MINISTRY OF HIGHER EDUCATION
& SCIENTIFIC RESEARCH

TIKRIT UNIVERSITY
COLLEGE OF ENGINEERING

ENGINEERING CONTROLS& INSTRUMENTS

LECTURE NOTES (4^{TH} YEAR – I SEM) (2021-2022)

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2021-2022

CONTROL SYSTEMS

COURSE OBJECTIVES: The main objectives of the course are:

- Introduce the principles and applications of linear control systems and Laplace transform.
- The basic concepts of block diagram reduction, transfer function representation, time response and time domain analysis, solutions to linear time invariant systems.
- Study and analyze the different methods of stability analysis.

UNIT - I:

Introduction: Concept of control system, Classification of control systems - Open loop and closed loop control systems, Differences, Examples of control systems- Effects of feedback, Feedback Characteristics.

Transfer Function Representation: Block diagram algebra, Determining the Transfer function from Block Diagrams, Signal flow graphs(SFG) - Reduction using Mason's gain formula- Transfer function of SFG's.

UNIT - II:

Time Response Analysis: Standard test signals, Time response of first order systems, Characteristic Equation of Feedback control systems, Transient response of second order systems - Time domain specifications, Steady state response, Steady state errors and error constants.PID controllers: Effects of proportional derivative, proportional integral systems on steady state error.

UNIT - III:

Stability Analysis in S-Domain: The concept of stability – Routh-Hurwitz's stability criterion – qualitative stability and conditional stability – Limitations of Routh-Hurwitz's stability.

Root Locus Technique: Concept of root locus - Construction of root locus, Effects of adding poles and zeros to G(s) H(s) on the root loci.

UNIT - IV:

Frequency Response Analysis: Introduction, Frequency domain specifications, Bode plot diagrams-Determination of Phase margin and Gain margin, Stability analysis from Bode plots, Polar plots.

UNIT - V:

State Space Analysis of Continuous Systems: Concepts of state, state variables and state model, Derivation of state models from block diagrams, Diagonalization, Solving the time invariant state equations, State Transition Matrix and it's properties, Concepts of Controllability and Observability.

TEXT BOOKS:

1. Control Systems Engineering - I. J. Nagrath and M. Gopal, New Age International (P) Limited, Publishers.
2. Control Systems - A. Ananad Kumar, PHI.
3. Control Systems Engineering by A. Nagoor Kani, RBA Publications.

REFERENCE BOOKS:

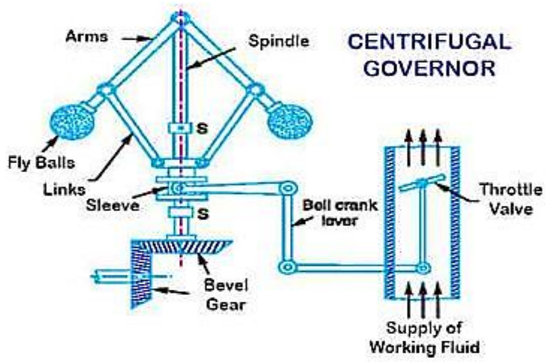
1. Control Systems Theory and Applications - S. K. Bhattacharya, Pearson.
2. Control Systems Engineering - S. Palani, TMH.
3. Control Systems - N. K. Sinha, New Age International (P) Limited Publishers.
4. Control Systems by S.Hasan Saeed, KATSON BOOKS.
5. Solutions and Problems of Control Systems by A.K. Jairath, CBS Publishers.

COURSE OUTCOMES: After going through this course the student gets

- A thorough knowledge on open loop and closed loop control systems, concept of feedback in control systems.
- Understanding of transfer function representation through block diagram algebra and signal flow graphs.
- Time response analysis of different order systems through their characteristic equation.
- Time domain specifications, stability analysis of control systems in s-domain through-H criteria.
- Root locus techniques, frequency response analysis through Bode diagrams and Polar plot.

نظره تاريخية لتطور مفهوم السيطرة الطوعية(التحكم الالي)

أول عمل ذو أهمية في مجال السيطرة الطوعية تم بواسطة العالم جيمس واط (James Watts) والذي طبقه على حاكم الطرد المركزي (centrifugal governor) للسيطرة على سرعة المكائن البخارية في القرن الثامن عشر.



