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# BINARY VALVES IN ANALOG CONTROL

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***Abstract***

*Continuous control systems are built with standard transducer measured signal, the controller and actuator. The actuator is responsible for the direct setting of the size of the control object. The actuator is connected to the control valve and the actuator position change signal into the flow rate of the working medium. Since the operating element is required the linear characteristics in the standard signal range to work. The other hand, the control valve provides flow characteristics linear or equal percentage. This flow control principle is used in various control systems. The actuator of the control valve is always equipped with a positioner, which corrects errors in the position of the valve relative to the input signal. The presented design of the control valve is an analogue system. Using the technique of converting multiple digital signal causes, the system is susceptible to damage. Remove the intermediate elements can improve the quality control and safety system. Such benefits give a design of the operating element based on direct digital processing unit and control program. The examples of control present article.*

***Keywords:*** *control, digital signal, actuator, control valve, transducer, positioner*

## 1. Introduction

Adjusting digital develops over several decades, [6]. Regulators replaced programmable logic controllers. Control programs are able to control the entire production line. Applies only digital controller output for direct or continuous control system. Digital signals do not require processing, are compatible with the digital signal processor used. Hence, they are widely used in the control object through relays on-off and work fine. The tasks of adjustment are also to maintain the parameter at a constant value. In this case, a continuous signal is not compatible with the digital signal. Apply processing and digital-to-analogue converters. The analogue signal is a remnant of the development period of continuous linear regulators. This period is also a regulating valve, which is based on the signal continuously, changes its location and the flow rate of the working medium. For this reason, it is necessary from digital to analogue converter, [7]. If the design of the control valve is changed, it can be dispensed with digital to analogue converter.

The opposite form of adjustment is the two-point control. It is very simple in its essence and operates on Boolean on off or zero and one. The digital signal also uses a binary zero and one as a string. The digital signal and the two-position signal is a similar to each other, and seek control of the intermediate form to eliminate processing and digital-to-analogue converter. This will improve the control, security and reliability of control systems.

## 2. The digital signal

The digital unit of controller operates in a digital format, [2]. Digital signal processing is based on integer format – eight or sixteen bits by writing a fixed position. Floating-point format is used in the calculations, but the outputs shall be always an integer value after formatting. Weight one depends only on the position at which it is stored. Every number one on the next position is the doubled value.

| Decimal value | digital value | bit + weight |
|---|---|---|
| 13 | 1101 | $1\cdot2^3 + 1\cdot2^2 + 0\cdot2^1 + 1\cdot2^0$ |
| $13\cdot\dot{m}$ | | $8\cdot\dot{m} + 4\cdot\dot{m} + 0 + 1\cdot\dot{m}$ |

Values zero and one are used directly in the two-step control, [11]. These are the digital outputs switch on – switch off. Bit value can be translated into the flow.

## 3. The digital valve

A single bit can be control a single valve. It is possible to construct a set of valves and each valves are connected directly to the next bit words. Each subsequent bit is a value twice – each additional valve should force the flow doubled from the previous one. The single control valve should be replaced by a multivalve, which will consist on-off valves electrically controlled bits of the digital signal as an open-closed. The sum of the flow from each valve will give us final value of the regulated flow. The task is implemented by each controller. Multi valve can be compact structure or single team of valves connected in parallel, [5].

Fig. 1a shows four-bit control valve, which takes sixteen values. For a continuous signal in the range of the standard 4-20 mA output is also present at 1 mA sixteen values. The direct digital control is comparable to the continuous control of the digital to analogue converter and the control valve at a resolution of at 1 mA.

The control valve may be longer or shorter, Fig 1b.

