



~~Block diagram of a control system~~

$$\Delta L_R = A_{PC} x_{PC} + [A_T F_T + A_P F_P F_T + A_U F_U F_P F_T] (-1) D C \Delta L_R$$

$$= A$$

$$\Delta L_R = A_{PC} x_{PC} + (-G) \Delta L_R$$

$$(1 + G) \Delta L_R = A_{PC} x_{PC}$$

$$(1 + G) \frac{d_e}{C} = A_{PC} x_{PC}$$

$$(d_e = C \Delta L_R)$$

$$\Delta L_R = d_e / C$$

$$d_e = \frac{C}{1 + G} A_{PC} x_{PC}$$

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$$d_e = C (A_T x_T + [A_T F_T (-1) D + A_P F_P F_T (-1) D + A_U F_U F_P F_T (-1) D] d_e)$$

$$d_e = C A_T x_T + (-G) d_e$$

$$(1 + G) d_e = C A_T x_T$$

$$d_e = \frac{C}{1 + G} A_T x_T$$

$$d_e = C (A_T F_T (-1) D d_{err} + A_P x_P + A_P F_P F_T (-1) D d_e + A_U F_U F_P F_T (-1) D d_e)$$

$$d_e = C A_P x_P + (-G) d_{err}$$

$$(1+G) d_e = C A_P x_P$$

$$d_e = \frac{C}{1+G} A_P x_P$$

$$d_e = C (A_T F_T + A_P F_P F_T + A_U F_U F_P F_T) (-1) (x_D + D d_e)$$

$$d_e = -C A x_D + C A (-1) D d_e$$

$$d_e = -C A x_D + (-G) d_e$$

$$(1+G) d_e = -C A x_D$$

$$d_e = -\frac{C}{1+G} A x_D$$

$$d_e = \frac{C}{1+G} A_{PC} x_{PC} \Rightarrow \frac{C}{1+G} = \frac{1}{A_{PC}} \frac{d_e}{x_{PC}}$$

$$d_e = \frac{C}{1+G} K_T(t) A_0^T x_T$$

$$d_e = \frac{C}{1+G} K_P(t) A_0^P x_T$$

$$\Rightarrow K_T(t) = \frac{1}{A_0^T} \left(\frac{1+G}{C} \right) \frac{d_e}{x_T} = \frac{1}{A_0^T} \frac{A_{PC}}{A} \left(\frac{x_{PC}}{d_e} \right) \left(\frac{d_e}{x_T} \right)$$

$$\Rightarrow K_P(t) = \frac{1}{A_0^P} \left(\frac{1+G}{C} \right) \left(\frac{d_e}{x_T} \right) = \frac{A_{PC}}{A_0^P} \left(\frac{x_{PC}}{d_e} \right) \left(\frac{d_e}{x_P} \right)$$

$$\Rightarrow d_e = -\frac{C}{1+G} [k_T(t) A_o^T F_T + k_P(t) A_o^P F_P F_T + k_U(t) A_o^U F_U F_P F_T] x_D$$

~~$$\frac{d_e}{x_D} = -\frac{C}{1+G} [k_T(t) A_o^T F_T + k_P(t) A_o^P F_P F_T + k_U(t) A_o^U F_U F_P F_T]$$~~

$$\frac{d_e}{x_D} = -\frac{C}{1+G} k_T(t) A_o^T F_T + \frac{-C}{1+G} k_P(t) A_o^P F_P F_T + \frac{-C}{1+G} k_U(t) A_o^U F_U F_P F_T$$

$$\frac{d_e}{x_D} = -k_T(t) F_T \frac{A_o^T}{A_{PC}} \frac{d_e}{x_{PC}} - k_P(t) F_P F_T \frac{A_o^P}{A_{PC}} \frac{d_e}{x_{PC}} - k_U(t) F_U F_P F_T \frac{A_o^U}{A_{PC}} \frac{d_e}{x_{PC}}$$

$$A_{PC} \begin{pmatrix} x_{PC} \\ d_e \end{pmatrix} \begin{pmatrix} d_e \\ x_D \end{pmatrix} + k_T(t) A_o^T F_T + k_P(t) A_o^P F_P F_T = -k_U(t) F_U F_P F_T A_o^U$$

$$k_U(t) = -\frac{1}{A_o^U F_U F_P F_T} \left[k_T(t) A_o^T F_T + k_P(t) A_o^P F_P F_T + A_{PC} \begin{pmatrix} x_{PC} \\ d_e \end{pmatrix} \begin{pmatrix} d_e \\ x_D \end{pmatrix} \right]$$