



Stewart platform simulation using the LabView environment

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ABSTRACT

Purpose: Disabled persons, who wants to learn to drive a car, are often forced to buy own car and adapt it to their personal abilities. The other chance for them is to use the car simulator. Such simulator was built, but one of the most important issues was to make the experiences as realistic as possible. All parameters have been set experimentally and tested by many drivers. It was necessary to find a compromise between safety and reality. In order to protect the simulator from damages, it was necessary to build the computer model and to conduct the simulation virtually before setting up the parameters of the real simulator.

Design/methodology/approach: In the paper is presented the method of modelling the Stewart platform (which is the base of the car simulator) in LabView Robotics software. The application uses the CAD model of the platform and conducts digital simulation of its movements to show all possible positions of the simulator. The simulation tests also have been done earlier, conducted in the NX program, during the design process. These results are used as the reference for the current simulation in order to check the correctness of the LabView model.

Findings: The digital model of the simulator allows analysing the Stewart platform workspace with the high accuracy. The collision in the virtual world will not cause any damages, which could be possible in real tests. This method of verification shows also if there is possible to extend the platform's workspace.

Research limitations/implications: The variety of experiments concerning static, kinematic and dynamic parameters of the platform has been done using the virtual model. Such experiments are especially dangerous for real simulator, because of extreme values of parameters like velocity or acceleration. The real static tests should be performed slowly and hence there is time to react when the signs of damage appear, but during the real dynamic tests, the time for reaction is very short and it is easier to destroy the simulator.

Practical implications: The virtual tests of system dynamics are divided into two stages. In the first one, the values of velocities and accelerations are set by the software in the motion parameter window. It is measured the impact on the driver. In the second stage it is used the virtual model of mechanical part of the simulator. The UDP protocol is used to communicate with the control system and obtain the motion parameters.

Originality/value: The tests allow checking the real parameters of the simulator work. The hazards and improper parameter, which cannot be detected in real test, have been revealed. The results allow setting more proper dynamic parameters and ensuring the better usage of the simulator workspace.

Keywords: Steward platform; Modelling; LabView

Reference to this paper should be given in the following way:

W. Banaś, A. Sękala, A. Gwiazda, K. Foit, G. Kost, Stewart platform simulation using the LabView environment, Archives of Materials Science and Engineering 75/2 (2015) 82-88.

METHODOLOGY OF RESEARCH, ANALYSIS AND MODELLING

1. Introduction

The car simulator for a driving school for disabled persons (Fig. 1) was designed a few years ago [1-4]. All parameters of movement of the platform have been set and the right engine with power reserve has been used. But because of the lack of a good tool enough for the simulation of vehicle movement in real time the first run was made very carefully. The simulator was steered from the outside and all the motion parameters of the simulator, important for the design, were tested. For the driver safety reasons, before the first start the dynamic performance of engines was reduced. In the next test it was increased and measured the acceleration acting on the simulator and the driver.



Fig. 1. Car simulator for driving school for disabled persons

It should be done very careful because the driver was sitting in the simulator. The tests took a very long time and require simultaneous work of many people. Another problem was the other driver behaviour. Even the same driver has not driven the same route twice just to be able to compare results with different parameters engines. However we set the parameters so that the driver was safe and driving feelings were similar to driving a real car [5,6].

Since that time the work on improving the performance of the simulation is continuing. They are used newer and newer tools to set better parameters. National Instruments LabVIEW Robotics is a new module that allows not only performing the dynamic tests but also importing a CAD model to obtain its appropriate parameters and execute dynamic motion simulation.

2. Model simulator in the LabVIEW robotics

In recent years newer and newer programs to simulate the movement of machines were created. It is possible to connect an external source of data and programs from the virtual reality [7-9]. In this paper is presented the method of modelling and the use of Labview Robotics. It is described the Stewart platform model and the method of checking its parameters and the example of connection with the real controller.