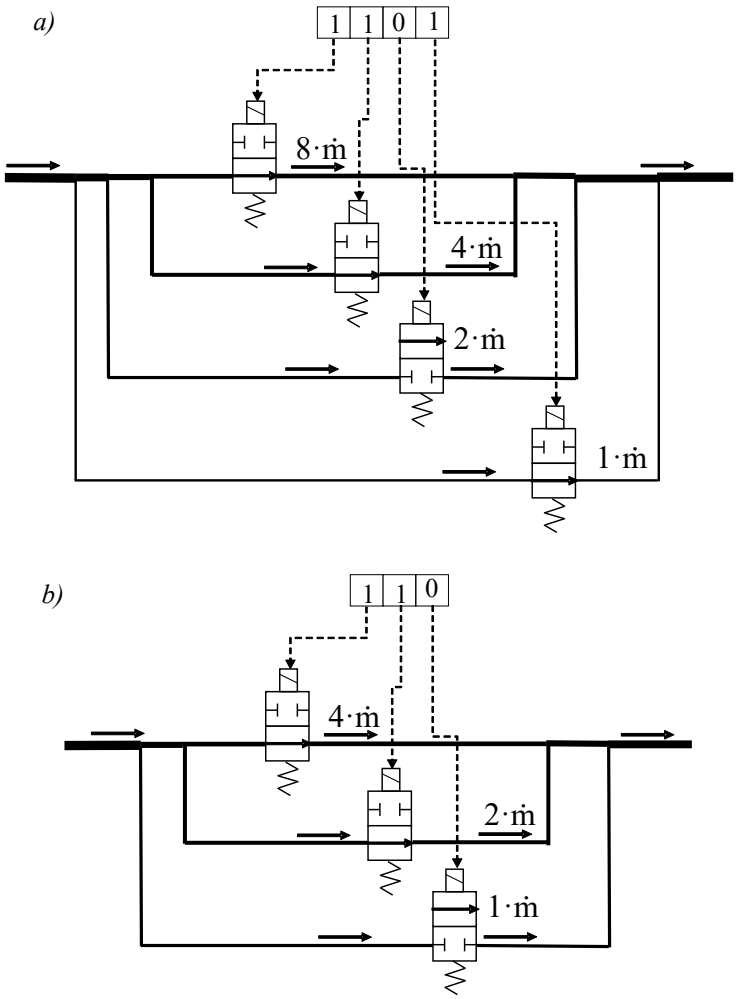


*Fig. 1. Diagram of the control valve, a – four bits, b – three bits*

Possible implementation of the control valve is shown in Fig 2. The characteristics of the flow are shown in Fig. 3. It is a discontinuous linear characteristic.

*Fig. 2. Electromagnetic control valve – three bits*

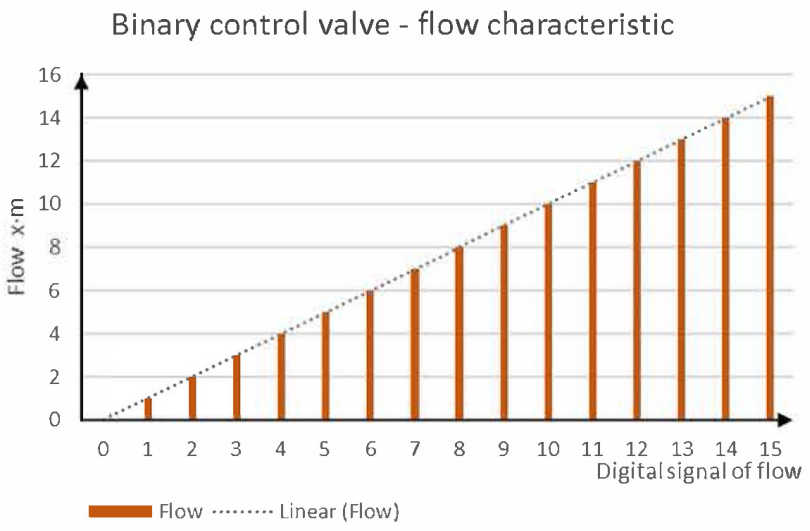


*Fig. 3. Characteristic of flow through the binary control valve*

Continuous signal control can be replaced by word with four bit. Discretization of this signal should not degrade the quality of control systems. May be expected deviation caused by discretization signal, which is used in control systems. In other forms of regulation also occurs deviation. In the two-step, control is based on controlling the one bit exists a constant output signal amplitude adjustment and is a form often used in view of the simplicity of the system. The presented multi-valve control goes from one bit to the multibit maintaining the simplicity of the system and shall be enforceable for each controller.

Controllers are using an eight-bit word length or sixteen-bit. Using word length by current controller can improve the quality of the control valve adjustment. Expansion of multi-valve can bring negative regulation. Big size of control valve decreases much the youngest bit. At the same time switching frequency of this element will be the largest due to the frequent changes in the value of the youngest bit. The design of the control valve should begin with a two-bit word length or three, four bits. Each controller may convert the current word length to the length required by the executive block-valve. This will also limit the switching frequency of valves in the block. This means a stable and long life the control valve. It is a choice between component reliability and the quality of regulation.

