PARALLEL RESONANCE

ELECTRONICS & TELECOMMUNICATION

(1ST Yr. B.E. PRESENTATION)

PRESENTED BY

RAHUL RAI (140080111042)

DARSHI CONTRACTOR (140080111016)

DARSHAN ASAWA (140080111008)

CHAITANYA R TEJASWI (140080111013)

What is Resonance?????

Every object has a tendency to oscillate at a natural frequency.

When external power is applied to an object , If the frequency of power matches the natural frequency then RESONANCE is attained.

What is resonance and where we exactly use it?

- When you are tuning the radio station you are actually using resonance.
- A particular radio station transmits electromagnetic waves of a special frequency.
- When you change the node, you are varying capacitance of the circuit and thus indeed frequency is varied.
- When the frequency of the radio circuit matches the LCR circuit this resonance.

Basic condition for Parallel resonance

- In series R-L-C circuit ,resonance takes place when X l= Xc or in other words power factor of the circuit approaches unity
- Power factor of the entire circuit being unity remains the same for parallel circuit also.

What is POWER FACTOR?

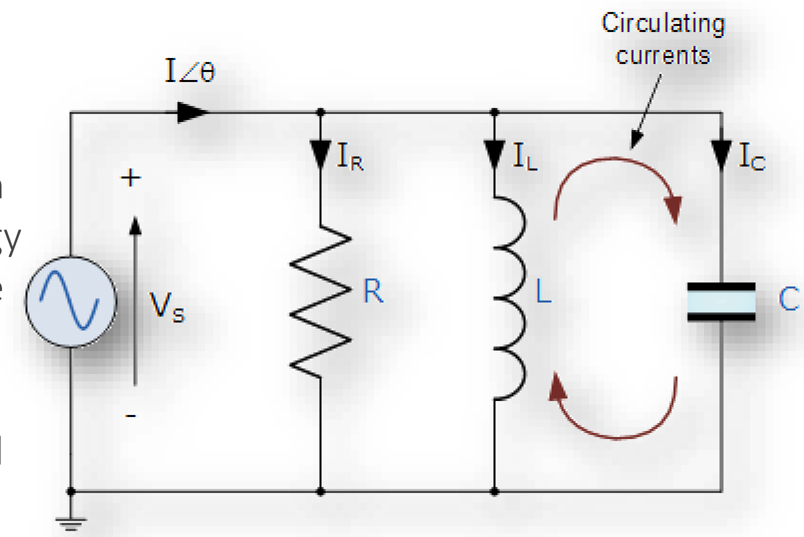
The ratio of resistance upon impendence

CONDITIONS FOR RESONANCE

- In R-L-C Series & Parallel ckts, the electrical resonance takes place when voltage across the inductance is equal to voltage across the capacitance ($X_L = X_C$).
- Alternatively, resonance takes place when the power factor of the ckt becomes unity.

PARALLEL RESONANT CIRCUIT

- A parallel circuit containing a resistance, R, an inductance, L and a capacitance, C will produce ***parallel resonance circuit*** when the resultant current through the parallel combination is in phase with the supply voltage. At resonance there will be a large circulating current between the inductor and the capacitor due to the energy of the oscillations, then parallel circuits produce current resonance.
- A ***parallel resonant circuit*** stores the circuit energy in the magnetic field of the inductor and the electric field of the capacitor. This energy is constantly being transferred back and forth between the inductor and the capacitor which results in zero current and energy being drawn from the supply. This is because the corresponding instantaneous values of I_L and I_C will always be equal and opposite and therefore the current drawn from the supply is the vector addition of these two currents and the current flowing in I_R.



