

Application of the MatLab Opportunities During the Study of the Fourier Series by Future Border Guard Officers

Liudmyla BOROVYK¹,
Lilia TRASKOVETSKA²,
Olha VALCHUK³,
Iryna BASARABA⁴,
Iryna GASHCHUK⁵

¹ National Academy of the State Border Guard Service of Ukraine, Khmelnytsky, Ukraine, blv_nadpsu@ukr.net

² National Academy of the State Border Guard Service of Ukraine, Khmelnytsky, Ukraine, tlm5@email.ua

³ National Academy of the State Border Guard Service of Ukraine, Khmelnytsky, Ukraine, olavalchuk17@gmail.com

⁴ National Academy of the State Border Guard Service of Ukraine, Khmelnytsky, Ukraine, irynaborovyk2017@ukr.net

⁵ National Academy of the State Border Guard Service of Ukraine, Khmelnytsky, Ukraine, lobanovaiv70@gmail.com

Abstract: The article is devoted to the analysis of the possibilities of using modern applications in the teaching of higher mathematics for future border guard officers of the State Border Guard Service of Ukraine. The article describes the possibilities of the software stand developed on the basis of the mathematical package of the MatLab system, which allows cadets to perform spectral analysis of signals, which is important for solving professional problems of future professional activity. In addition, the article describes the process of the stand and presents its program code. The interface of the developed software stand allows to choose a window for the analysis of a kind of pulses, to receive their images, corresponding radio pulses, and also their spectra. The obtained amplitude spectra allows to compare and state the similarities and differences in the radio signal and signal spectra. In addition, if it is necessary to demonstrate the form of an arbitrary (periodic or non-periodic) signal or a signal with noise, the presented software product allows the cadet to generate a signal depending on its characteristics. The article notes that conducting classes using this software product develops the motivation of cadets to study fundamental disciplines, promotes interest and increases their knowledge and skills in higher mathematics and related disciplines, as the classes have a purposeful informational and emotional impact on future officers, their analytical-synthetic skills and critical thinking develop. In addition, the article considers the features of experimental verification of the classes effectiveness using a program stand to improve the knowledge and skills of cadets in professionally-oriented disciplines, as well as the reliability of the results using mathematical statistics.

Keywords: *MatLab system; program stand; higher mathematics; Fourier transform; efficiency.*

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1. Introduction

Formulation of the problem. In the current conditions of the reform of the State Border Guard Service of Ukraine, an important issue is the training of highly qualified border guard officers, able to use modern means of communication and telecommunications, use the latest technical means of border protection in carrying out operational and professional tasks. Therefore, during the training of border guards in the specialty 172 "Telecommunications and Radio Engineering" it is necessary to pay special attention to the training of future communicators in the conditions of study at a higher military educational establishment. It is clear that in such training attention should be paid to the applied orientation of all general scientific cycle disciplines in general and higher mathematics in particular. For example, the topic of this discipline "Fourier series" has an applied value, because its material is directly used for spectral analysis of signals, design of communication systems, analysis of linear circuits, signal filtering. On the other hand, the higher military educational establishment of the border guard agency prepares first of all a border guard-operator, not a communication engineer, so one must know the physical essence of telecommunication processes, signals and be able to analyze them using application software, not deep know the relevant theoretical material of higher mathematics, necessary for the design of communications. Given this, the teacher faces the task of intensifying and improving the educational process in such a way as to increase the cognitive activity of cadets, motivate them to study the discipline and at the same time ensure the assimilation of the necessary theoretical material.

Therefore, research and teaching staff have a problem choosing the content, forms, methods and teaching aids that would allow cadets to master the material effectively. According to R. Mann, O. Kravcheko and I. Hanzhala, "to ensure the ability of students to non-standard and creative thinking, it is important to introduce innovative approaches to teaching disciplines in the educational process, using the latest methods and forms of teaching, namely interactive methods using information and communication technologies "(Mann, et al., 2020, p.146).

In modern society, information, communication and innovative pedagogical technologies become the basis of promising methodological training systems, the use of which will intensify the educational and research activities of future border guards, increase their mathematical and

professional training, reveal their creative potential and increase their role independent and individual work.

Analysis of recent research and publications. A large number of scientific papers devoted to the study of the process of teaching mathematics using information and telecommunication technologies, which confirms the importance of the chosen topic. In particular, the features and functional possibilities of using modern information and telecommunication technologies are described in Klochko (1997), Semerikov (2009), Sinko (2009), Stefan Steinhaus (2008), Yu. Trius (2005), Tmienova & Sus (2020), etc. Didactic and psychological aspects of their application are given in studies Taras Kobylnyk et al.(2020), Antonenko (2000), Verlan & Tverezovska (1998), Matokhniuk (2018), Smyrnova-Trybulskaia (2007), Spivakovskiy (2003) and others.

