UNIT -3

CONTROL SYSTEM REPRESENTATION

Signal Flow Graphs (SFGs)

It is a pictorial representation of a system that graphically displays the signal transmission in it.

Basic Definitions in SFGs:

- **Input or source node:** It is a node that has only outgoing branches i.e. node 'r' in Fig.6.1.
- **Output or sink node:** It is a node that has only incoming branches i.e. node 'c' in Fig.6.1.
- **Chain node:** It is a node that has both incoming and outgoing branches i.e. nodes 'x_1', 'x_2','x_3','x_4','x_5'and 'x_6' in Fig.6.1.
- **Gain or transmittance:** It is the relationship between variables denoted by two nodes or value of a branch. In Fig.6.1, transmittances are 't_1', 't_2','t_3','t_4','t_5'and 't_6'.
- **Forward path:** It is a path from input node to output node without repeating any of the nodesin between them. In Fig.6.1, there are two forward paths, i.e. path-1:'r-x_1-x_2-x_3-x_4-x_5-x_6-c' andpath-2:'r-x_1-x_3-x_4-x_5-x_6-c'.
- **Feedback path:** It is a path from output node or a node near output node to a node near inputnode without repeating any of the nodes in between them (Fig.6.1).
- **Loop:** It is a closed path that starts from one node and reaches the same node after trading through other nodes. In Fig.6.1, there are four loops, i.e. loop-1:'x_2-x_3-x_4-x_1', loop-2:'x_5-x_6- x_5', loop-3:'x_1-x_2-x_3-x_4-x_5-x_6-x_1' and loop-4:'x_1-x_3-x_4-x_5-x_6-x_1'.
- **Self Loop:** It is a loop that starts from one node and reaches the same node without trading through other nodes i.e. loop in node 'x_4' with transmittance 't_{55}' in Fig.6.1.
- **Path gain:** It is the product of gains or transmittances of all branches of a forward path. In Fig.6.1, the path gains are $P_1 = t_1t_2t_3t_4t_5$ (for path-1) and $P_2 = t_9t_3t_4t_5$ (for path-2).
- **Loop gain:** It is the product of gains or transmittances of all branches of a loop In Fig.6.1, there are four loops, i.e. $L_1 = -t_2t_3t_6$, $L_2 = -t_5t_7$, $L_3 = -t_1t_2t_3t_4t_5t_8$, and $L_4 = -t_9t_3t_4t_5t_8$.

- **Dummy node:** If the first node is not an input node and/or the last node is not an output nodethan a node is connected before the existing first node and a node is connected after the existing last node with unity transmittances. These nodes are called dummy nodes. In Fig.6.1,'r' and 'c' are the dummy nodes.
- **Non-touching Loops:** Two or more loops are non-touching loops if they don't have any common nodes between them. In Fig.6.1, L_1 and L_2 are non-touching loops

Example:

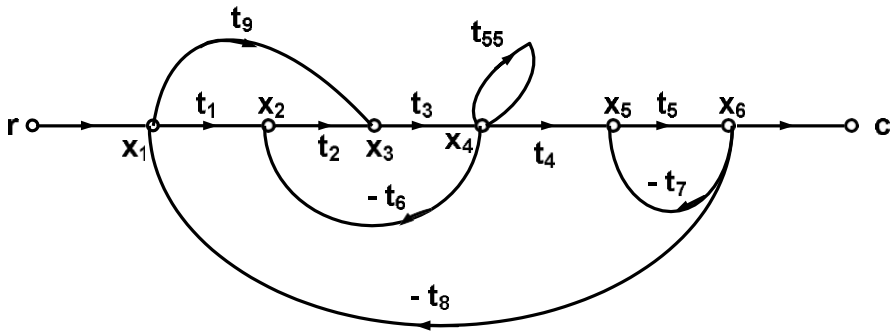


Fig.1. Example of a SFG model

Properties SFGs:

- Applied to linear system
- Arrow indicates signal flow
- Nodes represent variables, summing points and take-off points
- Algebraic sum of all incoming signals and outgoing nodes is zero
- SFG of a system is not unique
- Overall gain of an SFG can be determined by using Mason's gain formula

SFG from block diagram model:

Let's find the SFG of following block diagram model shown in Fig.6.2.

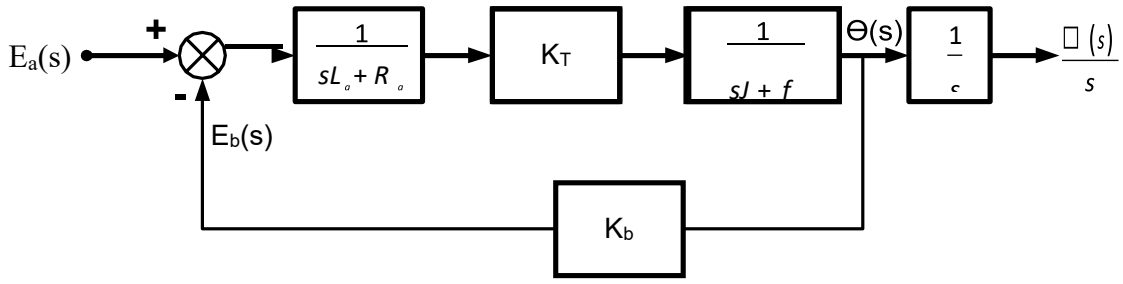


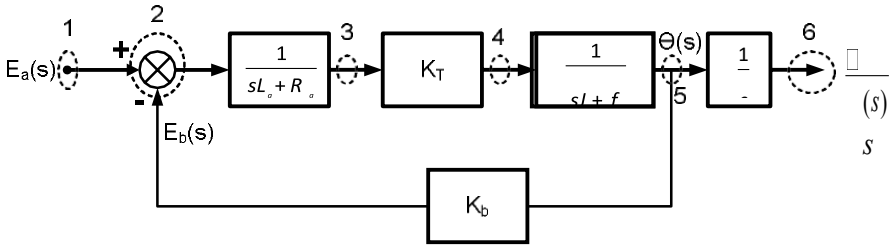
Fig.2. Armature type speed control of a DC motor

Step-1: All variables and signals are replaced by nodes.

Step-2: Connect all nodes according to their signal flow.

Step-3: Each ofgains is replaced by transmittances of the branches connected between two nodesof the forward paths.

Step-4: Each ofgains is replaced by transmittances multiplied with (-1) of the branches connectedbetween two nodes of the forward paths.


1
2
3
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6
Ea(s)
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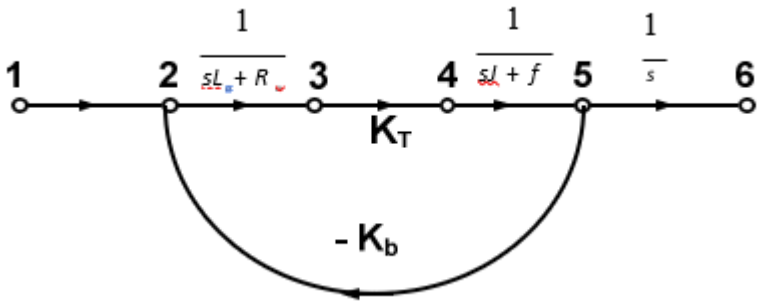
Eb(s)
1
sLa + Ra
KT
1
sJ + f
Θ(s)
1
s
Kb


1
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sLa + Ra
1
sJ + f
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s
KT
- Kb