R_L Q dependence varies with each circuit

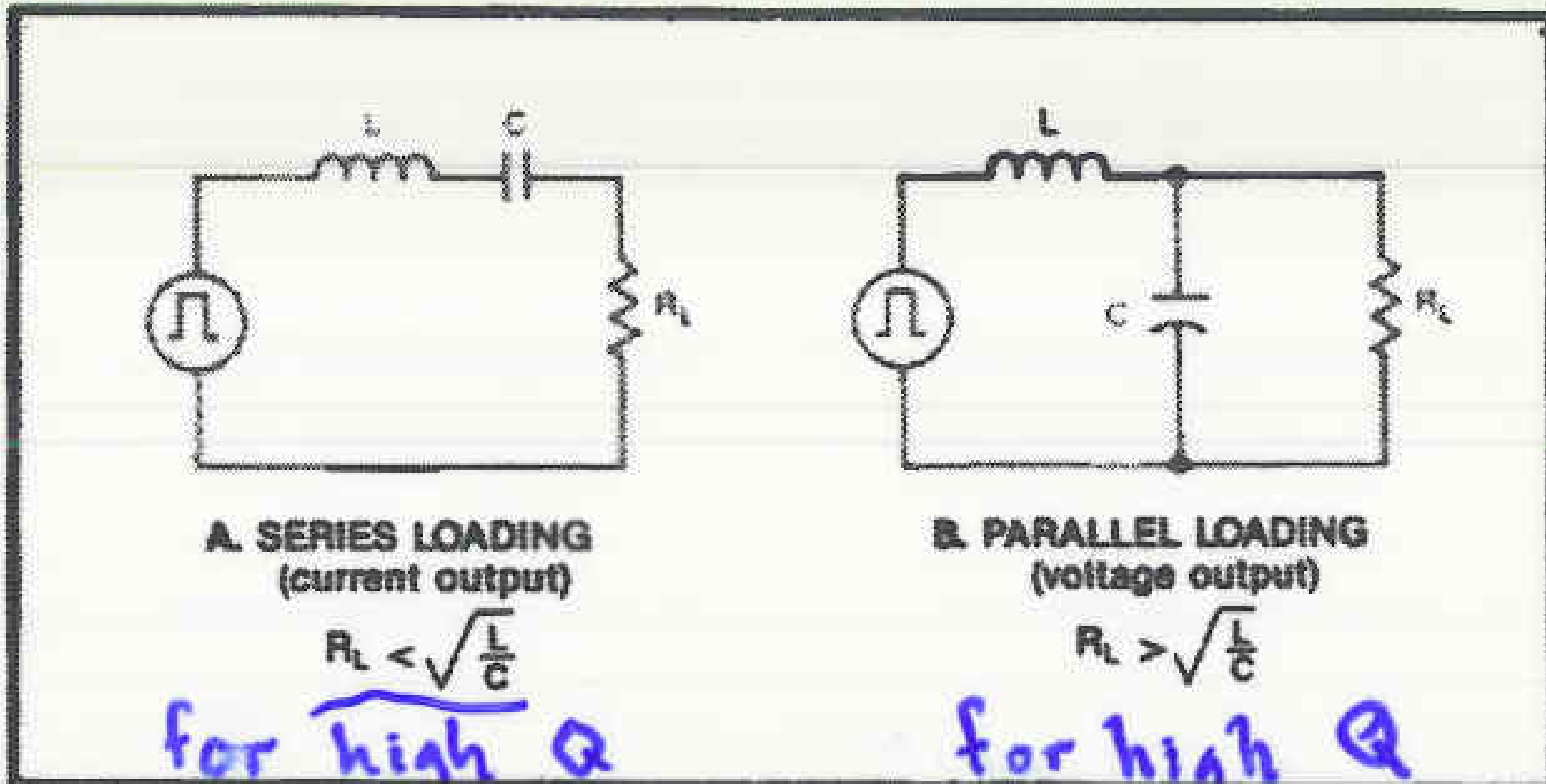
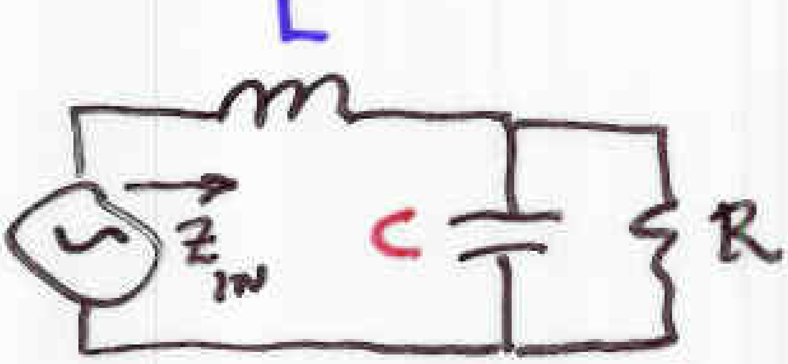


Fig. 9 - Resonant Mode Loading

$Q(\text{series}) \simeq \dfrac{Z_0}{R}$ $\qquad$ $Q(\text{parallel}) \simeq \dfrac{R}{Z_0}$ ← Suprise Pbm 19.A

$R\downarrow$ $Q\uparrow$ $\qquad$ $R\uparrow$ $Q\uparrow$



$$\frac{V_o}{V_{IN}} = \frac{Z_2}{Z_{IN}}$$

Z_2

Z_{RC}

Do the $\frac{V_o}{V_i}$ again with

<u>Same</u> $R > Z_c = \sqrt{\frac{L}{C}}$

Same $f_{RC} < f_{LC} < f_{RL}$

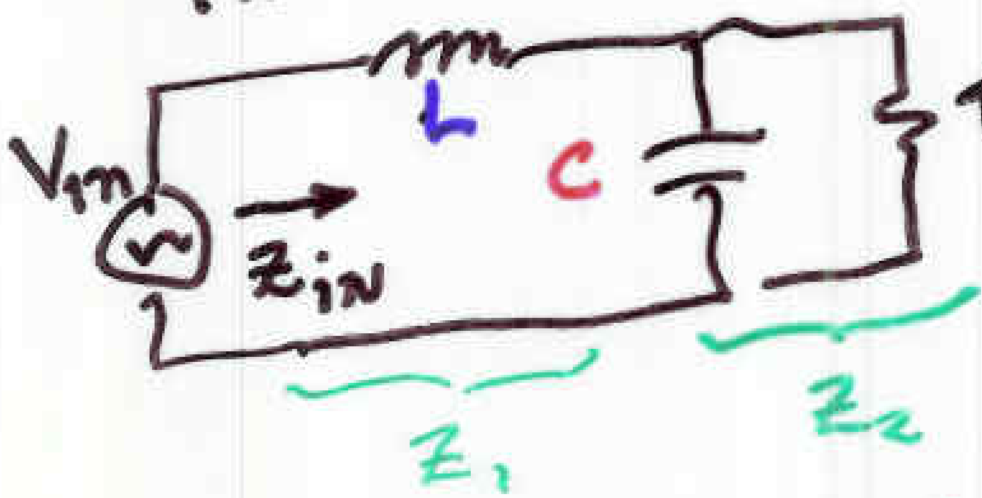
1st plot $\overbrace{R \parallel Z_c}^{Z_2}$ vs f

plot $Z_{IN}(f)$

Divide $\frac{Z_2}{Z_{IN}}$

Voltage Divider for Load across C in a series resonant circuit

Call it a parallel res



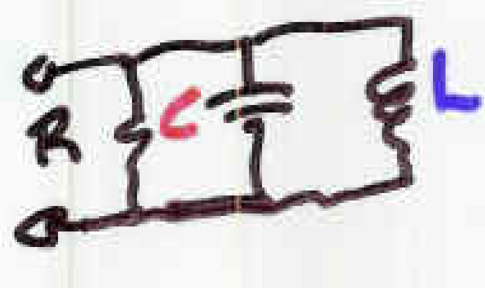
V_{out} ← Z_{out}

$R \parallel L \parallel C$

$$\frac{V_o}{V_i} = \frac{Z_2}{Z_1 + Z_2} = \frac{Z_2}{Z_{in}}$$

$$= Z_1 \underbrace{\frac{Z_2}{Z_1 + Z_2}}_{Z_{out}} \frac{1}{Z_1} = \frac{Z_{out}}{Z_1}$$