2.1. Stewart platform modelling

In mostly of the programs allowing for motion simulation the modelling process is very complex. Usually one can use only primitives like a box, cylinder and sphere but modelling is very time consuming. There are many CAD programs that support drawing and have additional libraries containing models of typical elements used in mechanical engineering. These programs can export files in many standards. LabVIEW Robotics can import some of them.

At the beginning it was planned to use the file on the basis of which the simulator was made (Fig. 2). The model is very detailed and contains all the information on the

constituent parts such as screws, rails, shell and holes. But the import to LabVIEW is very difficult. It was noticed that a lot of elements are fastened together and move together. So, all the components were linked together in one piece. Such substitute element can have different mass and inertial parameters. In this case the NX CAD program was used to correct them.

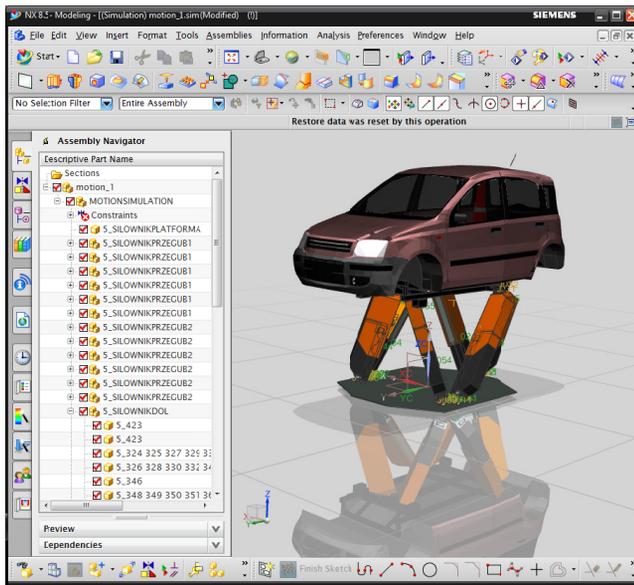


Fig. 2. Simulator model in NX

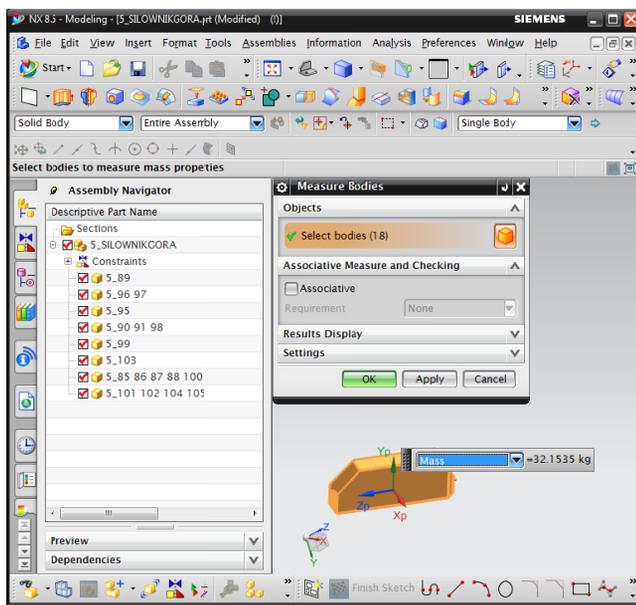


Fig. 3. Simulator model in NX

Easy to see in Fig. 3 that 18 pieces fixed together can be replaced by one. This model is easier to calculate and gives the same results. By selecting the menu “Analysis”, and next “Measure bodies”, it is possible to check all the mass and inertial parameters (Fig. 4).

It should be remembered that each additional element makes mathematical description more complicated. This is important especially for real time visualization. It often happens that the fixed elements, especially generated automatically, at the start of visualization, fly into space and destroy the model.

