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INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER  
AFASES 2015  
Brasov, 28-30 May 2015

## SIMPLE SOFTWARE FOR EDUCATION

Hošek Jaromír\*, Alexandr Štefek\*

\*Faculty of Military Technology, University of Defense, Brno, Czech Republic

**Abstract:** *The paper deal with education of the students of technical branches. The one of the basic subjects for most technical branches in technical colleges is subject Automatic control. The teaching is focused on theory of automatic control and next revision theoretical knowledge in practical laboratory exercises. It is very suitable to make another experiment or "playing" with basic elements of automatic control for better understanding automatic control lectures. The aim of this paper is to show possibilities of the experimenting and better understanding of the theoretical and practical lessons for every student without using very expensive software.*

**Keywords:** *automatic control, practical experiences, simulating program.*

### 1. INTRODUCTION

The University of Defense prepare students to three main branches: commanders for fighting units of Czech Army, technical experts for the Czech Army and the last branch prepare general practitioners for health service of Czech Army. The technical branches like construction and maintenance of aircraft, pilots, construction and maintenance of control systems of the rocket, radar engineering and antiaircraft systems have the Automatic Control subject like one of the basic subject. The aim of the lectures in that subject is to grasp a core of control systems and understand relation in control techniques by the students. There is presumption that these future professionals which will operate with military equipment can use capabilities of that equipment at maximum level.

Another benefit is the noticeable amount of these technical specialists leave army after fulfilment their contract. These technicians

have good reputation in civilian factories and they are good valued. These professionals have big experiences with management team in extreme conditions and knowledge and skills from control engineering.

### 2. THE SIMPLE SOFTWARE FOR EDUCATION

**2.1 The basic idea for design the software.** The knowledge gained from lectures and exercises must be verifies using practical lectures – laboratory exercises. Laboratory is equipped with devices from company Feedback. The Feedback is verified kit used at many schools, colleges and universities. The electro kit and pneumatic kit is mainly used. Nowadays a low-cost LEGO Mindstorm NXT system is used for teaching modern control theories. Theoretically counted examples are verified on those kits. Students must set calculated parameters and they watch changes in behavior of the kit immediately. The higher

level of laboratory exercise then combines calculations and settings a combination of more parameters of the regulated circuit. Laboratory equipment is expensive and setting of kits parameters is limited. The most of those kits operate with excellent but expensive software, for example MATLAB software. In this case students have not expensive kits or software, but they can verify their knowledge at laboratory even during breaks between lectures.

The frequent teaching in laboratory, mean less time for students experiments. This leads to decision to design simple single-purpose tools which enables exploration and testing automatic control principles for students. Described tool allows simulate simple system with P control and change parameter of regulated system. The students are not limited neither to classrooms nor expensive licensed software. Developed software can be used on widely available computers like home computers are. The software allows not only set P parameter but also partially change structure of the regulated system.

This single-purpose program has simple and intuitive operation. The students can concentrate on study and experimenting and they do not waste time by another problems like study manuals. This program can students use on their private computer without any license and it do not require any special software.

**2.2 Software and its ability.** The software is based on freely available language C# (CSharp). This language use object-oriented design patterns (OOP language). Basic version of developer environment can use everybody, but it is limited to nonprofit applications. Programs created with these language runs safety with common computers e.g. home computers.

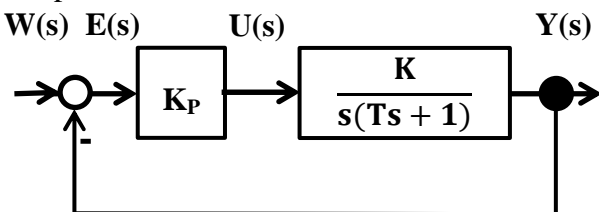


Fig.1 Scheme of the simple system

Example of possible simulated system structure is on Fig.1.

This is a negative feedback circuit with proportional element that is commonly used.

As shown in Fig.1 (compare with Fig. 2), students can set gain of a proportional element  $K_P$  from 0 to 50, they can set gain  $K$  of a regulated element, order of astatic and time constant  $T$ . The element  $K_P$  can be set by mouse, click to circle and move by pointer or after click to circle can set by keyboard and key + or -. To set other simulation parameters constant user must click to chart and rewrite numbers, Fig2.

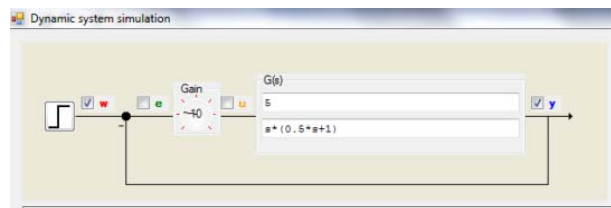


Fig.2 Setting gains and constants

On the bottom of the screen Fig.3, are the classic controls of the program stop, play, fast move and back to start. The data of the measuring exercise we can save in Microsoft Excel®, associated icon is in the right of controls.

