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REGULACE SOUSTAVY „KASKÁDA TŘÍ NÁDRŽÍ“ POMOCÍ ŘÍDICÍHO SYSTÉMU REX

Three Tanks Cascade Control with the Use of Rex Control System

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Abstract: This paper presents Rex control system and its use to three tanks cascade control. The basics of the Rex control system and the Wincon PAC are described and some examples of the three tanks cascade are shown in the paper.

Key words: Wincon, PID controller, control, three tanks cascade

1. Introduction

The three tanks cascade is a laboratory model that allows testing various control algorithms. It is simple model which contains nonlinearities as a variable time constants, variable sensitivities or nonlinear valve characteristics. It is mostly used as a tool for students. The new controller for the three thanks cascade based on PAC WinCon and Rex control system is being developed.

2. REX block set and RexLib library

RexLib library contains all block which are necessary to develop control algorithm and which are also contained in RexDraw (see fig. 1) program. RexLib library is designated to the use with Simulink (see fig. 2). The algorithm configuration blocks are include also, so it is possible to simulate whole algorithm even in situations if the algorithm is divided into more individual block schemes. The possibility to simulate all of particular algorithms separately is also available. The description of all blocks of RexLib and Rex block set is in [4].

When the algorithm which is designated for the use outside the Simulink is developed in Simulink it is necessary to use only block included in RexLib library. It is possible to use other blocks also but only for simulation purposes, they cannot be a part of developed algorithm. It can be use the extension of Rex control system that allow to leave these block in the scheme if they are named so that their name contain the word simulation. Then it is not necessary to delete these block before the final compilation of developed algorithm.

3. User defined functions

The Simulink itself contains user defined function blocks MATLAB function and S-Function. RexLib library contains block Rexlang. Language of this block is derived from ANSI C language but it has some restrictions and of course some extensions that compensate the restrictions.

The advantage of block RexLang in comparison to block MATLAB function is more simple initial statement definition and makes easy algorithm portability into other device. The advantage in comparison to the block S-Function is nonuse of internal Simulink states so it is not necessary to respect Simulink restrictions.

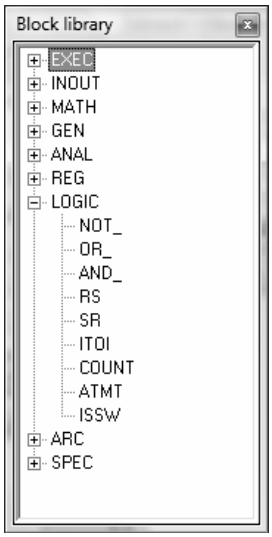

Fig. 1 – Rex block set as a part of standalone program RexDraw

The block RexLang have to work properly inside the Simulink scheme and also outside simulink scheme. It is not allowed to use variables defined in the Matlab workspace. Block RexLang can use only its own variables. The next restriction is the maximum number of used variables. It is possible to use at most 16 input variables, 16 output variables and 16 parameters. The number of internal variables is not restricted.

