HOJA DE FORMULAS *DISPOSITIVOS DE ESTADO SÓLIDO*

$$F(E) = \frac{n_i}{g_i} = \frac{1}{1 + e^{\frac{E-Ef}{KT}}} \qquad k = 1.38\times10^{-23}\frac{J}{°K} = 8.62\times10^{-5}\frac{eV}{°K}$$

$$1eV = 1.602\times10^{-19} J$$

$$n_o = Nc\cdot e^{-\frac{(E_c-E_f)}{KT}} \qquad N_c = 2\left(\frac{m_e^* KT}{2\pi\hbar^2}\right)^{\frac{3}{2}}$$

$$p_o = Nv\cdot e^{-\frac{(E_f-E_v)}{KT}} \qquad N_v = 2\left(\frac{m_p^* KT}{2\pi\hbar^2}\right)^{\frac{3}{2}}$$

$$n_o = n_i\cdot e^{\frac{E_f-E_i}{KT}} \qquad p_o = n_i\cdot e^{\frac{E_i-E_f}{KT}} \qquad n_o p_o = n_i^2 \qquad E_i \approx \frac{E_c+E_V}{2}$$

Tipo N $n_o = n_i + N_d \approx N_d$

Tipo P $p_o = n_i + N_a \approx N_a$

A temperatura ambiente:

$$KT \ @ \ (27°C = 300°k) = 8.62\times10^{-5}\frac{eV}{°K}\cdot 300°K = 0.026eV$$

$$m_o = 9.11\times10^{-31}Kg$$

	$n_i(cm^{-3})$	$E_{gap}(eV)$	$\mu_n\left(cm^2/V\cdot s\right)$	$\mu_p\left(cm^2/V\cdot s\right)$	$D_n\left(cm^2/s\right)$	$D_p\left(cm^2/s\right)$	m_e^*	m_p^*
Si	1.13×10^{10}	1.12	1500	450	39	11.7	$1.1m_o$	$0.56m_o$
Ge	2.31×10^{13}	0.67	3900	1900	101.4	49.4	$0.55m_o$	$0.37m_o$

$$V_e = -\left(\frac{q\tau}{m_e^*}\right)E = -\mu_n E$$

$$J_a = \sigma E \qquad \sigma = q(n\mu_n + p\mu_p) \qquad J_a = q(n\mu_n + p\mu_p)E$$

$$R = \frac{1}{\sigma}\frac{L}{A} \qquad I = J\cdot A$$

Corriente dif: $J_d = qD_n\frac{dn}{dx} - qD_p\frac{dp}{dx}$

$$J_{TOTAL} = qn\mu_n E + qp\mu_p E + qD_n\frac{dn}{dx} - qD_p\frac{dp}{dx}$$

Carga electrón: $q = 1.602\times10^{-19}C$

Continuidad Electrones

$$\frac{1}{q}\frac{\partial J_n}{\partial x}-\frac{\delta n}{\tau_n}=\frac{\partial \delta n}{\partial t} \qquad D_n\frac{\partial^2 n(x,t)}{\partial x^2}+\mu_n\frac{\partial(\overline{E}\,n(x,t))}{\partial x}-\frac{\delta n(x,t)}{\tau_n}=\frac{\partial \delta n}{\delta t}$$

Continuidad Huecos

$$-\frac{1}{q}\frac{\partial J_p}{\partial x}-\frac{\delta p}{\tau_p}=\frac{\partial \delta p}{\partial t} \qquad D_p\frac{\partial^2 p(x,t)}{\partial x^2}-\mu_p\frac{\partial(\overline{E}\,p(x,t))}{\partial x}-\frac{\delta p(x,t)}{\tau}=\frac{\partial \delta p}{\delta t}$$

$$\frac{D}{\mu}=\frac{KT}{q} \qquad V_o=\frac{KT}{q}Ln\left(\frac{NaNd}{n_i^2}\right) \qquad Nd\cdot X_{no}=Na\cdot X_{po}$$

$$\varepsilon=\varepsilon_o\varepsilon_r \qquad \varepsilon_0=8.85x10^{-14}\,F/cm \qquad \varepsilon_r=11.8$$

$$V_0=-\frac{1}{2}WE_0$$

$$W=X_{n0}+X_{p0}$$

$$W=\left(\frac{2\varepsilon V_0}{q}\frac{Na+Nd}{NaNd}\right)^{1/2} \qquad W(V)=\left(\frac{2\varepsilon(V_0-V)}{q}\frac{Na+Nd}{NaNd}\right)^{1/2}$$

$$X_{po}=W\frac{Nd}{Na+Nd} \qquad X_{no}=W\frac{Na}{Na+Nd}$$

Unión PN Bajo polarización:

$$p(X_{no})=p_n\cdot e^{\frac{qV}{KT}} \qquad \Delta p_n=p_n\left(e^{\frac{qV}{KT}}-1\right) \qquad L_p=\sqrt{D_p\tau_p}$$

$$n(-X_{po})=n_p\cdot e^{\frac{qV}{KT}} \qquad \Delta n_p=n_p\left(e^{\frac{qV}{KT}}-1\right) \qquad L_n=\sqrt{D_n\tau_n}$$

$$J_{dn}=q\frac{D_n}{L_n}n_p\left(e^{\frac{qV}{kt}}-1\right) \qquad J_{dp}=q\frac{D_p}{L_p}p_n\left(e^{\frac{qV}{kt}}-1\right)$$

$$J_{TOTAL}=q\left(\frac{D_p}{L_p}p_n+\frac{D_n}{L_n}n_p\right)\left(e^{\frac{qV}{KT}}-1\right)$$

$$I_{TOTAL}=qA\left(\frac{D_p}{L_p}p_n+\frac{D_n}{L_n}n_p\right)\left(e^{\frac{qV}{KT}}-1\right) \qquad I_{TOTAL}=I_0\left(e^{\frac{qV}{KT}}-1\right)$$

