III	IV	V
B	C	
Al	Si	P
Ga	Ge	As
In		Sb

$$n_i = BT^{3/2}e^{\left(\frac{-E_g}{2kT}\right)}$$
$$J = qn\mu_n E + qp\mu_p E$$
$$\sigma = q(n\mu_n + p\mu_p)$$
$$p = \frac{n_i^2}{N_d}$$

$$k = 86 \times 10^{-6} Ev/K$$
$$k = 1.38 \times 10^{-23} J/K$$
$$q = 1.6 \times 10^{-19}$$
$$V_T = \frac{kT}{q}$$

$$J_n = qD_n \frac{dn}{dx}$$
$$J_p = -qD_p \frac{dp}{dx}$$
$$\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = \frac{kT}{q}$$

$$V_{bi} = \frac{kT}{q}\ln\left(\frac{N_a N_d}{n_i^2}\right)$$

$$C_j = \frac{C_{j0}}{\sqrt{1 + \frac{V_R}{V_{bi}}}}$$

$$i_D = I_S\left[e^{\left(\frac{v_D}{nV_T}\right)} - 1\right]$$

$$r_d = \frac{V_T}{I_{DQ}}$$

BJT

$$V_R = \frac{V_M}{fRC}$$

$$i_E = I_{EO}\left[e^{\frac{v_{BE}}{V_T}} - 1\right] \cong I_{EO}\left[e^{\frac{v_{BE}}{V_T}}\right]$$

$$i_C = \alpha i_E$$
$$i_C = \beta i_B$$
$$i_E = i_C + i_B$$

Pnp

$$i_E \cong I_{EO}\left[e^{\frac{v_{EB}}{V_T}}\right]$$

$$i_C = I_S\left[e^{\frac{v_{BE}}{V_T}}\right]\left(1 + \frac{V_{BE}}{V_A}\right)$$

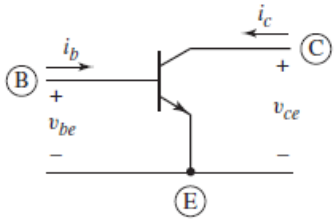
$$Si:\ E_g = 1.1eV, B = 5.23 \times 10^{15}$$
$$GaAs: E_g = 1.14eV, B = 2.10 \times 10^{14}$$
$$Ge: E_g = 0.66eV, B = 1.66 \times 10^{15}$$

$$V_{CE,sat} = 0.2\ V$$
$$V_{BE(on)} = 0.7V$$
$$\beta i_b = g_m V_\pi$$

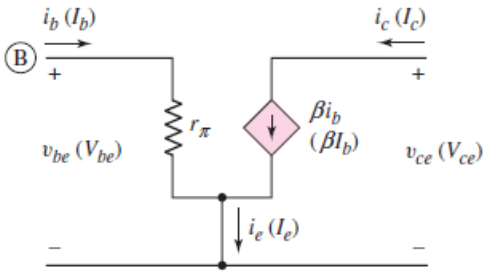
$$R_{TH} = R_1 // R_2$$
$$V_{TH} = V_{CC}\frac{R_2}{R_1 + R_2}$$
$$V_{TH} = V_{CC}\frac{R_2 - R_1}{R_1 + R_2}$$

Early etkisi: bağımlı akım kaynağına paralel r_o direnci.
Giriş empedansı: O noktadaki gerilim bölü o noktadan geçen akım
Çıkış empedansı: O noktadaki açık devre gerilimi bölü o noktadan geçen kısa devre akımı

$$r_\pi = \frac{V_T}{I_{BQ}}$$
$$g_m = \frac{\beta}{r_\pi} = \frac{I_{CQ}}{V_T}$$
$$r_o = \frac{V_A}{I_{CQ}}$$



=



MOS

$$i_{DS} = \begin{cases} K_n[2(V_{GS} - V_{TN})V_{DS} - V_{DS}^2] & V_{DS} < V_{GS} - V_{TN} \\ K_n(V_{GS} - V_{TN})^2 & V_{DS} > V_{GS} - V_{TN} \end{cases}$$

pMOS

$$V_{GS} \to V_{SG}$$
$$V_{DS} \to V_{SD}$$
$$V_{TN} \to -V_{TP}$$

$$K_n = \frac{W}{L}\frac{1}{2}\mu_n\frac{\epsilon_{ox}}{t_{ox}}$$
$$k_n' = \mu_n\frac{\epsilon_{ox}}{t_{ox}}$$

$$\lambda > 0\ ise: SAT\ için$$
$$i_{DS} = K_n(V_{GS} - V_{TN})^2(1 + \lambda v_{DS})$$

$$r_o = \frac{1}{\lambda I_{DQ}}$$

$$g_m = 2\sqrt{K_n I_{DQ}}$$