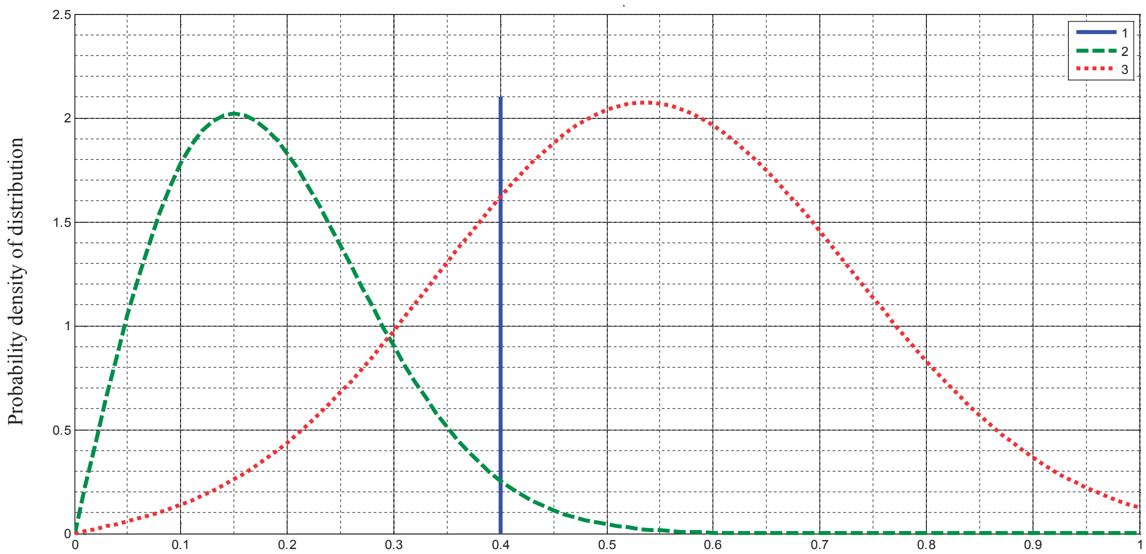


Fig. 4. The random value of the amplitude of the signal after detection
1 – analog comparator threshold, 2 – noise probability distribution, 3 – signal and noise probability distribution

A math model of signal of interest is often described as stable nonfluctuating amplitude A_s pulse train or noise-like with a RMS amplitudes σ_s . The corresponding distributions are given as follows for nonfluctuating pulse train

$$f_{s+n}(U)=\frac{U}{\sigma_n^2}\cdot e^{\frac{-(U^2+A_s^2)}{2\sigma_n^2}}\cdot I_0(\frac{UA_s}{\sigma_n^2}),\quad (4)$$

where $I_0(\frac{UA_s}{\sigma_n^2})$ is a Bessel function; and for noise-like pulse train

$$f_{s+n}(U)=\frac{U}{\sigma_n^2+\sigma_s^2}\cdot e^{-\frac{U^2}{2(\sigma_n^2+\sigma_s^2)}}.\quad (5)$$

For (4) the P_s is calculated via equation (3), and for (5) it easy to derive the equation for P_s

$$P_s=\int_{U_0}^{\infty} f_{s+n}(U)dU=\int_{U_0}^{\infty}\frac{U}{\sigma_n^2+\sigma_s^2}\cdot e^{-\frac{U^2}{2(1+\rho^2)}}dU=e^{-\frac{U_0^2}{2(\sigma_n^2+\sigma_s^2)}}\quad (6)$$

The false alarm probability P_n^* for each channel is calculated

$$P_n^*=\sum_{l=n_0}^{n} C_n^l P_n^l(1-P_n)^{n-l},\quad (7)$$

where $n_0=E(1.5\sqrt{n}+0.5)$ is empiric value for the digital comparator threshold [6], $E(.)$ – Antier function. The same equation is then derived for P_s^* of each detector

$$P_s^*=\sum_{l=n_0}^{n} C_n^l P_s^l(1-P_s)^{k-l}.\quad (8)$$

The false alarm probability F for the whole system is calculated via (7) replacing P_n with P_n^*, n with m and threshold n_0 with

$$m_0=E(1.5\sqrt{m}+0.5)$$

$$F=\sum_{l=m_0}^{m} C_m^l P_n^{*l}(1-P_n^*)^{m-l}.\quad (9)$$

Replacing in (9) P_c with P_s^*, the detection probability of the system is derived

$$P=\sum_{l=m_0}^{m} C_m^l P_s^{*l}(1-P_s^*)^{m-l}.\quad (10)$$

Plots fig. 5and fig.6 depict detection characteristics of nonfluctuating (4) and noise-like (5) signals calculated via (10) in dependence of SNR and for given F of 10^{-3}, 10^{-5}, 10^{-7}, 10^{-9}, relatively.

The equations (2-10) allow to calculate detection characteristics of UWB signals, received and processed in the proposed on the fig. 1 system, which is in fact the digital modification of the proposed in [7] schematic. However the proposed in the given work digital schematic allows to change the processing sequence.

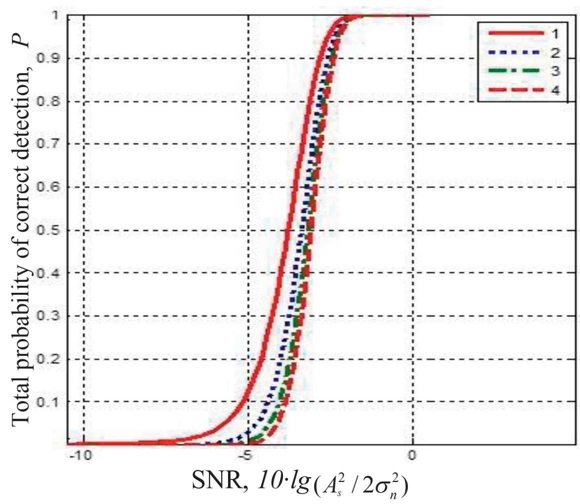
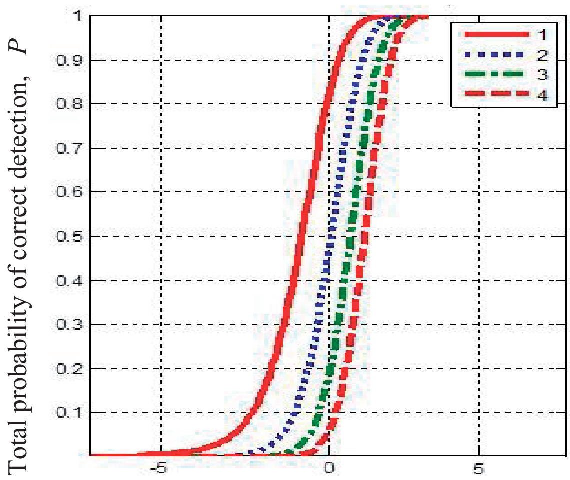


Fig. 5. Probability plot of correct detection of the SNR on a scale of $10\cdot lg(A_s^2/2\sigma_n^2)$



SNR, $10{\cdot}lg\,(\sigma_s^2/\sigma_n^2)$

Fig. 6. Probability plot of correct detection of the SNR on a scale of $10{\cdot}lg\,(\sigma_s^2/\sigma_n^2)$

Relatively to the fig. 1 sequence of digital processing can be altered – first the number of analog comparator threshold excesses in each channel is counted, while receiving one pulse, then the pulse train accumulation is performed. Additionally the altered approach will require less hardware resources.

While counting the probabilities for the altered algorithm, the equations (2)-(6) remain unchanged, whereas the false alarm probability $P_n^{'}$ for one pulse detection in several frequency channels is described with equation

$$P_n^{'} = \sum_{l=m_0}^{m} C_n^l P_n^l (1-P_n)^{m-l}\,, \qquad (11)$$

where $m_0 = E(1.5\sqrt{m}+0.5)$, $E(.)$ – Antier function. The true detection probability $P_s^{'}$ of one pulse is given as follows

$$P_s^{'} = \sum_{l=m_0}^{m} C_m^l P_s^l (1-P_s)^{m-l} \qquad (12)$$

The whole receiver false alarm F is calculated

$$P = \sum_{l=n_0}^{n} C_n^l P_s^{'l} (1-P_s^{'})^{n-l}\,, \qquad (13)$$

where $n_0 = E(1.5\sqrt{n}+0.5)$, $E(.)$– Antier function. The true signal detection probability P of the whole altered receiver algorithm is given as follows

$$P = \sum_{l=n_0}^{n} C_n^l P_s^{'l} (1-P_s^{'})^{n-l}\,. \qquad (14)$$

In case when $m=n$ both algorithms show the same performance. When $m<n$ x according to (14) and (10) the altered algorithm has better performance relatively to the algorithm proposed in fig. 1. Whereas $m>n$, the altered algorithm shows less performance. Therefore not taking into account technological drawbacks, the proposed on fig. 1 algorithm gives better performance when the number of channels exceeds the number of pulses in pulse train. On the other hand, when the number of pulses exceed the number of channels, the better performance shows the altered algorithm, additionally significantly saving hardware resources.

IV. CONCLUSIONS

The UWB receiver-detector flowchart was proposed containing m frequency channels, each utilizing a criterion *«n_0 of n»* while detecting a train of n UWB pulses. The decision of true signal detection is made according to the criterion *«m_0 of m»* in each of frequency channels. The equations, allowing to calculate the characteristics of the receiver-detector and calculated curves of detection for some special cases are given. Operation of detection *«n_0 of n»* and *«m_0 of m»* is implemented as a physical layout and as a mathematical model. The mathematical modeling of the results is performed in the form of voltage signals diagrams explaining the operation of the detector.

Detecting operation *«n_0 of n»* and *«m_0 of m»* in the proposed scheme can be rearranged. The modification of the receiver-detector operating algorithm *«m_0 of m»* and then *«n_0 of n»*, i.e. at first one pulse processing is performed in all frequency channels and then accumulation and detection of the pulse train. The calculated equations for such a modification of a receiver-detector are given. As follows from calculations that when the *m* number of frequency channels exceeding the number of pulses in a received burst, the algorithm should be used *«n_0 of n»* and *«m_0 of m»*, and in case when the number of frequency channels is less than the number of pulses in a train $m<n$, preferably criterion *«m_0 of m»* and *«n_0 of n»*. In case of equality $m = n$ the characteristics of both detection algorithms are equivalent.

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THE CHOICE OF THE BASIC PARAMETERS AND THE CALCULATION RANGE OF THE RADAR CONTROL UNAUTHORIZED ACCESS TO THE AIRFIELD

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I. INTRODUCTION

The paper considers the problem of constructing a radar control unauthorized access (RCUV) to the airfield in all weather conditions. The objects are considered aircraft, vehicles and people. This must be the primary radar and do not require any additional hardware on the aircraft and airport vehicles, except radio communication equipment. This provides control of the movement of objects on the tarmac in the fog and rain, and the potential to recognize and classify objects. The most similar characteristics to the RCUV has airfield control radar (ACR), installed at major international airports.

II. TACTICAL-TECHNICAL REQUIREMENTS FOR ACR

The main characteristics of the ACR

Name specifications	Value
The maximum range of a ground plane, m	5000
The minimum range to the ground plane, not more than, m	90
The viewing angle in the horizontal plane, degree	360^0
The resolution of the circular scan mode : - by range, m - by azimuth, degree	 15 15
Update period, sec	1±0,1
Operating waves, cm	0,8-1,5
The standard error of measurement of target coordinates: - by range, m - by azimuth, degree	 10 0,2

Coverage : in range – 150 to 4500 m; height - from the surface to 30 – 60 m.

Dimensions purposes – ranging from small ground vehicles and small planes to airliners maximum size.

Weather conditions – all, including rain intensity up to 16 mm/h.

Detection characteristics: the minimum detection probability of 90%; probability of false alarm is not more than 10^{-6} [1–3].

For radar RCUV can prevent lower resolution, while RCUV should be cheaper as compared to the ACR.

III. SELECTION OF THE OPERATING FREQUENCY

For high resolution radar azimuth desirable to increase its operating frequency in order to minimize the size of the antenna, as well as reduce its cost, weight, wind load and the power actuator. The upper value of the operating frequency is due to the deterioration of the characteristics of a valid RCUV due to the phenomenon of back reflection and energy absorption of radio waves in the rain. With increasing frequency and increased loss in a waveguide path, but the effect of these losses can be reduced by placing a transceiver as close to the antenna.

In practice the operating frequency is selected from the ACR 9–35 GHz range [4].

For reasons of power reduction and hence the cost of the transmitter RCUV operating frequency select value – 9.37 GHz (corresponding to a wavelength of 3.2 cm).

IV. THE DESIGN OF THE ANTENNA SYSTEM

To optimize the size of the radar antenna aperture in the azimuthal plane should be increased to obtain a high antenna gain, low levels of the clutter of rainfall and good resolution in azimuth. Size antenna elevation is influenced by such factors as the required survey zone by height, the need to reduce the volume of the resolved to reduce the level of the clutter and the choice of the form of precipitation bottom pattern (defined by a range of desired minimum and maximum height of the radar antenna tower). To obtain sufficient data update rate necessary to display fast-moving objects on the tarmac, the speed of rotation of the antenna should be quite high. However, as speed increases, and the antenna aperture having difficulties associated with maintenance of the required tolerances for the mirror shape of the antenna, creating mechanical design and physical limitations on the size, weight and load to be transmitted to the supporting structure. Furthermore, with the antenna radome should have a minimum aerodynamic resistance testing minimum wind loads, may have a smaller mass and generate small noise and vibration. The last requirement is particularly important when it is desirable to place the antenna on the roof of the tower located on the control tower.

Based on the above requirements is chosen parabolic antenna with a height of 1.2 m and a diameter of 0,45 m.

V. CALCULATION OF THE RANGE

The Radar equation establishes the dependence of the ratio of the magnitude of the signal/noise ratio at the receiver input of the parameters of the radar them given the effective area of scattering targets and the distance to it.

In some cases, such characteristics radar as ensuring minimum probability of correct detection of targets at a given false alarm probability of correct detection of targets at a given probability of false alarm, the ability to distinguish between the nature of the various objectives or work under the influence of interference is more important than the usual target detection.

For all these cases requires a special form of the equation of radar. In this connection it is expedient administering generalized parameter, which serves as the use amount ratio of the received energy to noise power at 1 Hz bandwidth. Power at the input of the radar receiver P_S may be represented as [5]:

$$P_S = \frac{P_t \cdot G^2 \cdot \eta^2 \cdot \lambda^2 \cdot \delta_{trg}}{(4\pi)^3} \cdot \gamma \qquad (1)$$

P_t – transmitter power, W; G – gain antenna device; η – the efficiency of the antenna-feeder device; λ – wavelength, m; δ_{trg} – the effective reflecting surface of the observed target; R – distance to the observed target, m.

Equation (1) is valid for free space in which there are no hydrometeors (rain, snow, hail, fog etc.)

In the presence of hydrometeors formula takes the form (2):

$$P_S = \frac{P_t \cdot G^2 \cdot \eta^2 \cdot \lambda^2 \cdot \delta_{trg}}{(4\pi)^3} \cdot \gamma \qquad (2)$$

γ – coefficient characterizing P_s attenuation due to fading on the propagation path due to the presence of hydrometeors (especially rain).

Receiver noise power can be determined according to the formula:

$$P_n = k \cdot T \cdot \Delta F \cdot N \qquad (3)$$

k – Boltzmann constant k = 1,38*10^{-23}; T – absolute temperature (in Kelvin), when using a temperature of 20 Celsius, K=4*10^{-21}; N – noise ratio of the input stage of the receiving device, ΔF – the required bandwidth of the receiver.

In its most general form, the ratio of signal power to noise power can be written as the following formula:

$$\frac{P_S}{P_N} = \frac{P_t \cdot G^2 \cdot \eta^2 \cdot \lambda^2 \cdot \delta_{trg}}{(4\pi)^3 \cdot R^4 \cdot 4 \cdot 10^{-21} \cdot \Delta F \cdot N} \cdot \gamma \qquad (4)$$

where ΔF – the required bandwidth of the receiver, depending on the duration of the pulse τ is used and is defined by the formula

$$\Delta F = \frac{1{,}2}{\tau} \qquad (5)$$

If instead of the signal considered clutter, the formula becomes:

$$\frac{P_{clutter}}{P_N} = \frac{P_t \cdot G^2 \cdot \eta^2 \cdot \lambda^2 \cdot \delta_{clutter}}{(4\pi)^3 \cdot R^4 \cdot 4 \cdot 10^{-21} \cdot \Delta F \cdot N} \cdot \gamma = $$

$$= \frac{P_S}{P_N} \cdot \frac{\delta_{clutter}}{\delta_{trg}} \cdot \gamma \qquad (6)$$

Let us now consider the ratio of signal power to the combined action of noise and interfering reflections

$$\frac{P_S}{P_N + P_{clutter}} = \frac{\frac{P_S}{P_N} \cdot \gamma}{1 + \frac{P_{clutter}}{P_N} \cdot \gamma} \qquad (7)$$

$$\frac{P_S}{P_N + P_{clutter}} = \frac{\frac{P_S}{P_N} \cdot \gamma}{1 + \frac{P_{clutter}}{P_N} \cdot \gamma \cdot \frac{\delta_{clutter}}{\delta_{trg}}} \qquad (8)$$

Taking into account the type of polarization of the signal equation becomes:

$$\frac{P_S}{P_N + P_{clutter}} = \frac{\frac{P_S}{P_N} \cdot \gamma}{1 + \frac{P_{clutter}}{P_N} \cdot \gamma \cdot \frac{\delta_{clutter} \cdot \beta_{clutter}}{\delta_{trg} \cdot \beta_{trg}}} \qquad (9)$$

Where the linear polarization of the measured field $\beta_{clutter}$ = 0 dB, β_{trg} = 0 dB and, when close to the circular polarization of the radiated field, $\beta_{clutter}$ = -3 dB, β_{trg} = -2 dB.

We accept the following parameters radar.

The parabolic antenna has dimensions a_a =1,2 m, a_b =0,45 m. It works on wave λ =3,2 cm. Wherein the horizontal beam width at 2.1° sidelobe – 29 dB. Vertical beam width of 4.8° at the side lobe level – 23dB. The gain of the antenna G=2000.

To ensure accuracy in the range of 15 m choose impulse duration $\tau = 0{,}1 \cdot 10^{-6}$ sec.

In this case ΔF = 12 · 10^6 Hz.

In the calculation of the noise figure introduce N = 2 and the power transmission device 5 kW per pulse.

In this case, the free space for the purpose, in which the effective reflective surface δ_{trg} = 1 m^2 in accordance with the equation (4) γ =0 dB

$$\frac{P_S}{P_N} = \frac{P_t \cdot G^2 \cdot \eta^2 \cdot \lambda^2 \cdot \delta_{trg}}{(4\pi)^3 \cdot R^4 \cdot 4 \cdot 10^{-21} \cdot \Delta F \cdot N}$$

Calculation of this equation is performed for the following parameters: P_t = 5 · 10^3 W; ΔF = 12 · 10^6 Hz; G=2000; N = 2; η^2=0,7 with δ_{trg} = 1 m^2, δ_{trg} = 2 m^2, δ_{trg} = 4 m^2, δ_{trg} = 10 m^2 and R up to 20 km; P_n =96 · 10^{-15} W (fig. 1).

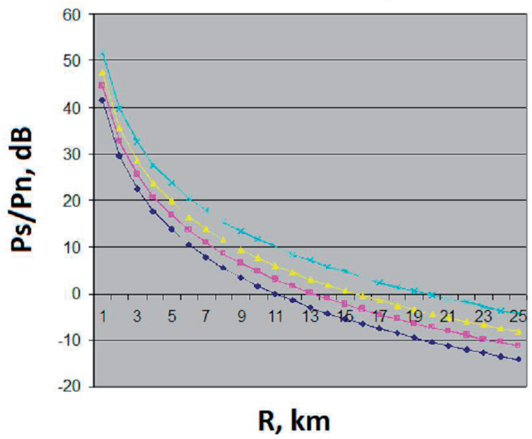

Fig. 1. The radar range

Similar calculations according to equation (4) are produced in the presence of rain r = 4 mm/hour (rime 0.25 mm/h, light rain 1 mm/hour, moderate rain 4 mm/h, heavy rain of 16 mm/h) (fig. 2).

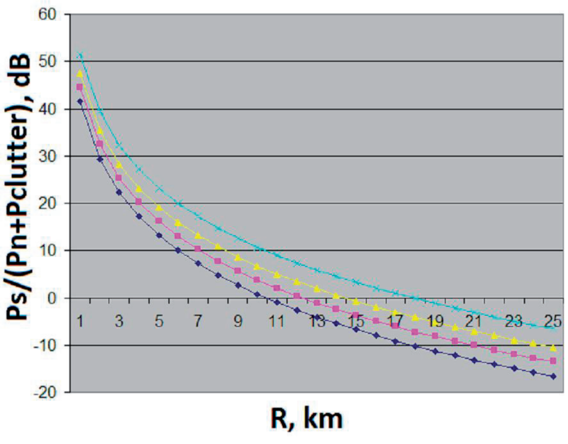

Fig.2. The radar range during rain 4 mm/h

When the rain comes signal attenuation. Attenuation should be negative. Previously constructed curve is reduced by the amount γ_{dB}. In this case, we believe that the target is outside the rain, that is $P_{clutter}$ =0, γ_{dB} = R · 0,091, where R is in kilometers.

In the case where the target is in the area of rain is necessary to use the equation (9).

We introduce the notation:

$$A = \frac{\delta_{clutter} \cdot \beta_{clutter}}{\delta_{trg} \cdot \beta_{trg}} = f(R_1)$$

The linear polarization of the emitted signal $\beta_{clutter}$ = 1, β_{trg} = 1 and when elliptical polarization of the emitted signal $\beta_{clutter}$ =0,01 (-20 dB); β_{trg} =0,5 (-3 dB); for the case when the axial ratio b/a = 0,91.

Note that when b = a = 1 circular polarization and $\beta_{clutter}$ =0 (fig. 3).

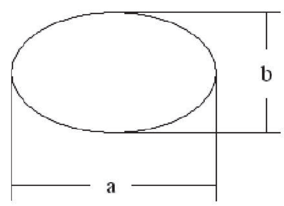

Fig. 3. Elliptical polarization

To calculate the coefficient A is necessary to determine $\delta_{clutter}$ =n·V, where n – the effective specific surface rain m^2/m^3

$$n = \frac{\pi^5}{\lambda^4} \cdot (0{,}93) \cdot (200 \cdot r^{1{,}6}) \cdot 10^{-18}. \quad (10)$$

Irradiated volume is given by

$$V = \frac{\tau}{2} \cdot \frac{R^2 \cdot \theta \cdot \alpha}{(57{,}3)^2} \cdot \frac{\pi}{4}, \quad (11)$$

$\frac{\tau}{2}$ = 15 m; α = 2,1° antenna beamwidth in the horizontal plane, radians; θ = 4,8° – antenna beamwidth in the vertical plane, radians (fig. 4).

