# ALGEBRA BLOKOVA

## PODLOGE ZA AUDITORNU VJEŽBU

**Podloge pripremio**

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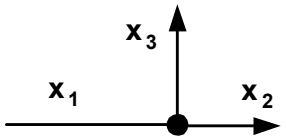
Iz funkcionalnog blok-dijagrama jednostavnim se algebarskim operacijama dobiva rješenje kao odnos izlazne i ulazne veličine složenog sustava.
Svrha je analize da se broj blokova sažima sve dotle dok se ne dobije jedan jedini blok s jednom ulaznom i jednom izlaznom veličinom.

## OPERACIJE NAD SIGNALIMA NA PUTU MEĐU BLOKOVIMA

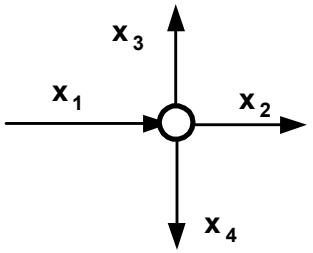
### 1) Točka račvanja




$$x_1 = x_2 = x_3$$

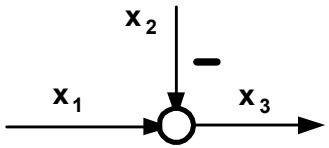
- nema toka energije (struja, protok)
- signal se prenosi ili električnim naponom ili tlakom (pnemuatski, hidraulični)

### 2) Točka zbrajanja




$$x_1 = x_2 + x_3 + x_4$$

- pri prijenosu signala postoji tok energije (električna struja, protok)
- uz točku račvanja stavljamo i predznake signala



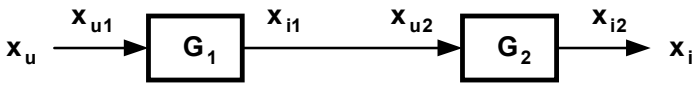

$$x_3 = x_1 - x_2$$

**PRETPOSTAVKE** koje važe pri spajanju blokova:

1. Nema protudjelovanja unutar bloka – izlazna veličina ne djeluje ne ulaznu
2. Djelovanje bloka je JEDNOSMJERNO – promjena ulazih veličina djeluje na izlazne i to u pravilu s nekim kašnjenjem
3. Ulazne i i zlazne veličine bloka povezane su JEDNOZNAČNO (isključuju se pojave poput histereze ili labavosti)

## OPERACIJE MEĐU BLOKOVIMA

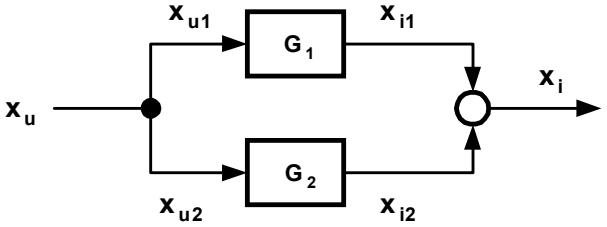
### 1) Serijski spoj




$$G(s) = \frac{x_i(s)}{x_u(s)} = \frac{x_{i2}(s)}{x_{u2}(s)} \quad \frac{x_{i1}(s)}{x_{u1}(s)} = G_1 G_2$$

- za više blokova u seriji vrijedi : $G(s) = G_1 G_2 \ldots G_n = \prod_{i=1}^{n} G_i$

### 2) Paralelni spoj

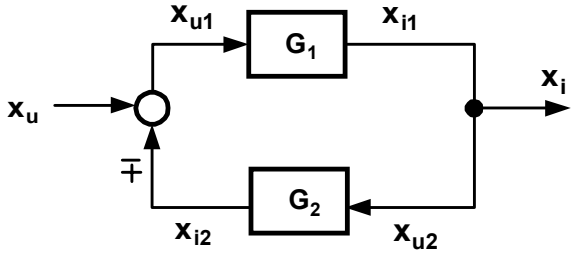



$$G(s) = \frac{x_i(s)}{x_u(s)} = \frac{x_{i1} + x_{i2}}{x_u} = \frac{x_{i1}}{x_u} + \frac{x_{i2}}{x_u} = G_1(s) + G_2(s)$$