Undoubtedly, a significant role in the effective implementation of these technologies belongs to the instructor, it depends on how and for what purpose the software will be used in the classroom will depend on the quality of learning material and the degree of achievement of the lesson's goal. With this in mind, research and teaching staff should pay close attention to their own computer literacy and ability to use information and telecommunications technology in training. According to S. Karakozov (2000), a modern professionally competent teacher must be informationally literate and competent, because today these features characterize his general pedagogical culture and professional skills. Therefore, an important issue is the issue of self-development and self-improvement of teachers in order to implement information technology in the educational process, their development of new software products, the use of which will increase the efficiency of learning and understanding of educational material.

The modern educational process should be built and organized in such a way as to form in future professionals computer literacy, which, according to M. Antonenko (2000), characterizes the ability of the specialist to solve typical problems that arise in real life and professional situations, using modern information technology. in order to achieve meaningful goals. And it is hard to disagree with that, especially when it comes to modern military professionals who use modern weapons and communications in their own careers. This, in turn, sets requirements for the training of future officers, for the formation of their ability to critically analyze the operational information received, and on its basis to develop recommendations for the implementation of professional tasks. It is the use of information and

telecommunications technologies in the study of such fundamental disciplines as higher mathematics, contributes to the development of analytical skills, professional imagination and critical thinking of cadets.

In 2006, the European Commission, following the results of the project "Digital Competence in Practice" published in the form of "European Recommendations of the European Union" requirements for key competencies of future professionals, among which one of the most important is information and digital competence (Ferrari, 2012). This personal characteristic, according to the authors of the project, is based on confidence and ability to use information technology to achieve vital and professional goals, it contributes to the formation of critical thinking, analytical and creative abilities of the individual (Ferrari, 2012).

It is clear that the creation of an effective and high-quality information environment is an urgent and key task of the current stage of development of society in general and the stage of intensification and reform of education in particular. The introduction of information and telecommunication technologies in the process of organizing the protection of the state border, in border control and in the border service makes the problem of computerization of training of future border guard officers urgent and relevant. According to L. Matokhniuk (2018), in the process of training a person with the use of modern computer technology is the formation of features of innovation, creativity, as only information-competent specialist will be ready for responsible, intellectually correct and logically sound actions during their training and professional activities. Researchers O.V. Didenko et al. researching the peculiarities of the use of electronic educational resources in the training of future officers of border guard units, note that "the use of information and communication technologies is one of the biggest priorities and effective means of improving the education of servicemen" (2020, p. 42).

Didactic and psychological aspects of the information use and telecommunication technologies in the educational process are given in the studies of M. Antonenko (2000), A. Verlan (1998), L. Matokhniuk (2018), E. Smyrnova-Trybulska (2007), O. Spivakovskiy (2003) and others. The introduction of these technologies in the educational process "requires comprehensive information and resource and methodological support. Education should focus on the prospects of modern society and the orientation of the individual to the information society, which determines the need to use in the modern educational process of certain new

information technologies "(Matokhniuk, 2018, p.62). In this context, an important aspect is the teacher's readiness to use modern information and telecommunications technologies in higher mathematics, his computer literacy, psychological readiness to use application packages during classes, knowledge of the possibilities of these programs and their modifications, his methodical training, as well as a deep awareness of the teacher of the potential use of information and telecommunications technologies for the formation of cognitive activity of future military professionals, their understanding of the material need and its importance, being investigated for further study and future professional activity.

It is difficult to disagree with the opinion of S. Burchak (2016), who believes that the use of computer technology to teach such fundamental disciplines as mathematics provides ample opportunities for teachers as it contributes to the improvement of learning, creates conditions for cognitive and creative activity. In this context, S. Shumyhai (2010) notes that the mastery of modern information technology contributes to the formation of information and mathematical culture of the future specialist, which is part of the general culture of man. Supporting this thesis, A. Pivtorak (2015) argues that the use of information and computer technology in the educational process and in the teaching of mathematics acts as a catalyst that leads to qualitative changes in the education system and learning content; activates all types of educational activities.

Thus, the introduction of modern information technologies in the educational process of training future specialists in general and the military in particular is a topical and important issue, but the analyzed scientific works do not consider methodological aspects of using information technology to train liaison officers of the State Border Guard Service of Ukraine special application software for teaching higher mathematics for this category of future officers. Therefore, this article is devoted to the study of methodological aspects of the use of modern information and telecommunications technologies for the training of future border guard officers, as well as analysis of the Matlab system functionality to improve the efficiency of learning material.

The aim of the article is to highlight the possibilities of using the MatLab application program in studying Fourier transforms in the course of higher mathematics and the results of experimental training of future border guard officers of the State Border Guard Service of Ukraine.

