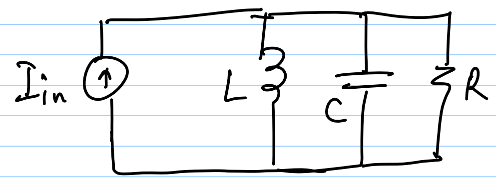
31/7/13

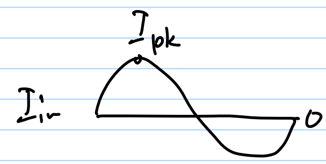
# Lec 1

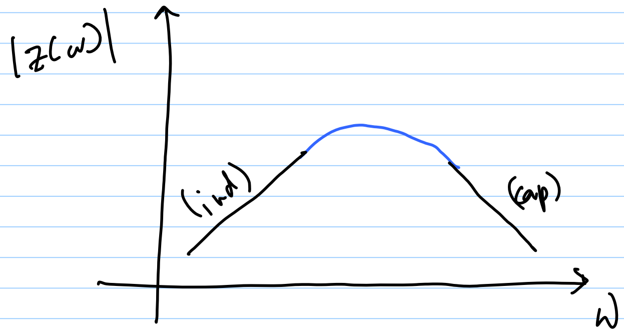
Resonance ← amplify only the freq. of interest

* Local Osc. — noise (LC oscillators have lower noise)
* Most RF circuits are narrowband
* Series & Parallel Resonance

## 1) Parallel Resonance



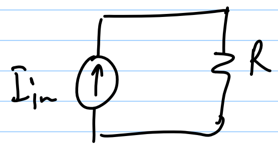

$$Y(\omega) = \frac{1}{R} + j\omega C + \frac{1}{j\omega L}$$

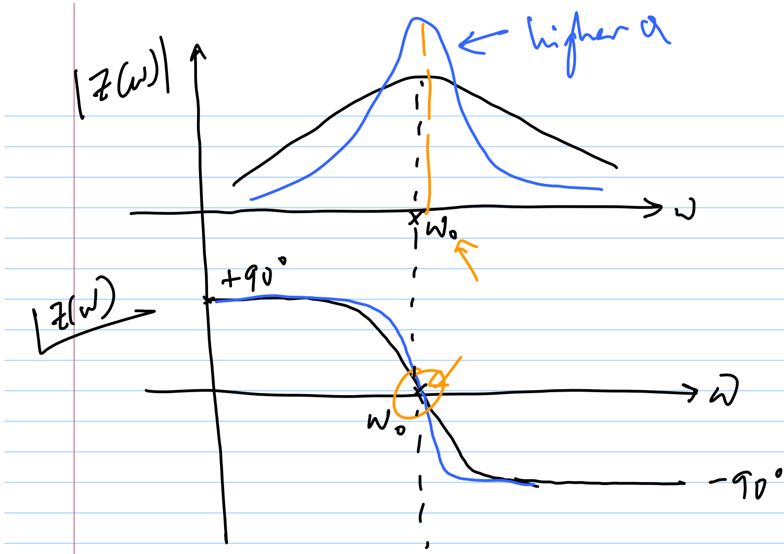
$$= \frac{1}{R} + j\left(\omega C - \frac{1}{\omega L}\right)$$

@ resonance ($\omega_0$)

$$\omega_0 C = \frac{1}{\omega_0 L} \Rightarrow \boxed{\omega_0 = \frac{1}{\sqrt{LC}}}$$

$$Y(\omega_0) = \frac{1}{R}$$




Quality Factor $\equiv Q$

$$Q \equiv \omega \cdot \frac{\text{Energy stored}}{\text{Average power dissipated}}$$

@ $\omega = \omega_0$, $V_{out} = I_{in} \cdot R$

$$V_{out\,pk} = I_{pk} \cdot R \Rightarrow E_{tot.} = \frac{1}{2} C \left(I_{pk} \cdot R\right)^2$$