- za više blokova u paraleli vrijedi :

$$G(s) = G_1 + G_2 + \ldots + G_n = \sum_{i=1}^{n} G_i$$

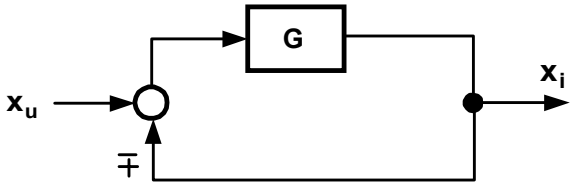
## 3) Povratni spoj



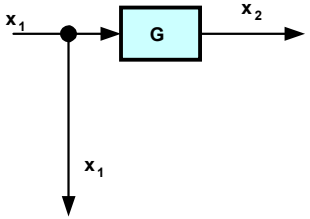
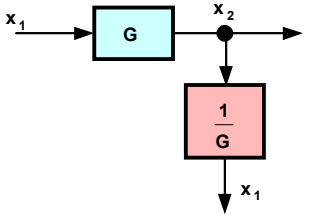
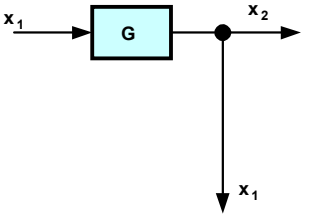
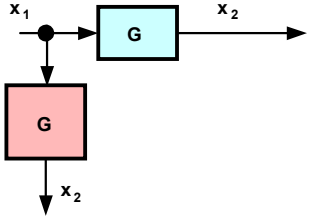
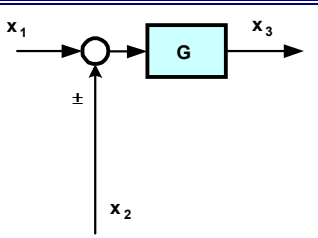
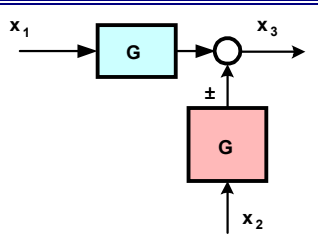
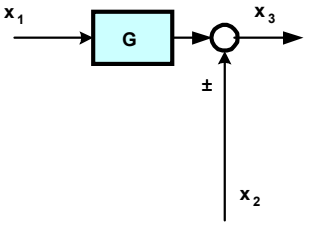
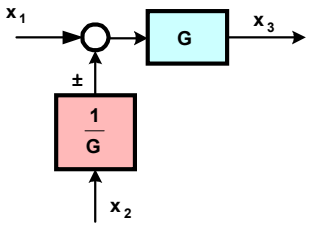

$$G(s)=\frac{x_i(s)}{x_u(s)}=\frac{x_i}{x_{u1}\pm x_{u2}}=\frac{\frac{x_i}{x_{u1}}}{1\pm\frac{x_{i2}}{x_{u1}}}=\frac{\frac{x_{i1}}{x_{u1}}}{1\pm\frac{x_{i2}\,x_{i1}}{x_{u2}x_{u1}}}=\frac{G_1}{1\pm G_1G_2}$$

- ostvareno načelo povratne veze već prema tome da li signal $x_{i1}$ djeluje pozitivno ili negativno u odnosu na signal $x_u$, povratna je veza pozitivna ili negativna
- u regulacijskom krugu je neophodno da povratna veza bude NEGATIVNA