2. Theoretical fundamentals of research

To achieve this goal, theoretical methods were used: analysis of methodological, psychological and pedagogical literature on the subject, work programs of academic disciplines, textbooks and manuals on mathematical analysis; empirical methods: observation of the educational process of cadets, study of advanced pedagogical experience of teachers, as well as conducting an educational pedagogical experiment.

In order to consider the methodological features of teaching the topic "Fourier Transform" with the use of modern information and telecommunication technologies and to explain the importance of this training material for the training of border guard officer, we will focus on the disclosure of its theoretical and practical significance.

Fourier series is based on a simple but very effective idea - an arbitrary periodic function is represented as the sum of individual harmonic components. By decomposing the received signal described by this function into different frequency components, it is possible to find out how the signal originated, which way it follows or what external influence it was subject to. That is, you can perform spectral analysis and obtain information about the origin of the signal. Spectral analysis is one of the methods of signal processing, which allows to characterize their frequency composition. The ability to conduct such analysis allows to solve specialized problems and practical problems in the field of telecommunications and radio engineering, which is characterized by complexity and uncertainty, and this ability is one of the key competencies of graduates of 172 "Telecommunications and Radio Engineering" according to higher education standards.

The mathematical basis of spectral analysis is the Fourier transform, which relates the time signal to its representation in the frequency domain. The analytical solution of the Fourier transform problem (for those functions for which this solution exists) usually does not cause great difficulties (Shkil, 2005). Problems arise in understanding such a transformation, when the problem of numerical determination of the signal spectrum and the feasibility of recording using infinite sums of relatively complex trigonometric functions.

When studying the topic "Fourier Transform", it is difficult for cadets to understand that when superimposing simple trigonometric functions with different amplitudes and frequencies of the $y_i = A_i \sin(\omega t + \alpha_i)$ form, the functions obtained are completely different

from them. Moreover, the process of decomposition of a periodic function into a Fourier series involves the use of concepts and methods of integral calculus, namely the definite integral, its properties, Newton-Leibniz formula, the method of variable replacement, as well as boundary theory and so on. Moreover, this process is long and difficult, as it involves finding the coefficients of this schedule for complex analytical expressions and requires thorough mathematical training of cadets.

3. Research methodology

We demonstrate clearly the Fourier series decomposition of the periodic sequence of rectangular pulses.

We develop an ideal periodic sequence of rectangular pulses $s(t)$ in a Fourier series with period T , amplitude A and duration τ of each pulse. The analytical record of this sequence has the form

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

Since this is a pair function, it is convenient to use a sine-cosine representation of the Fourier series for its decomposition, in which only cosine components will be present, which can be calculated by the formula in accord with (Pavleino, & Romadanov, 2007).

$$\begin{aligned} a_k &= \frac{2}{T} \int_{-\tau/2}^{\tau/2} s(t) \cos(k\omega_1 t) dt = \frac{2}{T} \int_{-\tau/2}^{\tau/2} A \cos(k\omega_1 t) dt = \frac{2}{T} \cdot \frac{A}{k\omega_1} 2 \sin k\omega_1 \frac{\tau}{2} = \\ &= \frac{2A}{T} \cdot \frac{T}{k \cdot 2\pi} 2 \sin k\omega_1 \frac{\tau}{2} = \frac{2A}{k\pi} \sin k \cdot \frac{2\pi}{T} \cdot \frac{\tau}{2} = \frac{2A}{k\pi} \sin \frac{k\pi\tau}{T}; \end{aligned}$$

Then the Fourier decomposition of the periodic sequence of rectangular pulses will look like:

$$s(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} (a_k \cos k\omega_1 t + b_k \sin k\omega_1 t) = \frac{A\tau}{T} + \sum_{k=1}^{\infty} \frac{2A}{k\pi} \sin \frac{k\pi\tau}{T} \cos \frac{2k\pi t}{T} \quad (2)$$

The resulting series represents the initial sequence of pulses synthesized from the constituent elements: formula (1) describes the signal in the time domain, and formula (2) in the frequency domain.

It is obvious that the presented Fourier series decomposition process is complex, and cadets who do not have a deep knowledge of higher mathematics immediately lose interest in solving the problem and put a psychological barrier to their ability to solve the problem. That is, on the one hand, such tasks provoke negative emotions in future border guards and

form a psychological barrier and uncertainty in their own knowledge and skills. On the other hand, cadets must be able to conduct a spectral analysis of the received signal, which will allow them as border guard officers of the State Border Guard Service of Ukraine to understand how the signal arose, which way it follows or what external influence it was subject to. There is a contradiction between a certain psychological resistance to solving a complex mathematical problem and the need to be able to solve it to increase the level of preparedness of the future officer to solve professional problems.