- في المرحلة الأولى لإنماء نظريات السيطرة الطوعية تمت بواسطة مينورسكي (Minorsky) ونيكويست (Nyquist) وهازن (Hazen)
- في عام (١٩٢٢) عمل Minorsky في مجال السيطرة الطوعية لقيادة السفن وبَيّن كيف أن الإستقرارية يمكن الحصول عليها عن طريق (Differential equations) التي بدورها تصف الحالة الحركية للنظام .
- في عام (١٩٣٢) أوجد Nyquist طريقة مبسطة لإيجاد الاستقرار للنظام ذو الدائرة المغلقة (Closed loop control system) بالاعتماد على أداء النظام ذو الدائرة المفتوحة (open loop control system) لحالة الثبوت Steady state عندما يكون الدخل (Input) هو موجة جيبية .
- في عام (١٩٣٤) أوجد Hazen عبارة Servo mechanisms للسيطرة على الموقع .
- خلال الأربعينات طريقة Frequency response جعلت ممن الممكن للمهندس تصميم (Linear feedback control system) والذي مكننا من الحصول على الأداء المطلوب .
- في نهاية الأربعينات وبداية الخمسينات تم أكمال طريقة Root-Locus في تصمم أنظمة السيطرة الطوعية .
- طريقتا Root-Locus & Frequency response هما قلب ما تسمى Classical control theory و اللذان يؤديان الى نظام مستقر وتحقق الأداء المطلوب .هذان النظامان لا يؤديان الى الأداء المثالي .في أواخر الخمسينات استخدمت التصاميم التي تؤدي الى الأداء المثالي.
- بعد أن أصبحت الأنظمة معقدة جداً وتحتوي على عدة مداخل ومخارج وبما أنه Classical control يتعامل مع الأنظمة التي لها دخل واحد وخرج واحد single input single output (SISO) لذلك جرى تحديث السيطرة

الطوعية واستحدث ما تسمى بالسيطرة الحديثة Modern control والتي تتعامل مع عدد كثير من المعادلات ولا تحتاج الى جهد كبير في التصميم للأنظمة الاليه المتضمنه عدة مداخل ومخارج Multiple input multiple output (MIMO).

- في الستينات دخلت السيطرة الطوعية في الأنظمة المعقدة ذات الاستخدامات العسكرية والفضائية و الإنتاجية .
- نظراً للتطور الكبير الحاصل في الحاسبات أصبح استخدام الحاسبة في التصميم والتنفيذ أمراً يسيرا أو معتادا" .
- السيطرة الحديثة أصبحت باتجاه السيطرة المثالية optimal control في مجال المنظومات التي تحتوي على ضوضاء Noise والتي لا تحتوي على ضوضاء .
- وكذلك باتجاه السيطرة المتكيفة Adaptive control والسيطرة الذكية مثل Neural control والتي تستخدم الشبكات العصبية الصناعية والسيطرة الضبابية Fuzzy Control والسيطرة الوراثية Genetic control بالإضافة الى السيطرة المتينة Robust Control .

1- Introduction to control system

Automatic control system played a vital role in the advancement of engineering and science

- لعب نظام السيطرة الطوعية دورا حيويا في تقدم ألهندسة والعلوم.

In addition to its extreme importance in space-vehicle missile guidance and aircraft-piloting system.

- إضافة الى ألاهميه القصوى في المركبات الفضائية وفي توجيه الصواريخ و أنظمة قيادة الطائرات...

Automatic control has become an important and integral part of modern manufacturing and industrial processes. For example automatic control is essential in such industrial operations as controlling pressure, temperature, humidity, …

- أصبحت السيطرة الطوعيه مهمه وجزء متمم في المعامل الإنتاجية الحديثة وعلى سبيل المثال هي ضرورية في عمليات السيطرة على الضغط والحرارة والرطوبة واللزوجة ... الخ

Since advance in the theory and practice of automatic control provide means for attaining optimal performance of dynamic systems, improving the quality and lower the cost of production. Expand the production rate.

- التقدم في نظريات وتمارين السيطرة الطوعية زودنا بوسائل الحصول على الأداء المثالي للمنظومة الحركية وتحسين النوعية وتقليل الكلفة في الإنتاج وزيادة معدلات الإنتاج

Most of engineers and scientist must now have a good understanding of this field.

- يجب أن يكون هناك إلمام كافي لدى معظم المهندسين والعلماء في هذا المجال.

2- Basic Control System Component

DEFINITIONS OF IMPORTANT TERMS

Control Problem: If we want something to act or vary according to a certain performance specification, then we say that we have a control problem.

Ex. We want to keep the temperature in a room at certain level and as we order, then we say that we have temperature control problem.

Plants:

A piece of equipment's the purpose of which is to perform a particular operation (we will call any object to be controlled a plant).

Note :- we call any physical object to be controlled a plant (such as a heating furnace, a chemical reactor, or space craft).

