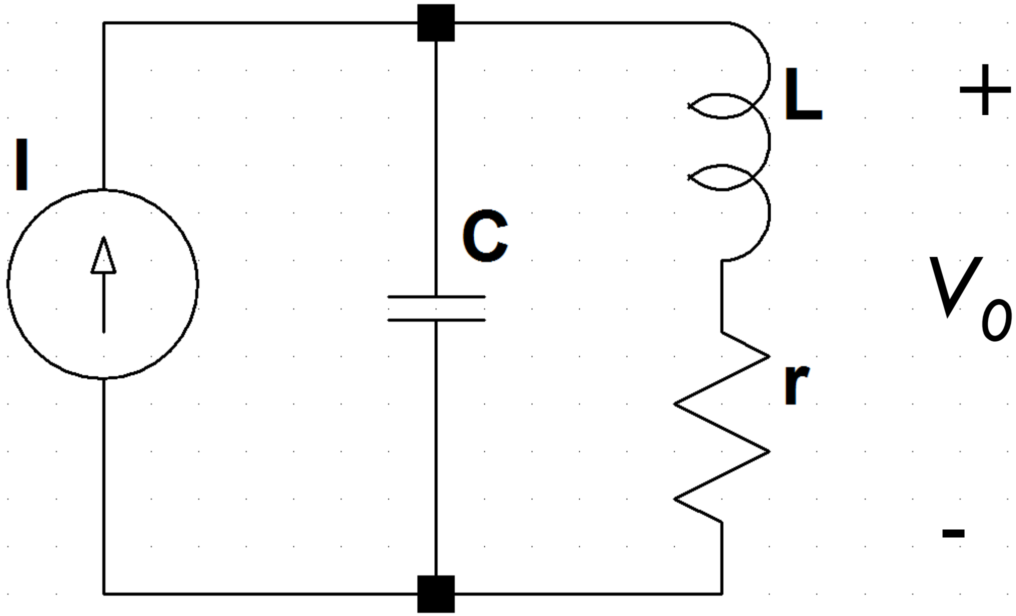
PARALLEL RESONANT CIRCUITS

Lecture 3

Parallel Resonant circuit



$$Transfer\ \ function = \frac{V_0}{I} = Z = \frac{1}{Y}$$

Impedance of parallel resonant circuit

$$Transfer\ \ function = \frac{V_0}{I} = Z = \frac{1}{Y}$$

$$Z = \cfrac{1}{j\omega C + \cfrac{1}{r + j\omega L}}$$

$$= \cfrac{1}{j\omega C + \cfrac{r - j\omega L}{r^2 + \omega^2 L^2}}$$

Resonance in parallel resonant circuit

$$Z = \frac{1}{j\omega C + \dfrac{r - j\omega L}{r^2 + \omega^2 L^2}}$$

At resonance Z is maximum

ω_0 *is resonant frequency*

$$\omega_0 C = \frac{\omega_0 L}{r^2 + \omega_0^2 L^2}$$

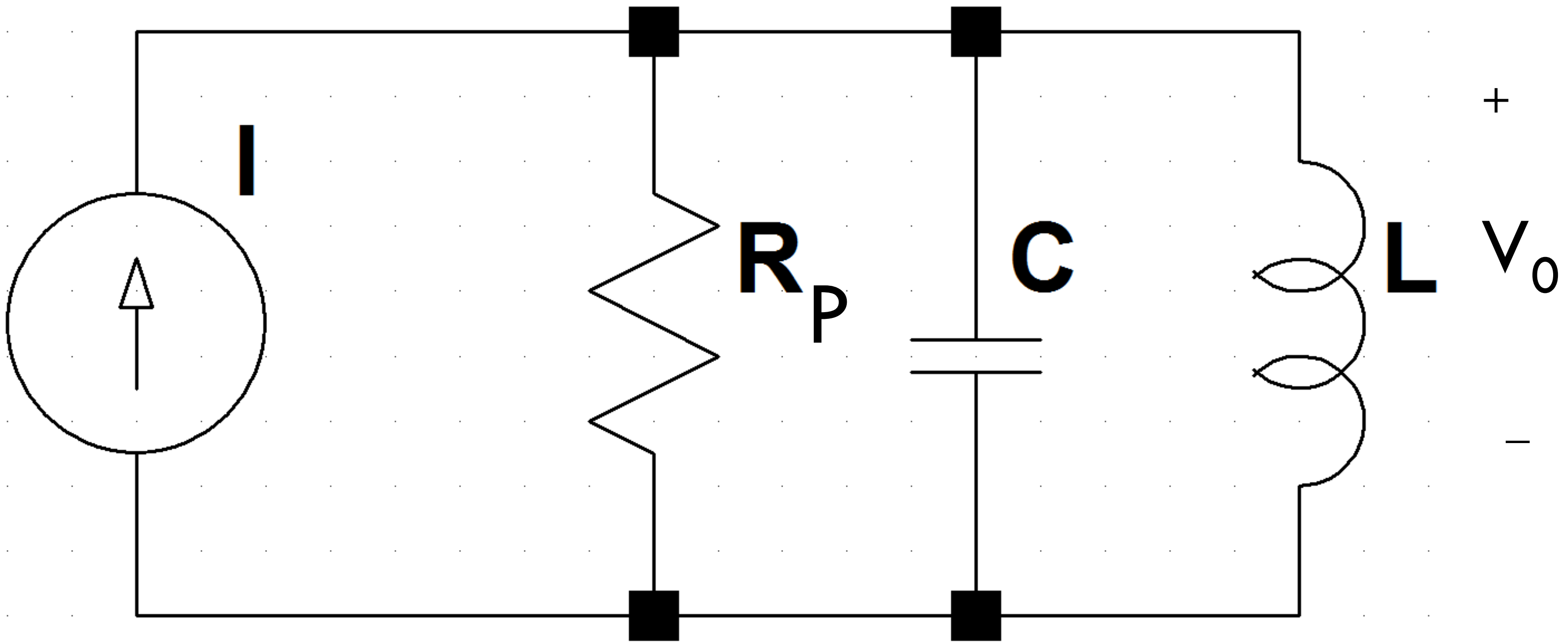
Resonant frequency

$$\omega_0 C = \frac{\omega_0 L}{r^2 + \omega_0^2 L^2}$$

