Graphical Guides: $Z(f)$

Semilog scale vs f

$\log Z$ vs f (linear)

base or per unit employed

$10\,\Omega \longrightarrow 20\,db$

$1\,\Omega \longrightarrow 0\,db$

$\frac{1}{10} \longrightarrow -20\,db$

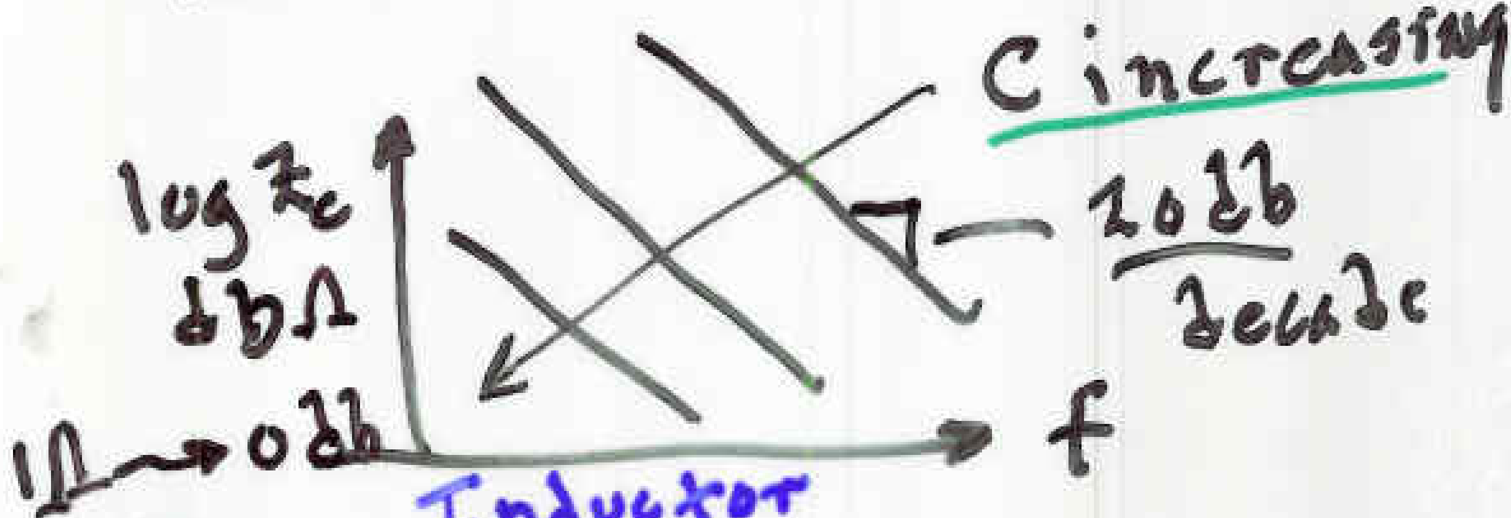
$20\log\frac{Z}{1}$ $\Rightarrow Z = 1$ is 0 db

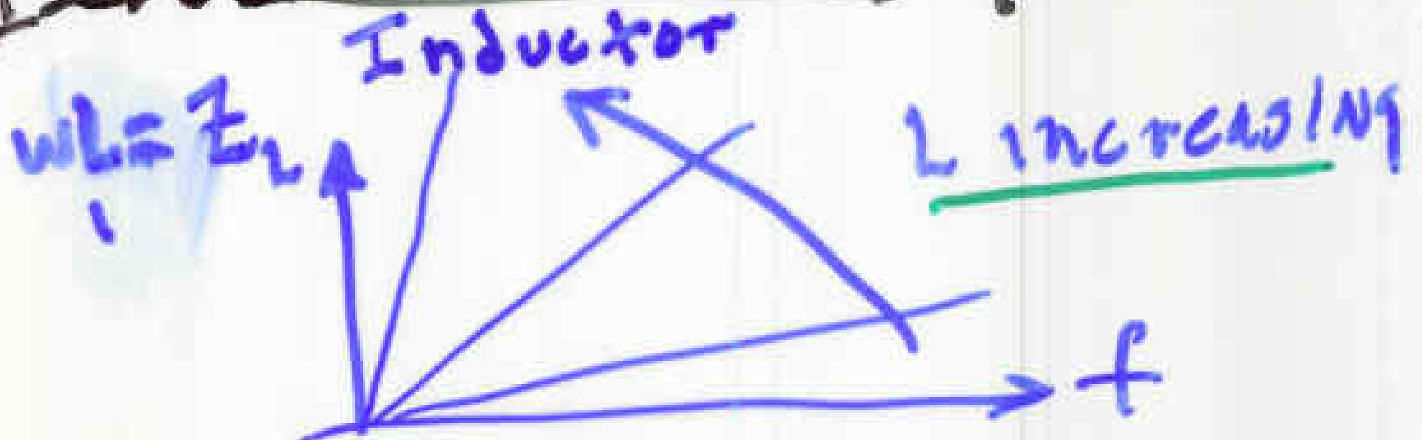
Recall also the

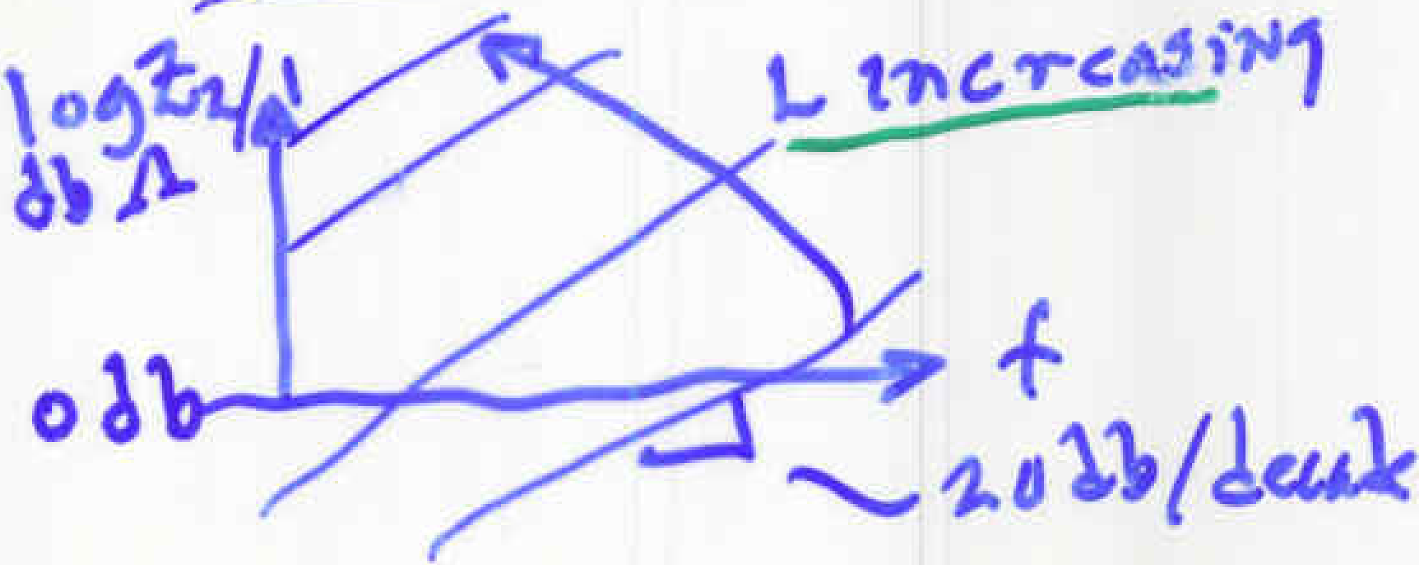
$\pm 3\,db \begin{cases} -3\,db \longrightarrow .707 \text{ of base} \\ +3\,db \longrightarrow * 1.414 \text{ or } \sqrt{2} \text{ of base} \end{cases}$

$\pm 6\,db \begin{cases} -6\,db \longrightarrow \frac{1}{2} \text{ of base} \\ +6\,db \longrightarrow * 2 \text{ of base} \end{cases}$

