Practice 4

Topic: **Algebra of structural transformations**

Rule 1. The transfer function of the consistently connected parts is equal to product of separate transfer functions of parts which are included in a chain:

$$W(s) = \prod_{i=1}^{k} W_i(s).$$

Rule 2. The transfer function of the in parallel connected parts is equal to the sum of transfer functions of separate parts which are included in a chain:

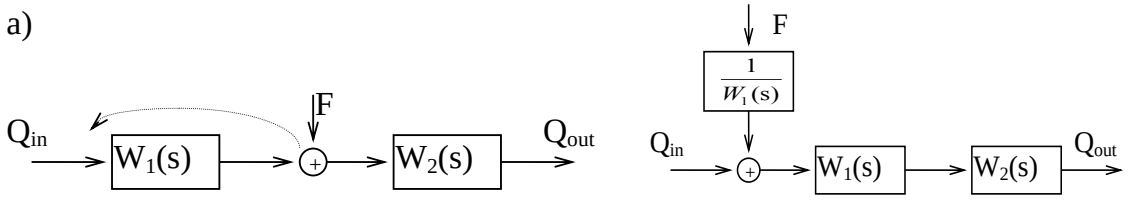
$$W(s) = \sum_{j=1}^{n} W_j(s).$$

Rule 3. The transfer function of the closed contour of system is equal transfer function of a direct part, division on 1 plus product of transfer function of a direct part of system $W_{dr}(s)$ on transfer function of a feedback $W_{fb}(s)$:

$$W_{cl}(s) = \frac{W_{dr}(s)}{1 + W_{dr}(s) W_{fb}(s)}.$$

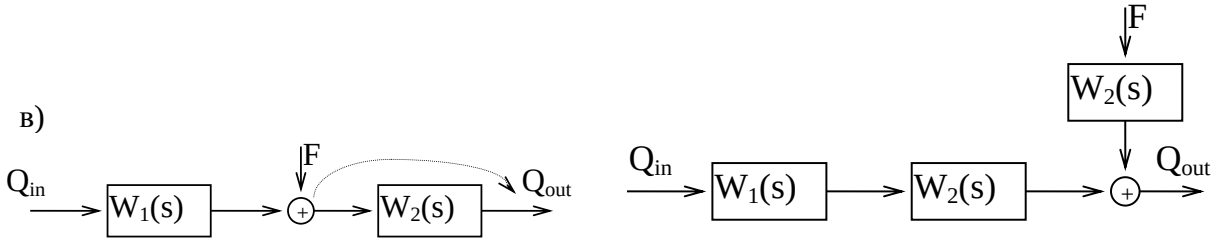
Rule 4. Carry of unit through a part. If unit is transferred against a direction of the basic signal, in system the part with transfer function, opposite to the transferred part is added:

a)



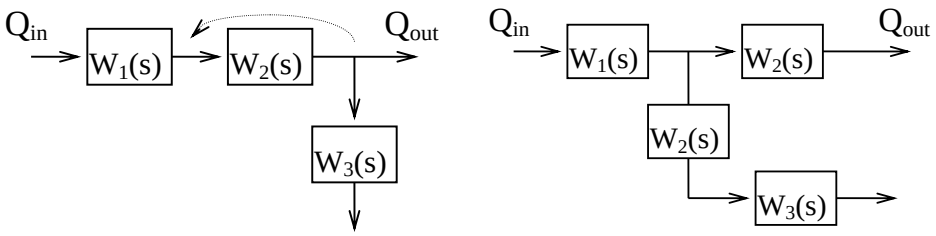
Rule 5. Carry of unit through a part. If unit is transferred in a direction of the basic signal, in system the part with the transfer function equal to a transferred part is added:

в)



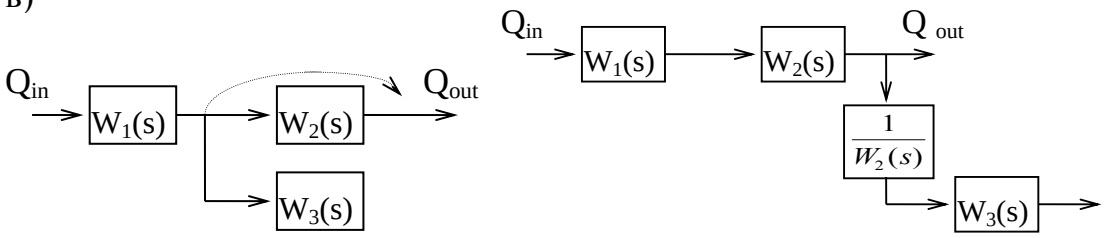
Rule 6. Carry of a point of branching. If the point of branching is transferred against a direction of the basic signal, in system the part with the transfer function equal to a transferred part is added:

а)

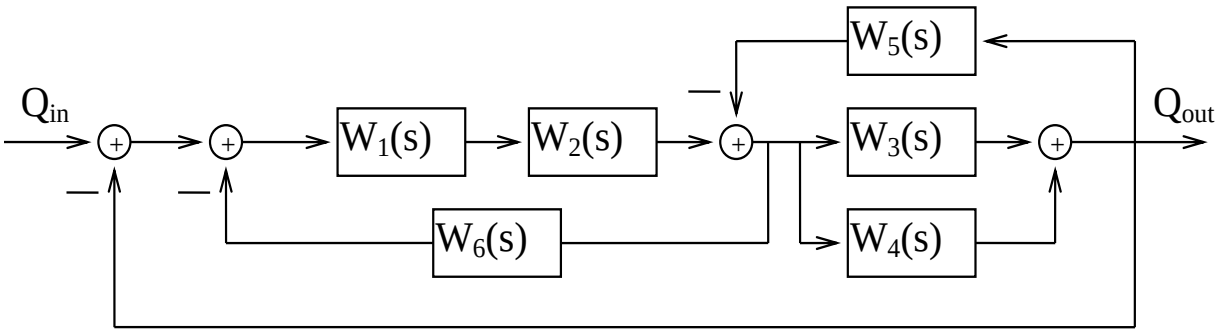


Rule 7. If the point of branching is transferred in a direction of the basic signal, in system the part with transfer function, opposite to the transferred part is added:

в)



Example. The structural diagram of the following look is set:



To receive transfer function of system if transfer functions of separate links are set $W_1(s) \div W_6(s)$.

Algorithm and solving

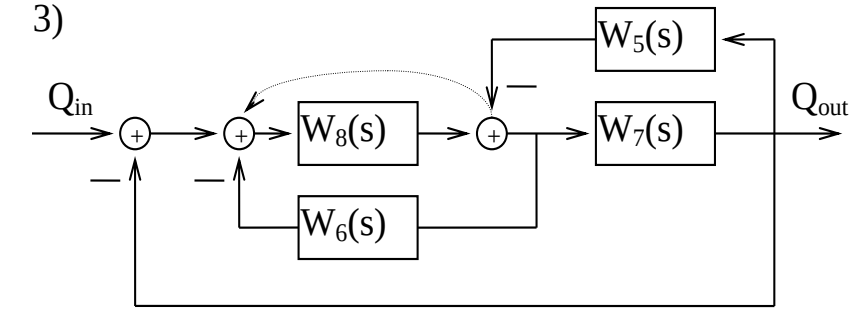
1) We carry out decomposition of the given system on the known circuits; we write transfer functions of the selected circuits according to rules.

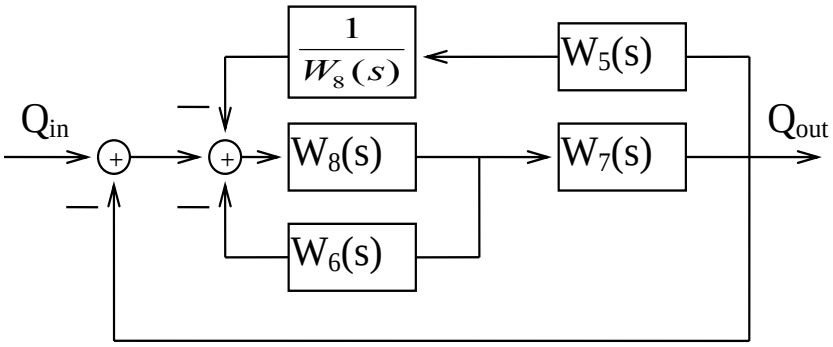
$W_7(s) = W_3(s) + W_4(s)$

2) $W_8(s) = W_1(s)\, W_2(s)$

We show what we do conversions:

3)