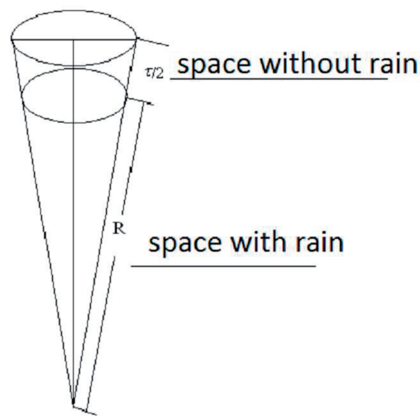

Fig. 4. Beam radar

At a distance of R = 10 km

$$V = 15 \cdot \frac{100 \cdot 10^6 \cdot \pi^4 \cdot 4{,}8 \cdot 2{,}1}{4 \cdot (57{,}3)^2} = 36 \cdot 10^5 \text{ (m}^3\text{)}$$

$$\delta_{clutter} = n \cdot V = 5{,}25 \cdot 10^{-7} \cdot 36 \cdot 10^5 = 1{,}9 \text{ (m}^2\text{)}$$

$$A = \frac{\delta_{clutter} \cdot \beta_{clutter}}{\delta_{trg} \cdot \beta_{trg}}$$

The linear polarization at a distance R = 10 km, $\delta_{clutter}$ =1,9 m^2, $\beta_{clutter}$ =1, δ_{trg} =4 m^2, β_{trg} =1, A=0,475.

$$\frac{P_S}{P_N + P_{clutter}} = \frac{\frac{P_S}{P_N} \cdot \gamma}{1 + \frac{P_{clutter}}{P_N} \cdot \gamma \cdot 0{,}475}$$

When elliptical polarization at a distance R = 10 km, $\delta_{clutter}$ =1,9 m^2, $\beta_{clutter}$ =0,01, δ_{trg} =4 m^2, β_{trg} =0,5, A=0,0095~0,01.

Obtain the formula

$$\frac{P_S}{P_N + P_{clutter}} = \frac{\frac{P_S}{P_N} \cdot \gamma}{1 + \frac{P_{clutter}}{P_N} \cdot \gamma \cdot 0{,}01}$$

VI. CONCLUSION

1. As a result of this work were selected and proved the basic parameters of the radar control unauthorized access and calculated the range of the radar control unauthorized access to the airfield at different parameters (in terms of the range of the signal/noise ratio of 5 dB at a target with a reflective surface 1 m^2 up to 7, 5 km).
2. Reduce the range of the rain caused moderate intensity is not more than 1.5 km.
3. The effectiveness of the introduction of elliptical polarization (with a decrease of the signal reflected from the target by only 3 dB, clutter from hydrometeors are reduced by 20 dB).
4. The small size of the antenna 1.2×0,45 m and low transmitter power of 5 kW radars allow us to cheaper compared to airfield control radar.

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SIMPLE TRANSFER PROTOCOL AN APPLICATION LAYER FOR IoT AND WNS

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Abstract

This document describes an Application Layer protocol that can be used in different scenarios of IoT and WSN. The protocol is designed to facilitate the development of application for WSN and IoT providing an abstraction to the programmer who can build distributed applications without having to manage the low-level communication and remote device as if they were local. This protocol has been implemented in C language and tested on an STM32 microcontroller.

I. INTRODUCTION

The Internet of Things (IoT) is an intelligent network of objects that can be monitored and controlled through the Internet for the purpose of exchanging information. The IoT system can collect physical environmental parameters such as temperature, humidity, light intensity, etc. So far, much work has been done on realizing the IoT into practice [1]. Many capabilities of IoT is showed in [2].

This paper describes Simple Transfer Protocol (STP), it is an Application Layer thought to IoT that adapts to the scenarios of WSN. It supports a Master/Slave communication, where a Master can be used to collect information produced by slave or to implement a control algorithm on field devices controlled by the slave. This protocol is flexible to be used in different domains and applications and it is designed to abstract the user from the hardware specifications of the device you are using, working at a high level using the APIs provided by the protocol.

In this document we will describe the protocol and we will provide some guidelines for its implementation. We will show an application scenario, finally, we discuss some future developments.

II. SIMPLE TRANSFER PROTOCOL

Simple Transfer Protocol is an application layer protocol based on a star topology type Master Slave. Subsequently, the Master device will be indicated as Smart Device, so Slave device as Simple Device. Smart Device interacts only with its Simple Device. Every Simple Device is indicated with an unambiguous ID, controls its own field devices said Field and can communicate only with his Smart Device. This is described in fig. 1.

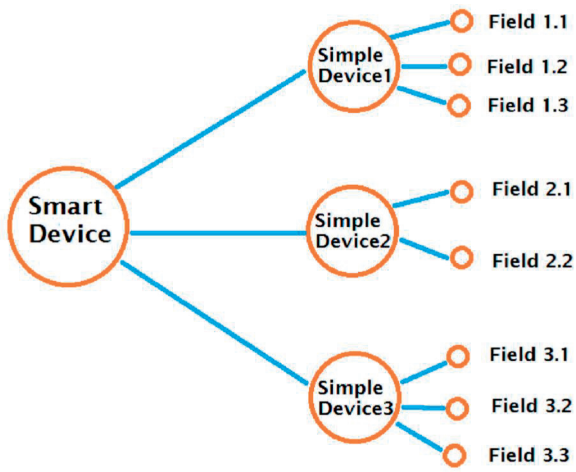

Fig. 1. Protocol schemata

STP refers to a protocol stack ISO/OSI collapsed, there are only three layers:

- physical layer;
- data link layer;
- application layer.

The use of a stack collapsed is well accepted in the industrial automation and devices with limited computational resources in order to optimize performances and reduce delay. STP assumes that the underlying layers are reliable, or that there is a service of retransmission in case of loss and that packets arrive in the order of transmission.

Above the application layer we find the user application. The purpose of the Application Layer is to mask the user application all the details related to communication between nodes and the existence of a MAC address level. The application user sees only the remote fields, as if they were local, so it can be accessed with simple procedures of Read and Write. Each request references a Field, regardless that it is an ADC, GPIO, DAC, etc. Then the protocol is also involved disguise implementations of low level relative to the management of devices.

The smart device must maintain a dynamic picture of each local Simple Device, see in fig. 2.

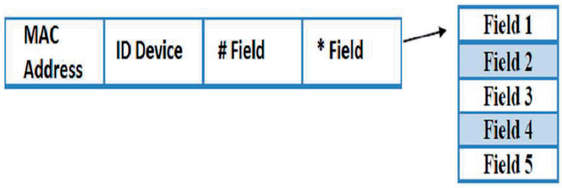

Fig. 2. Process Image of Simple Device

Smart device will store a table with a row for each Simple Device. This table will be initialized at system startup. This allows the application user to access a particular field device only by specifying the ID of the device to which want access to the Field and you are interested in without having to manage the MAC address. The system will automatically send a message to the specific Device.

III. COMMUNICATION

Communication between Smart and Simple Device occurs by exchanging messages. STP is a stateless protocol. Each request will be treated in a completely independent of the others. The requests are therefore not idempotent and therefore it is necessary that the channel is reliable. The messages are encapsulated within the package (fig. 3).

Fig. 3. Packet

The field size is expressed in bits and they are:

– Command – 4 bit. Directive sent;

– Reserved – 4 bit. Reserved;

– ID Device – 8 bit. Contains the ID of Simple Device message recipient. The simple device recipient will know so if the package is intended to him. With 8 bits we can handle up to 255 devices, namely 1 and 254 Smart Device Simple Device;

– ID Field – 8 bit. Contains the device ID of the field to which you want to access. Every Simple Device can handle up to 255 devices including sensors and actuators;

– Payload Len – 8 bit. Length in bytes of payload;

– Payload. Of variable size, contains a value that will have sent a different meaning depending on the Command.

The possible field Command directives are listed in the table 1.

Table 1

Command List

Command	Hex code	Binary code
PUT	0x1	0b0001
READ	0x2	0b0010
READ_CONFIRM	0x3	0b0011
WRITE	0x4	0b0100
WRITE_CONFIRM	0x5	0b0101
EVENT_NOTIFICATION_TO_SMART	0x6	0b0110
EVENT_NOTIFICATION_TO_SIMPLE	0x7	0b0111
WRITE_ON	0x8	0b1000
WRITE_OFF	0x9	0b1001
CONFIRM_WRITE_ON	0xA	0b1010
CONFIRM_WRITE_OFF	0xB	0b1011
RESERVED	0xC	0b1100
RESERVED	0xD	0b1101
RESERVED	0xE	0b1110
RESERVED	0xF	0b1111

IV. COMMAND DESCRIPTION

Follows a description of the directives.

PUT. Used by Simple Device to send to the Smart Device value of a Field without this had been previously requested. This value will be included in the payload. Upon receiving a PUT, the Smart Device store that value in the memory for that process image.

READ. Used by the Smart Device to request the Simple Device sending the Field ID specified in the Field. The Payload field will be empty. Upon receiving a READ, the Simple Device will perform the reading from the sensor and will respond with a READ_CONFIRM.

READ_CONFIRM. Replies to following a READ. The payload will contain the measured value.

WRITE. Used by the Smart Device to apply to Simple Device to write a value in the device specified by ID Field. The value is inserted into the payload. Upon receiving a WRITE, the Simple Device proceed to change the status of the specific actuator and respond to the Smart Device with a WRITE_CONFIRM.

WRITE_CONFIRM. Used by Simple Device for the Smart Device confirm the successful writing on the field device.

EVENT_NOTIFICATION_TO_SMART. Posted by Simple Device to the Smart Device, to notify the occurrence of an event. In the payload will be a code, and receipt of it, the Smart Device will pass control to the application which will decide the action to be taken.

EVENT_NOTIFICATION_TO_SIMPLE. Similar to the previous case, but this time will be the smart device to notify something to Simple Device.

WRITE_ON. Used by the Smart Device to indicate a Simple Device to turn on the Field ID specified in the FIELD. Must be specified so that a previous operation of READ/WRITE to be effective it is necessary that the device is set to ON.

CONFIRM_WRITE_ON. Upon receiving a WRITE_ON, the Simple Device will respond to the Smart Device with a confirm.

WRITE_OFF. used by the Smart Device to turn off the specified Field.

CONFIRM_WRITE_OFF. Used by Simple Device to confirm the Smart Device WRITE_OFF the previous.

V. EVENT NOTIFICATION

EVENT_NOTIFICATION is a command used to notify the occurrence of an event. The event is identified by a unique code inserted in the payload of the directives.

EVENT_NOTIFICATION_TO_SMART or EVENT_NOTIFICATION_TO_SIMPLE. Were defined events default, also many have been left free so as to enable the user application to define some that are relevant for the application.

The notification codes is shown in table 2.

Table 2

Event Notification Code

Name	Code
ERROR	0x00
SUCCESS	0x01
COMMAND_NOT_VALID	0x02
IMPOSSIBLE WRITE ON	0x03
IMPOSSIBLE WRITE OFF	0x04
SERVICE NOT AVAILABLE	0x05
RESERVED	0x06
ILLEGAL DATA	0x07
TIMEOUT	0x08
FIELD NOT VALID	0x09
ID DEVICE NOT AVAILABLE	0x0A
WRONG IF	0x0B
IMPOSSIBLE READ OFF FIELD	0x0C
IMPOSSIBLE WRITE OFF FIELD	0x0D
IMPOSSIBLE READ	0x0E
IMPOSSIBLE WRITE	0x0F
READ ONLY VARIABLE	0x10
WRITE ONLY VARIABLE	0x11
ADC NOT VALID	0x12
DAC NOT VALID	0x13
PORT NOT VALID	0x14
PIN NOT VALID	0x15
RESERVED	0x16 – 0x1F

The codes ranging from 0x16 to 0xlF are reserved for future use, while the definition of codes ranging from 0x20 to 0xFF is left free to the user. Upon receipt of an event notification, the notification code will be passed to the application which may decide to take the appropriate decisions. This in order to provide greater flexibility to the same.

VI. IMPLEMANTATION

In order to test the protocol has been implemented on the STM32 microcontroller. In order to allow communication, were also carried the Physical Layer and the Data Link Layer for the device Nordic nRF24L01.

STM32F3 Discovery. It's a Discovery Board having the microcontroller STM32F303VCT6 – CORTEX-M4 to 72 MHz and 32 bits. It has 256 KB of flash memory and 48 KB of RAM [3].

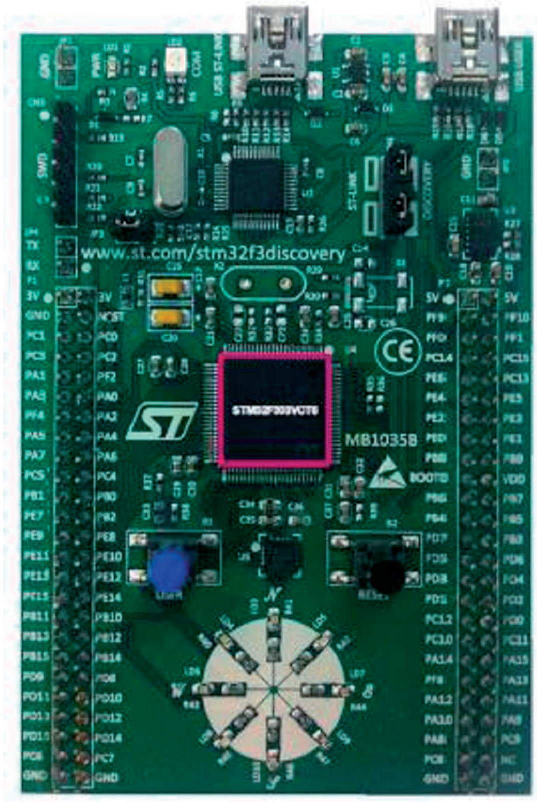

Fig. 5. STM32F3

NORDIC nRF24L01. Transceiver 2.4 GHz and a maximum data rate of 2Mbps. Suitable for low power communications at a low cost and high performance. Communication with the microcontroller is via the SPI port [4].

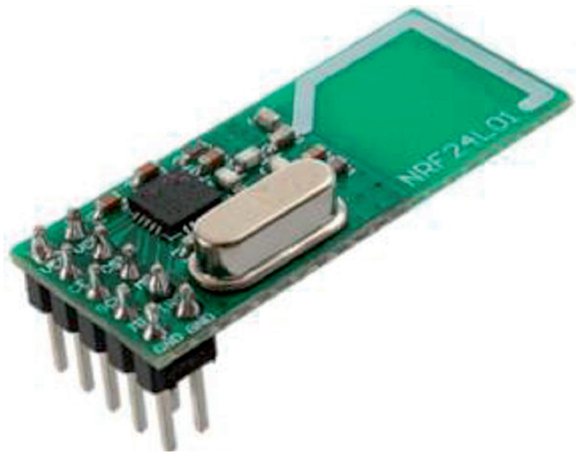

Fig. 6. NORDIC nRF24L01

The protocol has been implemented on the micro STM32 in C language. The structure of the package is as follows:

```
typedef struct Packet
{
        uint8_t command;
        uint8_t reserve;
        uint8_t id;
        uint8_t field;
        uint8_t length;
        uint8_t *payload;
}Packet;
```

This package will be sent with the function:

```
void sendPacket(uint8_t *address,
                Packet *packet)
```

In receiving the package will be rebuilt with the function:

```
void splitPacket(uint8_t* rbuf, uint8_t size,
                 Packet *packet)
```

Simple Device for each under its control, the Smart Device will maintain the following structure:

```
typedef struct SimpleDevice
{
        uint8_t addressSimpleDevice
              [ADDRESS_SIZE];
        uint8_t idSimpleDevice;
        uint8_t numField;
        Field *fieldArray;
} SimpleDevice;

typedef struct Field
{
        uint8_t id_field; //ID Simple Device
        uint8_t state; //ON - OFF
        uint8_t type; //SENSOR - ACTUATOR
        uint32_t value;
} Field;
```

VII. API

API description of the protocol.

Initialization functions:

– STP_Init_Field: initializes a Field;

– STP_Smart_Init_Simple_Device: if invoked on a smart device used to initialize the image of a Simple Device on Smart Device; if invoked on a Simple Device used to initialize the same device. It will pass the Field previously initialized;

– STP_Set_Number_Simple_Devcice: defines the number of Simple Device that will be controlled by a single smart device.

API Smart Device:

– STP_Smart_Read: invokes the directive Read a file of a given Simple Device. The system with the function getAddress(), get the address of the simple device, so encapsulate a package that will be sent to the specified Simple Device;

– STP_Smart_Write: invokes the directive Write on a field to the specified Simple Device;

– STP_Smart_Write_ON: send the directive of WRITE_ON to the specified Simple Device;

– STP_Smart_Write_OFF: send the directive of WRITE_OFF;

– STP_Smart_EventNotification_To_Simple: send an Event Notification to the specified Simple Device.

API Simple Device:

– STP_Put: invokes the directive Put, encapsulating a special package and sending it to the Smart Device;

– STP_Simple_Read_Field_Value: this feature allows you to read the Field in the same local Simple Device. There will be a memory scan to see which device I/O is associated with the given Field and it will be called a proper procedure;

– STP_Event_Notification_To_Smart: send a notification to the Smart Device.

VIII. TESTBED

In order to test the protocol, was made according the scenario in fig. 7.

Periodically Smart Device sends a Simple Device 0x46 Read on Field 0xAA on which there is a temperature sensor LM35. Upon receipt of the Read, the Simple Device will read the value and respond with a Confirm Read. The reading will be sent to the serial port of a PC through a link USART as shown in fig. 8.

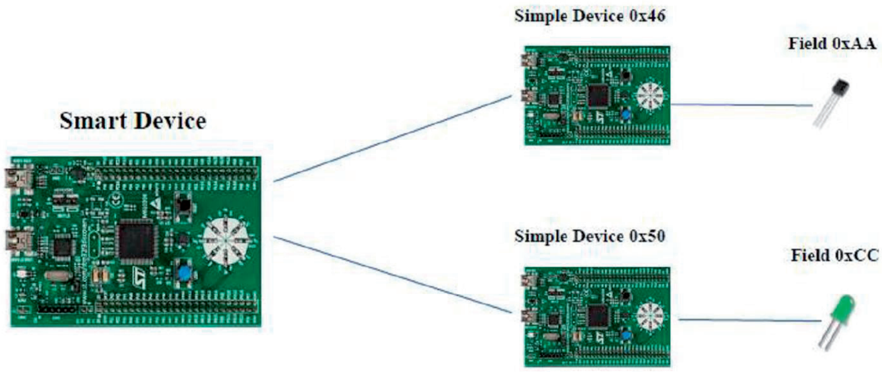

Fig. 7. Testbed

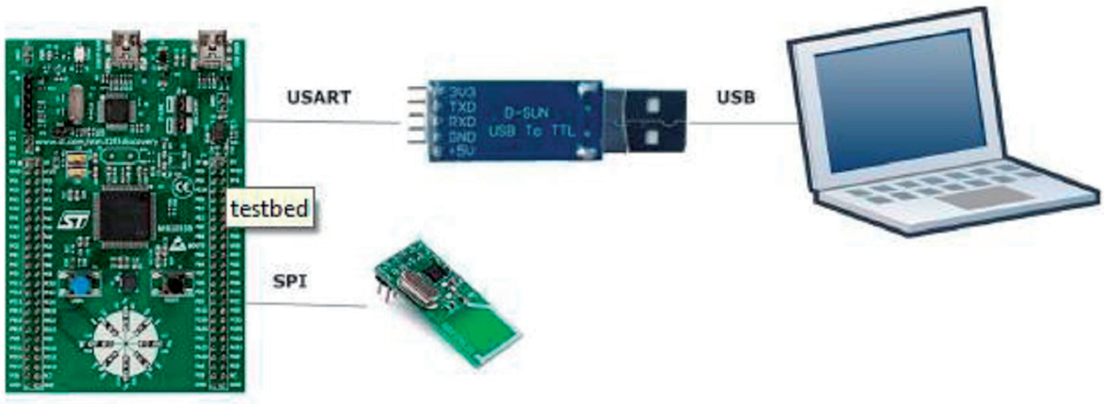

Fig. 8. Serial port communication

With a period of 2 seconds, the Smart Device sends to Write a Simple Device 0x50 on Field 0xCC alternating a value of 0 and a value of 1 to flash the LED.

IX. CONCLUSIONS AND FUTURE DEVELOPMENTS

STP is designed to facilitate the implementation of distributed applications within the IoT. The protocol facilitates the development by abstracting the programmer from having to manage communication. It's a general protocol that can be used for various applications such as simple control systems or monitoring systems. The protocol has been implemented in C and tested on a microcontroller family ST.

The protocol could be extended by providing remote access to the variables. At these variables there may access through the normal directives of READ / WRITE thinking though to split the Field ID field in such a way that 4 bits are used for the variables and 4 bits used for the Field. Or you may think of leaving unchanged the ID field Field and add new directives using the codes reserved field Command. A further development would be to add in the initial phase a phase of automatic discovery, which enables the smart device to independently configure their own tables without this having to be done in a static way by the programmer.

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RASPBERRY PI SENSOR NETWORK/INTERNET-OF-THINGS GATEWAY
A framework

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Abstract

This work aims to provide a preliminary framework for implementing a Sensor Network/Internet-of-Things gateway running on a Raspberry Pi platform. The design employed, together with hardware/software implementation details, are illustrated in this paper.

Keywords: Raspberry Pi; Internet-of-Things; sensor networks; gateway.

I. INTRODUCTION

This work provides design and implementation details of a preliminary framework realized for the implementation of a gateway-based, thin-client sensor network or Internet-of-Things application. The main goal of the gateway is to provide Internet access to smart sensors/actuators, for the purposes of remote monitoring and control. The gateway would provide several network interfaces, as well as local GPIO control.

The basic system requirements to be fulfilled and the guidelines to be followed are as follows: a remote database must be present for data storage and analysis; sensor monitoring should be performed by either a web-based (indirectly) or stand-alone client (directly) control panel; data pre-and post-processing should be performed on the gateway and database-server side, for the storage and monitoring of historical data. The gateway should provide connection to the Internet by cell phone-suited 3G network and activate the 3G link periodically, in order to either update sensors' data or search for new remotely submitted tasks to be executed. Lastly, a direct socket connection should be provided to a stand-alone client application on demand.

II. GENERAL ARCHITECTURE

A. Design survey and network architecture

The general network architecture can be identified in the classic hub-and-spoke model. As [1] describes, among the state-of-the-art practices in the Internet-of-Things (IoT) area, IoT designs are converging towards three main architectures: *hub-and-spoke, front-loaded embedded devices* and *smart client models*.

In the hub-and-spoke model, it is assumed that IoT devices are ultra-thin clients, namely devices equipped with limited resources for either processing or network access. Devices link to the gateway for relaying acquired data. The gateway's purpose is to pre-process and collect data, managing devices, handling wan protocols (e.g. IPv4/v6) and exposing services to the outside world.

Front-loaded devices possess processing power and a network interface – for instance to connect with a local router wirelessly. For example, these devices can notify an event externally only if a system-related threshold is surpassed, that is, after pre-processing at the device level is applied. The presence of a local gateway is still necessary for the overall system control and management.

In the smart client model, devices are fully autonomous and central intervention is no longer necessary. Control and information sharing are performed locally and wan access can seldom be used for data storage and analysis. That is to say, a peer-to-peer model is enabled.

The proposed network architecture is illustrated in fig. 1.