Systems

A system is a combination of components that act together and perform a certain objective.

Disturbance

A disturbance is a signal that tends to adversely affect the value of the output of a system.

Feedback control

Feedback control refers to an operation that, in the presence of disturbances, tends to reduce the difference between the output of a system and some reference input and that does so on the basis of this difference.

Servo Systems

A servo system (or servomechanism) is a feedback control system in which the output is some mechanical position, velocity, or acceleration.

Automatic Regulating Systems

An automatic regulating system is a feedback control system in which the reference input or the desired output is either constant or slowly varying with time and in which the primary task is to maintain the actual output at the desired value in the presence of disturbances.

Closed- loop Control Systems

Feedback control systems are often referred to as *closed- loop control systems.*

Open Loop and Closed Loop Control Systems

Control Systems can be classified as open loop control systems and closed loop control systems based on the feedback path. In ***open loop control systems***, output is not fed-back to the input. So, the control action is independent of the desired output.

The following figure shows the block diagram of the open loop control system.

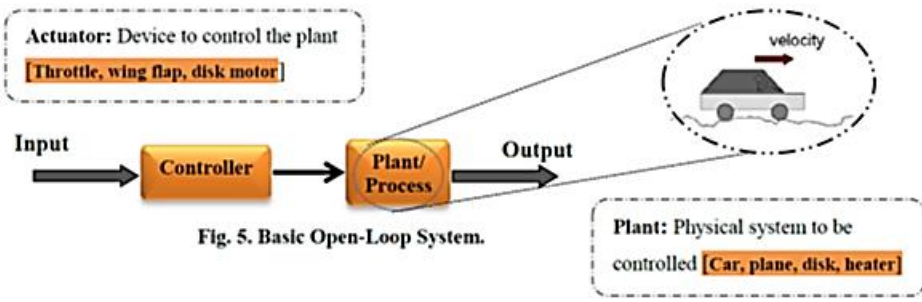
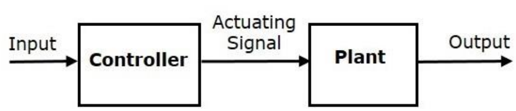


Fig. 5. Basic Open-Loop System.

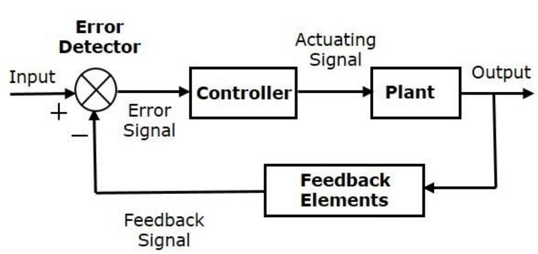


Here, an input is applied to a controller and it produces an actuating signal or controlling signal. This signal is given as an input to a plant or process which is to be controlled. So, the plant produces an output, which is controlled. The traffic lights control system which we discussed earlier is an example of an open loop control system.

- ***A traffic control system*** is a good example of an open loop system. The signals change according to a preset time and are not affected by the density of traffic on any road.
- ***A washing machine*** is another example of an open loop control system. The quality of wash is not measured; every cycle like wash, rinse and dry' cycle goes according to a preset timing

In closed loop control systems, output is fed back to the input. So, the control action is dependent on the desired output.

The following figure shows the block diagram of negative feedback closed loop control system.



The error detector produces an error signal, which is the difference between the input and the feedback signal. This feedback signal is obtained from the block (feedback elements) by considering the output of the overall system as an input to this block. Instead of the direct input, the error signal is applied as an input to a controller.

So, the controller produces an actuating signal which controls the plant. In this combination, the output of the control system is adjusted automatically till we get the desired response. Hence, the closed loop control systems are also called the automatic control systems. Traffic lights control system having sensor at the input is an example of a closed loop control system.

- ***Air Condition System*** is a good example of a closed loop system. The system changes from on to off according to the desired temperature.

The differences between the open loop and the closed loop control systems are mentioned in the following table.

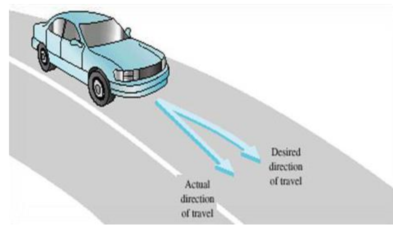
Open Loop Control Systems	Closed Loop Control Systems
Control action is independent of the desired output.	Control action is dependent of the desired output.
Feedback path is not present.	Feedback path is present.
These are also called as non-feedback control systems.	These are also called as feedback control systems.
Easy to design.	Difficult to design.
These are economical.	These are costlier.
Inaccurate.	Accurate.

