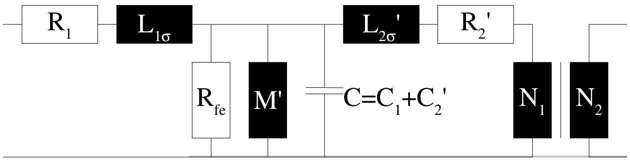
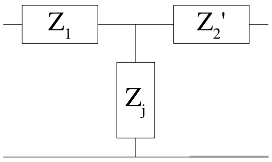
Transformator





$Z_1 = R_1 + j\omega L_{1\sigma}$

$Z_2' = R_2' + j\omega L_{2\sigma}'$

$Z_j = R_{fe} \| j\omega M' \| (j\omega C)^{-1}$

Vierpolparameter

$z_{11} = Z_1 + Z_j$ $\quad z_{12} = \frac{Z_j}{ü}$ $\quad\quad z_{11} = Z_1 + Z_j$ $\quad z_{12} = Z_j$

$z_{21} = \frac{Z_j}{ü}$ $\quad z_{22} = \frac{Z'_2 + Z_j}{ü^2} = Z_2 + \frac{Z_j}{ü^2}$ $\quad\quad z_{21} = Z_j$ $\quad z_{22} = Z'_2 + Z_j$

Projektion der Sekundärgrößen auf die Primärseite

$u' = ü\,u$ $\quad i' = \frac{i}{ü}$

$Z' = ü^2 Z$ $\quad R' = ü^2 R$ $\quad L' = ü^2 L$ $\quad C' = \frac{C}{ü^2}$ $\quad\quad u_1 = L_1 \dot{i}_1 + M \dot{i}_2$ $\quad u_2 = L_2 \dot{i}_2 + M \dot{i}_1$

Übersetzungsverhältnis

$ü = \frac{N_1}{N_2} = \frac{u_1}{u_2} = -\frac{i_2}{i_1}$

Kopplungsgrad

$k = \sqrt{\Phi_1 \frac{h}{\Phi_1} \Phi_2 \frac{h}{\Phi_2}} = \sqrt{L_1 \frac{h}{L_1} L_2 \frac{h}{L_2}} = \frac{M}{\sqrt{L_1 L_2}}$

Gegeninduktivität

$M = ü\,L_2 h = L_1 \frac{h}{ü} = \frac{N_1 N_2}{R_m} = N_2 \Phi_1 \frac{h}{i_1} = N_1 \Phi_2 \frac{h}{i_2} = k\sqrt{L_1 L_2} = \sqrt{L_1 h L_2 h}$ $\quad\quad M' = ü\,M$

Schwingkreise

Resonanzfrequenz

$\omega_0 = \frac{1}{\sqrt{LC}} = 2\pi f_0$

Verstimmung

$v = \frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}$

Dämpfung/normierte Bandbreite

$\Delta\Omega = \frac{1}{Q} = \frac{\Delta\omega}{\omega_0} = \frac{\Delta f}{f_0}$

Seriell

$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$ Impedanz

$Z_k = \omega_0 L = \frac{1}{\omega_0 C} = \sqrt{\frac{L}{C}} = \frac{1}{Y_k}$ Kennwiderstand

$\frac{Z}{R} = 1 + j\frac{Z_k}{R} v = 1 + jQv$ Normierte Impedanz

$Q = \frac{P_b}{P_w} = \frac{Z_k}{R} = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 R C}$ Güte

$\varphi_{i \to u} = -\arg(Z) = -\arctan(Qv)$

Parallel

$Y = G + j\left(\omega C - \frac{1}{\omega L}\right)$ Admittanz

$Y_k = \omega_0 C = \frac{1}{\omega_0 L} = \sqrt{\frac{C}{L}} = \frac{1}{Z_k}$ Kennleitwert

$\frac{Y}{G} = 1 + j\frac{Y_k}{G} v = 1 + jQv$ Normierte Admittanz

$Q = \frac{P_b}{P_w} = \frac{Y_k}{G} = \frac{\omega_0 C}{G} = \frac{1}{\omega_0 L G}$ Güte

$\varphi_{u \to i} = -\arg(Y) = -\arctan(Qv)$

Leistung

Augenblicksleistung

$p(t) = \frac{1}{2} U_S I_S \left(\cos(\varphi) - \cos(2\omega t + \varphi)\right)$

Wirkleistung

$P_w = U_{eff} I_{eff} \cos(\varphi) = \frac{1}{T}\int_0^T u(t)\, i(t)\, dt$

Scheinleistung

$P_S = U_{eff} I_{eff}$

Blindleistung

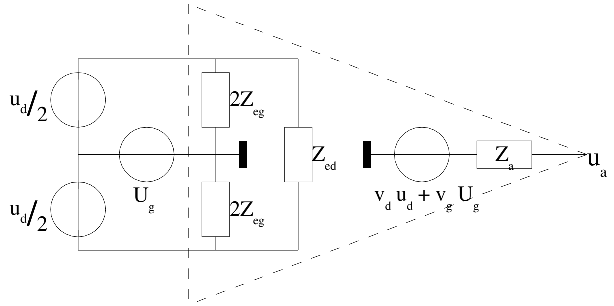
$P_b = U_{eff} I_{eff} \sin(\varphi)$

Operationsverstärker

Idealer OPV

$$\frac{u_a}{u_d}=\infty \qquad u_d=0$$

Realer OPV



Differenzverstärkung

$$v_d=\frac{u_a}{u_d}\Big|_{U_g=0}$$

Gleichtaktverstärkung

$$v_g=\frac{u_a}{u_g}\Big|_{u_d=0}$$

Gleichtaktunterdrückung

$$G=\frac{v_d}{v_g}$$

Differenzeingangsimpedanz

$$Z_{ed}=\frac{u_d}{i_{ed}}=\frac{R_{ed}\approx M\Omega}{1+i\omega R_{ed}C_{ed}}$$