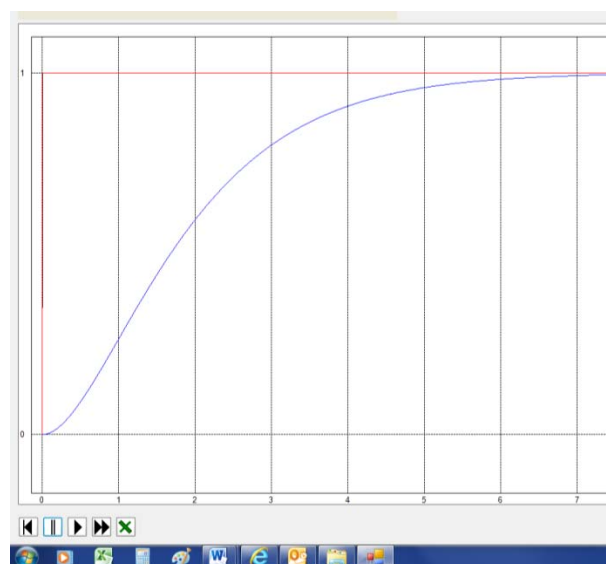


Fig.3 Print screen of the characteristic  $K_P=10$ ,  $K=0.5$ ,  $T=0.05$

The interface allows change gain (P control parameter) during the simulation. This functionality offers to users some kind of



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interactivity and observation of system behavior.

### 2.3 Calculation of the shown example.

The calculation of the shown figure3 is very easy, but in comparison to available laboratory kit the proposed solution (software) an user can set system parameters and see resolution immediately.

Parameters are:

$$K_P = 10; K = 0.05; T = 0.5$$

Now students have to calculate Transfer function of open and closed circuit:

$$G_O(s) = \frac{0.05K_P}{s(0.5s+1)}; G(s) = \frac{1}{s^2 + 2s + 1}$$

The step response function is:

$$H(s) = \frac{1}{s} - \frac{1}{(s+1)^2} - \frac{1}{s+1}$$

Now application of inverse Laplace transformation to step response function give function in time domain.

$$h(t) = 1 - te^{-t} - e^{-t}$$

We can see that transition process is aperiodical.

The program enables to insert steps in any time arbitrarily by clicking on icon step in the input of the chart. The new steps are red lines. The new characteristic is funny, fig4.

The students must calculate one example according to instructions to know what parameters set at first and then can make experiments and change all changeable parameters and explore substance of regulated systems.

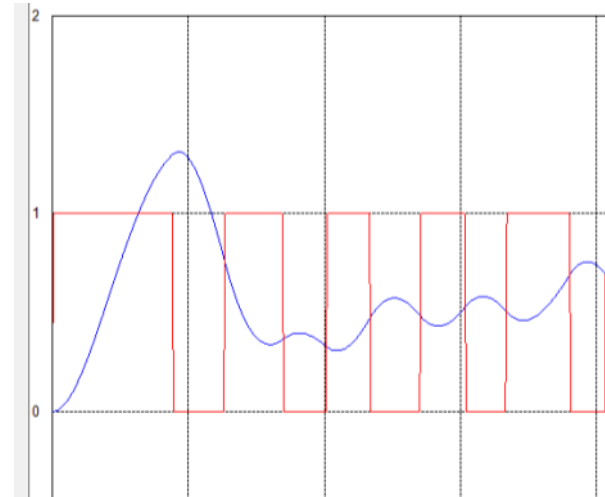


Fig.4 Print screen of the funny characteristic  $K_P=10, K=0.5, T=0.5$

**2.4 Practical experiences** Practical part of a teaching, laboratory exercises is focused to use Feedback kit. The students are divided to group and every of that must evaluate own task. Practice shows that some students "fear" our laboratory kit and because of that they don't understand some parts of that subject so good. The students can use special computer classrooms where they can train automatic control problems in common simulators (like MATLAB software is). The laboratory and computer classrooms are accessible only in breaks and afternoon. Laboratory availability creates space for this special software. The hesitant students obtain simple program and can explore secrets of automatic control. They can play with program in the comfort of their home and are not fixing on schools laboratory or classrooms. The additional homework for students is to identify unknown system according to the characteristic.

During checking tests students have deeper knowledge about automatic control problems. They are not afraid to discuss about that problems and they have bigger certainty in

their answers. The final examines are evaluated better and students are less feared.

The students start aware importance of differential equations and role of the coefficients. We can say that it is comeback to stage where they studied mathematic (nearly a year back). Here we apply the motto “the school of the game” but at a higher level than in elementary school.

The aim was not to design some new software (what is time-consuming) but to design very simple application with ability to run anywhere. The user has not worry about setting incorrect values to damage laboratory tool. As usually, during playing with that program students meet some problems or something interesting behavior, for example unusual characteristic. During solving this problem they understand setting values and connections in regulated system much more than during reading or counting of the examples.

After passing laboratory lesson of that subject students can depend on their skill and knowledge.

**2.4 Extended use.** The software is provided with source code. As it does not use any special external libraries students are encouraged to try understand simulation problems deeply. Nearly same approach can be used in control system software on embedded microcontrollers.

### **3. CONCLUSIONS & STUDENTS KNOWLEDGE**

It was very pleasing and interesting after ending this subject when answer on question what was the subject give you the answer was: “I finally understood importance of the

differential equations, their creating on base of the physical principles. I know how coefficients of linear differential equations are created and their influence on behavior of the regulated systems.” and others. The students changed their sight on mathematics and physics. Those lessons are not boring counting loads of examples but they gain ability to interpret (explain) meaning of a calculated results.

At the end we can say that except deeper understanding automatic control problems, setting parameters of a regulated systems and their behavior, the students change opinion on other previous subjects like mathematics, physics and others and understand their place in technics.

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