$\underline{U = R \cdot I}$ $\quad R = \frac{U}{I} \quad I = \frac{U}{R} \quad [F] = \left[\frac{As}{V}\right] \quad [\Omega] = \left[\frac{V}{A}\right]$

$f = \frac{1}{t} \quad w = 2p \cdot f = \frac{2p}{t}$

<u>Reihenschaltung</u> I=const

$R_{ges} = R_1 + R_2 + \ldots \quad U_{ges} = U_1 + U_2$

<u>Parallelschaltung</u> U=const

$$\frac{1}{R_{ges}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \qquad I_g = I_1 + I_2$$

$$R_{ges} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

<u>Transistor:</u>

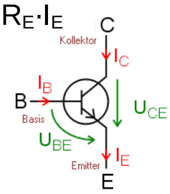
$I_B = \frac{U_B - U_{BE}}{R_B} = \frac{I_C}{B} \qquad I_C = B \cdot I_B \qquad U_{BE} \approx 0{,}7V$

$I_c = \frac{U_B - U_{CE}}{R_C}$ ó $\quad U_B = U_{CE} + R_c \cdot I_c + R_E \cdot I_E$

$P_{Transistor} = U_{CE} \cdot I_C \quad U_{CE} = U_B - R_c \cdot I_c - R_E \cdot I_E$

$I_E = I_C + I_B = B \cdot I_B + I_B$

$I_E = I_C + \frac{I_C}{B} = I_C \cdot (1 + \frac{1}{B})$



Mit B>>1 gilt: $I_c \approx I_E$

$U_{CE} = U_B$ und $I_C = \frac{U_B}{R_C}$

<u>(Nur für Wiederstandsgeraden-zeichnung)</u>

<u>Leistung:</u>

$P = U \cdot I \quad P = R \cdot I^2 \quad P = \frac{U^2}{R}$

Vielfache und Teile der Grundeinheiten

Tera	T	=	10^{12}	Zenti	c	=	10^{-2}
Giga	G	=	10^9	Milli	m	=	10^{-3}
Mega	M	=	10^6	Mikro	µ	=	10^{-6}
Kilo	k	=	10^3	Nano	n	=	10^{-9}
Hekto	h	=	10^2	Piko	p	=	10^{-12}
Deka	da	=	10^1	Fanto	f	=	10^{-15}
Dezi	d	=	10^{-1}	Alto	a	=	10^{-18}

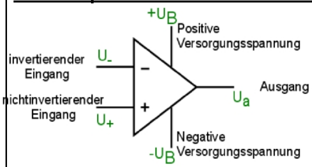
<u>dB-Verstärkung</u>

Spannungsbezogen; Leistungsbezogen; Verhältnis

$$v = 20dB \cdot \log_{10}\left(\frac{U_a}{U_e}\right); \quad v = 10dB \cdot \log_{10}\left(\frac{P_a}{P_e}\right)$$

$$\frac{P_a}{P_e} = \left(\frac{U_a}{U_e}\right)^2$$

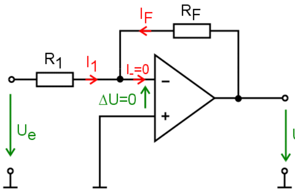
<u>OP-Operationsverstärker</u>



$v = \frac{U_a}{U_+ - U_-}$ mit $v \rightarrow \infty$

idealisiert: $R_e \rightarrow \infty$

<u>Invertierende Verstärker</u>

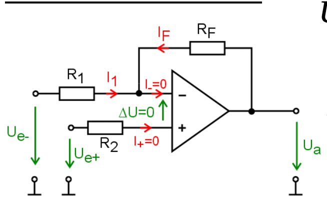


$v = \frac{U_a}{U_+ - U_-} = \frac{U_a}{\Delta U} \Rightarrow \infty$

$\Rightarrow \Delta U = \frac{U_a}{v} \rightarrow 0; \quad I_F = -I_1$

$I_F = \frac{U_a}{R_F}; \quad I_1 = \frac{U_e}{R_1}; \quad U_a = -\frac{R_F}{R_1} \cdot U_e$

<u>Differenzverstärker:</u>

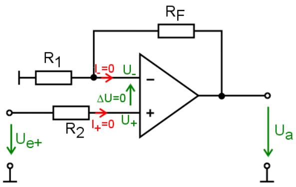


$U_a = U_{e+} \cdot \left(\frac{R_F}{R_1} + 1\right) - U_{e-} \cdot \frac{R_F}{R_1}$

$I_F = \frac{U_a - U_{e+}}{R_F} = -I_1 = \frac{U_{e+} - U_{e-}}{R_1}; \quad I_F = -I_1$

R_2 ist unwichtig!