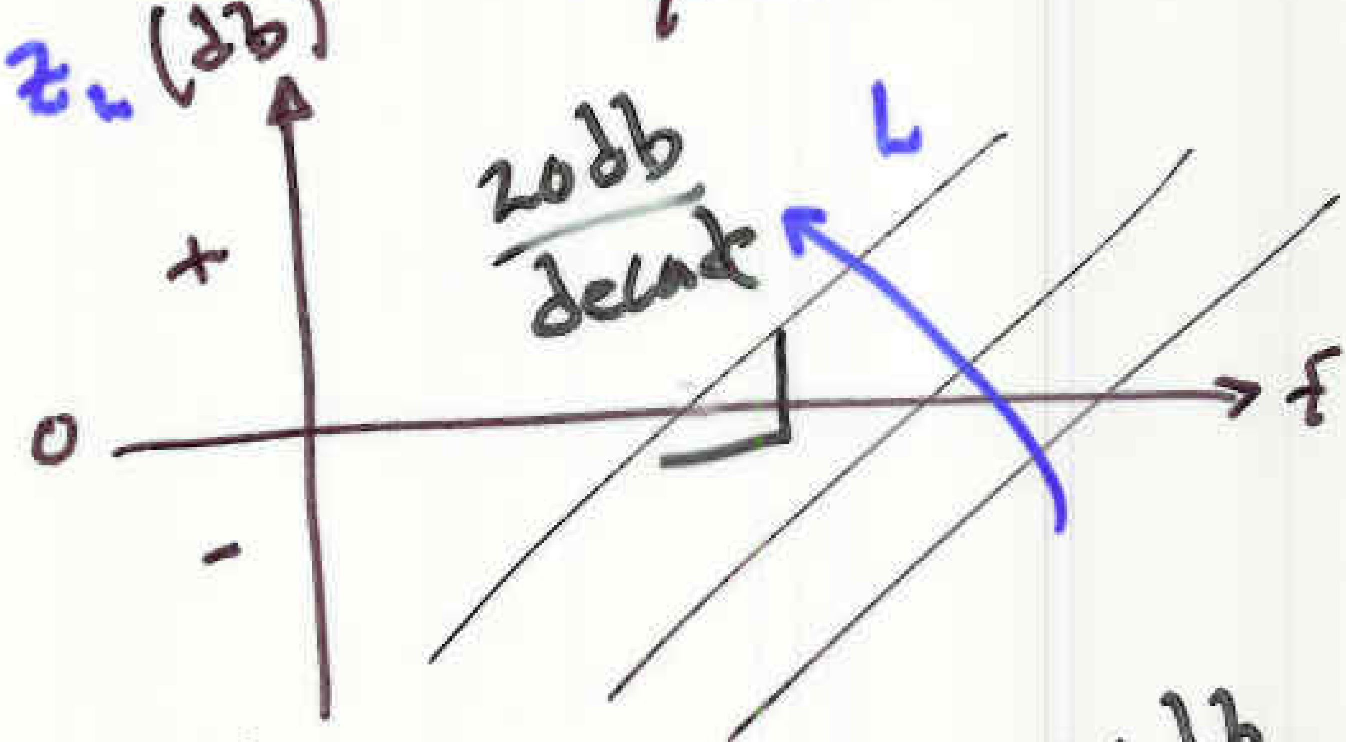
Ultra Basics: $Z_C = \frac{1}{\omega C}$

