types of circuit analysis

- DC analysis
- transient analysis
- steady state – response to sinusoidal inputs
  – frequency response

inductor

frequency response

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inductor

$$\phi = LI$$

$$V = \frac{d\phi}{dt} = \frac{d}{dt}(LI)$$

$$\boxed{V = L\frac{dI}{dt}}$$

Loop radius R
wire diameter d

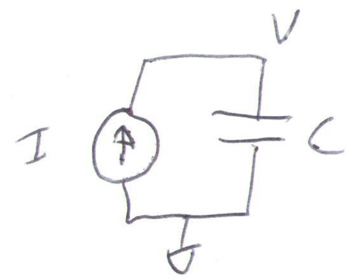
$$L \cong \mu R \ln\left(\frac{R}{d}\right)$$

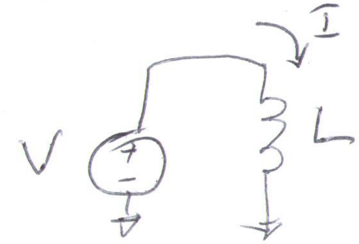
μ ↑ $4\pi \times 10^{-7}\,\frac{H}{m}$

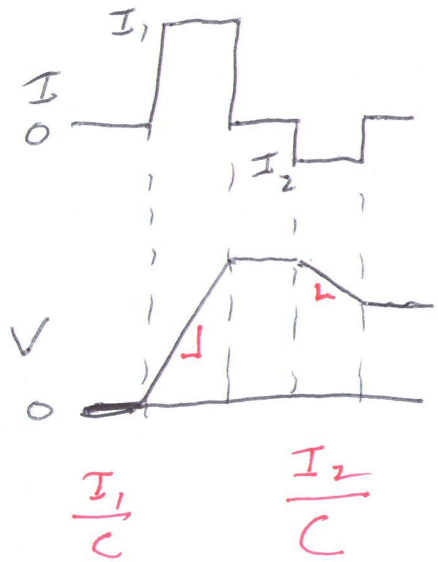
$$Q = CV \qquad \phi = LI$$

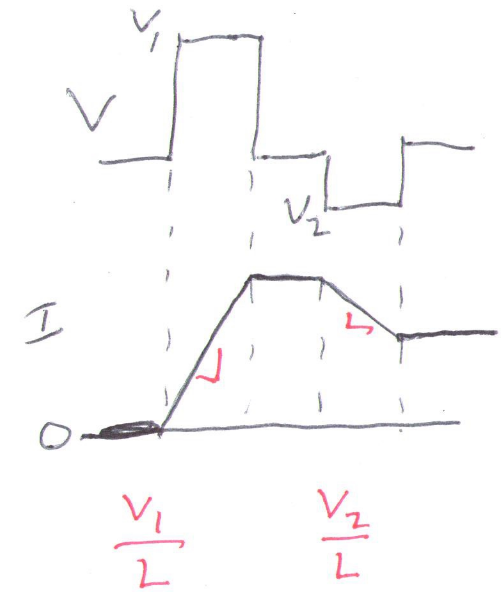
$$I = C\frac{dV}{dt} \qquad V = L\frac{dI}{dt}$$

