Announcements:

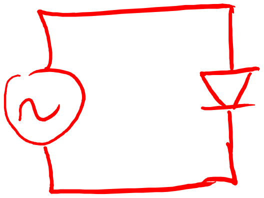
1. Announcement

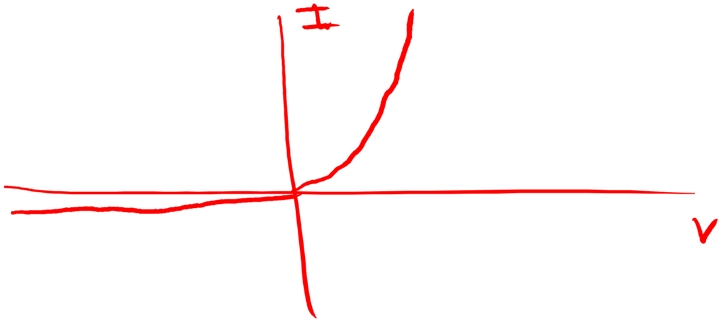
EECS 70A: Network Analysis

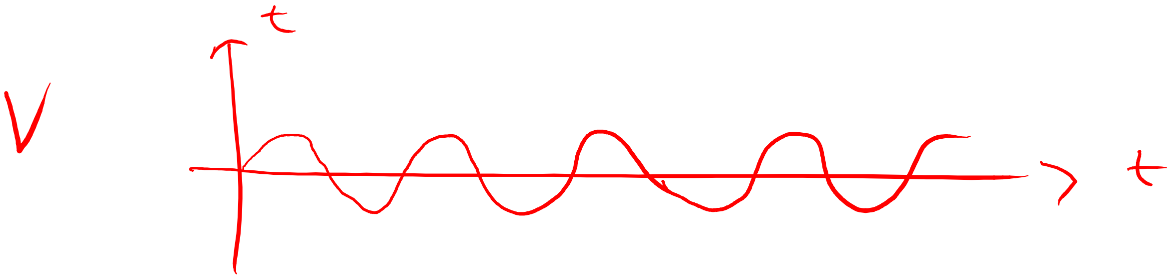
3 June 2014

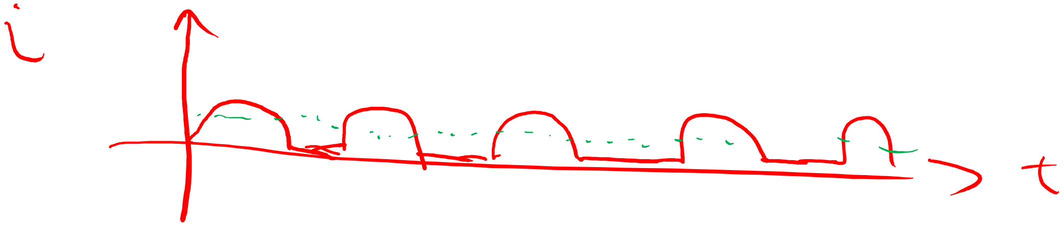
http://www.peachparts.com/shopforum/showthread.php?t=256624