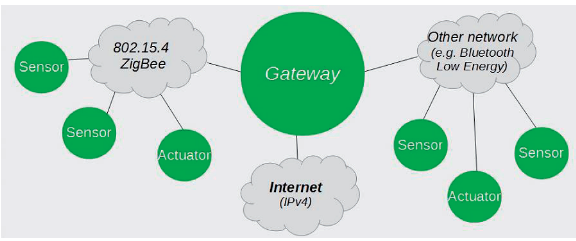

Fig. 1. Proposed network architecture: *hub-and-spoke* model

A similar description of current IoT designs can be found in [2]. For an introduction on the Internet-of-Things paradigm, see [3]. A survey on Internet-of-Things visions and enabling technologies can be found in [4–6] provide further high level visions of the IoT paradigm. A survey on sensor networks is provided in [7].

B. System components

Several external components were considered and implemented:

− Remote database – the gateway deposits sensors' data to a remote database. The database serves also as a task deposit to be polled and executed by the gateway;

− Web control panel – users can send commands and access data asynchronously via a web control panel. Data charts and other information are refreshed via AJAX calls to a web server [8];

− Stand-alone control panel – additionally, a standalone control panel application should synchronously control and monitor all sensors' and actuators' statuses by a direct socket connection to the gateway.

C. System operation

Interaction with the gateway (hence, with sensors/actuators) can be indirect or direct.

Indirect interaction. The web control panel offers a form of asynchronous interaction with the network (as always, through the gateway). The database is used as a relay point between the gateway and the control panel. On the one hand, data can be deposited by the gateway and be read by users. On the other hand, tasks can be deposited by users and be executed by the gateway. The gateway periodically activates the wan 3G link, deposits new collected data from sensors into the database and polls for new tasks. Afterwards, it disconnects and sleeps until the next reconnection.

Users can read and display deposited data and also deposit new tasks to be retrieved and executed by the gateway in the next re-connection. Data from and commands to the gateway are thus exchanged indirectly. The gateway interacts with the database via HTTP REST calls to the application server (a web service is thus exposed) [9–11]. Objects are exchanged as JSON strings [12].

Direct interaction. The stand-alone control panel (a client Java application) offers synchronous interaction with the gateway, bypassing the database relay mechanism and by exchanging data and commands at every instant. The connection establishment with the stand-alone client, however, is performed by the gateway to the client, which remains listening for a connection on a particular port. The connection establishment is performed as follows:

− the client deposits a CONNECT task to be polled and executed by the gateway along with the clients' IP address and port. The client then remains listening;

− the gateway eventually retrieves the task on the next re-connection to the database after a fixed amount of time;

− the gateway opens a socket with the clients' IP address. The periodic link disconnection is overridden and the interaction becomes direct;

− as the link is permanent, commands and data are exchanged instantaneously. Eventually, the client disconnects and normal periodic operation is restored. Overall system operation is summarized in fig. 2.

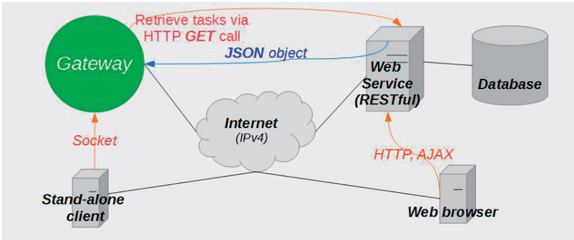

Fig. 2. Overall system operation

III. MATERIALS AND METHODS

A. Technologies

− The Raspberry Pi gateway application was written in JAVA (JDK 1.7) and includes the Pi4J and RXTX libraries for Raspberry Pi for GPIO control and serial communications [13–15].

− The RESTful web service was generated by Netbeans 7.4 in Java and deployed on the GlassFish 4 JavaEE7 application server (it is possible to re-implement another equivalent RESTful web service in any other language and with another RESTful-compliant server and link it to the existing database) [17, 28].

− The database was implemented on MySQL. A database connection was created on GlassFish for database access [18].

− The stand-alone client was written in plain Java.

− An xBee series 1 radio was connected to the Raspberry Pi via a USB UART adapter [16, 19–24].

− A microcontroller-based wireless sensor was provided with another xBee series 1 radio, in order to send data to the Pi. The two radios were properly configured for simple point-to-point communication via AT commands [25].

− An LED in series with a 220 Ω resistor was attached to the Pi GPIO1 and to GND for the simulation of a real actuator.

− A Huawei E220 3G modem was used for 3G connectivity. Connection establishment and control was performed by PPP protocol and SAKIS3G script [26, 27];

− A sim card with a TIM Italy subscription plan was used.

B. Gateway software

The gateway software consists of the main package iotgateway. This package contains classes for the modeling of each sensor/actuator node, for the support periodic connection to the application server, for task creation and management and for issues related to serial port communication.

The main class, Gateway.java, is worth discussing more thoroughly. It contains almost all of the application logic. In simple terms: it manages a nodes map with all nodes' status and information, along with GPIO connections and establishes serial port communication. It spawns 3 main threads:

- *SensorDataPollerAndSender;*
- *TaskPollerAndExecutor*;
- *MainSequencer*.

All of the above are defined as private inner classes. Each thread has its own semaphore, placed in certain execution points. In particular, the first two threads implement a special class, named PeriodicRunnable, which contains special logic for threads that have to execute a loop only after a fixed amount of time. These particular threads remain blocked at the beginning of their loop and are awakened by the MainSequencer thread by unlocking their semaphore when it is time to execute their loop (by this time, MainSequencer will have slept for a fixed amount of time, keeping the 3G link down, and will have reestablished 3G connection). The mainSequencer thread initially acquires its semaphore at the start-up, establishes 3G connection, awakens all blocked periodicThreads scanning a semaphore list and remains blocked trying to acquire again its semaphore and waiting for another thread to release it. Meanwhile, the other two periodicThreads remain active. Each periodicThread verify at the end of its loop, before exiting the while-loop, if it is the last one executing or if other periodicThreads have not yet finished, by reading a total active periodicThreads count. If that is not the case, the periodicThread cycles the loop and remains blocked trying to acquire its semaphore, ready to be awakened by the MainSequencer on the next connection epoch. Otherwise, if it is the last one, the periodicThread applies the 'last-one-closes-the-door' rule: it terminates the 3G connection and notifies the MainSequencer that all threads have finished their work, releasing its semaphore. Then, the periodicThread cycles and remains blocked as above. The MainSequencer can now sleep for the chosen amount of time to keep the 3G link off. Afterwards, it reestablishes the connection, awakens periodicThreads and so on. This is an alternative method for joining threads (otherwise, the connection termination could be also performed by MainSequencer after being notified by the last thread).

To better understand the gateway's behavior, Fig. 3 summarizes the gateway's internal thread activity and synchronization. The steps are the following:

- the mainSequencer acquires its semaphore for the first time, establishes 3G connection and awakens blocked periodicThreads. It then awaits for its already acquired semaphore to be released when all threads have completed;
- while MainSequencer is blocked, previously awakened periodicThreads are executing (e.g. polling tasks from database or sending sensors' data);
- when a periodicThread finishes, it checks whether it is the last one remaining. If not, it cycles and remains locked as before;

if a thread discovers that it is the last one executing, it closes 3G connection and unlocks the MainSequencer's semaphore, which then sleeps for a certain amount of time. The MainSequencer cycles and all steps are then repeated as above. For a more comprehensive description of classes, methods and fields, refer to the software documentation. *C. Web service side software*

The web service main package contains a JSP page for displaying web control panel. It polls the database for sensors' data and nodes' status each second/custom interval via AJAX asynchronous calls.

The *models* package contains Netbeans autogenerated object models for each of the three database tables [28].

The *models.service* package contains Netbeans autogenerated REST HTTP servicing methods for each requested resource, triggered by each received HTTP request for that particular resource. One Java method is present for each HTTP method (GET, PUT, POST, DELETE).

D. Database design

Three tables were created in a database named iotgateway:

- *data;*
- *nodes;*
- *tasks.*

The data table is represented in Table 1.

Table 1.

Data table

Field	Field values				
	Type	*Null*	*Key*	*Default*	*Extra*
time-stamp	time-stamp	NO	PRI	CURRENT_TIMESTAMP	On update CURRENT_TIMESTAMP
netid	tiny-int(4)	YES		NULL	
nodeid	int(11)	YES		NULL	
value	float	YES		NULL	

The web service collects only a fixed amount of rows in this table to maintain memory capacity and shifts each row by one position after the fixed window is full, to give a 'sliding' effect to the web page sensor charts (a function more likely to be implemented in the JSP page). Historical data analysis and storage are yet to be implemented.

Nodes and tasks tables are represented respectively in Table 2 and Table 3.

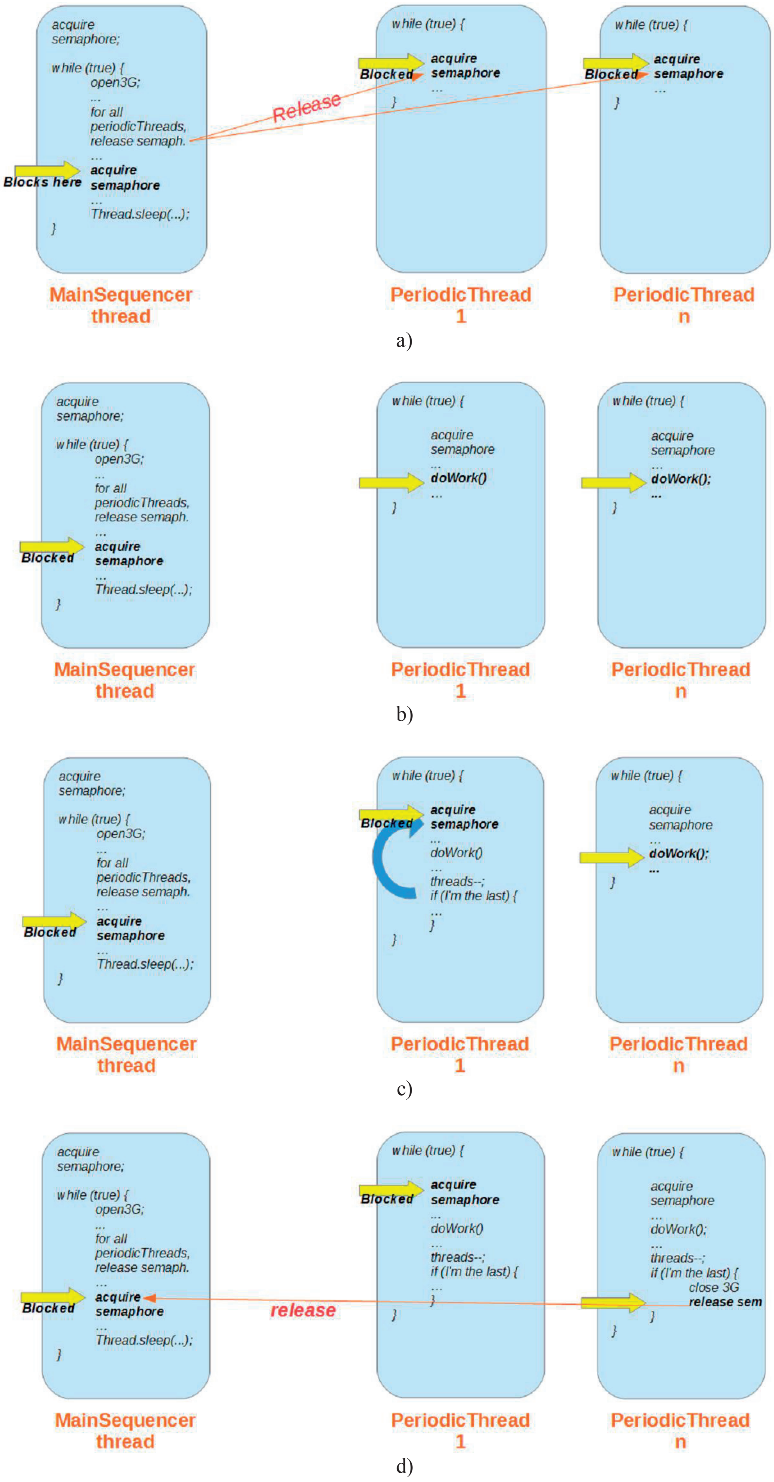

Fig. 3. Threads synchronization

Table 3.

Tasks table

Field	Field values				
	Type	*Null*	*Key*	*Default*	*Extra*
Id	int(11)	NO	PRI	NULL	auto_incre-ment
action	var-char(20)	NO		NULL	
deviceNetId	tiny-int(4)	NO		NULL	
deviceNodeId	int(11)	NO		NULL	
remoteAppI-pAddress	var-char(21)	YES		NULL	

E. Usage

For instructions on the overall system and its usage refer to the software documentation.

A screenshot of the web control panel is provided in Fig. 4. Actuators' and gateway's statuses are indicated, in addition to sensors' data by means of two charts. All values are read from the database. Every time the gateway refreshes values in the database (depending on the period value set by the user)? charts and status are refreshed as well. actuators can be commanded asynchronously, as previously started.

Fig. 4. Web control panel

IV. CONCLUSIONS AND FUTURE WORK

This work provided an illustration of the requirements, the general architecture and hardware/software details of a simple framework for the implementation of a sensor network/Internet-of-Things application. System-wide external components were also presented, as well as two basic methods for the interaction with the gateway and, therefore, with the internal network itself. A basic structure made of synchronized threads and dedicated classes is available for expansion.

Interfaces with database server and RESTful web service were designed accounting for their compatibility with other external components. Both the database and the web service can indeed be re-written using any other DBMS for the former, enterprise framework or programming language for the latter, and thus deployed in any other compatible application server. Compatibility is maintained thanks to the RESTful nature of all the operations.

Future work could evaluate a suitable user interface for both web and stand-alone client sides, security methods in the gateway for accessing the network of 'things', and the definition of a standard format for data to be exchanged between the gateway and sensors/actuators. In addition, a standard format for a node descriptor, consistent in both the gateway and the nodes, should be provided. A more complex network topology should also be explored [29]. Historical data analysis and storage is another aspect to be further examined.

IV. ACKNOWLEDGMENTS

This work was completed as a course project for a class on industrial automation networks.

I would like to thank Dr. M. Condorelli for the editing of this paper.

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"DOMUS": A SELF-MANAGED SMART HOME

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Abstract

In these years where technology become more and more dominant, we always try to offer more solutions in order to improve our daily lives. Home automation leverages the computing and electronics in order to increase the efficiency of our homes and, at the same time, make the devices, and the equipment increasingly easier to use inside and especially outside. In this paper we show the prototype of a smart home controlled remotely through a java application.

I. INTRODUCTION

The goal of this paper is to create a smart home, which through the use of a technology always present but not invasive [1], meets the needs of the user, improving the quality of life within the home environment.

All this results in greater comfort, "security" and energy savings, thanks to a home automation simple to use and intuitive, is aimed at users who agree to simplify their lifestyle.

DOMUS is a "smart home" able to communicate with the user when it is not in the house, use multiple functions simultaneously and remodel when its housing needs change.

When we talk about home automation we have to consider some fundamental aspects, such as comfort, safety, and attention to energy saving.

This paper is so organized: Section II presents the system model, while the section III presents the "Domus app" that control the system, Section IV present the "smart home" prototype , and finally the Section IV summarises the paper.

II. SYSTEM MODEL

The core of the project has been realized through the Matlab software.

The main aspects analyzed for a home automation system efficiently designed were: security, lighting and air conditioning. This aspects are realized trough the presence of sensors and actuators placed in strategic point of the home. "Domus" is able to manage themselves in automatic mode, or allows the user to make the choice you wish for his well-being and his safety. "Domus" provides several features.

Security

Report and detects the presence of an intruder, both when the dwelling is unattended with a volumetric sensor and perimetral sensor, both at night watching the accesses to the outside, only with perimetral sensor.

Once an intrusion is detected, the siren is activated and the system tells you whether any forcing of windows or door.

Before the total alarm starts, the system waits 10", so as to allow the user to leave the house without causing false alarms due to the activation of the volumetric sensor.

In the event of total alarm activation, the system will turn off all the lights on.

A particular feature of the security called "ghost", it is able to protect the house when it is unoccupied. If the total alarm is not deactivated within 24 h after the activation, "Ghost" starts, working for 1 h at intervals of 5 h thus covering all hours of the day. "Ghost" simulates the presence of a person, by operating the random scenes. deal to activate the interior and exterior lighting, and blinds.

Lightning

The lights are managed according to the output of the volumetric sensors and photoresistor, for example, allowing to turn on the light when the photoresistor communicates a situation of low light outside. That does not allow the natural lighting of the dwelling, and the volumetric sensor detects a presence in the room. While off occurs only after it has spent a time of three minutes without detecting the presence in the room, thus avoiding unnecessary waste of energy. In the case in which the volumetric sensor detects a presence and the photoresistor sensor communicate that light is sufficient, the illumination is not activated. The user is always able to decide whether to manual handling.

The blinds open as soon as the volumetric sensor detects a person in the room concerned, and once these remain open until night comes, or until the total alarm goes on leaving the house. Also in this case the user is able to manually use the shutters.

Air conditioning

The temperature sensor placed inside, detects the internal temperature and comparing it with that desired by the user, activates the heating system or air conditioning until reaching the value of internal temperature desired by the user. In automatic mode, the temperature is set in a range of thermal comfort between 25°C–29°C in summer and 17°C–20°C in winter.

The hardware side has been assigned to a board developed by the KORE University of Enna "multi F24 KORE" whose core is the microcontroller "PIC24FJ256GB108", instead the software side has been assigned to the java infrastructure.

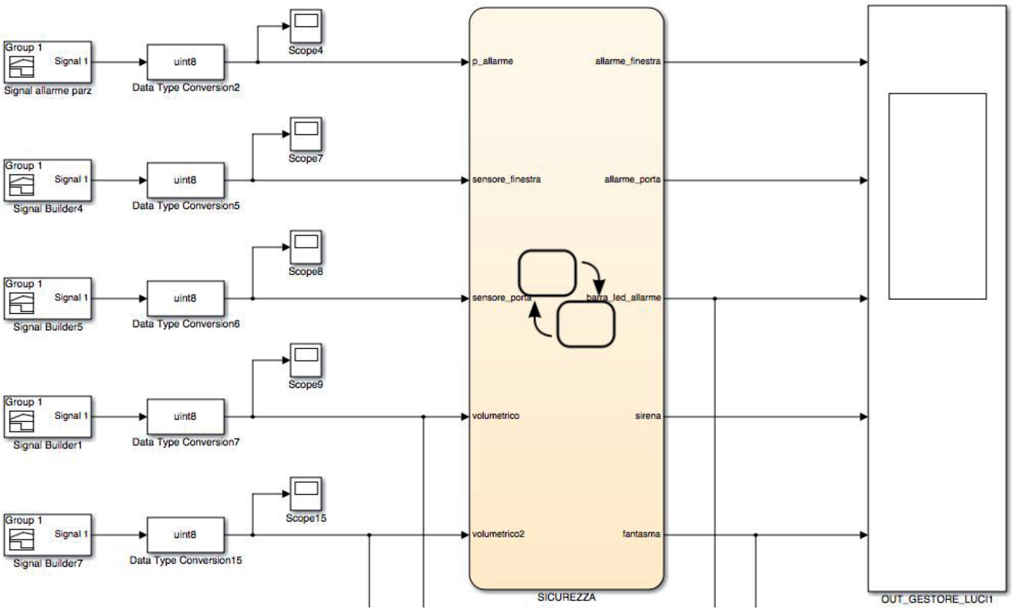

Fig. 1 System model

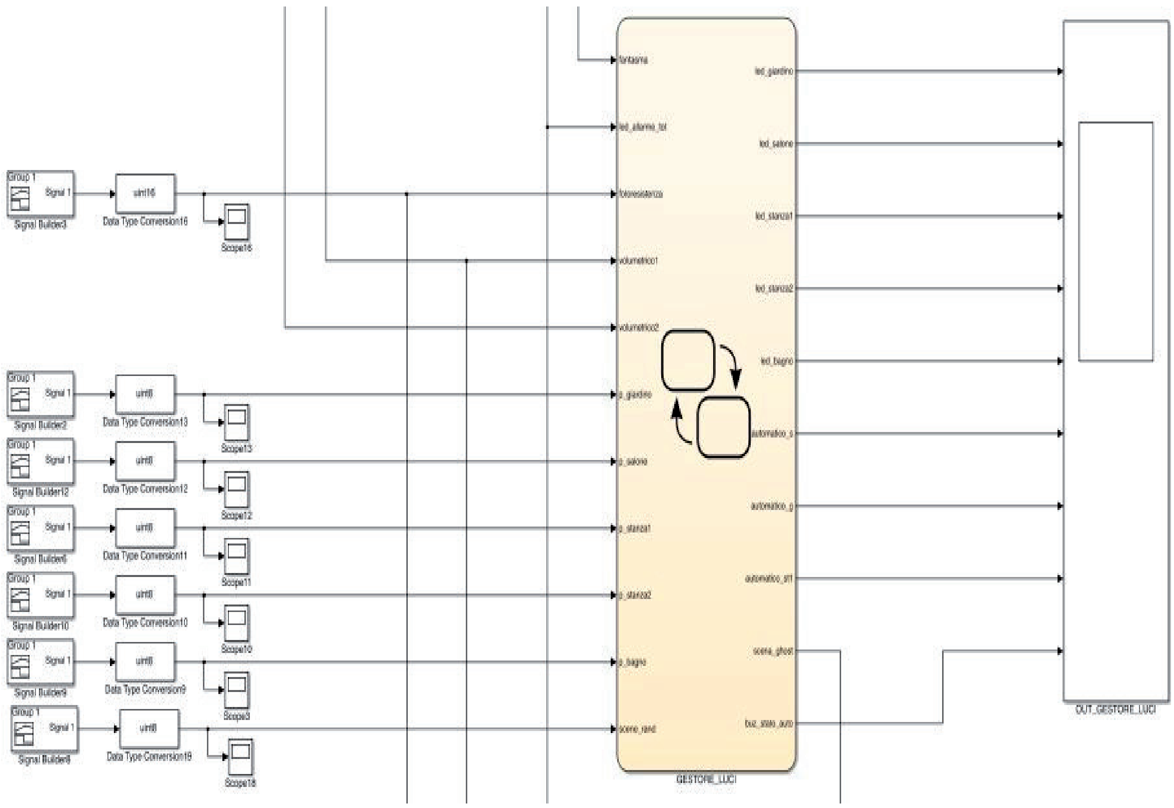

Fig. 2. Controller

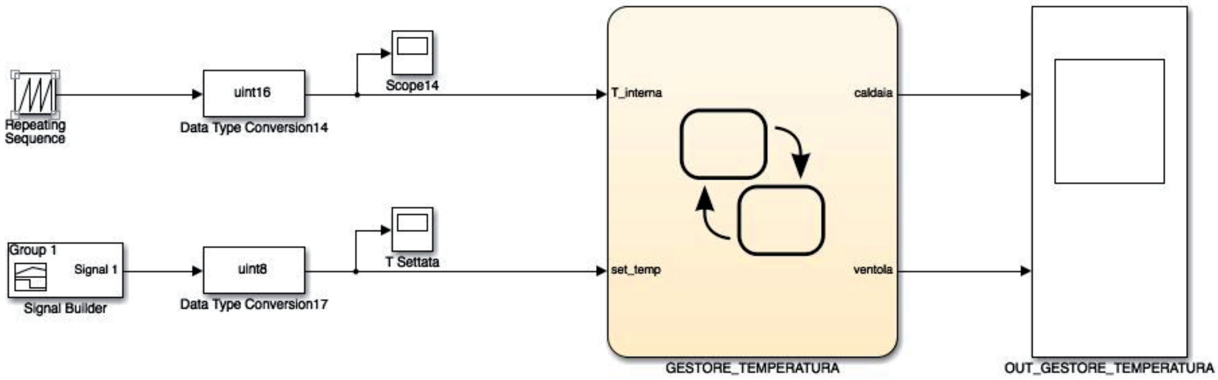

Fig. 3. Stateflow management

III. DOMUS APP

The home automation system "DOMUS" offers the ability to be controlled easily via Wi-Fi using the "domus app". This application allows you to manage external and internal spaces to housing, both in automatic and manual mode, showing the appropriate changes status to user to allow an easy and immediate management of available resources. For example: comfort –- you can remotely control lighting and climate (fig. 4), or security system (fig. 5)

Fig. 4. Comfort management

Fig. 5. Security Management

This application is designed to be as simple as possible to use, for any type of user.

