ISTANBUL COMMERCE UNIVERSITY

Electrical-Electronics Engineering
EEE202 Electro-technic Laboratory

Theory

Part 9

Contents

RESONANCE

9.1 INTRODUCTION

In LC parallel or serial AC circuits “**resonance**” occurs when the inductive reactance and the capacitive reactance of the circuit are of equal magnitude. Inductive reactance increases as the frequency increases. The capacitive reactance decreases as the frequency increases. Regardless of the values of inductor and capacitor, resonance occurs at a specific frequency. This frequency is called “**resonance frequency**”. To formulate;

$$XL = XC$$

$$2\pi FL = \frac{1}{2\pi FC}$$

$$1 = 2\pi FL.2\pi FC$$

$$1 = 4\pi^2 F^2 LC$$

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

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

$$F = \frac{1}{2\pi\sqrt{LC}}$$

Resonance frequency is a special value and symbolized by “**fo**” in mathematical operations.

$$fo = \frac{1}{2\pi\sqrt{LC}}$$

In Formula;

Fo = Resonance Frequency (**Hertz**)
2Π = Coefficient
L = Inductor’s inductance (**Henry**)
C = Capacity of Capacitor (**Farat**)

Parallel or serial resonance circuits are pure resistance circuits at the resonance frequency. As we know, circuit voltage and current are at the same phase in pure resistance circuits.

9.2 EXAMINATION OF PARALLEL RESONANCE

Parallel resonance circuits are simple structured circuits such as the ones mostly used in radio, TV, receivers and transmitters. although their structure is simple, they perform important works. Parallel resonance circuits are used for choosing signal with a specific frequency in various frequency signals, to prevent the other signals to pass or grounding them.

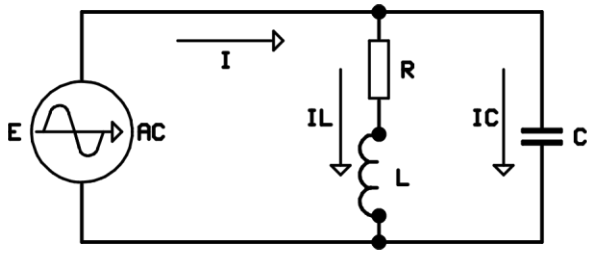

Figure 9.1

The parallel resonance circuit that is formed by parallel connection inductor and capacitor is shown in figure 9.1 “**R**” is serially connected to the inductor and it is the internal resistance of the inductor. Every inductor has a resistance though it may be too small. Capacitors also have internal resistances. However it is too small compared to the capacitive reactance. For this reason, internal resistances of capacitors are mostly omitted. As we know, at resonance moment XL=XC. In a parallel circuit, if XL=XC then IL=IC. Phasor diagram of parallel resonance circuit will be as in figure 9.2

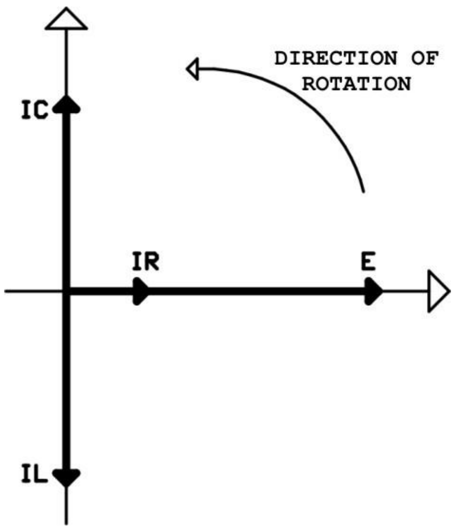

Figure 9.2

Because IL=IC, these two current zeroes each other. So, the only current passing through the circuit is IR. Therefore, circuit current is equal to the current passing through the resistor.

$$I = IR$$
$$\frac{E}{Z} = \frac{E}{R}$$
$$Z.E = R.E$$
$$Z = R$$

As seen in mathematical operations, circuit impedance is equal to the internal resistance of inductor. This resistance is the highest resistance that parallel resonance circuit can present. At that moment the current is at its smallest.

Resistance of parallel resonance circuit is smaller at higher and lower frequencies of resonance. Variation slopes for resistance and current related to the frequency are shown in figure 9.3

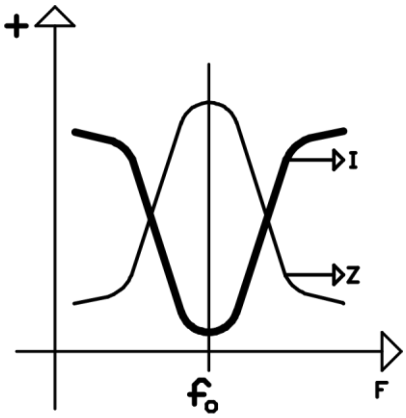

Figure 9.3

Inductivity or capacitivity of the parallel circuit is determined by the circuit component through which the most current passes. Most current passes through the component which has the lowest resistance. At lower frequencies than the resonance frequency inductive reactance is smaller than the capacitive reactance. So the circuit is inductive in lower frequencies. At higher frequencies than the resonance frequency the capacitive reactance is smaller than inductive reactance. In that situation, higher current passes through the capacitor. So the circuit is capacitive in higher frequencies.