We receive transfer functions of the intermediate links:

$$W_9(s) = \frac{W_8(s)}{1 + W_6(s)W_8(s)} = \frac{W_1(s)W_2(s)}{1 + W_1(s)W_2(s)W_6(s)}$$

$$W_{10}(s) = W_7(s)\, W_9(s) = [\, W_3(s) + W_4(s)]\, W_9(s)$$

$$W_{11}(s) = \frac{W_{10}(s)}{1 + \dfrac{W_5(s)W_{10}(s)}{W_8(s)}} = \frac{W_8(s)W_{10}(s)}{W_8(s) + W_5(s)W_{10}(s)}$$

5) We receive transfer function of the whole system:

$$W(s) = \frac{W_{11}(s)}{1 + W_{11}(s)}.$$

6) Having added the given transfer functions of separate links in transfer function of the whole system, we will receive required transfer function of system through basic data:

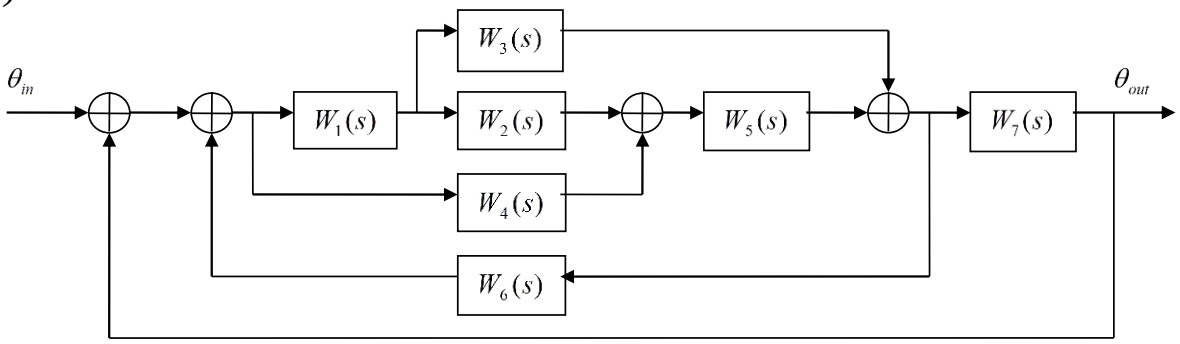
$$W(s) = \frac{W_1(s)W_2(s)[W_3(s) + W_4(s)]}{1 + W_1(s)W_2(s)W_6(s) + W_5(s)[W_3(s) + W_4(s)] + W_1(s)W_2(s)[W_3(s) + W_4(s)]}.$$

Task *(on variant)*

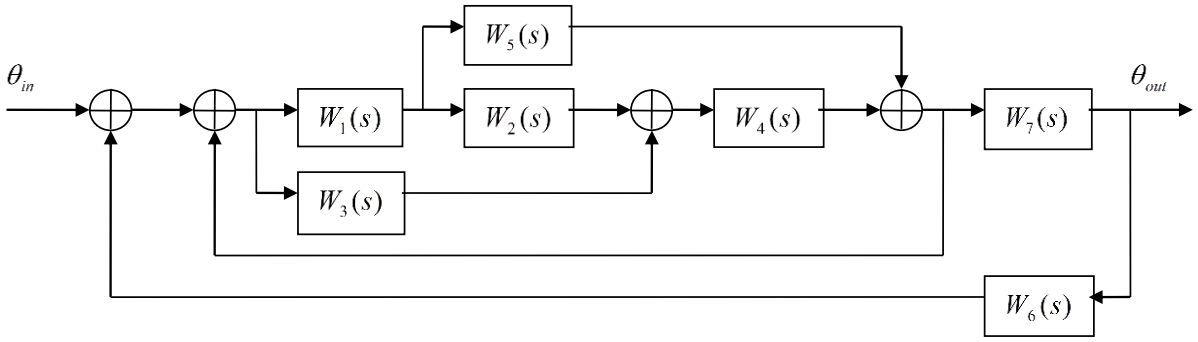
Let are given the transfer functions of separate parts of system. Receive transfer function of all system as a whole.