It has been developed in Java language and can be used on any computer platform supports java.

To manage all devices connected to the network has been used an access point using IEEE 802.11 b/g/n that allows to control all the devices connected with the home.

IV. PROTOTYPE

Fig. 6. Prototype

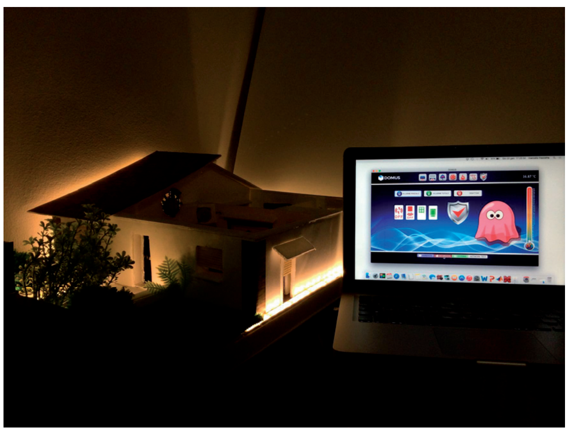

Fig. 7. Testbed

IV. CONCLUSIONS

In this paper, we have shown the use of the Matlab software and the Java application, that use the IEEE 802.11 standard protocol. We realize a smart home prototype in order to test and show all the feature of this work. The easy use of the proposed approach has been shown trough the screenshots.

This is an example of a smart home that is placed in a future period for the development of eco-sustainable homes.

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CODE SEQUENCES DEVELOPMENT FOR SAW TAGS IN THE SYSTEMS OF AUTHENTICATION

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Abstract

Noncontact authentication of objects in the distance is presently an actual problem. Necessity to watch and control certain commodities in the transportation system, to carry out remote monitoring of motor-car and railway motion, to accelerate the inventory process, to keep account of the personnel and other great deal promoted in area of development and production of radio-frequency authentication devices (further RFID).

Therefore works on development of encoding methods and creation SAW tag models are conducted now. This article is devoted to research code sequences with using FSK radio signals and finding class of them.

I. GENERAL INFORMATION ABOUT THE SAW TAGS

Reader radiates a radio signal in the air, the transponder antenna fastened on a tag accepts a radio signal. The leads of antenna unite with the corresponding tires of interdigital transducer. The typical SAW tag structure is shown in fig. 1.

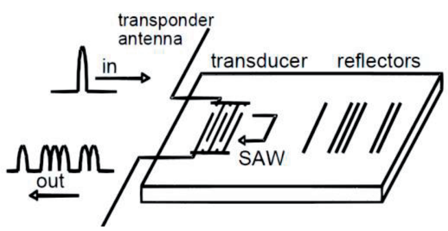

Fig. 1. Passive tag structure

The interdigital transducer is a device that transforms an electric signal from antenna to the surface acoustic waves that spread on the surface of crystal. Width of electrode in equidistant interdigital transducer is determined by: $p = \frac{v_a}{4f}$, where p is a width of electrode, v_a – is speed of SAW in the set crystallography direction, f – is frequency of electro-acoustic synchronism. Rayleigh waves spread on the surface of crystal until meet on the way of distribution the heterogeneity of environment called the reflectors, cause of that SAW are reflected. Reflectors on the surface of crystal can be executed as metallic electrodes or as the ditches got an etching in material of piezo substrate. Width of reflecting elements is also equal $p = \frac{v_a}{4f}$.

The acoustic impulses reflected from reflectors are modulated under the law of placing of reflectors. The interdigital transducer transforms this reflected pulse sequence to electromagnetic oscillation that is radiated with antenna and accepted back by reader.

The possessing of the accepted radio signal for extraction from them information takes place in reader.

II. FREQUENCY SHIFT KEYING SIGNALS

Radio signal with frequency shift keying (FSK) modulation is a set of rectangular radio impulses (symbols) adherent to each other. Filling frequency of symbols intermittently changes from an impulse to the impulse in compliance some law. Set M – the amount of impulses (symbols) in FSK signal. Filling frequency of impulses can take on either two values (binary encoding) or K of values (K-ary encoding).

The requirement produced to RFID tags is a large information capacity. Define the information capacity of signal as $Q = M \log_2 K$. At the binary encoding of $Q = M$ (bit). An information capacity can be megascopic at K-ary encoding. For example, at M = 16 and K = 16, information capacity Q = 64 bit, and at the binary encoding Q = 16 bit.

Therefore signals with K-ary modulation is researched. Oscillation frequency in symbols changes intermittently from a symbol to the symbol in accordance with a random code word. A code word (determines filling frequency of every symbol in a sequence of M symbols) is formed by the generator of the random uniform distribution numbers in a range from 1 to M. Oscillation frequency in symbols are similarly determined by the uniform distribution values, and get out from the range of frequencies $f_H, \ldots, f_B$, where f_H and f_B – lower and higher frequencies of the active width of FSK signal spectrum. An interval between contiguous frequencies of symbols is constant and determined from the condition $\Delta f = \frac{\Delta F}{K}$, where ΔF – is the active width of FSK signal spectrum, K – is a number of frequencies in the examined range. In general case ratio between M and K is arbitrary.

The formed FSK signal can be written:

$$S(t) = \sum_i A(t - iT)\cos[2\pi k\Delta f(t - iT)], \quad (1)$$

where

$$A(t) = \begin{cases} 1 & -\frac{T}{2} < t \le \frac{T}{2} \\ 0 & |t| > \frac{T}{2} \end{cases}, \quad (2)$$

where T – duration of symbol, Δf – a step of frequency change from a symbol to the symbol, i – a number of symbol in a signal, k – the random uniform distribution number in the range *(k=1.K)* that determine the value symbol filling frequency.

A tag is a passive device. Transformation of the electromagnetic waves taken from reader to the acoustic waves and reverse transformation take place with losses. Therefore reemitted from tag signal is too small. In addition, limit power of radiation of reader and loss on distribution of electromagnetic waves is cause of the small size relation signal to noise on the reader entrance. For the increase of this relation the principle of matched filtering is used.

A signal on the exit of the matched filter matches with the signal autocorrelation function (ACF) and can be written [1]:

$$S_{1ex}(t) = \psi_{11ex}(t) = \int_{-\infty}^{t} S_1(\tau)h(\tau - t)d\tau, \quad (3)$$

where $h(t)$ – filter impulse response for the matched filter $h(t) = S_1(-t)$, than expression (3) can be rewhitten:

$$S_{1ex}(\tau) = \int_{-\infty}^{t} S_1(t)h(t - \tau)dt \quad (4)$$

If the signal $S_2(t)$ comes on the entrance of matched with $S_1(t)$ filter, then a signal on the exit of filter is a cross-correlation function:

$$S_{2ex}(\tau) = \psi_{12ex}(\tau) = \int_{-\infty}^{\tau} S_2(t)S_1(t - \tau)dt, \quad (5)$$

$$\psi_{12ex}(\tau) << \psi_{11ex}(\tau)$$

A maximum of autocorrelation function is determined by energy of signal and does not depend on the form of signal. Therefore the possible method of realization of the RFID system can be described as. There is N tags, impulsive responses $h(t)_N$ that are known beforehand. Reader consistently radiates the signals of type $s(t) = h(-t)_N$. Thus only a *N*-th tag is matched with a query signal and reemits on reader a signal that consilient with the ACF of query signal. All other tags reemit a signal as a cross-correlation function (CCF) of query signal with the impulse response of corresponding tag. The system is built so, that the rationed maximal level of any of CCF are less than 0.3. This limitation allows to select useful signal that is reemitted with *N*-th tag by applying a threshold estimation distinguish on a background of the other marks responses.

Therefore the problem to create class of FSK of signals was set, that the any CCF maximum are not exceeded by 0.3 from the maximum ACF level.

III. THE ALGORITHM FOR SEARCHING FSK SIGNALS CLASS

The search of signals class is based on the parameters of the real SAW tags. Characteristics that limit the duration and active width of FSK signal spectrum are interdigital transducer bandwidth of transformation and time during that an acoustic impulse spreads along the crystal of tag. In practice, SAW tag realization is presently possible on central frequency $F_c = 450$ Mhz with the interdigital transducer bandwidth of transformation ΔF=128 Mhz. Duration of signal that constrained by the time distributions of wave on the surface of crystal is equal 2 us.

M is a common amount of symbols in gets out equal 20. Duration of symbol makes $\tau_c = 100$ ns. Amount of values of *K*, that frequency of symbol can accept, 32 equals, consequently a step of frequency between two nearby values is determined as $\frac{\Delta F}{32} = 4$ Mhz. *L* is an amount of addresses to the random generator of numbers, determined by a program algorithm.

STEP 0. Initial parameters are set: the period of sampling $T = 0.5 \cdot 10^{-9}$ sec is determined by the Nyquist–Shannon sampling theorem. Amount of counts in the symbol *N*=200, central frequency in the signal $F_c = 450 \cdot 10^6$ Hz and frequency deviation $\Delta F = 128 \cdot 10^6$ Hz. *M* = 20 is an amount of symbols in a signal. L gets out equal 10^3.

STEP 1. Formed vector of random numbers *k* length *M*: vector of random uniform distribution numbers in an interval from 1 to *K*, where *K* is an amount of possible values of symbol in a signal.

STEP 2. On the basis of random sequence FSK radio signal *N* symbols long is formed. Filling frequencies in symbols correspond to the values of elements of sequence.

STEP 3. Find the maximum ACF of FSK signal.

STEP 4. The first signal is written to the array of signal class.

STEP 5. In the arithmetic loop for *i=1, ..., L* step 1 and step 2 recur.

STEP 6. On every step of loop CCF of new signal with all signals from the array of the selected signals is calculated. If one of calculated CCF excels the set level, a signal is cast aside, otherwise a signal is written down in the array of "good signals".

STEP 7. On the basis of calculated code sequences array the correlation matrix of FSK radio signals is built.

IV. RESEARCH RESULTS

As a result of the conducted calculations class is formed from 100 signals, for that signals the rationed level of ACF equal 1, and the rationed (to the ACF maximum) CCF level all possible combinations of two signals from class did not exceed 0.3. Calculations show that the algorithm has a saturation property. With increasing number of signals in class the process of accumulation is slowed. Therefore the number of addresses to the generator of random numbers is limited. Correlation properties of signals class are confirmed by the correlation matrix shown on a fig. 2.

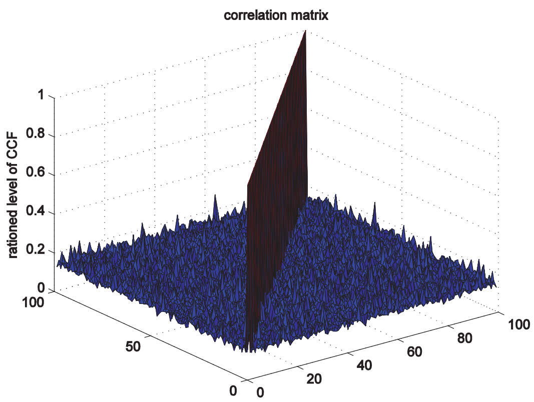

Fig. 2. Correlation matrix of FSK signals class

Sections of correlation matrix fig. 3 show an amount and position of pairwise signals combinations from class that CCF is excelled by the set level.

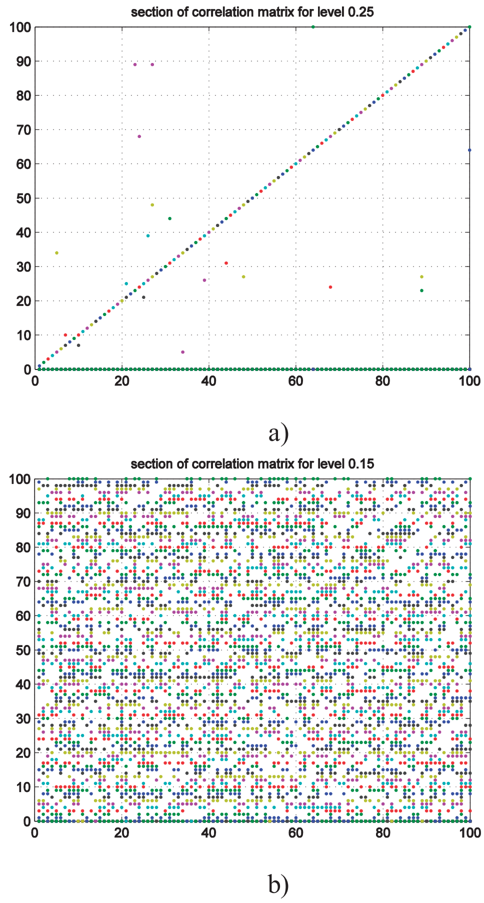

Fig. 3. Sections of correlation matrix for set level a) 0.25, b) 0.15

V. CONCLUSION

The created algorithm allows to find class of FSK signals. The amount of the selected signals of depends on time of calculations. With the increase of amount of signals in class the fast-acting of search diminishes. On the basis of the got code sequences is possible to build RFID system in that passive tags are executed on SAW.

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CHARACTERISTICS OPTICAL SPECTRAL DEVICE BASED ON ACOUSTO-OPTIC TUNABLE FILTER

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Abstract

As part of the research acousto-optic interaction is thought of as a bilinear transformation of the spectral components, which are radio and optical radiation. The result of the research is the relation describing the electrical oscillations at the output of the photodetector, which in turn are the result of the spectral measurements at different rates of change of the instantaneous frequency of oscillation control.

I. INTRODUCTION

Extremely widespread due to the importance of spectroscopic instruments and a variety of received information with their help, both in fundamental studies of the structure of matter, and for the solution of applied problems. Harmonic analysis is among the most important physical measurements, especially in the study of the optical signal range, as in the optical range – unlike radio range, where possible the study of signals in the time and space (oscillograms), and in the spectral space (spectrum analysis), dynamic optical signals range can be studied only by means of spectroscopic instruments, oscilloscope observation of optical signals is currently not possible.

Acousto-optical spectral instruments belong to the new diffractive optical spectral instruments. The principle of these devices lies in the fact that optical radiation is diffracted by grating structure in the form of acousto-optic modulator, which is generated by the acoustic wave spread along a selected direction of the crystal acousto-optic modulator. We can say that such devices are based on acousto-optic tunable filter [2].

However, to date, a number of problems in the theory of spectral instruments remains unresolved, in particular, has not been solved, such as the most important task of the theory of the effect of the speed of adjustment of the control frequency fluctuations in the metrological characteristics based acousto-optical tunable filter.

II. BILINEAR SPECTRAL TRANSFORMATION

Diffraction of light by acoustic waves explains fig. 1 [1].

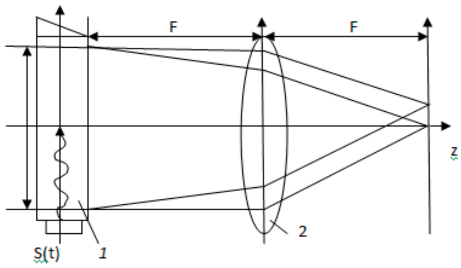

Fig. 1. Diffraction of light by acoustic waves
1 – solid acousto-optic modulator,
2 – cylindrical lens with a focal length F.

Find the light distribution in the plane z=F, making assumptions:

– transparency function is a linear map of the electric oscillations S(t), the exciting crystal acousto-optic modulator in a plane acoustic wave $U(x_1, t)$;

$$U(x,t)=\mathbf{V}_s(t), \qquad (1)$$

– where t – current time; V_s – linear operator transition from fluctuations s(t) to a uniform plane acoustic wave;

– plane light wave e(t), is normally incident on an acoustic wave $U(x_1,t)$;

– attenuation and dispersion of acoustic waves in the acousto-optic modulator crystal neglect;

– an optical Fourier transform processor comprising a cylindrical lens and two layers of space ideally performs either a spatial Fourier transform or spatial Fresnel transform [3];

– signals s(t) and e(t), determined by acoustic and light waves are adequately defined and Fourier-Stieltjes integrals

$$S(t)=\left(\frac{1}{2\pi}\right)\int_{-\infty}^{\infty}\exp i\omega'_s\, dt\dot{Z}_s(\omega'_s); \qquad (2)$$

$$e(t)=\left(\frac{1}{2\pi}\right)\int_{-\infty}^{\infty}\exp i\omega'_1\, dt\dot{Z}_1(\omega'_1) \qquad (3)$$

It is assumed that the fluctuations of e(t) correspond to a uniform plane light wave. The function

$A(\omega'_S, \omega'_1, x_2, t)$ is the kernel of the bilinear transform spectral

$$F(x_2,t)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} A(\omega'_S, \omega'_1, x_2, t)\, d\dot{Z}_S(\omega'_S) d\dot{Z}_1(\omega'_1) \quad (4)$$

If $\omega'_1 = \omega_{1_0}$const$_1$, $dZ_1(\omega'_1)=\delta(\omega'_1 - \omega_{1_0})d\omega'_1$ we get a comprehensive hardware function diffraction spectral instrument optical range in the fall of acousto-optic modulator homogeneous plane monochromatic light wave.

$$S(\omega_{1_0}, \omega'_S, x_2, t)= a\, exp i(\omega_{1_0} + \omega_S)\, t S_0(\omega_{1_0}, \omega'_S, x_2)= =\dot{a}\exp(\omega_{1_0}, \omega'_S)t \int_{-0,5L}^{0,5L} exp i\, [\omega_{1_0} x_2 \frac{1}{F}\frac{1}{C} - \dot{k}_s(\omega'_s)] x_1 dx_1. \quad (5)$$

At $\omega'_S = \omega_{S_0}$ = const$_2$, $dZ_S(\omega'_S - \omega_{S_0})\ d\omega'_S$, $\dot{k}(\omega_{S_0}) = \omega_{S_0}\frac{1}{v_0}$, we get a comprehensive hardware function diffraction spectral instrument optical range in the fall of acousto-optic modulator homogeneous plane monochromatic light wave.

$$\dot{L}(\omega_{S_0}, \omega'_1, x_2, t)= a\, exp i(\omega_{S_0} + \omega'_1)\, t L_0(\omega_{S_0}, \omega'_1, x_2)= a\, exp i(\omega_{S_0} + \omega'_1)\, t \int_{-0,5L}^{0,5L} exp i(\omega_{S_0}\frac{1}{v_0} - \omega_1^1 x_2 \frac{1}{F}\frac{1}{C}) x_1 dx_1 \quad (6)$$

where in the acoustic wave acts as a diffraction grating, thereby forming a structure in the form grating structure acousto-optic modulator.

Integrated hardware functions (5) and (6) define moving (instant) spectra and light electric oscillations, provided movement analyzed by fluctuations fixed window, and the ratio (4) makes sense superposition integral for the corresponding spectral instrument, that is the acousto-optic analyzer radio spectrum or diffraction spectral instrument optical range in the diffraction optical radiation grating structure in the form of acousto-optic modulator.

Since the information signals are adequately described in the theory of stochastic processes, in case the analysis of the spectrum of radio signals takes place deterministic diffraction light wave on a stochastic screen, and the analysis of the optical spectrum, diffraction occurs at a determinate wave stochastic screen.

For oscillations with finite spectrum frequency dependence can be approximated by entire functions on the basis of this and the Paley-Wiener $\dot{S}_0(\omega_{S_0}, \omega'_1, x_2)$ и $\dot{L}(\omega_{S_0}, \omega'_1, x_2)$ are entire functions of exponential type in both variables, their values at all points determined by two-dimensional sampling theorem in the spectral region.

Acousto-optic modulator in fig. 2 as an one-dimensional transparency, converts the complex amplitude of $E_1(x)$ incident thereon uniform plane light wave by the rule $E_2(x,t)=E_1T(x,t)$, where in E_2 (x,t) the complex amplitude distribution at the output face (the right along the axis z) of the acoustooptic modulator; T (x, t) – transparency function acousto-optic modulator as a banner.

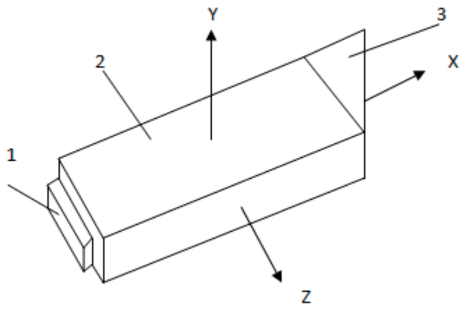

Fig. 2. Diagram of the acousto-optic modulator
1 – piezoelectric transducer, 2 – media, 3 – acoustic absorber

III. HARDWARE FUNCTIONS OF OPTICAL SPECTRAL INSTRUMENTS BASED ACOUSTO-OPTIC TUNABLE FILTER

In this paper the analysis of the optical spectrum at its diffraction by elastic waves excited by a periodic sequence of rectangular radio pulses with a duration τ with linear variation of the instantaneous frequency [1] and a repetition period 2T. Next there is a view of an idealized model of observing the diffraction of light by elastic waves, assuming that the condition.

To determine the integrated hardware functions is sufficient to consider one cycle of operation, this corresponds to an electrical oscillation as a function of time t,

$$s(t)=S_m\exp[-i(\Omega_0 t+0,5Mt^2)],\ t\in[-\frac{\tau}{2},\frac{\tau}{2}], \quad (7)$$

where M – the rate of change of the instantaneous frequency control electric fluctuations; Ω_0 – average frequency electric fluctuations.

$$M = \frac{d\Omega(t)}{dt} = \text{const} \quad (8)$$

Within the radio-optical analogies connection input-output optical processor under consideration is given by

$$g(x_1)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(\xi)\exp[i\gamma_1(\eta-\xi)^2]\, \exp(i\gamma_1\eta^2)\cdot exp[i\gamma_2(\eta - x_1)^2]d\xi d\eta \quad (9)$$

Integration over η leads to the expression

$$g(x_1) = \frac{\pi^{\frac{1}{2}}}{i}\exp(-i\gamma_1^2\frac{1}{\gamma_0}x_1^2) \int_{-\infty}^{\infty} f(\xi)\exp\left[i\gamma_0\left(\xi - \gamma_1\frac{1}{\gamma_0}x_1\right)^2\right]d\xi, \quad (10)$$

where $\gamma_0 = \gamma_1(1-\gamma_1\frac{1}{\gamma_2}) = \omega'\frac{1}{2c_0F_0}(1-z_0\frac{1}{F_0})$ we obtain from the original formula for the complex hardware function optical spectral device based on acousto-optic tunable filter

$$K(M,t,\Delta\omega') = A_0\,\omega' \int_{-L_0}^{L_0} \exp\left\{i\left[Mt\frac{1}{v} + \Delta\omega'\frac{1}{\omega_0}\ \Omega_0\frac{1}{v}\right]\xi\right\}\cdot \cdot \exp(\omega'\frac{1}{\omega_0}M2\frac{2}{v}\xi^2)\, d\xi. \quad (11)$$

IV. CONCLUSION

The present work shows the role of spectral measurements in the optical range and marked dignity optical spectral device based on acousto-optic tunable filter.