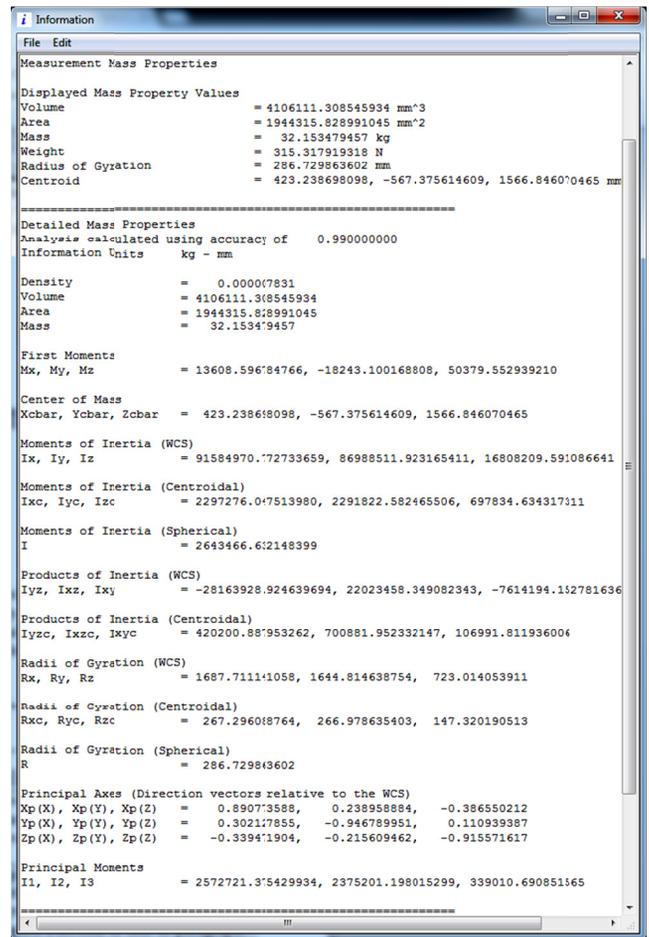


Fig. 4. Mass and inertial parameters of one simulator element

In most simulation programs the motion is not such important like the values of the mass and inertial parameters [10,11].

The new model (less detailed but with the same mass and inertial parameters) was exported as the *.wlr file (Fig. 5).