If either the output or some part of the output is returned to the input side and utilized as part of the system input, then it is known as feedback. Feedback plays an important role in order to improve the performance of the control systems. In this chapter, let us discuss the types of feedback & effects of feedback.

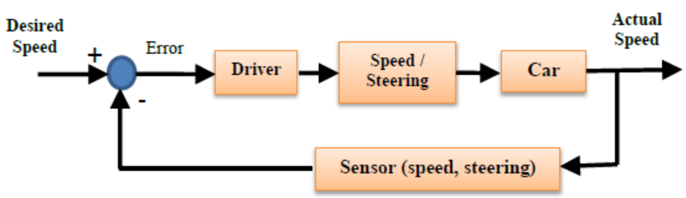
Closed loop & open loop Control (In Class Exercise)

1- Car and Driver

Objective: To control direction and speed of car

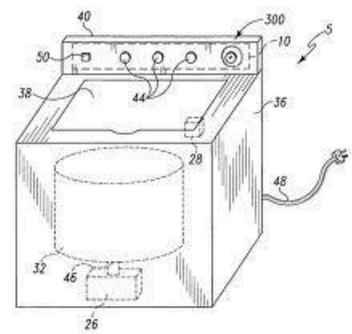


- Outputs: Actual direction and speed of car
- Control inputs: Road markings and speed signs
- Disturbances: Road surface and grade, wind, obstacles

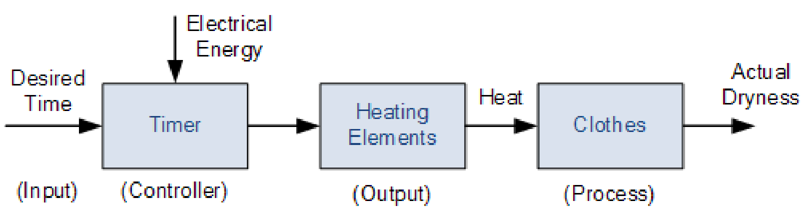


2- Washing Machine

Objective: To wash, rinse and dry Clothes

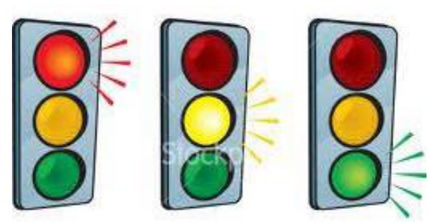


- Outputs: Clean Clothes
- Control inputs: Non
- Disturbances:



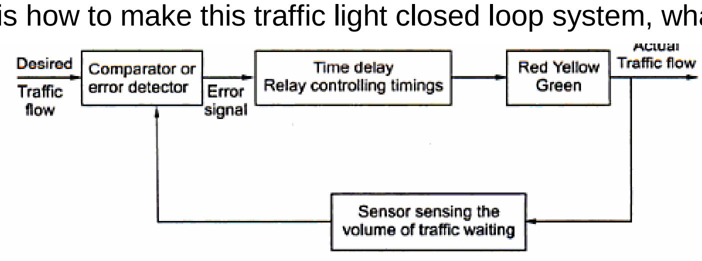
3- Traffic Light

Objective: To control the traffic lights in sequence.



- Outputs: Traffic flow
- Control inputs: Timing mechanism.

The question is how to make this traffic light closed loop system, what we shall add?



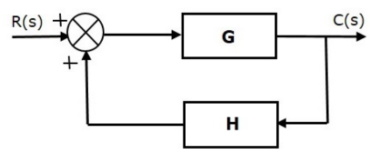
2-1 Types of Feedback

There are two types of feedback −

- Positive feedback
- Negative feedback

Positive Feedback

The positive feedback ***adds*** the reference input R(s) and feedback output. The following figure shows the block diagram of **positive feedback control system**.



The concept of transfer function will be discussed in later chapters. For the time being, consider the transfer function of positive feedback control system is,

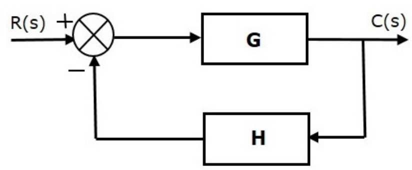
Transfer function (T) =G /1−GH --------(1)

Where,

- **T** is the transfer function or overall gain of positive feedback control system.
- **G** is the open loop gain, which is function of frequency.
- **H** is the gain of feedback path, which is function of frequency.

Negative Feedback

Negative feedback reduces the error between the reference input, R(s) and system output. The following figure shows the block diagram of the negative feedback control system.