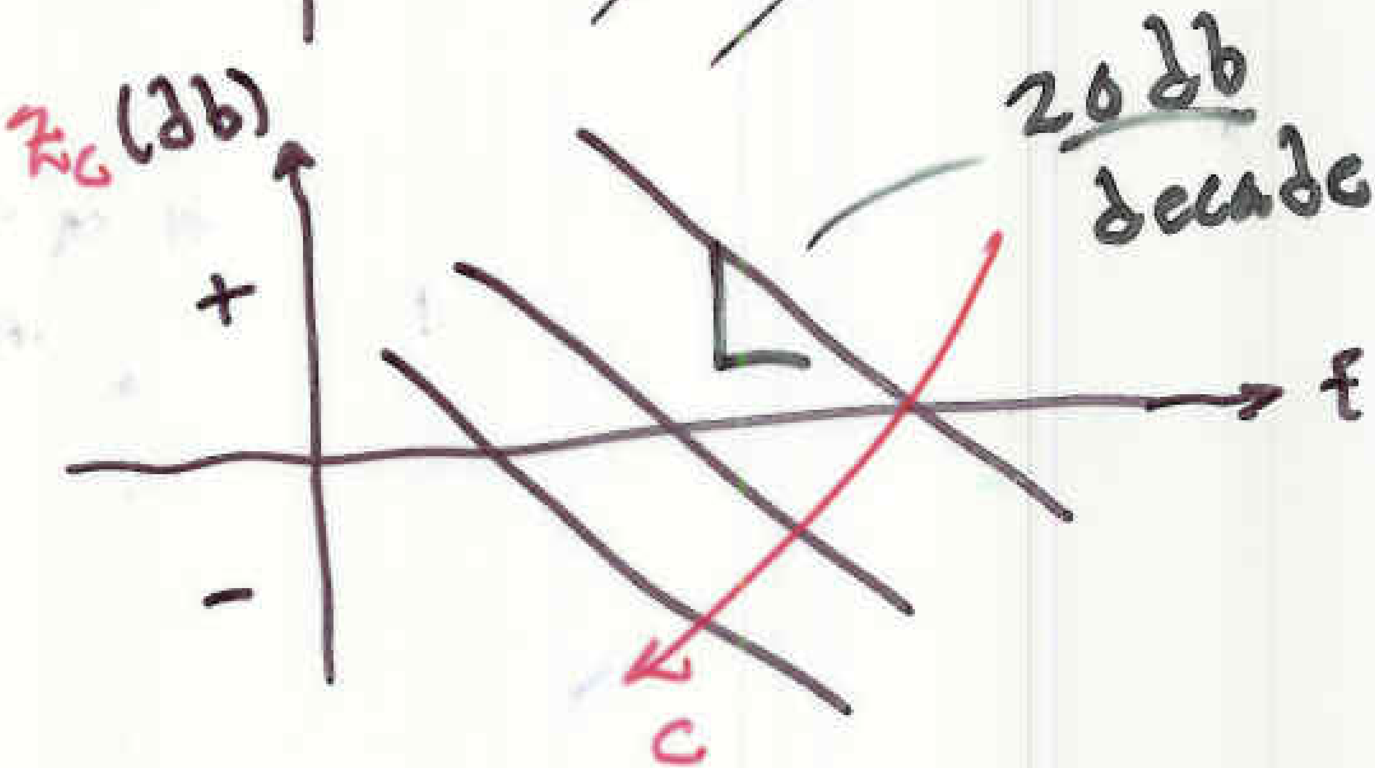






Base impedance could be
50 Ω in rf circuits
μwave

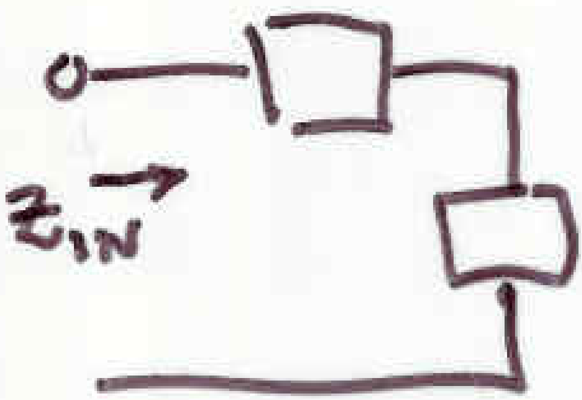




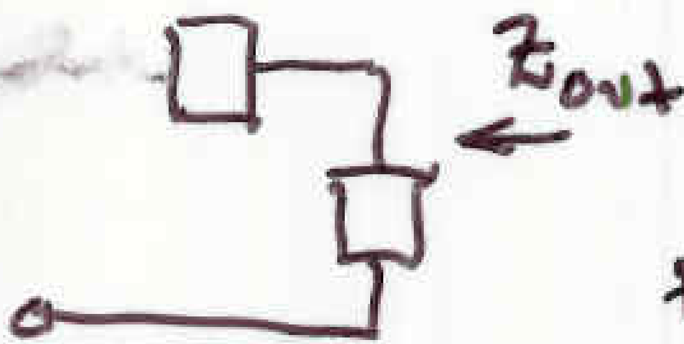
R-C and R-L Circuits

$\dfrac{Z_R}{\text{base}}$ $\dfrac{Z_C}{\text{base}}$ $\dfrac{Z_L}{\text{base}}$

0 db when $|Z| = \text{base}$



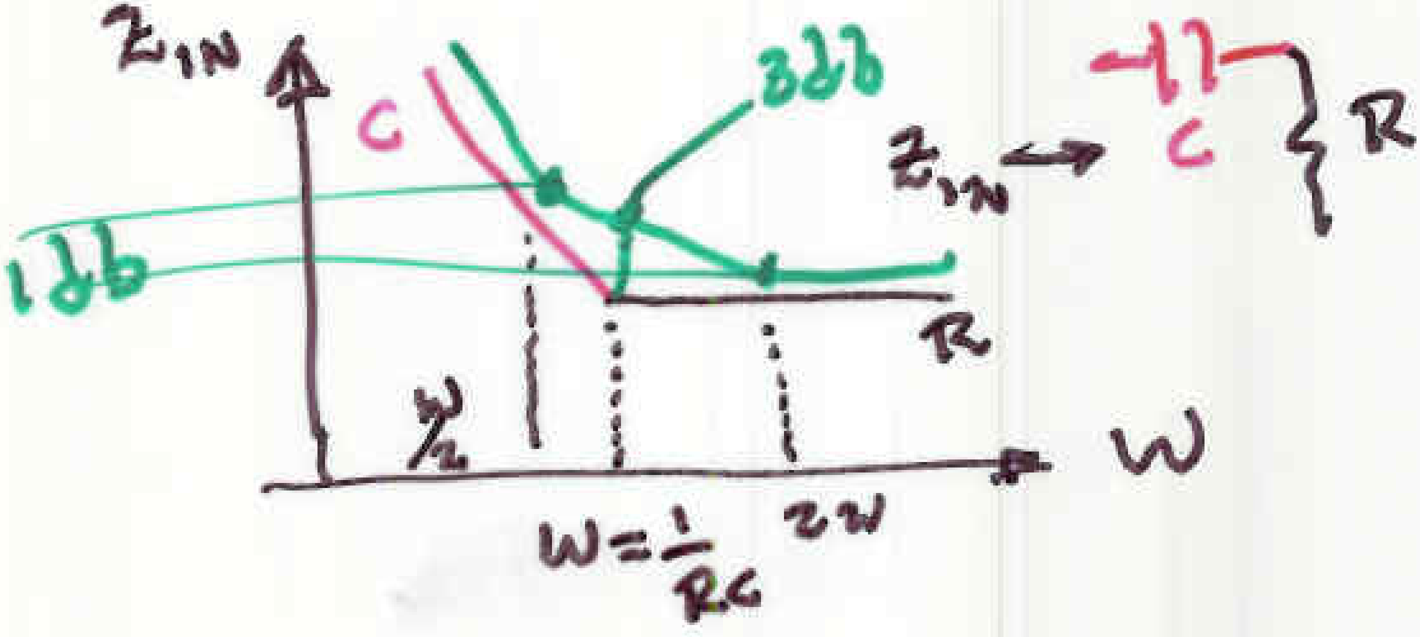
Series case always take the largest at any f



Parallel Case always take the smallest at any f

$Z_R = Z_C \rightarrow R = \dfrac{1}{WC} \rightarrow W_{RC} = \dfrac{1}{RC}$

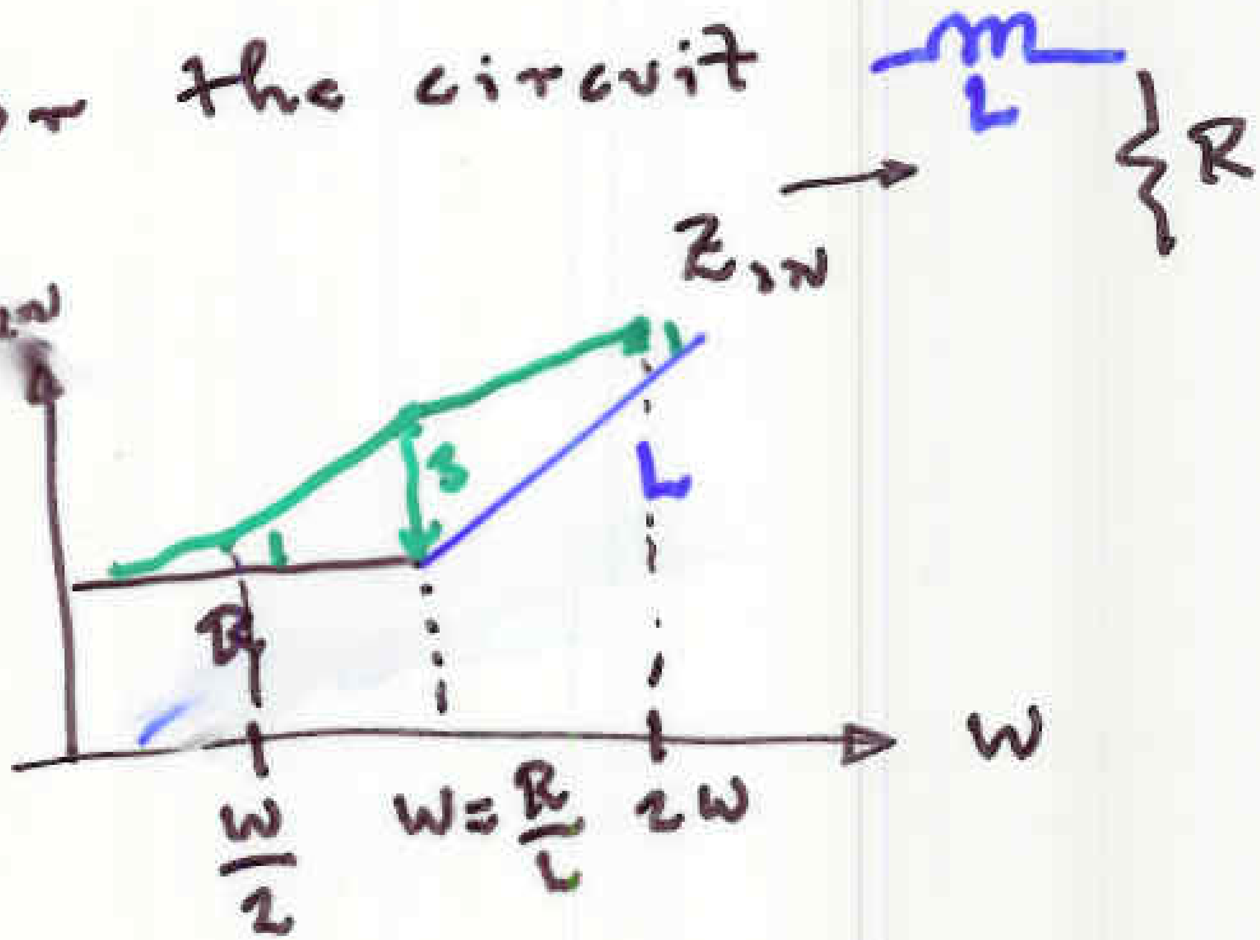
$Z_R = Z_L \rightarrow R = WL \rightarrow W_{RL} = \dfrac{R}{L}$