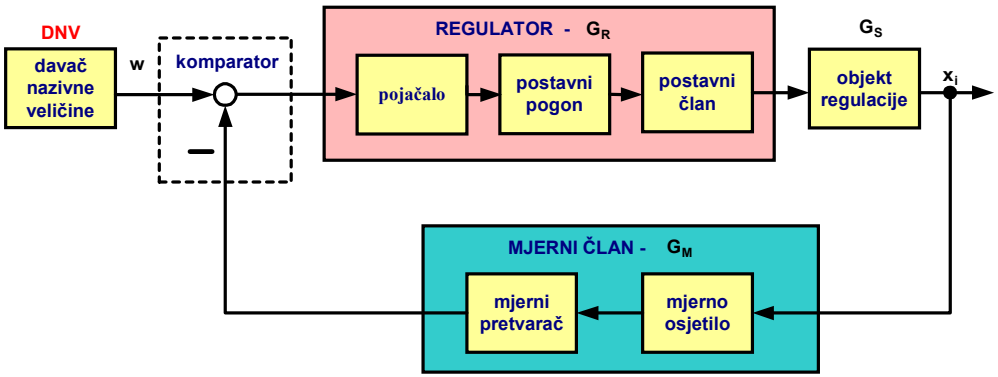
- posebno za $G_2=1$ (blok sa zanemarivnom dinamikom) :

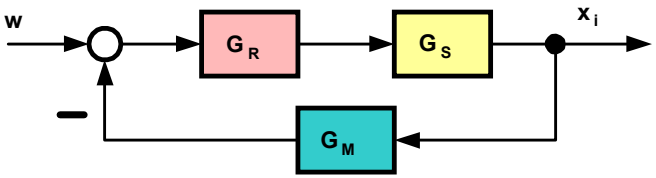



$$G(s)=\frac{x_i(s)}{x_u(s)}=\frac{G}{1\pm G}$$

| OPERACIJA | PRVOBITNI SKLOP | IZVEDENI SKLOP |
|---|---|---|
| **Točka računanja u desno** $x_2 = G\,x_1$ |  |  |
| **Točka računanja u lijevo** $x_2 = G\,x_1$ |  |  |
| **Točka zbrajanja u desno** $x_3 = G(x_1 \pm x_2)$ |  |  |
| **Točka zbrajanja u lijevo** $x_3 = G\,x_1 \pm x_2$ |  |  |

