SOFTWARE SYSTEM FOR SYNTHESIS AND ANALYSIS OF COMMUNICATION CIRCUITS AND PROCESSES USING MATLAB

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Abstract: *In this paper a software system for synthesis and analysis of communication circuits and processes is described. It is used in the educational process in the course "Communication Circuits", included as compulsory in the curriculum of the specialty "Telecommunication Systems" for the Bachelor educational degree. The software system is developed by MATLAB and offers the possibility to solve problems for independent work during the practical exercises to the following sections of material: oscillating circuits, electrical filters and modulations.*

Keywords: *MATLAB, communication circuits and processes, oscillating circuits, electrical filters, modulations.*

1. INTRODUCTION

In this paper the operation and architecture of the software system developed for synthesis and analysis of communication devices (oscillating circuits, electrical filters) and processes (modulations) is described. The system will be used in the practical exercises by the students in the course "Communication Circuits" in the specialty "Telecommunication systems" of Bachelor degree at the University of Ruse "Angel Kanchev".

The software system was implemented using MATLAB 7 on Windows, a dialog programming environment for scientific and technical computing and visualization of results [3]. The system allows solving the problems provided for independent work of students during the practical exercises, making the learning process more attractive and more effective for the students and the teacher. The system developed has the following four modules: communication module, training module, calculation module and test module.

2. TEACHING TECHNOLOGY

According to the current syllabus for the course "Communication Circuits" included as mandatory in the curriculum of the specialty "Telecommunication Systems" for the Bachelor educational degree at the University of Ruse "Angel Kanchev", the material is taught weekly in the two-hour seminars. These exercises cover topics from the following three sections: 1) Oscillating (resonant) circuits; 2) Electrical filters; 3) Modulation [2].

Each student receives an individual assignment from the teacher. The student must solve the problems according to the provided methods [1, 2] and present the results to the teacher at the end of the exercise through his/her report. A report will be accepted by the teacher, if it contains up to 4 wrong answers for the exercise. It was established by the practice in order to eliminate “the tricks” by students for recording numerical calculations values “by eye”. If the student has not submitted reports for individual exercises, he/she does not receive certification by the teacher for the practical exercises. Heavy labor-consumption of the process of verifying the work of the students by the teacher required the development of the software system described in the paper. The system aims to facilitate the activity of the teacher in assessing students' knowledge partially.

The training technology in the course was introduced in the academic 2010/2011 year. Since there are always students who fail to submit their reports by the end of the current academic year, it requires storing the information for each academic year and continuous “monitoring” the status of the students to “clear” all “indebted” students.

A flow-diagram illustrating the process of creating and using the developed MATLAB-based application is given in Fig. 1. Participants in this process are the teacher conducting the practical exercises, and students studying the course “Communication Circuits”.

Before the creation of the software system (Fig. 1, Block 1) materials which will be used by the application are prepared (by the teacher). For this purpose widespread and accessible products as MS Word, MS Excel, MS PowerPoint and Paint are used. A “database” with multiple graphical images stored in a format *.png* is created. The images are used by the training module of the application developed. Then the actual development of the application by MATLAB (Fig. 1, Block 2) follows.

Surrounded by a dotted line Block 1 and Block 2 (Fig. 1) are namely the application contribution of the system developed.

The next blocks in Fig. 1 (Block 3 … Block 6) illustrate the use of MATLAB-based application, the students work in parallel with the four modules of the system: communication module, training module, calculation module and test module. The system will be put into practice in the academic 2014 – 2015 year (due to replacement of the course “Communication Circuits” from the fourth term into the fifth term according to the the new curriculum of the specialty “Telecommunication Systems”).

The test module of the system enables the teacher to form the final assessment of a problem, of an exercise or for the term (Fig. 1, Block 7) for each student. The marks will be published online in the platform for e-learning [2] in the course “Communication Circuits” at the University of Ruse.

The four modules of the system are connected with each other and operate in parallel in time. So, the presentation of the connectivity of blocks 3 to 6 with one-way arrows is formal. Practically continuous transition from working with a module of the system to working with its other module is carried out. For example, the test module requires the student to enter a numerical value of a calculated quantity, which means the student communicates with the system, i.e. one of the activities of the communication module.