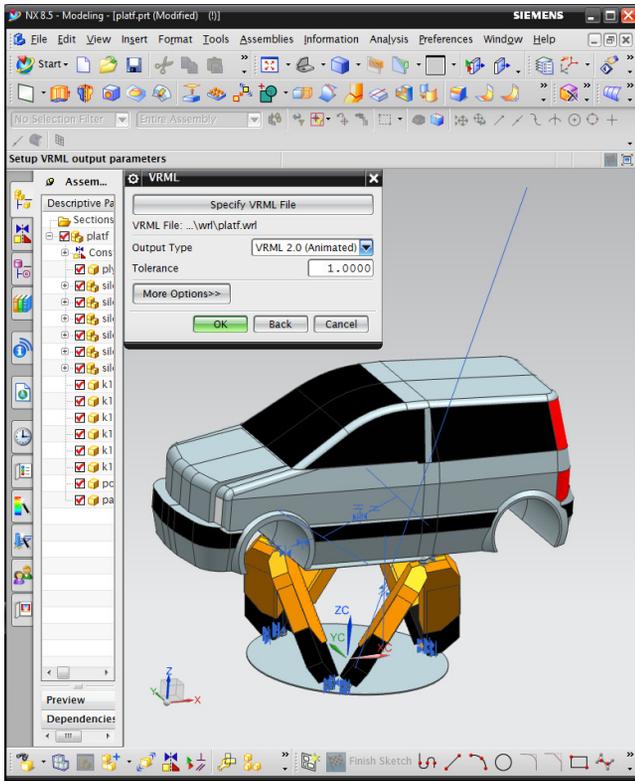


Fig. 5. Less detailed model

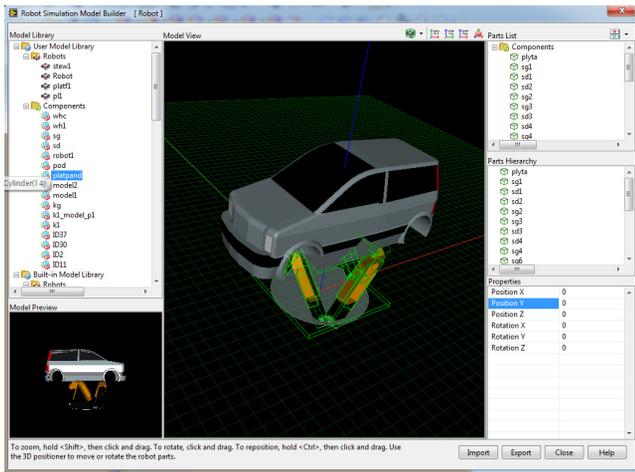


Fig. 6. Robot Simulation Model Builder

This file was imported into LabVIEW Robotics. CAD model is imported into LabVIEW Robotics by the tool “Robot Simulation Model Builder” (Fig. 6). It is a difficult and two-stage process. First one have to import geometry from the *.wrl file. In the “Model Library” a new model is added and a new window “CAD Model Import” opens

(Fig. 7). Because in the VRLM file is only included information about surfaces, it is necessary to indicate which surface are in one body and what kind of solid it is.

