A Study of Control Systems Based on its Important Characteristics and Practical Applications in Modern Industrial Automation with Respect to the Theoretical Approach and Basic Knowledge about the Programming of Systems in MATLAB

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Abstract
This paper presents the applicability of control systems in the modern industry like automation and describes a basic introduction about control systems. The main elements which are present in the block diagram of control systems are described and the definition of different parameters of a control system like open loop gain, closed loop gain, feedback factor, frequency response, transfer function etc. are discussed. A brief information about the automation industry is given along with the various types of controllers like PID, PD controllers and the programming basics of control systems which are based on MATLAB are presented. The overall advantages of a control system with respect to the modern engineering field is presented. The advantages of a control system are given and the applications of automation are discussed.

Keywords: Control Systems, PID Controller, Feedback Ratio, Transfer Function, MATLAB, Automation

I. INTRODUCTION

A control system is a device, or set of devices, that manages, commands, directs or regulates the behavior of other devices or systems. Industrial control systems are used in industrial production for controlling equipment or a machine.

There are two common classes of control systems, open loop control systems and closed loop control systems. In open loop control systems output is generated based on inputs. In closed loop control systems current output is taken into consideration and corrections are made based on feedback. A closed loop system is also called a feedback control system. The human body is a classic example of feedback control system. Fuzzy logic is also used in control systems.

II. OVERVIEW

The term "control system" may be applied to the essentially manual controls that allow an operator, for example, to close and open a hydraulic press, perhaps including logic so that it cannot be moved unless safety guards are in place.

An automatic sequential control system may trigger a series of mechanical actuators in the correct sequence to perform a task. For example various electric and pneumatic transducers may fold and glue a cardboard box, fill it with product and then seal it in an automatic packaging machine. Programmable logic controllers are used in many cases such as this, but several alternative technologies exist.

In the case of linear feedback systems, a control loop, including sensors, control algorithms and actuators, is arranged in such a fashion as to try to regulate a variable at a setpoint or reference value. An example of this may increase the fuel supply to a furnace when a measured temperature drops. PID controllers are common and effective in cases such as this. Control systems that include some sensing of the results they are trying to achieve are making use of feedback and so can, to some extent, adapt to varying circumstances. Open-loop control systems do not make use of feedback, and run only in pre-arranged ways.

Fig. 1: A Basic Feedback Loop
III. LOGIC CONTROL

Logic control systems for industrial and commercial machinery were historically implemented at mains voltage using interconnected relays, designed using ladder logic. Today, most such systems are constructed with programmable logic controllers (PLCs) or microcontrollers. The notation of ladder logic is still in use as a programming idiom for PLCs.[1]

Logic controllers may respond to switches, light sensors, pressure switches, etc., and can cause the machinery to start and stop various operations. Logic systems are used to sequence mechanical operations in many applications. PLC software can be written in many different ways – ladder diagrams, SFC – sequential function charts or in language terms known as statement lists.[2]

Examples include elevators, washing machines and other systems with interrelated stop-go operations.

Logic systems are quite easy to design, and can handle very complex operations. Some aspects of logic system design make use of Boolean logic.

![Programmable Logic Controller](image)

Fig. 2: Programmable Logic Controller

IV. ON-OFF CONTROL

A thermostat is a simple negative feedback controller: when the temperature (the "process variable" or PV) goes below a set point (SP), the heater is switched on. Another example could be a pressure switch on an air compressor: when the pressure (PV) drops below the threshold (SP), the pump is powered. Refrigerators and vacuum pumps contain similar mechanisms operating in reverse, but still providing negative feedback to correct errors.

Simple on–off feedback control systems like these are cheap and effective. In some cases, like the simple compressor example, they may represent a good design choice.

In most applications of on–off feedback control, some consideration needs to be given to other costs, such as wear and tear of control valves and perhaps other start-up costs when power is reapplied each time the PV drops. Therefore, practical on–off control systems are designed to include hysteresis: there is a dead band, a region around the set point value in which no control action occurs. The width of dead band may be adjustable or programmable.

V. LINEAR CONTROL

Linear control systems use linear negative feedback to produce a control signal mathematically based on other variables, with a view to maintain the controlled process within an acceptable operating range.

The output from a linear control system into the controlled process may be in the form of a directly variable signal, such as a valve that may be 0 or 100% open or anywhere in between. Sometimes this is not feasible and so, after calculating the current required corrective signal, a linear control system may repeatedly switch an actuator, such as a pump, motor or heater, fully on and then fully off again, regulating the duty cycle using pulse-width modulation.

VI. PID CONTROLLER

![PID Controller Diagram](image)
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Fig. 3: A PID Controller

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an error value as the difference between a measured process variable and a desired setpoint. The controller attempts to minimize the error by adjusting the process through use of a manipulated variable.

The PID controller algorithm involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted P, I, and D. Simply put, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change.[1] The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, a damper, or the power supplied to a heating element.

VII. CONCLUSION

In this paper, a brief introduction about the basics of control systems is discussed along with supporting theories and examples. An introduction about the different types of controllers like PD, PID controllers is described which illustrates the importance of control systems in the modern world. The merits and demerits of control systems with respect to applications in industrial automation is described which presents the impact of control systems in automation industry. The programming basics of design of a control system is discussed with MATLAB as a software domain. The various syntax and functions which are useful in the design of control systems are illustrated and can be helpful in understanding the components of a control system. According to our study, control systems will dominate the engineering platform and bring a revolution in the field of automata and Intelligent Transportation Systems.

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REFERENCES