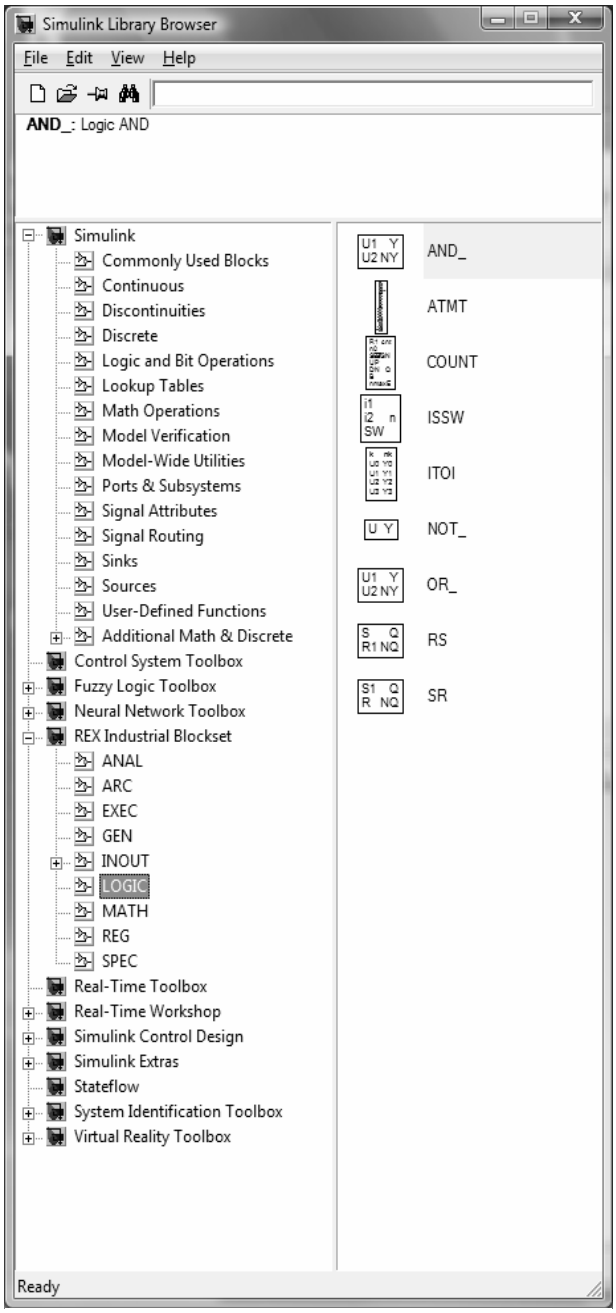

Fig. 2 – RexLib library as a part of Simulink block library

4. Communication block

Rex control system contains communication block RDC. It can be used as a communication tool among devices in the distributed control loop or as a communication tool with superior device. Of course it is possible to use this block to connect more Simulink schemes too. The communication is based on UDP internet protocol. One block RDC can transfer at most 16 variables into other device. If the requisition to transfer more than 16 variables occurs it is necessary to use more RDC blocks.

5. WinCon PAC

The fundamental hardware part is control device. As a control device the PAC WinCon (PAC means Programmable Automation Controller) have been chosen. There exists more types of this PAC that differs in built-in devices. For example W-8741-G contains seven expansion card slots, two LAN connectors, two USB connectors, one RS-232 connector, one RS-485 connector, one VGA connector and one Compact Flash card slot, W-8331-G contains three expansion card slots, one LAN connector, one USB connector, one RS-232 connector, one RS-485 connector, two PS/2 connectors (keyboard and mouse), one VGA connector and one Compact Flash card slot. Because the PAC is based on ARM processor the embedded operating system is used. WinCon use Windows CE as an operating system. There exists also LinCon product line which use Linux as an operating system.

6. The three tanks cascade

The three tanks cascade consists of three tanks, three pressure sensors and two water pumps as is shown in the fig. 3. The pressure sensors are used as water level detectors.

The scheme of the control algorithm is shown in the fig. 4. There is only one controller of PID type in the scheme. The controller drives the pump P1. The pump P2 is driven manually to simulate a disturbance. The pump P1 can be driven manually also to allow to get chosen initial state. Because the controller is only one, it can be chose which tank water level is controlled.