In order to overcome the identified contradiction, the possibilities of modern information and telecommunication technologies were used, in particular the MatLab application program with a wide range of special applications. The MatLab system is specially created for carrying out engineering calculations. The mathematical apparatus used in it is extremely close to the latest mathematical apparatus of an engineer, researcher, scientist and is based on work with matrices, vectors and complex numbers. Graphical representation of functional dependencies in this application program is organized in the form required by modern engineering documentation. Unlike most computer mathematics systems, MatLab is an open system: this means that almost all MatLab procedures and functions are available not only for use but also for modification, i.e. the user can expand the base of procedures and functions by creating their own routines, including using the built-in graphical user editor GUIDE (Badryev et al., 2010).

4. Research results

In order to visualize arbitrary signals and their spectra, the teachers of the department developed software in a special visual programming environment GUIDE system Matlab in the form of a standard application for the Windows operating system with a graphical user interface. The application is built in the form of a software stand, the interface of which is easy to use and allows you to clearly demonstrate the direct and inverse discrete Fourier transform.

The use of the author's program allows to demonstrate, first, the importance of the topic "Fourier Transform" for solving the professional tasks of the border guard officer of the State Border Guard Service; secondly, to increase the cognitive activity of the cadet and his motivation and interest in the study of the discipline "Higher Mathematics" in general and this topic in particular.

4.1. Work with the software stand and spectral analysis of the generated signals

One of the types of training in higher mathematics is laboratory work, during which cadets independently solve an applied problem using computer technology and submit a report to the teacher, which describes the progress of calculations and presents sound conclusions obtained on the basis of calculations. At the beginning of the lesson, the teacher conducts a short repetition of theoretical material, explains the solution of the problem and the possibilities of the developed software stand, after which the future border guard officers begin to perform the task of laboratory work, which has a professional nature.

An example of such a professionally-oriented task is: *In order to process a radar signal designed to measure the range of an object (aircraft, military equipment, etc.) to determine the spectral density and amplitude-frequency response of the signal specified by the function (the function is added to the condition).*

To solve this problem a program stand is used, the content of which can be found in the following figures and explanations to them.

The program stand consists of a main window that acts as a user menu and six modal windows that open in the main program window. The work begins with the "Select signal" button, after which you need to fill in four fields: the beginning of the signal, the period, the length of the signal, the number of harmonics. You can then select one of the five suggested signals or generate another signal (Figure 1)

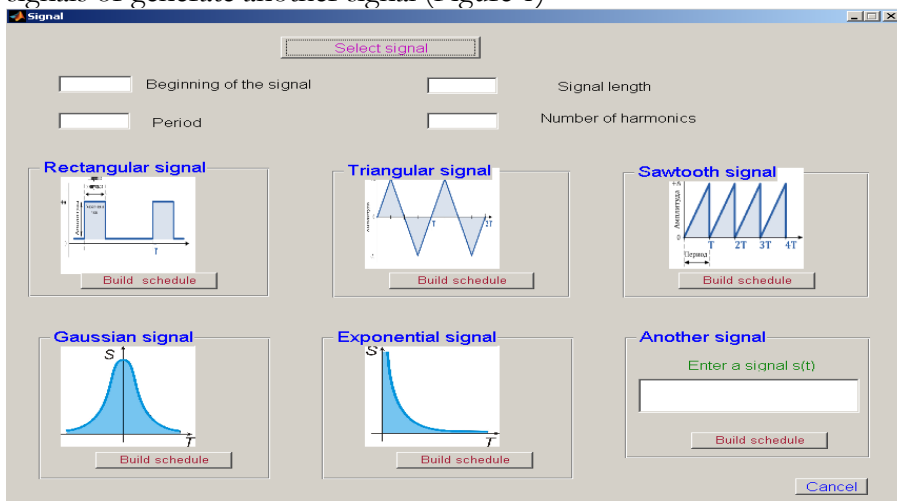


Fig. 1. The main window

Source: Author's own conception

When selecting a rectangular signal, four graphs will be constructed in the newly opened window (Figure 2).