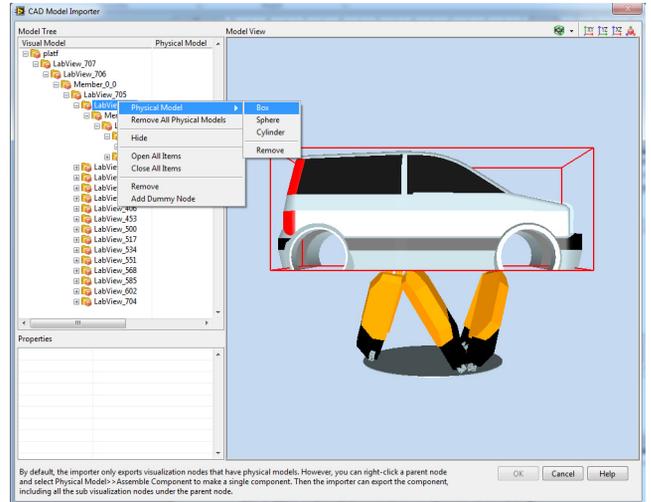


Fig. 7. CAD Model Import window

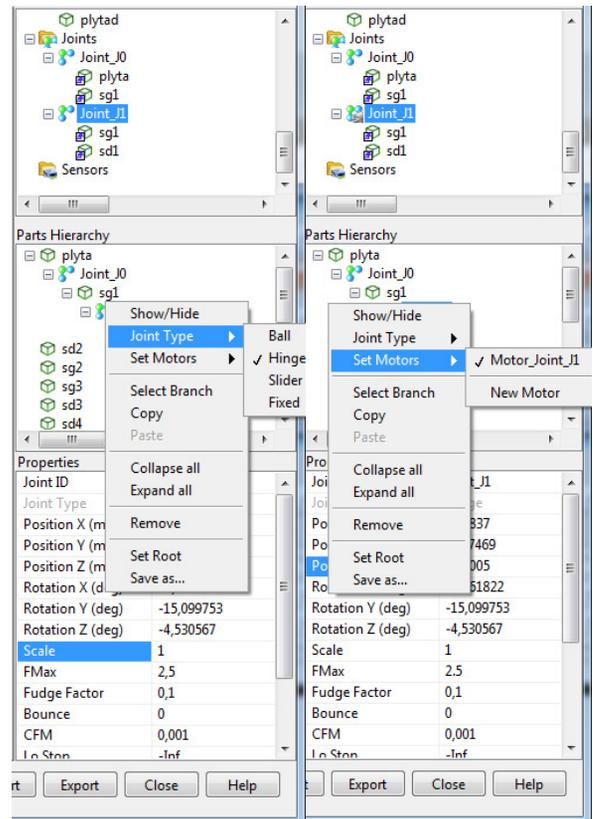


Fig. 8. Setting Joint parameter

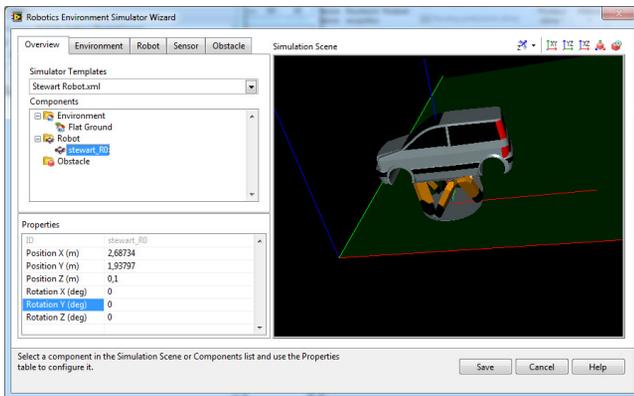


Fig. 9. Robotics Environment simulator Wizard window

After identifying all features, one should return to the “Robot Simulation Model Builder” (Fig. 6). Now it is possible to enter new model parameters obtain from the “Measure Body” module (Fig. 7). Unfortunately, one has to redefine the connection between bodies, their location, type and drive (Fig. 8).

Finishing this procedure allows obtaining the model that could be used in many different LabVIEW Robotics Projects. It is presented in the Fig. 9. Such prepared model of the simulator was used in virtual tests presented below.

2.2. Stewart platform basic movement

In Fig. 10 is shown the “Front Panel” window and the “Block Diagram” level. These are the basic applications that contain all necessary elements needed to run motion simulation of the platform of the simulator.

