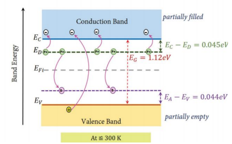
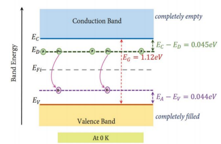
compensated **semiconductor: *n*-type ($N_D > N_A$)**



compensated **semiconductor: *n*-type ($N_D > N_A$)**



PN Junction Built in Potential:

$$\vec{J}_n^{drift+diff} = en\mu_n\vec{E}_x + eD_n\frac{dn(x)}{dx}$$

$$\vec{J}_n^{drift+diff} = en\mu_n\left(\vec{E}_x + D_n\frac{dn(x)}{dx}\frac{1}{n\mu_n}\right)$$

$$\boxed{\vec{E}(x) = -\frac{d\phi}{dx}} \quad \boxed{\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = \left(\frac{kT}{e}\right)}$$

$$0 = (q)\{n(x)\}(\mu_n)\left(\vec{E}_x + V_T\frac{dn(x)}{dx}\frac{1}{n(x)}\right)$$

$$\int d\phi = \int V_T\frac{dn(x)}{n(x)}$$

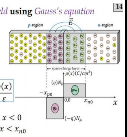
$$\phi_n - \phi_p = V_T \ln n(x)\Big|_{n_{po}}^{n_{no}}$$

$$\phi_n - \phi_p = V_T\ln\frac{n_{n0}}{n_{p0}} = V_T\ln\left[\frac{n_{n0}}{1}\frac{1}{n_{p0}}\right]$$

The PN Junction: *Electric field* **using** *Gauss's equation* 14

Poisson's equation:

$$\boxed{\frac{d^2\phi(x)}{dx^2} = -\frac{\rho(x)}{\varepsilon} = -\frac{d\vec{E}(x)}{dx}}$$



Gauss's equation:

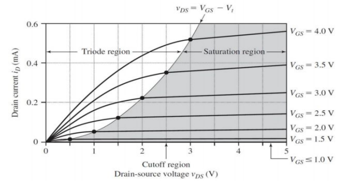
$$\boxed{\oint \vec{E}.dA = \frac{Q}{\varepsilon}} \Rightarrow \boxed{\frac{d\vec{E}(x)}{dx} = \frac{\rho(x)}{\varepsilon}}$$

$\rho(x) = (-q)N_A$ ***for*** $-x_{p0} < x < 0$
$\rho(x) = (q)N_D$ ***for*** $0 < x < x_{n0}$

The electric field in the p-region $(-x_{p0} < x < 0)$ can be computed as:

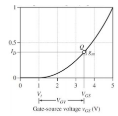
$$\vec{E}(x) = \int\frac{\rho(x)}{\varepsilon_{Si}}dx = \int\frac{(-q)N_A}{\varepsilon_{Si}}dx = \frac{(-q)N_A}{\varepsilon_{Si}}x + C_1$$

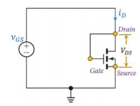
The *n-MOSFET*– i_D *vs.* v_{DS} *Characteristics* cont'd. 52



Transcond in the diode mode operation:

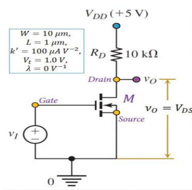
$$g_m = k * V_{OV} = 2\frac{I_D}{V_{OV}} = \sqrt{2k * I_D}$$

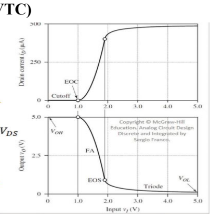




$$\frac{di_D}{dv_{GS}}\bigg|_{V_{GS}} = \frac{k}{2}\left[\frac{d}{dv_{GS}}(v_{GS} - V_t)^2\right]\bigg|_{V_{GS}}$$

Voltage Transfer Curve(VTC)

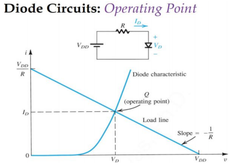




DC analysis with Multiple diodes:

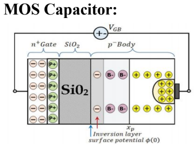
1. Open all diodes present in the circuit (n diodes = n opens).
2. Find voltage drops across all opens.
3. Identify all the open voltage drops that could bring the diode in its place to forward bias.
4. From all the open voltage drops that could bring the diode in its place to forward bias, SHORT the open with the highest voltage drop.
5. Discarding all previous calculations, repeat circuit analysis for the remaining opens.
6. Repeat steps 2-5 till the state (diode is OPEN or SHORT) for the last open has been obtained.
7. Final answer: After the states (diode is OPEN or SHORT) of all the opens have been determined, discard all previous calculations and repeat circuit analysis one last time with correctly applied states (diode is OPEN or SHORT) for all the opens.

