

VIRTUAL ANALOG COMPUTER COMDYNA GP-6

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ABSTRACT

This paper describes the software that simulates the analog computer. Analog computer COMDYNA GP-6, which is available on the market and usually used for educational purposes, is observed. Its preferences and constraints are taken into consideration when the Matlab simulation model is formed. The model provides to a user a way to configure analog computer elements and connections among them. User interface is implemented in Visual Basic program. It enables configuration editing, triggers cyclic simulations of the Matlab simulation model and presents simulation results. Cyclic simulations enables user to interactively change parameters of a simulation system.

1. INTRODUCTION

Modeling and simulation are very useful in engineer's practice for solving practical problems. Procedure for simulating a system starts with determining the mathematical model describing the physical quantities of interest. The tool that has made simulation of system model is analog computer, which should solve the complex system of equations that describes real physical system. A general purpose analog computer is usually made of active electrical circuits to provide high speed of operation, good accuracy, and a high degree of versatility [1].

A typical simulation of physical system involves a mathematical model consisting of a set of one or more differential equations and variables initial conditions. The voltage transfer characteristics of the electrical network are analogous to the desired mathematical operations and they could be "programmed" on an analog computer.

Analog computer COMDYNA GP-6, which is usually used for educational purposes, is observed in this paper. If mathematical model is linear then operations required for its solving are summation, sign inversion, multiplication by a constant, and integration or differentiation. Active electrical networks consisting of resistors, capacitors, and operation amplifiers are capable to simulate any linear system. By proper connections among these elements is also possible to simulate nonlinear systems.

Accuracy of results obtained by the analog computer simulation depends on the quality of elements built in it. When a linear model is simulating 1 % error could be sufficient, and for nonlinear models error is usually bigger than 5%.

If an output of any active component reach 10V (the upper voltage limit) then the overload lamp lights up to indicate that simulation results are no more valid. To avoid such behavior, the proper time and amplitude scaling of mathematical variables is necessary.

Today, digital computers (like PCs) are usually used for simulations and practical applications with analog computers are significantly reduced. However, analog computers theory is still educated, because they are necessary in some applications. The virtual analog computer could help in education of students that have to become familiar with the use of the analog computer.

2. ANALOG COMPUTER SIMULATION MODEL

Simplified mathematical models of analog computer components are well known. Models of amplifiers, integrators and potentiometers are described by simple algebraic and differential equations [1]. Simulation models of such components could be found in many simulation software programs (tools), like Matlab for example.

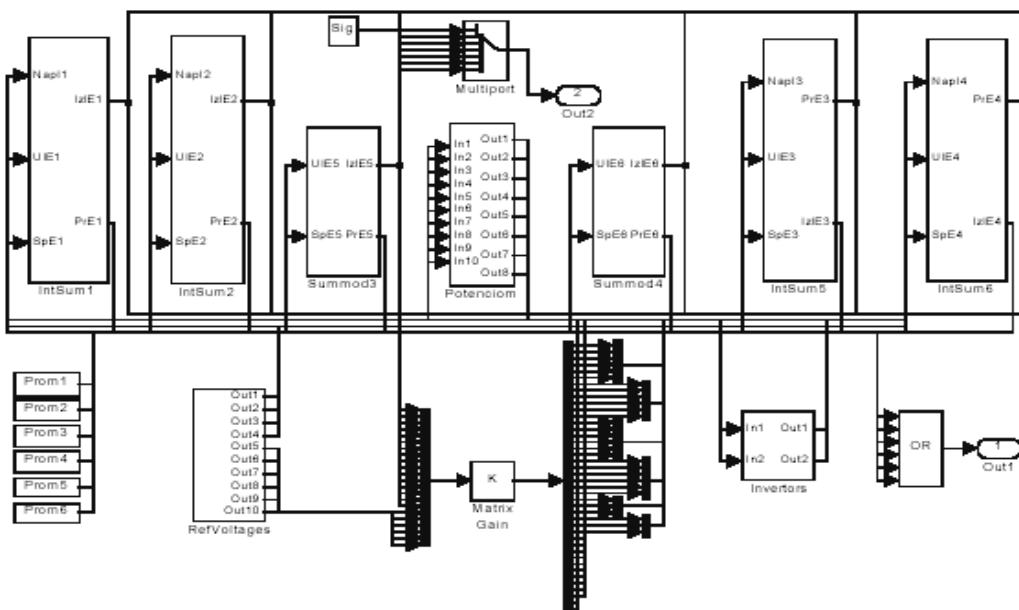
On the other hand, connections among analog computer components depend on the problem which analog computer solves. So, the main task here (when such analog computer simulation model is made), was to find out the proper way to model such connections among components.

