E 24 Reihe

1.0 | 1.1 | 1.2 | 1.3 | 1.5 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.6 | 2.9 | 3.2 | 3.5 | 3.8 | 4.2 | 4.6 | 5.1 | 5.6 | 6.2 | 6.8 | 7.5 | 8.3 | 9.1

Giga	Mega	Kilo	Milli	Mikro μ	Nano	Piko	Femto
10^9	10^6	10^3	10^{-3}	10^{-6}	10^{-9}	10^{-12}	10^{-15}

Knotenregel, $\sum I = 0$ Maschenregel $\sum U = 0$

Parallelwiderstände $R_1 \parallel R_2 = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}} = \frac{R_1 \cdot R_2}{R_1+R_2}$

Spannungsteiler $U_2 = U \cdot \frac{R_2}{R_1+R_2}$

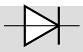
Stromteiler $I_1 = I \cdot \frac{R_2}{R_1+R_2}$

3 dB-Grenzfrequenz $f_{3\text{dB}} = \frac{1}{2\pi \cdot C \cdot R}$

Übertragungsfunktion normiert: $\frac{1}{1+j\omega K}$ bzw $\frac{j\omega K}{1+j\omega K}$

$\omega_{3\text{dB}} = \frac{1}{K} \Rightarrow f_{3\text{dB}} = \frac{1}{2\pi K}$ $Z_L = j\omega L, Z_C = \frac{1}{j\omega C}$

$|H(\omega)| = |a + bj| = \sqrt{a^2 + b^2}$

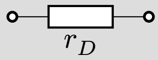
Diode 

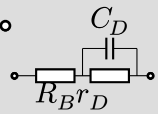
mit $U_T = \frac{k_B \cdot T}{e} \approx 26\text{mv}$

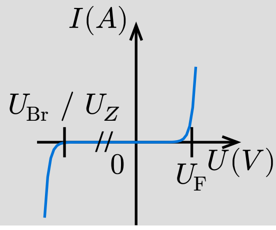
Diodenstrom $I_D = I_s \cdot \left(e^{\frac{U_D}{U_T}} - 1\right)$

Diodenspannung $U_D = U_T \cdot \ln\left(\frac{I_D}{I_S}\right)$

Kleinsignal $r_D = \frac{U_T}{I_D}$

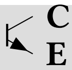
Kleinsignalersatzschaltbild 

Erweitertes Kleinsignalersatzschaltbild 



U_F Flussspannung

U_{Br} / U_Z Durchbruchspannung / Zenerspannung

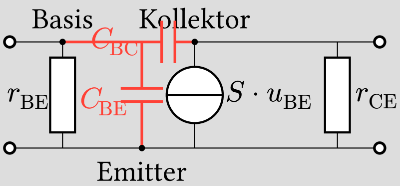
Bipolartransistor 

Steilheit $S = \frac{I_{C,A}}{U_T}$

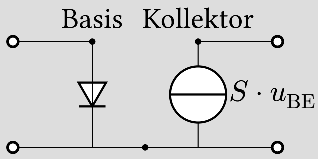
Kleinsignal-Eingangs-Widerstand $r_{\text{BE}} = \frac{\beta}{S}$

Stromverstärkung $\beta = \frac{I_C}{I_B}$

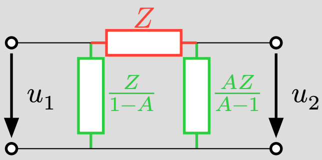
Ausgangswiderstand $r_{\text{CE}} = \frac{|U_A| + U_{\text{CE}}}{I_C}$



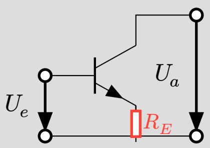
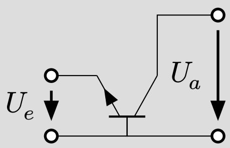
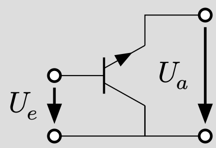
vollständiges Kleinsignalersatzschaltbild