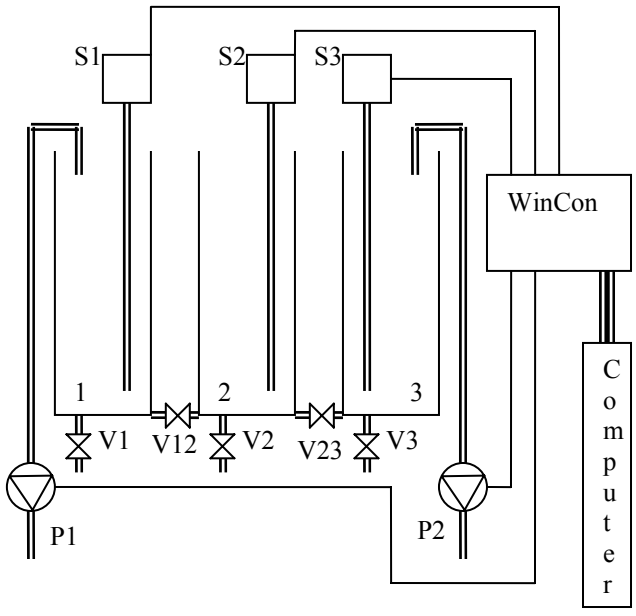

Fig. 3 – Three tanks cascade scheme

There are two block RDC in the scheme. One of them is used to transfer process variables from and to the superior device (Simulink is the superior device in this case), the second is used to transfer constraint values, e. g. the pressure values corresponding to maximum allowed water level. The reason of use of two independent RDC block is separation of process and constraint values.