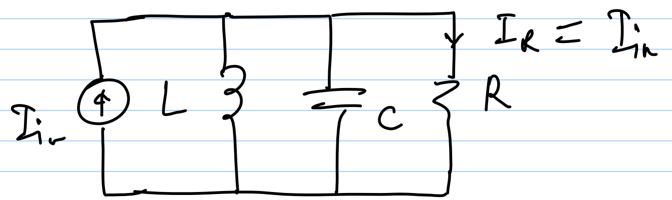
$$P_{av.} = (I_{rms})^2 \cdot R = \left(\frac{I_{pk}}{\sqrt{2}}\right)^2 \cdot R = \frac{1}{2} I_{pk}^2 \cdot R$$

$$Q = \omega_0 \cdot \frac{\frac{1}{2} C\, I_{pk}^2 \cdot R^2}{\frac{1}{2} I_{pk}^2 \cdot R} = \omega_0 C R$$

$$Q = \omega_0 C R = \frac{R}{\omega_0 L} = \frac{R}{\sqrt{L/C}} \longleftarrow \text{characteristic impedance}$$

@ resonance

$$|Z_L| = \omega_0 L = \sqrt{L/C} = |Z_C|$$




$$* \quad |I_L| = \frac{|V_{out}|}{\omega_0 L} = \frac{|I_{in} \cdot R|}{\omega_0 L} = Q \cdot |I_{in}|$$

$$= |I_C|$$ (worry about this during layout)

**BW & Q**

$$Y(\omega) = \frac{1}{R} + \frac{j}{\omega L}\left(\omega^2 LC - 1\right)$$

$$Y(\omega_0 + \Delta\omega) = \frac{1}{R} + \frac{j}{(\omega_0 + \Delta\omega) L}\left[(\omega_0 + \Delta\omega)^2 LC - 1\right]$$

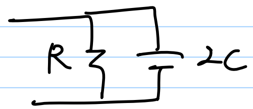
$$= \frac{1}{R} + \frac{j}{\omega_0 L\left[1 + \frac{\Delta\omega}{\omega_0}\right]}\left[\cancel{\omega_0^2 LC} + 2\omega_0 \Delta\omega LC - \Delta\omega^2 LC \cancel{-1}\right]$$

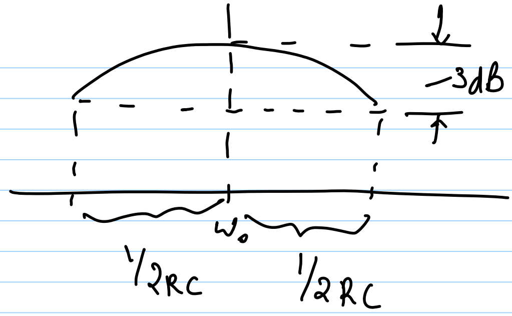
$$= \frac{1}{R} + \frac{j}{\cancel{\omega_0 L}\left[1+\frac{\Delta\omega}{\omega_0}\right]} \cdot \cancel{\omega_0}\,\Delta\omega \cancel{L} C\left[2+\frac{\Delta\omega}{\omega_0}\right]$$

$$\approx \frac{1}{R} + j\Delta\omega C\left(2+\frac{\Delta\omega}{\omega_0}\right)\left(1-\frac{\Delta\omega}{\omega_0}\right)$$

$$= \frac{1}{R} + j\Delta\omega C\left[2 - \frac{2\Delta\omega}{\omega_0} + \frac{\Delta\omega}{\omega_0} - \left(\frac{\Delta\omega}{\omega_0}\right)^2\right]$$

$$\approx \frac{1}{R} + j2\Delta\omega C$$




total $BW = \frac{1}{RC}$

$$\frac{\omega_0}{BW} = \frac{\omega_0}{1/RC} = \omega_0 RC \equiv Q$$

## Definitions of Q

1) Physical def.

$$Q \equiv \omega_0 \frac{E_{tot.}}{P_{av.}}$$

can be used for RC, RL networks also

2) $$Q = \frac{Im(Z(\omega))}{Re(Z(\omega))}$$ ← either +ve or −ve part of $Im(Z(\omega))$

3) $$Q = \frac{\omega_0}{BW}$$

4) $$Q = \frac{\omega_0}{2}\left|\frac{d\phi}{d\omega}\right|$$

$\phi(\omega)$ = phase of OL TF