Rectification





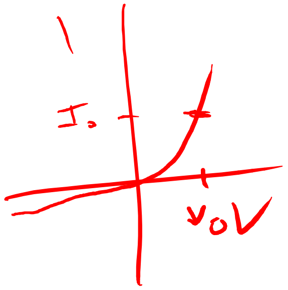




$$i(t) = i_{dc} + i_{ac} \cos(2\omega t) + \dots$$

$$I(V) = I(V_0) + \frac{dI}{dV}\Big|_{V_0}(V-V_0)$$

$$+ \frac{d^2I^2}{dV^2}\Big|_{V_0}(V-V_0)^2 + \cdots$$



$$V(t) = \underset{DC}{V_0} + V_{ac}\cos(\omega t)$$

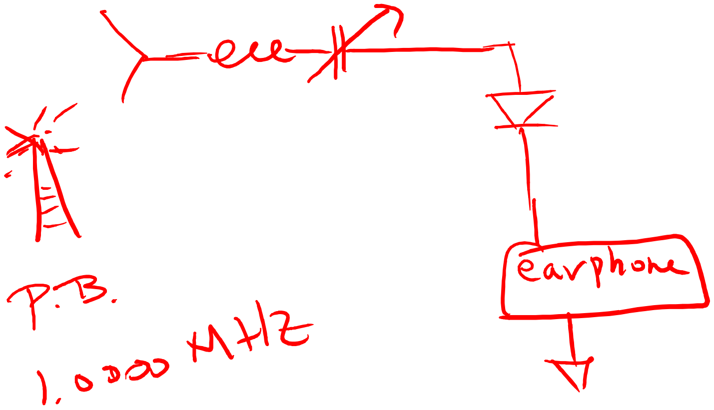
$$I = \underset{DC}{I(V_0) +} \quad \underset{\omega}{\frac{dI}{dV}\Big|_{V_0}(V_{ac}\cos\omega t)} + \frac{d^2I}{dV^2}\Big|_{V_0}(V_{ac}\cos\omega t)^2 + \cdots$$

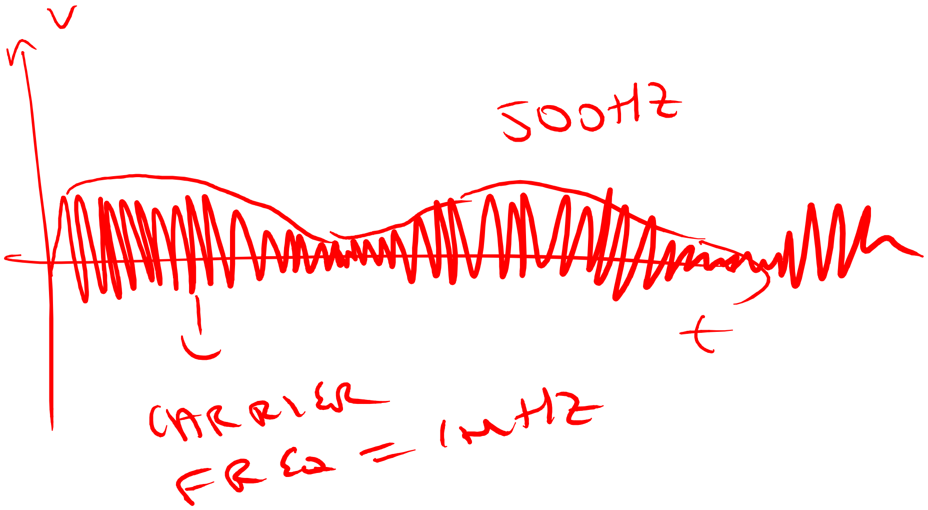
$$\frac{1}{2}\frac{d^2I}{dV^2}\Big|_{V_0} V_{ac}^2 \leftarrow$$

$$+ \frac{1}{2}V_{ac}^2\frac{d^2I}{dV^2}\Big|_{V_0}\cos(2\omega t)$$

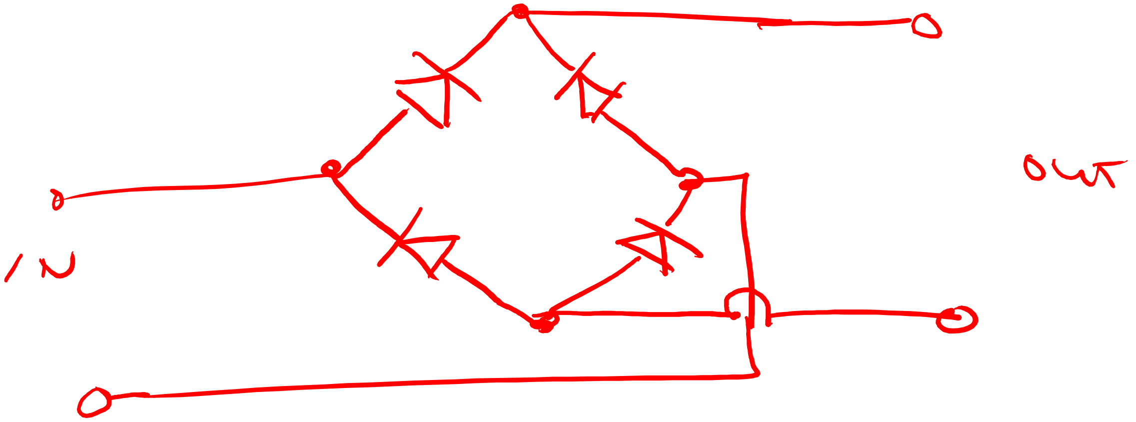
$$\cos^2\theta = \frac{1}{2}(1+\cos 2\theta)$$