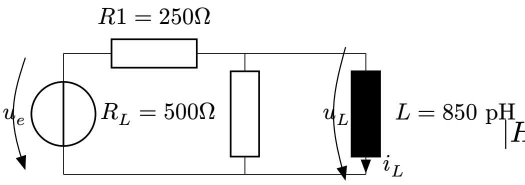
Großsignalersatzschaltbild



Miller-Theorem: $A = \frac{u_2}{u_1}$ verbundene Impedanz Z wird zu zwei getrennte Impedanzen

Ermitterschaltung	Basisschaltung	Kollektorschaltung
		
$A = -SR_C$ $r_e = r_{\text{BE}}$ $r_a = r_{\text{CE}} \parallel R_C$ Stromgegen-kopplung $A = -\frac{R_C}{R_E}$ $r_e = r_{\text{BE}}$ $r_a = r_{\text{CE}} \parallel R_C$	$A = SR_C$ $r_e = \frac{1}{S}$ $r_a = r_{\text{CE}} \parallel R_C$	$A = 1$ $r_e = r_{\text{BE}} + \beta R_E$ $r_a = \frac{1}{S}$

Übergangsfunktion und 3dB-Grenzfrequenz



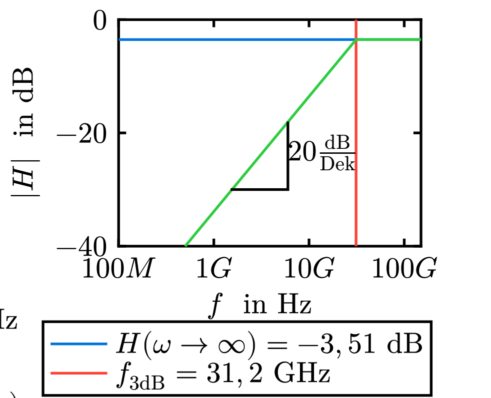
$$H(\omega) = \frac{u_l}{u_e} = \frac{j\omega L \parallel R_2}{R_1 + (j\omega L \parallel R_2)} = \frac{j\omega L \cdot R_2}{R_1 \cdot R_2 + j\omega L \cdot (R_1 + R_2)} = \frac{R_2}{R_1 + R_2} \frac{j\omega K}{1 + j\omega K}$$

$$\text{mit } K = L \cdot \frac{R_1 + R_2}{R_1 \cdot R_2} = 5,1 \text{ ps}$$

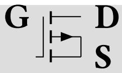
$$|H(\omega)| = \frac{R_2}{R_1 + R_2} \frac{\omega K}{\sqrt{1 + (\omega K)^2}}$$

$$\Rightarrow f_{3\text{dB}} = \frac{\omega_{3\text{dB}}}{2\pi} = \frac{1}{2\pi K} = \frac{1}{2\pi * 5,1 \text{ ps}} = 31,2 \text{ GHz}$$

$$H(\omega \to \infty) = \frac{R_2}{R_1 + R_2} = \frac{2}{3} \mid 20\log(x) = -3,51 \text{ dB}$$



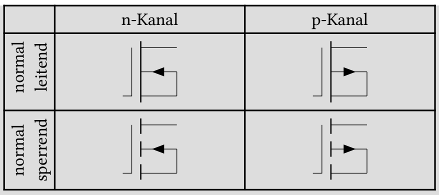
Feldeffekttransistor (FET)

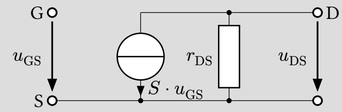


$$r_{DS} = \frac{\partial U_{DS}}{\partial I_D} = \frac{|U_A| + U_{DS}}{I_D}$$

$$S = \frac{\partial I_D}{\partial U_{DS}} = \beta(U_{GS} - U_{th})$$

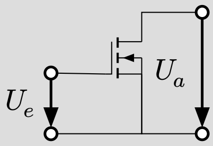
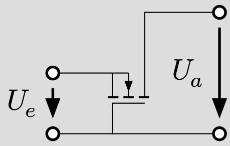
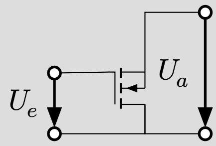
$$\beta = \mu \cdot C'_{ox} \cdot \frac{\omega}{l}$$