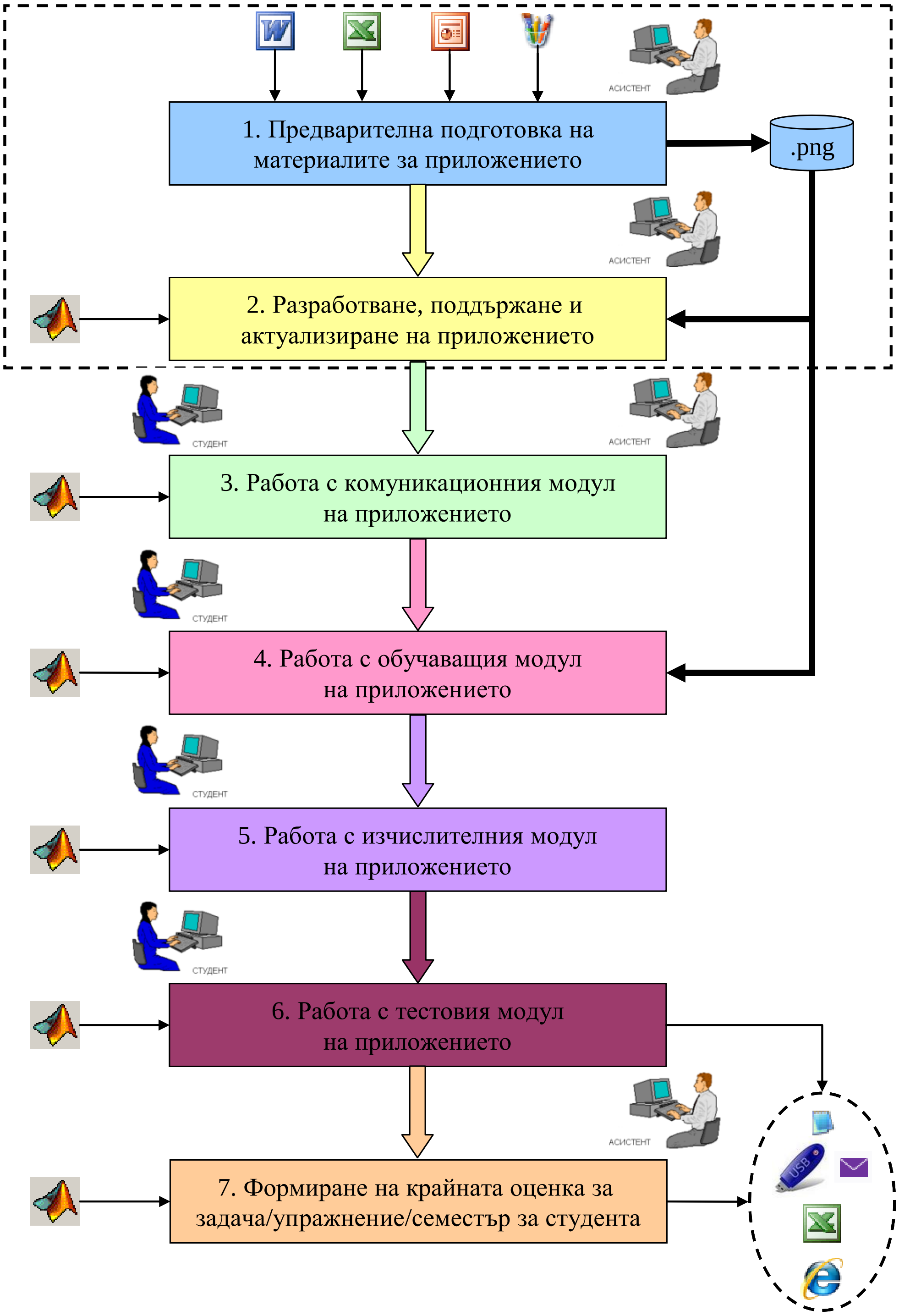
