RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

QUALITY AND DYNAMIC CHARACTERISTICS OF CONTROL SYSTEM VISUALIZATION IN CONTROL WEB

German MICHAĽČONOK, Maximilián STRÉMY, Andrej ELIÁŠ

Abstract

Progress of information technologies and their applications create the necessary need to explore the analysis of techniques to estimate the impact of architecture control system on dynamic characteristics of control. Major impact factors on dynamics and quality of visualization, control modes selection and impact analysis are described in the article.

Key words

Visualization, Control Web, Modicon, control, real-time

Purpose of the article

Progress of information technologies and their applications create the necessary need to explore the analysis of techniques to estimate the impact of architecture control system on dynamic characteristics of control. Major impact factors of dynamics and quality of control are described in the article.

Experimental control system & program

Experimental structure of control and visualization complex consisted of Modicon Micro 612 programmable controller and computer which carried out functions of the tasks control and process visualization in Control Web. Models for the system analysis were created in Matlab.

The visualization program carried out the following functions:
- signal output of the task to the monitor,
- generation of the sine wave signal of the task (with virtual driver),

German Michaľčonok, Assoc. Prof., Ph.D., Maximilián Strémy, Ph.D., Andrej Eliáš, Ph.D. – Institute of Applied Informatics, Automation and Mathematics, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Hajdóczyho 1, 917 01 Trnava, Slovak Republic, maximilian.stremy@stuba.sk

- signal output of the task through the Modbus channel 100 to the port COM2,
- reception and process of input signals from COM2 port through the Modbus channels 121 and 305 into the software visualization,
- signal output to the screen from COM2 port.

Control Web program ran on a Windows platform and represented the real time program with the sample period T_C=0.05 sec. The size of the program and the architecture of the computer did not allow us to reduce the sample period [1].

The set point value represented by the digital signal from the Control Web was transformed by the analogue/digital (A/D) converter and transferred to the Modicon Micro 612. The control program in the Modicon was really simple to ensure the opportunity of the dynamic characteristic tracking. Program processed the signal from the output of A/D converter and redirected it on the input of 12 bit D/A converter, and the signal returned through COM2 port and channel 305 of the Modbus driver to the visualization in Control Web. The program also contained SUB function for matching of digital codes on an input and an output of the controller. The matching result was read out by Control Web program on the channel 121 of the Modbus drivers. Cycle time of the controller was set up by the timer with period T=0.001s.

Block scheme of the control and visualization complex is shown in Fig. 1

.