The simulation model of the analog computer COMDYNA GP-6 is shown in Picture 1 .It is built in simulink, which is an extension to Matlab program for simulating dynamic systems [2]. Simulink block libraries imply blocks that can present components of analog computer (operational amplifier, summator, integrator, multiplier...). These blocks are taken from libraries and integrated our model of analog computer.

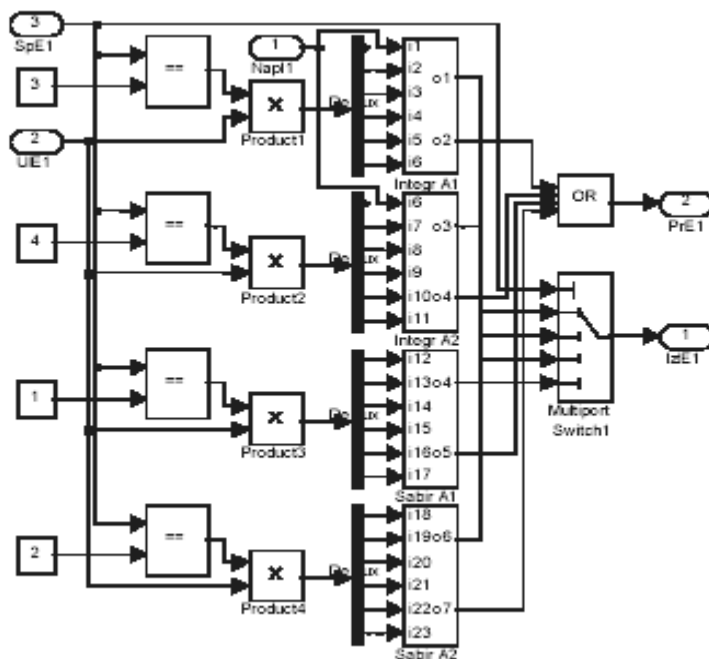
The model consists of following components:

- Matrix Gain, which is used to model connections among elements,
- 4 subsystems which should operate as integrators or summers (*IntSum*),
- 2 subsystems which should operate as summers (*Summod*),
- 8 potentiometers,
- 2 inverters, which inverts sign of input signal and
- constant voltages as +10V and -10V references

Matrix Gain represents connections between elements in model. This component consists of 22 inputs and 42 outputs (22x42 Matlab matrix) that are connected to, respectively, outputs and inputs of model elements [3]. For example, if second output is connected to ninth input then $\text{MatrixGain}(2,9)=1$, otherwise $\text{MatrixGain}(2,9)=0$. Model of *IntSum* is given in Picture 2.



