Regelungstechnisches Praktikum

Versuch 3

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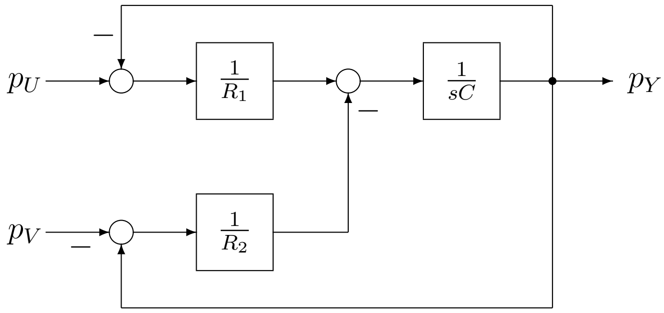
Aufgabe 1

Blockschaltbild



$$p_Y = \frac{1}{s\,C}\left(\frac{p_U - p_Y}{R_1} - \frac{p_Y - p_V}{R_2}\right)$$

$$\begin{aligned}
s\,C\,p_Y &= \frac{R_2(p_U - p_Y) - R_1(p_Y - p_V)}{R_1\,R_2} \\
s\,C\,p_Y\,R_1\,R_2 &= R_2\,p_U + R_1\,p_V - R_1\,p_Y - R_2\,p_Y \\
p_Y(s\,C\,R_1\,R_2 + R_1 + R_2) &= R_2\,p_U + R_1\,p_V
\end{aligned}$$

$$\begin{aligned}
p_Y &= \frac{R_2\,p_U + R_1\,p_V}{s\,C\,R_1\,R_2 + R_1 + R_2} = \frac{1}{R_1 + R_2}\cdot\frac{R_2\,p_U + R_1\,p_V}{1 + s\,C\,\frac{R_1\,R_2}{R_1+R_2}} = \\
&= \frac{1}{1 + s\,C\,\frac{R_1\,R_2}{R_1+R_2}}\cdot\left(p_U\,\frac{R_2}{R_1+R_2} + p_V\,\frac{R_2}{R_1+R_2}\right) \overset{!}{=} \frac{1}{1 + s\,T_C}\cdot(p_U\,K_1 + p_V\,K_2)
\end{aligned}$$

$$\begin{aligned}
T_C &= C\,\frac{R_1\,R_2}{R_1 + R_2} \\
K_1 &= \frac{R_2}{R_1 + R_2} \\
K_2 &= \frac{R_1}{R_1 + R_2}
\end{aligned}$$

Aufgabe 2

Strecke

$$\Delta p_Y = \frac{K_1}{1 + s\,T_C}\,\Delta p_U$$

$$\Rightarrow$$

$$G(s) = \frac{K_1}{1 + s\,T_C}$$

Stellglied

$$\Delta p_Y = K_S\,\Delta u_U$$

$$\Rightarrow$$

$$G(s) = K_S$$

Messglied

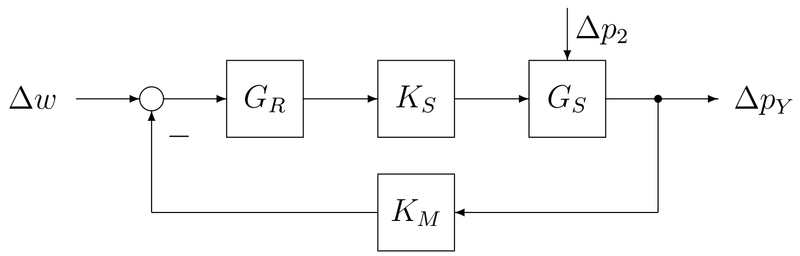
$$\Delta u_Y = K_M\,\Delta p_Y$$

$$\Rightarrow$$

$$G(s) = K_M = \frac{10\,\mathrm{V}}{2\,\mathrm{bar}}$$

Regler

$$G_R(s) = K_R\left(\frac{1 + s\,T_N}{s\,T_N}\right)$$



$$G_0(s) = G_R(s)\,K_S\,G_S(s) = K_R\left(\frac{1 + s\,T_N}{s\,T_N}\right)K_S\,\frac{K_1}{1 + s\,T_C} =$$

$$= K_R\,K_S\,K_1\,\frac{1 + s\,T_N}{s\,T_N(1 + s\,T_C)}$$

Aufgabe 3

Führungsübertragungsfunktion

$$\begin{aligned}
\Delta p_Y &= (\Delta w - K_M\,\Delta p_Y)\;G_0\\
&\Rightarrow\\
G_W(s) &= \frac{\Delta p_Y}{\Delta w} = \frac{1}{K_M + \frac{1}{G_0}} = \frac{1}{K_M + \frac{s\,T_N(1+s\,T_C)}{K_R\,K_S\,K_1\,(1+s\,T_N)}} =\\
&= \frac{1+s\,T_N}{K_M\,(1+s\,T_N) + \frac{s\,T_N(1+s\,T_C)}{K_R\,K_S\,K_1}} =\\
&= \frac{1}{K_M}\cdot\frac{1+s\,T_N}{1+s\,T_N\left(1+\frac{1}{K_R\,K_S\,K_M\,K_1}\right)+s^2\,\frac{T_N\,T_C}{K_R\,K_S\,K_M\,K_1}}
\end{aligned}$$