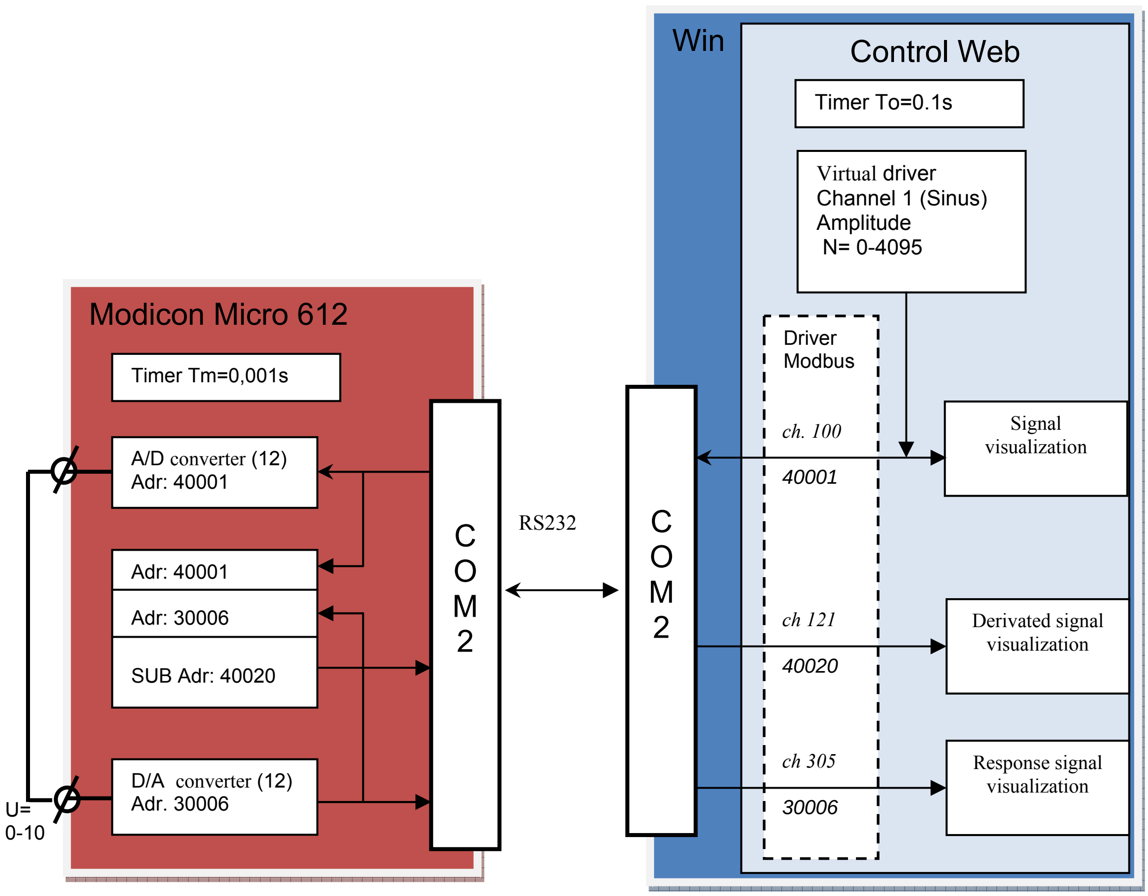


***Fig. 1** The block scheme of the complex*

The given structure practically allowed us to explore dynamic and interfering characteristics of such combination of hardware and software.

Control mode

There are two ways of how to organize the cycle of the control program:

1. Real-time mode - determination of hard cycle time of the program.
2. Control mode by the dataflow – processing the program instructions based on interruptions system which reacts to inquiries of separate units of a control system.

The first way assumes pre-computation of the maximum sum of temporary (in many cases stochastic) delays of the individual program routines. Thus, we can receive constant period of regulation and may calculate the characteristics of regulators in the control system. Disadvantage of such process is e.g. not optimum loading of the processor, depending on the event state in the system and the conditions of regulation. Examples of real-time mode application:

- direct digital regulation of the continuous processes,
- simulation of control systems in real time,
- visualization of a control system with exact binding on real time / necessities to follow the communications between both entry and output equipment.

The second way provides the variable period of the cycle, duration of which is automatically adapted to real needs of the control system and processing of the generated events in system. This approach also provides optimized processor loading, but there can be problems e.g. in time-critical processes with the precise timing. Dataflow control mode may be used e.g. if there is a necessity to provide only state visualization of the object or the technological process. Such necessity arises when the majority of control functions is carried out at the level of microcontroller, and the computer is used only for process visualization or like a human machine interface (HMI).

Impact analysis

Control Web program is used also for setting up the desired/required values of the controlling system as well as for the measurement of the deviations and quality or noise analysis. If the control is defined as the function of the time, there is a question of correct determination of maximum frequency and accuracy of the control [2]. At the given accuracy, it is possible to define necessary number bits count or, on the contrary, to determine limiting accuracy of the control at the given number bits. For example, both converters (D/A and A/D) of the microcontroller Modicon 612 have 12-bit resolution. Relative precision (RP) of the convertors and corresponding signal is:

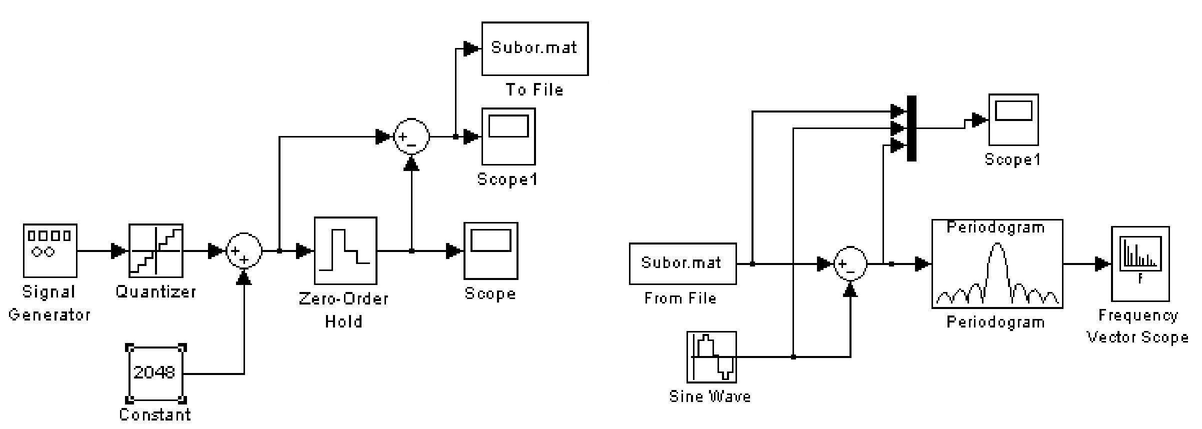
$$RP = 100/2(N-1) = 100/2(4096-1) \approx 0.01 \,. \qquad (1)$$

If the period of the cycle is known, it is possible to determine maximum frequency of the signal at given amplitude A_N:

$$\varpi = \frac{1}{A_N T_C} \qquad (2)$$

So, in our case, Control Web program should not exceed 0.005 radian/sec at complete amplitude frequency of the harmonic signal. This value provides maximum dynamic accuracy of the control system. In practice, such accuracy is usually not required. It is therefore possible to increase frequency of the control system considering that the controlled object usually has a property of a low-frequency filter.

We have to consider a noise signal (generated by the quantization) and its spectral characteristics. To display its impact, we created a model in MATLAB using SIMULINK tools. Figure 2 shows the models for generation of quantization noise (a) and for a spectral analysis of a noise signal (b).



a) b)

Fig. 2 *Models of generation(a) and the analysis (b) of quantization noise/signal*

Noise signal $A_V(t)$ for $f_C = 1/T_C$ can be described by the following expressions:

- in an interval $0 \le \omega_S \times t \le \pi$:

$$A_V(t) = A_S \times \omega_S \times T_C \times \{\pi - 2[\frac{Sin(2\pi f_C \times t)}{1} + \frac{Sin(4\pi f_C \times t)}{2} + \frac{Sin(6\pi f_C \times t)}{3} + ...]\} \times Sin(\omega_S \times t);$$

- in an interval $\pi \le \omega_S \times t \le 2\pi$:

$$A_V(t) = A_S \times \omega_S \times T_C \times \{-\pi + 2[\frac{Sin(2\pi f_C \times t)}{1} + \frac{Sin(4\pi f_C \times t)}{2} + \frac{Sin(6\pi f_C \times t)}{3} + ...]\} \times Sin(\omega_S \times t);$$

The following parameters were used in the simulation:

$$A_S = 2048; \quad \omega_S = 0.628\sec^{-1}; \quad T_C = 0.1\sec; \quad f_C = \frac{1}{T_C} = 10Hz;$$