PICTURE 1. SIMULATION MODEL OF ANALOG COMPUTER COMDYNA GP-6

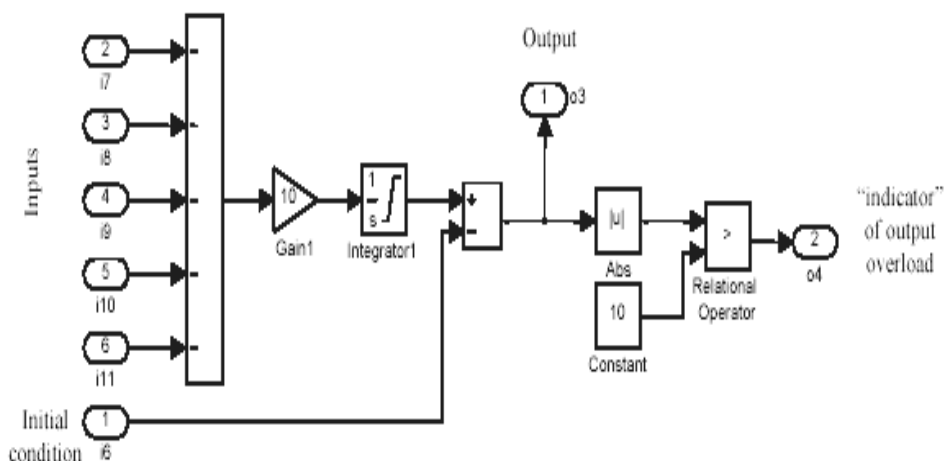


PICTURE 2. MODEL OF INTSUM

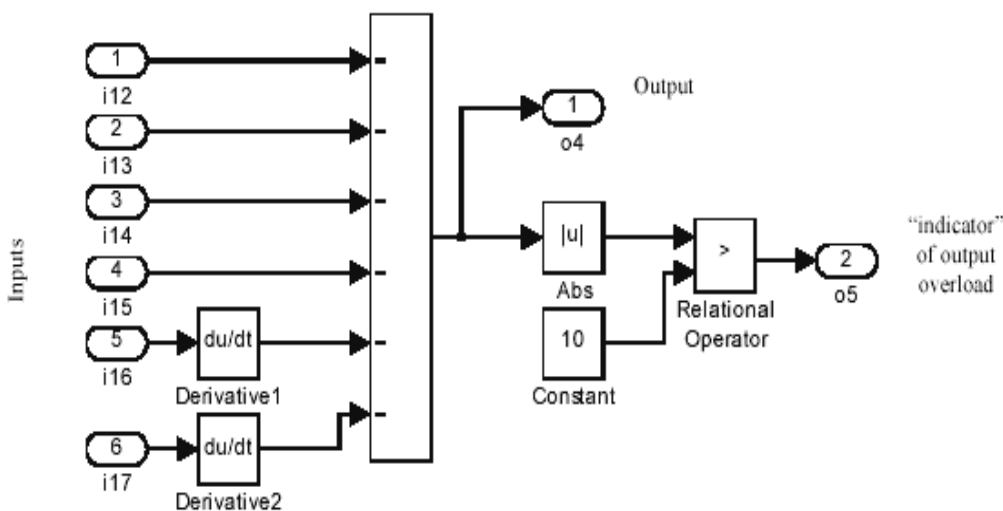
This model consists of four mutual exclusive subsystems, which work independently next to each other. Two of them are integrators have gains 1 and 10, and othertwo are summers have gains 1 and 10. When IntSum is in use only one subsystem is active, which depends on a user configuration.

In Picture 3, simulation model of integrator with gain 10 is shown, and simulation model of summer with gain 1 is given in Picture 4. This summer can work like differentiator, too.

The simulation model of a Summod is similar to IntSum but simpler than it, and it can't operate as a differentiator.

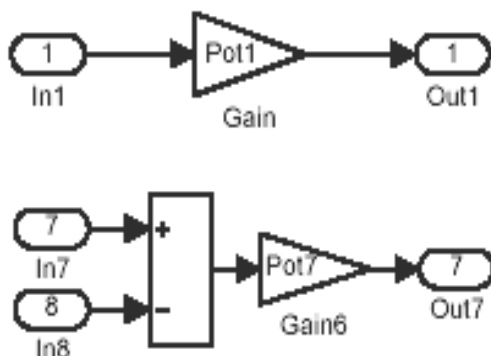


PICTURE 3. SIMULATION MODEL OF INTEGRATOR WITH GAIN 10

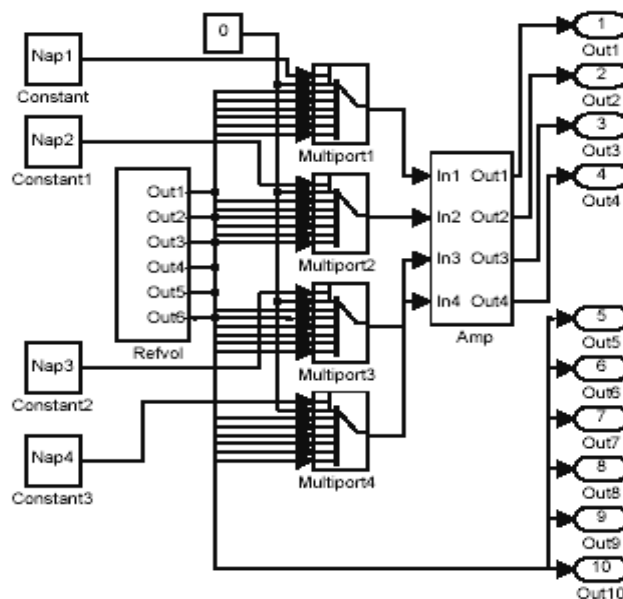


PICTURE 4. SIMULATION MODEL OF SUMMER WITH GAIN 1

Potentiometers are used primarily for entering parameters (constants) into a program. They operate as multiplier by adjustment constant or as voltage dividers (Picture 5). The model of reference voltage subsystem is given in Picture 6.