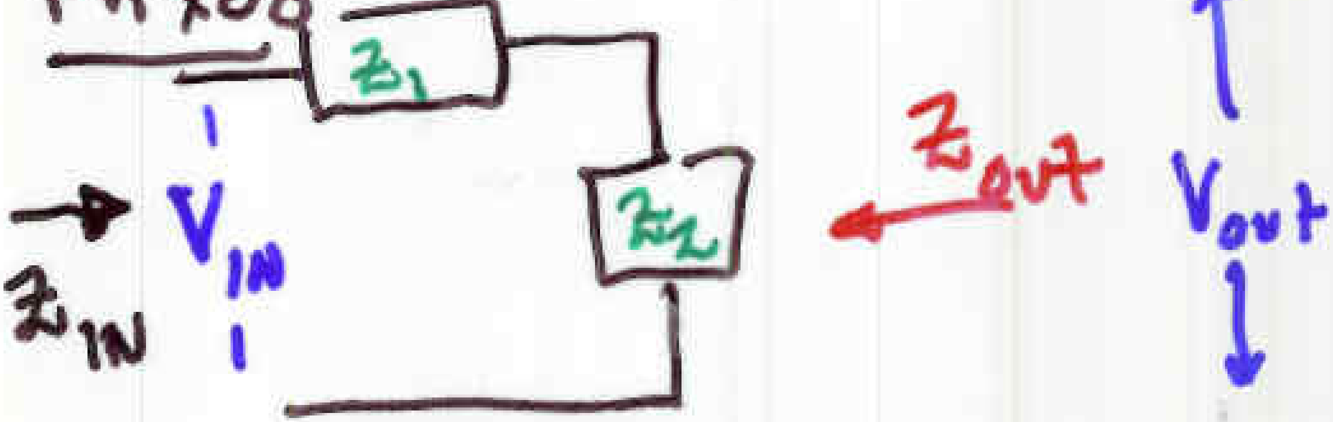
Recognize Z_{out} is



Take the case $R > Z_C$

$\Longrightarrow$ heirarchy of frequencies

Mixed

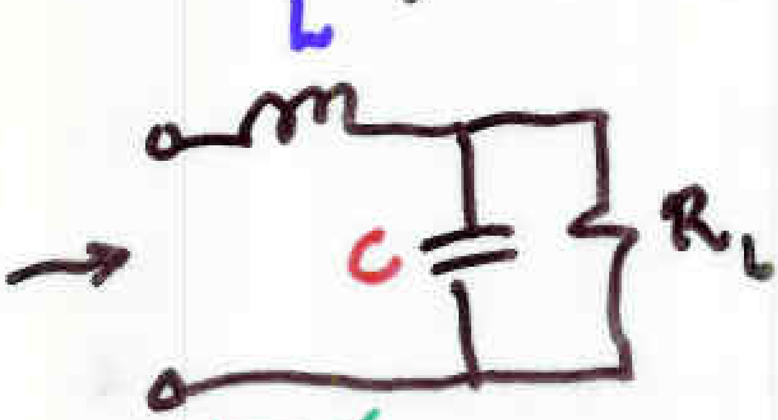


$Z_{IN} = Z_1 + Z_2$, $Z_{out} = Z_1 \parallel Z_2$

$Z_1 Z_2 / Z_1 + Z_2$

$$\frac{V_o}{V_{IN}} = \frac{Z_2}{Z_1 + Z_2} = \underbrace{\frac{Z_2}{Z_{IN}} = \frac{Z_{out}}{Z_1}}_{\text{Choose easier one}}$$

Example



$$\frac{V_o}{V_i} = \frac{\overbrace{L \parallel C \parallel R}^{Z_{out}}}{wL}$$

$Z_1 = wL$

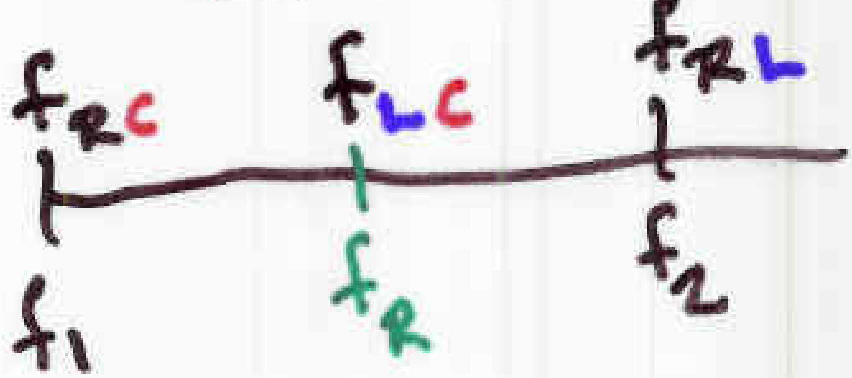
$Z_{out} = R \parallel L \parallel C$

Consider the cases in Z_{out}

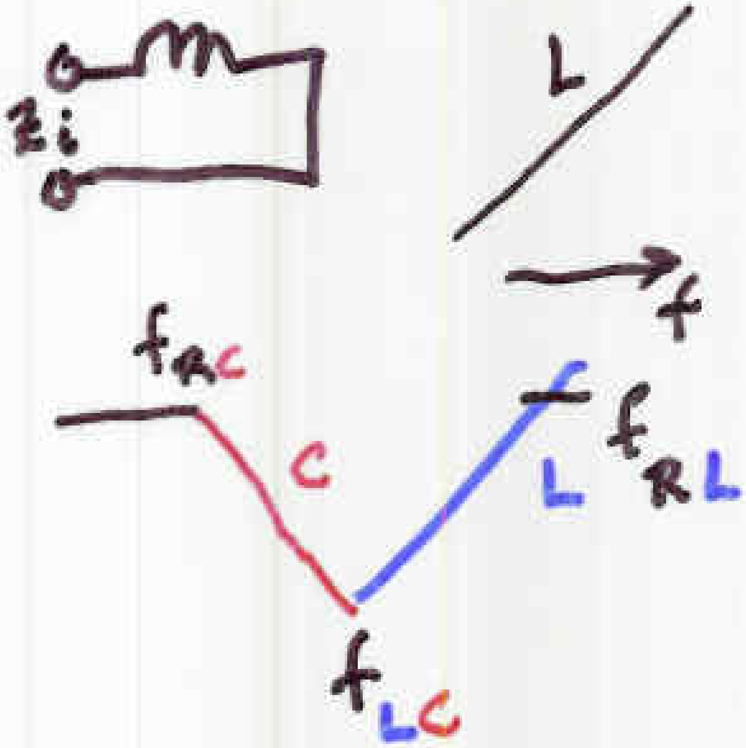
$$f_1 = \frac{1}{2\pi R C} \quad \text{is lowest} = f_{RC}$$

$$f_R = \frac{1}{2\pi\sqrt{LC}} \quad \text{middle} = f_{LC}$$

$$f_2 = \frac{R}{2\pi L} \quad \text{highest} = f_{RL}$$



$$\frac{V_o}{V_{IN}} = \frac{Z_{out}}{Z_1} = \frac{R \,\|\, Z_L \,\|\, Z_C}{Z_L}$$