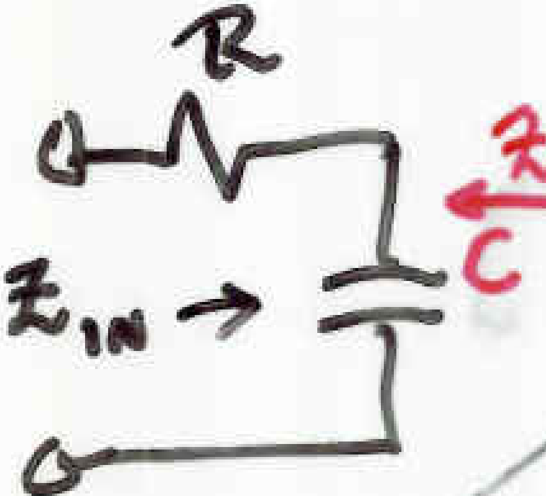


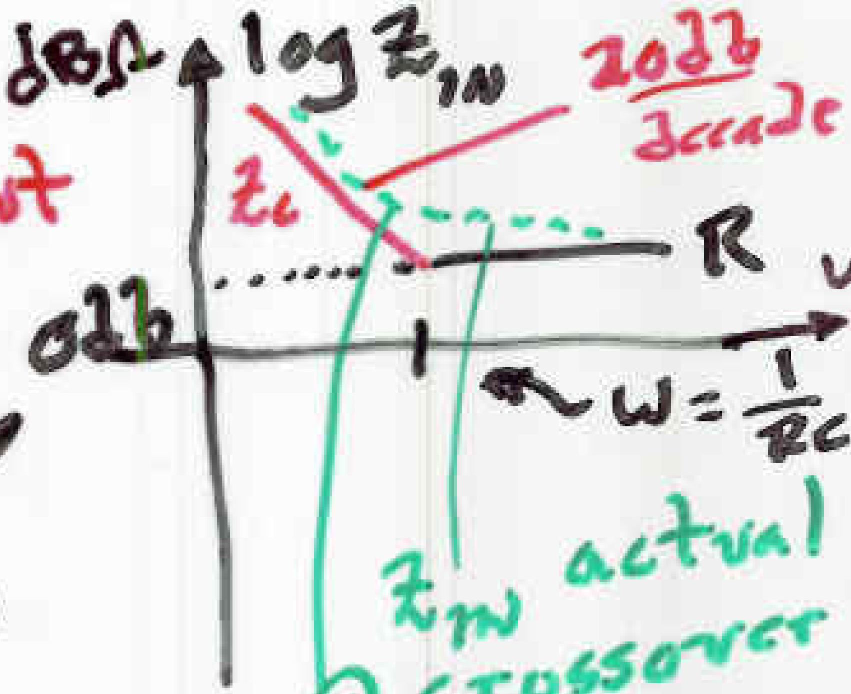
3db point @ w break

1db points @ 2w, $\frac{w}{2}$

For the circuit







db	Z_{IN}
0dbΩ ↔	1Ω
20dbΩ ↔	10Ω
-20dbΩ ↔	$\frac{1}{10}$Ω

$w = \frac{1}{RC}$

Z_{IN} actual @ crossover 3db higher

Series elements take the largest

Recall from asymptotes

$$f = \left.\begin{array}{l} 2 f_{cross} \\ \frac{1}{2} f_{cross} \end{array}\right\} Z_{IN} \uparrow 3db \text{ from asymptotes}$$

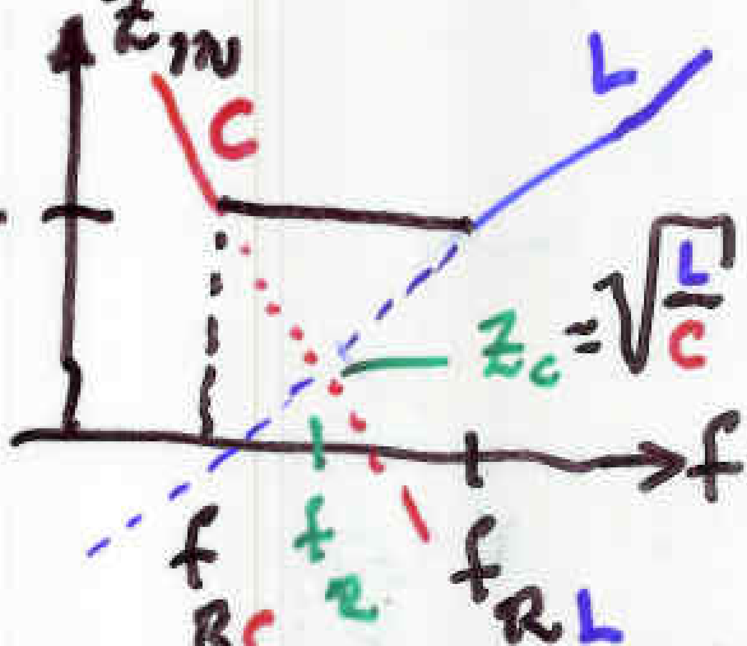
Z_{out} 3 db lower

$Z_{out} = R \| C$

|| elements take the smallest

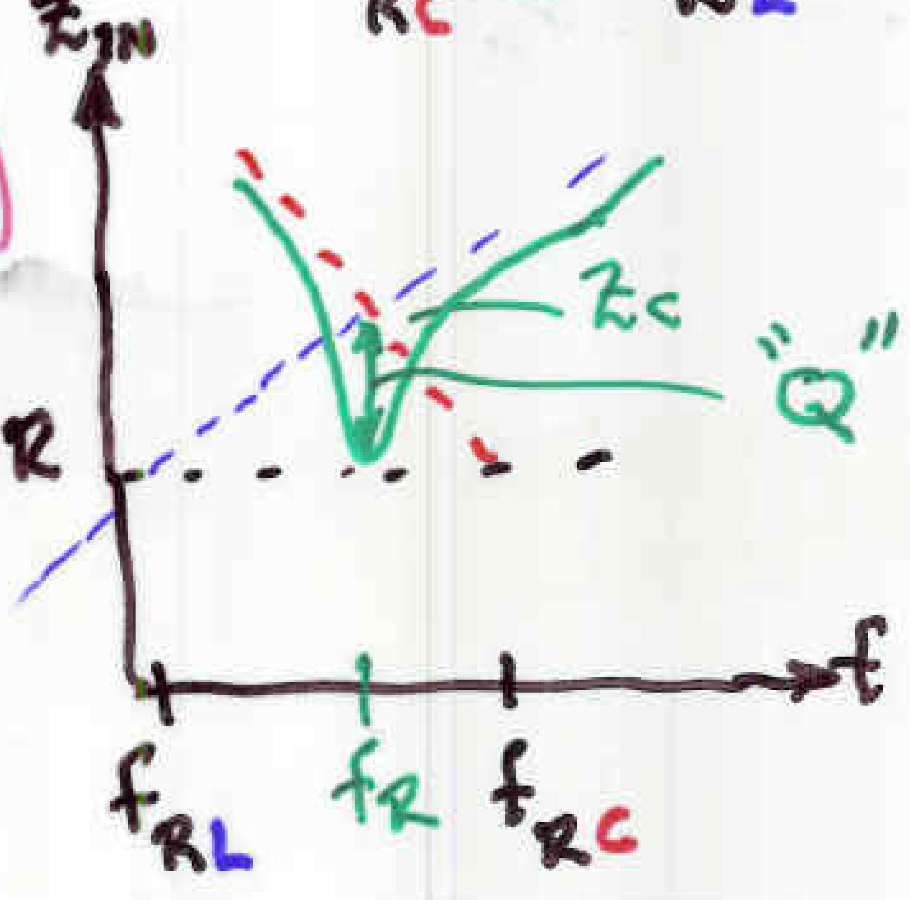
$$Z_{IN} = R + j\omega L - j\frac{1}{\omega C}$$