Corriente saturación inversa: $I_0=qA\left(\frac{D_p}{L_p}p_n+\frac{D_n}{L_n}n_p\right)$

Compendio total corrientes diodo:

$$I_{dh+}(X_n) = qA\frac{D_p}{L_p}p_n\left(e^{\frac{qV}{KT}}-1\right)e^{-\frac{X_n}{L_p}}$$

$$I_{de-}(X_p) = qA\frac{D_n}{L_n}n_p\left(e^{\frac{qV}{KT}}-1\right)e^{-\frac{X_p}{L_n}}$$

$$I_{ah+}(X_p) = qA\frac{D_p}{L_p}p_n\left(e^{\frac{qV}{KT}}-1\right)+qA\frac{D_n}{L_n}n_p\left(e^{\frac{qV}{KT}}-1\right)\left(1-e^{-\frac{X_p}{L_n}}\right)$$

$$I_{ae-}(X_n) = qA\frac{D_n}{L_n}n_p\left(e^{\frac{qV}{KT}}-1\right)+qA\frac{D_p}{L_p}p_n\left(e^{\frac{qV}{KT}}-1\right)\left(1-e^{-\frac{X_n}{Lp}}\right)$$

Carga Regiones Neutras:

$$Q_p = qA\Delta p_n L_p \qquad I_p = \frac{Q_p}{\tau_p} \qquad I_p = \frac{qA\Delta p_n L_p}{\tau_p} = \frac{qA\Delta p_n D_p}{L_p}$$

$$Q_n = -qA\Delta n_p L_n \qquad I_n = \frac{Q_n}{\tau_n} \qquad I_n = \frac{qA\Delta n_p L_n}{\tau_n} = \frac{qA\Delta n_p D_n}{L_n}$$

$$\Delta p_n = p_n\left(e^{\frac{qV}{KT}}-1\right) \qquad \Delta n_p = n_p\left(e^{\frac{qV}{KT}}-1\right)$$

Transitorio:

$$I_p = \frac{Q_p}{\tau_p}+\frac{\partial Q_p}{\partial t} \qquad I_n = \frac{Q_n}{\tau_n}+\frac{\partial Q_n}{\partial t}$$

Capacitancia:

$$C = \frac{\varepsilon A}{W(V)}$$

Corrientes:

$$I_{EP} = qA\frac{D_p}{L_p}\left[\Delta p_E \coth\left(\frac{W_b}{L_p}\right)-\Delta p_c \operatorname{csc}h\left(\frac{W_b}{L_p}\right)\right]$$

$$I_{EN} = qA\frac{D_n}{L_n}\Delta n_E$$

$$I_C = qA\frac{D_p}{L_p}\left[\Delta p_E \operatorname{csc}h\left(\frac{W_b}{L_p}\right)-\Delta p_c \coth\left(\frac{W_b}{L_p}\right)\right]$$

$$I_B = qA\frac{D_n}{L_n}\Delta n_E + qA\frac{D_p}{L_p}(\Delta p_E+\Delta p_C)\tanh\left(\frac{W_b}{2L_p}\right)$$

Transistores

$$I_E = I_B + I_C$$
$$I_E = I_{Ep} + I_{En}$$

$$B = \frac{I_C}{I_{EP}} \qquad \gamma = \frac{I_{EP}}{I_E} \qquad \alpha = \frac{I_C}{I_E}$$

$$B\gamma = \alpha \qquad \beta = \frac{I_C}{I_B} \qquad \beta = \frac{\alpha}{1-\alpha}$$

Corrientes simplificadas:

$$I_E = qA\frac{D_p}{L_p}\Delta p_E\left(\frac{L_p}{W_b}+\frac{W_b}{3L_p}\right)$$

$$I_C = qA\frac{D_p}{L_p}\Delta p_E\left(\frac{L_p}{W_b}-\frac{W_b}{6L_p}\right)$$

$$I_B = qA\frac{D_p}{L_p}\Delta p_E\left(\frac{W_b}{2L_p}\right)$$

$$\beta_{simplificdo} = \frac{2L_p{}^2}{W_b{}^2}$$

JFET CANAL N

$$w(x) = \left[\frac{2\varepsilon}{qN_d} \left(V_0 - V_g + V_x \right) \right]^{1/2}$$

$$V_p = \frac{qN_d a^2}{2\varepsilon} - V_0$$

$$I = \frac{2Z\sigma a}{L} \left(V_0 + V_p \right) \left[\frac{V_d}{V_0 + V_p} - \frac{2}{3} \left(\frac{V_d + V_0 - V_g}{V_0 + V_p} \right)^{3/2} + \frac{2}{3} \left(\frac{V_0 - V_g}{V_0 + V_p} \right)^{3/2} \right]$$

$$Vd_{sat} = V_p + V_g$$

$$I_{dss} = \frac{2\sigma za}{L} \left(V_0 + V_p \right) \left[\frac{V_p}{V_0 + V_p} + \frac{2}{3} \left(\frac{V_0}{V_0 + Vp} \right)^{3/2} - \frac{2}{3} \right]$$

MOSFET

$$V_{TH} = \frac{qn_0 ab}{\varepsilon}$$

$$I_{dss} = \frac{\varepsilon \mu_n w V_{TH}^2}{2bL}$$

$$I_{sat} = I_{dss} \left(1 + \frac{V_{gs}}{V_{TH}} \right)^2$$