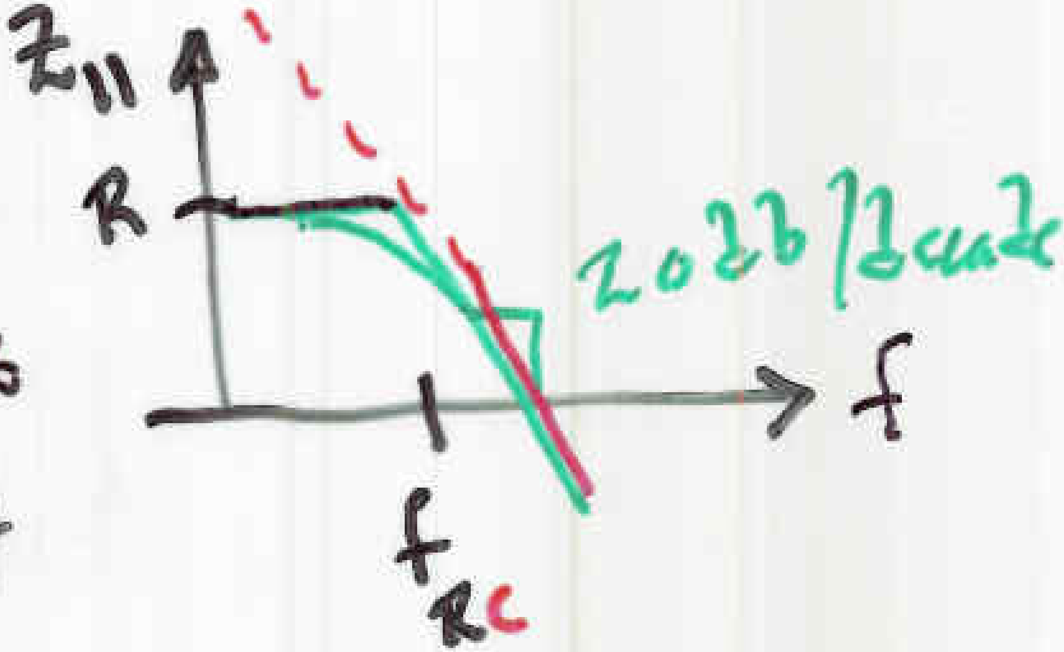
Compare $Z_i(f)$

$f < f_{LC}$ $\quad Z_i\left(\begin{smallmatrix}\text{large}\\ R\end{smallmatrix}\right) > Z_i\left(R=0\right)$

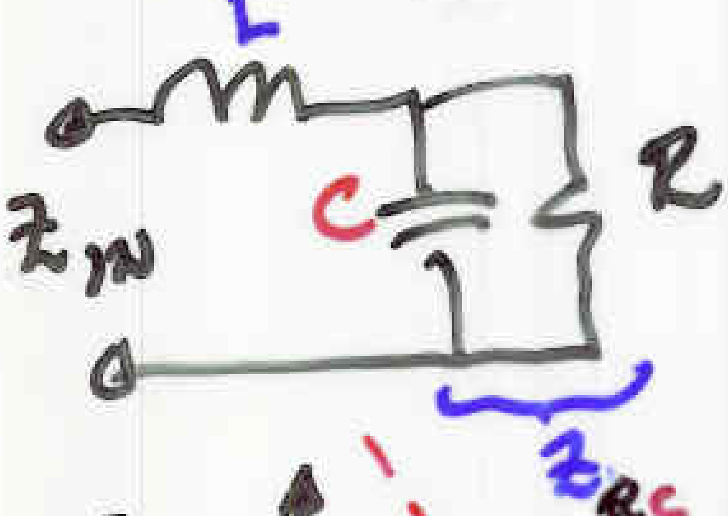
$i_{IN}(R=0) > i_{IN}(R=\infty)$

$f > f_{RL}$ $\quad Z_{IN}$ <u>same</u> for $R=0$ or R large

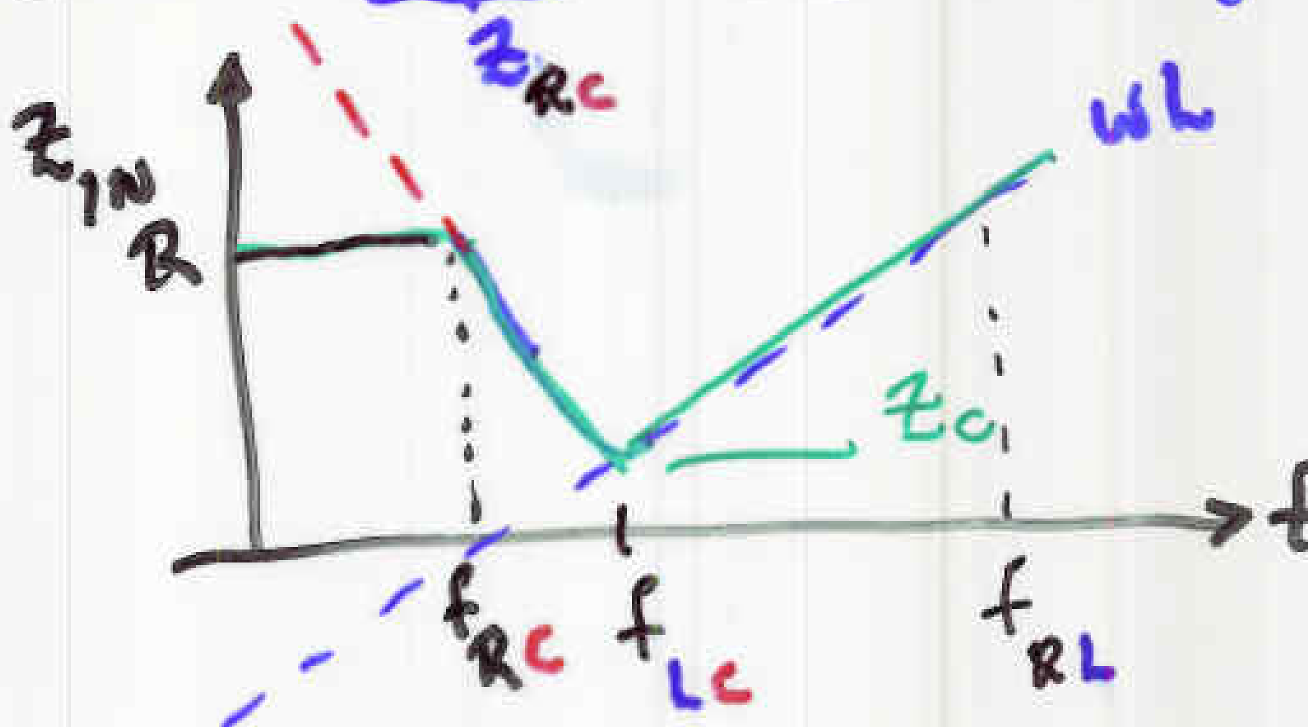
$f_{LC} < f < f_{LR}$?



