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RESEARCH OF AUTOMATIC CONTROL SYSTEMS

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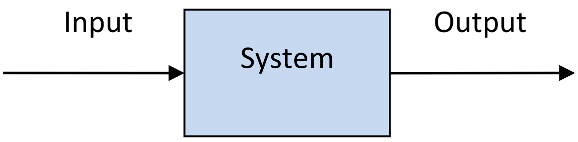
Annotation
In this article, studies of the structural scheme of automatic control systems and its control tools were carried out.

Keywords: Control, incorporated, transducer, difference between.

Introduction

Components of Control System



Input: The excitation or actual signal applied to the system from anexternal source to attain an output is called input signal.
Output: The actual response obtained from a system is called output.
System: A system is a combination of components that act together to perform a specific goal.
Control: The word control is usually taken to mean regulate, direct or command a system so that the desired objective is attained.
Process Control: In the system there are some variable at which the whole system works are controlled automatically. This is called process control. variables like pressure, temperature can we change as per the need.
Process Controller: To control the variables of the system the devices are need to be Incorporated. These devices are called process controller.
Feedback: This is very important component of automatic control system. This is the output value of the system which is compared with the input given the system [1].
Regulator: When there is a need of keeping the value of variables at a constant value there is a device name regulator' is used.
Error Detector: This is a device which uses differential method to detect any error in the system. It compares the output value with the actual desired value of the system. Through this comparison the error in the automatic control system can be detected.
Lag In Response: As the result obtained from the command given to the system is called response. In an automatic control system, when there is a delay to obtain the response from the command due to some causes, delayed is called lag in response. This delay causes the difficulty in the measurement of input and output at the same time [2].

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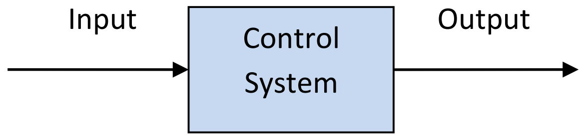
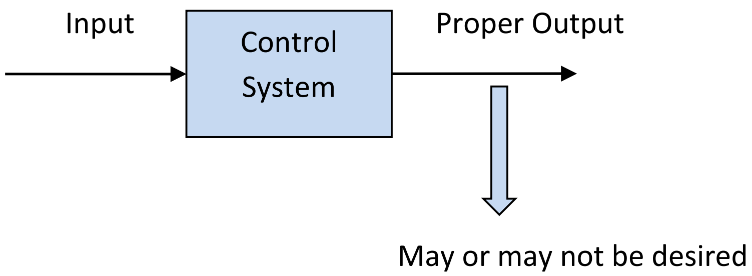
Amplification: The process of increasing the amplitude of the signal is called amplification. When there is a need to change the intensity of the input signal amplification method is used. And there is an error in the system detected by the error detector. The error detector is not able to correct that error by itself. Hence the amplitude of the input signal has to be amplified to eliminate that error and get the desired output [3].

Transducer: This is a unit that takes the input and converts it into another form get to get the desired result. For example there are Some devices which takes pressure as input and converts it into the form of distance to indicate the value of the pressure. Other examples are speedometer, ammeter which converts voltage into the angular distance.



It is an arrangement of different physical elements connected in such a manner so as to regulate, direct or command itself to achieve a certain objective.

Difference between System and Control System



Requirement of good control system

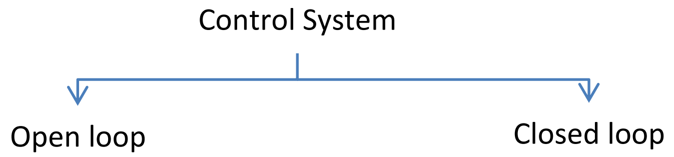
Accuracy: Accuracy is the measurement tolerance of the instrument and defines the limits of the errors made when the instrument is used in normal operating conditions. Accuracy can be improved by using feedback elements. To increase accuracy of any control system error detector should be present in control system.

Sensitivity: the parameters of control system are always changing with change in surrounding conditions, internal disturbance or any other parameters. This change can be expressed in terms of sensitivity. Any control system should be insensitive to such parameters but sensitive to input signals only.

Noise: An undesired input signal is known as noise. A good control system should be able to reduce the noise effect for better performance [4].