Always take in series the largest term



$\boxed{\#1 \quad R > Z_c}$

$f_{RC} < f_R < f_{RL}$

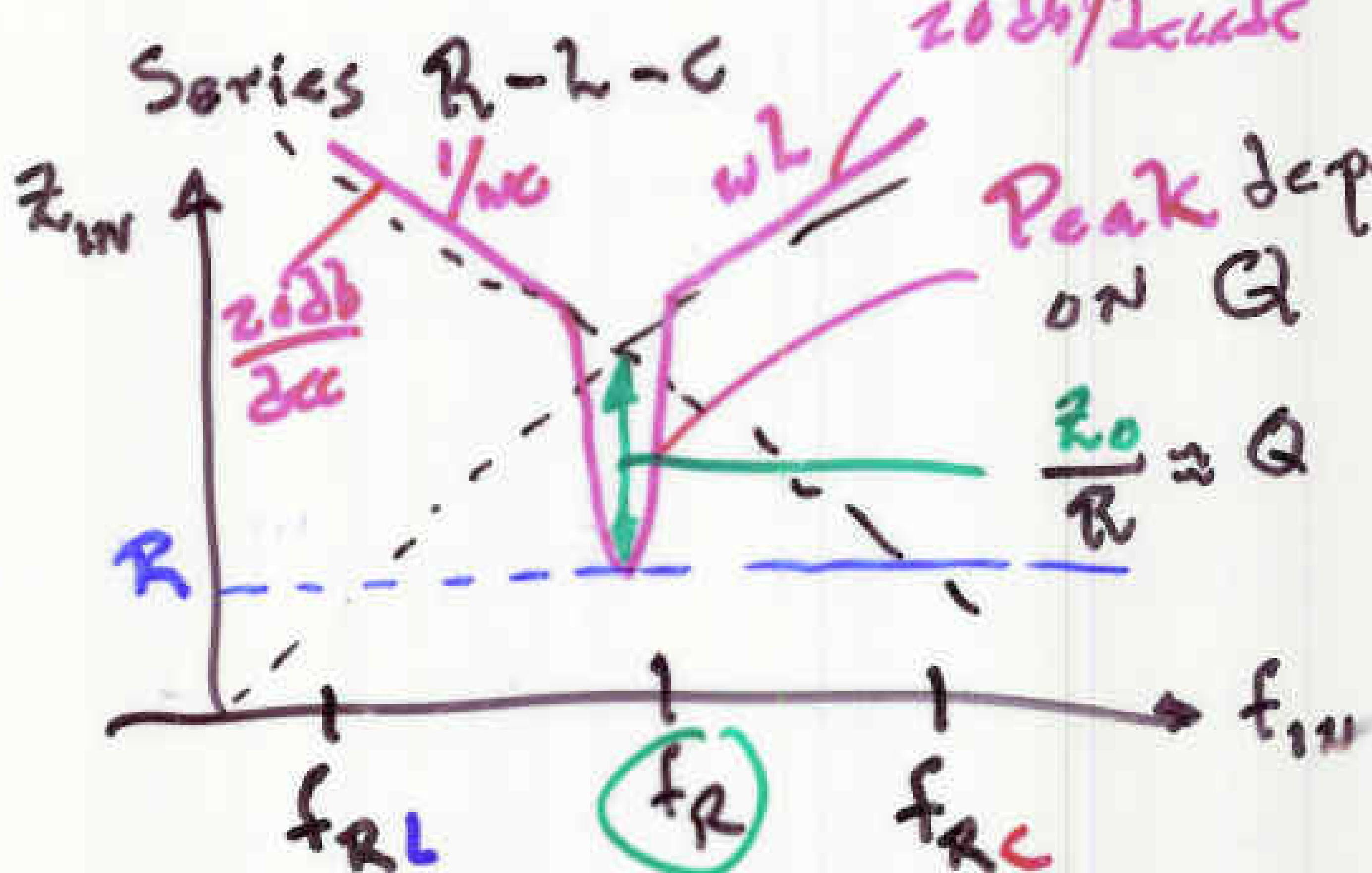


$\boxed{\#2 \quad R < Z_c}$

$f_{RL} < f_R < f_{RC}$

$$Q \equiv \frac{Z_c}{R}$$

Resonant circuits display $Q(R)$

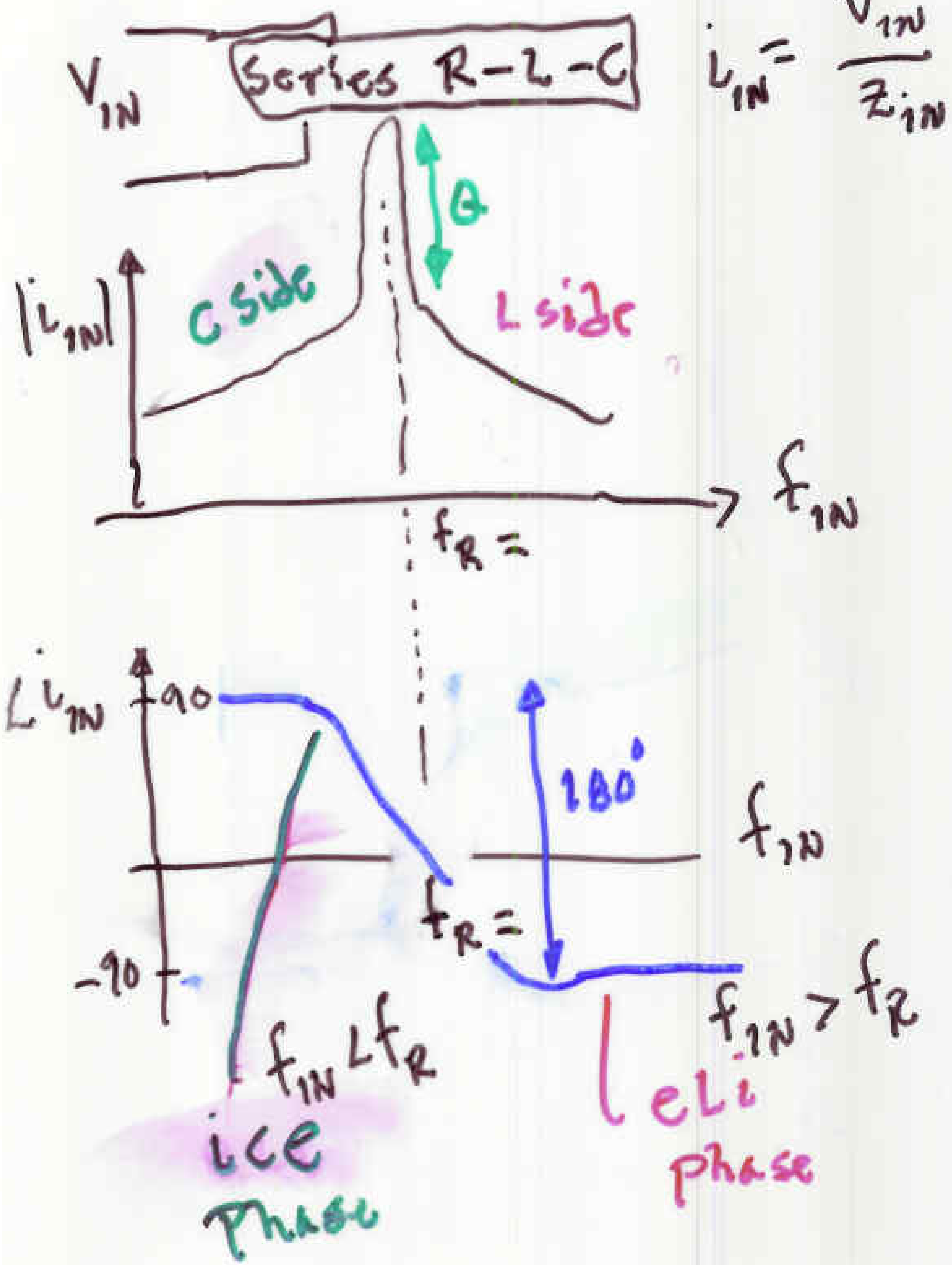


$Z_0 = \sqrt{\frac{L}{C}}$ Choices for L, C

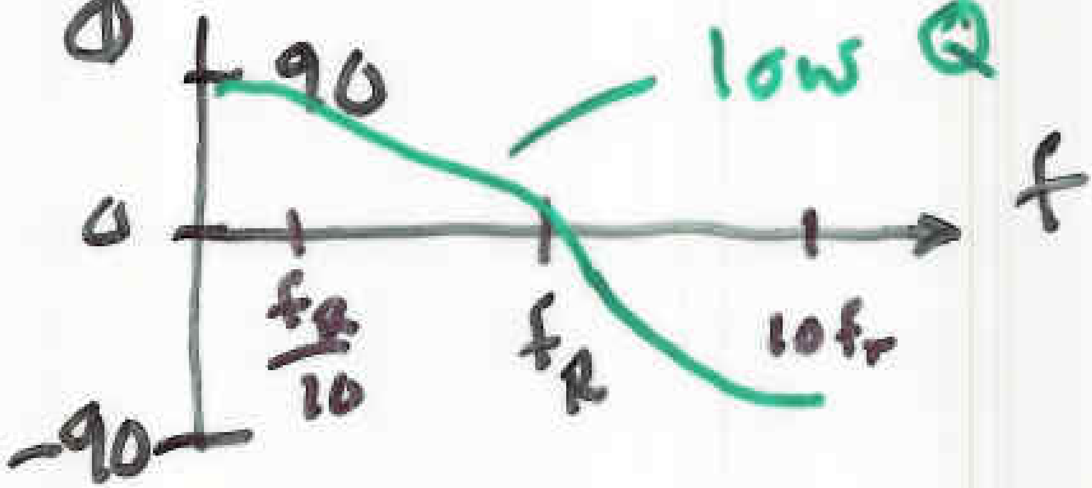
R is series resistance