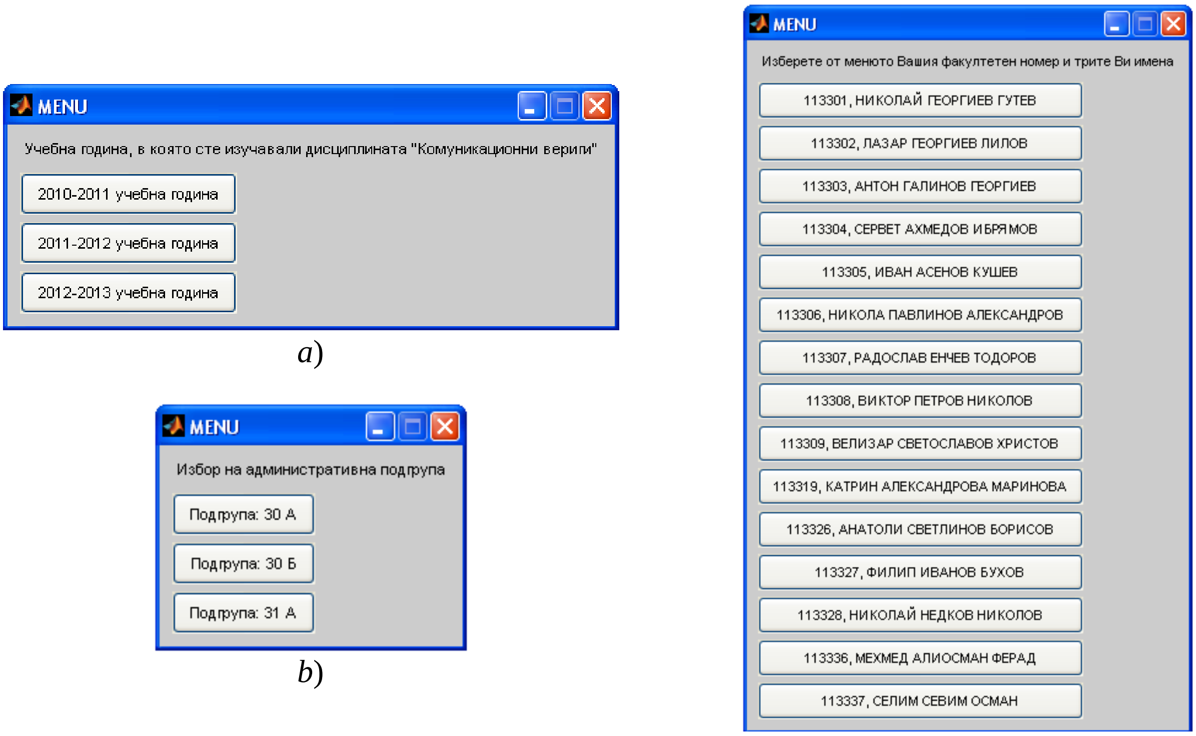


