

ECE 388 – Automatic Control

Block Diagrams

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Compulsory Course in Electronic and Communication
Engineering
Credits (2/2/3)

Course Webpage: <http://ECE388.cankaya.edu.tr>

Block Diagram: Description

Characteristics of the Block Diagram

A block diagram is a graphical representation of the cause-effect relationship between signals by blocks and directed lines

⇒ Visualization of direction of action and interdependencies

Block Diagram Components

- Directed Lines: System signals and their direction of action
- Circles: Summation of signals

Gap 1

Block Diagram: Description

Gap 2

Block Diagram Components

- Rectangles: Dynamic relationship between signals: unique mapping from input signal to output signal

Gap 3

⇒ Rectangles and circles are transfer blocks

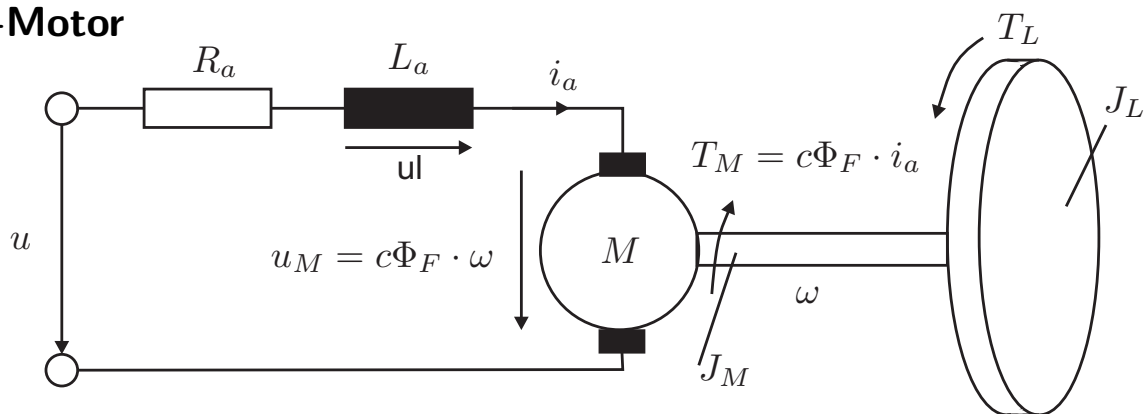
Block Diagram: RLC-Circuit Example

Computation

Gap 4

Block Diagram: DC Motor Example

DC-Motor



Variables

- u, i_a : input voltage, current
- u_M : induced voltage
- ω : rotational velocity
- T_M : motor torque
- T_L : load torque

Parameters

- R_a : resistance
- L_a : inductance
- $c\Phi_F$: motor constant
- $J_a = J_M + J_L$: moment of inertia

Block Diagram: DC Motor Example

Computation

Gap 5

Block Diagram: DC Motor Example

Graphical Representation

Gap 6

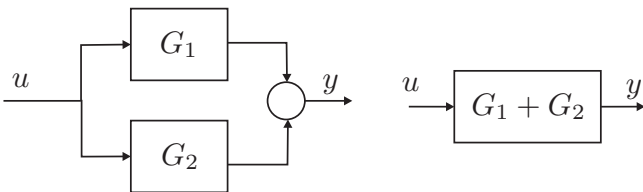
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Block Diagram Simplification: Connection Rules

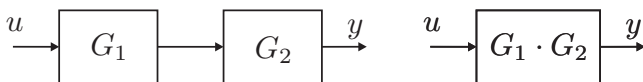
Parallel



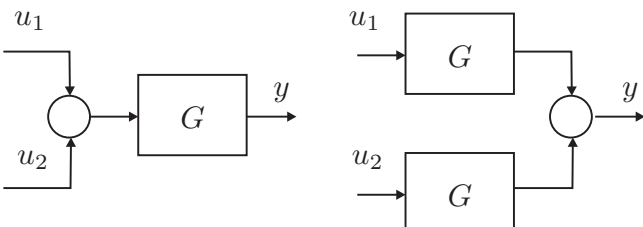
Computation

Gap 7

Series



Summation 1



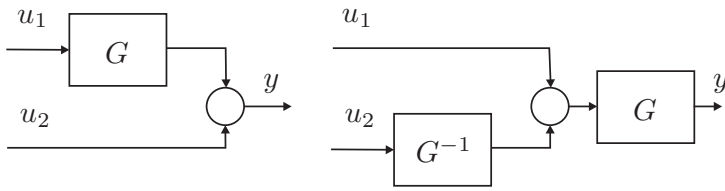
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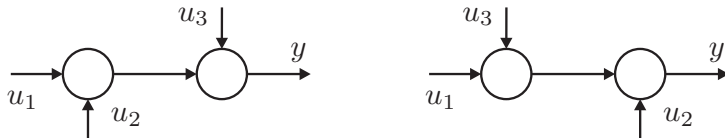
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Block Diagram Simplification: Connection Rules