- Resonance occurs when XL = XC and the imaginary parts of Y become zero. Then:

$$X_L = X_C \quad \Rightarrow \quad 2\pi f L = \frac{1}{2\pi f C}$$

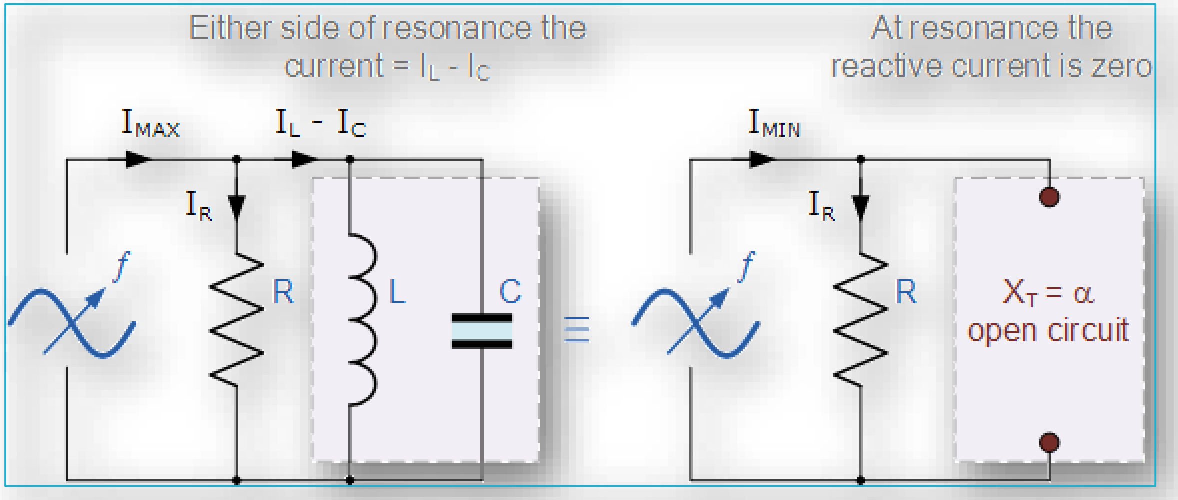
$$f^2 = \frac{1}{2\pi L \times 2\pi C} = \frac{1}{4\pi^2 LC}$$

$$f = \sqrt{\frac{1}{4\pi^2 LC}}$$

$$\therefore \; f_r = \frac{1}{2\pi\sqrt{LC}} \,(\text{Hz}) \quad \text{or} \quad \omega_r = \frac{1}{\sqrt{LC}} \,(\text{rads})$$

CIRCUIT INTERPRETATION

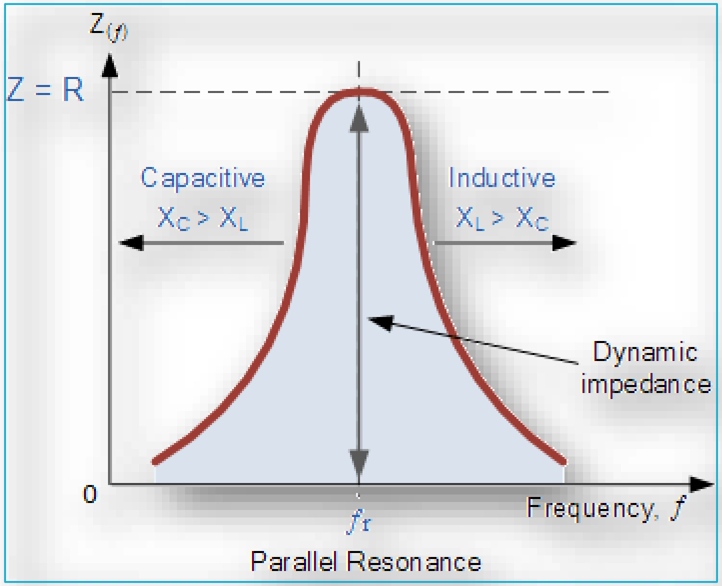
- Notice that at resonance the parallel circuit produces the same equation as for the series resonance circuit. Therefore, it makes no difference if the inductor or capacitor are connected in parallel or series. Also at resonance the parallel **LC** tank circuit acts like an open circuit with the circuit current being determined by the resistor, **R** only. So the total impedance of a parallel resonance circuit at resonance becomes just the value of the resistance in the circuit and **Z = R** as shown.