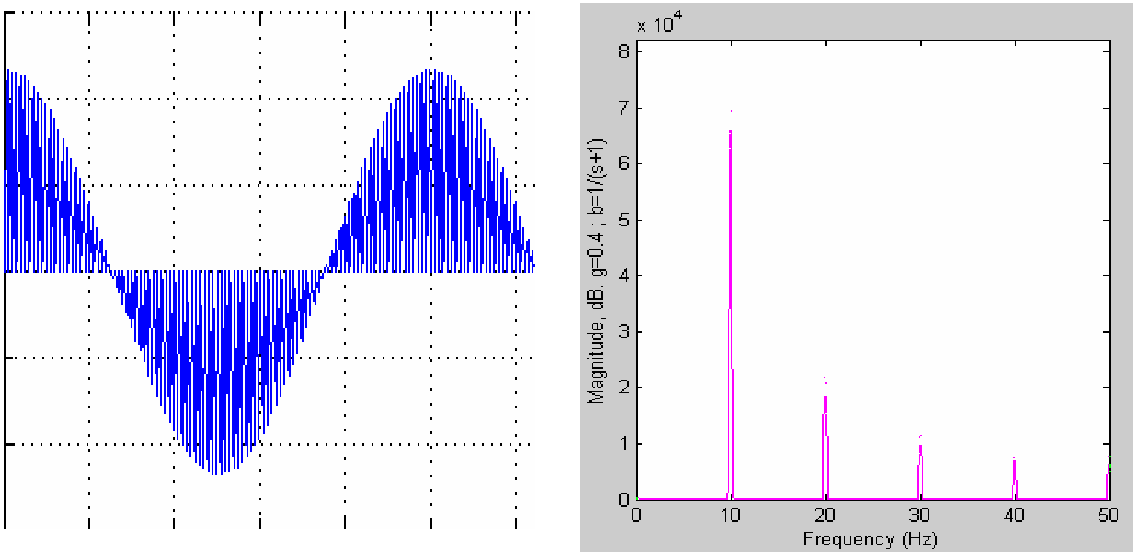


Fig. 3 *Parsed signal and its spectrum after discharge of harmonic modulation*

The model scheme of the spectral analysis contains an auxiliary unit for compensation of low-frequency modulation of a researched signal $Sin(\omega_S \times t)$. Such compensation helped us precisely to allocate high-frequency making a noise signal. The amplitude of the first harmonic noise signal at simulation made 128 units, that coincided with the designed value.

Conclusion

Based on the obtained results, we can conclude:

- By using software products such as Control Web as a controlling or regulating unit of the technological process, it is necessary to take into account its low dynamic characteristics.
- By the visualization of the state of the objects or technological processes, control mode by the dataflow should be preferably used.
- The detailed analysis of behaviour of the architecture of the computer and the operating system is necessary to exactly define the possible temporary delays of software of visualization of processes.
- By the exact definition of control system behaviour and its visualization, there is a possibility of program compensation of measurement errors.

References:

[1] BÍLÝ, R. 1999. *Control Web 2000*. Praha: Computer Press, 1999.

[2] ŠIMON, M. IT security in process control systems. In *Infokommunikacionnye technologii v nauke, proizvodstve i obrazovanii : tretja meždunarodnaja naučno-trechničeskaja konferencija*. Časť I. - Stavropoľ: Severo-Kavkazskij Gosudarstvennyj Techničeskij Universitet, 2008, pp. 94-100. ISBN UDK 004 (06)

[3] TRNKA, A. 2010. Six Sigma Methodology with Fraud Detection. In *Advances in Data Networks, Communications, Computers : 9th WSEAS International Conference on Data Networks, Communications, Computers (DNCOCO`10)*. University of Algarve, Faro, Portugal, November 3-5, 2010. [b.m.v.]: WSEAS Press, 2010, pp. 162-165. ISBN 978-960-474-245-5, ISSN 1792-6157

Reviewers:

Pavel Važan, Assoc. Professor, Ph.D. - Institute of Applied Informatics, Automation and Mathematics, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology Bratislava

Anton Kachaňák, Assoc. Professor, Ph.D. – Faculty of Mechanical Engineering, Slovak University of Technology Bratislava