ECE250 Equation Sheet Test 1 April 1, 2010 (KEH)

Diode Equation: $Id = Is \cdot (e^{Vd/(nV_T)} - 1)$ where Is = reverse saturation current. Is ***DOUBLES*** for every 10 degree C rise

Vd is the anode-to-cathode voltage and Id is current flowing into anode

Thermal Voltage: V_T = kT/q = 25.7 mV at room temperature T = 300K.

DC load voltage: $Vdc = V_{m,s} - 0.7V - V_r/2$ (half-wave rect) $Vdc == V_{m,s} - 1.4V - V_r/2$ (full-wave rect)

Half-wave rectifier ripple voltage: $V_r = \frac{(V_{m,s} - 0.7V - V_r/2)/R_L}{f_{source} \cdot C}$ $V_{m,s}$ = peak source voltage

Full-wave diode bridge rectifier ripple voltage: $V_r = \frac{(V_{m,s} - 1.4V - V_r/2)/R_L}{2 f_{source} \cdot C}$ $V_{m,s}$ = peak source voltage

Full-wave diode bridge peak diode current: $I_{d\max} = \frac{V_m}{R_L} \cdot (1 + 2\pi) \cdot \sqrt{\frac{V_m}{2 \cdot V_r}}$, where $V_m = V_{m,s} - 2(0.7V)$

Small-Signal ac Model of Diode: $rd = \frac{n \cdot V_T}{Id_Q}$, where Id_Q is the dc (quiescent) component of the diode current.

Plotting Load Lines over nonlinear element's IV curve: First find Thevenin equivalent "looking out" from the terminals of the nonlinear element. Then plot load line: $I_{INTERCEPT}$ = Vth/Rth, and $V_{INTERCEPT}$ = Vth

Multiple Diode Analysis using 0.7 V battery model of diode: Define Id's flowing into each anode. Define Vd's anode-to-cathode. Guess which diodes are ON and replace them with 0.7 battery, replace OFF diodes with open circuit. Analyze circuit. Check to ensure diodes that are assumed ON have Id > 0, and diodes that are assumed OFF have Vd < 0.7 V.

Carrier Concentration in Intrinsic Si (1/cm³): $n_i^2 = BT^3 e^{-Eg/kT}$

at T=300K: B=5.4x10^{31}/(K^{3}cm^6), Eg=1.12 eV, k= Boltzmann's Constant = 8.62x10^{-5} eV/K, n_i=1.5 x 10^{10} 1/cm^3

Diffusion Current Density (A/cm²): $J_p = -qD_p \frac{dp}{dx}$ $J_n = qD_n \frac{dn}{dx}$ q = 1.6 x 10^{-19} Coulombs

D_p = 12 cm^2/s, D_n = 34 cm^2/s

Drift current Density (A/cm²): $J_{drift} = q(p\mu_p + n\mu_n)E$

Resistivity (Ω-cm) and Resistance (Ω): $\rho = 1/[q(p\mu_p + n\mu_n)]]$ R = ρL/A

***Carrier Concentration in n*-type Si (1/cm³)**: $n_{n0} = N_D$, $p_{n0} = n_i^2 / N_D$ ***in p-type Si* (1/cm³)**: $p_{p0} = N_A$, $n_{p0} = n_i^2 / N_A$

Built-In Junction Voltage (V): $Vo = V_T \ln(\frac{N_A N_D}{n_i^2})$

Depletion Region Capacitance (F): $C_j = \frac{C_{j0}}{(1 + \frac{V_R}{Vo})^m}$ ***where*** $C_{j0} = \varepsilon_{Si} A / (W_{depletion\_region})_{V_R=0}$

and m = junction grading coefficient = 1/3 to ½,

also note V_R is diode's CATHODE to ANODE voltage = -Vd