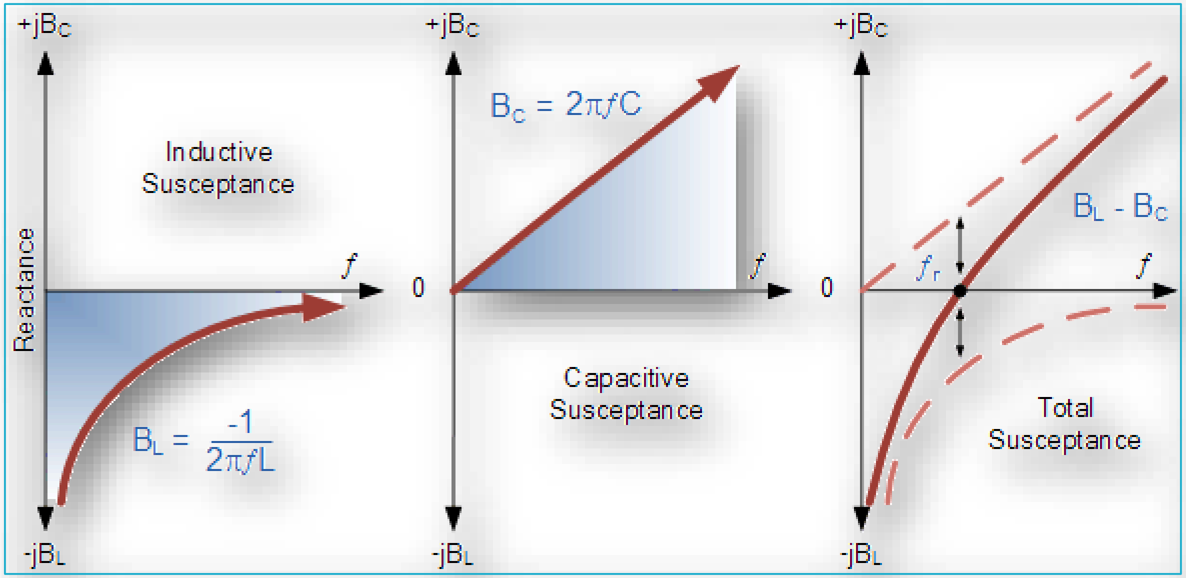
At resonance, the impedance of the parallel circuit is at its maximum value and equal to the resistance of the circuit. Also at resonance, as the impedance of the circuit is now that of resistance only, the total circuit current, I will be "in-phase" with the supply voltage, VS. We can change the circuit's frequency response by changing the value of this resistance. Changing the value of R affects the amount of current that flows through the circuit at resonance, if both **L** and **C** remain constant. Then the impedance of the circuit at resonance **Z** = **RMAX** is called the "dynamic impedance" of the circuit.

IMPEDANCE

- if the parallel circuits impedance is at its maximum at resonance then consequently, the circuits **admittance** must be at its minimum and one of the characteristics of a parallel resonance circuit is that admittance is very low limiting the circuits current. Unlike the series resonance circuit, the resistor in a parallel resonance circuit has a damping effect on the circuits bandwidth making the circuit less selective.
- Also, since the circuit current is constant for any value of impedance, **Z**, the voltage across a parallel resonance circuit will have the same shape as the total impedance and for a parallel circuit the voltage waveform is generally taken from across the capacitor.
- We now know that at the resonant frequency, f_r the admittance of the circuit is at its minimum and is equal to the conductance, **G** given by **1/R** because in a parallel resonance circuit the imaginary part of admittance, i.e. the **susceptance**, **B** is zero because $B_L = B_C$ as shown.