$$U = \frac{1}{2}CV^2 \qquad U = \frac{1}{2}LI^2$$

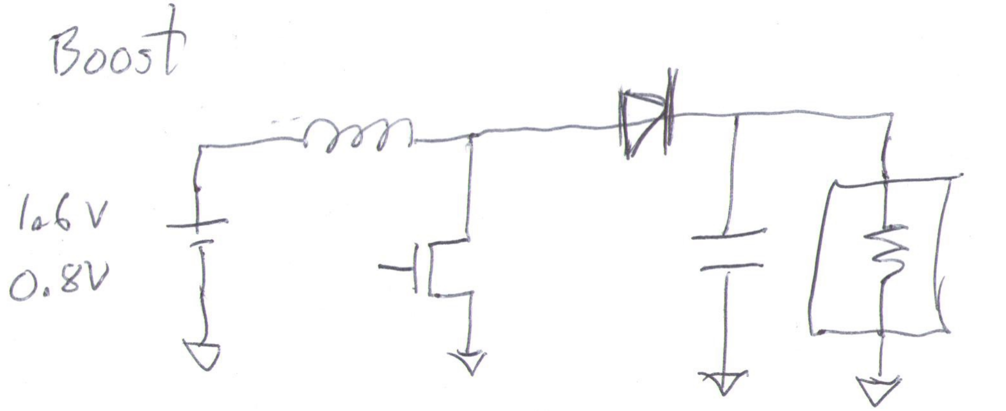








Boost



wants 5V

EX: 2 chips: wire 1mm long

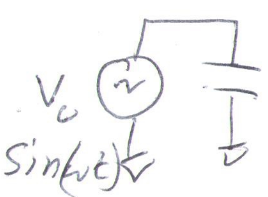
$C = 1pF$

$L = 1nH$

Chip 1

$f = 60\ Hz$

$\omega = (2\pi)(60\ Hz) = 400\ \frac{rad}{s}$



chip 2

3 GHz

$\omega = (2\pi)(3\times10^9\ Hz)$

$= 2\times10^{10}\ \frac{rad}{s}$

$I = C\frac{dV}{dt} = C\frac{d}{dt}(V_0 \sin \omega t)$

$= \omega C V_0 \cos(\omega t)$

Resistor: $V = IR$ $R = \frac{V}{I}$

capacitor, inductors } $\tilde{V} = \tilde{I} Z$

$|Z| = \frac{|V|}{|I|}$

$|Z_c| = \frac{|V|}{|I|} = \frac{|V_0 \sin(\omega t)|}{|\omega C V_0 \cos(\omega t)|} = \frac{V_0}{\omega C V_0}$

$|Z_c| = \frac{1}{\omega C}$

$f = 60\ Hz$

$\omega = 400\ \frac{rad}{sec}$

$|Z_c| = \frac{1}{(400)(10^{-12} F)}$

$= 2.5\times10^9\ \Omega$

$= 2.5\ G\Omega$

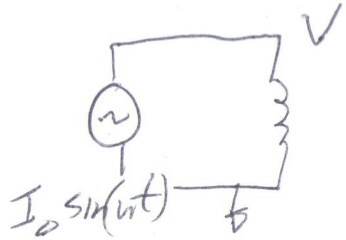
$f = 3\ GHz$

$\omega = 2\times10^{10}\ \frac{rad}{s}$

$|Z_c| = \frac{1}{\omega C}$

$= \frac{1}{(2\times10^{10}\ \frac{rad}{s})(10^{-12} F)}$

$= 50\ \Omega$



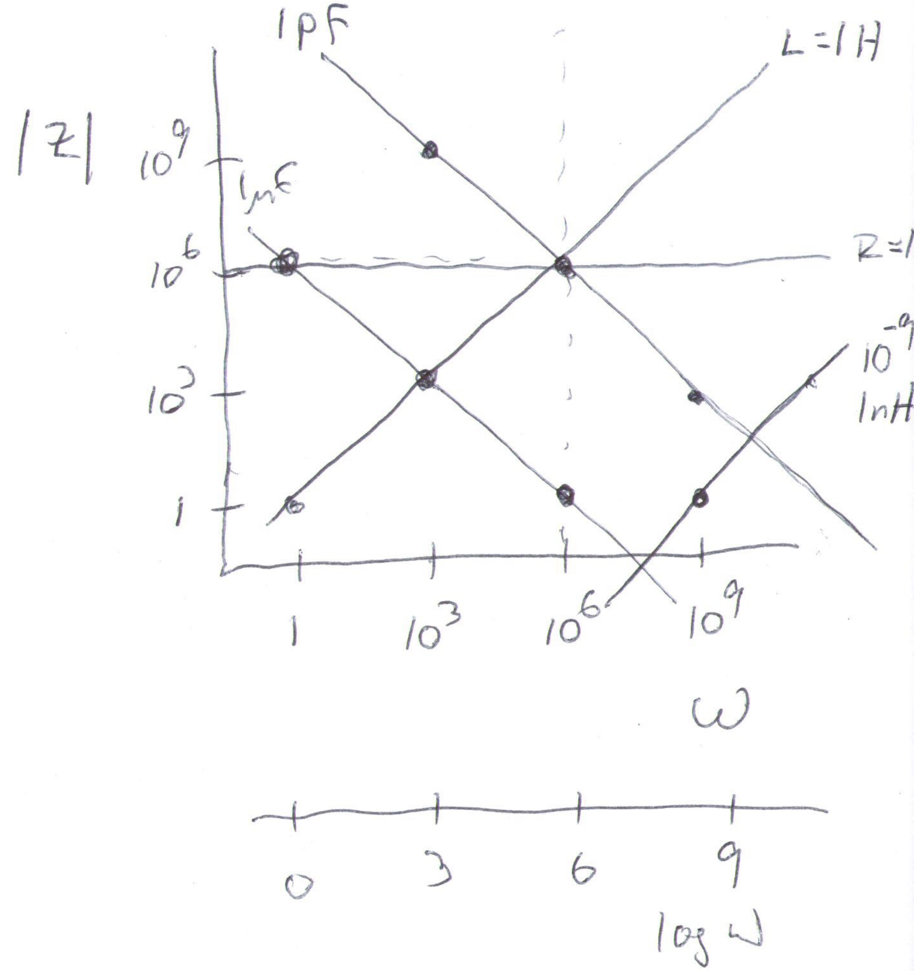
$$V = L\frac{dI}{dt}$$
$$= L\frac{d}{dt}\left(I_0 \sin\omega t\right)$$
$$= \omega L I_0 \cos(\omega t)$$