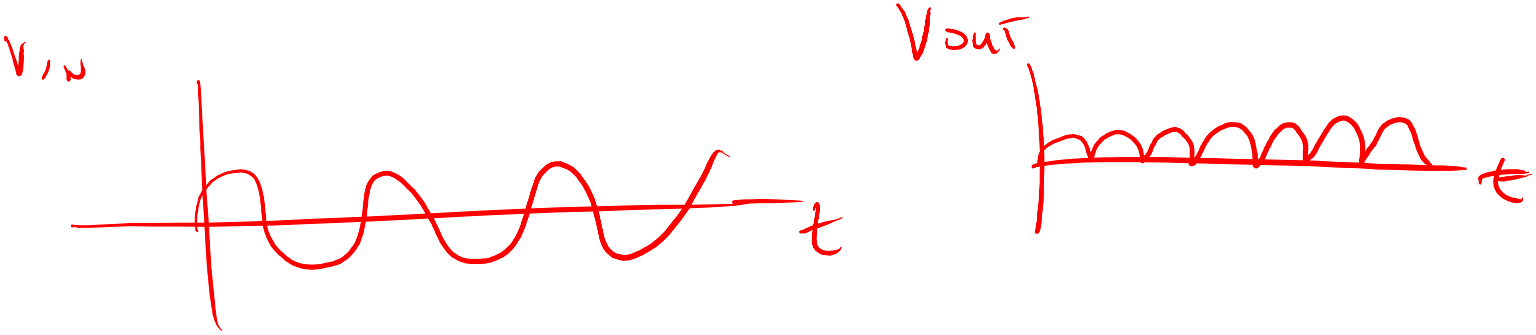
AM Radio Schematic





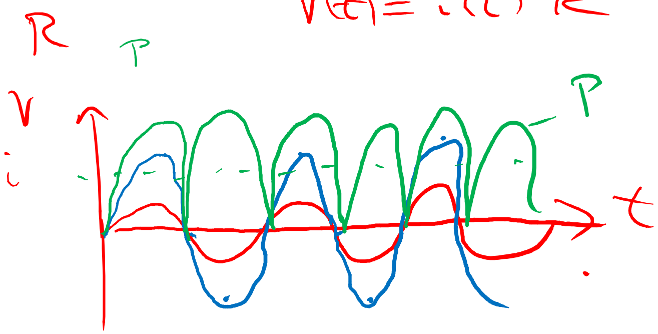
DIODE BRIDGE





Power

$V(t) = i(t)\ R$



$$P(t) = i(t)\,v(t)$$

$$v(t) = V_m \cos(\omega t + \theta_v)$$

$$i(t) = i_m \cos(\omega t + \theta_i)$$

$$P(t) = i(t)\,v(t) = V_m i_m \cos(\omega t + \theta_v)\cos(\omega t + \theta_i)$$

$$= \tfrac{1}{2} V_m i_m \cos(\theta_v - \theta_i) \leftarrow$$

$$+ \tfrac{1}{2} V_m i_m \cos(2\omega t + \theta_v + \theta_i)$$

$$\langle P \rangle = \frac{1}{T}\int_0^T P(t)\,dt = \tfrac{1}{2} V_m i_m \cos(\theta_v - \theta_i)$$

$$\tfrac{1}{2}\bar{V}\bar{I}^* = \tfrac{1}{2} V_m i_m e^{j(\theta_v - \theta_i)}$$

$$\bar{V} = V_m e^{j\theta_v}$$

$$\bar{I} = i_m e^{j\theta_i}$$

$$\mathrm{Re}\left[\tfrac{1}{2}\bar{V}\bar{I}^*\right] = \tfrac{1}{2} V_m i_m \cos(\theta_v - \theta_i)$$

$$= \langle P \rangle$$

Case 1: Resistor

$$\tilde{V} = \tilde{I} \, Z = \tilde{I} R$$

$$\langle P \rangle = \frac{1}{2} \mathrm{Re}\left[\tilde{I} R \tilde{I}^* \right] = \frac{1}{2} R \, \mathrm{Re}\left[\tilde{I} \tilde{I}^* \right]$$