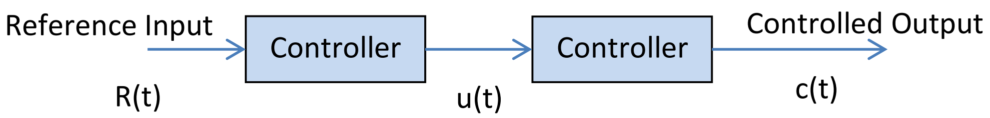
Stability: It is an important characteristic of control system. For the bounded input signal, the output must be bounded and if input is zero then output must be zero then such a control system is said to be stable system.
Bandwidth: An operating frequency range decides the bandwidth of control system. Bandwidth should be large as possible for frequency response of good control system.
Speed: It is the time taken by control system to achieve its stable output. A good control system possesses high speed. The transient period for such system is very small.
Oscillation: A small number of oscillation or constant oscillation of output tend to system to be stable.

Classification of Control System



Open Loop Control System

A system in which the control action is totally independent of the output of the system is called “open loop system”.



Examples of Open Loop Control System

Open Loop Control System
Advantages of OLC system:

- Simple in construction and design.
- Economical
- Easy to maintain
- Generally Stable
- Convenient to use as output is difficult to measure.

Disadvantages of OLC System:

- Incorrect and unreliable
- Affected by system parameter variation and external noise
- Any change in output cannot be corrected automatically.

Definition: A system in which the control action is dependent on the output is called “close loop control system”.

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In close loop system current output is taken into consideration and corrections are made based on feedback. A close loop system is also called feedback control system. A feedback control system looks at the output and generates the correct input to be fed to the system so that the output behaves in some desired way.

Closed-loop Control System

Example: When driving a car, we look at the speedometer, decide if we are going too fast or slow, and then press either the gas pedal or the brakes in order to reach the speed we want to get to. So the system is the car, the input is the gas (controlled by gas pedal) and the resistance at the wheels (controlled by the brake pedal) and the output is the speed of the car. The driver is acting as the speed control system [7].

Other examples:

- Automatic electric Iron
- Missile launched and auto tracked by Radar
- Water level controller

Closed loop Control System

Advantages of CLC System

- Accuracy is high
- Reduced effect of non-linearity
- High Bandwidth
- Facilitates automation
- The sensitivity of system may be made small to make system more stable
- Less affected by noise

Disadvantages of CLC system

- Costly
- Complicated to design
- Required more maintenance
- Reduced the gain with negative feedback
- Stability is the major problem and more care is needed to design a stable CLC system

Comparison between OLC & CLC System

S.NO	Open Loop Control System	Closed Loop Control System
1.	No feedback	Feedback is always present
2.	No error detector	Error detector is present
3.	stable	May become stable
4.	Easy to construct	Complicated to construct
5.	Economical	Costly
6.	Having small bandwidth	Having large bandwidth
7.	It is inaccurate	It is accurate
8.	Less maintenance	More maintenance
9.	Unreliable	Reliable
10.	e.g. Hand drier, Tea maker	Electric Iron, Missile launcher

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Time invariant vs Time variant Control System

Time invariant	Time variant
A time invariant system simply means the behavior of the system is independent of the time you choose to start `running' the system, given the same initial condition and input profile. If input u(t) generates output y(t), then if you fed in the input w(t) = u(t-T) instead (this is like a delayed input) , you get an output h(t) with the property that h(t) = y(t-T).	Time Variant System are systems where the system itself changes over time. This change is reflected in the differential equation for the system as a parameter that is varies over time. For example: As the rocket burns tremendous amount of fuel the mass reduces quickly over short periods of time. This is an example of a time varying system..

Laplace Transform

Why Laplace is important?

- In order to compute the time response of a dynamic system, it is necessary to solve the differential equations (system mathematical model) for given input. Laplace transform converts the problem from the time domain to the Laplace domain. i.e. converts the differential equation into an algebraic equation in "s" [9].
- To evaluate the performance of an automatic control system commonly used mathematical tool is "Laplace Transform".
- Laplace Transform exist for almost all signals of practical interest.

Laplace Transform: It transform a time domain function f(t) into an "s" domain function F(s), where "s" is a complex variable such that $s=a+ib$. The Laplace transform of a function f(t) is defined as

$$L[f(t)] = \int_0^\infty f(t)e^{-st}dt = F(s)$$

Inverse Laplace transform: Inverse transformation is easily achieved by using partial fraction to break down "s" domain function to standard components and then use Laplace transform pairs

$$f(t) = L^{-1}[F(s)] = \frac{1}{2\pi i}\int_{a-ib}^{a+ib} F(s)e^{st}ds$$

Derivatives: The Laplace transform of a derivative is

$$\frac{d^n}{dt^n}f(t) = s^n F(s) - s^{n-1}f(0) - s^{n-2}f^{'}(0) - ....$$

Where f(t) and its derivatives at t=0 are the initial conditions.

