LAB1: Design of Simulink Models from Systems

Objective: To design simulink models for open loop and closed loop configurations.

Description of system: The system to be controlled is shown below in the figure. It is a mechanical mass-spring damper system.

Input -> Force (u)

Output -> Displacement of the first mass (y)

Other parameters -> Mass (M), spring Constant (k) and damping factor (b)

Open loop system -> Blocks connected with dampers only and no spring

Closed loop system -> the complete system with the spring (Note: The spring provides feedback in the model)
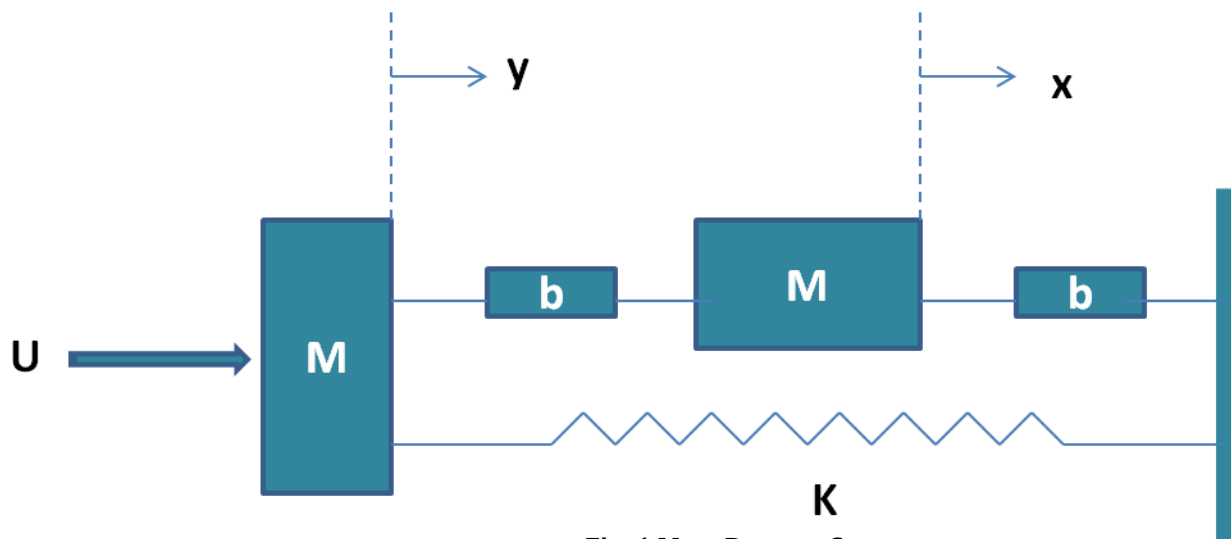

Fig: 1 Mass Damper System

Pre lab: (by Hand)

1) Solve for open loop model (Differential Equations) and its transfer function
2) Solve for closed loop model (Differential Equation) and its transfer function

Background:

Open Loop Control System: A control system in which the control action is totally independent of output of the system then it is called open loop control system. Manual control system is also an open loop control system. Fig - 2 shows the block diagram of open

loop control system in which process output is totally independent of controller action.
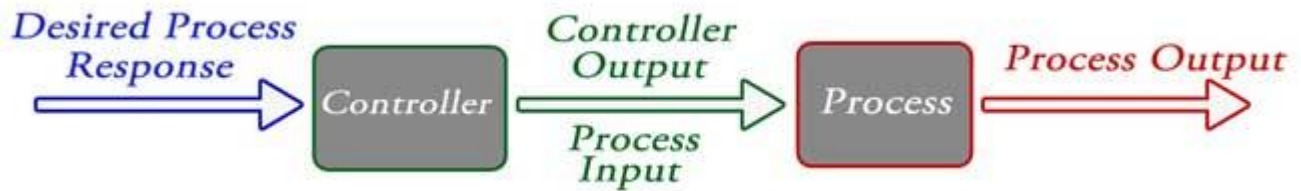

Fig: 2 Open Loop control system

Practical Examples of Open Loop Control System

1. *Electric Hand Drier* – Hot air (output) comes out as long as you keep your hand under the machine, irrespective of how much your hand is dried.
2. *Automatic Washing Machine* – This machine runs according to the pre-set time irrespective of washing is completed or not.
3. *Bread Toaster* - This machine runs as per adjusted time irrespective of toasting is completed or not.
4. *Automatic Tea/Coffee Maker* – These machines also function for pre adjusted time only.
5. *Timer Based Clothes Drier* – This machine dries wet clothes for pre – adjusted time, it does not matter how much the clothes are dried.
6. *Light Switch* – lamps glow whenever light switch is on irrespective of light is required or not.
7. *Volume on Stereo System* – Volume is adjusted manually irrespective of output volume level.