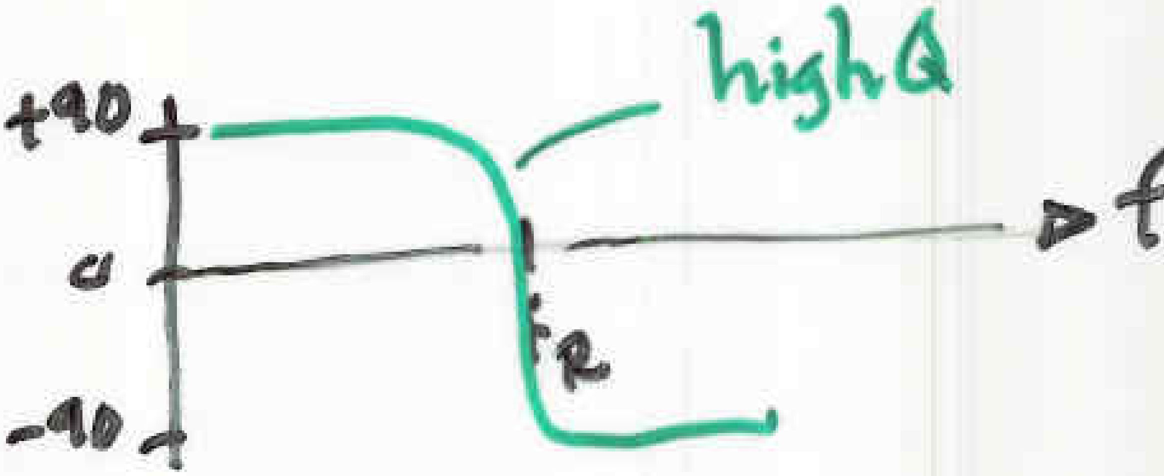
$$R = R_L + \underbrace{R_L(ESR) + R_C(ESR)}_{\text{limits } Q_{max}}$$

$Z_{in}(f_R) = R$



V_{IN}
Series R-L-C
$i_{IN} = \frac{V_{IN}}{Z_{IN}}$
Q
$|i_{IN}|$
C side
L side
f_{IN}
$f_R =$
$\angle i_{IN}$
90
180°
f_{IN}
$f_R =$
-90
$f_{IN} > f_R$
$f_{IN} < f_R$
eli
Phase
ice
Phase





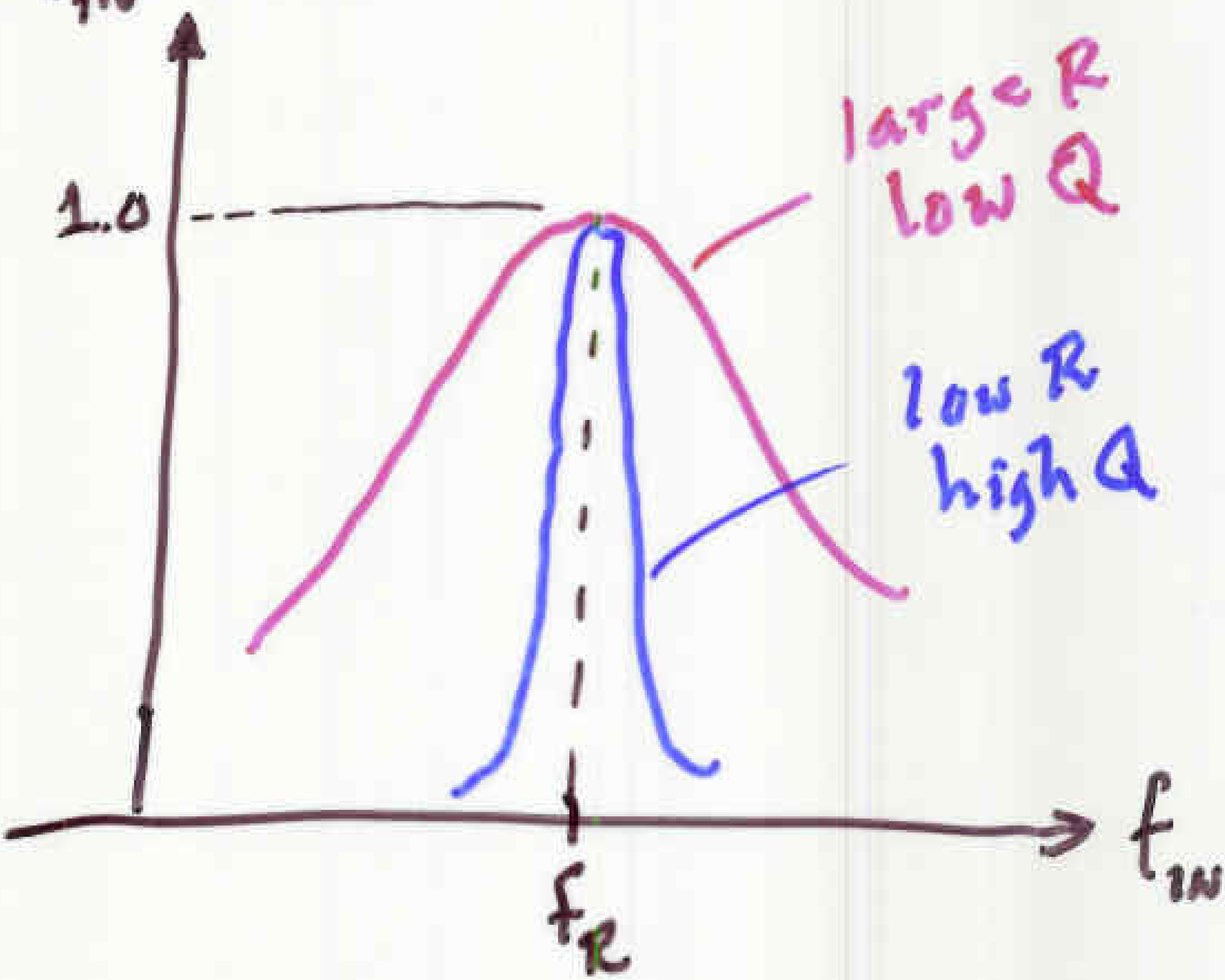
Slope of phase $\frac{-180^\circ Q}{\text{decade}}$