Parallel Z
Take
smallest

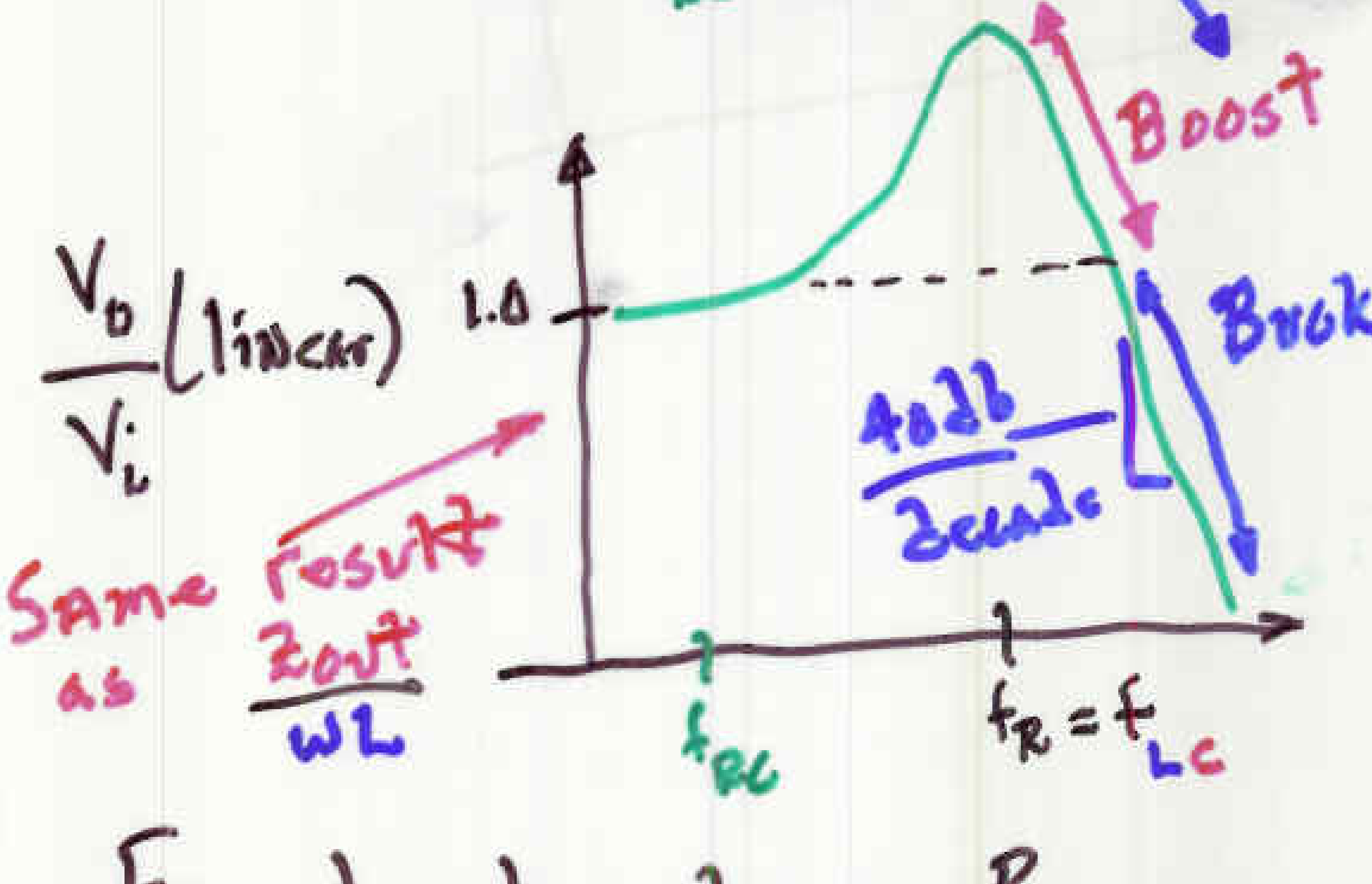


Add L in
series
take largest



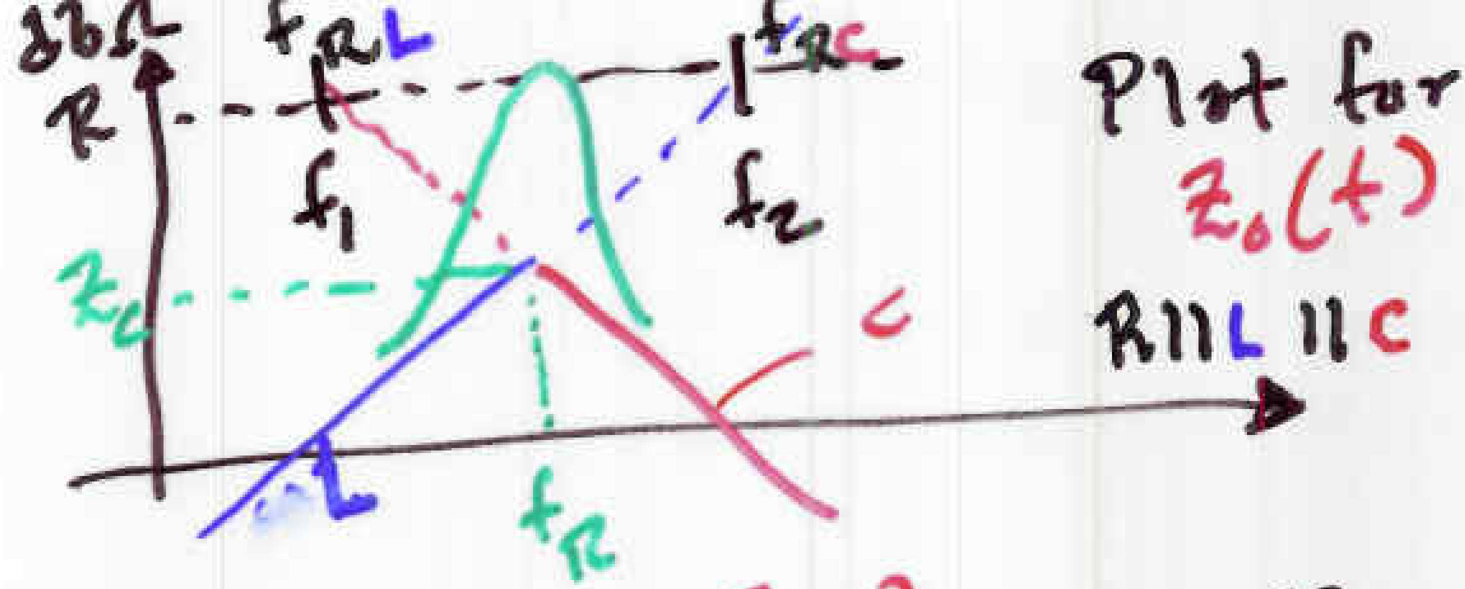
$$\frac{V_o}{V_{IN}} = \frac{Z_L}{Z_{in}}$$