$$|Z_L| = \frac{|V|}{|I|} = \frac{|\omega L I_0 \cos(\omega t)|}{|I_0 \sin(\omega t)|} = \frac{\omega L I_0}{I_0}$$

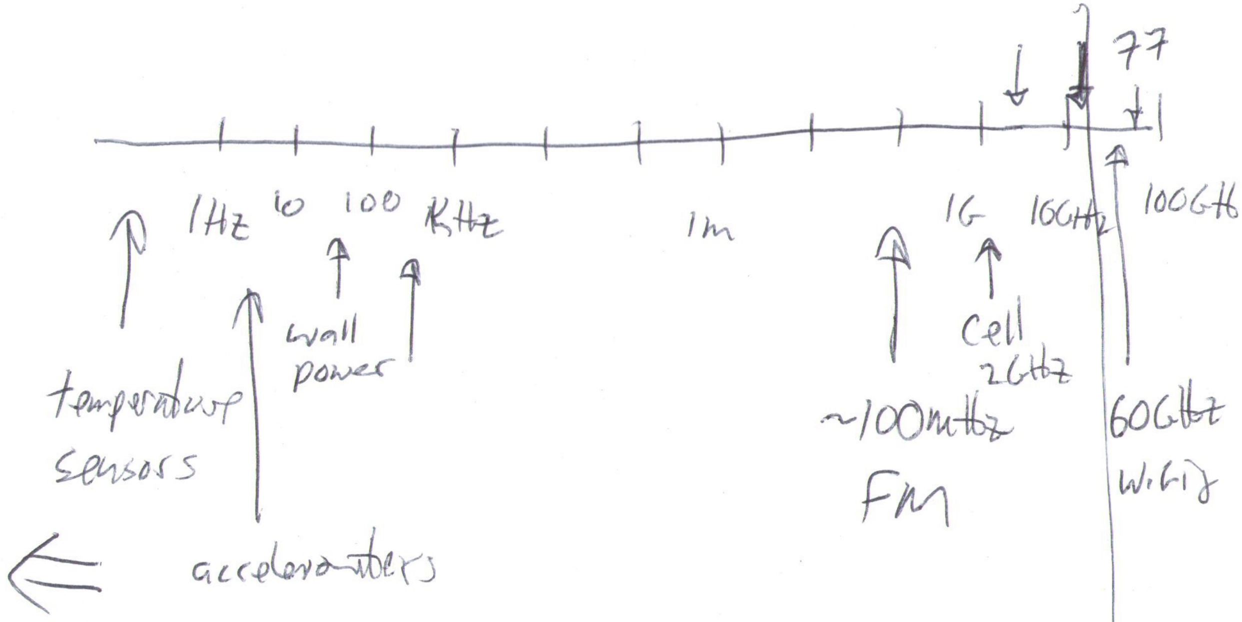
$$|Z_L| = \omega L$$

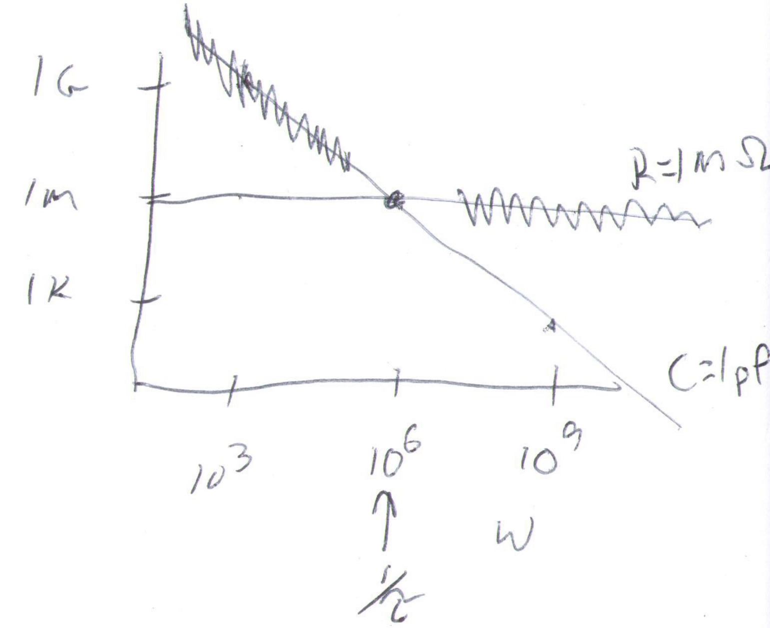
60 Hz	3 GHz
$\omega = 400$	$\omega = 2\times10^{10}$
$\lvert Z_L\rvert = \omega L$	$\lvert Z_L\rvert = \omega L$
$= \left(400\frac{\text{rad}}{s}\right)\left(10^{-9}\,H\right)$	$= (2\times10^{10})(10^{-9})$
$= 0.4\,\mu\Omega$	$= 20\,\Omega$