A general expression of complex hardware functions of optical spectral device based on acousto-optic tunable filter and parameters are specified on which it depends.

As a result of the research, it was found that the acousto-optic interaction can be considered as a bilinear transformation on the spectral components that are physically: radio spectrum and the spectrum of the optical radiation. In the general form of linear transformations defined by the expansions of the nonlinear operator in a Taylor series and the establishment of the linear approximation. This technique is suitable to describe the linear approximation of any dynamic physical system.

As a result of this work, a formula for calculating the square of the modulus of the instrumental function of the optical spectral device based on acousto-optic tunable filter. This formula takes into account all the parameters and modes of operation of the optical spectral device based on acousto-optic tunable filter.

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BIOMETRIC PERSON IDENTIFICATION SYSTEM AS ACCESS CONTROL AUTOMATION TOOL

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Abstract

Automation is one of the main directions in constructing and managing any complex system. The rapid development of information technology and modern security requirements require the use of the latest technologies in designing automated systems. One example of the information technologies usage in the field of automated access management systems is development of the biometric identification complex, which is working with person's image.

The paper presents developed recognition algorithm, structural scheme of the access management with the use of biometric person identification system and its competitiveness test in the field of automated security systems.

I. INTRODUCTION

Modern scientific and technical development level requires purposeful development of information technologies (IT) as one of the most important mechanisms to ensure effective interaction of technology with a human. The most important objectives of this development are maximization of the automation and multifunctional use of finite elements and subsystems. It is also necessary to pay particular attention to the indexes such as reliability, durability and accuracy, provided during complex systems' operations.

Today, modern IT is actively used in the field of security systems and access control. It is connected with constantly growing needs of mankind for the own safety. It is important to remember about human factor in the development of any security systems. Digital systems, in difference from person, do not know fatigue, do not take bribes and always strictly follow a certain algorithm. For this reason main objective in modern security systems design is full absence or minimization of human factor and maximization of automation of access control process.

Biometric person identification systems becoming more common, they allow to detect objects with high precision, by measuring physiological parameters and characteristics. Person identification technology is based on the face image, which is, unlike other biometric indicators (fingerprint, iris), do not require physical contact with the device. With the rapid development of digital technologies, this system becomes more acceptable for mass productions.

II. BIOMETRIC PERSON IDENTIFICATION SYSTEM

Developed as the request of the Federal Science and Innovation Agency, biometric person identification system (BPIS) is a fully automated control and access management system [1].

BPIS is the modern IT, representing unique complex of control and access management, which can simultaneously recognize more than 20 faces. BPIS's cameras have two matrix: for visible and infared ranges. So, shooting can be made in a full darkness. BPIS's purpose is automatic detection and identification of people's biometric features. Person identification is made by comparing biometric characteristics of individual citizens with the images databases using methods of constructing three-dimensional models from two-dimensional images [2].

Fig. 1 lists the basic requirements of access control systems, which are fully implements in BPIS.

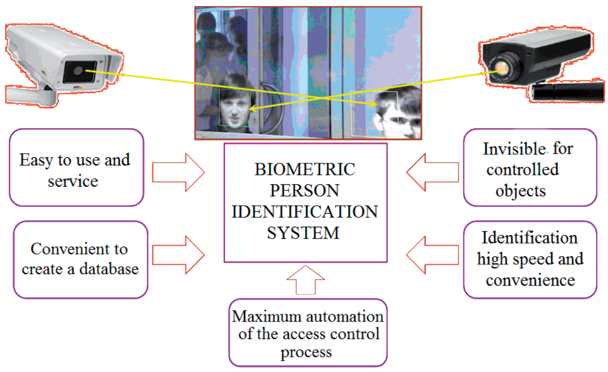

Fig. 1. Requirements which are implemented in BPIS

III. IDENTIFICATION METHODS

Typical scheme of functioning biometric identification can be describe as follows. At registration in the system the user must demonstrate one or several his own biometric signs. These signs (known as original) are registered by the system as control sample of legit user. Biometric sample is processed by the system for obtaining information in the form of the user's standard ID (USI), which is numerical sequence, at the same time the sample itself can not be recovered from USI. USI is stored in the system in digital form and used for identity check of everyone pretends to be a legit user. User characteristic, which have been taken in the process of identifying, is comparing to USI. Depending on match degree system consider this user legit (if match degree is high) or illegal [3].

In the recent years there have been propose a lot of various image recognition methods and algorithms, such as principal component analysis (K. Pearson), neural network methods (D. Hinton, H.A. Rovli), standards comparison methods (H. Davoud, J. Janier), Viola-Jones object detection framework [4], methods, based on geometric face characteristics (D.I. Samal, V.V. Starovoytov), hidden Markov models (L.E. Baum, J. Baker, F. Jelineck, M. Slimane), discriminant function analysis (R. Fisher), elastic graphs comparison methods (L. Wiskott, J. Fillous) [5] and others.

However, none of these methods can not fully solve the automated recognition problem. The main disadvantages of these methods are [6]:

– insufficiently high recognition correctness rates within single standard;

– high algorithmic complexity, leading to inability to apply these methods in real-time with lots of images in database;

– need of exact centering and scaling of the recognized images, which makes algorithms more complicated;

– basic inapplicability in case one standard.

BPIS uses several methods simultaneously. Main goal in combined use of different methods is bigger use of the information from one image. Various algorithms for image conversion and feature vectors construction, used in BPIS, allow to recognize different types of objects.

Besides already existing methods, BPIS offers the following new recognitions procedures:

– cascade method of application image processing algorithms [6], allowing to use various cards of images brightness for recognition, and also to reduce the number of feature vectors' elements, that speeds algorithms up;

– method, based on ordinal histograms [6], which produces statistical study of small-textural features of recognizable object, not its contours, making this method more robust to camera angles.

Recognition methods, which are implemented in BPIS have the following advantages:

– hossibility to use BPIS to recognition of various objects;

– using different image processing procedures allows to make recognition simultaneously from various transformations' positions;

– methods work independently, that allows to receive more reliable results;

– due to high computational complexity of the algorithms, there is software accelerate of recognition procedures.

Such software integration of different methods allows BPIS to fully solve automated face image recognition task.

IV. ACCESS CONTROL PROCESS WITH BPIS

Fig. 2 shows the block scheme of access management with BPIS, base on BPIS's component's presented data.

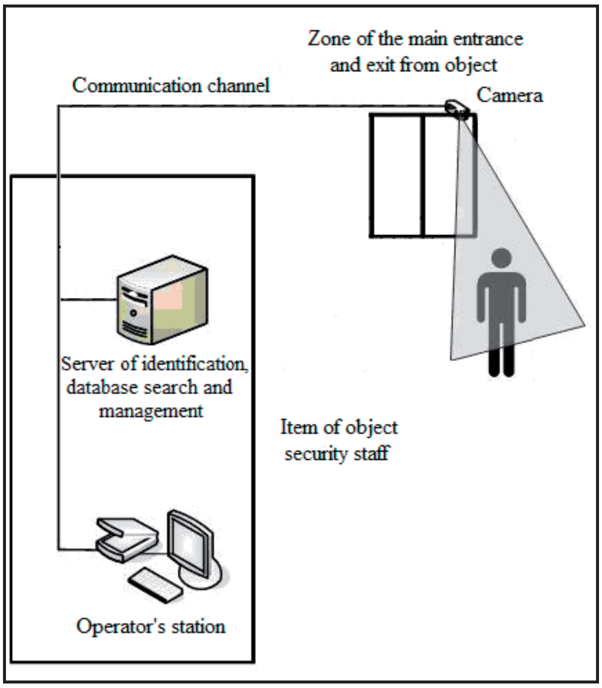

Fig. 2. Control management process scheme

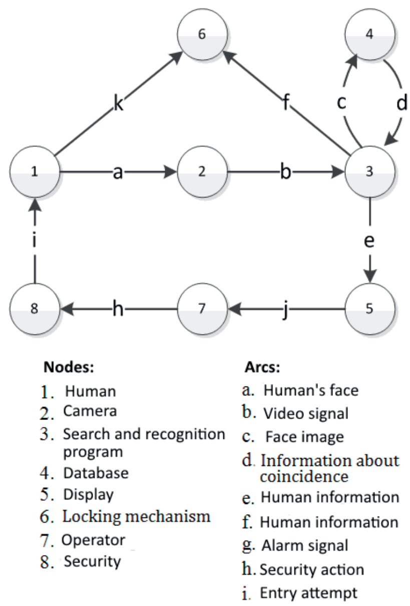

Fig. 3. Access control management

Three seconds after a man enters "control zone" his information comes to complex's operator. During this time, the systems compares the image, which is obtained in real time, with image from database by several hundreds parameters [1].

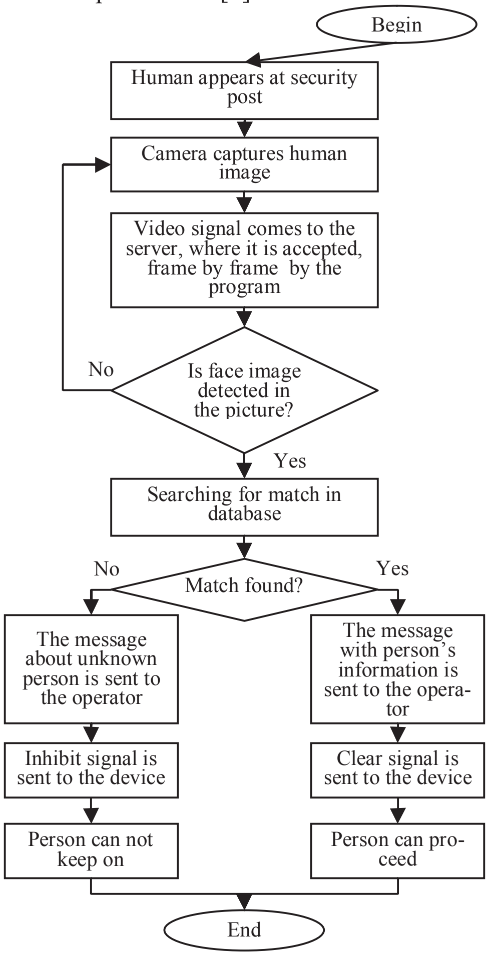

Fig. 4. Recognition process algorithm

Access control process using BPIS can be represented as a connected directed graph (fig. 3).

The developed algorithm of person recognition process is shown in fig. 4.

Thus, BPIS use helps to minimize the human factor and maximize automation in the access control.

V. BPIS'S COMPETITIVENESS ANALYSIS

As a result of the carried out earlier the comparative analysis BPIS's competitors [1, 2], including traditional types of control and automated systems, it has been revealed that BPIS sufficiently competitive automated system.

One of the most common automated identification systems among BPIS's competitors is biometric fingerprint system. However, such system have significant drawback - for receiving access on protected territory direct contact with controller person is necessary for scanning, that does not allow to automate properly access control process. In addition, it prevents the application of this method for identification in the flow of people or identifying on a distance. In such cases, face identification seems to be most effective method, which is used in BPIS.

For the purpose of verifying the competitiveness of BPIS and its high automation level the GAP analysis (fig. 5) was carried out, which showed that for most items quality indexes of BPIS not only cover almost all market demands, but also have a sufficiently high level of competitiveness in the field of automated access control systems

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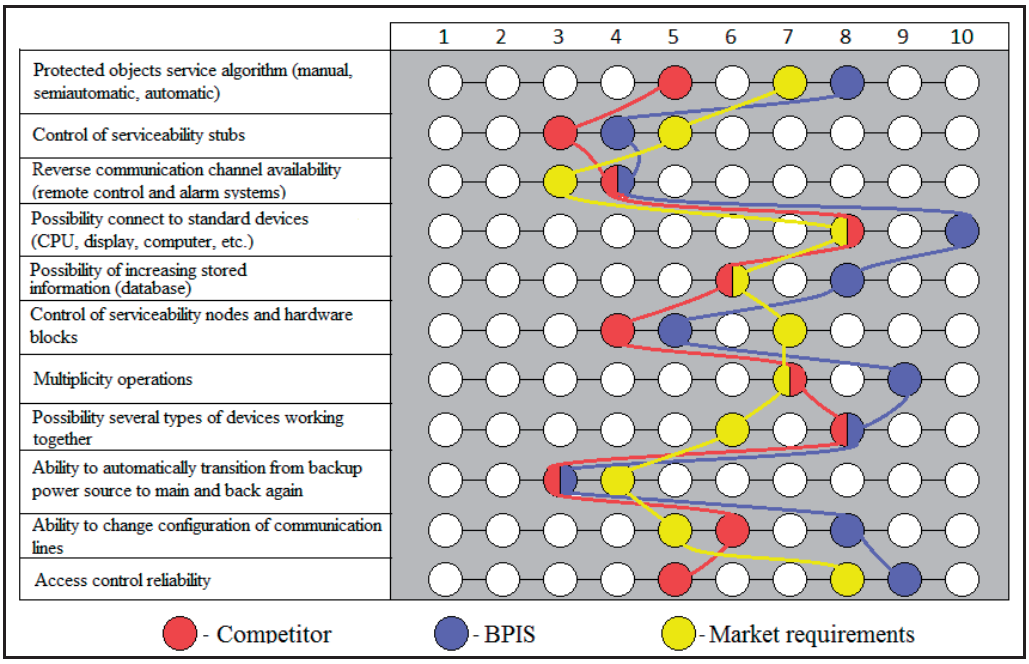

Fig. 5. GAP-analysis

Proceeding from the carried-out analysis it is possible to make the conclusion that BPIS is rather reliable, automated and competitive system. This system will give any company maximum automation of access control process and will reduce costs by reducing staff count.

The disadvantages of BPIS (and other high-security systems) can be its high value [1]. However, this fact is drawback only for companies with limited financial opportunities and it can be liquidated by the use of cheaper accessories of the system.

VI. INFORMATION TECHNOLOGY'S ROLE AT COMPETITIVENESS INCREASE

Competitiveness of automated systems and organizations in which these systems are used, is in many ways connected with the level of the development of IT branch: constantly increasing computing power of microprocessor, volume and reliability of memory elements, etc. allow to provide compliance of the automated systems to the growing requirements of the modern world. The use of new IT allows to increase productivity of automated systems that provides additional competitive benefits.

In order to maintain competitiveness of BPIS in the field of the automated security systems, as recommendations offered regular increase its productivity by improving not only the software, but also the hardware of the system due to use new IT. This in turn will enhance the automation of the process and quality of access control.

VII. CONCLUSION

The use of the modern IT in security systems allows to reach an adequate level of automation and reliability of the access control process.

The biometric person identification system, developed by young Russian inventors is great achievement in the field of modern IT. BPIS's software combines the synergy of different recognition methods, that fully allows it to solve image recognition task. Due to cameras in BPIS's hardware, identification can be made even in total darkness.

The paper presented the block diagram of access control process using BPIS, recognition algorithm and competitiveness analysis.

According to the results of the analysis, it can be concluded, that BPIS is sufficiently reliable and competitive. Furthermore, this system will allow any company to automate access control process and eliminate the possible negative influence of a human factor.

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MODELING OF SPECTRAL EFFICIENT SIGNALS BASED ON FINITE SPLINES

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Abstract

Spectral efficient signals based on finite splines, which are obtained by repeated usage of discrete convolution procedure, are considered. An energy spectrum of random sequence of signals is presented. Practical realization of device for generation and reception is proposed. Generation of SEPSK signals is done by matched filter with feedback line. Proposed method for reception of SEPSK signals is similar to method for reception of classical OFDM signals. High reduction rate of out-of-band emissions for random sequence of SEPSK signals is provided by proposed atomic functions.

Keywords: SEPSK, atomic functions, finite spline, out-of-band emissions.

I. INTRODUCTION

Application of spectrally efficient signals with phase shift keying (SEPSK), constructed on the basis of atomic functions or finite splines [1, 2], allows to obtain efficient compression of the energy spectrum of a random sequence of signals. Application compression method based on atomic functions allows the usage of their formation and receiving simple to implementation approach based on the calculation of convolution and deconvolution of functions [1].

The objective of this paper is to study possibility of realization of device for forming and receiving SEPSK signals, obtained based on atomic functions.

II. BASIC PROPERTIES OF ATOMIC FUNCTIONS

Atomic functions has properties of polynomials and splines [1]. Splines of degree γ are functions which are "piecewise" polynomials of degree γ. Reduction of out-of-band emissions for signals on the basis of finite splines of degree γ is equal to $C/\omega\gamma + 1$ (if all derivatives of the envelope of signal up to $(\gamma - 1)$-th order have no discontinuities, and γ-th derivative is everywhere finite). Distinctive features of the atomic functions are:

- analyticity;
- combination of finitely of function and high decreasing rate of Fourier transformation (faster than any power);
- connection with the derivative of functions and explicit expression for the spectrum.

Let`s consider generation of spectral efficient signals with duration T and based on application of finite splines. Repetition of convolution of basis functions is used for generation those signals. For rectangular form of envelope for PSK signals with amplitude A and centered about start of timing

$$a(t) = \begin{cases} A, & |t| \le T/2 \\ 0, & |t| > T/2 \end{cases}. \quad (1)$$

N-fold convolution $(N + 1)$ $a(t)$ may be represented in the form of finit splines $\Theta_N(x)$ [1]. Expression (1) may be rewritten as follows:

$$\varphi(t) = \frac{A}{2\pi} \int_{-\infty}^{\infty} e^{jut} \frac{\sin(u/2)}{u/2} du. \quad (2)$$

We obviously have for (2):

$$\varphi(t) = \mathrm{F}^{-1}\left[\nu(u)\right],$$

where $\mathrm{F}^{-1}\left[\nu(u)\right]$ – Fourier transform of function $\nu(u) = \dfrac{\sin(u/2)}{u/2}$. Convolution of functions can be written (using the theorem of Borel and the symmetry of the Fourier transform):

$$\varphi(t)*\varphi(t) = \mathrm{F}^{-1}\left[\nu^2(u)\right]. \quad (3)$$

Then:

$$\varphi(t)*\varphi(t) = \frac{A^2}{2\pi} \int_{-\infty}^{+\infty} e^{jux} \left[\frac{\sin(u/2)}{u/2}\right]^2 du. \quad (4)$$

This process may be repeated N times for obtaining more smoother function, i.e. calculation of convolution procedure functions such $\varphi(t)*\varphi(t)*\ldots*\varphi(t)*\ldots$. Thus, the result of infinite convolution is a new finite function defined on the interval $[-NT/2; NT/2]$.

III. FORMATION OF SPECTRALLY EFFECTIVE SIGNALS ON THE BASIS OF ATOMIC FUNCTIONS

In general, we can write the expression for the spline $\Theta_N(t)$ for any value of N by next expression:

$$\Theta_N(t) = \frac{A^{N+1}}{2\pi}\int_{-\infty}^{\infty} e^{jut}\left(\frac{\sin(u/2)}{u/2}\right)^{N+1} du. \quad (5)$$

Let`s consider the form of the function $\Theta_N(t)$ for $N = 1\ldots5$.

For $N = 1$:

$$\Theta_1(t) = \frac{A^2}{2\pi}\int_{-\infty}^{+\infty} e^{jut}\left[\frac{\sin(u/2)}{u/2}\right]^2 du\ ;$$

$N = 2$:

$$\Theta_2(t) = \frac{A^3}{2\pi}\int_{-\infty}^{+\infty} e^{jut}\left[\frac{\sin(u/2)}{u/2}\right]^3 du\ ;$$

$N = 3$:

$$\Theta_3(t) = \frac{A^4}{2\pi}\int_{-\infty}^{+\infty} e^{jut}\left[\frac{\sin(u/2)}{u/2}\right]^4 du\ ;$$

$N = 4$:

$$\Theta_4(t) = \frac{A^5}{2\pi}\int_{-\infty}^{+\infty} e^{jut}\left[\frac{\sin(u/2)}{u/2}\right]^5 du\ ;$$

$N = 5$:

$$\Theta_5(t) = \frac{A^6}{2\pi}\int_{-\infty}^{+\infty} e^{jut}\left[\frac{\sin(u/2)}{u/2}\right]^6 du\ .$$

Form of envelope $a(t)$ of SEPSK signals for each value of N is determined by function $\Theta_N(t)$. $a(t)$ for $N = 1,\ldots,5$ is shown on fig. 1. Normalized duration of SEPSK signals for $N = 1, \ldots, 5$ is increased from $T = 0.2$ to $T = 0.6$ at this figure. SEPSK signal for $N = 0$ has rectangular form of envelope (1) and duration $T = 0.1$. The degree of smoothness of the envelope of SEPSK signals with fixed energy increases with increasing of N (fig. 1).

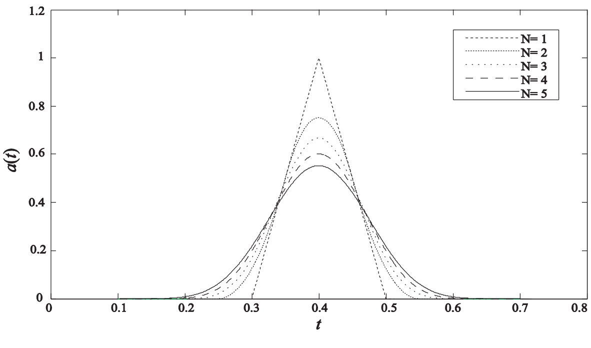

Fig. 1. Envelope $a(t)$ of SEPSK signals

Spectrum of random sequence of SEPSK signals, whose number is M, may be represented in the following form:

$$S(\omega) = A\int_0^{MT}\sum_{k=0}^{M-1} a(t-kT)\,d_r^{(k)}\cos\omega_0 t\cdot\exp(-i\omega t)\,dt =$$

$$= S_+(\omega) + S_-(\omega),$$

where

$$S_+(\omega) = \frac{A_0}{2}\int_0^{MT}\sum_{k=0}^{M-1} a(t-kT)d_r^{(k)}\exp(-i(\omega_0+\omega)t)dt,$$

$$S_-(\omega) = \frac{A_0}{2}\int_0^{MT}\sum_{k=0}^{M-1} a(t-kT)\times d_r^{(k)}\exp(i(\omega_0-\omega)t)dt$$

and values of symbols of message depends on the location of symbol in the sequence and the index $r = 1, 2$. In particular, $d_1^{(k)} = 1$ and $d_2^{(k)} = 2$; $r = 1, 2$.

