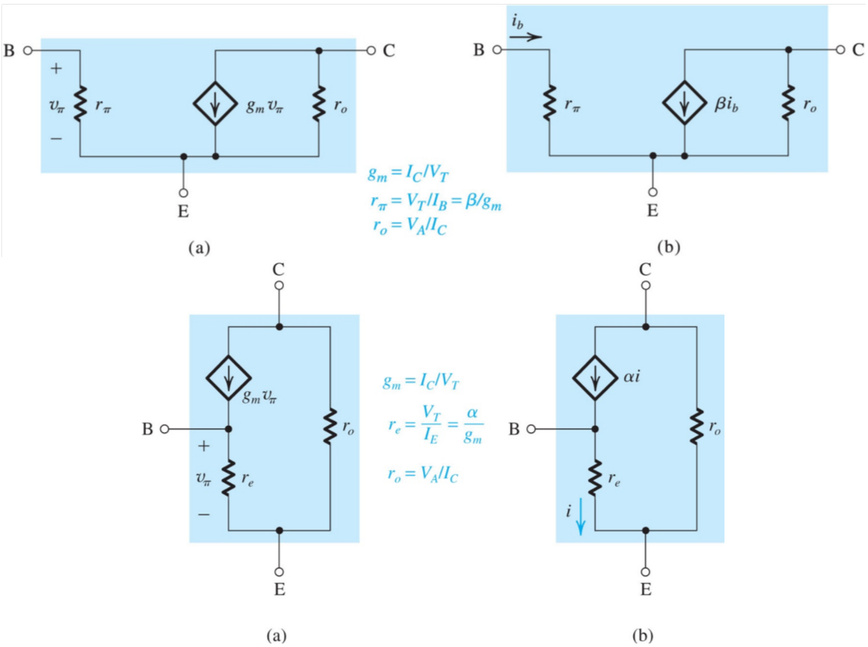

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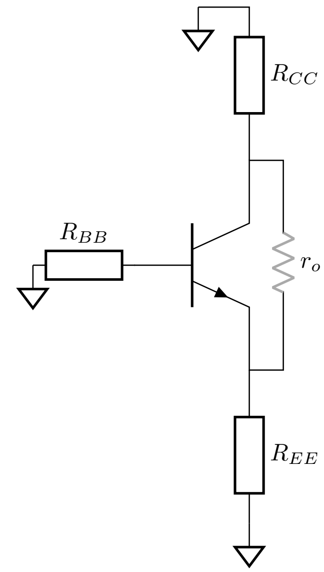
Impédance vue depuis le collecteur

$$r_o + R_{EE}\left[\frac{r_\pi + R_{BB} + r_\pi r_o g_m}{r_\pi + R_{BB} + R_{EE}}\right]$$

$$\text{si } R_{BB}\to 0\text{: } r_o\left[1 + g_m\left(r_\pi \parallel R_{EE}\right)\right] + \left(r_\pi \parallel R_{EE}\right)$$



Impédance vue depuis la base

$$r_\pi + (\beta+1)\left[R_{EE} \parallel (r_o + R_{CC})\right]$$

$$(\beta+1)\left[r_e + R_{EE} \parallel (r_o + R_{CC})\right]$$

$$g_m \equiv \frac{\partial I_C}{\partial V_{BE}} = \frac{I_c}{V_T} \quad r_e = \frac{V_T}{I_E} \quad r_\pi = \frac{V_T}{I_B} \quad r_o \equiv \frac{\partial V_{CE}}{\partial I_C} = \frac{|V_A|}{I_C}$$

$$r_e = \frac{\alpha}{g_m} \quad r_\pi = \frac{\beta}{g_m} \quad g_m + \frac{1}{r_\pi} = \frac{1}{r_e} \quad g_m = \frac{\alpha}{r_e} = \frac{\beta}{r_\pi}$$

$$\beta = \frac{\alpha}{1-\alpha} \quad \alpha \equiv \frac{\beta}{\beta+1} \quad \beta + 1 = \frac{1}{1-\alpha} \quad r_\pi = (\beta+1)\, r_e$$