Fig. 1. Flow-diagram illustrating the process of creating and using the MATLAB-based application developed

The communication module of the system realizes the communication with the student, including: **1)** the student's registration in the system; **2)** entering the input data needed to solve the problem; **3)** entering numerical values for calculated quantities through the key-board; in fact it is testing of the student and also communicating of the student with the system.

When starting the application by typing in the command window of MATLAB its name *ILM_CCs* a menu for choosing the academic year in which the student studies (or has studied) the course “Communication Circuits” appears (Fig. 2 *a*). It is necessary because of the students who have not submitted their reports by the end of the current academic year in which they have studied the discipline, and for the collection and further processing the statistical data on training.



a) *b*) *c*)

Fig. 2. Registration of students in the system

After selecting the academic year, a menu for choosing the administrative subgroup which the student is assigned to (according to the division of the Dean's Office) appears. Students in the specialty “Telecommunication Systems” form the administrative groups 30 and 31, and the group 30 has two subgroups (Fig. 2 *b*). After selecting the subgroup a menu with a list of the students in the subgroup for the academic year selected is displayed (Fig. 2 *c*). The menu contains buttons with the data of each student (faculty number and full name), of which the student must select and press “his/her button”. In Fig. 2 *c* a list of second-year students in the subgroup 31 *A* studying the course “Telecommunication Systems” during the academic 2012-2013 year is given. In such a way the student is registered in the system. The system stored in a file information about the academic year, the subgroup, the faculty number and full name of the student and the student's work with the system during the practical exercise. Using the generated file the teacher can monitor the actions of the student after completing the exercise in his/her convenience, and the generation of the file allows the teacher to store information about the actions of students during the practical exercises. The generated text file can be opened using widely-spread product Notepad, be carried through flash drive or possibly be sent by email to e-mail address of the teacher (Fig. 1, block 7). At the moment sending the generated file by e-mail in MATLAB is not realized due to difficulties in the use of the built-in MATLAB function *sendmail* for sending e-mails to servers that require authentication and a solution to fix the problem is looking for. The content of the generated file is described in [9]. Currently, registration of students in the system is relatively low. This requires improving it, for example, through the usage of passwords. For the moment, the system only provides a synthesis and analysis of the relevant communication devices and processes, not the processes of authentication or authorization of the student.

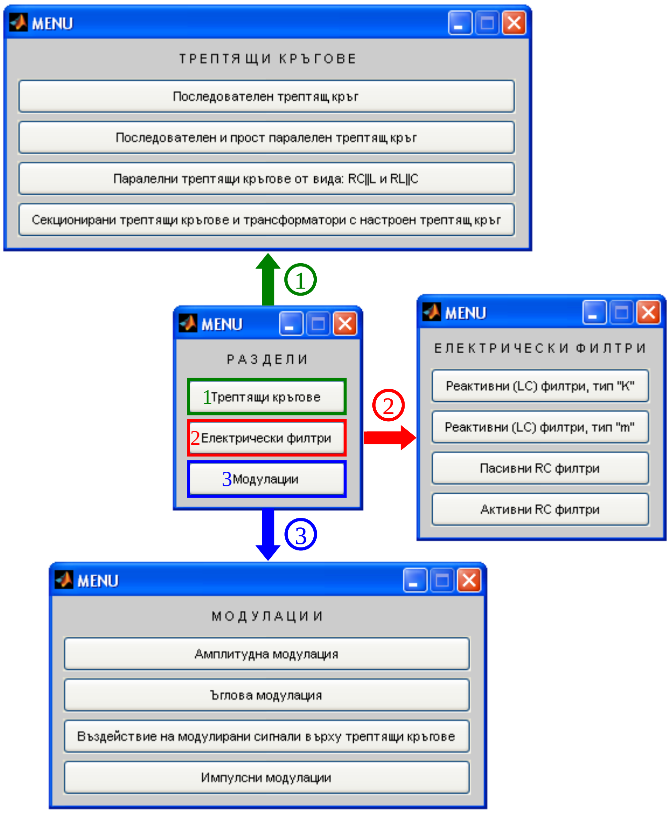


Fig. 3. Series of menus for selecting the section and the topic

After registration of the student, through a series of menus the choice of the section and the topic is done (Fig. 3), and a problem in the topic to be solved, the numbering of pages and problems is according to [1] (for the section “Resonant circuits”: Fig. 4 *a*, for the section “Electrical filters”: Fig. 4 *b*, and for the section “Modulations”: Fig. 4 *c*). According to the curriculum each section is planned to be studied within four weeks, so the themes to each section are four (Fig. 4).

The calculation module of the system allows computing the desired values for each of the problems on the basis of previously entered input data from the students via the communication module. In the implementation of the calculation module the methods presented in [1, 2] for solving the problems for independent work during the practical exercises are used.

The most attractive module is **the test module** of the system, which aims to assess the knowledge and skills of the student, allowing the teacher to form the final assessment of a problem, for an exercise or for the term (for each student).