The presented design is very simple, use the binary system for non-electrical quantities. At the design stage multi-valve, foresee numerous technical problems to solve as length of the word, to build smaller or larger valve, switching frequency and quality of regulation.

## 4. Simulation

Separation of control bits from the control word is a simple arithmetic operation. Simulation of the digital valve operation was performed in MATLAB and Simulink, Fig. 4. The values of the control signals are shown in Fig. 5, 6 and 7.

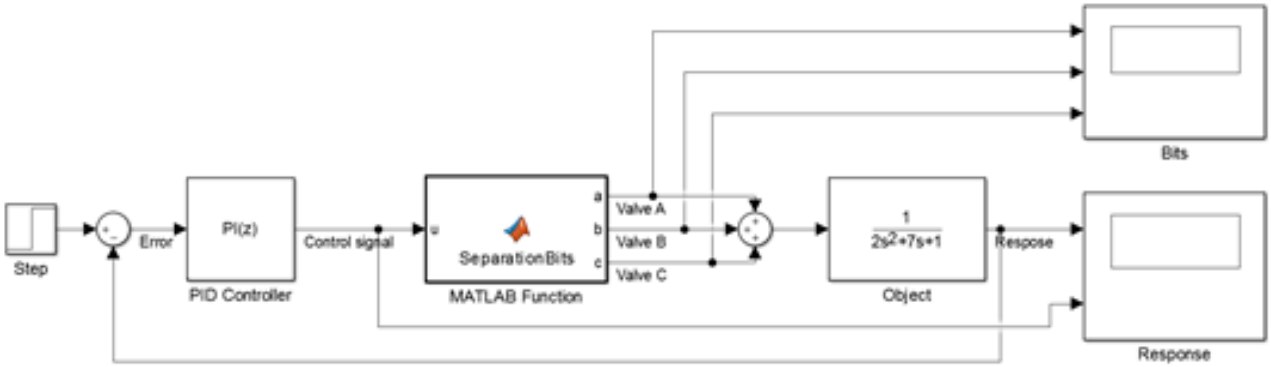


*Fig. 4. The project simulation of control in MATLAB Simulink*

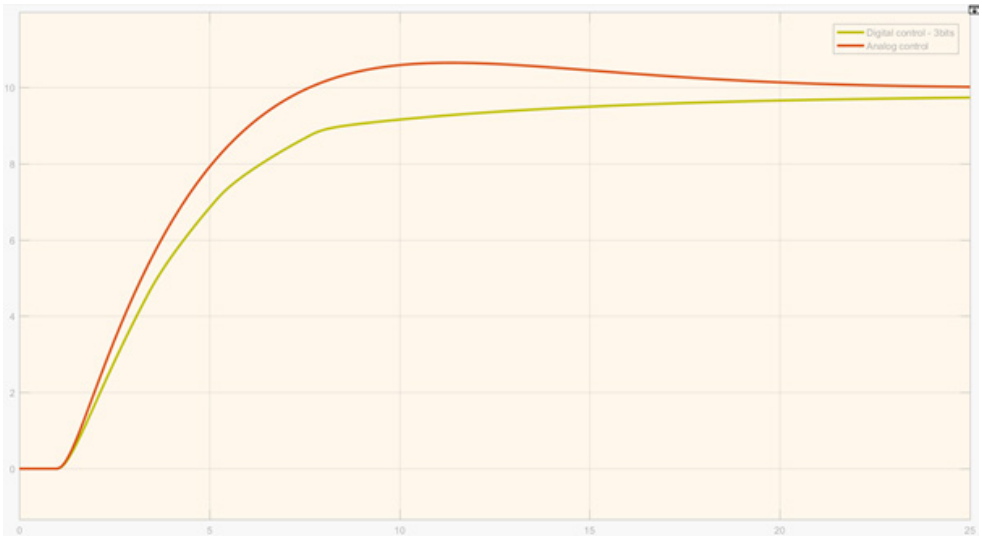

*Fig. 5. Comparing the response in continuous control and binary control in a simulated example*