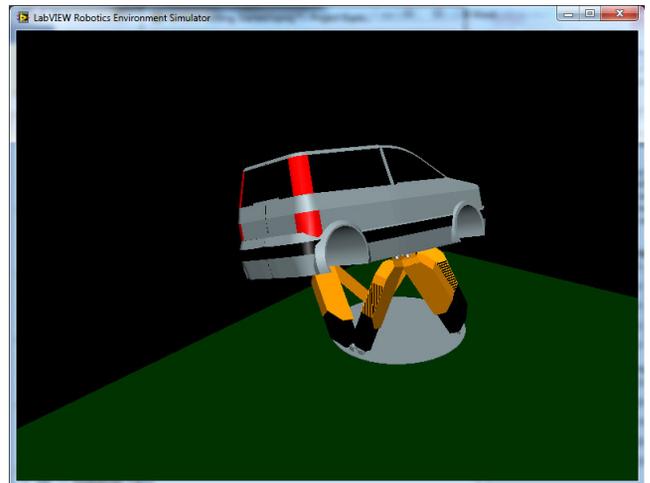


Fig. 11. Stewart Platform in LabVIEW Robotics

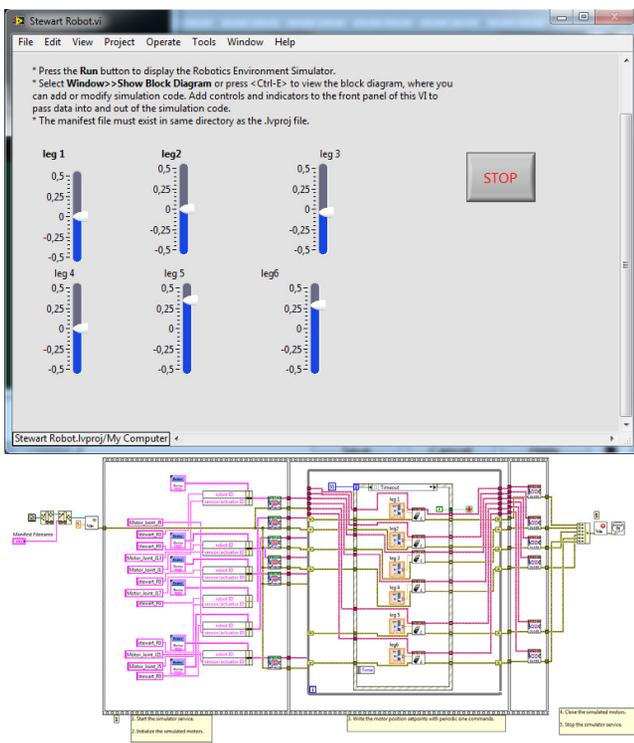


Fig. 10. Basic applications used for platform visualization

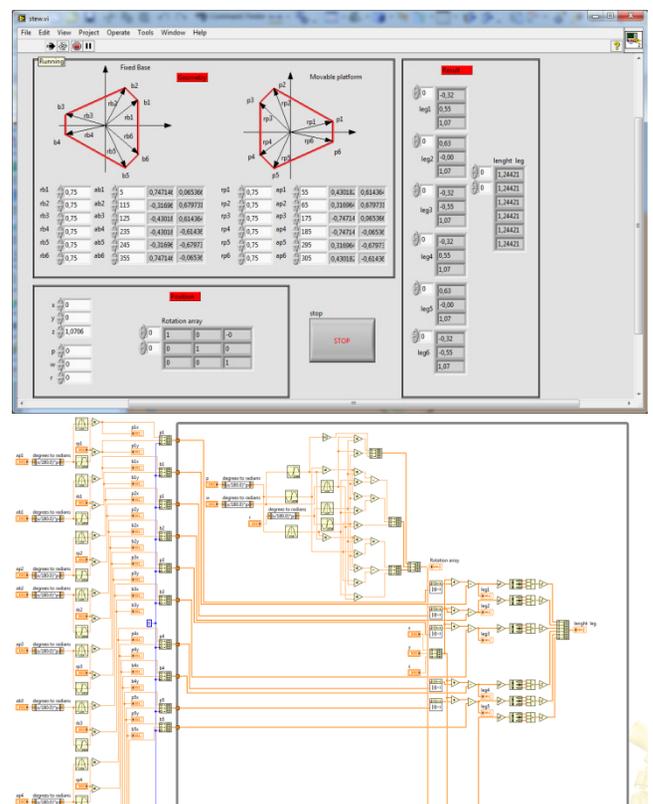


Fig. 12. Program for determining the length of platform legs

On the “Front Panel” are six sliders. Each of them is responsible for the movement of one of the actuators. By changing its position it is possible to virtually control the movement of the simulator platform.

An example of such control is shown in Figure 11. It is very easy to control each actuator separately. When one wants to move the platform to the desired position, the length of each of the actuators must be determined.

This program could be used also to determine the length of the legs, what is presented in Figure 12. Below is presented the LabView block program.

By connecting together these programs it is possible to enter the position and orientation of the platform in the Cartesian coordinates. It facilitates the collaboration with other programs, and to determine the workspace of the platform what is presented in Figure 13.

In Figure 13 there are two workspaces. Light green is the safe work space, now used in the real simulator. The blue area (presented as the contour) is the area drawn in LabVIEW Robotics. One should notice that the space created in LabVIEW is larger and has a different shape.