$$|Z_C| = \frac{1}{\omega C} \qquad |Z_L| = \omega L$$

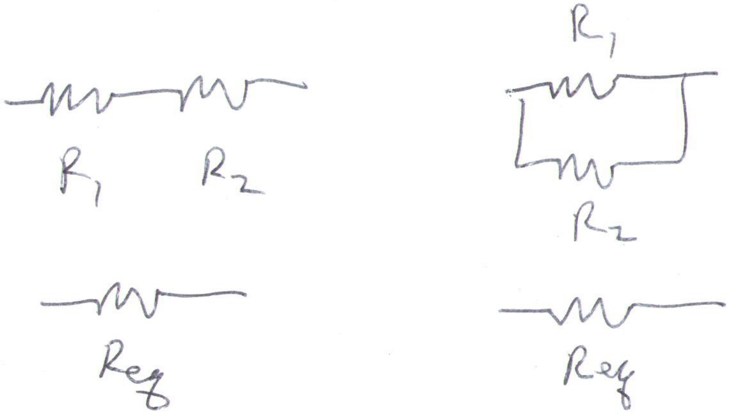


$$|Z_C| = \frac{1}{\omega C} \qquad |Z_L| = \omega L$$

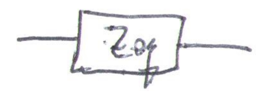




Series & parallel resistors



$\max(R_1, R_2)$ $\min(R_1, R_2)$



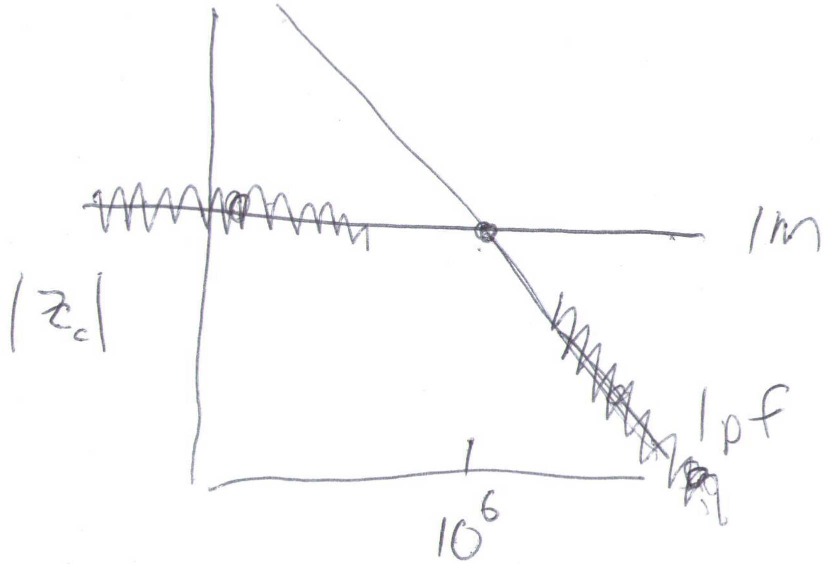
$$|Z_{eq}| = \max(R, |Z_c|)$$

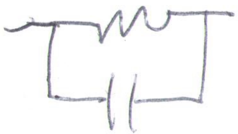
$$\frac{1}{\omega C}$$

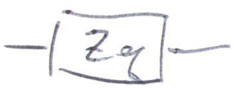
$$|Z_c| = R$$

$$\frac{1}{\omega C} = R$$

$$\omega = \frac{1}{RC} = \frac{1}{\tau}$$

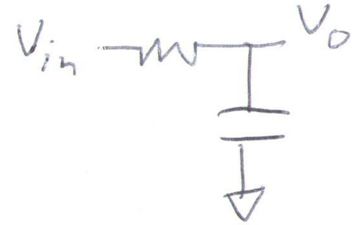






$\min(R, |Z_c|)$

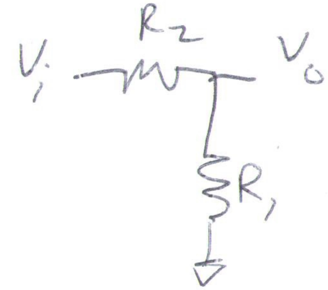
filters



$V_o = (\quad) V_{in}$