Transfer function of negative feedback control system is,

T=G/ 1+GH ------------ (2)

Where,

T- is the transfer function or overall gain of negative feedback control system.
G - is the open loop gain, which is function of frequency.

H - is the gain of feedback path, which is function of frequency.

2-2 Effects of Feedback

Let us now understand the effects of feedback.

- ***Effect of Feedback on Overall Gain***

From Equation 2, we can say that the overall gain of negative feedback closed loop control system is the ratio of 'G' and (1+GH). So, the overall gain may increase or decrease depending on the value of (1+GH).

_ If the value of (1+GH) is less than 1, then the overall gain increases. In this case, 'GH' value is negative because the gain of the feedback path is negative.

_ If the value of (1+GH) is greater than 1, then the overall gain decreases. In this case, 'GH' value is positive because the gain of the feedback path is positive.

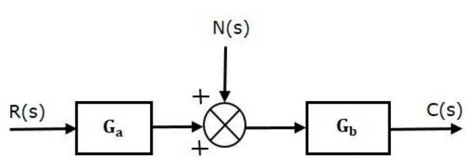
In general, 'G' and 'H' are functions of frequency. So, the feedback will increase the overall gain of the system in one frequency range and decrease in the other frequency range.

- **Effect of Feedback on Stability**

A system is said to be stable, if its output is under control. Otherwise, it is said to be unstable.
In Equation 2, if the denominator value is zero (i.e., GH = -1), then the output of the control system will be infinite. So, the control system becomes unstable.
Therefore, we have to properly choose the feedback in order to make the control system stable.

- **Effect of Feedback on Noise**

To know the effect of feedback on noise, let us compare the transfer function relations with and without feedback due to noise signal alone.
Consider an open loop control system with noise signal as shown below

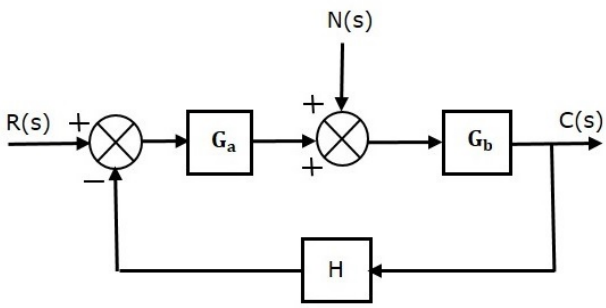


The **open loop transfer function** due to noise signal alone is

$$C(s) / N(s) = G_b \text{ ----------(3)}$$

It is obtained by making the other input R(s) equal to zero.

Consider a closed loop control system with noise signal as shown below.



The closed loop transfer function due to noise signal alone is

$$C(s) / N(s) = G_b / 1 + G_a G_b H \text{ --------(4)}$$

It is obtained by making the other input R(s) equal to zero.

Compare Equation 3 and Equation 4,

In the closed loop control system, the gain due to noise signal is decreased by a factor of $(1+G_aG_bH)$ provided that the term (1+GaGbH) is greater than one.

Command input i/p : The motivating input signal to the system which is independent of the output of the system.

Reference i/p elements: An element which modifies the command i/p into suitable signal (called reference i/p) for the controlled system.

Actuating signal: The difference between the reference input and feedback (f/b) signals. It actuates the control unit (controller) to maintain the output at the desired value.

Control unit (Controller) : The unit which receives the actuating signal and delivers the control signal.

Controlled variable (actual o/p): The variable which we need actually to control it.

Ex. temperature, pressure, liquid level, flow rate, etc.

2-3 CLASSIFICATION OF CONTROL SYSTEMS

- **Linear versus Nonlinear Control Systems**

For linear systems, the principle of superposition applies. Those systems for which this principle does not apply are nonlinear systems. Most real life control system have non linear characteristics to some extent.

- **Time invariant versus Time−varying Control Systems**

A time invariant control system (constant coefficient control system) is one whose parameters do not vary with time. A time−varying control system is a system in which one or more parameters vary with time. The response depends on the time at which an input is applied.

- **Continuous−time versus Discrete−time Control Systems**

In a continuous−time control system, all system variables are functions of a continuous time t. A discrete- time control system involves one or more variables that are known only at discrete instants of time.

- **Single - input, Single - output versus Multiple -input, Multiple - output Control Systems**

A system may have one input and one output. Such a system is called a single- input, Single-output control system. Some systems may have multiple inputs and multiple outputs.

- **Lumped- parameter versus Distributed- parameter Control Systems**

Control systems that can be described by ordinary differential equations are Lumped- parameter control systems, whereas distributed−parameter control systems are those that may be described by partial differential equations.