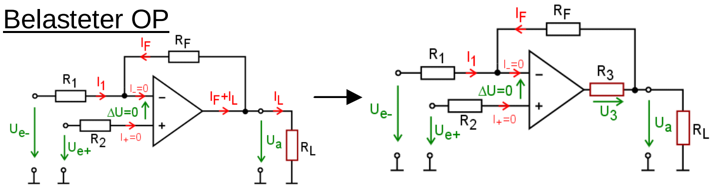
<u>Nichtinvertierender Verstärker</u>



$U_- = U_a \frac{R_1}{R_F + R_1}$

$U_a = U_{e+} \cdot \left(\frac{R_F}{R_1} + 1\right)$

<u>Belasteter OP</u>

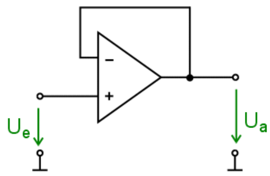


$U_a = U_{e+} \cdot \left(\frac{R_F}{R_1} + 1\right) - U_{e-} \cdot \frac{R_F}{R_1} \qquad I_F = \frac{U_a - U_{e+}}{R_F} = -I_1 = \frac{U_{e+} - U_{e-}}{R_1}$

$U3 = R_3 \cdot (I_F + I_L)$ hier ist Ausgangsleitung = R_3

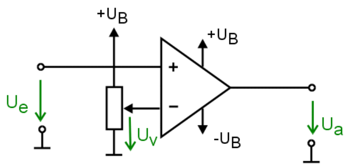
<u>Impedanz-Wandler</u>

$U_a = U_e$



<u>Schwellwertschalter</u>

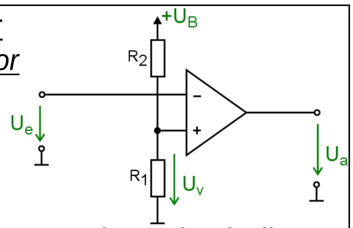
<u>nichtinvertierender Operator</u>



Für <u>Ue > Uv gilt Ua → ∞</u> bzw. durch die Begrenzung der Ausgangsspannung auf die Betriebsspannung: <u>Ua → +UB</u>

Für <u>Ue < Uv gilt Ua → −∞</u> bzw. durch die Begrenzung der Ausgangsspannung auf die Betriebsspannung: <u>Ua → −UB</u>

Schwellwertschalter
invertierender Operator

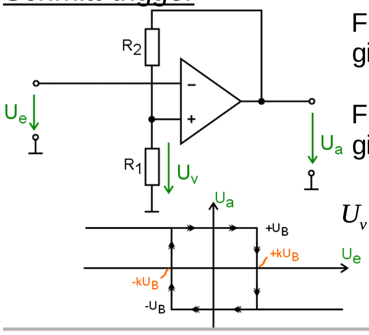


Für Ue > Uv gilt Ua → −∞ bzw. durch die Begrenzung der Ausgangsspannung auf die Betriebsspannung: Ua → −UB

Für Ue < Uv gilt Ua → ∞ bzw. durch die Begrenzung der Ausgangsspannung auf die Betriebsspannung: Ua → +UB