Advantages of Open Loop Control System

1. Simple in construction and design.
2. Economical.
3. Easy to maintain.
4. Generally stable.
5. Convenient to use as output is difficult to measure.

Disadvantages of Open Loop Control System

1. They are inaccurate.
2. They are unreliable.
3. Any change in output cannot be corrected automatically.

Closed Loop Control System: In a Control system the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated. Open loop control system can be converted in to closed loop control system by providing a feedback. This feedback automatically makes the suitable changes in the output due to external disturbance. In this way closed loop control system is called automatic control system. Figure below shows the block diagram of closed loop control system in which feedback is taken from output and fed in to input
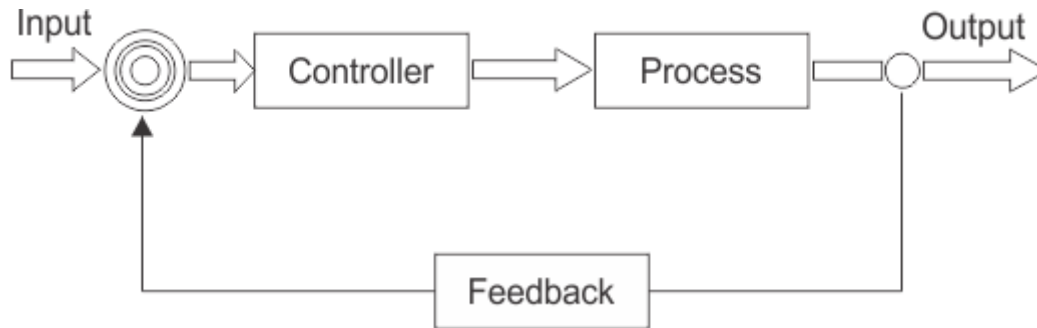
Fig: 3 Closed loop System

Practical Examples of Closed Loop Control System

1. *Automatic Electric Iron* – Heating elements are controlled by output temperature of the iron.
2. *Servo Voltage Stabilizer* – Voltage controller operates depending upon output <u>voltage</u> of the system.
3. *Water Level Controller*– Input water is controlled by water level of the reservoir.
4. *Missile Launched & Auto Tracked by Radar* – The direction of missile is controlled by comparing the target and position of the missile.
5. *Air Conditioner* – An air conditioner functions depending upon the temperature of the room.
6. *Cooling System in Car* – It operates depending upon the temperature which it controls.

Advantages of Closed Loop Control System

1. Closed loop control systems are more accurate even in the presence of non-linearity.
2. Highly accurate as any error arising is corrected due to presence of feedback signal.
3. Bandwidth range is large.
4. Facilitates automation.
5. The sensitivity of system may be made small to make system more stable.
6. This system is less affected by noise.

Disadvantages of Closed Loop Control System

1. They are costlier.
2. They are complicated to design.
3. Required more maintenance.
4. Feedback leads to oscillatory response.
5. Overall gain is reduced due to presence of feedback.
6. Stability is the major problem and more care is needed to design a stable closed loop system.

To get Simulink model from system equations: please refer to the link below and Intro slides from Dr.DeSouza website.
http://ctms.engin.umich.edu/CTMS/index.php?example=CruiseControl&section=Simulink Modeling

Lab:

1) Implement a simulink model (Using the Differential equations) for the open loop system with M=1000kg, b= 70 N.sec/m and a step input of 1 for 100s
2) Implement a simulink model for the closed loop system (Using Differential equations)with M=1000kg, b=70N.sec/m , k= 490 N/m and a step input of 1 for 100s

Lab Procedure:

1) Open the simulink 'Library Browser' by clicking on Start → Simulink. Open a new model file (.mdl). Build a model of the above closed loop system by using the respective blocks.
2) Double-click on the blocks to open its property editor. This will give you options of changing the parameters of the blocks.
3) Arrange the blocks in the proper order, and connect them.
4) Also save your workspace to mat lab.
5) Go to Simulation → Configuration Parameters. Set the Stop Time as 100s.
6) Simulate the model and look at the output by double-clicking on the Scope.
7) Save the result Step input for open loop transfer function with given parameters
8) Save the result Step input for closed loop transfer function with given parameters
9) Generate a plot of the error (input to the plant) by connecting another Scope at the appropriate location for closed loop system.
❖ Also show the MATLAB PLOTS along with SIMULINK plots.

Post Lab: Write a report in Abstract, Objective, theory, procedure, results, conclusion and appendices. All steps should be clearly mentioned. Include all plots and results.