- **Deterministic versus Stochastic Control Systems**

A control system is deterministic if the response to input is predictable and repeatable. If not, the control system is a stochastic control system.

2- 4 Transfer Functions:

Transfer function: It's a mathematical representation which relates the input and the output of an element, a subsystem or a complete system. It may be denoted by T(D) or T(s), where (D) and (s) are the time derivative operator and the Laplace operator respectively. The transfer function (T.F) is **T.F(s) =** ***outputl input*** . T.F(s) may be represented by a block as shown in figure Fig.1.

Fig. 1. Block diagram.

The arrow in the diagram indicates the direction of control action thus the block diagram has a unilateral property in the direction of arrow. The transfer function is expressed as the ratio of output quantity to input quantity. Therefore, g=c/r.

The transfer function is also expressed as a ratio of Laplace transform of output to Laplace transform of input.

Thus if, R(s) = Laplace transform of the input function

C(s) = Laplace transform of the output function

then the block diagram for a control system is drawn as per fig.2

Fig. 2. Block diagram of a ontrol system.

The transfer function is expressed as, $G(s) = \frac{C(s)}{R(s)}$

Definition of Transfer Function

Transfer function of a given system is defined as the ratio of the Laplace transform of output variable to Laplace transform of input variables at zero input conditions.

How you can obtain the transfer function (T. F.)?

The transfer function is defined as the ratio of the Laplace transform of the output to the Laplace transform of the input under the assumption that all initial conditions are zero.

- Consider the linear system having input X(t) ,y(t) is the output of the system the output –input relation can be described by the following nth differential equation .

$$a_n \frac{d^n C(t)}{dt^n} + a_{n-1} \frac{d^{n-1} C(t)}{dt^{n-1}} + \cdots + a_1 \frac{dC(t)}{dt} + a_o C(t)$$
$$= b_m \frac{d^m r(t)}{dt^m} + b_{m-1} \frac{d^{m-1} r(t)}{dt^{m-1}} + \cdots + b_1 \frac{dr(t)}{dt} + b_o r(t)$$

Where **a** and ***b*** are constant

Take Laplace transform for equation above ,we got

$$(a_n s^n + a_{n-1}\, s^{n-1} + \cdots + a_1 s + a_o\,)C(s) = (b_m\, s^m + b\, s^{m-1} + \cdots + b_1\, s + b_o\,)\, R\,(s)$$

We can define the transfer function as $G(s) = \frac{C(s)}{R(s)}$

$$G(s) = \frac{C(s)}{R(s)} = \frac{(b_m\, s^m + b\, s^{m-1} + \cdots + b_1\, s + b_o\,)}{(a_n s^n + a_{n-1}\, s^{n-1} + \cdots + a_1 s + a_o\,)}$$

The numerator and the denominator can be factored into n and m terms respectively, with such a factorization the above expression for the transfer function can be expressed as,

$$G(s) = \frac{A(s)}{B(s)} = \frac{K(s-s_1)\,(s-s_2)\ldots(s-s_n)}{(s-s_a)\,(s-s_b)\ldots(s-s_m)}$$

where ***K*** = a_o/d_o is known as the ***gain factor*** of the transfer function.

Then $s_1, s_2, s_3, \ldots\ldots s_n$ are called system zeros.

and $s_a, s_b, s_c, \ldots\ldots s_m$ are called as system poles.

For e.g $\quad G(s) = \dfrac{3(s+3)(s+1.5)^3}{(s+5)(s+7)^2}$ -------------------------- 1

Poles of the transfer function :

The value of **s** for which the system magnitude | G(s) | becomes infinity are called poles of G(s). When pole values are not repeated, such poles are called as ***simple poles***. If repeated such poles are called ***multiple poles*** of order equal to the number of times they are repeated.

For example in equation (1) : poles are at s = −5 and s = −7. The pole at s = −5 is simple pole and the pole at s = −7 is multiple pole of 2nd order multiplicity.

Zeros of the transfer function :

Zeros The value of **s** for which the system magnitude | G(s) | becomes zero are called zeros of transfer function G(s). When they are non repeated, they are called simple zero, otherwise they are called multiple zeros.

For example in equation (1), zeros are at s = −3 and s = −1.5. The zero at s = −3 is simple zero whereas the zero at s = −1.5 is repeated of order three.

.