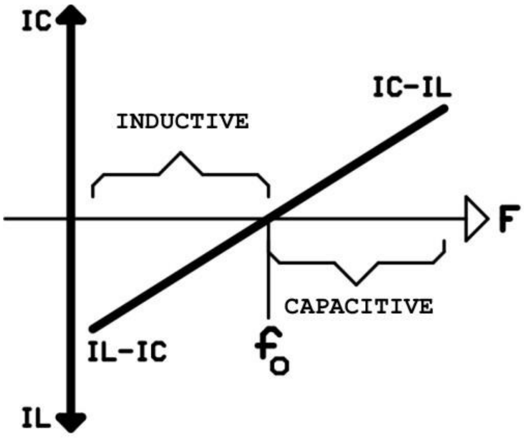

Figure 9.4

There is maximum voltage on the terminals of parallel circuit at the resonance frequency. At that moment resistance of the resonance circuit is at maximum, current is at minimum. Bandwidth is between two frequencies where the current is "**Imin.1,41**" under and over the resonance frequency. Bandwidth over the voltage slope is shown in figure 9.5

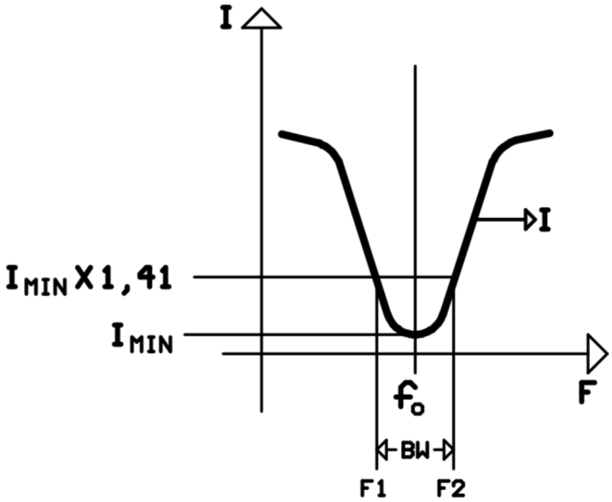

Figure 9.5

In Formula;

BW= Bandwidth (**Hertz**)
F1 = Low Frequency (**Hertz**)
F2 = High frequency (**Hertz**)

If we assume that 200 mAmper current passes through the parallel circuit at resonance frequency; F1 and F2 are the frequencies when the current is at 200x1,41=282 mAmper.

Example: An inductor has an inductance of 1 Henry and an internal resistance of 100R. It is parallelly connected with a 100nf capacitor.

1- Find the resonance difference of parallel circuit.
2- Find the circuit impedance at resonance frequency.

Solution:

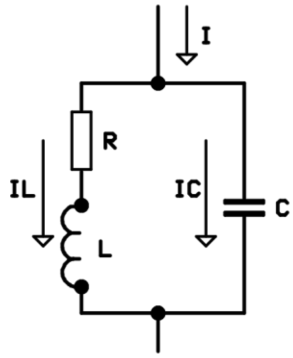

Figure 9.6

1- Resonance frequency:

$$fo = \frac{1}{2\pi\sqrt{LC}}$$

$$fo^2 = \frac{1}{2^2.\pi^2.L.C} = \frac{1}{4.9,85.1.100.10^{-9}} = 253807$$

$$fo = \sqrt{253807} = 503Hz$$

2- Circuit impedance is equal to the internal resistance of the inductor.

$$Z = R = 100R$$

9.3 EXAMINATION OF SERIAL RESONANCE

Serial resonance circuits are used for choosing signal with a specific frequency in various frequency signals, to prevent the other signals to pass. Its practical applications are very limited.

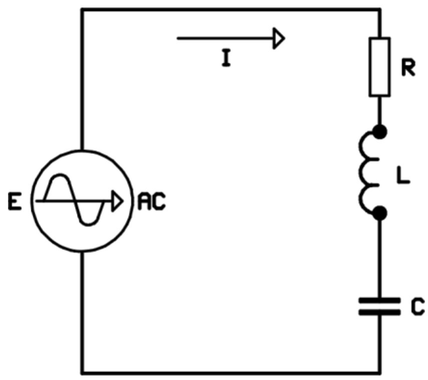

Figure 9.7

The serial resonance circuit that is formed by serial connection of inductor and capacitor is shown in figure 9.7 "**R**" is serially connected to the inductor and it is the internal resistance of the inductor. Every inductor has a resistance though it may be too small. Capacitors also have internal resistances. However it is too small compared to the capacitive reactance. For this reason, internal resistances of capacitors are mostly omitted. As we know, at resonance moment XL=XC.