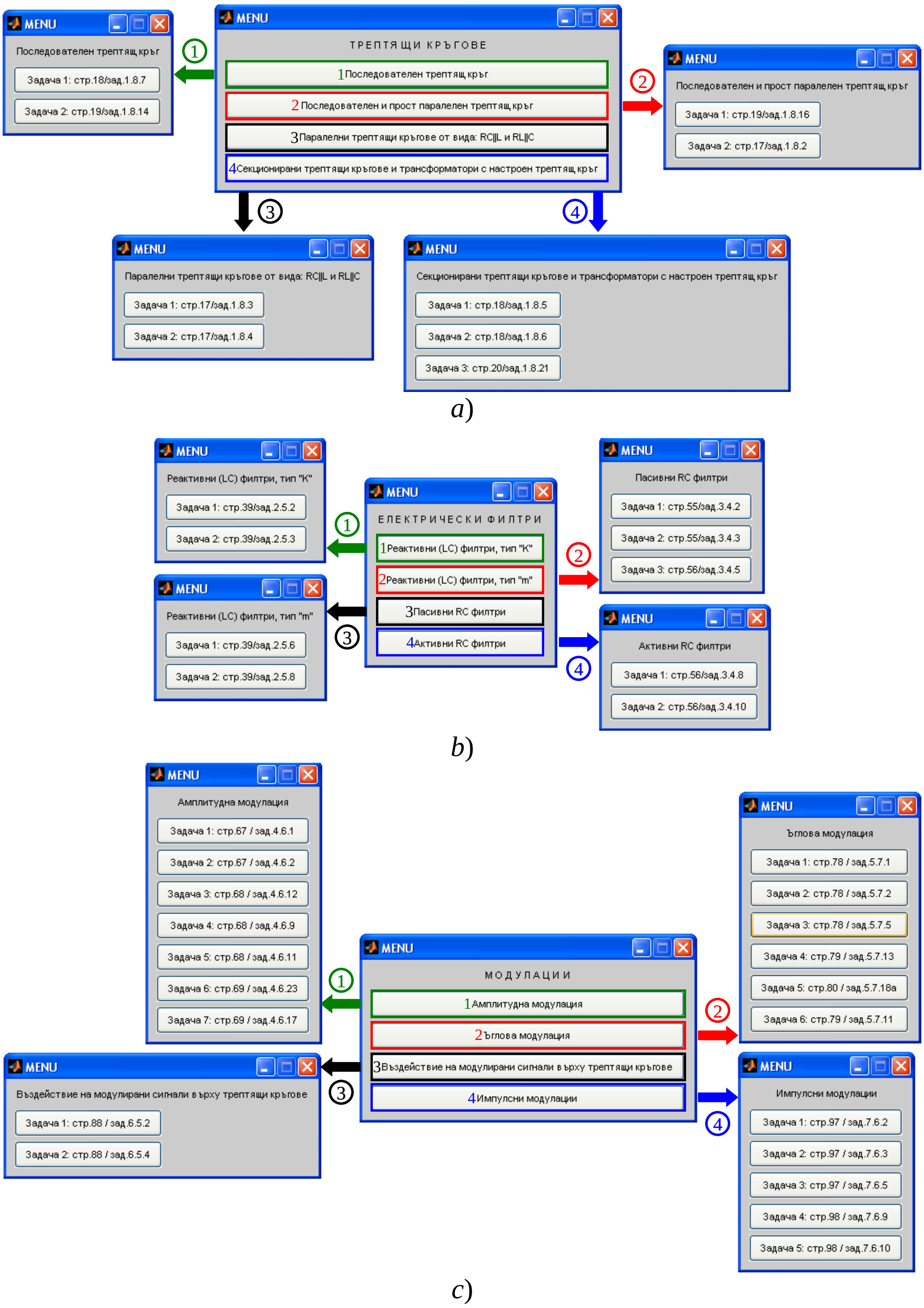


Fig. 4. Choice of a problem to be solved through a series of menus:
a) for the section “Resonant circuits”; *b*) for the section “Electrical Filters”,
c) for the section “Modulation” (via the communication module)

3. ARCHITECTURE OF THE SOFTWARE SYSTEM

The architecture of the software system developed for synthesis and analysis of communication devices (resonant circuits, electrical filters) and processes (modulations) is given in Fig. 5.