Diode Circuits: *Operating Point*



Mosfets:

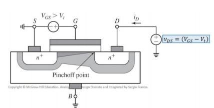
MOS Capacitor:

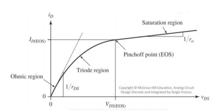


$V_{GB}(Q = 0) = -\phi_0$ **(flatband)**

Onset of strong inversion @ $\phi(0) = -\phi_p$

$$V_{GB0} = -\phi_0 - 2\phi_p - \frac{Q_{b0}}{C_ox}$$





MOSFET channel resistance in ohmic Region(r_{DS} **):**

$$i_D = k(V_{GS} - V_t)v_{DS}, \quad r_{DS} = \frac{v_DS}{i_D} = \frac{1}{k*V_{OV}}$$

MOSFET channel resistance in Saturation Region(r_o **):**

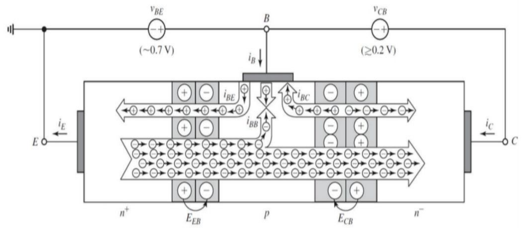
$$\boxed{i_D = \frac{1}{2}k(1 + \lambda v_{DS})(V_{OV})^2}, \quad \boxed{\frac{1}{r_o} = \frac{\partial i_D}{\partial v_{DS}}},$$

$$\frac{\partial i_D}{\partial v_{DS}} = \frac{1}{2}k(V_{OV})^2\lambda = \left[\frac{1}{2}k(V_{OV})^2\right]\lambda = I_{D(EOS)}\lambda, \quad r_o = \frac{1}{\lambda I_D(EOS)}$$

Im not writing its just pictures over pictures

How do you write over the doc

BJTS:



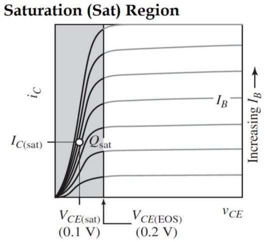
NPN BJT	
Edge of Conduction	$V_{BE(EOC)} = 0.6\,V$
On/FA/EOS	$V_{BE(on)} = 0.7\,V$
Saturation	$V_{BE(sat)} = 0.8\,V$
Edge of Saturation	$V_{CE(EOS)} = 0.2\,V$
Saturation	$V_{CE(sat)} = 0.1\,V$

$\alpha_F = \frac{\beta_F}{\beta_F+1} = \frac{i_c}{i_E}$

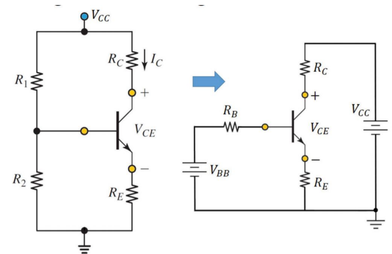
$\beta_F = \frac{i_c}{i_E}$

$$\boxed{\beta_{sat} = \left.\frac{I_{C(sat)}}{I_B}\right|_{Q_{sat}} < \beta_{FA}}$$

The Saturation (Sat) Region



__**Voltage Divider Biasing BJT:**__



$$R_B = \frac{R_1 R_2}{R_1 + R_2}$$

$$V_{BB} = V_{TH} = \frac{V_{CC}}{R_1 + R_2} R_2$$

$$\boxed{I_C = \beta_F \frac{V_{BB} - V_{BE}}{R_B + (\beta_F + 1) R_E}}$$

$$\boxed{V_{CE} = V_{CC} - I_C R_C - \frac{I_C}{\alpha_F} R_E}$$

If $V_{CE} > 0.2\,V$,
then the BJT is in FA mode