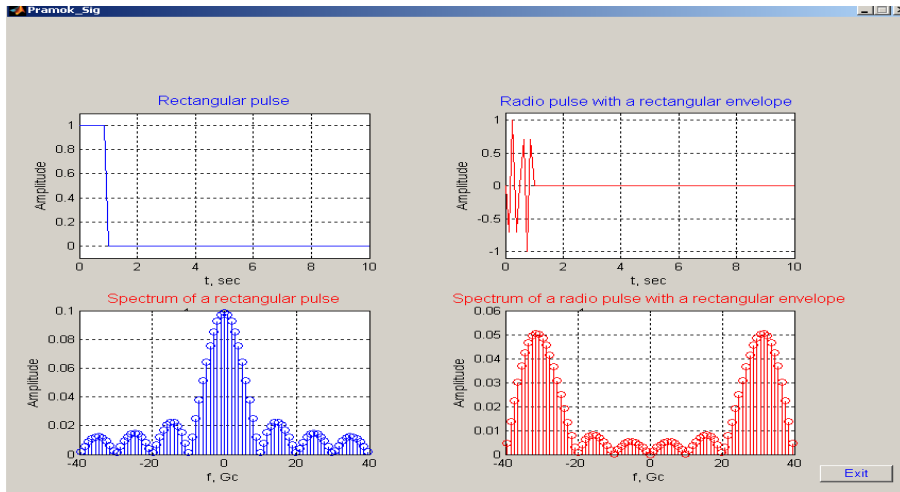


Fig. 2. Rectangular signals and their spectra

Source: Author's own conception

On the left is a rectangular signal and its spectrum, and on the right is a radio signal with a rectangular bypass and its spectrum. The graphs show that the amplitude spectra differ: the rectangular spectrum has one peak, and the spectrum of the radio signal has two peaks.

The interface of the developed software stand allows to select a window for the analysis of a triangular pulse and to receive its image and the corresponding radio pulse, and also their spectra. The obtained amplitude spectra allow us to state that except for two peaks in the radio signal, the spectra do not differ, although the type of signals at the input they are different. By selecting, for example, a sawtooth signal, you can get a new window, which shows that the input signals and their spectra differ little from each other.

The capabilities of the developed software stand also allow to construct spectra of a Gaussian pulse, which resembles the shape of the signal itself and an exponential signal, the spectrum of which coincides with the spectrum of the Gaussian signal. In addition, this stand allows you to imagine single pulses and their spectra, which are often found in the technique of spectral analysis.

If you want to show the shape of an arbitrary (periodic or non-periodic) signal or a signal with noise, you can call from the window of the main menu of the user "Other signal", enter from the remote control an arbitrary signal as a function of time. After receiving the task, the cadet can generate a signal depending on its characteristics (Figure 3).

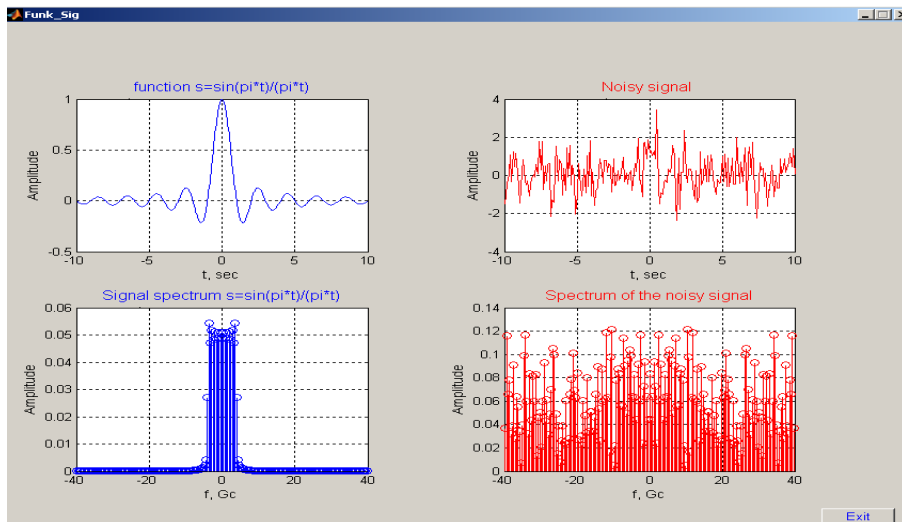


Fig. 3. The generated signal $\frac{\sin \pi t}{\pi t}$

Source: Author's own conception

Work with this software stand allows cadets to better understand the content of spectral analysis of signals, which is important for solving specialized applications of telecommunications and radio engineering. In addition, the organization of classes using a software stand creates favorable conditions for the formation of the ability to perform computer modeling of devices, systems and processes using universal application packages, which is a professional competence of the specialty, and achieve program learning outcomes, namely, the ability to analyze, to argue, make decisions in solving specialized problems and practical problems of telecommunications and radio engineering, explain the results obtained as a result of measurements, in terms of their significance and relate them to the relevant theory, apply basic and applied sciences for analysis and development of processes occurring in telecommunications and radio systems.