$$\frac{V_o}{V_i} = \frac{\frac{1}{wC} \| R}{wL + \frac{1}{wC} \| R}$$

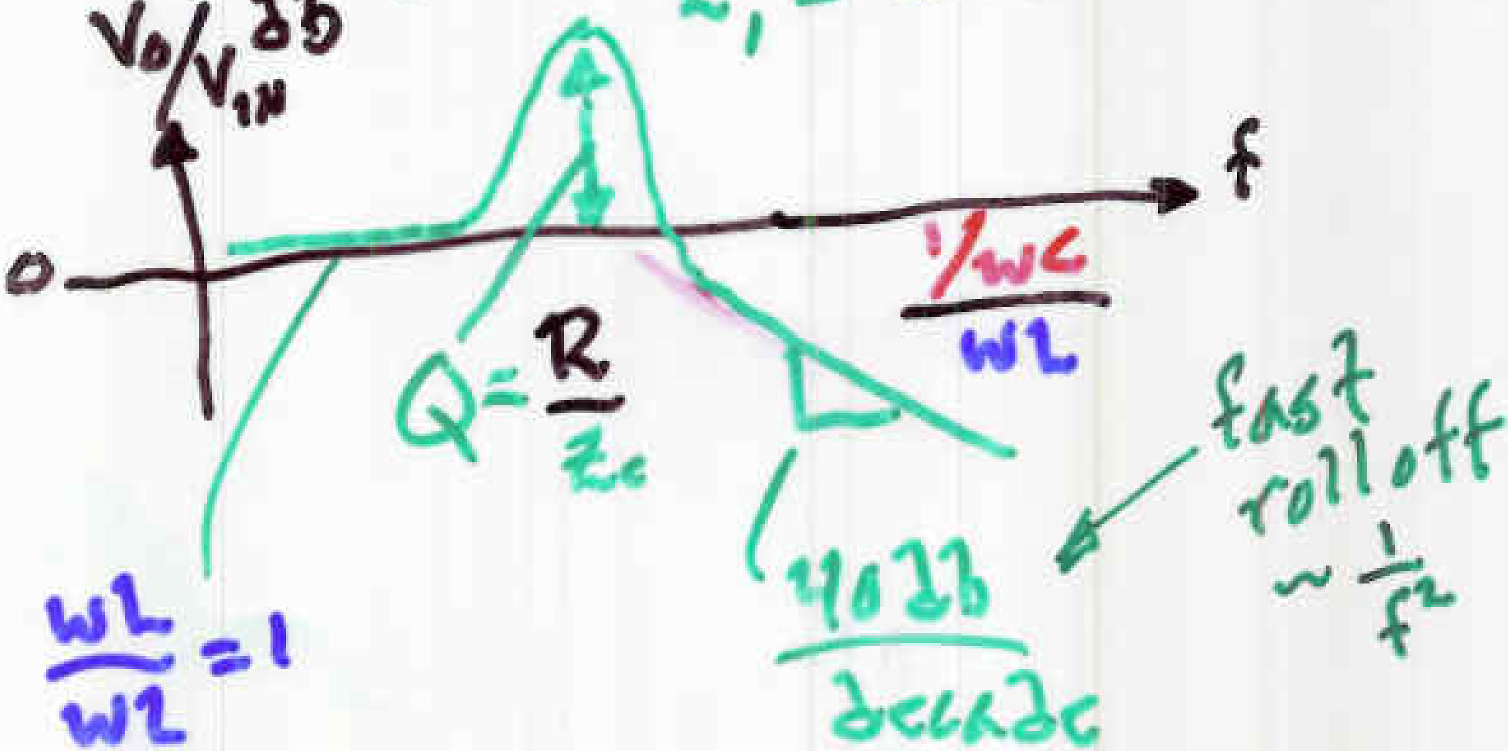


For boost action: $\frac{R}{Z_0} >> 1$

$Z_0 = \sqrt{\frac{L}{C}}$ Choices .... $w_R = \frac{1}{\sqrt{LC}}$



Next plot $\frac{Z_{out}}{Z_1 = \omega L}$ unitless in dB

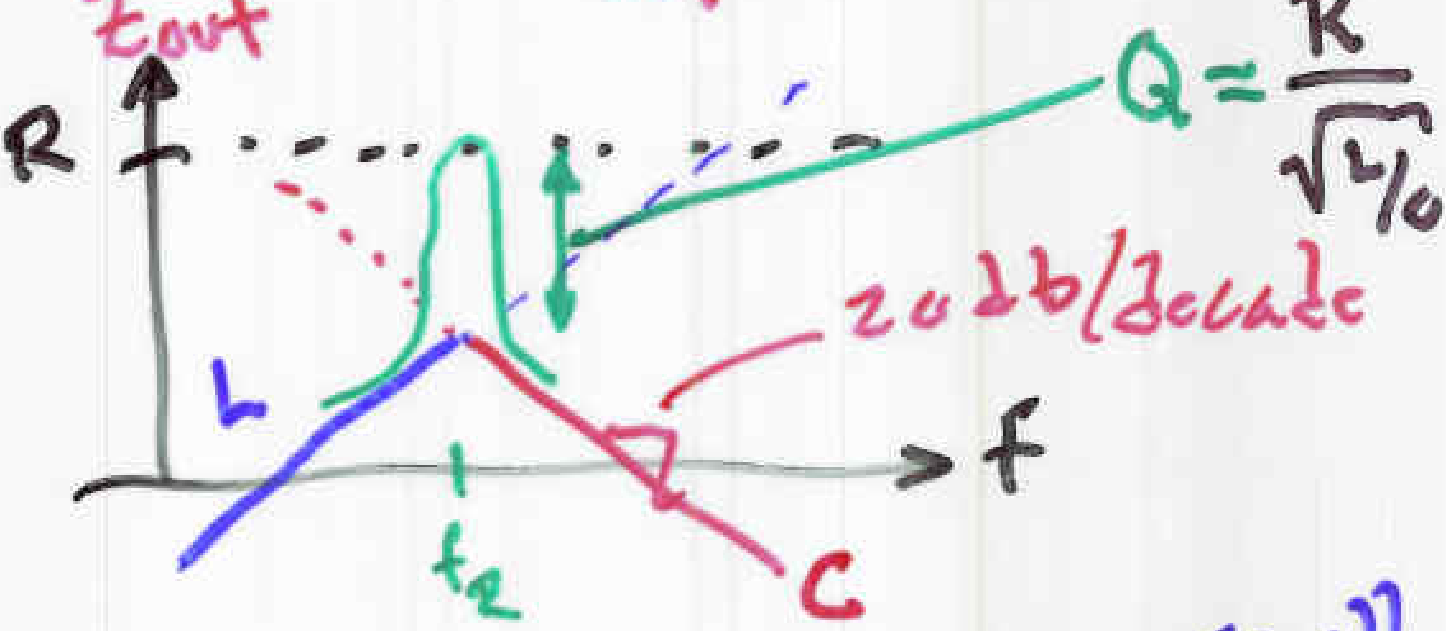


Note: V_{out} "Q's up" @ f_R

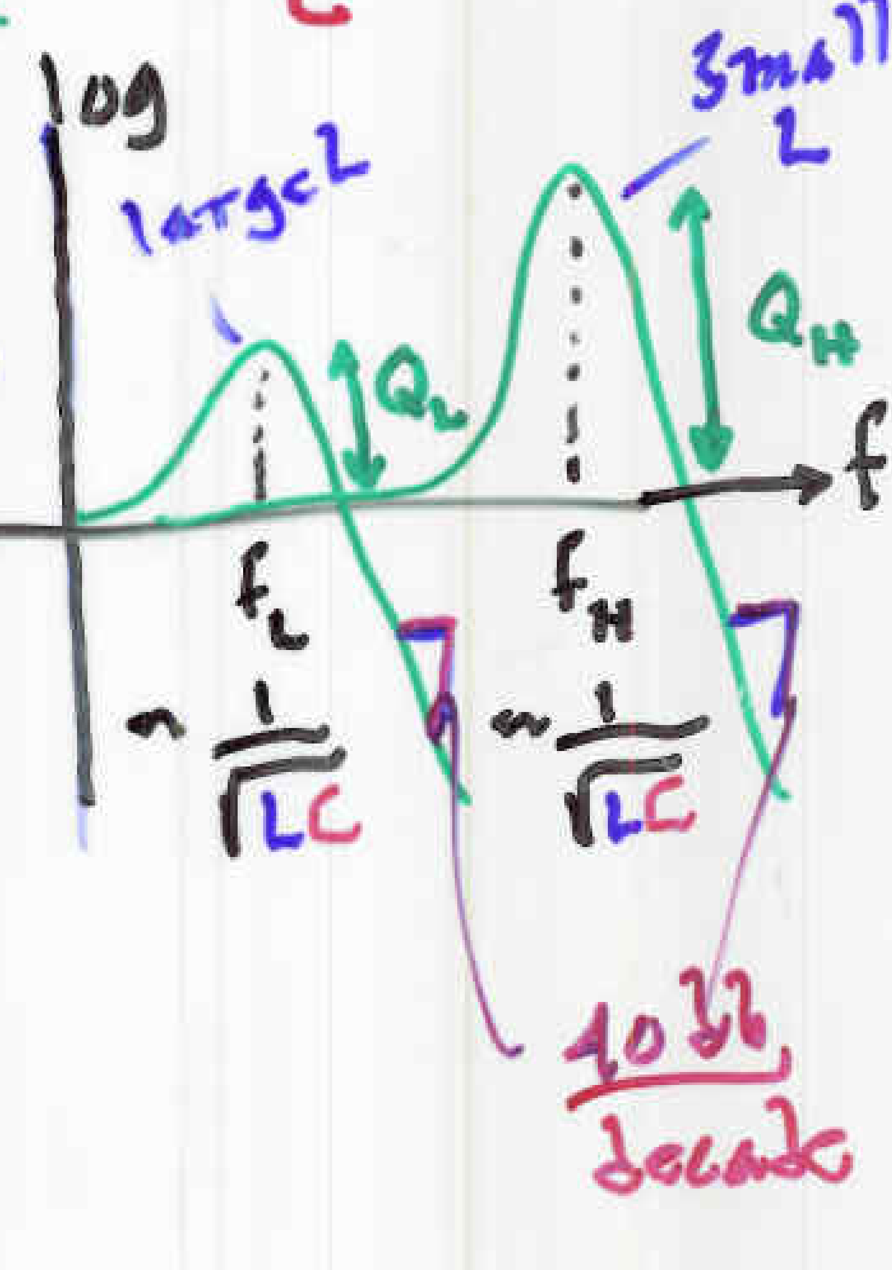
V_{R-C} has peak vs f