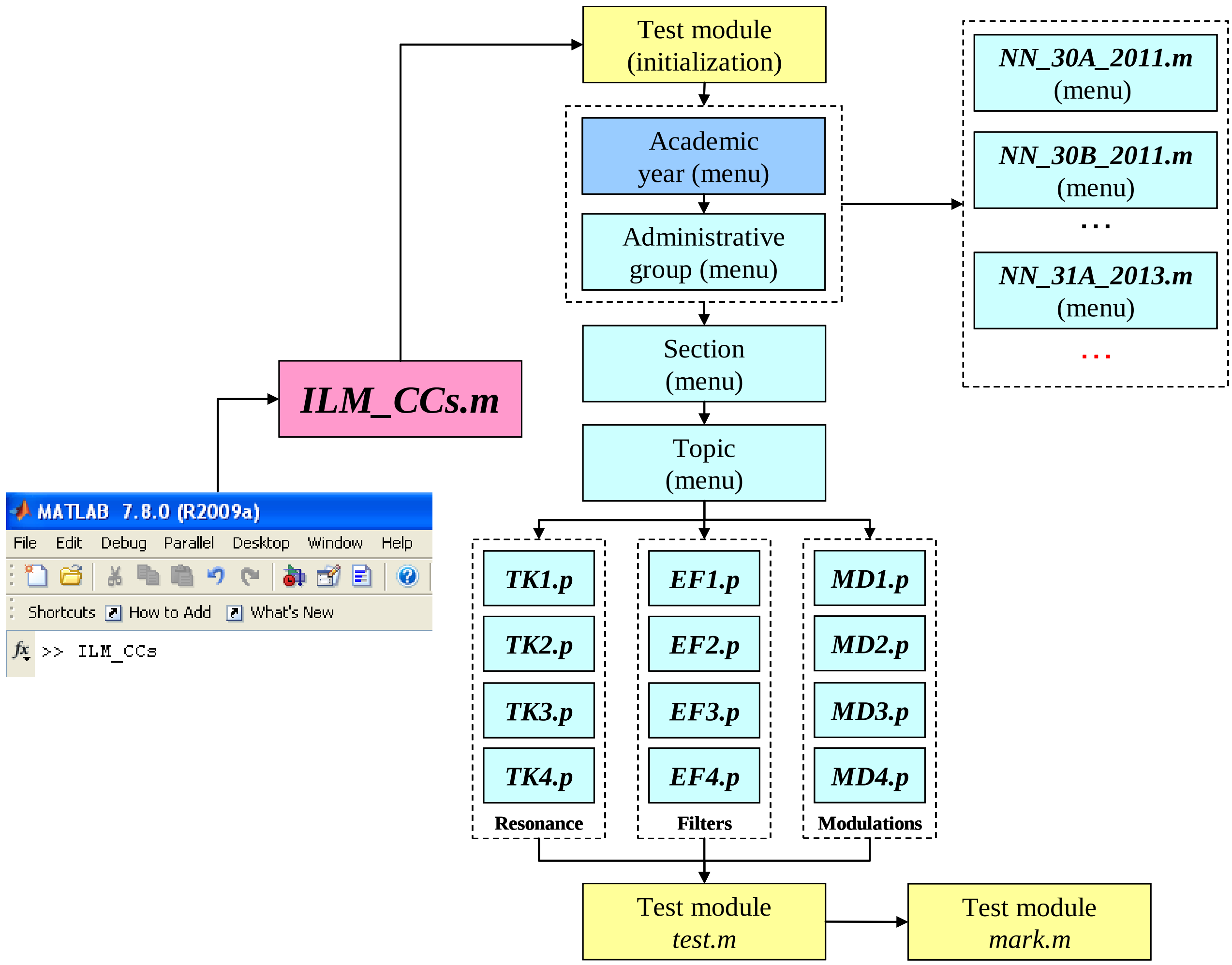


Fig. 5. Architecture of the software system developed for synthesis and analysis of communication devices and processes