$$\omega_0 = \sqrt{\frac{1}{LC} - \frac{r^2}{L^2}}$$

$$\omega_0 \approx \sqrt{\frac{1}{LC}}$$

Parallel circuit

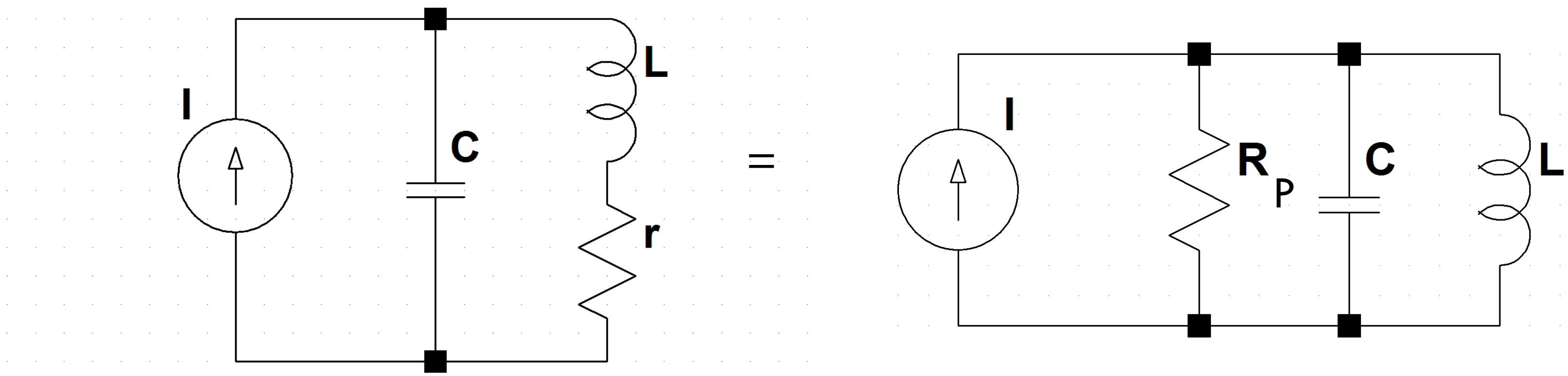


$$Transfer\ \ function = \frac{V_0}{I} = Z = \frac{1}{Y}$$

Equivalent circuit

$$Z = \frac{1}{j\omega C + \dfrac{r - j\omega L}{r^2 + \omega^2 L^2}}$$

$$Z = \frac{1}{Y} = \frac{1}{\dfrac{1}{R_P} + j\omega C + \dfrac{1}{j\omega L}}$$



Important relation

$$Z = \frac{1}{j\omega C + \dfrac{r - j\omega L}{r^2 + \omega^2 L^2}}$$

$$R_p = \frac{L}{Cr}$$

$At\ \ resonance$

$$R_p = \frac{r^2 + \omega_0^2 L^2}{r}$$

$$R_p = \frac{\omega_0 L}{\omega_0 C r} = \frac{Q}{\omega_0 C}$$

$$C = \frac{L}{r^2 + \omega_0^2 L^2}$$

$$Q = R_p \omega_0 C = \frac{R_p}{\omega_0 L}$$

Problem 4

A parallel tank circuit has $L = 10\ \mu H$ and $C = 10\ pF$. Q of the inductor is 100. If 100 kohms is connected across the tank circuit what is the circuit Q?

Circuit $Q = 50$

Solution to Problem 4

$$\omega_0 = \frac{1}{\sqrt{LC}} = 10^8$$

$$R_p = Q\omega_0 L = 100\,k\Omega$$

$$R_L = 100\,k\Omega$$

$$R = R_p \parallel R_L = 50k\Omega$$

$$Q_c = \frac{R}{\omega_0 L} = \frac{50000}{10^8 \times 10 \times 10^{-6}} = 50$$

Problem 5

- A parallel resonant circuit is driven from a voltage source in series with a resistance of 25 kohms. $L = 100\ \mu H$ and $C = 100\ pF$. The coil Q is 40. If the voltage source has the value of 2 volts find the output at resonance
- Answer : 1.23 volts