MOSFET: $\beta \to \infty,\ \alpha \to 1,\ r_\pi \to \infty,\ r_e = \frac{1}{g_m},\ g_m \sim \frac{2I_D}{V_{GS}-V_t}$

Impédance vue depuis l'émetteur

$$\frac{(r_\pi + R_{BB})\,(r_o + R_{CC})}{(r_\pi + R_{BB}) + (\beta+1)\, r_o + R_{CC}}$$

$$\underset{r_e \ll r_o}{\sim} \frac{\left[r_e(\beta+1) + R_{BB}\right](r_o + R_{CC})}{(\beta+1)\, r_o + R_{BB} + R_{CC}}$$

$$\sim \frac{r_\pi + R_{BB}}{(\beta+1)} \parallel r_o$$

$$\underset{\text{MOSFET}}{\overset{\beta\to\infty}{}} : \frac{1}{g_m} + \frac{R_{CC}}{g_m r_o}$$

Table 7.5 Characteristics of BJT Amplifiers[a,b]

	R_{in}	A_{vo}	R_o	A_v	G_v
Common emitter (Fig. 7.36)	$(\beta+1)r_e$	$-g_m R_C$	R_C	$-g_m(R_C \parallel R_L)$ $-\alpha \dfrac{R_C \parallel R_L}{r_e}$	$-\beta \dfrac{R_C \parallel R_L}{R_{sig}+(\beta+1)r_e}$
Common emitter with R_e (Fig. 7.38)	$(\beta+1)(r_e+R_e)$	$-\dfrac{g_m R_C}{1+g_m R_e}$	R_C	$\dfrac{-g_m(R_C \parallel R_L)}{1+g_m R_e}$ $-\alpha \dfrac{R_C \parallel R_L}{r_e+R_e}$	$-\beta \dfrac{R_C \parallel R_L}{R_{sig}+(\beta+1)(r_e+R_e)}$
Common base (Fig. 7.40)	r_e	$g_m R_C$	R_C	$g_m(R_C \parallel R_L)$ $\alpha \dfrac{R_C \parallel R_L}{r_e}$	$\alpha \dfrac{R_C \parallel R_L}{R_{sig}+r_e}$
Emitter follower (Fig. 7.43)	$(\beta+1)[r_e+R_E]$	$\dfrac{R_E}{R_E+r_e}$	$r_e \parallel R_E$	$\dfrac{R_E \parallel R_L}{(R_E \parallel R_L)+r_e}$	$\dfrac{R_E \parallel R_L}{(R_E \parallel R_L)+r_e+R_{sig}/(\beta+1)}$ $\left[r_e+\dfrac{R_{sig}}{\beta+1}\right] \parallel R_E$

[a] For the interpretation of R_{in}, A_{vo}, and R_o refer to Fig. 7.34.
[b] Setting $\beta=\infty$ ($\alpha=1$) and replacing r_e with $1/g_m$, R_C with R_D, and R_e with R_s results in the corresponding formulas for MOSFET amplifiers (Table 7.4).

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Table 3.1 Summary of Important Equations