## *BLOK-DIJAGRAM REGULACIJSKOG KRUGA*



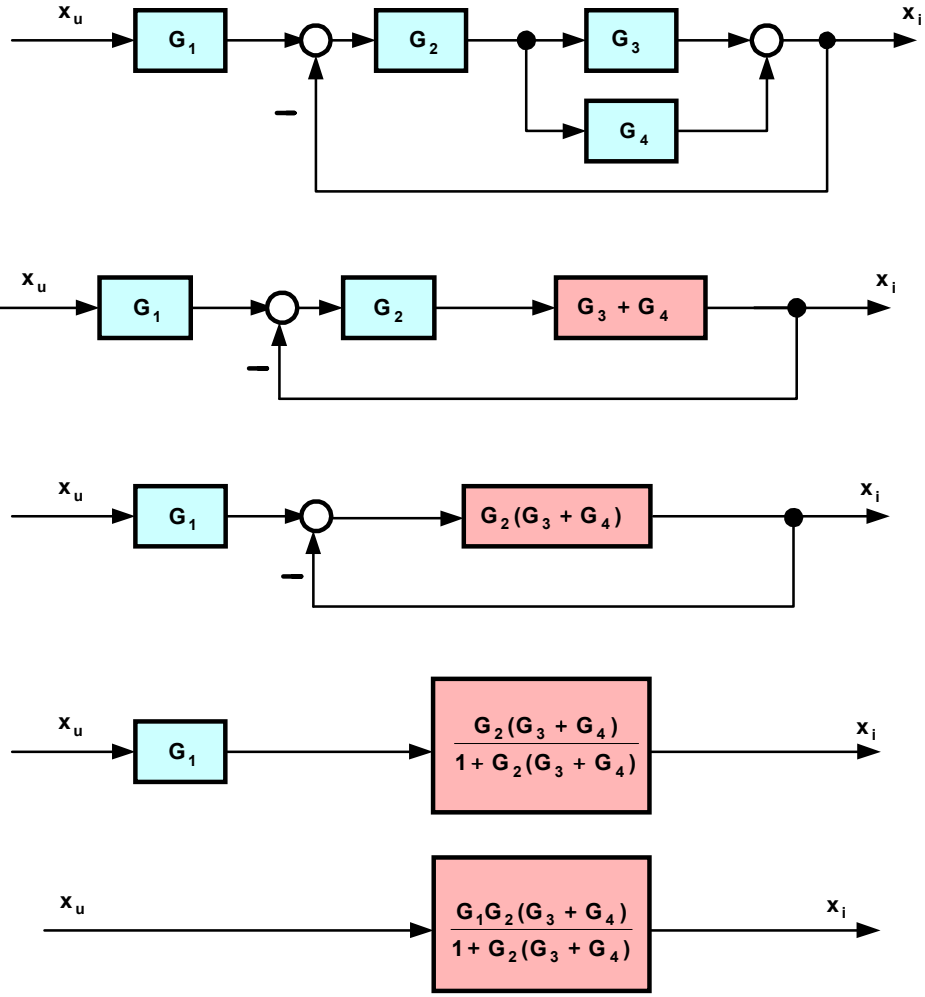




$$G(s) = \frac{x_i}{w(s)} = \frac{G_R\, G_S}{1 + G_R\, G_S\, G_M} \quad , \quad G_O = G_R\, G_S\, G_M$$

**Za $G_M$=1 (mjerni član zanemarive dinamike) vrijedi:**

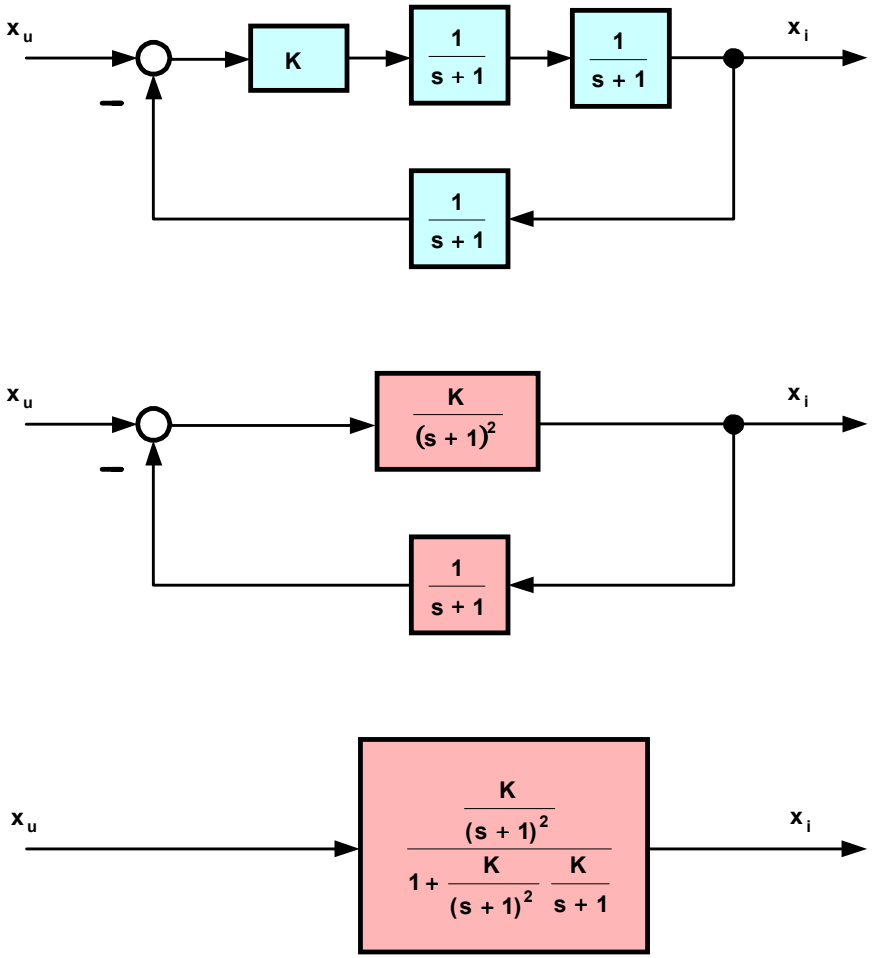
$$G_O = G_R\, G_S \quad , \quad G(s) = \frac{x_i}{w(s)} = \frac{G_R\, G_S}{1 + G_R\, G_S} = \frac{G_O}{1 + G_O}$$