$$= \frac{1}{2} R \, |\tilde{I}|^2$$

$$u = a + jb \qquad u^* = a - jb$$

$$u u^* = a^2 + b^2 = |u|^2$$

$$\langle P \rangle = \frac{1}{T} \int_0^T V_m \cos(\omega t + \theta_v) \cos(\omega t + \theta_i) \, dt$$

$$= \frac{1}{T} V_m i_m \underbrace{\int_0^T \cos^2 \omega t) \, dt}_{\frac{1}{2}}$$

$$= \frac{1}{2} V_m i_m$$

Case 2: Capacitor

$$I I^* = |I|^2$$

$$V = I Z = I \frac{1}{j\omega C}$$

$$\langle P \rangle = \frac{1}{2} Re\left[V I^*\right] = \frac{1}{2} Re\left[I \frac{1}{j\omega C} I^*\right]$$

$$= \frac{1}{2} Re\left[|I|^2 \frac{1}{j\omega C}\right] = \frac{1}{2}|I|^2 Re\left[\frac{1}{j\omega C}\right] = 0$$

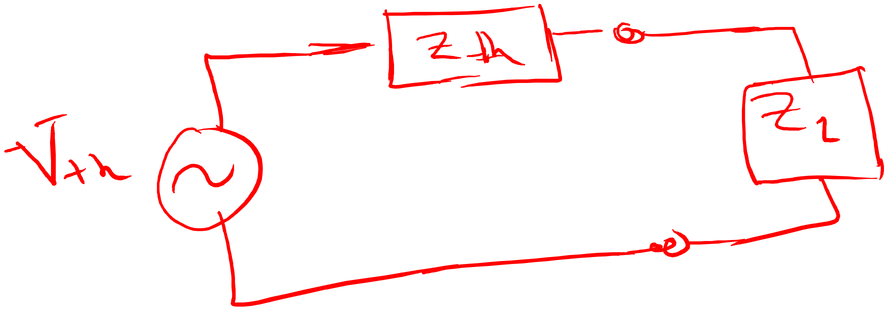
$$\frac{1}{j\omega C} = -j\frac{1}{\omega C} = 0 + \left(-\frac{1}{\omega C}\right) j$$

$$V = I j\omega L$$

$$\langle P \rangle = \frac{1}{2} Re\left[I j\omega L I^*\right] = \frac{1}{2}|I|^2 Re\left[j\omega L\right]$$