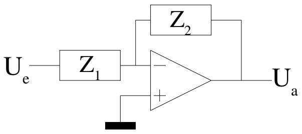
Gleichtakteingangsimpedanz

$$Z_{eg}=\frac{U_g}{I_{eg}}=\frac{R_{eg}\approx G\Omega}{1+i\omega R_{eg}C_{eg}}$$

Ausgangsimpedanz

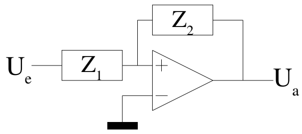
$$Z_a=\frac{u_a}{i_a}=R_a+i\omega L_a$$

Invertierender Verstärker

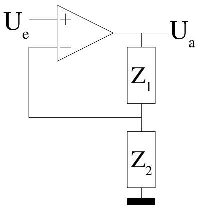


$$H(s)=-\frac{Z_2}{Z_1}$$

Nicht invertierender Schmitt-Trigger

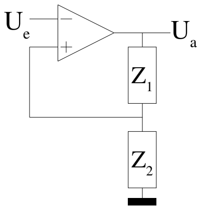


Nicht invertierender Verstärker

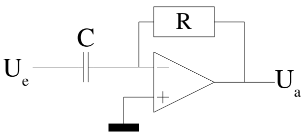


$$H(s)=1+\frac{Z_1}{Z_2}$$

Invertierender Schmitt-Trigger

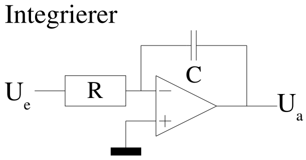


Differenzierer



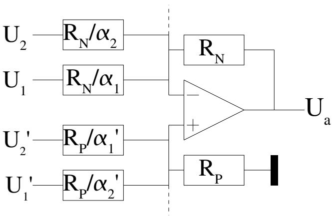
$$H(s)=-sRC=-S$$

Integrierer



$$H(s)=-\frac{1}{sRC}=-\frac{1}{S}$$

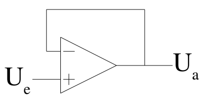
Addierer



$$\sum_{i=1}^{n}\alpha_i'=\sum_{i=1}^{m}\alpha_i \Rightarrow$$

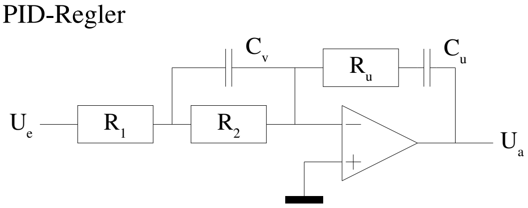
$$U_a=\sum_{i=1}^{n}\alpha_i' U_i'-\sum_{i=1}^{m}\alpha_i U_i$$

Spannungsfolger/Impedanzwandler



$$H(s)=1$$

PID-Regler



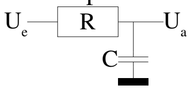
$$H(s)=-\frac{(1+sR_uC_u)(1+sR_2C_v)}{sC_u(sR_1R_2C_v+R_1+R_2)}=\frac{(1+S_1)(1+S_2)}{S_3(1+S_4)}$$

$$V=-\frac{1}{(R_1+R_2)C_u} \qquad T_1=R_uC_u \qquad T_2=R_2C_v \qquad T_0=\frac{R_1R_2}{R_1+R_2}C_v$$

$$K_P=-\frac{R_uC_u+R_2C_v}{(R_1+R_2)C_u} \qquad K_I=-\frac{1}{(R_1+R_2)C_u} \qquad K_D=-\frac{R_uR_2C_v}{R_1+R_2} \qquad T_I=R_uC_u+R_2C_v \qquad T_D=\frac{R_uR_2C_uC_v}{R_uC_u+R_2C_v}$$

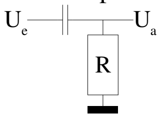
Passive Filter

RC-Tiefpaß



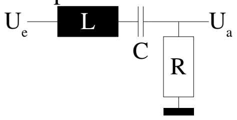
$$H(s)=\frac{1}{1+sRC}=\frac{1}{1+S}$$

RC-Hochpaß



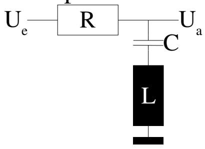
$$H(s)=\frac{sRC}{1+sRC}=\frac{S}{1+S}=\frac{1}{1+\frac{1}{S}}$$

Bandpaß



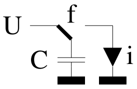
$$H(s)=\frac{sRC}{s^2LC+sRC+1}=\frac{S_1}{S_1S_2+S_1+1}=\frac{1}{1+Q\left(S+\frac{1}{S}\right)}=\frac{\Delta\Omega S}{S^2+\Delta\Omega S+1}$$

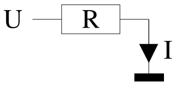
Bandsperre



$$H(s)=\frac{s^2LC+1}{s^2LC+sRC+1}=\frac{S_1S_2+1}{S_1S_2+S_1+1}=\frac{Q\left(S+\frac{1}{S}\right)}{1+Q\left(S+\frac{1}{S}\right)}=\frac{S^2+1}{S^2+\Delta\Omega S+1}$$

Switched Capacitor





$$R_{eq}=\frac{1}{Cf}$$