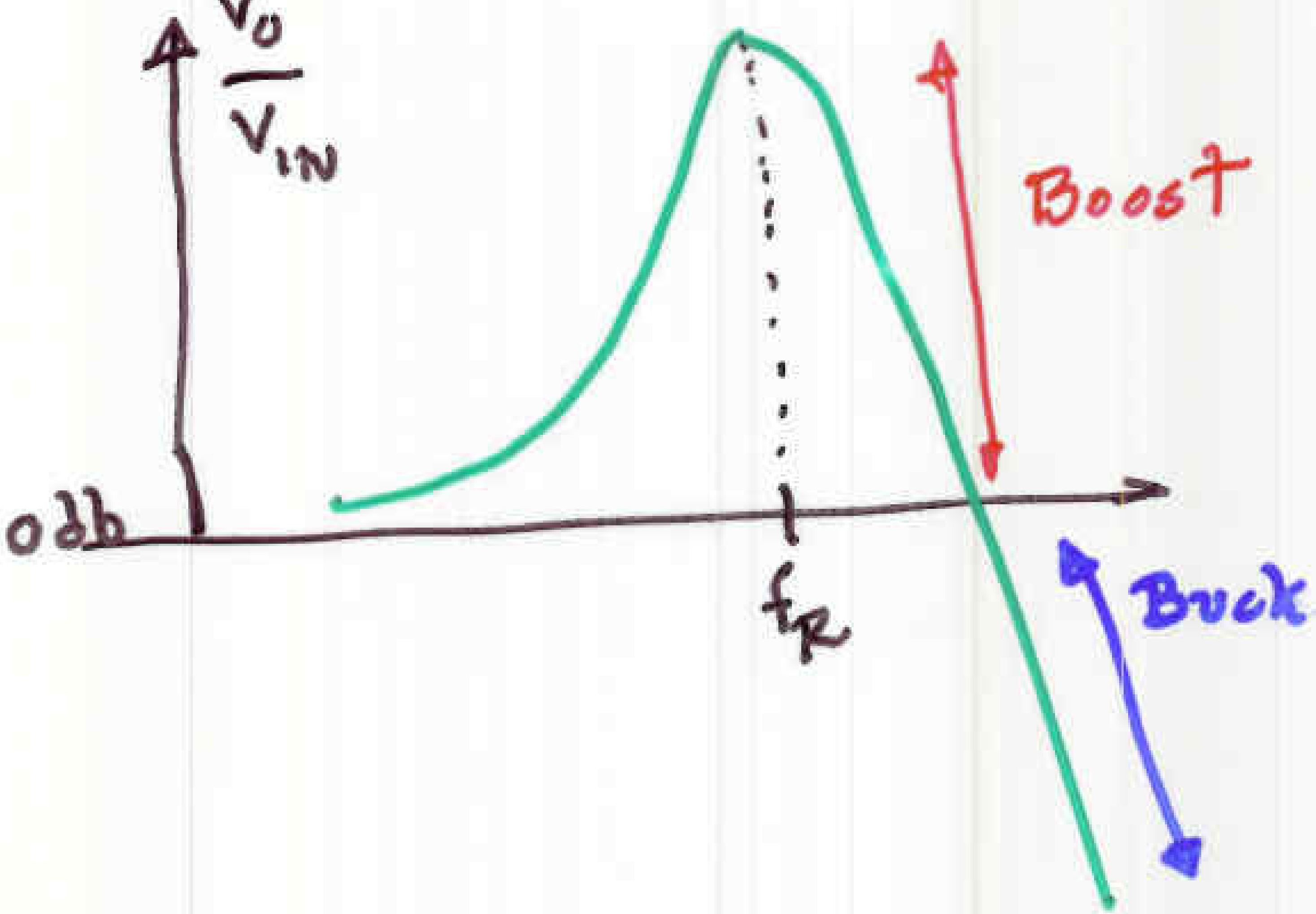
Use ? lighting
other

$z(R \parallel L \parallel C) = Z_{out}$ for $Z_C < R$



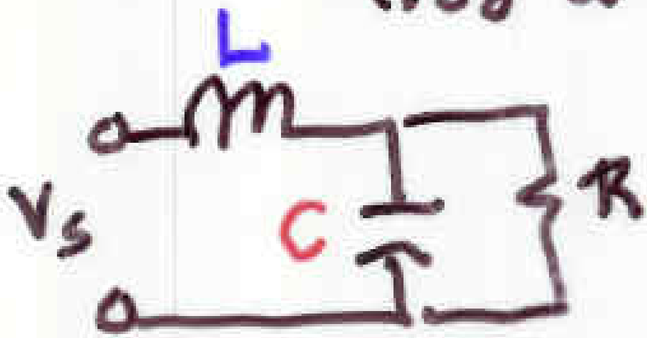
$$\frac{Z_{out}}{wL} = \frac{V_o}{V_{in}}$$



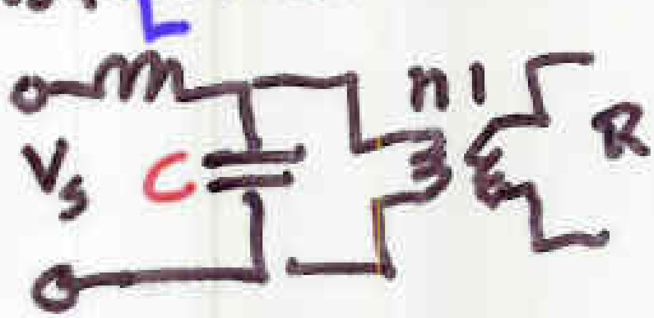


$\frac{V_0}{V_{IN}}$
0db
f_R
Boost
Buck

Add a transformer



vs

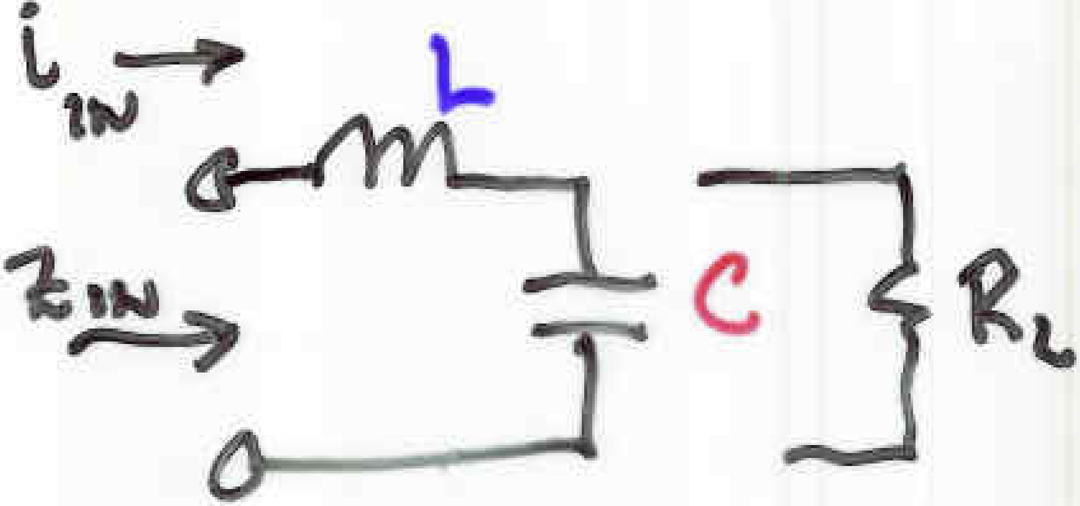


move all to secondary

$$f_{LC} = \frac{1}{\sqrt{LC}}$$ n^2 cancles

BUT Q is enhanced!