Solution to Problem 5

$$\omega_0 = \frac{1}{\sqrt{LC}} = 10^7$$

$$R_p = Q\omega_0 L = 40 \times 10^7 \times 100 \times 10^{-6}$$

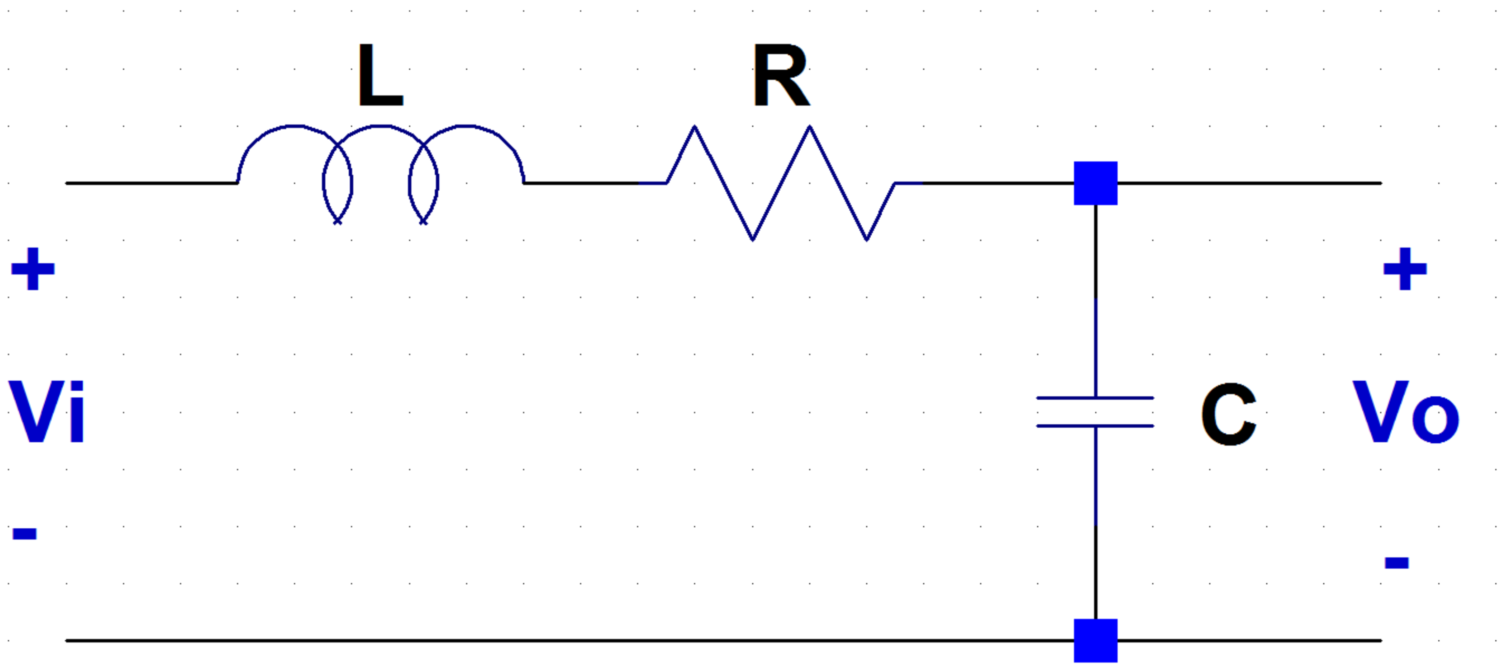
$$= 40\ k\Omega$$

$$V = 2 \times \frac{40}{40+25} = \frac{80}{65} = 1.23\ volts$$

LTspice

- Test the circuit of problem 5 on LT spice

Problem 6



What is the nature of filter ?

Find the magnitude of the ratio of output to input in terms of Q at resonance

Solution to problem 6

$$\frac{V_0}{V_i} = \frac{1/\,j\omega C}{Z} \quad : And \;\; at \;\; resonance$$

$$\frac{V_0}{V_i} = \frac{1/\,j\omega_0 C}{R} : \left|\frac{V_0}{V_i}\right| = \frac{1/\,\omega_0 C}{R}$$