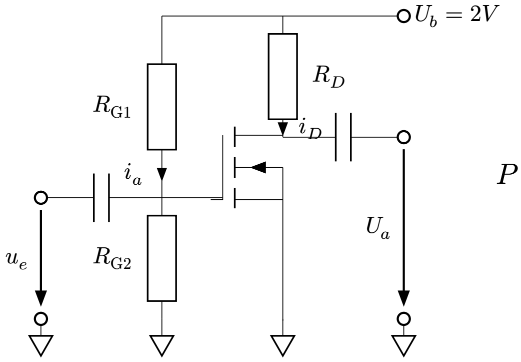


Kleinsignalersatzschaltbild

$$I_D = \begin{cases} 0 & U_{GS} \leq U_{th} \\ \beta \cdot \left((U_{GS} - U_{th}) - \frac{U_{th}^2}{2}\right) \cdot \left(1 + \frac{U_{DS}}{U_A}\right) & \text{linearer Bereich} \\ \frac{\beta}{2} \cdot (U_{GS} - U_{th})^2 \cdot \left(1 + \frac{U_{DS}}{U_A}\right) & \text{Sättigungsbereich} \end{cases}$$

Source-Schaltung	Gate-Schaltung	Drain-Schaltung
		
$r_e = \infty$ $r_a = R_D \parallel r_{DS}$ $A = -S \cdot (R_D \parallel r_{DS})$	$r_e = \frac{1}{S}$ $r_a = R_D \parallel r_{DS}$ $A = S \cdot (R_D \parallel r_{DS})$	$r_e = \infty$ $r_a = \frac{1}{S} \parallel R_S$ $A = \frac{S \cdot R_S}{1 + S \cdot R_S}$

Arbeitspunkt und Lastgerade

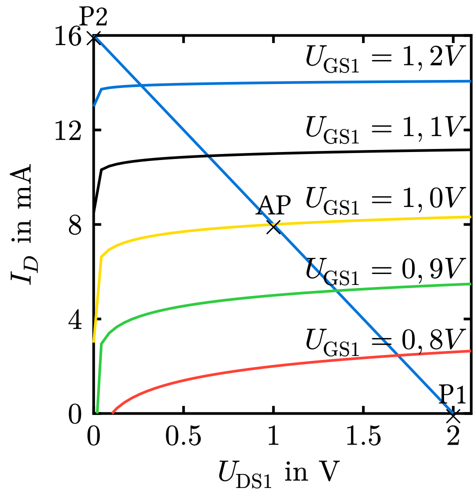


$$U_b = U_{DS1} + R_D \cdot I_D$$

$$\Leftrightarrow I_D = \frac{U_b - U_{DS1}}{R_D}$$

$$P1 : I_D(U_{DS1} = 0) = \frac{U_D}{R_D} = 16\text{mA}$$

$$P2 : I_D(U_{DS1} = U_b = 2V) = 0$$



Einstellen sodass $U_{GS1} = 1V$: $R_{G1} + R_{G2} = \frac{U_D}{I_D} \overset{!}{=} \frac{2V}{8\text{mA}} = 25k\Omega$

$$\frac{R_{G1}}{R_{G1} + R_{G2}} \overset{!}{=} U_{GS1} = 1V$$

$$\frac{R_{G2}}{R_{G1} + R_{G2}} \cdot U_D \overset{!}{=} U_D - U_{GS1} = 1V \Rightarrow R_{G1} = R_{G2} = 12,5k\Omega$$

NOT [1]o AND [&] OR [≥ 1]