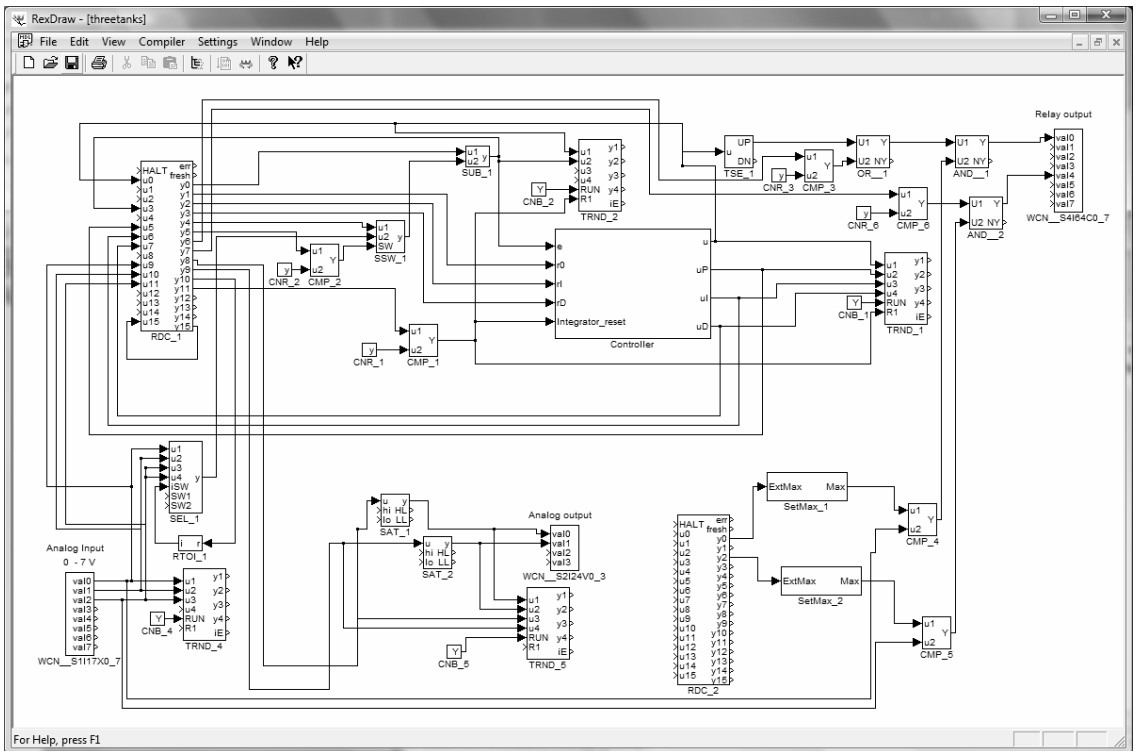

Fig. 4 – Controller algorithm scheme

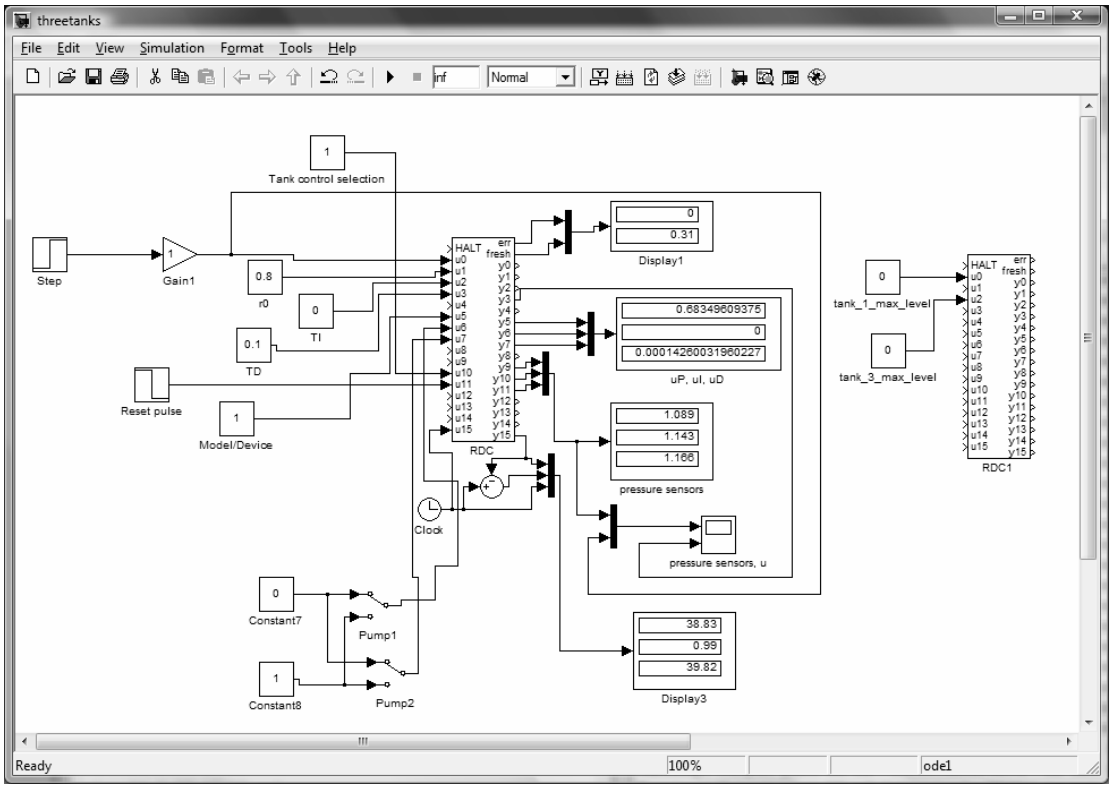

Fig. 5 – Superior algorithm scheme

The superior algorithm is shown in fig. 5. It is very simple algorithm which only allows to se set controller algorithm variables and monitor process variables (controlled values, manipulated values). It also contains two RDC blocks which are paired with the RDC blocks in the controller algorithm.