$$\left|\frac{V_0}{V_i}\right| = \frac{\omega_0 L}{R} = Q$$

Problem 7

- Draw the circuit of a band reject filter using

  (1) A series resonant circuit

  (2) A parallel resonant circuit

Mechanical and Electronic tuning

- Mechanical tuning

  Moving plate capacitor

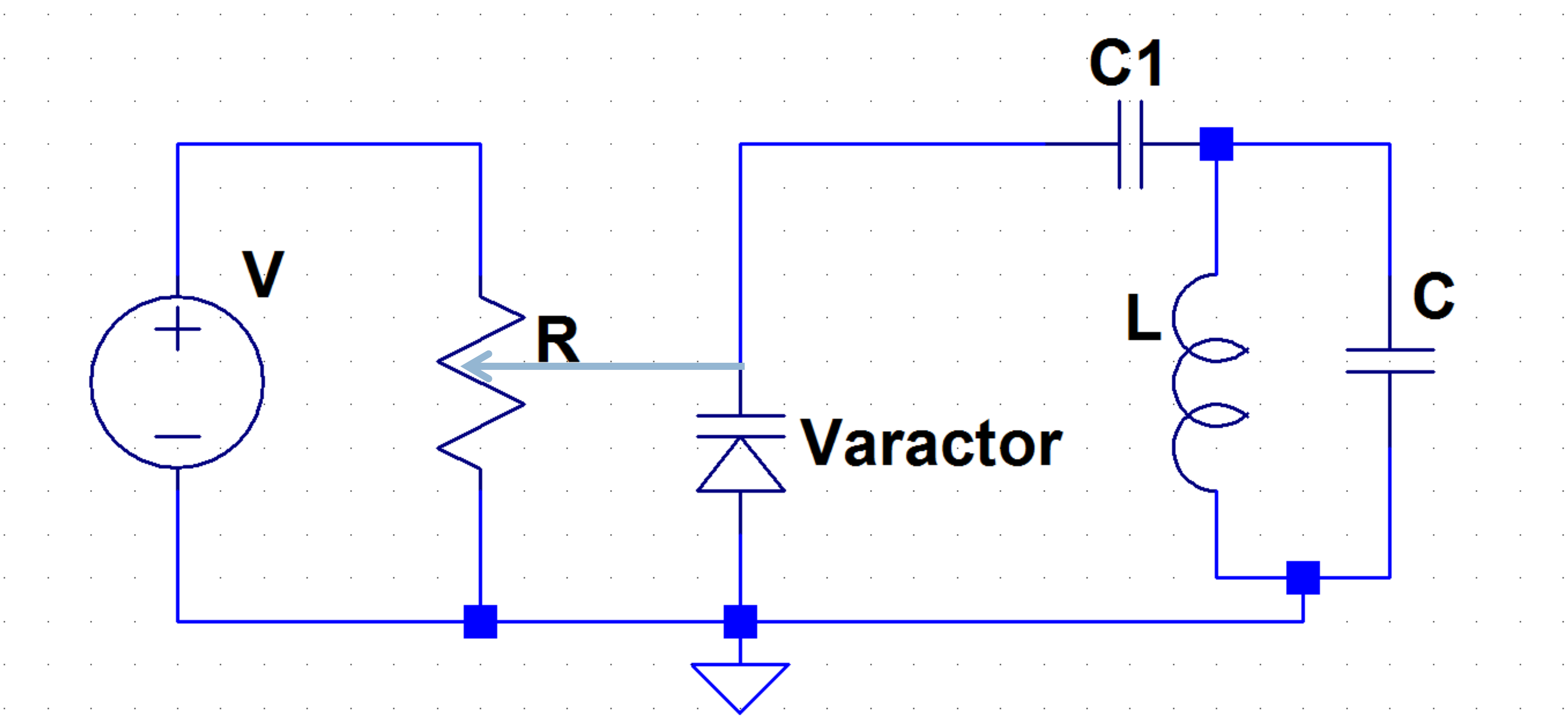
- Electronic tuning

  Varactor diode .

  Reverse biased diode

  The capacitance changes with the voltage

Circuit for electronic tuning



Problem

- A varactor has a linear characteristic between voltage and capacitance. The two points on the characteristic are given below

v (volts)	C(pF)
1	200
10	20

- Sketch the characteristic
- If v is 5 volts find the capacitance

Solution

$$C = mv + k$$

$$m = \frac{-180}{9} = -20 \quad pF / Volt$$

$$C = -20v + k$$

$$At \ v = 1 : C = 200 \ pF$$

$$200 = -20 + k \ : \ k = 220$$

$$C = -20v + 220$$

$$So \ when \ v = 5$$

$$C = -20 \times 5 + 220 = 120 \, pF$$