Variants:

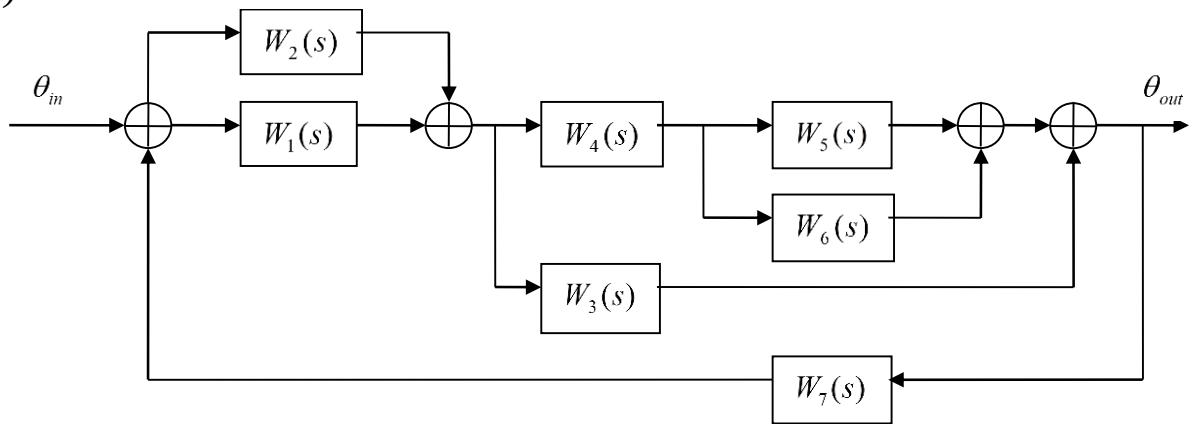
1)


θ_{in}
$W_1(s)$
$W_2(s)$
$W_3(s)$
$W_4(s)$
$W_5(s)$
$W_6(s)$
$W_7(s)$
θ_{out}

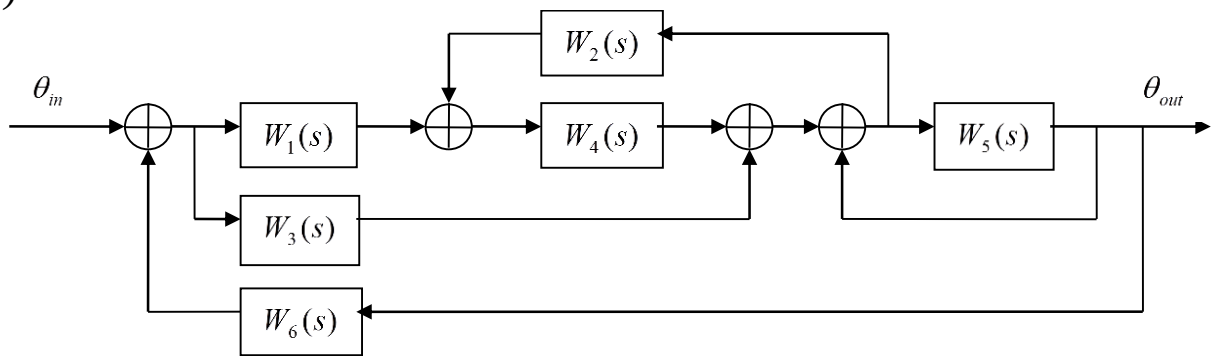
2)


θ_{in}
$W_1(s)$
$W_2(s)$
$W_3(s)$
$W_4(s)$
$W_5(s)$
$W_6(s)$
$W_7(s)$
θ_{out}

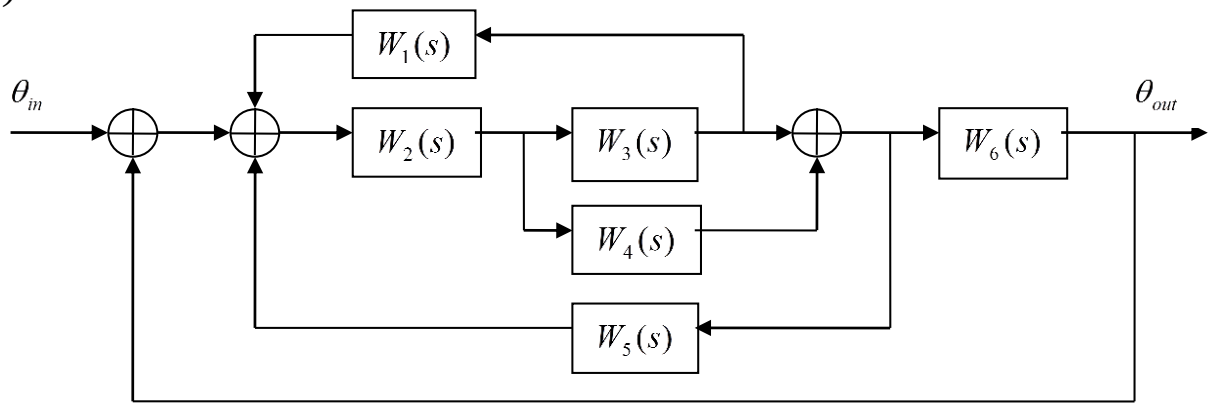
3)