For example, consider the following transfer function :

$$G(s) = \frac{(s+2)(s+4)}{s(s+3)(s+5)(s+2-j4)(s+2+j4)}$$

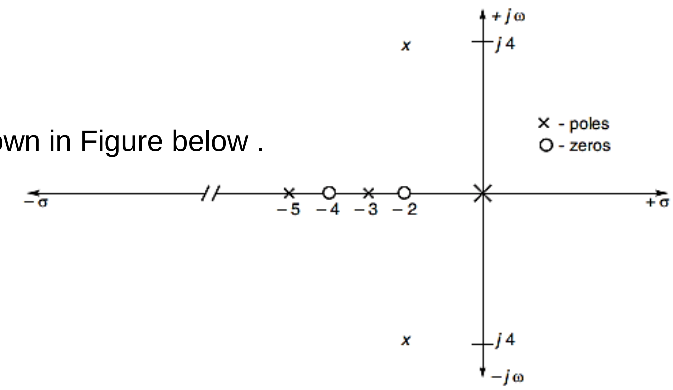
For the above transfer function, the poles are at $s_a = 0$, $s_b = -3$, sc = - 5, $s_d = (-2 + j4)$, $s_e = (-2 - j4)$ and. The zeros are at $s_1 = -2$, $s_2 = -4$.

Representation of Pole and Zeros on S−plane

Zeros are represented by **o**

Poles are represented by **x**

The pole-zero locations are plotted s-plane as shown in Figure below .



Poles-zeros in s-plane.

- **PROCEDURE FOR DETERMINING THE TRANSFER FUNCTION OF A CONTROL SYSTEM**

The following steps give a procedure for determining the transfer function of a control system:

1. Formulate the equations for the system.
2. Take the Laplace transform of the system equations, assuming initial conditions as zero.
3. Specify the system output and the input.
4. Take the ratio of the Laplace transform of the output and the Laplace transform of the input.

The ratio as obtained in step (4) is the required transfer function.

Properties of transfer functions.

The properties of transfer function are as follows:

- The transfer function of a system is the Laplace transform of its impulse response. I.e. if the input to a system with transfer function P(s) is an impulse and all initial conditions are zero, the transform of the output is P(s).

- The roots of the denominator are the system poles and the roots of the numerator are system zeros. The system stability can be described in terms of the location of the roots of the transfer function

Advantages of transfer function.

- It helps in the stability analysis of the system
- It helps in determining the important information about the system Poles, zeros, characteristic equation etc.
- Once transfer function is known, output response for any type ofreference input can be calculated.
- The system differential equation can be easily obtained by replacing variable 's' by d/dt.

Disadvantages of transfer function.

The disadvantages of transfer function approach are:

- Only applicable to linear time invariant systems.
- It does not provide any information concerning the physical structure of the system. From transfer function, physical nature of the system, whether it is electrical, mechanical, thermal or hydraulic cannot be judged.

Characteristic Equation

The denominator polynomial of the closed loop transfer function of a closed loop system is called as characteristics equation and is given by 1 + G(s) H(s) = 0

SOLVED EXAMPLES

Example 1. *For the transfer function* $G(s) = \frac{1}{2} \cdot \frac{(s^2+4)(1+2.5s)}{(s^2+2)(1+0.5s)}$ *. Plot the poles and zeros ins-plane and determine the value of the transfer function at* $s = 2$

Solution:- The poles are determined from the equation

$(s^2 + 2)(1 + 0.5s) = 0$

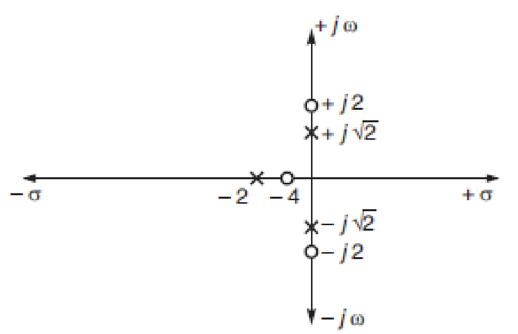
Therefore, the poles are,

$s = \pm J2$, and $s = -2$

- The zeros are determined from the equation.

$(s^2 + 4)(1 + 2.5s) = 0$

Therefore, the zeros are,



Pole zero configuration for example. 1.

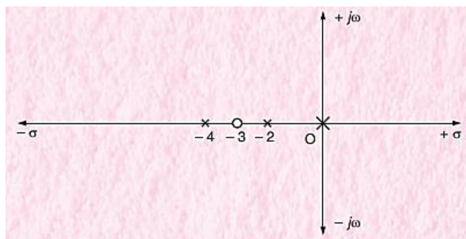
$s = \pm j\,2$ and $s = -1/2.5 = -0.4$

The pole zero configuration is plotted in *s*-plane as shown in Fig. beside

The value of G(s) at $s = 2$ is calculated below,

$$G(s) = \frac{1}{2} \cdot \frac{(2^2+4)(1+2.5\times 2)}{(2^2+2)(1+0.5\times 2)} = \frac{1}{2} \cdot \frac{8\times 6}{6\times 2} = 2.$$

Example 2. *The pole zero configuration of a transfer function is given in figure below. The value of the transfer function at s = 1 is found to be 3.2. Determine the transfer function and gain factor K.*



Pole-zero configuration for example 2.