4.1.1. Program code

Thus, the developed program code allows to carry out the spectral analysis of signals of various forms and to generate a signal depending on its characteristics. These skills are necessary and important for cadets in the future during the study of professional orientation disciplines and in solving professional-oriented problems.

```
function button_Ex_Callback(hObject, eventdata, handles)
X0=str2num(get(handles.edit_Poch,'String'));
T=str2num(get(handles.edit_Per,'String'));
h=hgload('Exponenta_Sig.fig','All');
tau=str2num(get(handles.edit_Pro,'String'));
N=str2num(get(handles.edit_Kst,'String'));
handles_Exponenta=guihandles(h);
hAxes =axes('Position',[0.08 0.58 0.32 0.30]);
axis([X0 2*T -0.1 1.1]);
% Radio signal
hAxes =axes('Position',[0.55 0.58 0.32 0.30]);
axes(hAxes);
cla;
u2=y.*sin(w0*t);
title('Radio pulse with exponential bypass ','FontSize',12,'Color','r')
grid on
hAxes =axes('Position',[0.08 0.14 0.32 0.32]);
axes(hAxes);
Y=fft(y);
f1=N*(ceil(N1/2)-N1:ceil(N1/2)-1)/N1;
ylabel('Amplitude','FontName','Arial Cyr')
title('Spectrum of a exponential pulse','FontSize',12,'Color','b')
```

4.2. The results of the experiment

Providing high quality educational services involves the identification of new approaches to both the organization and the content and structure of education. An important practical direction of this is the visualization of the educational process, in particular in technical disciplines on a new digitized basis with the use of visualizations, which perform the functions of direct visualization of phenomena and processes (Sadovy et al., 2020).

Visualization of educational material of the lesson with the use of software products allows the instructor to save time, consider more tasks, and, consequently, the effectiveness of such type lesson increases. In addition, this approach helps to enhance the cognitive activity of cadets in higher mathematics. Thus the teacher it is desirable to bring elements of a

problem at the beginning of employment. The methodological advantages of classes conducted using the developed program code are that the creation of coherent sound and visual images in the mind of the cadet arouses interest and curiosity in learning, and it has a purposeful informational and even emotional impact. The involvement of various senses for the perception of information contributes to the growth of the degree of material assimilation in comparison with traditional methods of teaching, i.e. the teacher creates a favorable multisensory learning environment (Ylyn, 2006) .

An important issue is the practical significance of the acquired knowledge for further educational and professional activities and the establishment of interdisciplinary links, as these aspects help to increase motivation to study the discipline. The teacher should emphasize the relevance of the study material on "Fourier Transform" for the study of other professionally and professionally oriented disciplines such as "Computer Aided Design", "Electrical and Radio Measurement", "Theory of Electrical Circuits", etc.

As it has been already mentioned, the use of the created software stand allowed to consider a much larger number of examples of practical tasks in the classroom. This had a rather positive effect on the quality of learning material and in general on the success of the discipline, in this case in higher mathematics. However, to confirm the effectiveness of the use of the developed subprogram in the classroom, the achievement of program learning outcomes and the effectiveness of the methodology of classes with its use, only the statement of increasing the intensity of the educational process is not enough. In order to obtain an objective assessment of the proposed method effectiveness, an additional study of the success of cadets majoring in "Telecommunications and Radio Engineering" in the disciplines "Computer Aided Design" and "Theory of Electrical Circuits", which use the knowledge gained in studying the Fourier transform» (During the 2018-2019 and 2019-2020 academic years).

The disciplines "Automated Design Systems" and "Theory of Electric Circuits" are studied by cadets of the above specialty during the third term. Therefore, the success of cadets in this discipline was checked during the examination session in the third term. For comparison, the discipline learning outcomes cadets of the 2018 and 2019 enrollment cadets were selected. This choice was due to the fact that for the cadets of the 2018 recruitment classes in the discipline "Higher Mathematics" were conducted according to traditional methods, and future recruitment officers in 2019 studied the discipline using the developed software stand.

To confirm the reliability of the study results, the homogeneity of these groups was checked. It should be noted that the main qualitative indicators at the time of group enrollment did not differ: the age of cadets from 17 to 20 years, the group consists of 25 people, women 8% (two people in each group). All cadets were enrolled according to the results of external evaluation and presented certificates in mathematics, physics and Ukrainian language. A comparative analysis of the results of the examination session (2nd term) in the disciplines of the training cycle is presented in table 1.

To statistically check the homogeneity of these groups, t – Student's criterion was used (Rudenko, V. M., & Rudenko, N. M., (2007)), the calculation formula of which in the case of unrelated samples of different volumes has the form:

$$t_{emp} = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{(n_1 - 1) \cdot s_1^2 + (n_2 - 1) \cdot s_2^2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}, \quad (3)$$

where \overline{X}_1 and \overline{X}_2 , s_1^2 and s_2^2 , n_1 and n_2 – statistics of the first and second samples, respectively. The calculations were performed using EXCEL software, the results of which are also presented in Table 1. The choice of criteria is due to changes in the sample size due to changes in the number of groups due to deductions for health and family circumstances (at the time of second year). In general, all the limitations of this criterion are met.