$Q = \frac{1}{2}$ $\qquad \frac{180^\circ}{\text{two decades}}$

$Q = 1$ $\qquad \frac{180^\circ}{\text{decade}}$

$Q = 5$ $\qquad \frac{180^\circ}{\text{octave}}$

$\frac{V_0}{V_{in}}$ (linear scale) take V_{out} across R



$f_{in} \neq f_R$ Buck Circuit

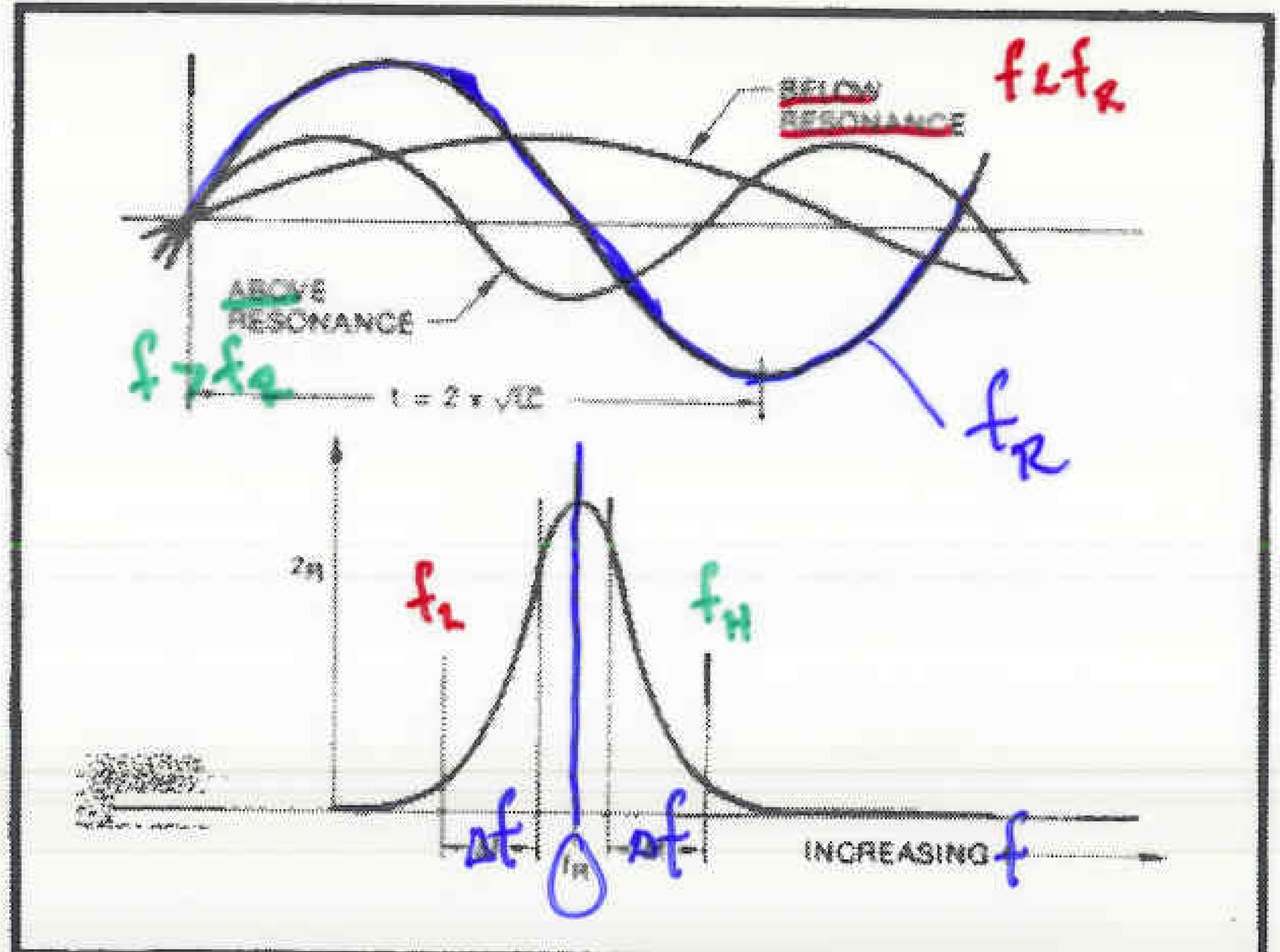
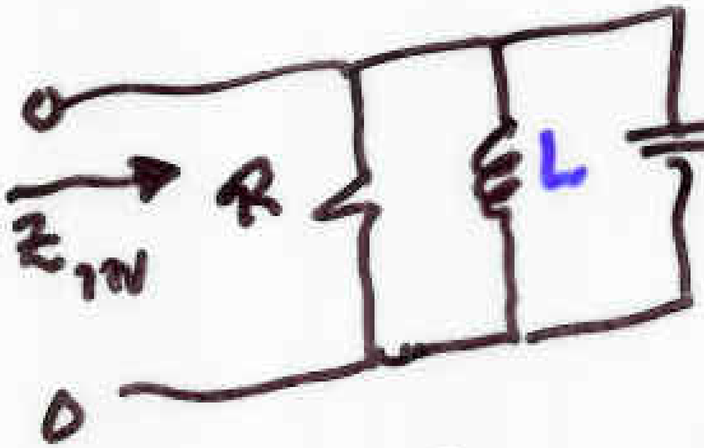


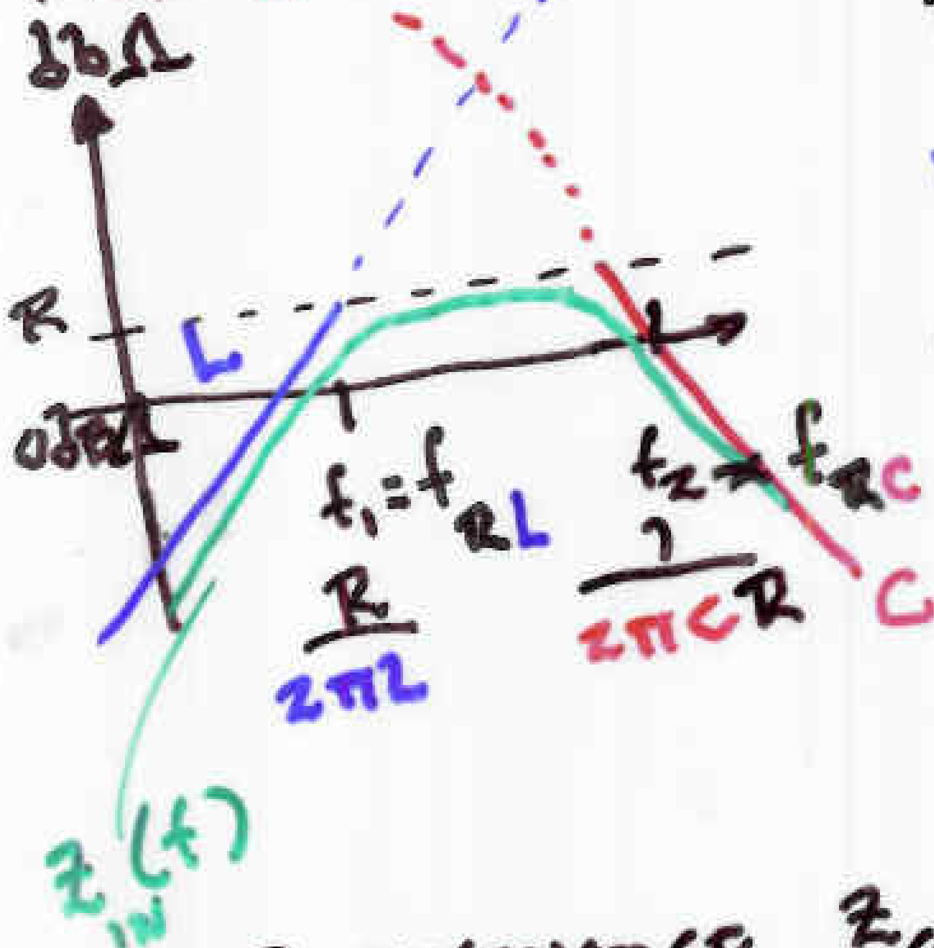
Fig. 11 - Variable Frequency Continuous Resonance

