Information Organization through Block Diagram

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Let us consider first the problems mooted in the last lecture

**Problem 1:**

From the cruise control perspective: we can have a simplified model for the automobile system.

Assuming \( M \) to be the mass of the car and \( u \) to be the velocity, the governing EOM could be written as:

\[
M \ddot{u} + D u = F(t)
\]

Where, \( D \) is the Drag/Resistance Coefficient and \( F(t) \) is the cruising force.
**Problem 2:**

Again, a simplified model could be developed by neglecting the disturbance, the EOM will be (C – shaft damping coefficient and k shaft stiffness)

\[
I_2 \ddot{\theta}_2 + C (\dot{\theta}_2 - \dot{\theta}_1) + k (\theta_2 - \theta_1) = M_c (t)
\]
\[
I_1 \ddot{\theta}_1 + C (\dot{\theta}_1 - \dot{\theta}_2) + k (\theta_1 - \theta_2) = 0
\]
**System Transfer Functions**

- The last two examples relate to the description of the systems in Time Domain.
- By Laplace transformation one can convert the equations into frequency domain.
- Assuming zero initial condition, the first mathematical model could be expressed as:

  \[ sMU(s) + BU(s) = F(s) \]

  \[ U(s) = \frac{1}{sM + B} F(s) \]

- Similarly, the second mathematical model could be expressed as:

  \[ \frac{\theta_2(s)}{M_c} = \frac{1}{s^2 I_2 + s C + k} \]

The RHS of both the equations are known as Transfer Function that describes the relationship between output and input. Example 1, pertains to a first order transfer function, while Example 2 presents a second order transfer function. Such relationship could be graphically represented for better perception and this technique will be discussed in this lecture.
The Lecture Contains

- Information Organization
- Information Hiding
- Block diagram of a closed loop system
- Block diagram algebra – I
- Block diagram algebra – II
- Advanced block diagrams
- Assignment
Information Organization

Graphical Information Organisation is an old practice. The picture below shows the graphical organization of Troop Force.
Information Hiding

One of the important part of such graphical representation is representing the actual system by a suitable mathematical transfer function thus hiding the physical system:

Figure Ref. Prof. Yu Ho, Harvard
Information Hiding

The Cause and Effect relationship between the input and outputs of a system could be represented graphically by using Block Diagrams.
**Subsystems of a Block Diagram**

There are four common subsystems in a block diagram:

- **Function blocks**

- **Summing Junctions**

- **Comparators**

- **Sampling an Analog Signal**
Block diagram of a Closed Loop System

\[ C/R = \frac{G}{1 + GH} = \frac{1}{H} \left[ \frac{1}{1 + 1/GH} \right] \]

- Only one input and one output from a block
- Signals may be summed at explicit summing junction
- A single signal fed to multiple blocks does not imply physical splitting of the signal, for example, the figure below shows a signal \( w_i \) which is used to simultaneously actuate two plants \( \varepsilon \) and \( 1-\varepsilon \).
## Block Diagram Algebra - I

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<tr>
<th>Original Block Diagrams</th>
<th>Equivalent Block Diagrams</th>
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<td><img src="image1" alt="Diagram 1" /></td>
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Block Diagram Algebra - II

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Advanced Block Diagrams: Simulink / MATLAB
Special References for this lecture

- *Using Block Diagrams in Control Systems Design* – Tim Wescott, Wescott Design Services

- *Modern Control Engineering* – K. Ogata, Prentice Hall

- *Feedback Control of Dynamic Systems* – Franklin, Powell and Naeini, Pearson Education Asia
Find out the Block Diagram Representation of a single degree of freedom SDOF mechanical system given by the following Equation of Motion:

\[
M \ddot{x} + C \dot{x} + K x = R(t)
\]

Here, \(M\), \(C\) and \(K\) are the mass, damping and stiffness parameters respectively and \(R(t)\) is the force applied to the system.