Statistical hypotheses were constructed as follows:

H_0 - the average score in the relevant discipline for the groups of 2016 and 2017 recruitments does not differ;

H_1 - the average score in the respective discipline for the groups of 2016 and 2017 recruitments differs significantly.

Table 1. Results of the examination session of cadets of the specialty "Telecommunications and Radio Engineering" (2nd term).

Grades	Grades from the discipline were obtained:		
	Informatics	Physics	Electrical and radio measurements

	recruitment		recruitment		recruitment	
	2018	2019	2018	2019	2018	2019
excellent	1	2	6	5	0	2
good	8	7	8	6	8	8
satisfactory	16	14	10	13	15	14
unsatisfactory	0	2	1	1	2	1
grade point average	3,4	3,36	3,76	3,6	3,24	3,44
t_{emp}	0,214		0,662		1,098	
$t_{crit} (\alpha \leq 0,05)$	2,010635					
$t_{crit} (\alpha \leq 0,01)$	2,682204					

Source: Author's own conception

The obtained empirical values of the statistical criterion were lower than the critical ones, which confirmed the hypothesis that there are no differences between the level of success of cadets in the 2018 and 2019 recruitments of disciplines of the cycle of professionally-oriented training.

Analysis of learning outcomes for cadets in 2019 in the third term after using the method using a software stand, allowed to significantly increase the average score of cadets in higher mathematics and significantly improved the level of knowledge in some professional disciplines such as "Computer Aided Design", "Theory of electric circuits". The results and statistical verification of the results of the examination session of the third term are presented in table 2.

Table 2. Results of the examination session of cadets of the specialty "Telecommunications and Radio Engineering" (3rd term)

Grades	Grades from the discipline were obtained:					
	Higher mathematics		Automated design systems		Theory of electric circuits	
	recruitment		recruitment		recruitment	
	2018	2019	2018	2019	2018	2019
excellent	3	5	4	6	3	4
good	5	13	6	11	6	14

satisfactory	15	5	12	7	13	6
unsatisfactorily	1	0	1	0	1	0
grade point average	3,48	3,92	3,57	3,96	3,48	3,92
t_{emp}	2,037		1,727		2,122	
$t_{crit}(\alpha \leq 0,05)$	2,014					
$t_{crit}(\alpha \leq 0,01)$	2,689					

Source: Author's own conception

Statistical hypotheses were built similarly to the previous ones. The calculated empirical values ($\alpha \leq 0,05$) turned out to be greater than the critical ones at a sufficient level of statistical significance for the academic disciplines "Higher Mathematics", "Automated Design Systems" and "Theory of Electric Circuits". This allows us to state with at least 95% confidence that the results of the examination session by cadets of the specialty "Telecommunications and Radio Engineering" in these disciplines differ significantly and since the compared groups are homogeneous, and work programs of disciplines have not changed, it can be stated that differences due to the use of the developed software stand.

In order to more clearly present the results of the study, the diagram presented in Figure 4 is constructed.

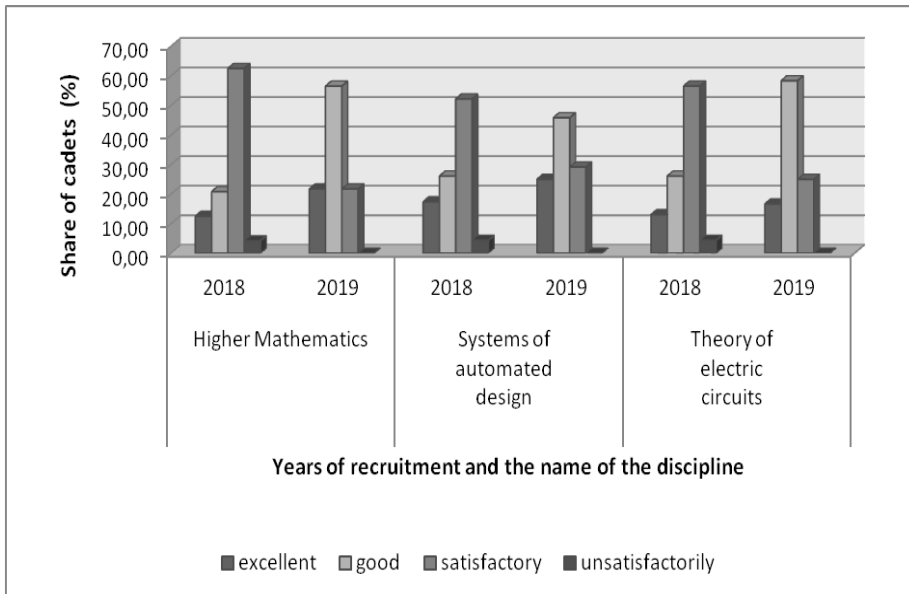


Fig. 4. Results of passing the examination session by cadets of the specialty "Telecommunications and Radio Engineering" by cadets of 2018 and 2019 of the recruitment

Source: Author's own conception

The analysis of the presented diagram shows a significant increase in the number of excellent and good grades in the cadets of 2019 recruitment in comparison with the cadets of 2018 recruitment, which is dominated by satisfactory grades.