Parallel Resonant Circuit

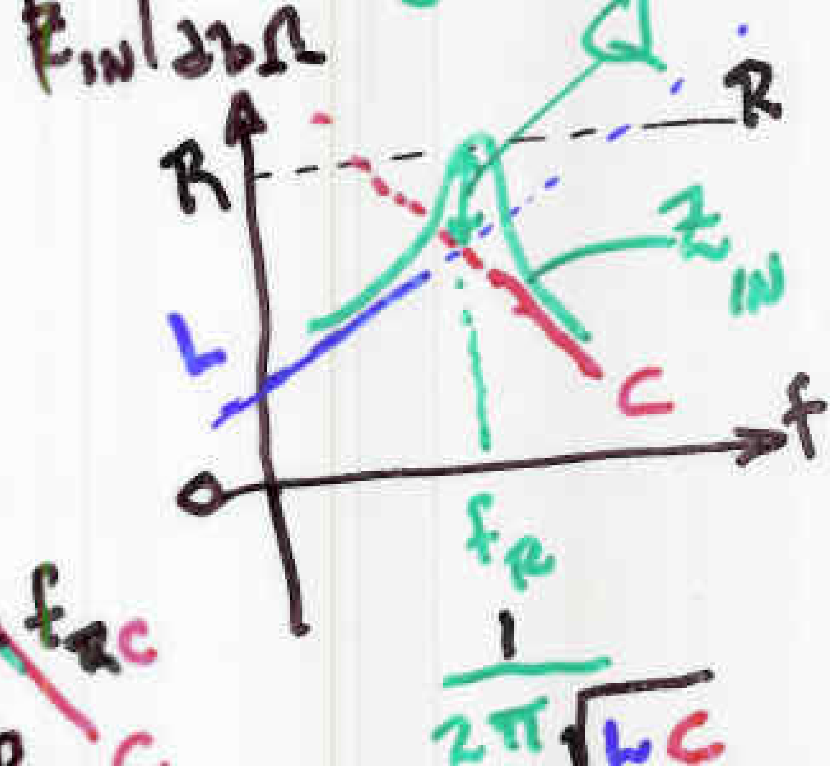


Two cases: R w.r.t. Z_c

$|Z_{IN}|$ $Z_c > R$



$Z_c < R$

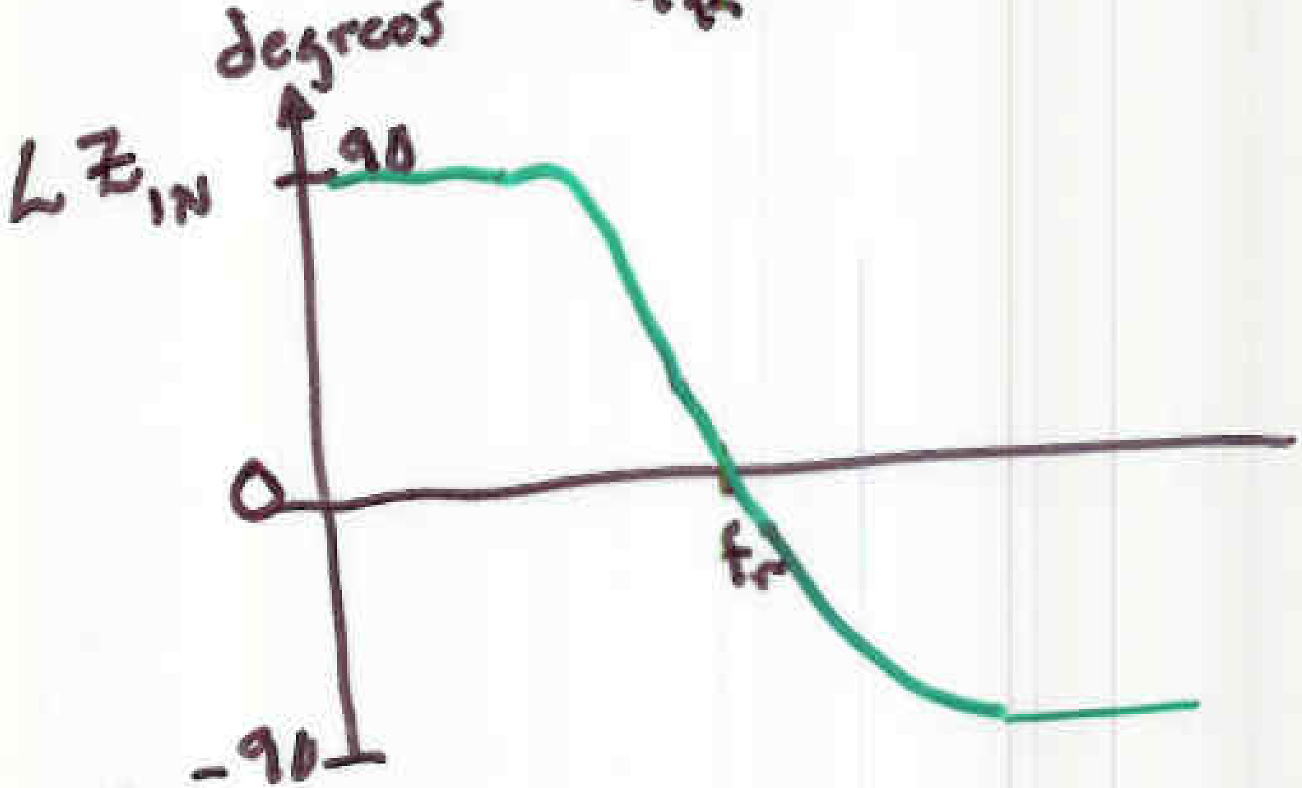


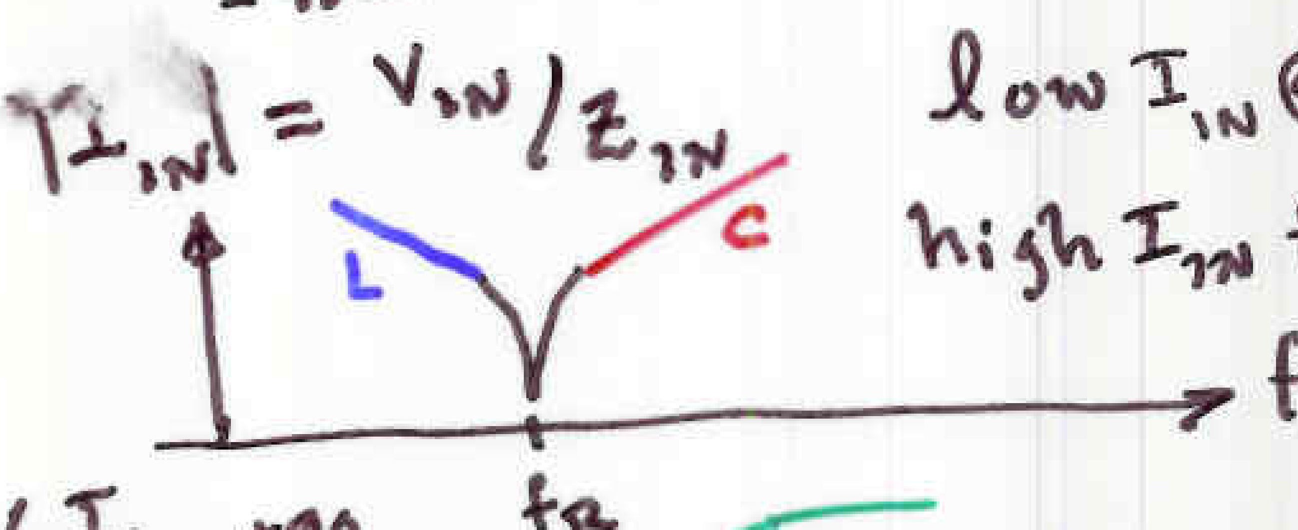
$$Q = \frac{R}{Z_c}$$

@ resonance $Z_c \parallel Z_L = \frac{Z_c Z_L}{Z_c - Z_L} \longrightarrow \infty$

$\Rightarrow Z_{IN} = R \parallel \infty = R$

$V_{out} = V_{IN}$ for all f <u>BUT</u>





low I_{IN} @ f_R

high I_{IN} $f \neq f_R$