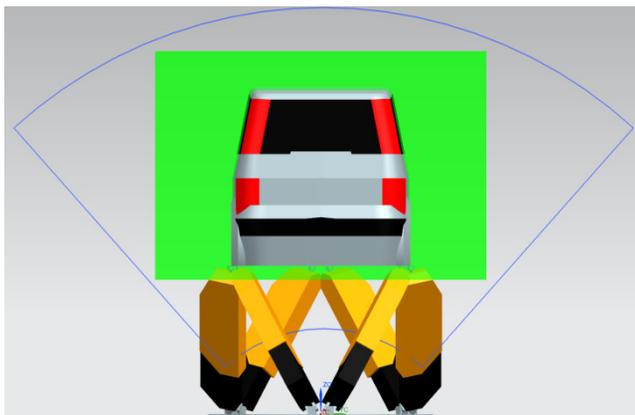


Fig. 13. Comparison of workspaces

2.3. Connection to simulator

The simulation was prepared to run in real time and for connecting it to the existing control system. The control system consists of 3 PC, Power Panel B & R and ACOPOS multi motor controllers. In this system it was necessary to use the network communication. The data is transferred between computers via an Ethernet network. UDP was used to ensure adequate transmission speed (Fig. 14). UDP sends information and any device plugged into the network can receive it. This is good because a new device could be plugged without changing the software on the others.

The UDP information is sent as a frame and if one wants to read the information, he needs to know how to build a frame. For this reason the program (Fig. 15) has two separate loops. One used to read data from the UDP, and other to translate these data.

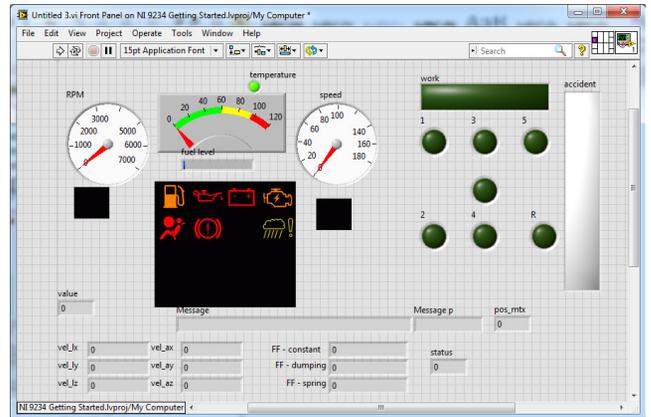


Fig. 14. UDP receiver

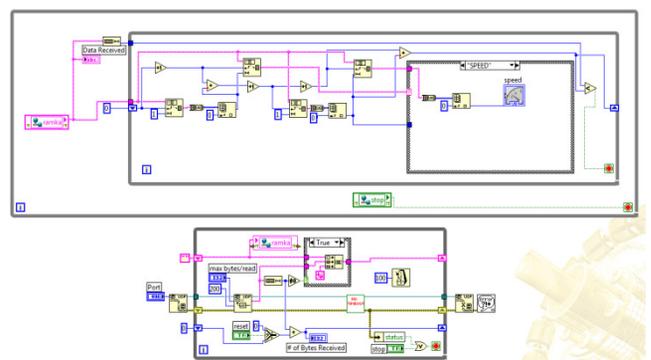


Fig. 15. LabVIEW program of the UDP receiver

The presented program, prepared in the LabVIEW environment, allows conducting virtual tests of the simulator and gathering data concerning the motion parameters.

3. Conclusions

It was created a lot of programs enabling not only the visualization but the simulation of designed objects. Many CAD programs include such modules, but it is difficult in them to model complex control systems. It is possible to enter simple functions or connect to an external data source [12,13]. LabVIEW provides a lot of tools and functions which are suitable for such tasks. They could be mixed to

match different applications even written in different environments [14-17].

The basic problem considered with the simulation programs is the underdeveloped part of the auxiliary drawing which imports standard file formats what helps to simplify the task. Particular attention should be paid to the correct determination of the joints.

Additional information

Selected issues related to this paper are planned to be presented at the 22nd Winter International Scientific Conference on Achievements in Mechanical and Materials Engineering Winter-AMME'2015 in the framework of the Bidisciplinary Occasional Scientific Session BOSS'2015 celebrating the 10th anniversary of the foundation of the Association of Computational Materials Science and Surface Engineering and the World Academy of Materials and Manufacturing Engineering and of the foundation of the Worldwide Journal of Achievements in Materials and Manufacturing Engineering.

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