SUSCEPTANCE



- From above, the *inductive susceptance*, BL is inversely proportional to the frequency as represented by the hyperbolic curve. The *capacitive susceptance*, BC is directly proportional to the frequency and is therefore represented by a straight line. The final curve shows the plot of total susceptance of the parallel resonance circuit versus the frequency and is the difference between the two susceptance's.
- Then we can see that at the resonant frequency point were it crosses the horizontal axis the total circuit susceptance is zero. Below the resonant frequency point, the inductive susceptance dominates the circuit producing a "lagging" power factor, whereas above the resonant frequency point the capacitive susceptance dominates producing a "leading" power factor.
- So at the resonant frequency, ƒr the current drawn from the supply must be "in-phase" with the applied voltage as effectively there is only the resistance present in the parallel circuit, so the power factor becomes one or unity, (θ = 0o).

CURRENT INTENSITY

- As the total susceptance is zero at the resonant frequency, the admittance is at its minimum and is equal to the conductance, **G**. Therefore at resonance the current flowing through the circuit must also be at its minimum as the inductive and capacitive branch currents are equal (**I**L **=** **I**C) and are 180º out of phase.
- We remember that the total current flowing in a parallel RLC circuit is equal to the vector sum of the individual branch currents and for a given frequency is calculated as:

$$I_R = \frac{V}{R}$$

$$I_L = \frac{V}{X_L} = \frac{V}{2\pi f L}$$

$$I_C = \frac{V}{X_C} = V.2\pi f C$$

Therefore, I_T = vector sum of $(I_R + I_L + I_C)$

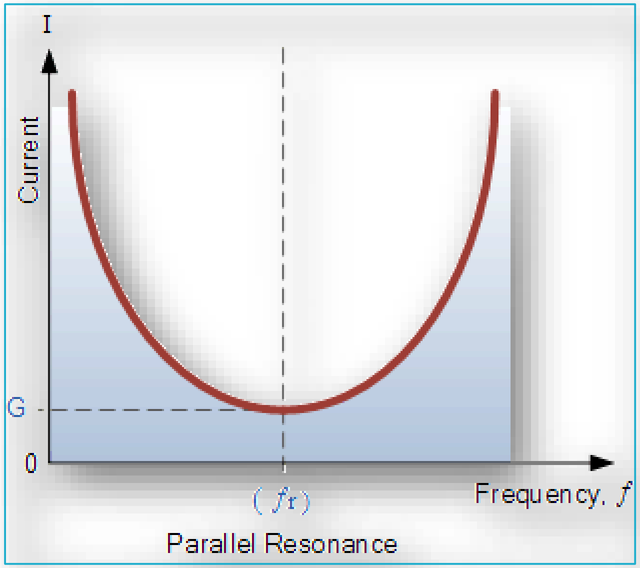
$$I_T = \sqrt{I_R^2 + (I_L + I_C)}$$

At resonance, currents $\mathbf{I_L}$ and $\mathbf{I_R}$ are equal and cancelling giving a net reactive current equal to zero. Then at resonance the above equation becomes:

$$I_T = \sqrt{I_R^2 + 0^2} = I_R$$

FREQUENCY RESPONSE

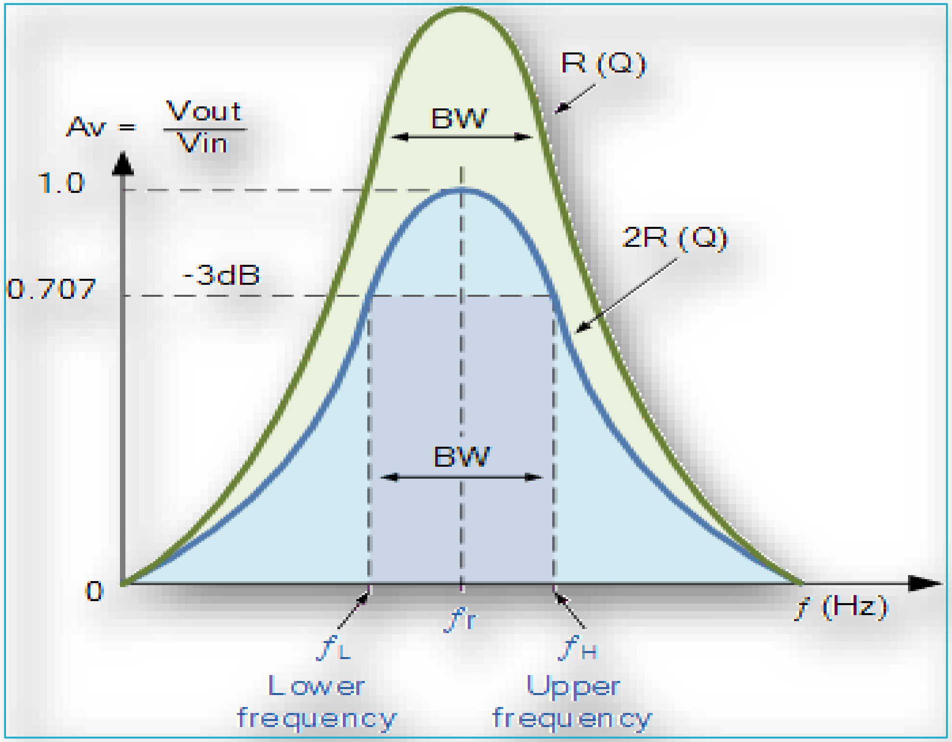
- Since the current flowing through a parallel resonance circuit is the product of voltage divided by impedance, at resonance the impedance, Z is at its maximum value, (=R). Therefore, the circuit current at this frequency will be at its minimum value of V/R and the graph of current against frequency for a parallel resonance circuit is given as:
- The frequency response curve of a parallel resonance circuit shows that the magnitude of the current is a function of frequency and plotting this onto a graph shows us that the response starts at its maximum value, reaches its minimum value at the resonance frequency when $I_{MIN} = I_R$ and then increases again to maximum as ƒ becomes infinite.



BANDWIDTH & SELECTIVITY

- The bandwidth of a parallel resonance circuit is defined in exactly the same way as for the series resonance circuit. The upper and lower cut-off frequencies given as: f_{upper} and f_{lower} respectively denote the half-power frequencies where the power dissipated in the circuit is half of the full power dissipated at the resonant frequency $0.5(I^2 R)$ which gives us the same -3dB points at a current value that is equal to 70.7% of its maximum resonant value, $(0.707 \times I)^2 R$.
- As with the series circuit, if the resonant frequency remains constant, an increase in the quality factor , **Q** will cause a decrease in the bandwidth and likewise, a decrease in the quality factor will cause an increase in the bandwidth as defined by: $BW = f_r /Q$ or $BW = f_2 - f_2$.
- Also changing the ratio between the inductor, L and the capacitor, C, or the value of the resistance, **R** the bandwidth and therefore the frequency response of the circuit will be changed for a fixed resonant frequency. This technique is used extensively in tuning circuits for radio and television transmitters and receivers.
- The selectivity or **Q-factor** for a parallel resonance circuit is generally defined as the ratio of the circulating branch currents to the supply current and is given as:

$$\text{Quality Factor, } Q = \frac{R}{2\pi f L} = 2\pi f CR = R\sqrt{\frac{C}{L}}$$



Note that the Q-factor of a parallel resonance circuit is the inverse of the expression for the Q-factor of the series circuit. Also in series resonance circuits the Q-factor gives the voltage magnification of the circuit, whereas in a parallel circuit it gives the current magnification.

THANK YOU

BIBLIOGRAPHY :

- WIKIPEDIA
- GOOGLE IMAGES
- AC CIRCUITS (E.S. KUH)