After the change of variable $x = t - kT$:

$$S_+(\omega) = F_a(\omega)\sum_{k=0}^{M-1} d_r^{(k)}\exp\left[-i(\omega_0-\omega)t\right],$$

where

$$F_a(\omega) = \int_0^T a(t)\exp\left[-i(\omega_0\right] \ .$$

$F_a(\omega) = \frac{A}{2}\int_0^T a(t)\exp\left[-i(\omega-\omega_0)\right]dt$ – spectrum of envelope $a(t)$.

Energy spectrum of random sequence of signals is calculated with tendency of M to infinity:

$$G(\omega) = \lim_{M\to\infty}\frac{1}{MT}m_1\left\{|S(\omega)|^2\right\}$$

and the mathematical expectation $m_1\left\{|S(\omega)|^2\right\}$ is determined by averaging over all possible finite sequences of symbols $d_r^{(k)}$.

Expression for energy spectrum (for narrowband signals) has the next form:

$$G(\omega) = G_+(\omega) + G_-(\omega),$$

where

$$G_+(\omega) = \lim_{M\to\infty}\frac{1}{MT}m_1\left\{|S_+(\omega)|^2\right\}.$$

It is easy to show that:

$$m_1\left\{\left|S_+(\omega)^2\right|\right\} =$$

$$= \left|F_a(\Delta\omega)\right|^2\sum_{k=0}^{M-1}\sum_{l=0}^{M-1}\exp\left[-i\Delta\omega(k-l)\right]m_1\left\{d_r^{(k)}d_q^{(l)}\right\},$$

where $\Delta\omega = \omega - \omega_0$.

For case of equally probable and independent symbols:

$$m_1\left\{d_r^{(k)}d_q^{(l)}\right\} = \begin{cases}1, & k = l,\\ 0, & k \neq l.\end{cases}$$

The final expression for calculating the power spectrum of the random sequence of SEPSK signal in area of $\omega > 0$:

$$G_+(\omega) = \lim_{M\to\infty}\frac{1}{4MT}\left\{M\left|F_a(\Delta\omega)\right|^2\right\} = \frac{1}{4T}\left|F_a(\Delta\omega)\right|^2.$$

Thus, energy spectrum of random sequence of SEPSK signals is determined by Fourier transform of single signals and has same frequency bandwidth.

Energy spectra for random sequences of SEPSK signals, which form of real envelope is finite splines, is shown on fig. 2. Normalized energy spectrum are presented on Y-axis, relative frequency $(f - f_0)T$ (where f_0 – central frequency) is shown on X-axis. As expected, the rate of out-of-band emissions increases with increasing of N.

We can see from analysis energy spectra of those signals that the reduction of out-of-band emissions is very high for large values of N (for example, $N = 3\text{-}5$).

The advantage of these signals is the principle of their generation and reception based on multiple repetitions of the convolution of functions.

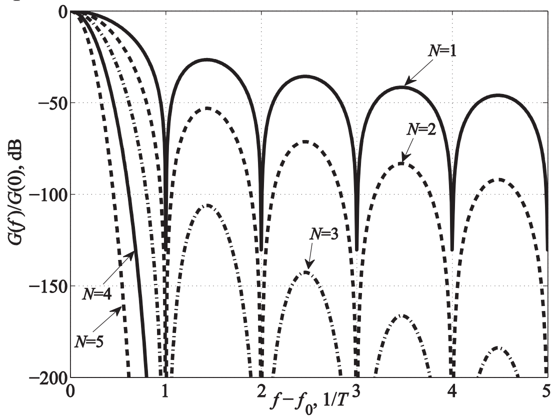

Fig. 2. Energy spectrum of SEPSK signals for $N = 1,\ldots,5$

Functional scheme of device for generation spectral effective signals based on finite splines is shown on fig. 3. This device is constructed by using matched filter with adjustable feedback. The impulse response of this filter has the envelope, which form is determined by (1). Signals from matched filter`s output come to input of delay line. Time delay of the filter response is determined by value of $N$. Delay of signal from matched filter`s output is equal to $2T$ for $N = 2$.

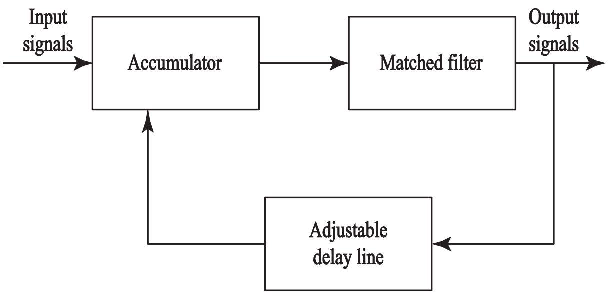

Fig. 3. Functional scheme of device for SEPSK signals generation

Voltage from matched filter`s output is transferred to its input again after calculating first procedure of convolution. Result of calculating second procedure convolution is response of matched filter as spline $\Theta_2(t)$. This spline is the same as form of envelope $a(t)$.

Reception of SEPSK signals may be done by several stage. On first stage, input process is converted to frequency domain by Fourier transform. On next stage, reception device must do nonlinear procedure of N-th degree root extraction from frequency function. Conversion to time domain by Fourier inversion is done on final stage. Output result is transmitted to classic demodulation algorithm, which based on application of correlation processing of PSK signals with rectangular form of envelope.

Of course, the proposed method of reception for SEPSK signal is not optimal. However, this method is simple (especially with usage of matched filter for realization). Proposed method for reception of SEPSK signals is similar to method for reception of classical OFDM signals.

IV. CONCLUSIONS

High reduction rate of out-of-band emissions for random sequence of SEPSK signals is provided by proposed atomic functions (finite splines). In particular, reduction of out-of-band emissions is equal to $1/f^{6}$ for 2–3 iterations of convolution.

Generation of SEPSK signals is done by matched filter with feedback line. Reception of SEPSK signals is performed sequentially for 3 stage. On the first stage transformation of input mix of signals with additive noise to frequency domain is done. On next stage, reception device must do nonlinear procedure of N-th degree root extraction. Reverse operation (transformation to time domain) is performed on final stage.

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REAL-TIME BUS LOCALIZATION PLATFORM IN “KORE” UNIVERSITY CAMPUS OF ENNA

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Abstract

In this paper a particular architecture for real-time bus localization within the area of “Kore” University Campus of Enna is described. Each bus is equipped with a system capable to send the GPS position to a server periodically. Students and passengers can interact with the server by using an ad-hoc Mobile Application so they can follow the buses on their smartphones and tablets and can optimize their waiting time. Moreover, the platform can be used for security purposes thanks to the monitoring of buses during the night when they are parked outdoor.

I. INTRODUCTION

The fast-growing popularity in the use of smartphones and tablets is leading to the implementation of new services through these devices as well as the extension to the mobile-world of the services usually used in traditional modes. An example is the continuous research to improve transport applications and in personal mobility field [1–3].

In this paper a particular architecture for real-time bus localization within the area “Kore” University Campus of Enna is described. This system allows students to monitor the position of the buses (usually known as KoreBuses) that connect the departments of the university.

Also in other university cities, not only in Sicily, a mobile platform for real-time bus localization has recently been activated [4, 5], improving the passengers’ travel experience and allowing them to have a more efficient use of their time, especially in case of students who have very strict requirements for school schedules.

So this project is a good contribution to optimize the waiting time and the movement of students within the schools/university campus and the city. But the architecture can be easily extended to the entire transportation network of the city, thus extending the benefit of optimizing the waiting time for all citizens.

This paper is organized as follows. In Section II describes the proposed architecture, in Section III some evaluations are presented, in Section IV conclusions and future works are presented.

II. THE ARCHITECTURE

System model

The basic components of the proposed architecture are:

- buses to be localized (KoreBuses);
- server platform;
- mobile application.

KoreBus

Each KoreBus is equipped with an integrated device capable to collect travel data and send them to a remote server. The device mainly consists of:

- a GPS module to manage the position and others useful data;
- a SIM Card module, for mobile network connection, in order to transmit the information received to the server;
- a cable for properly power supply;
- a set of diagnostical Leds and USB interfaces.

When the bus moves this device sends periodically an identification string to Server by using the mobile connection. This string mainly contains the bus ID, the GPS position, the speed of the bus and a timestamp information.

Server stores this information and make it available to the client Apps by means of a Web Service.

Students can follow the KoreBus position on their mobile devices by using these Apps.

GPS is a well-known solution for outdoor localization and it is used in many application for monitoring the vehicles on the road, especially for public transportation [6, 7].

The mobile network coverage (UMTS/LTE) over the city of Enna has already reach an acceptable level so it is possible to have a continuous connectivity along the routes of KoreBuses. So it is possible to use cellular data to send periodically the bus position to Server.

Server Platform

Server acts as intermediary between the buses and the client applications. The platform has three main functions:

– receive the coordinates from the buses,
– store them in a SQL database,
– make possible the server/client communication for Apps by means of a Web Service.

Database maintains the data about routes and average stop time within a certain period of time (weeks/months) for statistical purposes The use of Web Services on the World Wide Web is related to the need of more flexible communication between heterogeneous application and interoperability.

A Web Service has an interface described in a machine-processable format (WSDL) and client applications interact with the server side by using a prescribed protocol (SOAP) [8].

Mobile Application

The mobile application can show:

– the real-time position of the buses;
– the information about routes and timetables.

III. EVALUATION

The benefits of the introduction of this solution can be tested considering the following scenario. The survey is based on data collection of 50 passengers, observed for 30 days in rush hours.

The passengers know the timetables of the bus routes, so they usually arrive to their bus stop in advance on the scheduled time. Our analysis has considered three different stops along the bus route:

– A: Terminal Bus;
– B: Bus Stop at half route;
– C: Last stop before reach the Terminal Bus again.

The following table (Table 1) reports three measurements:

– average Time of Delay of the buses in rush hours,
– average Time of Advance with which passengers arrive at the bus stop (A,B,C),
– total Waiting Time of passengers at the bus stop (A, B, C).

Table 1.
The bus timetable and passenger waiting time

Bus Stop	***A***	***B***	***C***
Average Time of Delay - BUS (minutes)	2	12	16
Average Time of Advance - PASSENGERS (minutes)	5	12	19
Total Waiting Time - PASSENGERS (minutes)	**7**	**24**	**35**

The total waiting time at the bus stop is the sum of the first two measurements.

In rush hours (Table 2) the delay of the bus varies from 2 minutes (for bus stop A) up to 12 minutes (for bus stop C). So the passengers respond to this unpredictability moving to their bus stop in advance (here explained the average waiting time).

Table 2.
The bus timetable and passenger waiting time in rush hours

Bus Stop	***A***	***B***	***C***
Average Time of Delay - BUS (minutes)	~~2~~	~~12~~	~~16~~
Average Time of Advance - PASSENGERS (minutes)	4	5	4
Total Waiting Time - PASSENGERS (minutes)	**4**	**5**	**4**

The introduction of a reliable mechanism of bus real-time localization makes possible to users to optimize their waiting time at a specific bus stop. In this case, thanks to the predictability about the arrival of the bus, the Total Waiting Time at the bus stop is related only with the Time of Advance.

For passengers at the bus stop A there is an advantage in terms of waiting time of 3 minutes, for passengers at the bus stop B: 19 minutes, passengers at the bus stop C can spend 31 minutes more for their activities rather than stay at bus stop in busy waiting (Table 3)!

Table 3.
Total Waiting Time for passengers at the bus stop after the introduction of the platform

	Bus Stop	***A***	***B***	***C***
BEFORE	*Total Waiting Time - PASSENGERS (minutes)*	7	24	35
AFTER	*Total Waiting Time - PASSENGERS (minutes)*	4	5	4
ADVANTAGE	***Average Waiting Time - PASSENGERS (minutes)***	**3**	**19**	**31**

In addition to the advantage of localization features for mobile users, this platform allow also the monitoring of the buses during the night when they are parked in outdoor, and the monitoring of any critical situation (theft of the vehicle or accidents). So this system takes account of the security of the buses, for example they can also be equipped with ad-hoc sensors to monitor fire or unauthorized opening of fuel tank for example by night.

Considering the implementation cost of the project is something acceptable:

- the growing use of mobile connections in the last few years has lead also to cheaper data plans;
- the cost of hardware components embedded in the localization device is also fairly sustainable (GPS/UMTS modules, sensors, leds and interfaces);
- the human-cost of programming the server/client platform is null because the students of the courses in programming languages have implemented this work.

IV. CONCLUSIONS

In this paper a particular architecture for real-time bus localization within the area of Enna "Kore" University campus has been presented. This system allows students to monitor the position of the Kore-Buses that connect the departments of the university.

The students showed interest and appreciation towards the application since it helps them on various aspects of university life.

Future works will regard:

– the extension of the localization service also to all other bus routes of the city;

– the implementation of a path-finding algorithm to determine the bus route more suitable to reach a specific destination;

– the capability of the mobile application to be "social" by sharing real-time information about traffic and shops along the bus routes written directly from the passengers.

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AN ANDROID-BASED APPLICATION WITH THE AIM OF BEING A GUIDE FOR TRAVELLERS

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Abstract

The use of mobile devices is growing thanks to modern mobile operating systems that enable the development and the deployment of applications in various contexts. A lot of applications for Android and iOS devices have been implemented in order to guide travelers in their touristic experiences. In this paper a novel and innovative Android application with the main aim to lead travelers through an itinerary based on their own preferences is introduced.

I. INTRODUCTION

In recent years, there has been a rapid growth of the numbers of mobile devices available in the market (such as Tablet, Smarthphone, Smarthwatch and so on...) in order to facilitate the execution of a habit action that the user performs during the day. Simultaneously, to act as a support to this sudden growth, both the hardware and software of these devices were, from time to time, optimized to ensure a usage experience always better. This translates in a strong freedom of the developer that can realize the application in various contexts. A lot of applications for mobile devices have been implemented to act as a tour guide for the user such as in [1–3].

In this paper is proposed an innovative Android application that achieves this purpose. The guidelines that outline the project are numerous; first of all, one of the main targets in the development of the application is trying to make as simple and natural as possible the interaction with the user that must be able to fully exploit the potential of the application without having to perform too many operations. On the other hand, an equally important aspect assumes the cultural component through which the technology can be rediscovered and stranded out.

These are the principles behind the Android application called "Author's Guide", still in development phase. The implementation of this app follows simple architecture. There are provided a series of multimedia itinerary within the Enna area, each of which is targeted to make discover a particular facet of our lands. In order to improve further the user experience, was forecasted, in a future release of the app, a feedback system through which the device will be able to provide advice on the stages to be visited as a function of the previous actions of the user.

This paper is so organized: in Section II is provides an overview on Author's Guide application. Section III showed a brief statistic of the usability of the application. Finally, Section IV summarized the paper by discussing of the several future works in order to improve the app.

II. "AUTHOR'S GUIDE" APPLICATION

"Author's Guide" application (fig. 1) is available on all Android devices with operative system equal to or higher to Jelly Bean 4.1.

Fig. 1. "Author's Guide" for Android device: Splash Screen view

The application includes a number of itineraries; each of them is composed of a set of stages to be able to visit within the Enna area. A different expert will tell every route. For any stages are supplied multimedia content that surround the user's visit experience with many additional information and details, such as customs and traditions typical of the territory. Furthermore, the user, in proximity of a particular point of interest, can listen to an audio file that contains the comment of an expert.

The implementation of the application has followed the basic rules of interaction that Android gives to developers in order to ensure natural and direct control of it. The goal was that the navigation across the different views should be as clear as possible, for this reason the Author's Guide application implements a Tab Bar scrollable (fig. 2) which allows passing through one view to another simply sliding in the direction of that view or even tap the relative Tab Bar icon.

Fig. 2: Author's Guide: Tab Bar scrollable and Action Bar

"Home" section contains news and information about the new itinerary, the stages in the proximity that an user can visit or even restaurants or hotels in which can eat or rest. In addition, in this section the user will find the integration with the Facebook page of the app were each user can share his opinion or advice about to choose a stage rather than another; were he ate better or the room where he had the best view.

The "Maps" section is filled entirely by a map where is shown our actual position and all restaurants, hotels and stages in the neighborhood.

Finally, in the "Itinerary" section it is possible to find the available itinerary from which you can access all the stages of a particular route. Moreover, from this area it is possible to start the navigation to all the stages closest to my current position that belong to the particular itinerary that was chosen in the previous step and so begin the discovery of the territory.

Author's Guide is optimized also for Android tablets (fig. 3) exploit the size of these devices in order to show information organized in optimal manner.

Fig. 3: Author's Guide for Android tablet: Splash Screen view

III. USABILITY STATISTICS

In order to testing our first version of Author's Guide it was decided to perform a statistic to determine the popularity rating of the app from the users. At this purpose, was considered a sample of 200 people. Each of these has used the app for a whole week. After that every user have reported what, according to him, were the strengths and weaknesses of our application, showing what they liked and what they would change. Finally, on the base of his experience, to the user was asked to give a score from 0 to 100 to evaluate its approval rating toward the app which are summarized by the pie chart (fig. 4).

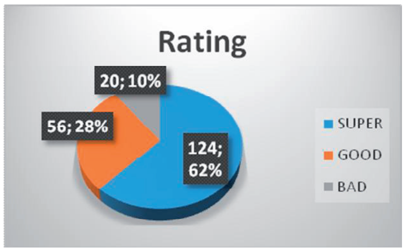

Fig. 4: Pie chart that measures the level of appreciation of Author's Guide

IV. CONCLUSIONS AND FUTURE WORKS

In this paper it was shown a real implementation of the Android application Author's Guide. Many users showed interest and appreciation towards the application since it is shown a lot of information and curiosity about a particular point of interest. This is a clear signal that the future of mobile platforms is in Information Technology (IT). A new version of the Author's Guide will be officially released as soon as possible and will implement a new feedback system that will lead to greater interaction with the user. The main idea is that the user, in a first step, will tell to the app his tastes about art, history, religion and so forth. So the application according to the parameters received, make a preliminary estimate of the user's interest and may calculate, based on these, a route made ad-hoc for him. Such interest may be refined by using the app. For instance, if the user is located at a particular point of interest, the new platform will put at his disposal a series of methods so that the user can express his opinion about the place he is visiting or can share a photo or rating a restaurant or a hotel or even give his opinion on the itinerary. The system will collect all this information in his database and through a particular algorithm will improve the other stages of that itinerary and the places where the user can eat or rest. The main goal is to continue and keep up the excitement of the visitors by introducing new approaches to learning the uses and costumes of our land with the help of new useful services because of an effective management of the territory resources.

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OBJECTS FOR AUTOMATION IN TRANSPORT NETWORKS ON THE EXAMPLE OF APPLIED PROGRAM PTV VISSIM

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Currently, the main problem in metropolis is the control of traffic flow (TF).The constant increase in public and personal vehicles, inevitably leads to overload of the road network, long hours of traffic jams, difficulties in moving for pedestrians and an increase in the amount of road accidents [1].

To solve these problems intelligent transport systems (ITS), which are in constant development, are used. At the core of ITS lie innovations in modeling transport systems and traffic management: it provides automatic and continuous monitoring based on data on the position and speed of vehicles and data from video cameras. The result is real-time information about the safety, quality and level of interaction of road transport (including infrastructure, vehicles, participants in the system, as well as traffic regulation) with other transport modes, as well as a prediction of the behavior of vehicles in the road network [2].

There are two approaches for prognosis traffic flow: comparative analysis and simulation. A significant drawback of the first method is that it compares with the past, without taking into account possible changes or deviations. Simulation allows predicting the consequences of unforeseen events and helps to apply countermeasures in areas with the high density this method gives us a full picture of possible changes in the traffic situation on the roads. Therefore it is necessary to consider this option in more detail on the example of software system PTV Vissim.

PTV Vissim allows simulating the movement of personal and public transport, and what is more important, verifies hypotheses on automation engineering organization of the movement flows. Key features:

– assessing the impact of the type of intersection bandwidth;
– design, testing and automation modes of traffic lights. Assessment the impact of the nature of the traffic flow;
– evaluation of the effectiveness of proposed transport measures;
– analysis of the impact of traffic management on the situation in the transport network;
– analysis of the capacity of large transportation networks with dynamic redistribution of traffic flows [4].

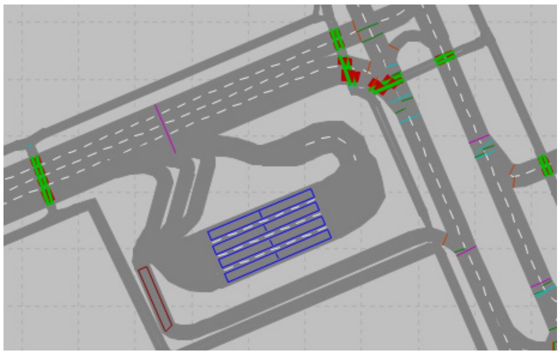

Fig. 1.Changing the location of bus station to transport interchange hub, as an example of verifying hypotheses of engineers

This software allows you to predict and develop some decision-making system in the future route of the vehicle to the physical implementation of the changes of the transport network. In most cases, objects in the automation system are signaling traffic control devices at intersections, since it is one of the main ways to minimize congestion. System devices, responds to changes in the flux density, consist of one or more sensors and traffic light corresponding to the sensor readings. The road network is divided into sections – from the intersection to intersection. The beginning of the area is the sensor, and it ends with a traffic light. The main parameters of the algorithm of such an object are (as well as Tact regulation and phase regulation):

– cycle – the duration of complete cycle (switching the order of the phases) traffic;
– section regulation – the ratio of the time allotted for each phase. By varying the percentage of time for each phase, you can control the duration of the green signal to the most loaded direction. On a separate crossroads it gives reducing latency;

– offset – the displacement of the cycle of a specific traffic from the specified system-wide point in time (cycles can reconcile different intersections between them) [3].

The decision to change the length of the cycle occurs on the basis of calculating the degree of saturation phase. (That is the number of cars that could travel in time during the "green" phase if they have occupied the empty space between the cars that capture sensors.) This figure should not exceed 90% for the busiest phase of the "green". In addition to the amount of forced stops and waiting time of vehicles, the program calculates the coefficient of efficiency. Depending on the value of the coefficient one of four phases are decided to be lengthened or shortened to one second. Before the beginning of a new phase in addition the offset in relation to other traffic lights is agreed – also within four seconds.

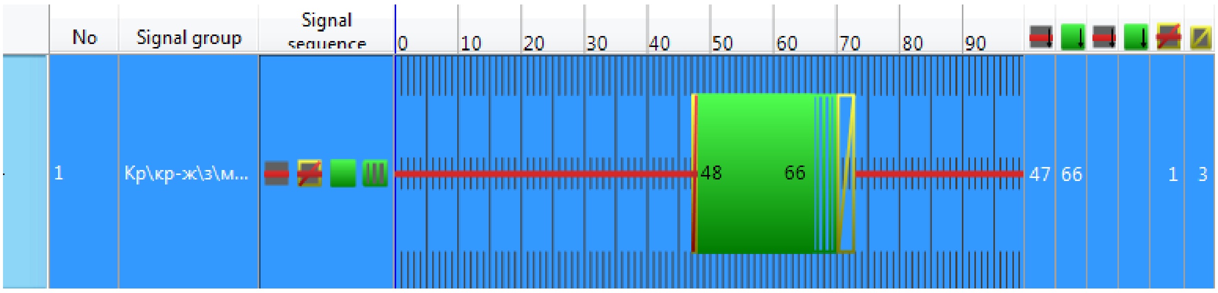

Fig. 2. Input signal of the program for one of the traffic lights

PTV Vissim combines modern methods of modeling traffic flow data detectors, the possibility of a preliminary analysis of the efficiency of input technical changes to the structure of the transport infrastructure and automation solutions for decision-making processes to reduce complex traffic situations. Simulation technology combines the most advanced techniques and algorithms using the dynamic flow distribution in operational forecasting any traffic situations.