$$= 0$$

Maximum Power Transfer



$$Z_{th} = R_{th} + jX_{th}$$

$$Z_L = R_L + jX_L$$

$$P = \frac{1}{2}\mathrm{Re}\left[V_L I_L^*\right] =$$

$$V_L = \frac{Z_L}{Z_{th}+Z_L} V_{th} \qquad I_L = \frac{V_{th}}{Z_{th}+Z_L}$$

$$P = \frac{1}{2}|V_{th}|^2 \frac{R_L}{(R_{th}+R_L)^2+(X_{th}+X_L)^2}$$

max $\quad X_{th} = -X_L \quad R_{th} = R_L$

$$\boxed{Z_L = Z_{th}^*}$$

Digital Circuits

0 1

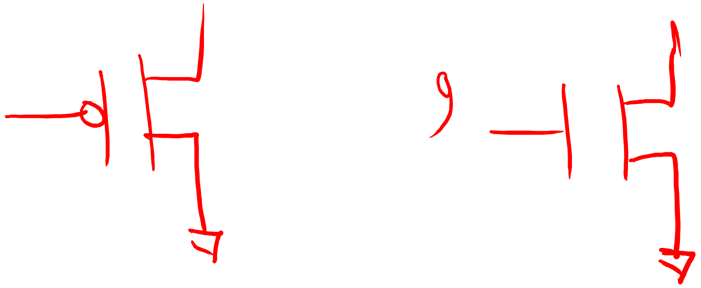
AND

NOR

NOT

INVERTER

pMOS nMOS



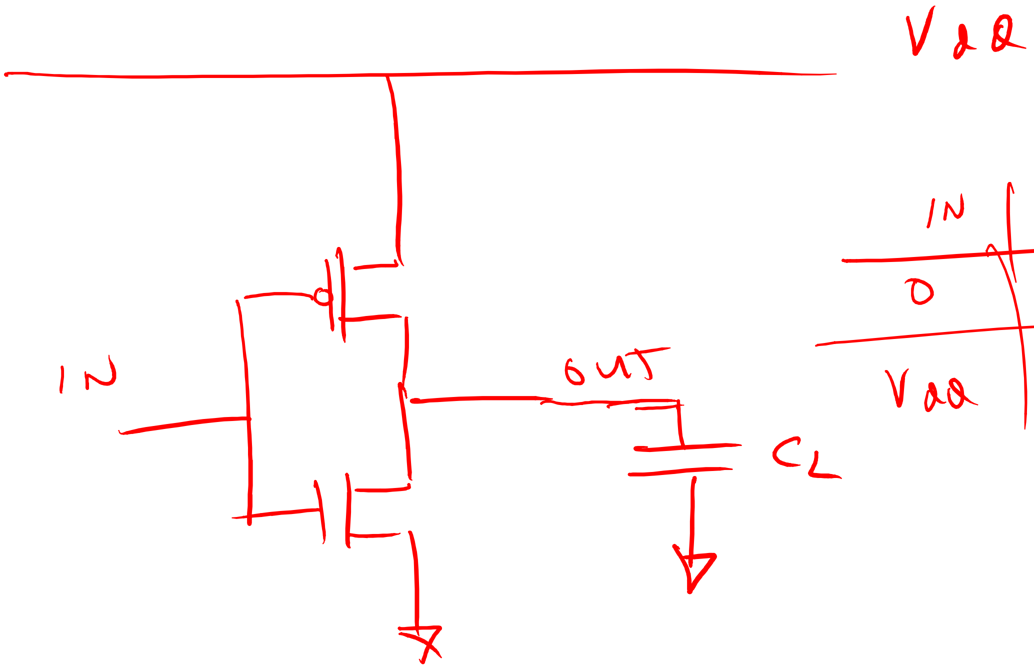
$V_g = 0$ SHORT

$V_g = V_{dd}$ OPEN

$V_g = 0$ OPEN

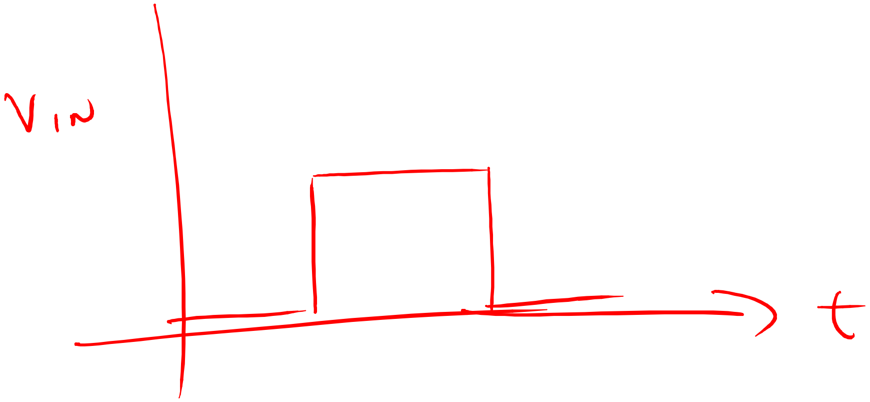
$V_g = V_{dd}$ SHORT

CMOS inverter

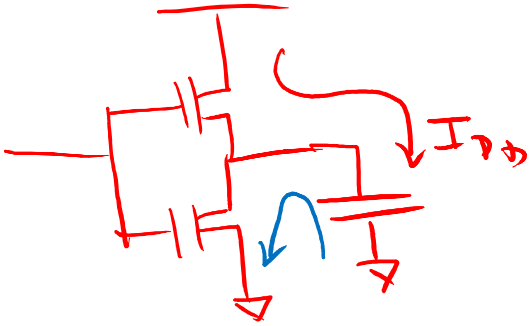


IN	OUT
0	Vdd
Vdd	0

Dynamic power



$$P_{DYN} = \frac{1}{2} C V_{dd}^2 F_{clk}$$



$$\frac{1}{2} C_{Load} V_{DD}^2$$

ENERGY COST
TO FLIP BIT