$$U_v = \frac{R_1}{R_1 + R_2} \cdot U_B = k \cdot U_B$$

Schmitt-trigger

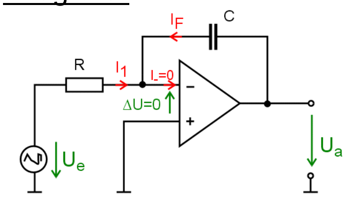


Für $U_a = +U_B$ gilt $U_v = k \cdot U_B$

Für $U_a = -U_B$ gilt $U_v = -k \cdot U_B$

$$U_v = \frac{R_1}{R_1 + R_2} \cdot U_A = k \cdot U_A$$

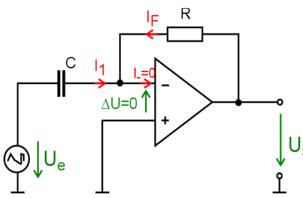
Integrator



$$I_F = -I_1 = -\frac{U_e}{R}$$

$$u_a = \frac{-1}{RC} \cdot \int u_e dt$$

Differenzierer

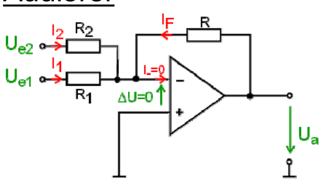


$$I_F = \frac{U_a}{R} = -C \cdot \frac{dU_e}{dt} = -I_1$$

$$I_1 = C \cdot \frac{dU_C}{dt} = C \cdot \frac{dU_e}{dt}$$

$$u_a = -RC \cdot \frac{du_e}{dt}$$

Addierer



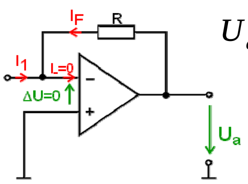
$$I_F + I_1 + I_2 = I_- = 0$$

$$\Rightarrow I_F = -(I_1 + I_2)$$

Für $R_F = R_1 = R_2$ gilt: $U_a = -(U_{e1} + U_{e2})$

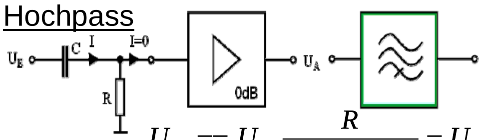
$$I_F = \frac{U_a}{R_F} = -(I_1 + I_2) = -\left(\frac{U_{e1}}{R_1} + \frac{U_{e2}}{R_2}\right)$$

Strom/Spannungswandler



$$U_a = -R_F \cdot I_1 \qquad I_F = \frac{U_a}{R_F} = -I_1$$

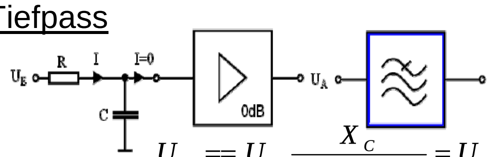
Hochpass



$$f_{Grenz} = \frac{1}{2pRC}$$

$$U_A == U_E \frac{R}{\sqrt{R^2 + X_C^2}} = U_E \frac{1}{\sqrt{1 + \frac{1}{(2pfRC)^2}}}$$

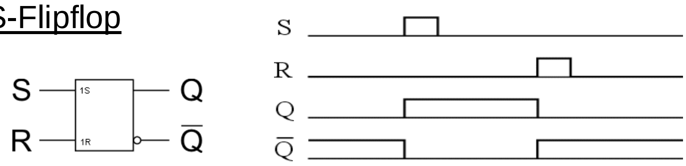
Tiefpass



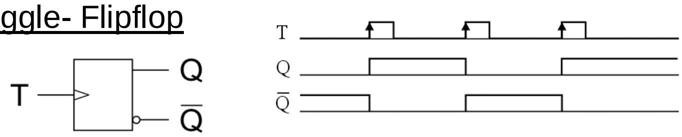
$$f_{Grenz} = \frac{1}{2pRC}$$

$$U_A == U_E \frac{X_C}{\sqrt{R^2 + X_C^2}} = U_E \frac{1}{\sqrt{(2pfRC)^2 + 1}}$$

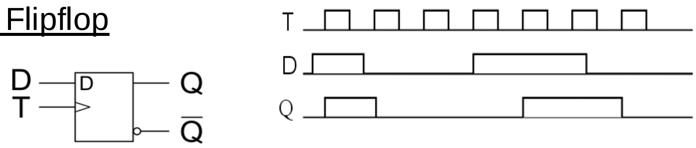
RS-Flipflop



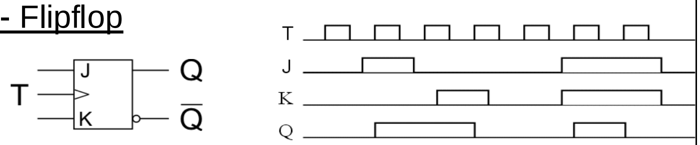
Toggle- Flipflop



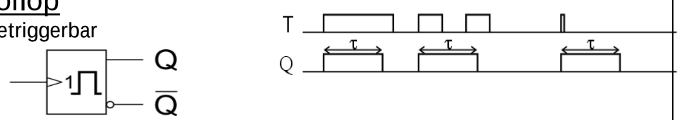
D- Flipflop



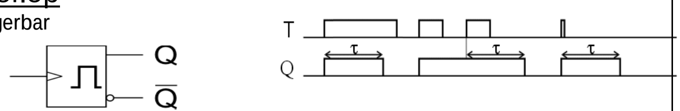
JK- Flipflop



Monoflop
Nicht retriggerbar



Monoflop
Retriggerbar



Toggel-Flipflop
Mit Set und Reset