The software system includes a main script file, *ILM_CCs.m*, by which the application is started when typing the name *ILM_CCs* (*Interactive Learning Module*, *Communication Circuits*) in the command window of MATLAB. This script file performs initialization of the test module by resetting the initial number of points $s = 0$ and displays consistently several menus for choosing the academic year (every year this menu must be completed by the current academic year), the administrative group, the section and the topic respectively. Depending on the choice made for the academic year and the administrative group, the script addresses to another *m*-file, one of *NN_30A_2011.m*, *NN_30B_2011.m*, ..., *NN_31A_2013.m*. These files show menu with a list of students (faculty numbers and full names) in the group for the academic year selected. Their number is increasing every year because it requires the creation of new data files of students for the next academic year.

Then the choice of the section, the topic and solving problems for the current practical exercise is done. The script addresses to the corresponding *p*-file: *TK*1*.p*, *TK*2*.p*, *TK*3*.p* and *TK*4*.p* (when choosing one of the four topics of the section “Resonant circuits”) or *EF*1*.p*, *EF*2*.p*, *EF*3*.p* and *EF*4*.p* (when choosing one of the four topics of the section “Electrical filters”) or *MD*1*.p*, *MD*2*.p*, *MD*3*.p* and *MD*4*.p* (when choosing one of the four topics of the section “Modulations”). In the performance of *p*-files in each problem the test module updates the value of the variable *s* by calling the function *test.m*, and finally, the final number of points *s* is transformed into a mark by the function *mark.m* [9].

P-files (files with the extension *.p*), generated by the command *pcode*, have the following features [3]:

1. *p*-codes are executed faster than the corresponding *m*-files.

2. If *m*-files and their *p*-codes are located in the same directory, when typing the name of a file (without extension) in a command, then the system executes the corresponding *p*-code.

3. If *m*-file and the corresponding *p*-code are in different directories, the system executes one of them, which is in the current directory or in a directory that precedes the other one in the list of available directories.

4. The usage of *p*-code allows hiding the original (source) code of programs by others.

The last feature is one of the advantages of the system, because the code for calculating the corresponding values in the problems remain hidden from students. This requires either independent programming in MATLAB or manually resolving the problem using a calculator by the student.

The algorithm (Fig. 6), embedded in the system, contains the following steps:

1. Registration of the student – by choice through a series of menus for the academic year, the administrative group, the names and the faculty number of the student (Fig. 2).

2. A menu for choosing one of the three sections, one of the four topics of the relevant section (Fig. 3) appears. After selecting the topic, again a menu for choosing the problem appears; the numbering of pages and problems are according to the reference [1], used during the practical exercises (Fig. 4).

3. To be used in the learning process the application developedt is extended by the following options – the following information is shown in separate graphical windows: 1) the condition of the problem; 2) the scheme of the communication circuit (if any); 3) formulas for the calculation of the demand values (Fig. 6, called “initialization phase”; it is designed for training students, i.e. training module).

4. Entering the input data necessary for the problem as hints and any restrictions on the choice of the value entered appear. A check for the correctness of the numerical values of the quantities is done and if necessary a message to re-enter input data displays.

5. The output data is calculated (an activity of the calculation module).

6. In the case of testing the student through the software system, the student enters the input data through keyboard and next the next value is calculated.

7. The output data is displayed on the screen and graphical dependencies (such as spectral charts, time-diagrams of the input and output signals) if required when solving the problem are visualized.

8. The willingness of students to solve a new problem is checked. If the student has finished with all the problems of the current practical exercise, his/her work with the system ends. If he/she wants to solve more problems, then a second choice of the problem through menu is performed (Fig. 4).

The functioning of the individual modules of the software system for synthesis and analysis of communication devices and processes is described in the previous publications of the authors [4, 5, 6, 7, 8, 9].