## PRIMJER 1.



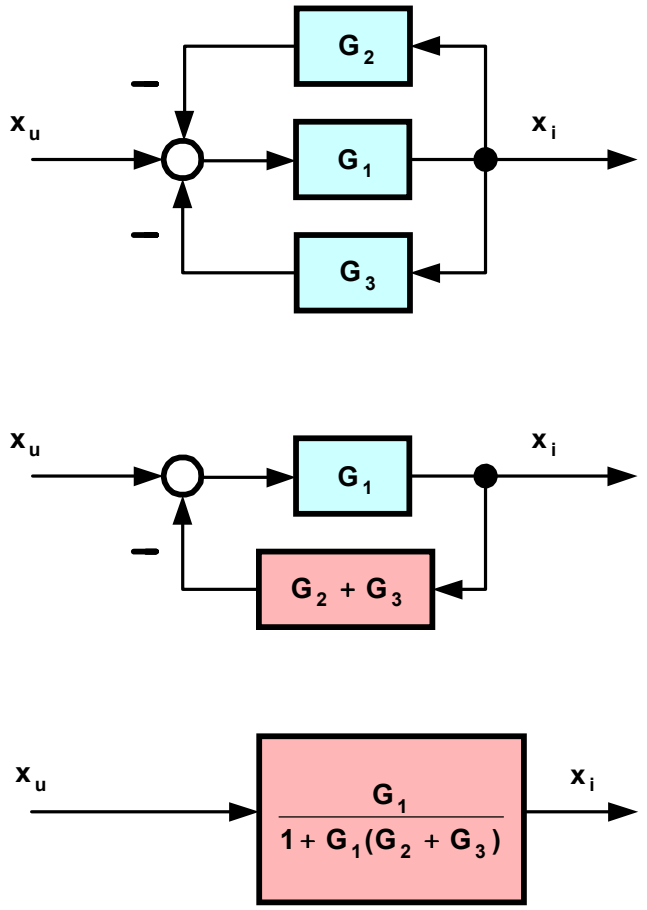

$$G(s) = \frac{x_i(s)}{x_u(s} = \frac{G_1 G_2(G_3 + G_4)}{1 + G_2(G_3 + G_4)}$$

**PRIMJER 2.**



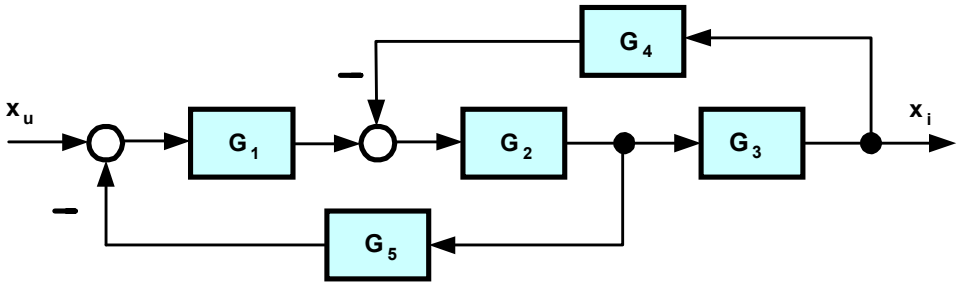

$$G(s) = \frac{x_i(s)}{x_u(s} = \frac{K(s+1)}{s^3 + 3s^2 + 3s + 1 + K}$$

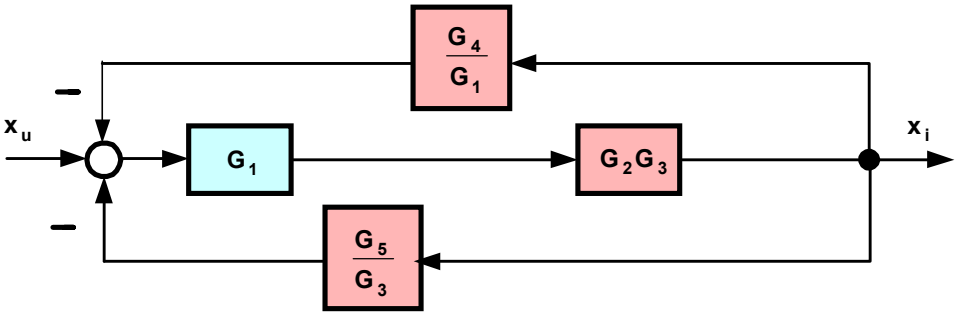