$$\begin{aligned}
T &= \sqrt{\frac{T_N\,T_C}{K_R\,K_S\,K_M\,K_1}}\\
2\,D\,T &= T_N\left(1+\frac{1}{K_R\,K_S\,K_M\,K_1}\right)\\
D &= \frac{T_N}{2\,T}\,\frac{1+K_R\,K_S\,K_M\,K_1}{K_R\,K_S\,K_M\,K_1} = \frac{T_N\,(1+K_R\,K_S\,K_M\,K_1)}{2\,\sqrt{\frac{T_N\,T_C}{K_R\,K_S\,K_M\,K_1}}\,K_R\,K_S\,K_M\,K_1} =\\
&= \frac{\sqrt{T_N}(1+K_R\,K_S\,K_M\,K_1)}{2\sqrt{T_C\,K_R\,K_S\,K_M\,K_1}}
\end{aligned}$$

Störübertragungsfunktion

$$\begin{aligned}
\Delta p_Y &= (-\Delta p_Y\,G_R\,K_S\,K_M\,K_1 + \Delta p_V\,K_2)\;\frac{1}{1+s\,T_C}\\
&\Rightarrow\\
G_V(s) &= \frac{\Delta p_Y}{\Delta p_V} = \frac{K_2}{1+s\,T_C+G_R\,K_S\,K_M\,K_1} = \frac{K_2}{1+s\,T_C+K_R\left(\frac{1+s\,T_N}{s\,T_N}\right)K_S\,K_M\,K_1} =\\
&= \frac{K_2\,s\,T_N}{K_R\,K_S\,K_M\,K_1+s\,T_N(1+K_R\,K_S\,K_M\,K_1)+s^2\,T_N\,T_C} =\\
&= \frac{K_2}{K_R\,K_S\,K_M\,K_1}\cdot\frac{s\,T_N}{1+s\,T_N\left(1+\frac{1}{K_R\,K_S\,K_M\,K_1}\right)+s^2\,\frac{T_N\,T_C}{K_R\,K_S\,K_M\,K_1}}
\end{aligned}$$

$$\begin{aligned}
T &= \sqrt{\frac{T_N\,T_C}{K_R\,K_S\,K_M\,K_1}}\\
D &= \frac{\sqrt{T_N}(1+K_R\,K_S\,K_M\,K_1)}{2\sqrt{T_C\,K_R\,K_S\,K_M\,K_1}}
\end{aligned}$$

Anfangs- und Endwert der Übertragungsfunktionen ohne I-Anteil: $\frac{1}{T_N} = 0$

$$G_W(s) = \frac{K_R\,K_S\,K_M\,K_1}{1 + K_R\,K_S\,K_M\,K_1 + s\,T_C} \cdot \frac{1}{K_M}$$

$$\lim_{t\to 0} h_W(t) = \lim_{s\to\infty} G_W(s) = 0$$
$$\lim_{t\to\infty} h_W(t) = \lim_{s\to 0} G_W(s) = \frac{K_R\,K_S\,K_1}{1 + K_R\,K_S\,K_M\,K_1}$$

$$G_V(s) = \frac{K_2}{K_R\,K_S\,K_M\,K_1} \cdot \frac{1}{1 + \frac{1}{K_R\,K_S\,K_M\,K_1} + s\,\frac{T_2}{K_R\,K_S\,K_M\,K_1}}$$

$$\lim_{t\to 0} h_V(t) = \lim_{s\to\infty} G_V(s) = 0$$
$$\lim_{t\to\infty} h_V(t) = \lim_{s\to 0} G_V(s) = \frac{K_2}{K_R\,K_S\,K_M\,K_1} \cdot \frac{1}{1 + \frac{1}{K_R\,K_S\,K_M\,K_1}} = \frac{K_2}{1 + K_R\,K_S\,K_M\,K_1}$$

Anfangs- und Endwert der Übertragungsfunktionen mit I-Anteil: $\frac{1}{T_N} > 0$

Führungsübertragungsfunktion

$$\lim_{t\to 0} h_W(t) = \lim_{s\to\infty} G_W(s) = 0$$
$$\lim_{t\to\infty} h_W(t) = \lim_{s\to 0} G_W(s) = \frac{1}{K_M}$$

Störübertragungsfunktion

$$\lim_{t\to 0} h_V(t) = \lim_{s\to\infty} G_V(s) = 0$$
$$\lim_{t\to\infty} h_V(t) = \lim_{s\to 0} G_V(s) = 0$$