These indicators form the basis for determining the quality and success of cadets in passing the examination session and the effectiveness of the educational process. The results of calculating the quality and success of a number of disciplines are presented in table 3.

Table 3. Quality and success of passing the examination session by cadets of 2018 and 2019 recruitment

Performance indicators	Higher Mathematics (HM)		Automated design systems (ADS)		Theory of electric circuits (TEC)	
	recruitment		recruitment		recruitment	
	2018	2019	2018	2019	2018	2019

Quality	37,50%	73,90 %	41,70%	73,90%	37,50%	78,30%
Progress	95,40 %	100%	95,80 %	100%	95,80%	100%

Source: Author's own conception

5. Conclusions and prospects of further research

Summing up the study, we can state the following:

- modern requirements for the training of future professionals in any field, including in the field of law enforcement activity, which includes the activities of the State Border Guard Service of Ukraine, provide for deep knowledge and skills to perform professional tasks of professional activity. Curricula for the training of border guards in the specialty 172 "Telecommunications and Radio Engineering" include disciplines that provide thorough preparation for the study of professionally oriented disciplines such as "Automated Design Systems", "Electrical and Radio Measurement", "Theory of Electrical Circuits", etc.;

- such fundamental training is provided by the discipline "Higher Mathematics", one of the topics of which is the topic "Fourier Transform". This topic is important and necessary for future officers to conduct spectral analysis of the signal, obtain information about its origin, obstacles and ways to overcome them. The ability to perform such analysis is important and necessary for solving the professional tasks of border guard officers of the State Border Guard Service of Ukraine;

- solving problems in the topic "Fourier transform" involves the use of knowledge and skills of cadets of concepts and methods of integral calculus, boundary theory, the theory of complex variables, etc. It should be noted that these topics are difficult for students to perceive, and, as a rule, the success of cadets in their study is reduced, there is a certain psychological barrier, which, in turn, affects the motivation of future border guard officers to study higher mathematics. Therefore, it is necessary to change the methodological approaches to teaching this topic. One of them is the approach based on the introduction of modern information and telecommunication technologies in the educational process. Its implementation will simplify the understanding and perception of educational material and demonstrate its importance in further professional activities;

- to this end, in the MatLab application system, the authors have developed a software stand that allows: to generate basic signals and radio

signals that are often used, to demonstrate signal spectra, to analyze the change of signal period, generate arbitrary signal with and without noise and analyze their spectral density. The description of possibilities of the constructed software stand is presented in article. Its use in higher mathematics solves a number of problems: allows the teacher to save time, consider more tasks, increases the effectiveness of such classes, and emphasizes the importance of mathematical training for future professional activities, to solve professional problems, motivates cadets to study fundamental disciplines and builds self-confidence. The methodological advantages of classes conducted using the developed software product are that the creation of consistent sound (teacher's explanation) and visual (images on the monitor screen) images in the mind of the cadet arouses interest and curiosity in learning, and it has a purposeful informational and emotional impact;

- in order to confirm the effectiveness of classes using a program stand and increase the training of future border guard officers studying in the specialty "Telecommunications and Radio Engineering", to study professional disciplines, methods of mathematical statistics were used. Application of Student's statistical criterion for comparison of results of passing of examination session by cadets of 2018 and 2019 of a set on the specified specialty on educational discipline "Higher mathematics" and on disciplines which use preparation on higher mathematics and are professionally oriented, "Theory of electric circuits" and "Systems automated design" revealed the presence of statistically significant differences. The quality and success of the cadets of the 2019 set is much higher compared to similar characteristics for the cadets of the 2018 set. It should be noted that future officers of both categories studied according to the same programs and before the introduction of the program stand in the educational process, their groups were homogeneous in composition;

- obtained results confirmed the effectiveness of the introduction of the program stand in the process of teaching higher mathematics in general and its topic "Fourier Transform" in particular. Conducting training sessions according to the method of using the software developed and described in the article increases the cognitive activity of cadets, optimizes their learning activities, promotes awareness of the importance of acquired knowledge and skills for further professional activity, increases the level of training of future border guard officers of the State Border Service Ukraine to the study of professionally-oriented disciplines, contributes to the achievement of program learning outcomes, as well as increases the efficiency of the educational process of higher military education.

Areas of further research are the development of methods for the application of new information technologies in the study of other professionally-oriented sections of higher mathematics in the training of future border guards in the educational process of higher military education.

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