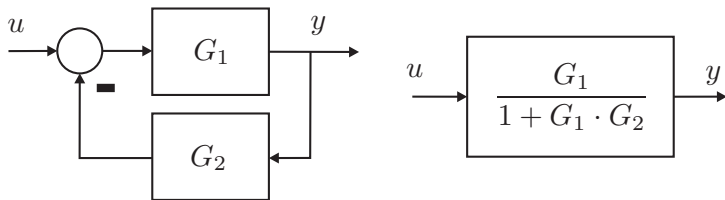
Summation 2



Summation 3



Feedback

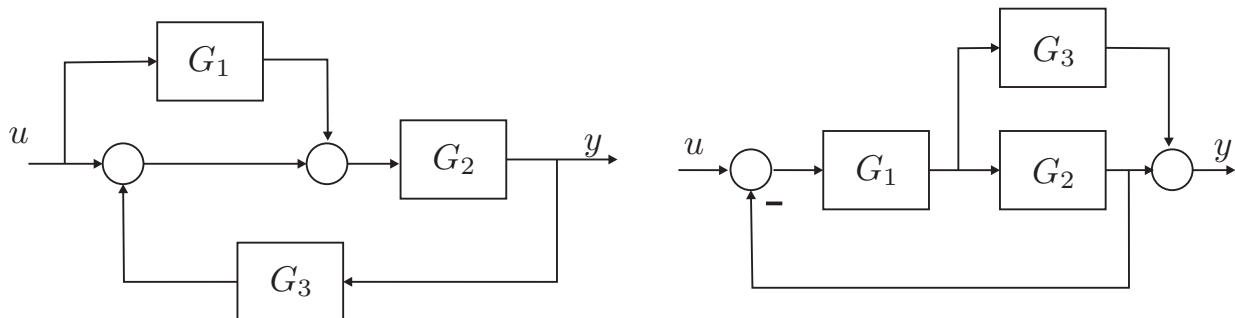


Computation

Gap 8

Block Diagram Simplification: Simple Examples

Example Block Diagrams



Computation

Gap 9

Block Diagram Simplification: Simple Examples

Computation

Gap 10

Block Diagram Simplification: Simple Examples

Computation

Gap 11

Block Diagram Simplification: Example

DC-motor Simplification

Gap 12

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Block Diagram Simplification: Example

DC-motor Simplification

Gap 13

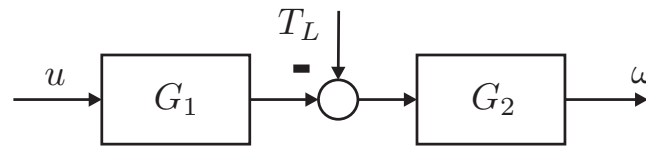
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Block Diagram Simplification: Result

DC-Motor



Input-Output Transfer Function

$$\frac{\Omega(s)}{U(s)} = G_1(s)G_2(s)$$

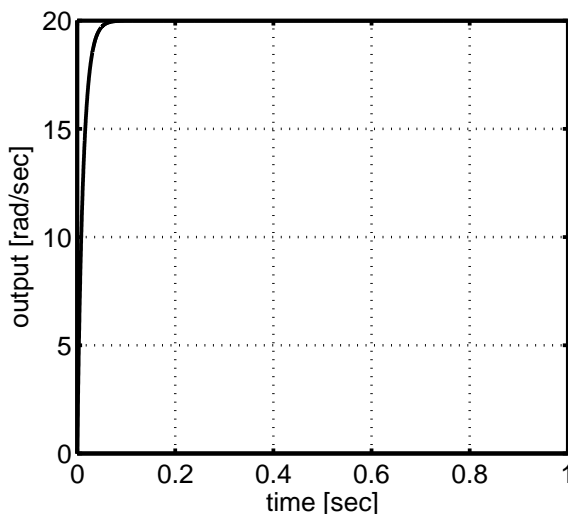
Disturbance-Output Transfer Function

$$\frac{\Omega(s)}{T_L(s)} = G_2(s)$$

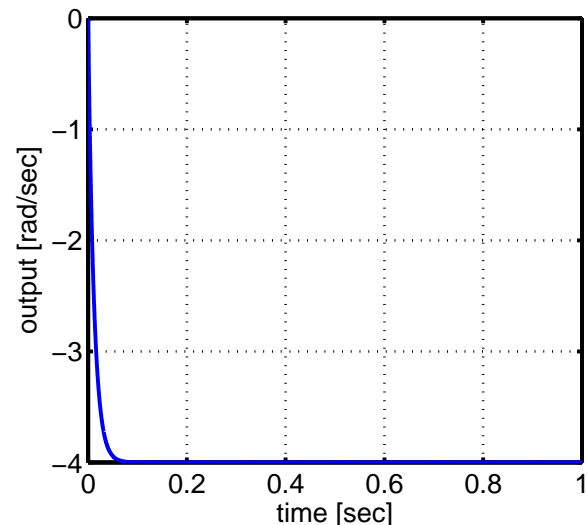
⇒ Always consider transfer blocks between the input signal and output signal of interest

Block Diagram Simplification: Simulation

Input-Output Step Response



Disturbance-Output Step Response



Parameters

- $J_a = 3 \cdot 10^{-6} \text{ kg m}^2$; $R_a = 10 \Omega$,
- $L_a = 2 \text{ mH}$, $c\Phi_F = 0.05 \text{ N m/A}$

Steps

- Input: voltage step of 1 V
- Disturbance: torque 10^{-3} Nm