**PRIMJER 3.**

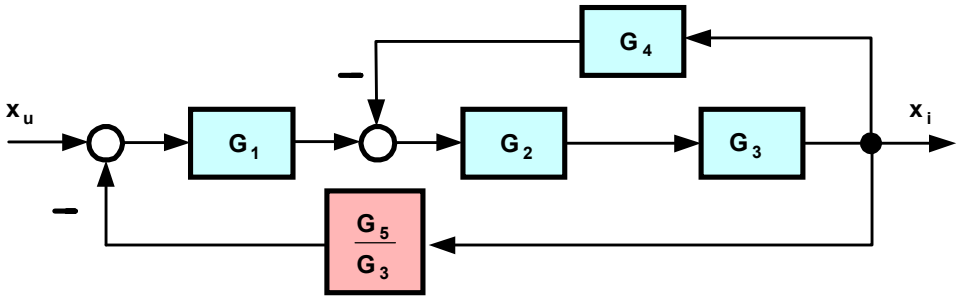


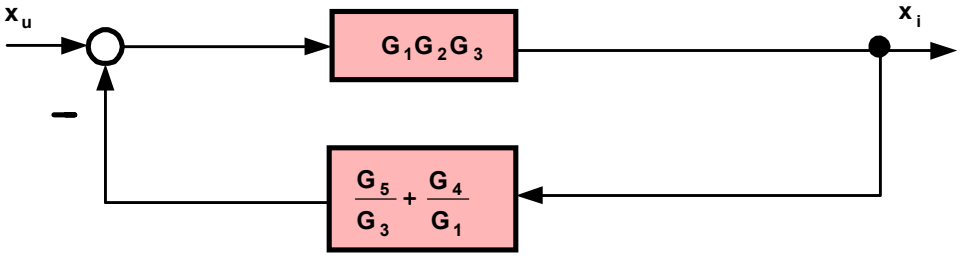

$$G(s) = \frac{x_i(s)}{x_u(s} = \frac{G_1}{1 + G_1(G_2 + G_3)}$$

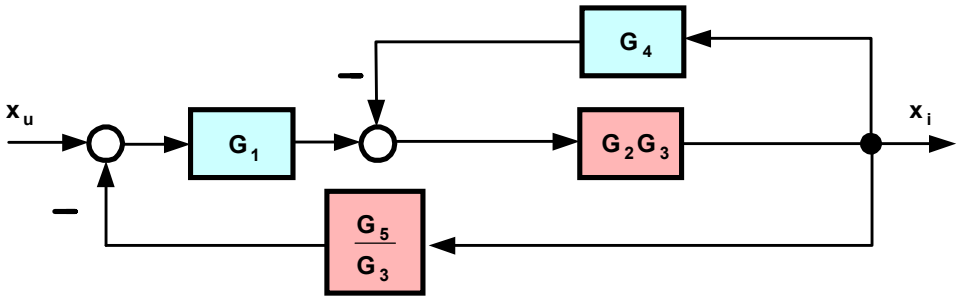
**PRIMJER 4.**

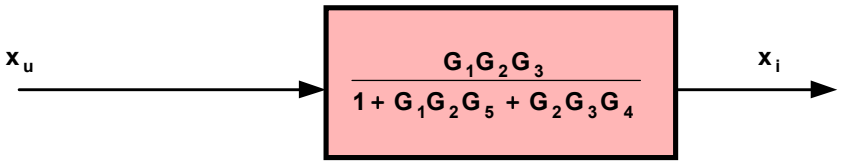



$$G(s) = \frac{x_i(s)}{x_u(s} = \frac{G_1G_2G_3}{1+G_1G_2G_5+G_2G_3G_4}$$