HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

CONTROL OF OBJECT PARAMETERS, CONTROL SYSTEMS AND THEIR OPERATING PRINCIPLES

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Doi: https://doi.org/10.5281/zenodo.23368609

Abstract. This article examines the structure of a programmable microprocessor-based system designed to measure, process, and control the physical parameters of technological objects.

Keywords: automation, microprocessor-based system, microcontroller, sensor, analog-to-digital converter, potentiometric sensor, control.

In industrial processes, maintaining temperature, pressure, level, flow rate, displacement, and other physical quantities within specified limits is directly related to product quality, equipment safety, and efficient resource utilization. Manual observation of these parameters or their monitoring using separate measuring instruments often limits the ability to respond promptly, store data, and jointly manage multiple measurement channels. Microprocessors and microcontrollers make it possible to process measurement signals digitally, display measurement results, and control actuators according to a predefined algorithm.

A microprocessor-based monitoring and control system consists of several interconnected functional blocks: the controlled object, sensors, a signal-conditioning or switching unit, an analog-to-digital converter (ADC), a microcontroller, memory, operator-interface devices, and actuators. A sensor converts a physical parameter of the object into an electrical signal. If the signal is analog, it undergoes signal conditioning when necessary and then passes through a multiplexer to the ADC input. The ADC converts the analog quantity into a digital code, while the microcontroller processes the resulting code according to the program, records the results in memory, displays them, or generates a control signal.

Digital-output sensor signals can be transmitted directly to the corresponding controller input ports. Control signals generated through the controller output ports are delivered to actuators via electronic switches or power drivers. Thus, measurement, logical decision-making, and transmission of control actions are coordinated by a single software algorithm.

Table 1.

Functions of the system blocks

Functional block	Main function
Sensors	Measure a physical parameter and convert it into an electrical signal.
Multiplexer / signal-conditioning unit	Select one of several analog channels and condition the signal for the ADC input.
Analog-to-digital converter (ADC)	Convert an analog signal into a digital code.
Microcontroller	Process data according to the program and

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	generate a control decision.
Memory and display	Store measurement results and display them to the operator.
Output driver and actuator	Convert the controller signal into a control action applied to the object.

Sensors are the input elements of an automatic control system and convert the monitored physical quantity into a signal that can be received by subsequent components of the system. The dissertation distinguishes between parametric and generating sensors. In parametric sensors, an external influence changes resistance, inductance, or capacitance, and an external power supply is usually required. Generating sensors, in turn, produce an electromotive force under the influence of the measured parameter.

A potentiometric sensor converts mechanical displacement into a change in electrical resistance and output voltage. Its movable contact travels along a resistive element; as the contact position changes, the output voltage also changes. Ideally, with a uniform resistive element and negligible loading effect, the output voltage depends linearly on displacement:

$$U_{out} = U_s \cdot x / l = k \cdot U_s$$

where Uout is the output voltage; Us is the supply voltage; x is the displacement of the slider relative to its initial position; l is the total active length of the resistive element; and k = x/l is the relative displacement. This relationship describes an ideal model with negligible loading effects. In a real electrical circuit, when the load resistance is finite, the output characteristic may become nonlinear. In addition, wear of the sliding contact, changes in contact resistance, and mechanical noise can affect measurement results.

The advantages of a potentiometric sensor include its simple design, compact size, easily interpreted electrical characteristic, and convenient connection to the analog input of a microcontroller. Its limitations include the presence of mechanical contact, friction and wear, as well as deviation of the static characteristic from ideal linearity as the load resistance decreases. Therefore, in systems with increased requirements for service life and reliability, sensor lifetime and maintenance conditions must be assessed separately.

The article describes the Proteus VSM software suite, including the ISIS module for developing circuit schematics and the ARES module for designing printed circuit boards, which are used in the development and simulation of electronic circuits. Such tools make it possible to assemble device circuits, check component interconnections, and design printed circuit board layouts. Simulation can help identify logical errors before a physical prototype is manufactured; however, its results cannot completely replace testing of the actual device.

When designing a microprocessor-based system, the following sequence is advisable: define the parameters to be monitored and their ranges of variation; select the sensor and controller types; determine the number of input and output channels; choose signal-conditioning and analog-to-digital conversion circuits for analog signals; develop the control algorithm; simulate the circuit; assemble and calibrate the prototype; and verify measurement errors and the algorithms for transition to a safe state. Particular attention should be paid to accounting for emergency situations in the software algorithm, such as parameters exceeding permissible limits, sensor disconnection, and instability of the supply voltage.

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Under industrial conditions, signal quality is affected by high temperatures, dust, electromagnetic interference, and considerable distances between the measurement point and the controller. The dissertation considers the RS-485 interface as an example of data exchange over long distances. In such cases, the selection of communication protocol, cable type, grounding and shielding methods, and the need for a signal repeater are determined with regard to the system's actual operating conditions. These parameters should be established on the basis of the technical specifications before the device is put into practical operation.

CONCLUSION

1. A microprocessor-based monitoring and control system integrates sensors, a signal-conditioning unit, an analog-to-digital converter (ADC), a microcontroller, memory, an operator interface, and actuators into a single functional chain. This structure enables the digital processing of measurement signals and the generation of control actions based on a predefined program.

2. Potentiometric sensors offer a simple solution for converting mechanical displacement into a change in voltage. However, due to contact wear and the occurrence of nonlinearity under load, their selection should take into account operating conditions and the required measurement accuracy.

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