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THE COMBINED PRODUCTION TECHNOLOGY IN THE SPACE INSTRUMENTATION FOR INCREASING THE POTENTIAL OF THE MARKET OF THE AIRCRAFT CONSTRUCTION AND IMPORTING THE SUBSTITUTION INTO RUSSIA

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Abstract

This article addresses the issue of Russian aircraft construction, which is about the need of enhancement and increasing of the reliability of the production process to improve the condition of the aircraft industry in general. Also it was provided with the task solution and its research based on implementation in the production of the combined technology.

I. INTRODUCTION

The project is aimed on the improvement of the condition of branch of aircraft industry in Russia. Following the results of the last years State takes the 3-rd place in the world on volumes of the releasing aviation production. Russian plans are to increase the position on the world market of aircraft construction and get a share of supply at the domestic market of the country to 60%.

Thereby the State program "Development of the aviation industry for 2013–2025" directed on creation of highly competitive aviation industry and fixing of its' position at the world market as the third manufacturer by volumes of releasing aircraft equipment (fig. 1) is created and approved by the resolution of the government of the Russian Federation of April 15, 2014 № 303 [1].

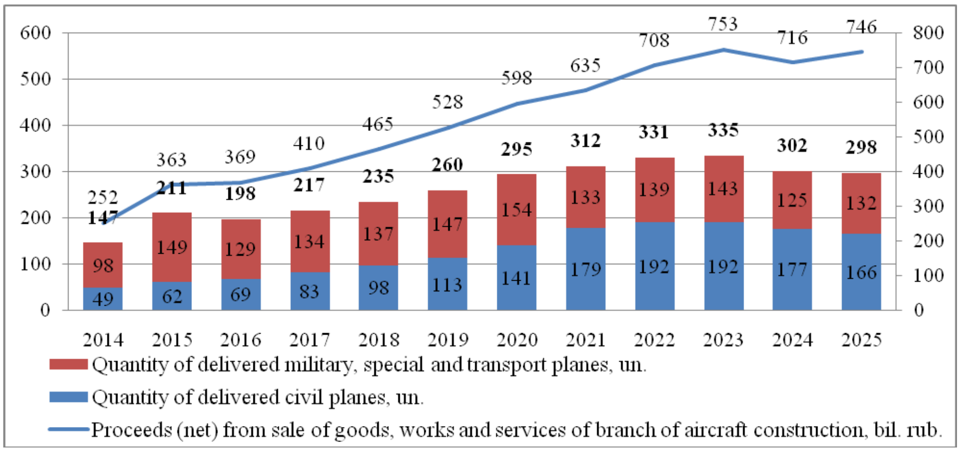


Fig. 1. The main target indicators of Aircraft construction of the State program for 2013–2025

II. ACHIEVEMENT OF THE OBJECTIVES

Achievement of this purpose requires the existence of powerful aviation potential and implementation in process of AS/EN 9100 series – Standards for the aerospace industry which is an essential condition for social-economic and innovative development of the country, and also ensuring safety of the Russian Federation [2].

Passing from global plans to the local purposes the possibility of their achievement will appear during the improvement of high-quality characteristics of the products, the reduction of the time and material costs, thereby – to increase of efficiency planes production technologies.

III. SOLUTION OF THE PROBLEM

Now the stamping, waterjet manufacturing and molding is used during the production of the plane trim.

The combined production technology in space instrumentation was studied and possibility of its application at the enterprises for increase of capacity of the aircraft market with the further import substitution in Russia was considered.

The Combined Production Technology represents the application of technology for the high-precision automated production of details of various forms and the sizes in production of planes where positioning with the least possible error is necessary. First of all it refers to the methods of the details production from composite materials and the control methods of their condition and also production of details from especially solid metals.

It is interesting for the technology the study of the waterjet which is based on the principle of the erosive influence of mix of a high-speed stream of water with firm particles of an abrasive on the processed material. Technology of waterjet cutting allows to cut out and processing various materials up to 300 mm thick (Table 1), herewith absence of material melting on edges of details excludes additional machining of a surface that leads to the economy of the raw materials and time. The pumps are capable to create the working pressure about 4000 bars.

Table 1
Technical characteristics of the abrasive waterjet cutter

Name	Parameter
Positioning accuracy	0,076 mm
Steel cut speed (10 mm of thickness in 1 min)	335 mm
Aluminum cut speed	1049 mm/min
Maximum thickness of a cut	300 mm
Additional processing after a cut	None
Heat zone, formation of scale and an edge	None
Possibility of a cut at an angle	Available
Conicity compensation	Available
Working pressure of the pump	60000 psi (4136) bars
Power and energy consumption of the pump	30 H.P. (22 kW)
Water consumption	1,4 – 2,7 l/min
Diameter of a diamond nozzle	0,3 mm
Diameter of a mixing tube	0,76 mm
Abrasive consumption	340 g/min

Also the development of technology requires the research of the production 3D-printers class system of the big sizes which uses the technology of stereolithograph [3] which allows to produce the products of the big sizes with the high detalisation and resolution which depends on the thickness of each polymeric layer equal to 0,025 mm (Table 2). The principle of the models creation consists of hardening of liquid photopolymer under the influence of the ultra-violet laser in those places where the laser beam had passed. As a result high-precision models with a smooth surface produces.

Table 2
3D-printer technical characteristics

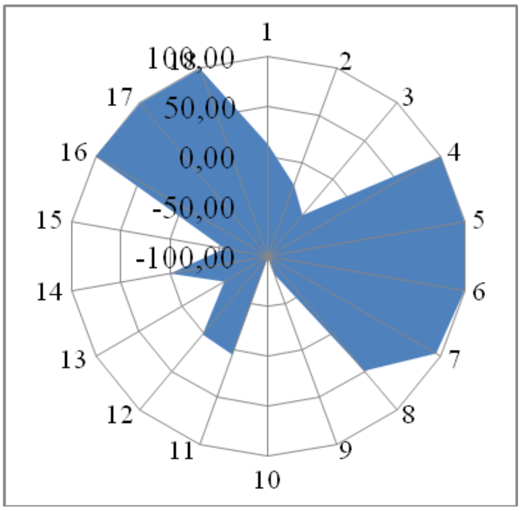
3D-printer technical characteristics	
Size of a working zone	650x750x550 mm
Minimum thickness of a layer	0,05 mm
Maximum mass of model	75 kg
SYSTEM of the laser	
Wavelength	354,7 nm
Power	1450 mW
SCANNING SYSTEM	
Definition of border ()	0,13 mm
Detail drawing speed ()	3,5 m/sec
POWER SUPPLY	
With the single RDM module	200 – 240 VAC 50/60 Hz, single-phase, 30 A
ENVIRONMENT	
Temperature	20–26 C
Maximum temperature fluctuations	1 C/hour
Relative humidity	20–50%
WEIGHT AND DIMENSIONS	
Overall dimensions	2120x1580x2210 mm

The equipment works on the basis of software intended for the personal computer (PC) with the WINDOWS operating system. The program allows to make all necessary operations from detail modeling to production of the detail.

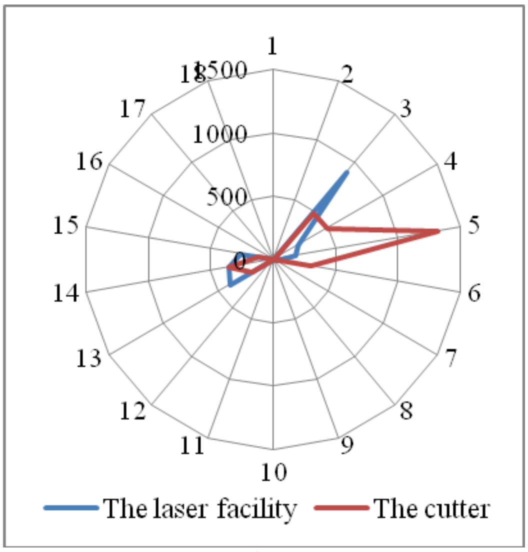
IV. JUSTIFICATION OF EXPEDIENCY OF THE PRESENTED SOLUTION

The map of the value stream demonstrates productivity of the project. It becomes possible to replace some links of a stream with one, thereby the saving of the time and materials will be reached.

During the researches comparative characteristics of indicators of quality were made and the deviation of indicators D (1) of combined technology plant from the analog were calculated. That gave the chance to estimate the critical directions (fig. 2) which are more advantages.



a)



b)

Fig. 2. Deviation of indicators of mixed technology plant (D, %) (a) and comparison of indicators of quality of plant and its analog (b)

$$D = \frac{P_H}{P_K} 100 - 100 , \quad (1)$$

where D – a deviation of the studied object from analog (%), Rn – indicators of quality of combined technology plant, Rc – indicators of the analog quality [4].

During the researches the technological level of the innovation (2) was also established. It is system of the indicators characterizing the qualitative properties of the object in comparison with reference samples. Based on results of an assessment of novation technological level it is possible to conclude about prospectivity of the made production [5].

$$ITLN = \frac{\sum P_H}{\sum P_K} \quad (2)$$

where *ITLN* – an indicator of a technological level of novation, P_H – indicators of quality of a cutter, P_K – indicators of quality of the laser.

Value of an indicator of commercial potential *P* (3) scientific and technical development matches to the chosen scale of the average level that shows the possibility of goals achievement due to the combined technology [6].

$$P = \sum_{i=1}^{n} K_i M_i \quad (3),$$

where *P* – an indicator of commercial potential, *K* – number of points on the estimated objects, *M* – parameter weight on the basis of expert estimates, *n* – number of parameters of an estimation.

Based on Gant's chart labor costs, expenses and the approximate duration of project introduction in production which doesn't exceed a half-year are calculated.

In our case the main consumer will be the Russian Federation's Ministry of Defence, and the technology will be directed on target audience on the planes' producers entering into United Aircraft Corporation.

V. CONCLUSION

The technology will lead to formation of steady production process of plane's components with the increased accuracy of more difficult details' production. The process is understood like a set of interrelated or interacting activities which transforms inputs and outputs in accordance with paragraph 3.4.1 of GOST ISO 9000-2011. The technology will allow to lower time, material costs, and waste of production. It also will lead to increase of functionality of production. The following steps are to improve and use the combined technology in a bigger share of the market of aircraft construction and to investigate technology as the main, applied in the latest knowledge-intensive projects on development of aircraft in the country. These measures will allow the Russian aviainstrumentation industry to get a new level of development.

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THE METHOD OF INFRASTRUCTURE RESEARCH AUTOMATION OF THE AIRPORT ON THE BASIS OF SIMULATION MODELING

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Nowadays airports are the basis of large multimodal hubs, parts of which are extremely difficult because of the huge number of elements, the multiple links between them and the complexity of the organization. Sometimes this fact has a negative impact on passengers who are faced with expectations, delays and discomfort while passing checkpoints. That's why solving a problem of optimization and automation appears in the busiest areas, in order to increase productivity and improve overall performance. To do this it is necessary to take a look at the sequence of passengers at the airport and isolate trouble spots [1 – 3].

A flowchart of a passenger at an airport operations is shown in fig. 1.

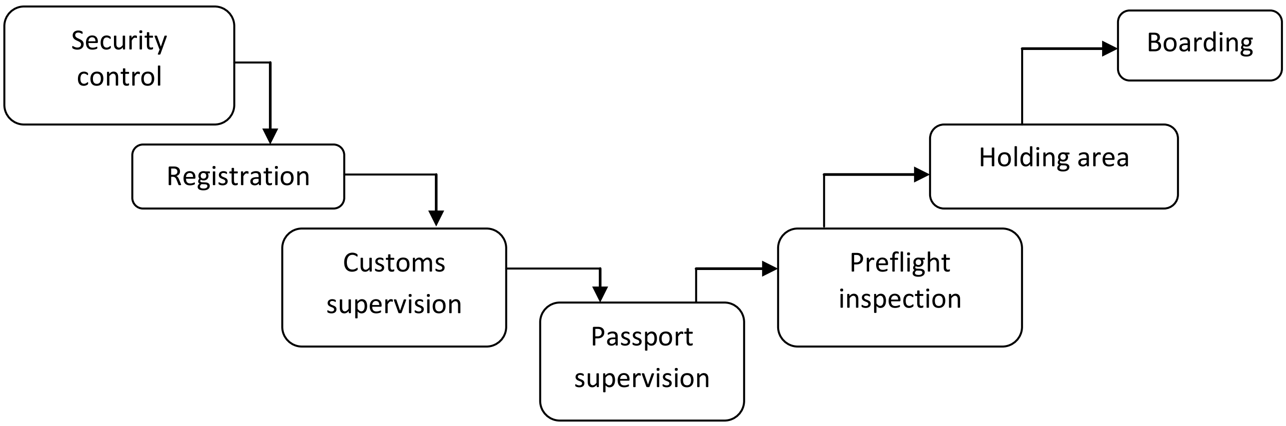

Fig. 1. The flowchart of a passenger at an airport operations

It shows that it is important to correct location of zones airport terminals, to rationally allocate and manage the flow of movement of passengers and staff on them. Also it is need to know the required amount of equipment, space and transport to ensure a quality service for passengers and cargo logistics. Therefore, we need an appropriate timely development of existing infrastructure and its automation, and it is requires a significant investment for the reorganization and reconstruction of the airport and surrounding areas. It is important to pre-verify the correctness of the design decisions and reduce the risks associated with the expediency of investment in reconstruction of the airport.

One of tools to visualize the operation of the system, depending on the load changes, is a simulation with the ability to plan and optimize the operation of the airport complex. Simulation modeling allows experiments to evaluate the performance of the system by changing parameters such as schedule and parameters of flights, arrival and departure of passengers, routes from the terminal, the amount of equipment in the areas of registration, customs and baggage claim area, the location of shops and Duty Free Zones and many others [4].

Questions which should be answered by simulation can be divided into three groups:

– definition of quantitative indicators: the number of staff, equipment, racks, boarding bridges, transportation, and other areas;

– optimization and automation of planning: the best mutual arrangement of the various zones of resources; topology conveyor systems;

– optimization of operating logic and rules of work: the possibility of increasing the efficiency of operation without additional investment in equipment to optimize control.

Strategic planning simulation is an instrument for making decisions about the concept and parameters of the designed system, to analyze the performance and efficiency of complex investments. It allows to avoid errors or predict the necessary arrangements when making tactical decisions. Periodically there is a need to make quick decisions about the redistribution of resources to change the timetable or on the order of service. For example, when flight delays or failure of any equipment.

Simulation modeling is also used for modernization and automation of other airport systems, including:

- airfield, parking and maintenance of aircraft;
- taxis, buses, trains and other means of transport of passengers;
- on-board food and service in the terminal complex.

The final model allows to evaluate the system, not only in its current state, but also in the multiple upgrade options. For example, under various scenarios working of the terminal it can assess the amount of equipment required for various peak loads and different profiles of passenger traffic, considering the specificity of flights of different directions.

Analysis of simulation results identify performance bottlenecks, adjusts and optimizes the use of design and technological solutions, so in practice a significant improvement in the daily processes of the airport could be revealed, including the planning and automation of registration, buses and gates.

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INCREASE POSITIONING ACCURACY OF RAILWAY TRANSPORT BASED ON SAW RADIO FREQUENCY IDENTIFICATION TAGS USING A KALMAN FILTER

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Abstract

The article examines the technology of radio frequency wireless positioning systems together with existing positioning systems, to monitor the density of rail traffic. Considered non-contact positioning technology based on the use of radio frequency identification systems on the surface acoustic waves with a frequency of 2.4 GHz. We investigate methods to significantly improve the accuracy of determining the true position of the train.

Keywords: RFID, SAW tag, railway transport, traffic control, Kalman filter, tags collision

I. INTRODUCTION

Currently, the technology of radio frequency identification (RFID) is widely used in positioning systems of railway transport, to control the rate of train traffic and optimize time spent on monitoring and accounting wagons rolling, temperature monitoring of live parts of high voltage equipment. Also, RFID systems let you create alarms emergencies, transferring them to the automatic control system. Trains have to stop at determined positions, for example because of safety doors on the platform or due to railway legislation. And sometimes the platform is shorter than the train, than only some doors may be opened.

Optical sensors often fail for positioning of a train at the station. Reasons for failure can be dust, dirt, water on sensor, or leaves. Mechanical contacts also can easily fail in such harsh environments. Contactless and maintenance free UHF RFID systems allow the precise and reliable positioning of trains [1].

The monitoring of positioning high-speed trains has special requirements. One of the possible applicability of the RFID technology for high-speed trains is a wireless technology positioning of rail transport based on the use of passive SAW tags, installed in a place spot gridding, and the reader with an antenna placed on the test object. The main advantages of wireless technology as using SAW tags are: low cost, high noise immunity, high precision positioning of the train, low power consumption and high reliability.

II. POSITIONING SYSTEMS BASED ON SAW RFID

In the systems based on SAW RFID technology, the reader emits interrogation pulse at the frequency of 2.4 GHz and responds to radio-frequency pulse modulated SAW tag. After receiving the response tag reader decodes and extracts from it a unique code of tag containing information about coordinates of its location [3].

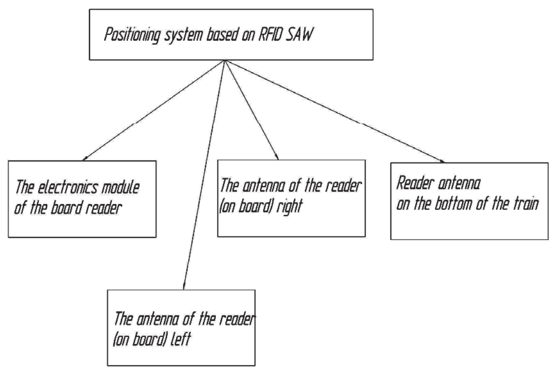

Fig. 1. Structure the wireless positioning system RFID on SAW tags

The system includes the electronics onboard the reader and antenna, which is mounted on the train, and passive SAW RFID tag installed on the railway. The tag is read in the reliable reading area. The mutual arrangement of tag and antenna is shown in the fig. 2.

The passive identification tag 1 mounted on a railway at an angle 30^0 to the normal. Antenna of onboard reader 2 is set to the test object, moving with speed V, at an angle of 260, as shown in the fig. 2.

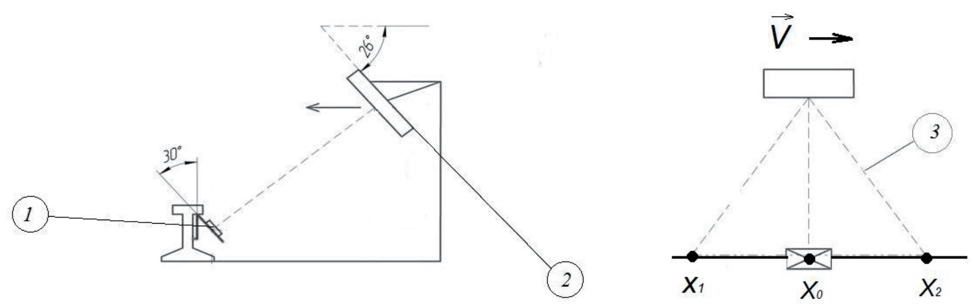

Fig. 2. Mutual disposition tags-1 and antenna -2 in the identification area -3

Thus, the motion of the train, the tag enters in the reliable reading area – 3 from X1 to X2. When the train is moving SAW tag is entering to the identification area from $t_{in} = X_1/V$ to $t_{out} = X_2/V$ in the time domain.

If the identification area is symmetrical, as shown in fig. 3, then when the tag 1 is located directly under the antenna 2 and its coordinates X_0. At a time that corresponds to the location tags calculated by the equation:

$$t_0 = \frac{t_{in} + t_{out}}{2} \quad (1)$$

Work board reader can be divided into two phases – sending probing signal to the tag and processing the received response signal tag. [3]. The duration of the probe signal $t_{\text{int}\,er}$ and the length of time processing the received response $t_{\text{int}\,er}$ shown in fig. 3.

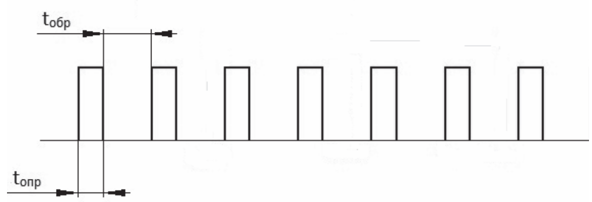

Fig. 3. Phases reader operation,
where the duration of the survey t_{inter}=5ms, processing t_{proc}=10ms

The tag identification will happen, if the interrogation occurred in time when tag is placed in area reliable reading, i.e. the strobe is completely enters in identification area (fig. 4).

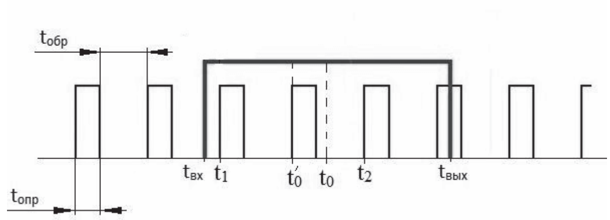

Fig. 4. The gating effect, resulting in an error ΔX

The gating effect causes the error determination input and output time SAW tag and, hence there is an error determining the coordinate ΔX:

$$\Delta X = (t_0 - t_0')V = \left(t_0 - \frac{t_1 + t_2}{2}\right)V, \quad (2)$$

where t_0 – time corresponding to the position of tag under the reader's antenna; t_{in} and t_{out} – time corresponding to the ingress tag to reading and out of this area; t_0' – a time corresponding to the position of tag under the antenna; V – velocity of the train; t_1, t_2 – the first and the last moments of reading tag.

ΔX error will depend on the time that shows how much time has passed from the moment of entering the tag to the identification area before interrogation. In addition, the length field, and the time of entry and exit tag will change due to the influence of external factors.

Purpose of this work was to develop a technique precise positioning of railway transport, considering errors caused by possible distortions of the identification area and limited speed reader operation.

In this paper, were tasked with developing the model work cycle of the reader, the algorithm accurately determine the coordinates of a moving train using RFID SAW tags, that are installed on the rail using the Kalman filter, taking into account the error in determining the coordinates of a moving train.

III. BUILDING A MODEL POSITIONING SAW TAGS CONSIDERING COORDINATE DETERMINATION ERROR USING KALMAN FILTER

Kalman filter for recursive estimation of the state vector of additional a priori known dynamical system. In our case, this change of position coordinates of the train. The use of a linear Kalman filter due to the minimum value of the mean square error. As known, one of the advantages of the filter is that for the special case of Gaussian error distribution filter provides an accurate estimate of the conditional probability distribution of the system state.