7. Illustrative example

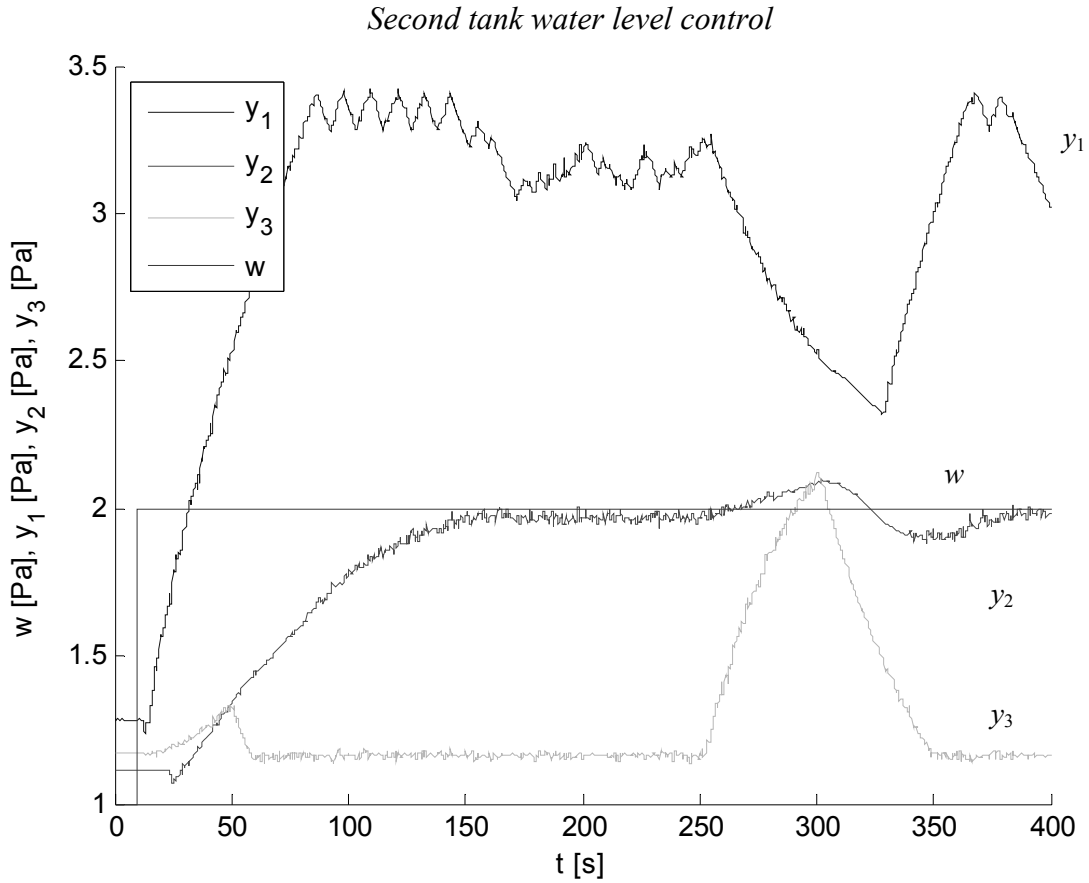

Fig. 6 – Illustrative example

Fig. 6 shows a control algorithm function example. The second tank water level y_2 is controlled, the course of its desired value w is shown as a straight line. The valves V1 and V2 are closed and the valves V12, V23 and V3 are opened. The pump P1 is manipulated, the pump P2 is used to make a disturbance. The control process starts at the time 10 s, when the desired value changes its value from value one to value two. Then the control error occurs and the pump P1 is switched on. The water levels in tanks number one and number two y_1 and y_2 start to increase. The water level in tank three y_3 starts to increase too, but it stared to decrease to its original level in 25 s. This first peak in the third tank water level course is caused probably by the water viscosity and by the tank and pressure sensor construction. Till the third tank water level y_3 reaches its peak the water does not flow out the tank, the water starts to flow out the third tank after the peak reaches its maximum.

The first tank water level y_1 reaches its maximum earlier then the second tank water level y_2 reaches its desired value w. When the first tank water level y_1 reaches its maximum it is necessary to switch the pump P1 off to avoid the first tank water level overflow. The control algorithm contains a hysteresis that causes the peaks under the first tank water level maximum. At time about 150 s the second tank water level reaches y_2 its desired value w.

The pump P2 (disturbance) is switched on at time 250 s and it is switched off at time 300 s. It causes the third tank water level y_3 increasing. The flow in the cascade is higher than the flow out the cascade so the second tank water level y_2 increases although the first tank water level y_1 decreases. After the pump P2 switch off the water level in all of three tanks decreases and at time about 330 s the first tank and second tank water level started to increase so that the second tank water level reaches y_2 its desired value.

8. Conclusion

The use of Rex control system is simple. Rex development environment is similar to well-known Simulink, Simulink can be also used to Rex algorithm development. Rex control system offers useful tools to connect more algorithms as is shown in this paper.

Acknowledgement

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