$\frac{V_o}{V_{in}} = (\quad)$

Voltage divider

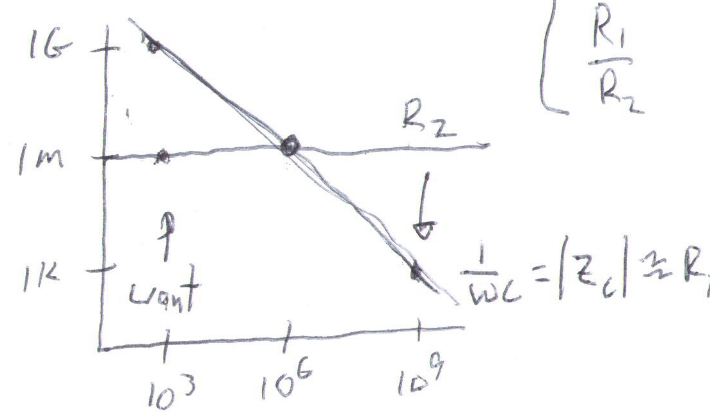


$V_o = \left(\frac{R_1}{R_1 + R_2}\right) V_{in}$

$\frac{V_o}{V_{in}} = \frac{R_1}{R_1 + R_2}$

$\simeq \begin{cases} 1 & R_1 >> R_2 \\ \frac{R_1}{R_2} & R_1 << R_2 \end{cases}$

R = 1M
C = 1pf

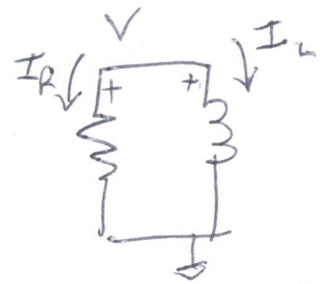


gain $= \frac{V_o}{V_i} \simeq 1$

$\frac{R_1}{R_2}$

low pass
single pole

time domain



$$V(t) = V_0 e^{-t/\tau}$$

$$\tau = RC$$

$$I(t) = I_0 e^{-t/\tau}$$

$$\tau = L/R$$

$$V = L \frac{dI_L}{dt}$$

$$V = I_R R = -I_L R$$

$$L \frac{dI_L}{dt} = -I_L R$$

$$\frac{dI_L}{dt} = -I_L \frac{R}{L}$$

$$= -\frac{1}{\tau} I_L \qquad \tau = L/R$$

$$I_L(t) = I_0 e^{-t/\tau}$$