273.15 + °C

Quantity	Relationship		Values of Constants and Parameters (for Intrinsic Si at $T = 300$ K)
Carrier concentration in intrinsic silicon (cm^{-3})	$n_i = BT^{3/2}e^{-E_g/2kT}$	Eq. 3.2	$B = 7.3 \times 10^{15}\ cm^{-3}K^{-3/2}$ $E_g = 1.12$ eV $k = 8.62 \times 10^{-5}$ eV/K $n_i = 1.5 \times 10^{10}/cm^3$
Diffusion current density (A/cm^2)	$J_p = -qD_p \frac{dp}{dx}$ $J_n = qD_n \frac{dn}{dx}$		$q = 1.60 \times 10^{-19}$ coulomb $D_p = 12\ cm^2/s$ $D_n = 34\ cm^2/s$
Drift current density (A/cm^2)	$J_{drift} = q(p\mu_p + n\mu_n)E$	Eq. 3.13	$\mu_p = 480\ cm^2/V \cdot s$ $\mu_n = 1350\ cm^2/V \cdot s$
Resistivity ($\Omega \cdot cm$)	$\rho = 1/[q(p\mu_p + n\mu_n)]$	Eq. 3.15	μ_p and μ_n decrease with the increase in doping concentration
Relationship between mobility and diffusivity	$\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = V_T$	Eq. 3.20	$V_T = kT/q \simeq 25.9$ mV
Carrier concentration in n-type silicon (cm^{-3})	$n_{n0} \simeq N_D$ $p_{n0} = n_i^2/N_D$	Eq. 3.5	$np = n_i^2$ Eq. 3.6
Carrier concentration in p-type silicon (cm^{-3})	$p_{p0} \simeq N_A$ $n_{p0} = n_i^2/N_A$	Eq. 3.6	
Junction built-in voltage (V)	$V_0 = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$	Eq. 3.21	
Width of depletion region (cm)	$\frac{x_n}{x_p} = \frac{N_A}{N_D}$ $W = x_n + x_p = \sqrt{\frac{2\epsilon_s}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)(V_0 + V_R)}$	Eq. 3.25	$\epsilon_s = 11.7\epsilon_0$ $\epsilon_0 = 8.854 \times 10^{-14}$ F/cm

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$$E = \frac{hc}{\lambda} \approx \frac{1.985 \times 10^{-16}\ \text{J}\cdot\text{nm}}{\lambda}$$

Table 3.1 *continued*

Quantity	Relationship		Values of Constants and Parameters (for Intrinsic Si at $T = 300$ K)
Charge stored in depletion layer (coulomb)	$Q_J = q\frac{N_A N_D}{N_A + N_D}AW$		
Forward current (A)	$I = I_p + I_n$ $I_p = Aqn_i^2 \frac{D_p}{L_p N_D}\left(e^{V/V_T} - 1\right)$ $I_n = Aqn_i^2 \frac{D_n}{L_n N_A}\left(e^{V/V_T} - 1\right)$		
Saturation current (A)	$I_S = Aqn_i^2\left(\frac{D_p}{L_p N_D} + \frac{D_n}{L_n N_A}\right)$	Eq. 3.41	
I–V relationship	$I = I_S\left(e^{V/V_T} - 1\right)$	Eq. 3.40	
Minority-carrier lifetime (s)	$\tau_p = L_p^2/D_p \qquad \tau_n = L_n^2/D_n$		$L_p, L_n = 1\ \mu\text{m to } 100\ \mu\text{m}$ $\tau_p, \tau_n = 1\text{ ns to }10^4\text{ ns}$
Minority-carrier charge storage (coulomb)	$Q_p = \tau_p I_p \qquad Q_n = \tau_n I_n$ $Q = Q_p + Q_n = \tau_T I$		
Depletion capacitance (F)	$C_{j0} = A\sqrt{\left(\frac{\epsilon_s q}{2}\right)\left(\frac{N_A N_D}{N_A + N_D}\right)\frac{1}{V_0}}$ $C_j = C_{j0}\Big/\left(1 + \frac{V_R}{V_0}\right)^m$	Eq. 3.48 Eq. 3.49	 $m = \frac{1}{3}$ to $\frac{1}{2}$
Diffusion capacitance (F)	$C_d = \left(\frac{\tau_T}{V_T}\right)I$	Eq. 3.57	

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MOSFET $\quad I_D = K\left[(V_{GS} - V_t)\,V_{DS} - \frac{1}{2}V_{DS}^2\right] \qquad I_D = \frac{1}{2}K\,(V_{GS} - V_t)^2$

$K = k'\left(\frac{W}{L}\right) \qquad g_m = K\,(V_{GS} - V_t) = \sqrt{2KI_D} = \frac{2I_D}{V_{GS} - V_t}$

$k'_{n,p} = \mu_{n,p} C_{ox} \qquad r_o = \frac{V_A}{I_D} = \frac{1}{\lambda I_D}$