θ_{in}
$W_1(s)$
$W_2(s)$
$W_3(s)$
$W_4(s)$
$W_5(s)$
$W_6(s)$
$W_7(s)$
θ_{out}

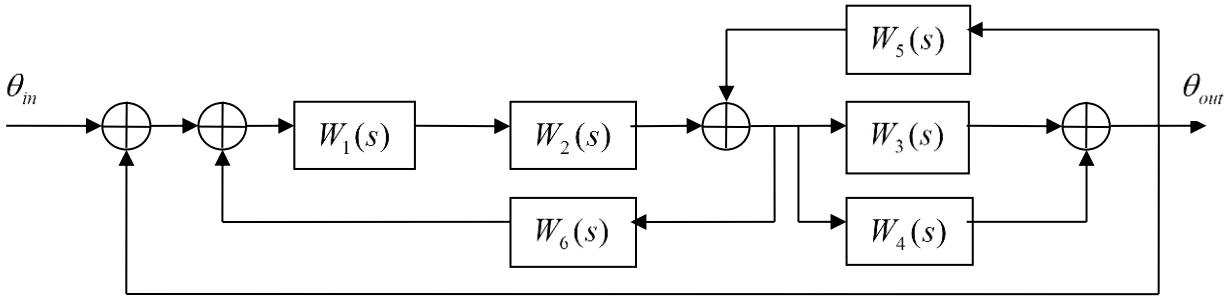
4)


θ_{in}
$W_1(s)$
$W_2(s)$
$W_3(s)$
$W_4(s)$
$W_5(s)$
$W_6(s)$
θ_{out}

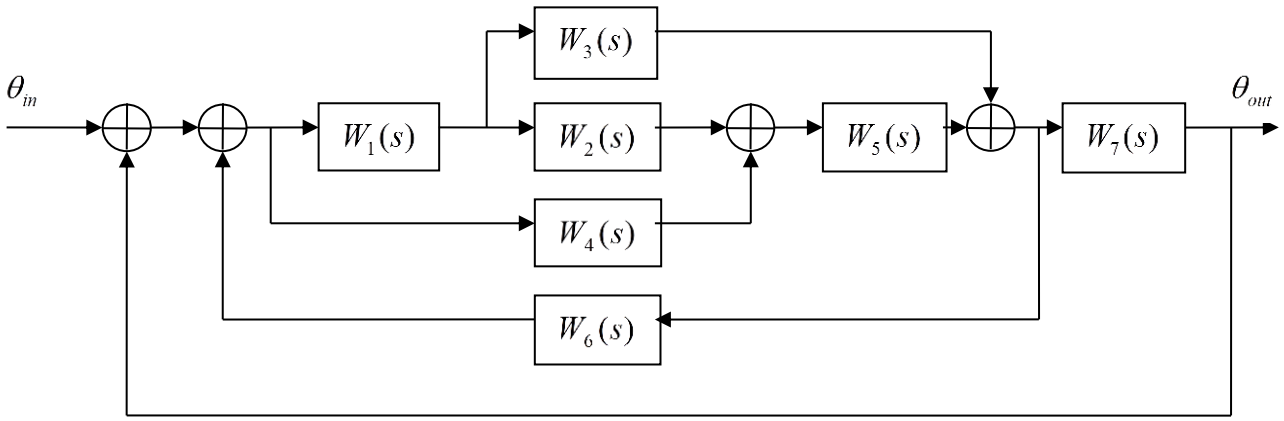
5)