Suppose that aboard railway transport set two positioning systems. The first system – the reference system, the second – RFID SAW positioning system. The reference positioning system measures coordinate of the train x_{k+1} at a given equation, considering errors in determining the coordinates of a random variable and ξ_k, where k = 0..N, where N□[1, ∞)

$$x_{k+1} = x_k + V_k \Delta t + \xi_k .$$

Here ξ_k a random error in determining the coordinates of x_{k+1} reference positioning system, with k=1..∞, Δt – time increment. Equation according to which changes coordinate train is as follows:

$$z_k = x_k + \Delta X .$$

The problem of precise positioning using a Kalman filter, is to find the best approximation x_k^{opt} to the true value coordinates x_k .

Use the equation to determine the coordinates of the error tag [3].

$$\Delta X = X_{in} + t_s V + \frac{t_{read} V}{2}\left(div\left(\frac{X_{out} - X_{in} - t_s V}{t_{сч} V} \right) + \right.$$
$$\left. + round\left(\frac{1}{3t_{req} V} div\left(\frac{1}{t_{req} V} \mathrm{mod}\left(\frac{X_{out} - X_{in} - t_s V}{t_{read} V} \right) \right) + 0.3 \right) - 1 \right) \quad (5)$$

where *div* – integer division; *mod* – the modulo; *round* – round numbers; X_{in} – coordinate of the start of the identification tag; X_{out} – coordinate of the end of the identification tag; t_s - time interval since the contact tag in the read area prior to survey tag; t_{req} – the survey tag reader; t_{read} – full cycle of reading the tag; V – velocity of the train.

The calculations in the formula (5) give an accurate result with a known time of entry and exit tag from reading area and symmetrical position identification zone. Under symmetric arrangement will be understood symmetrical arrangement of the start and end coordinates of the service area of the identification area projected on the horizontal axis. In practice, these conditions are not satisfied, since there will always be random distortion identification area. Thus, the amount of positional error ΔX can be called a random variable.

Thus, the magnitude of the positioning error ΔX may be called a random variable.

The calculations in the formula (5) give an accurate result for a known accurate measurement of the input and output tags from reading and symmetrical arrangement with respect to the identification zone label. Under symmetric arrangement will be understood symmetrical arrangement of the start and end coordinates of the service area of reading the label reader antenna projected on the horizontal axis. In practice, these conditions are not satisfied, since there will always be random distortion zone identification labels.

The algorithm for precise positioning of the train, set the initial position:

– errors ξ_k и ΔX – random variables, distribution law which is independent of time (the value iteration);

– the average values of the error is zero $E_{\xi k} = E_{\Delta X k} = 0$;

– error variance σ_ξ^2, $\sigma_{\Delta X}^2$ does not depend on the iteration step k, because the laws of distribution does not depend on it. It is assumed that all the errors are independent of each other: the error at time *k*, independent of the error at time k' . Thus, the reference system has a positioning error variance is less than the SAW RFID system.

In general, to find the current value of the Kalman coefficient K need to minimize the error e_{k+1} :

$$e_{k+1} = x_{k+1} - x_{k+1}^{opt} \quad (6)$$

Using equation (6) to rewrite the expression for the error:

$$e_{k+1} = (1-K)(e_k + \xi_k) - \mathrm{K}\,\Delta\mathrm{X_k} \quad (7)$$

where *K* – coefficient Kalman.

Define the value of the mean square error $E_{e_{k+1}^2}$:

$$E_{e_{k+1}^2} = \frac{\sigma_{\Delta X}^2 \left(E_{e_k^2} + \sigma_\xi^2 \right)}{E_{e_k^2} + \sigma_k^2 + \sigma_{\Delta X}^2} \quad (8)$$

Base iteration $E_{e_0^2}$ is defined as:

$$E_{e_0^2} = E_{\Delta X_0^2} = \sigma_{\Delta X}^2 \quad (9)$$

Kalman Gain:

$$K_{k+1} = \frac{E_{e_k^2} + \sigma_\xi^2}{E_{e_k^2} + \sigma_\xi^2 + \sigma_{\Delta X}^2} = \frac{E_{e_{k+1}^2}}{\sigma_{\Delta X}^2} \quad (10)$$

Thus, the coordinate value x_{k+1}^{opt}, obtained using Kalman filtering corresponds to the equation:

$$x_{k+1}^{opt} = K_{k+1} z_{k+1} + (1 - K_{k+1})(x_k^{opt} + V_k \Delta t) \quad (11)$$

$x_0^{opt} = z_0$ – base iteration, Δt – time increment

IV. DETERMINATION OF THE TRAIN COORDINATES, IN THE SAW TAGS COLLISION CASE

Using a SAW RFID system involves identifying the location of the rail SAW tags (1) with a predetermined pitch N. For a given step $N \geq X_{out} - X_{in}$, in the identification area (3) readers's antenna can detect are the same time by two or more tags, as shown in fig. 5.

While simultaneously reading signals, responses tags will be taken the same time reader. When uses time coding SAW tags [5], the identification of tags in this situation becomes more difficult. This problem is known as the tags collisions.

Consider the case of the two tags collision, as shown in fig. 5. This situation is possible if transit time distance $X_2 - X_1$, a commensurate with the reading time t_{read} . The final and the initial time the identification of RFID SAW tag is calculated respectively as $t_1 = X_1/V$, $t_2 = X_2/V$. The point in time at which the tag can be located directly below the antenna, as calculated $t_0 = X_0/V$. If SAW RFID tags using time position encoding, reader measures the time delay.

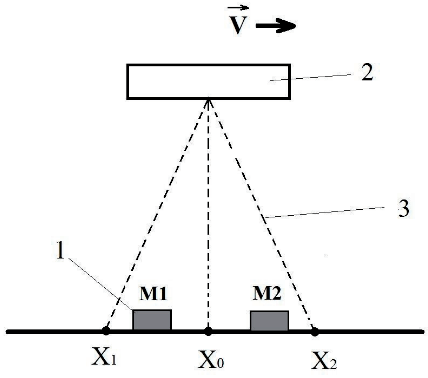

Fig. 5. Simultaneous reading tags M1, M2

By measuring the delay t_{M1}, t_{M2} of the each tag, we can divide two tags on the time t_0: $t_{d1} = t_0 - t_{M1}$, $t_{d2} = t_{M2} + t_0$, where t_{d1}, t_{d2} – delay time of tags.

V. RESULTS

In the investigation the function $\Delta X(t_3, V, X_{out}, X_{in})$ to train speed range of 10 to 200 km/h, were obtained the results shown in fig. 6. The maximum error value at 200 km / h, equal to 448 mm.

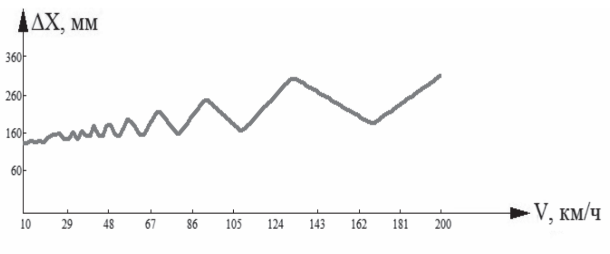

Fig. 6. Research dependence of the coordinate error ΔX on the train speed V

Evaluation results using a Kalman filter shown in fig. 7.

Three graphs are showing change of coordinate over time. Comparing graphs showing the coordinate value of the filtered linear Kalman filter and the true value of the coordinates at time t, considering the random measurement error, we obtain a coordinate value obtained by the Kalman filter is the more nearly to the true in comparison with the method of calculating the true coordinates taking into account the error in determining the coordinates calculated in (5). Error positioning system $X - X^{opt}$ using the Kalman filter, as compared with the system takes into account the positioning error ΔX is shown in fig. 8.

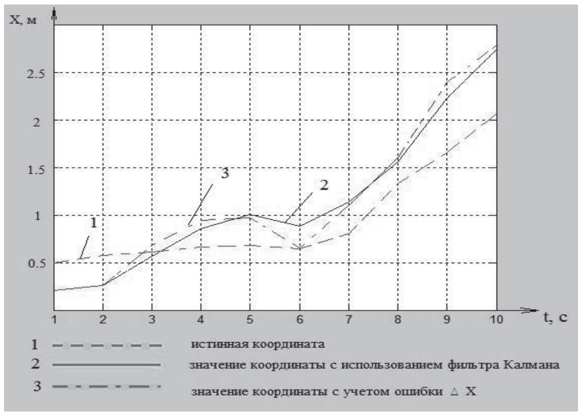

Fig. 7. The graphs of changes the coordinate values Xв depending on time t

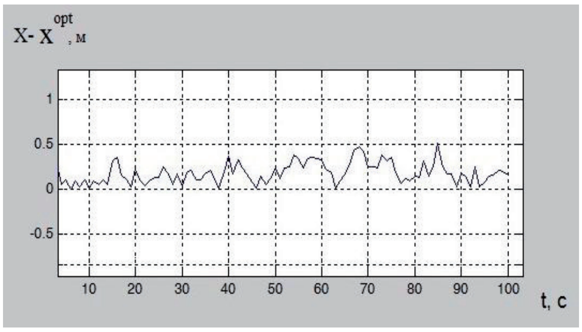

Fig. 8. Train positioning error using the Kalman filter, over time t

VI. CONCLUSION

The use of wireless SAW RFID technology for railway monitoring with existing positioning systems will significantly increase the density of rail traffic; provide the flexibility for traffic management. Promising direction of development of position technology-based RFID SAW is the possibility of its application in the automated control systems by train. The proposed method for accurate positioning of the train_assumed to use in positioning systems for railway transport. This solution, together with other positioning systems, allows for a 20% increase the positioning accuracy of the trains.

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DETERMINATION OF POLARIZATION PROPERTIES OF THE PROPAGATION MEDIUM OF HIGH-FREQUENCY RADIO SIGNALS

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Abstracts

The report is devoted to consideration of a method of determination of polarization properties of the propagation medium within the chosen method of the description of polarizing characteristics of electromagnetic signals. Research is based on introduction of vector model of signals and polarizing ranges of vector signals. The environment of distribution is considered as the polarizing system changing a the polarization spectrum of signals. Transformation of a the polarization spectrum of a signal is described on the basis of transfer function of the propagation medium which is expressed within Jones method.

I. INTRODUCTION

The propagation medium brings polarization distortions in structure of vector electromagnetic (EM) signals. It leads to deterioration of signal detection. The polarization structure of signals is completely described by polarization spectrum [1, 2]. Based on Jones method and results received earlier the concept of transfer function of the propagation medium of electromagnetic waves is entered. Transfer function of the propagation medium decides on the help of Jones matrix. Experimental measuring of elements of this matrix possibly on the basis of creation of measuring equipment. Which way of construction is stated in the inventor's application for the invention "Method of determination of polarization characteristics of the propagation medium of high-frequency signals" № 2013133568/07(050264) which was given 18.07.2013. On this inventor's application the positive decision of 07.07.2014 is received.

Polarization characteristics of the propagation medium are expressed by a polarization Jones matrix. Elements of polarization Jones matrix are analogs of parameters of the two-port network and are defined by polarization spectrum of input and output signals.

Here the polarization spectrum is considered as most a general characteristic of a vector electromagnetic signal. From a polarization spectrum by the corresponding transformations it is possible to receive all other characteristics and parameters of this signal.

As the parameter which characterizes polarization properties of the propagation medium transfer function was chosen. The purpose of work is definition of polarization characteristics of the propagation medium within the chosen description of polarization characteristics of EM of a signal.

In this work the propagation medium of EM wave is represented polarization system, by interaction of incident wave with it at the exit of system there are one or several modified plane waves. The propagation medium is considered within system approach and it is represented in the form of the two-port network with the corresponding transfer function.

II. POLARIZATION PROPERTIES OF THE PROPAGATION MEDIUM

In this work the propagation medium of EM wave is represented polarization system, by interaction of incident wave with it at the exit of system there are one or several modified plane waves [1, 2]. It is frequency dependent polarization properties of such system, according to Jones method, 2x2 look are described by a countable set of Jones matrixes [1, 2]

$$\mathbf{I}(\omega)=\begin{bmatrix} I_{11}(\omega) & I_{12}(\omega) \\ I_{21}(\omega) & I_{22}(\omega) \end{bmatrix}. \quad (1)$$

In turn, polarization structure of an input and output signal are described by a bounded countable set of Jones vectors [3, 4]:

$$\mathbf{J}^{вх,вых}(\omega)=\begin{bmatrix} \dot{S}_x^{вх,вых}(\omega) \\ \dot{S}_y^{вх,вых}(\omega) \end{bmatrix}, \quad (2)$$

where $\mathbf{J}^{вх,вых}(\omega)$ – bounded countable set of Jones vectors of an input and output signals, $\dot{S}_x^{вх,вых}$, $\dot{S}_y^{вх,вых}$ – spectral horizontal wave components of an input and output signals, spectral vertical wave components of an input and output signals.

If polarization state of an input signal are described by a bounded countable set of Jones vectors (2) and characteristics of polarization system are described by a bounded countable set of Jones matrixes (1), polarization characteristics of an output signal will write down in the following form:

$$\mathbf{J}_{вых}(\omega) = \mathbf{I}(\omega) \cdot \mathbf{J}_{вх}(\omega). \quad (3)$$

In the developed form [3, 4]:

$$\begin{bmatrix} \dot{S}_x^{вых}(\omega) \\ \dot{S}_y^{вых}(\omega) \end{bmatrix} = \begin{bmatrix} I_{11}(\omega) & I_{12}(\omega) \\ I_{21}(\omega) & I_{22}(\omega) \end{bmatrix} \cdot \begin{bmatrix} \dot{S}_x^{вх}(\omega) \\ \dot{S}_y^{вх}(\omega) \end{bmatrix} \quad (4)$$

Expression (4) can be rearranged in the form:

$$\dot{S}_x^{вых}(\omega) = I_{11}(\omega) \cdot \dot{S}_x^{вх}(\omega) + I_{12}(\omega) \cdot \dot{S}_y^{вх}(\omega); \quad (5)$$

$$\dot{S}_y^{вых}(\omega) = I_{21}(\omega) \cdot \dot{S}_x^{вх}(\omega) + I_{22}(\omega) \cdot \dot{S}_y^{вх}(\omega). \quad (6)$$

For finding of polarization characteristics of the propagation medium it is possible to use the theory of two-port networks.

Application of the theory of two-port networks allows to write transfer constant of horizontal components of a plane electromagnetic field in the form of [1 – 5]:

$$\dot{K}_x(\omega) = \frac{\dot{S}_x^{вых}(\omega)}{\dot{S}_x^{вх}(\omega)}. \quad (7)$$

where $\dot{S}_x^{вх}(\omega)$ and $\dot{S}_x^{вых}(\omega)$ are spectral horizontal wave components of a signal on an input and a output two-port network.

Similarly, the transfer constant of vertical component of a plane electromagnetic field is defined as

$$\dot{K}_y(\omega) = \frac{\dot{S}_y^{вых}(\omega)}{\dot{S}_y^{вх}(\omega)}. \quad (8)$$

Eq. (5) and Eq. (6) allow to transform Eq. (7) and Eq. (8) to the following forms:

$$\dot{K}_x(\omega) = I_{11}(\omega) + I_{12}(\omega) \frac{\dot{S}_{1y}(\omega)}{\dot{S}_{1x}(\omega)}, \quad (9)$$

$$\dot{K}_y(\omega) = I_{22}(\omega) + I_{21}(\omega) \cdot \frac{\dot{S}_{1x}(\omega)}{\dot{S}_{1y}(\omega)}. \quad (10)$$

The provided computation showed communication of transfer constant of the propagation medium of vertical and horizontal a component of an electromagnetic signal with elements of Jones matrixes which describe polarization properties of the propagation medium.

If polarization spectrum of input signal and transfer constants of vertical and horizontal spectral components of the signal which has passed through the propagation medium are known, it is possible to define an output signal:

$$\mathbf{s}_2(t,z) = \mathbf{i}\frac{1}{2\pi}\int_{-\infty}^{\infty} \begin{bmatrix} \dot{S}_{1x}(\omega)\dot{K}_x(\omega) \times \\ \times \exp[i(\omega t - kz)] \end{bmatrix} d\omega + \mathbf{j}\frac{1}{2\pi}\int_{-\infty}^{\infty} \begin{bmatrix} \dot{S}_{1y}(\omega)\dot{K}_y(\omega) \times \\ \times \exp[i(\omega t - kz)] \end{bmatrix} d\omega. \quad (11)$$

At distribution of signals through the propagation medium its polarization characteristics change in a random way. It eventually affects quality of signal detection. Determination of elements of a set of Jones matrixes of the propagation medium (1) gives its exhaustive characteristics in frequency area. The substance claim of determination of polarization characteristics of the propagation medium, and, means also the corresponding transfer function, is stated in materials of claim for a discovery for the invention "Method of determination of polarization characteristics of the propagation medium of high-frequency signals" № 2013133568/07(050264) of 18.07.2013. On this inventor's application the positive decision of 07.07.2014 is received.

By analogy with method of measurement of parameters of the two-port network, elements of a polarization matrix are measured as follows:

$$I_{11}(\omega) = \left. \frac{\dot{S}_x^{вых}(\omega)}{\dot{S}_x^{вх}(\omega)} \right|_{\dot{S}_y^{вх}(\omega)=0}, \quad (12)$$

$$I_{12}(\omega) = \left. \frac{\dot{S}_x^{вых}(\omega)}{\dot{S}_y^{вх}(\omega)} \right|_{\dot{S}_x^{вх}(\omega)=0}, \quad (13)$$

$$I_{21}(\omega) = \left. \frac{\dot{S}_y^{вых}(\omega)}{\dot{S}_x^{вх}(\omega)} \right|_{\dot{S}_y^{вх}(\omega)=0}, \quad (14)$$

$$I_{22}(\omega) = \left. \frac{\dot{S}_y^{вых}(\omega)}{\dot{S}_y^{вх}(\omega)} \right|_{\dot{S}_x^{вх}(\omega)=0}. \quad (15)$$

III. METHOD OF DETERMINATION OF POLARIZATION PROPERTIES OF PROPAGATION MEDIUM

Expressions (12)–(15) formed the basis of the claim for a discovery [6]. According to this claim polarization characteristics of the propagation medium can be measured by means of the device (fig. 1) which principle of work is stated below.

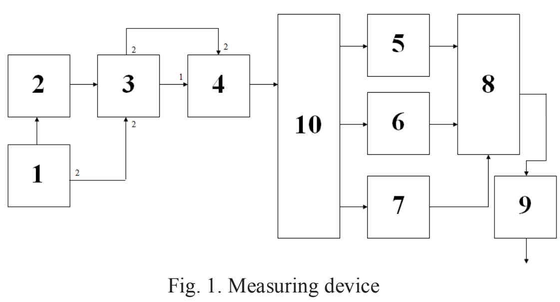

Fig. 1. Measuring device

The device contains series of cells synchronizer 1, the pulse former 2, the channel selector 3 and the two-channel on polarization antenna 4. The second input of the two-channel on polarization antenna is connected to the second output of the channel selector. The second input of the channel selector is connected to the second output of the synchronizer. Outputs of the receive antenna of horizontal polarization 5, the receive antenna of vertical polarization 6, the receive antenna 7 are connected to a two-channel spectrum analyzer 8. The output of a two-channel spectrum analyzer is connected to input of the processing unit 9, and its output is a device output. The observable propagation medium is 10.

In the every sensing period the synchronizer 1 develops XON which is given to the channel selector 3. Through the channel selector 3 XON comes to one of channels of the two-channel on polarization antenna 4, depending on polarization structure of the first distribution of a radio signal exploratory the propagation medium which is developed by the pulse former 2. From the first output of the synchronizer 1 to an input of the pulse former 2 couple of clock shifted in time after generation XON by the two-channel on polarization antenna 4, goes. The pulse former 2 develops two shifted in time and orthogonal on structure of a radio signal $S_x^{вх}(t)$ and $S_y^{вх}(t)$. As orthogonal radio signals can be used two step-by-step frequency-modulated signals. Synchronizer 1 impulses which give to an input of the pulse former 2, provide its synchronous functioning with the channel selector 3.

In the every sensing period the channel selector 3 by the impulses entering on its first input from the second output of the synchronizer 1 connects output radio signals of the shaper of radio signals 2 to the corresponding channels of the two-channel on polarization antenna 4, orthogonal on polarization, which radiates them on propagation medium 10.

Complex spectra of radio signals $\dot{S}_x^{вх}(\omega_n)$ and $\dot{S}_y^{вх}(\omega_n)$ radiated by the two-channel on polarization antenna 4 are known in advance, and information on them is in the processing unit 9.

Polarization characteristics of the propagation medium in the frequency range are characterized by Jones matrixes 2x2 on the corresponding frequency counting of complex spectra of the radiated orthogonal on structure radio signals [1]:

$$\{\mathbf{I}(\omega_n)\} = \left\{ \begin{bmatrix} I_{11}(\omega_n) & I_{12}(\omega_n) \\ I_{21}(\omega_n) & I_{22}(\omega_n) \end{bmatrix} \right\}. \qquad (16)$$

The XON which pass through propagation medium go into an input of the reception antenna 7. From an output of the receive antenna 7 XON go into the third input of a two-channel spectrum analyzer 8 and starts it.

After passing of the propagation medium 10 polarization structure of signals $S_x^{вх}(t)$ and $S_y^{вх}(t)$ changes. The receive antenna of horizontal polarization 5 and the receive antenna of vertical polarization 6 sequentially receive orthogonally the polarized components of radio signals after passing of the propagation medium 10: $S_x^{вых}(t)$ and $S_y^{вых}(t)$ – orthogonally the polarized components of the radio signals which passed propagation medium. Orthogonally the polarized components of radio signals go into an input of a two-channel spectrum analyzer 8. Where they are transferred to intermediate frequency, intensified, transformed to a digital form, subject operations of fast Fourier transform. As a result of these operations at the output of a two-channel spectrum analyzer 8 signals of complex spectra orthogonally of the polarized radio signals $\dot{S}_x^{вых}(\omega_n)$ and $\dot{S}_y^{вых}(\omega_n)$ are generated. Complex spectra of orthogonally polarized radio signals give on an input of the processing unit 9 where they are divided on a complex spectrum of the radiated radio signal according to eq. (12–15).

The created set of Jones matrixes which elements define in the processing unit 9, characterizes polarization characteristics of the propagation medium of high-frequency signals in the frequency range. Frequency range is defined by spectrum width of the radiated radio signals, and is given to the consumer.

The proposed method allows to receive quickly information on polarization properties of the propagation medium of high-frequency signals.

IV. CONCLUSION

Researches of polarization transformations of signals based on vector model of the radiated signal, its polarization spectrum and Jones matrix defining the polarization properties of the propagation medium of EM of waves. Elements of this matrix generally are complex functions of frequency.

The analysis of polarization distortions in the propagation medium of EM of waves demands creation of the equipment for measurement of these distortions and, perhaps, their automatic adaptive correction. As the parameter which characterizes propagation properties of the propagation medium coefficients of transfer vertical and horizontal spectral a component of the transmitted signal within the chosen description of polarizing characteristics of EM of a signal were defined.

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