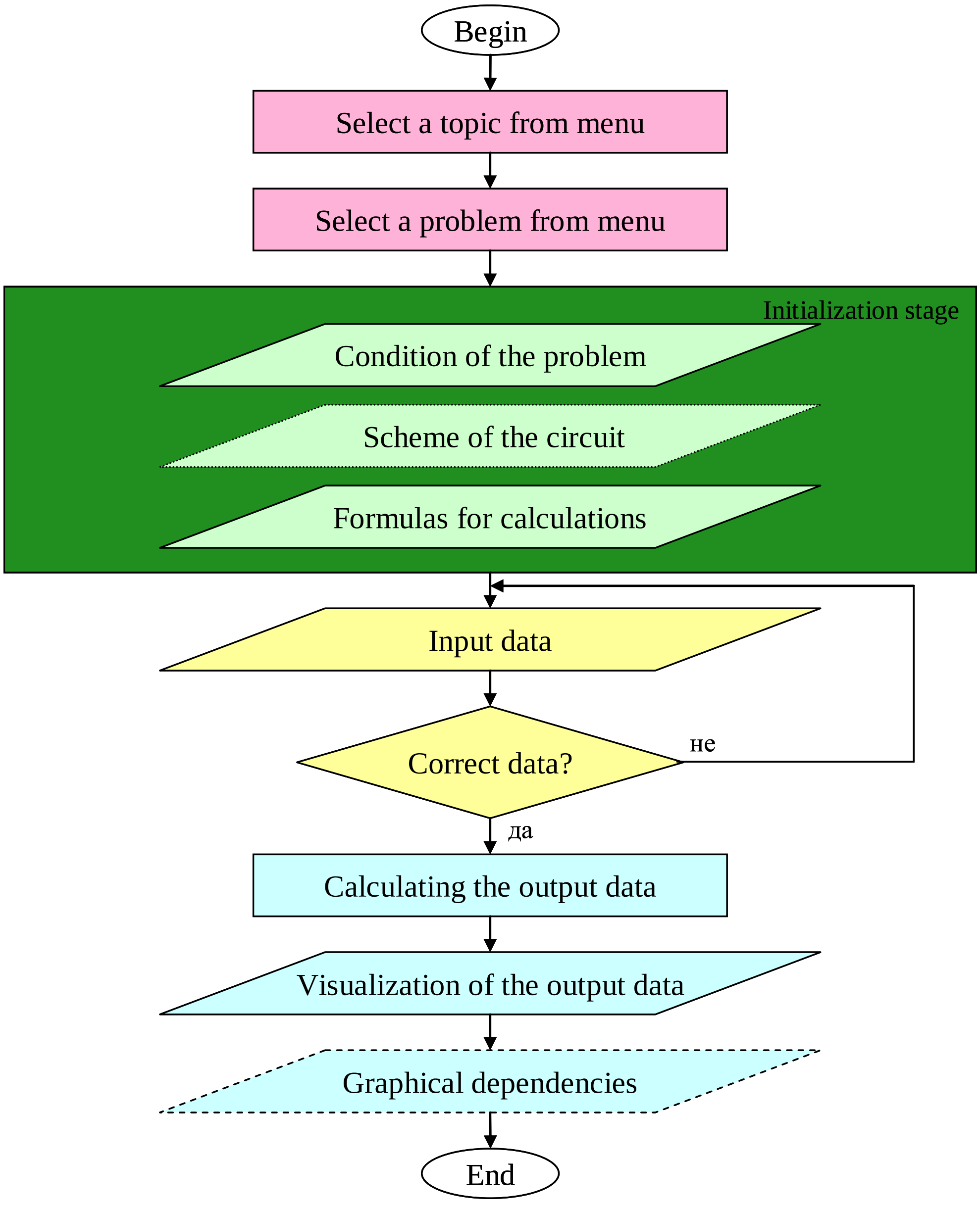


Fig. 6. Algorithm in the software system developed

4. CONCLUSIONS

The architecture and functioning of the software system developed for synthesis and analysis of some communication circuits and processes are considered in the paper. The system allows a faster process of synthesis and analysis by the students and an easier, more efficient, and at any time monitoring by the teacher when used in the course “Communication Circuits” included as mandatory in the curriculum of the specialty “Telecommunication systems” for Bachelor degree at the University of Ruse.

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