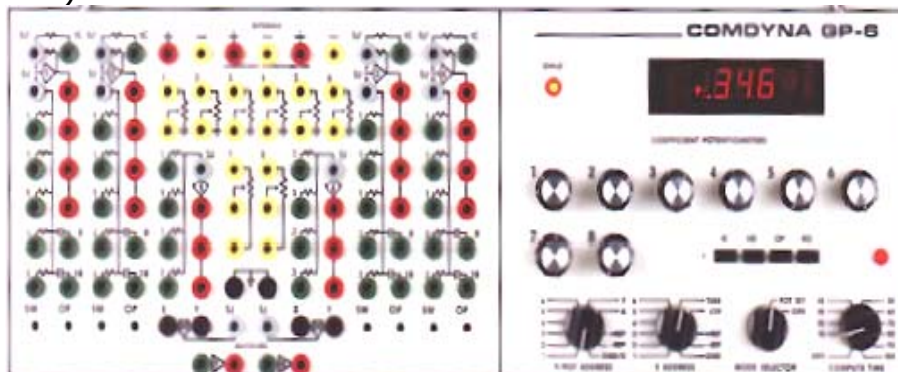
PICTURE 5. BLOCK DIAGRAM OF POTENTIOMETER



PICTURE 6. MODEL OF REFERENCE VOLTAGE SUBSYSTEM

3. DEVELOPMENT OF USER INTERFACE

The User interface is implemented as a Visual Basic program. The view of user interface that represents analog computer COMDYNA GP-6 is shown in Picture 8. It seems like Comdyna GP-6 Patch Panel (which is shown in Picture 7.) and has almost all components consists of (except its multiplier).

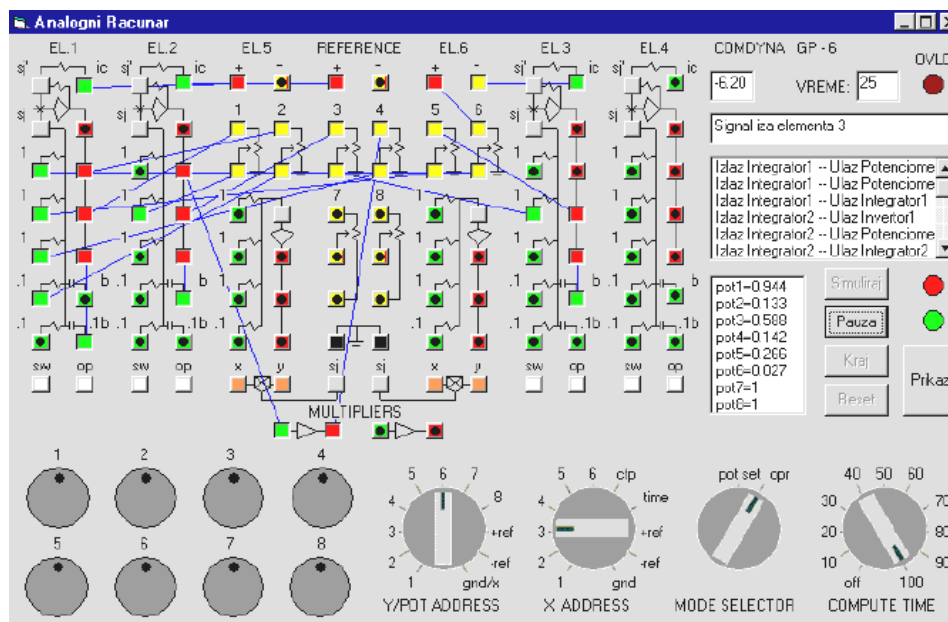


PICTURE 7. GP-6 PATCH PANEL

User interface is designed for novices. It is primary used for visual "programming" connection among analog computer components, to make the simulation model of the given system. To make a connection user should click on an output first and then click on some unused input. Error message is shown if a connection is not properly made. At the end, when all desired connections are made, the Matrix Gain is created and transferred to Matlab simulation model. After that, Visual Basic program starts cyclic simulations of Matlab model.

Cyclic simulation is introduced to enable a user to interactively change parameters of a simulated system. The whole simulation period is divided to many short interval simulations, which are started in

equidistant time instances. At the end of each cycle, state variable values are started in the Matlab workspace, and they are used as initial state variable values at next simulation cycle. The time between Pause among two-simulation has to be enough for the Visual Basic program to take simulation results and set new values for parameters if necessary.



PICTURE 8. VIEW OF USER INTERFACE

4. CONCLUSION

The virtual analog computer could be used as starting point for teaching analog computer COMDYNA GP-6. The simulation results are very close to the real analog computer behavior, but there are some differences. This virtual analog computer could save simulation model with parameters and some simulation results could be shown in diagrams. The simulation model enables a user to easy and comfortable work. It doesn't consider real characteristics of the analog computer's components (nonlinear characteristic of op amp, time delay, variations in resistor values, etc.). The presented solution works slower than real COMDYNA (it doesn't work in real-time and it is delayed by the program execution, but for the educational purposes is good enough.

ACKNOWLEDGMENT

This work has been financed by Ministry of Science and Tehnology gant NP EE 305-101A.

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