Midterm III

Information that will be provided with the exam

Permittivity of free space $\varepsilon_0 = 8.85*10^{-14}$ F/cm = $8.85*10^{-12}$ F/m

Element of charge q = $1.6*10^{-19}$ C

1 Coulomb is equivalent to $6.25*10^{18}$ charges.

Charge on an electron is -q

Relative permittivity (or relative dielectric constant) values for Si, SiO_2

Avagadro's number: $6.02*10^{23}$

Statement that if an element has an atomic weight of A, then A grams of that element will have $6.02*10^{23}$ atoms.

Saturation velocity for electrons in silicon: 10^7 cm/s

n_i (intrinsic carrier concentration in silicon at 300 K) = 10^{10} cm^{-3}

Conductivity (σ) and Drift Current Density (J) for electrons in Semiconductor:

$\boldsymbol{\sigma = qn\mu_n}$ where n is the volume carrier density and $\boldsymbol{\mu_n}$ is the electron mobility. Similar expression for holes with p (volume hole concentration) instead of n and hole mobility $\boldsymbol{\mu_p}$ instead of $\boldsymbol{\mu_n}$

J = σE, where **E** is the electric field

Parallel Plate Capacitor:

Capacitance per unit area = $\frac{\epsilon_0 \varepsilon_r}{t_{ox}}$ where t_{ox} is the dielectric thickness

MOSFET Linear Region:

NMOS: When $V_{DS} \le V_{GS} - V_T$

$$I_D = \mu_n C_{ox} \frac{W}{L}\left([V_{GS} - V_t]V_{DS} - \frac{v_{DS}^2}{2} \right)$$

PMOS: When $|V_{DS}| \le |V_{GS}| - |V_T|$

$$I_D = \mu_p C_{ox} \frac{W}{L}\left([V_{GS} - V_t]V_{DS} - \frac{v_{DS}^2}{2} \right)$$

Saturation Region:

NMOS: When $V_{DS} > V_{GS} - V_T$

$$I_D = \frac{1}{2}(\mu_n C_{ox})\left(\frac{W}{L}\right)(V_{GS} - V_t)^2$$

PMOS: When $|V_{DS}| > |V_{GS}| - |V_T|$

$$I_D = \frac{1}{2}(\mu_p C_{ox})\left(\frac{W}{L}\right)(V_{GS} - V_t)^2$$

Small signal model parameters:

Small signal transconductance $g_m = \frac{2I_D}{(V_{GS}-V_T)} = \sqrt{2\mu_n C_{ox}(\frac{W}{L})I_D}$

Unit conversion:

1 μm = 10^{-4} cm = 10^{-6} m; 1 nm = 10^{-7} cm = 10^{-9} m; 1 pA = 10^{-12} A; 1fF = 10^{-15} F

PART III

$$\begin{aligned}
\sin x &= \pm\cos(x \mp 90^\circ) \\
\cos x &= \pm\sin(x \pm 90^\circ) \\
\sin x &= -\sin(x \pm 180^\circ) \\
\cos x &= -\cos(x \pm 180^\circ) \\
\sin(-x) &= -\sin x \\
\cos(-x) &= \cos x
\end{aligned}$$

$$\mathbf{z} = x + jy = |\mathbf{z}|e^{j\theta}$$

$$x = \mathfrak{Re}(\mathbf{z}) = |\mathbf{z}|\cos\theta$$

$$y = \mathfrak{Im}(\mathbf{z}) = |\mathbf{z}|\sin\theta$$

$-\tan^{-1}(x) = \tan^{-1}(-x)$

Euler's Identity: $e^{j\theta} = \cos\theta + j\sin\theta$

$\mathbf{z}_1 = x_1 + jy_1$ $\qquad$ $\mathbf{z}_2 = x_2 + jy_2$

$\mathbf{z}_1 = \mathbf{z}_2$ iff $x_1 = x_2$ and $y_1 = y_2$ $\qquad$ $\mathbf{z}_1 + \mathbf{z}_2 = (x_1 + x_2) + j(y_1 + y_2)$

$\mathbf{z}_1\mathbf{z}_2 = |\mathbf{z}_1||\mathbf{z}_2|e^{j(\theta_1+\theta_2)}$ $\qquad$ $\dfrac{\mathbf{z}_1}{\mathbf{z}_2} = \dfrac{|\mathbf{z}_1|}{|\mathbf{z}_2|}\,e^{j(\theta_1-\theta_2)}$