Solution:-

The transfer function has three poles and one zero, therefore, the transfer function consists of one term in the numerator and three terms in the denominator.

And

- The poles are located at $s = 0$, $s = -2$ and $s = -4$
- The zero is located at $s = -3$

The transfer function is thus

$$G(s) = \frac{K(s+3)}{s(s+2)(s+4)}$$

It is given that at $s = 1$, the value of $G(s)$ is 3.2

$$\therefore \quad G(1) = 3.2 = \frac{K(1+3)}{1(1+2)(1+4)} = \frac{K\times 4}{1\times 3\times 5}$$

$$\therefore \quad K = \frac{3.2\times 1\times 3\times 5}{4} = 12$$

$$\therefore \quad G(s) = \frac{12(s+3)}{s(s+2)(s+4)}$$

HOME WORK .

1. The transfer function of a system is given below

$$G(s) = \frac{8(s+3)(s+4)}{s(s+2)^2(s^2+2s+5)}$$

Determine the poles and zeros and show the pole-zero configuration ins-plane.

2. The transfer function of a system is given by

$$G(s) = \frac{K(s+8)}{s(s+4)(s+5)(s^2+13s+42)}$$

Determine the poles and zeros of the transfer function. Plot the pole-zero configuration in s-plane.

SHORT QUESTION WITH ANSWER

1.1. What is meant by a system?

It is an arrangement of physical components related in such a manner as to form an entire unit.

1.2. What is a command input?

It is the excitation applied to a control system from an external source. It is also a motivating input signal to the system, which is independent of the output of the system.

1.3. Define output.

It is the actual response obtained from a control system, which must be maintained at a prescribed value.

1.4. What is an actuating signal?

It is the difference between the reference input and feedback signal. It is also called as actuating signal.

1.5. Define plant.

It is the process/body/ machine, of which a particular quantity or condition is to be controlled.

1.6. List the two types of control systems?

The two types of control system are, open loop systems and closed loop system.

1.7. What is an open loop system?

The control system in which the output has no effect upon the input quantity, is known as open loop control system.

1.8. What is meant by a controller?

It is the component required to generate the appropriate control signal applied to the plant.

1.9. Define manually controlled systems?

Systems that involve continuous manual control by a human operator are called manually controlled system.

1.10. For what purpose feedback element is used?

It is the component required to generate the appropriate control signal applied to the plant.

1.11. What is a closed loop system?

A system in which output has some effect upon the input quantity, in such a manner as to maintain the desired output value.

1.12. What is feedback?

The feedback is a control action, in which the output is sampled and a proportional signal is given to input for automatic correction of any changes in desired
output.

1.13. Give the types of feedback?

Negative feedback

Positive feedback.

1.14. What type of feedback is employed in control system?

Negative type of feedback is employed in control system.

1.15. Define - Servomechanism

It is the power amplifying feedback control system in which the controlled variable (output) is mechanical position, or a time derivative of position such as velocity or acceleration. Occasionally it refers to a mechanical system in which the steady state error is zero for a constant input signal.

1.16. Define - Regulator.

It is the system, in which the output is a steady state value for a variable input signal.

1.17. When will feedback exist in a system?

Feedback is said to exist in a system, when a closed sequence, of cause and effect relations exist between systems available.

1.18. Define transfer function.

Transfer function of a given system is defined as the ratio of the laplace transform of output variable to Laplace transform of input variables at zero input conditions.

1.19.Define order of the system.

The highest power of the complex variables in the denominator of the transfer function determines the order of the system.

1.20. Define linear system.

A system is said to be linear if it obeys the principle of superposition and homogeneity. The principle of superposition states that the response of the system to a weighted sum of the responses of the system to each individual input signals.

1.21. Give the important characteristics of open loop control system.

Their ability to perform accurately is determined by their calibration, which implies to establish the input-output relation to obtain a desired system accuracy.

1.22. List the advantages and disadvantages of feedback systems.

Increased accuracy.

Reduced sensitivity.

Reduced effects of non-linearity and distortion.

Increased bandwidth.

Tendency towards oscillation or instability.