θ_{in}
$W_1(s)$
$W_2(s)$
$W_3(s)$
$W_4(s)$
$W_5(s)$
$W_6(s)$
θ_{out}

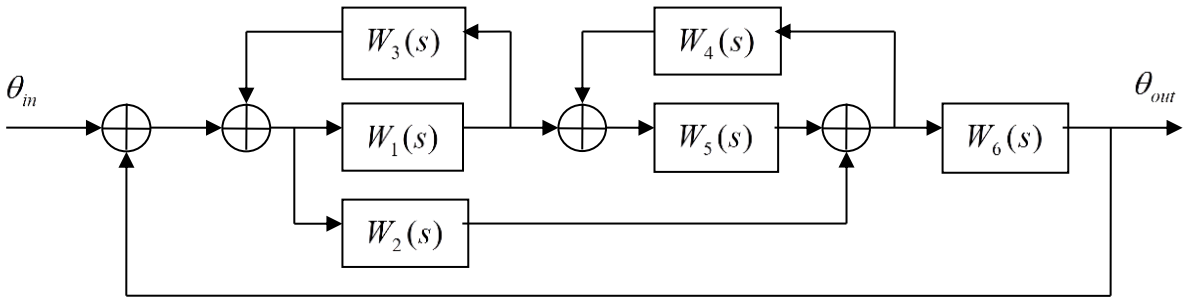
6)


θ_{in}
$W_5(s)$
$W_1(s)$
$W_2(s)$
$W_3(s)$
$W_6(s)$
$W_4(s)$
θ_{out}

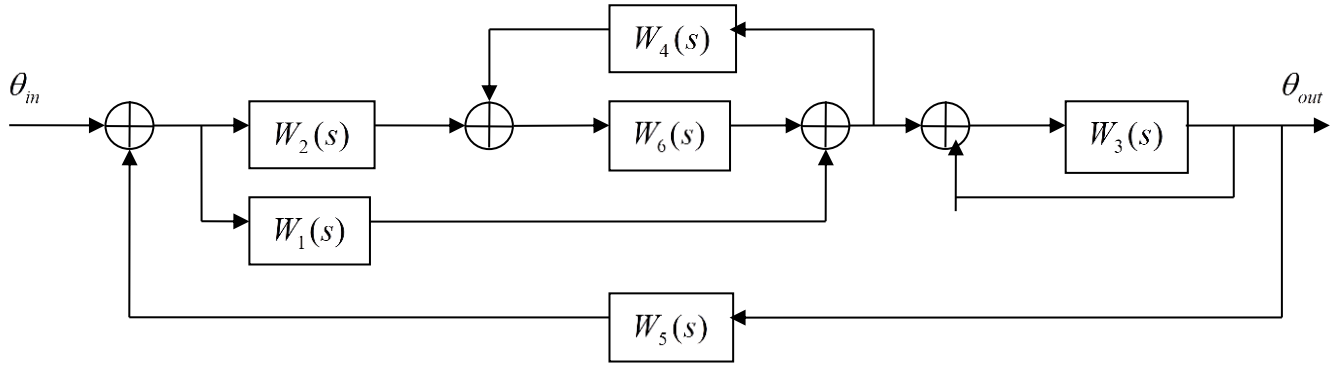
7)


θ_{in}
$W_3(s)$
$W_1(s)$
$W_2(s)$
$W_5(s)$
$W_7(s)$
$W_4(s)$
$W_6(s)$
θ_{out}

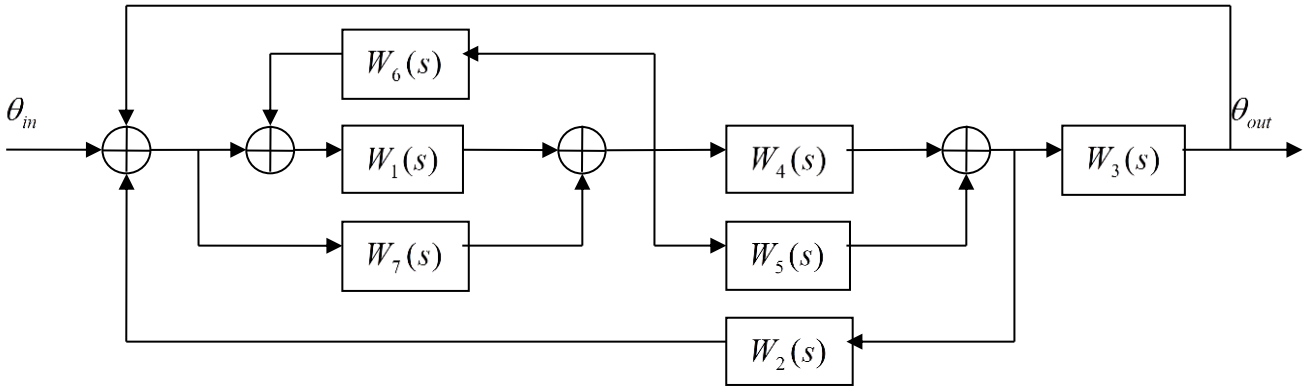
8)