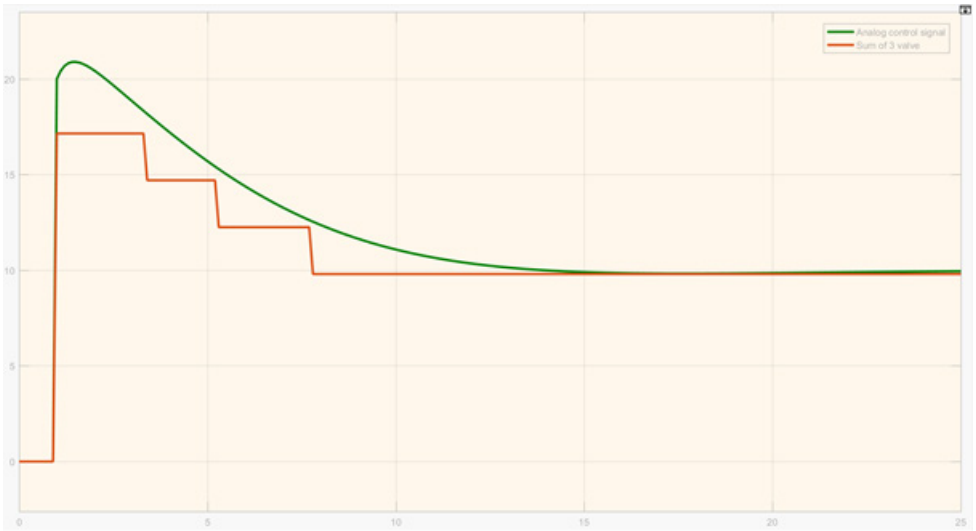

*Fig. 6. Comparing the error signal in continuous control and binary control in a simulated example*

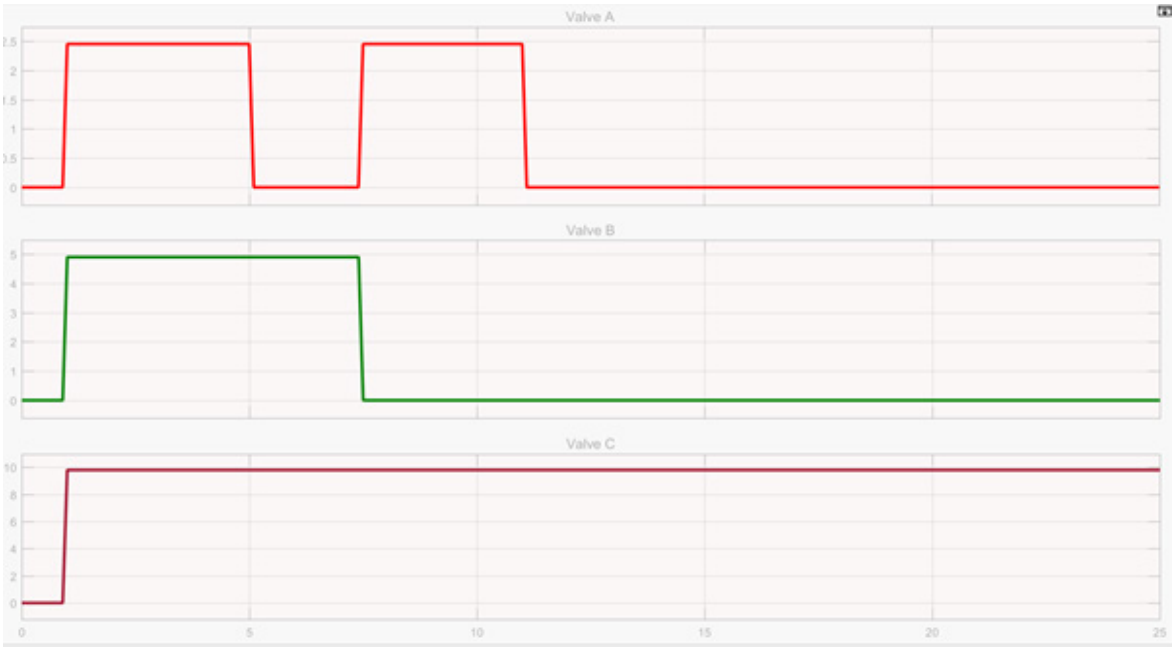


*Fig. 7. The extracted bits of signals in a simulated example: A – work time of first valve, B – work time of second valve, C – work time of third valve*

Simulation shows that the use only binary elements give a result comparable to the continuous control. In the simulation is used only word with three control bit.

## 5. Summary

The article presents new design of control valves that are suited to digital control. The solution eliminates digital-to-analogue converter from system and introduces the on-off solenoid valves. The amount of multi-valve elements and their size can be chosen depending differently shaped characteristic. Selected multi-valve design can mean the selection of individual digital control algorithm to process or standard PID control algorithm, [2, 10]. In each solution, new control parameters are included in the controller in order to achieve a good result quality control [1, 9].

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