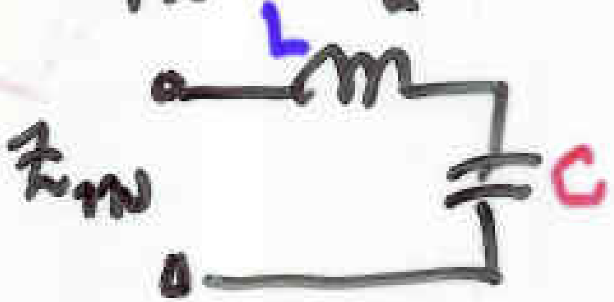
$$Q = \frac{R}{\sqrt{\frac{L_{eff}}{C_{eff}}}} = n^2 \frac{R}{\sqrt{\frac{L}{C}}}$$

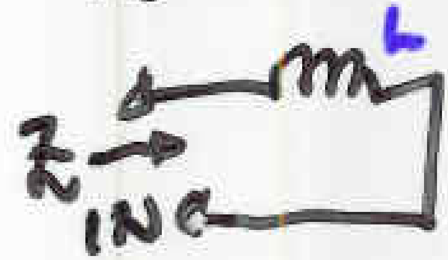


When is i_{IN} a maximum?
for sinusoidal V_{IN}?
$i_L(max)$ $R_L = ?$

Consider extreems: $R_L = 0$
$R_L = \infty$

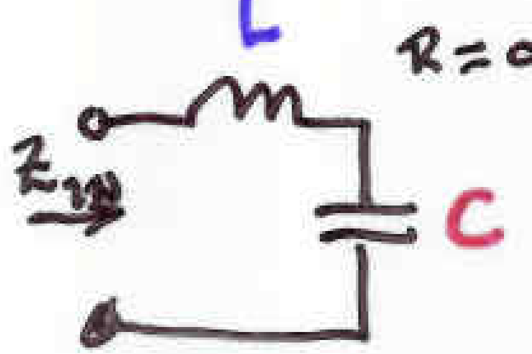
$Z_{IN}(R_L = \infty)$ vs $Z_{IN}(R_L = 0)$

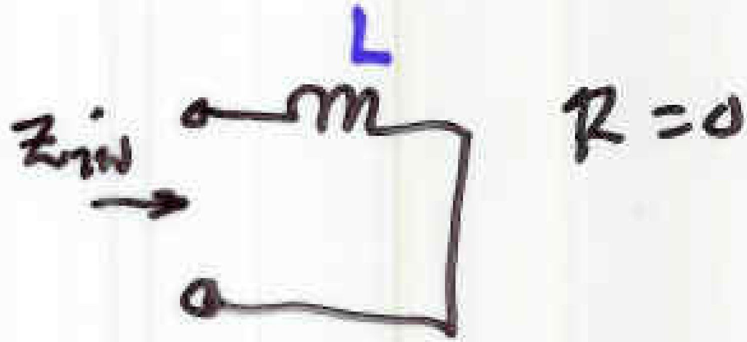


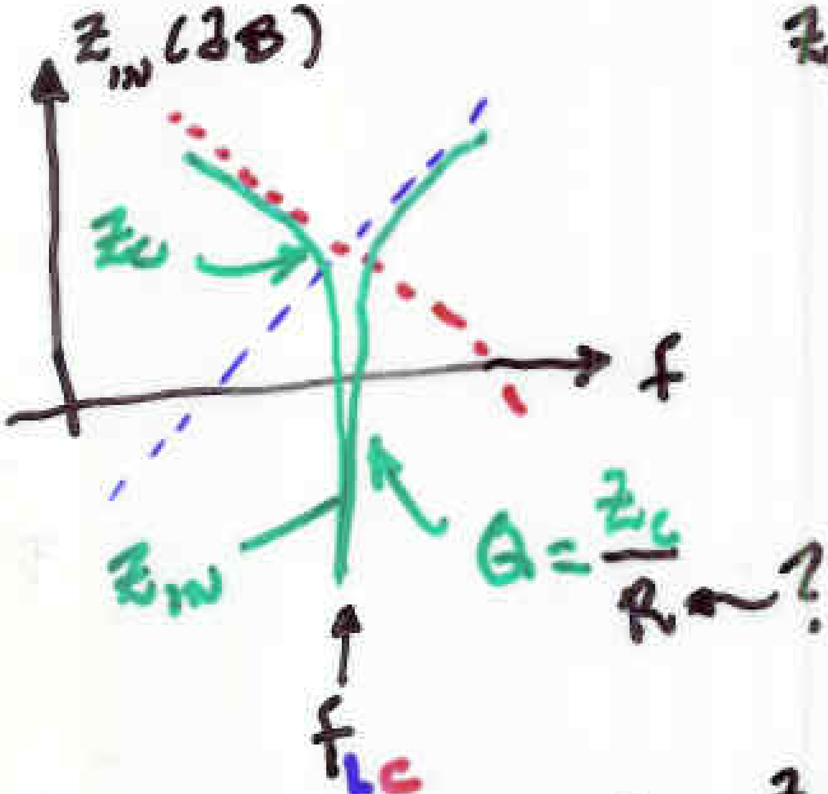


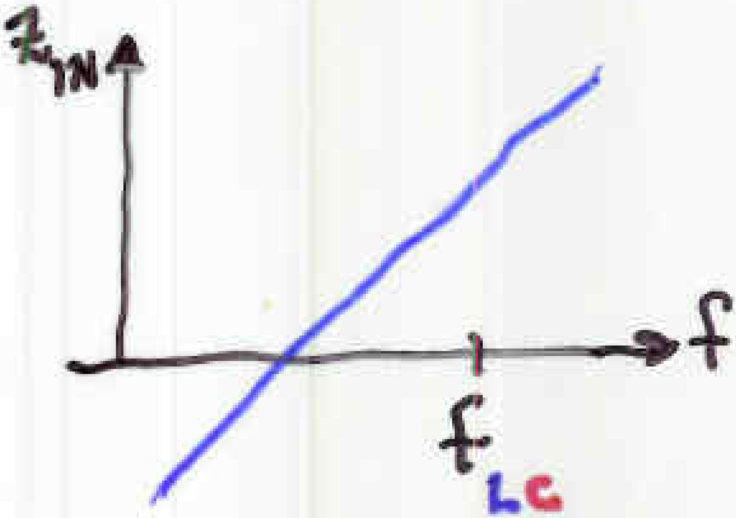
$Z_{IN}(f = f_R)$ $Z_{IN}(f = f_R)$

Which is smaller?









For below resonance: $f < f_{LC}$: $Z_{IN}(R=0) \le Z_{IN}(R=\infty)$ $\Rightarrow$ $i_{IN}(R=0) > i_{IN}(R=\infty)$

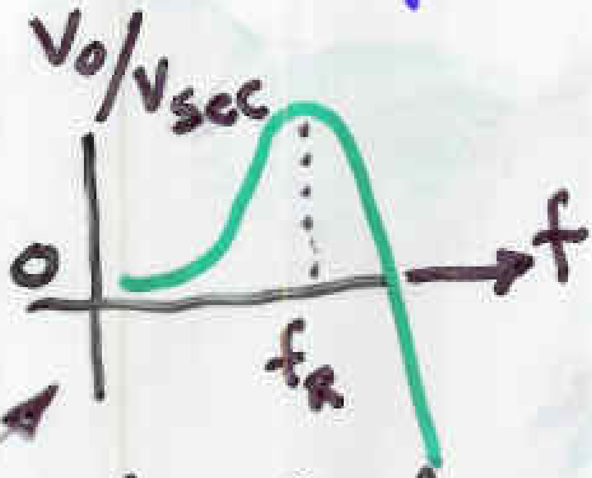
above f_R: $f > f_{LC}$: $Z_{IN}(R=0) \simeq Z_{IN}(R=\infty)$ same i_{IN}

$f = f_{LC}$ which is lower Z_{IN} higher i_{IN}

Doug data ERC

Add $\left[\frac{PWM}{Trf}\right]$ effects $\quad V_{sec} = D V_i$

$\leftarrow Z_{out}$ $\quad \uparrow V_o$



$$\frac{V_o}{V_i} = \left[\frac{Z_{out}}{Z_1}\right] D$$

$$\frac{V_o}{V_{sec}}$$

But what are D effects

Careful:

$$@V_i \quad Z_{IN} = \frac{1}{D^2}\left[Z_1 + Z_2\right]$$

$$@V_o \quad Z_{out} = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{Z_1 Z_2}{D^2 Z_{IN}}$$