θ_{in}
$W_3(s)$
$W_4(s)$
$W_1(s)$
$W_5(s)$
$W_6(s)$
$W_2(s)$
θ_{out}

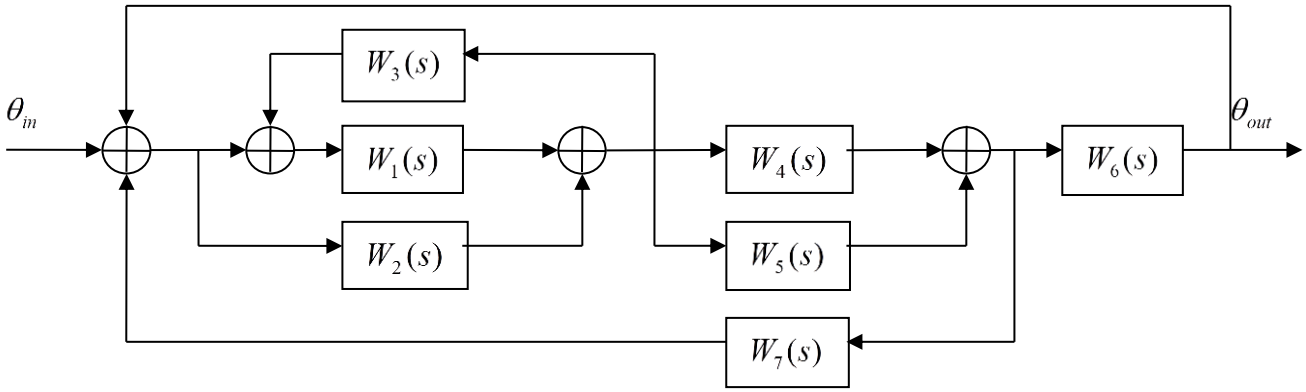
9)


θ_{in}
$W_4(s)$
$W_2(s)$
$W_6(s)$
$W_3(s)$
θ_{out}
$W_1(s)$
$W_5(s)$

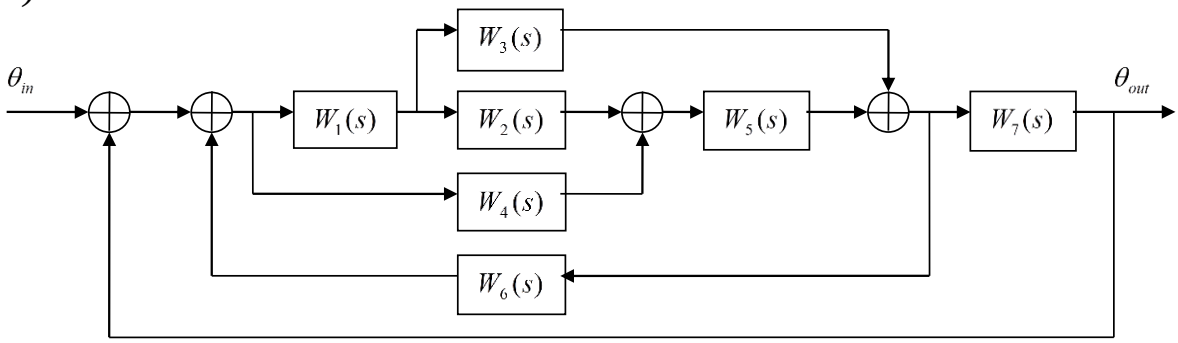
10)


θ_{in}
$W_6(s)$
$W_1(s)$
$W_4(s)$
$W_3(s)$
θ_{out}
$W_7(s)$
$W_5(s)$
$W_2(s)$

11)


θ_{in}
$W_3(s)$
$W_1(s)$
$W_4(s)$
$W_6(s)$
θ_{out}
$W_2(s)$
$W_5(s)$
$W_7(s)$

12)


θ_{in}
$W_3(s)$
$W_1(s)$
$W_2(s)$
$W_5(s)$
$W_7(s)$
θ_{out}
$W_4(s)$
$W_6(s)$