Example: Find Laplace transform for f(t) = 1 and f(t) = e^{-at}

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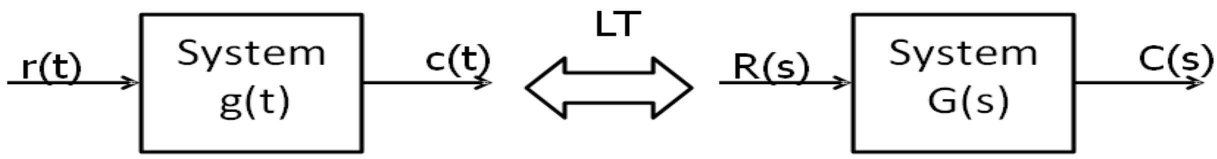
$$L[f(t)] = \int_0^{\infty} 1e^{-st}dt = [-\frac{1}{s}(e^{-st})]_0^{\infty}$$
$$= [-\frac{1}{s}(0-1)] = \frac{1}{s} = F(s)$$

$$L[f(t)] = \int_0^{\infty} e^{-at}e^{-st}dt = \int_0^{\infty} e^{-(s+a)t}dt$$
$$= [-\frac{1}{s+a}(e^{-(s+a)t})]_0^{\infty}$$
$$= [-\frac{1}{s+a}(0-1)] = \frac{1}{s+a} = F(s)$$

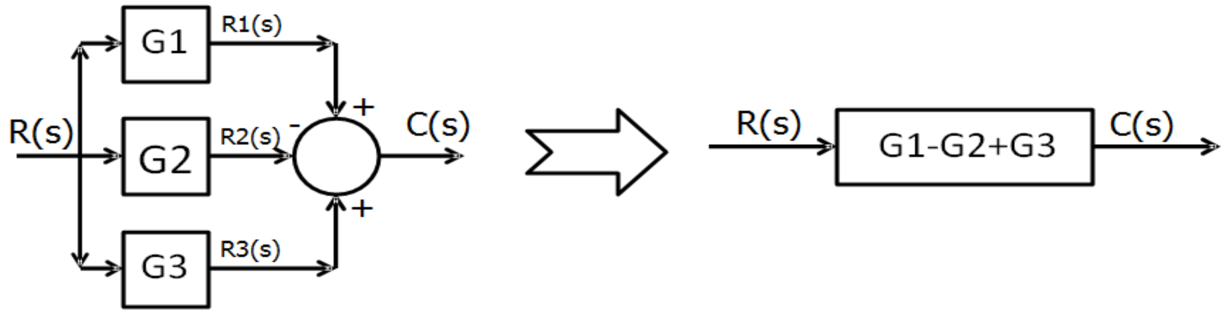
Transfer Function

Definition: The ratio of Laplace transform of the output to the Laplace transform of the input assuming all initial conditions to be zero is defined as “Transfer Function”.



Block Diagram Reduction Rules

Gain of blocksconnected in parallel gets added algebraically.



C(s)=R1(s)-R2(s)+R3(s)=G1R(s)-g2R(s)+G3R(s)
C(s)=(G1-G2+G3)R(s)

Summary

- There is a common theory that applies to ALL control systems.

“Open loop” control systems do not check the outcome to see whether it corresponds to the expected effect [6].

- “Closed loop” control systems compare the current output with some reference value (which is not necessarily constant) in order to calculate an error signal. The error

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is used to adjust the flow of energy into the controlled system in order to bring the output closer to the target value.

- Control systems differ considerably in their performance. Poor design or execution will impair accuracy, stability, resilience and speed.
- Signals varying at different frequencies traverse the feedback loop at different speeds. This means that the output is delayed (i.e. phase-shifted) with respect to the input, and these delays vary with the signal frequency.
- The greatest initial accuracy and resilience in the face of varying loads is achieved with a high gain error amplifier, and a large amount of negative feedback. Such systems are invariably unstable unless the negative feedback is very quick. Delayed feedback arrives late (i.e. phase-shifted) when the situation has already changed. This causes the feedback to be applied in the wrong direction, making the position worse instead of better.
- If the feedback is inherently slow then the resulting phase shifts limit the maximum usable gain and reduce the performance of the control system. High frequency gain and phase shifts must be correctly optimized for success.
- Very simple control systems operate by on/off control, but most effective control systems operate with smooth feedback that is proportional to the magnitude of the error [5].

Conclusion

Automatic control system is a wide subject. Lot of development has happened and lot of development is still going on. In coming days, this will prove a great boon to the world, since it will save a lot of electricity of power plants as well as time. This article is just an introduction to the automatic control system and I will write some application part to the automatic control in future.

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