D^2 effects cancel

$$Z_{IN} = \frac{1}{D^2} \frac{Z_1 Z_2}{Z_{out}}$$

Evaluate $Z_{IN}(f)$ @ V_i

① $f = f_R$ $\quad Z_{out} = R$

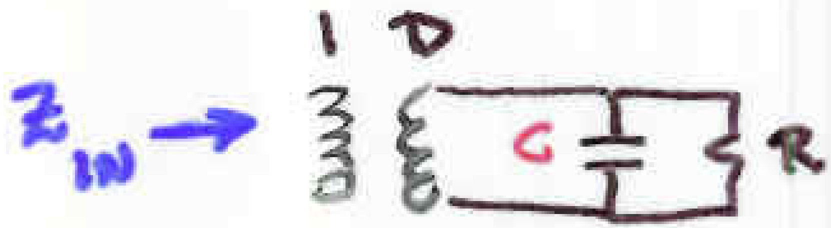
Z_1 and Z_2 both are

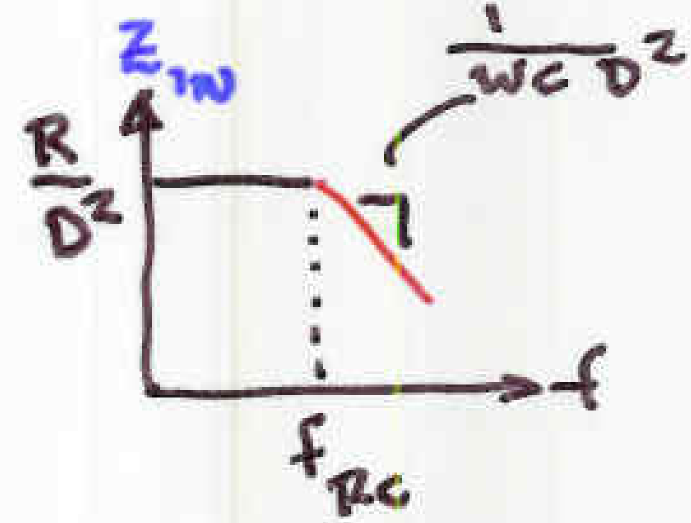
$$Z_0 = \sqrt{L/C}$$

$$Z_{IN}(f_R) = \frac{Z_0^2}{D^2 R}$$

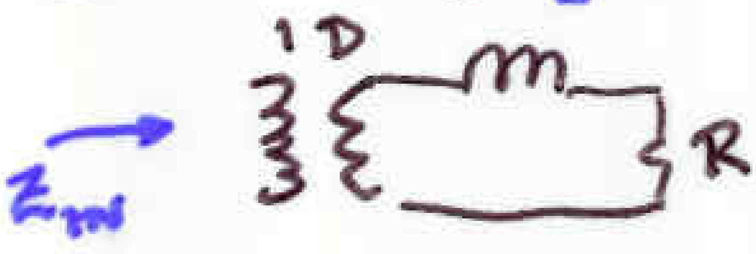
@ V_i

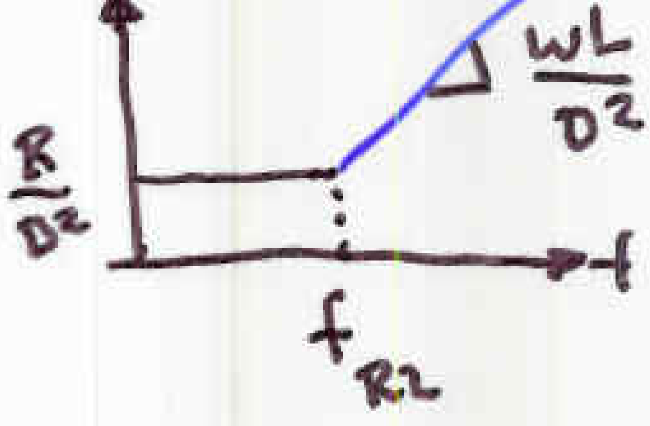
② $f \ll f_R$

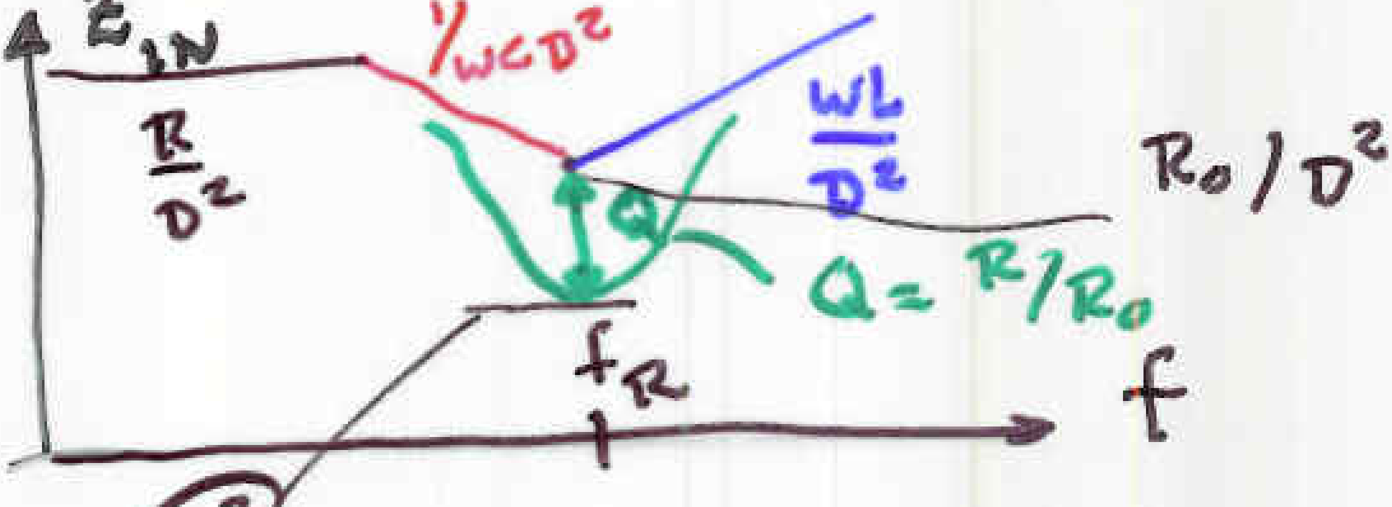




③ $f \gg f_R$ $\quad$ L



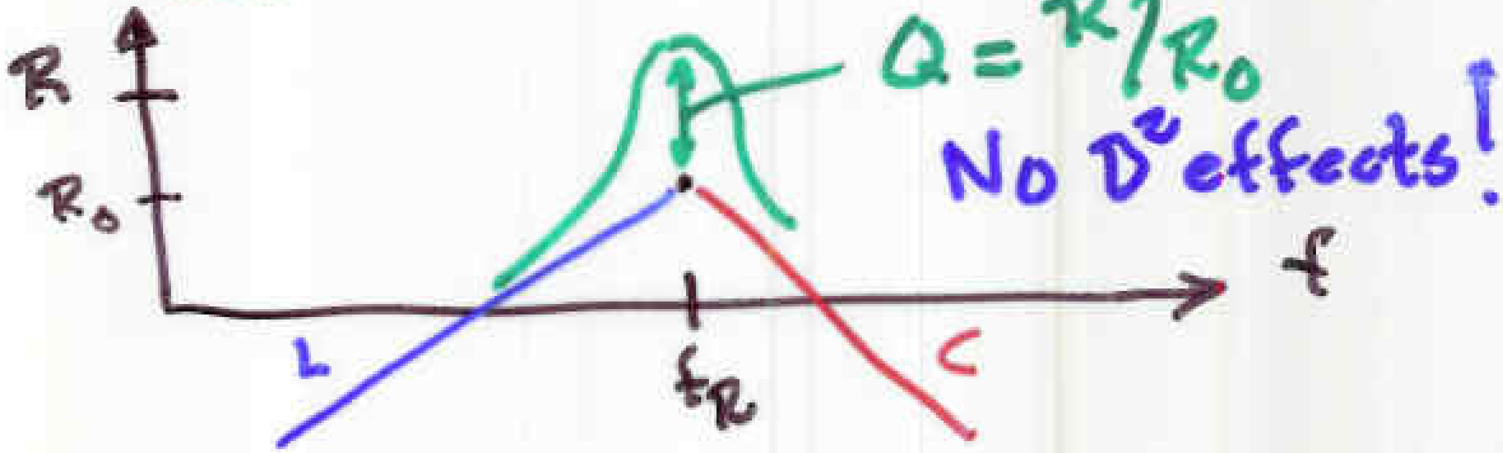




$\frac{R_0^2}{D^2 R}$

Z_{IN} has D^2 effects for $f \neq f_R$

Z_{out}



$$\frac{V_{out}}{V_{IN}} = \frac{Z_{out}}{\omega L}$$