In a serial circuit, EL=EC because the same current passes through all the components. Phasor diagram of parallel resonance circuit will be as in figure 9.8

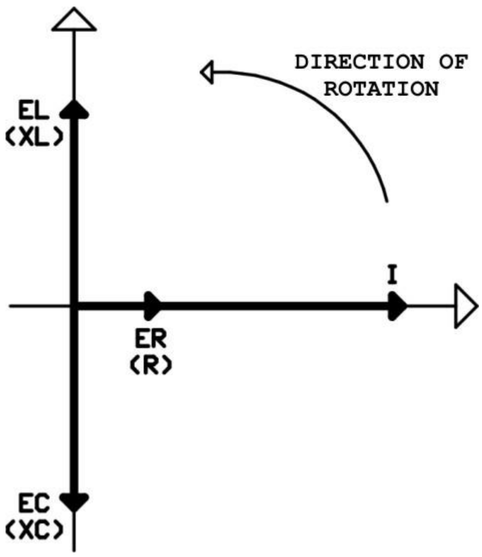

Figure 9.8

Because XL=XC, these two reactance zeroes each other. So, the only current passing through the circuit is IR.

Therefore, circuit current is equal to the current passing through the resistor.

$$I = IR$$
$$\frac{E}{Z} = \frac{E}{R}$$
$$Z.E = R.E$$
$$Z = R$$

As seen in mathematical operations, circuit impedance is equal to the internal resistance of inductor. This resistance is the smallest resistance that serial resonance circuit can present. At that moment the current is at its highest.

Resistance of serial resonance circuit is greater at higher and lower frequencies of resonance. Variation slopes for resistance and current related to the frequency are shown in figure 9.9

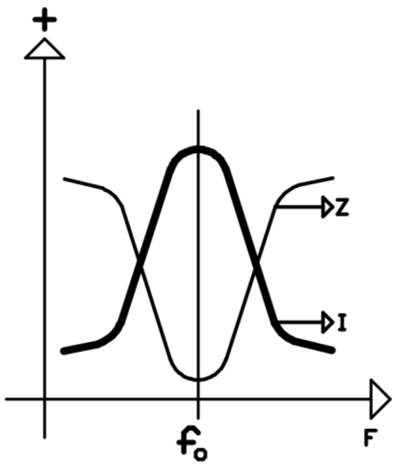

Figure 9.9

Inductivity or capacitivity of the serial circuit is determined by the circuit component on which there is the most voltage. There is the most voltage on the component which has the greatest resistance. At lower frequencies than the resonance frequency inductive reactance is smaller than the capacitive reactance. Then, the voltage on the inductor is smaller than the capacitor. So the circuit is capacitive in lower frequencies. At higher frequencies than the resonance frequency the capacitive reactance is smaller than inductive reactance. In that situation, there is greater voltage on the inductor. So the circuit is inductive in higher frequencies.

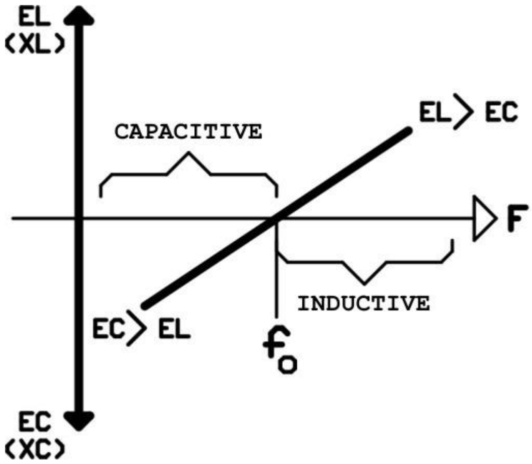

Figure 9.10

Maximum current passes through the serial circuit at the resonance frequency. Bandwidth is between two frequencies where the current is "**Imax.0,707**" under and over the resonance frequency. Bandwidth over the current slope is shown in figure 9.11

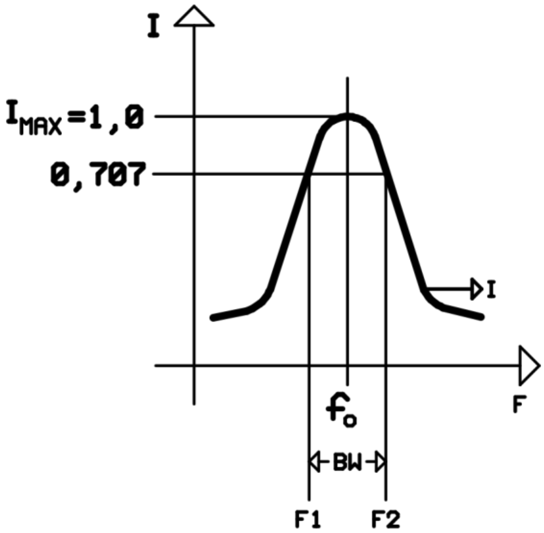

Figure 9.11

In Formula;

BW= Bandwidth (**Hertz**)
F1 = Low Frequency (**Hertz**)
F2 = High frequency (**Hertz**)

If we assume that 200mAmper current passes through the serial circuit at resonance frequency; F1 and F2 are the frequencies when the current is at 200x0,707=141mAmper.

Example: An inductor has an inductance of 2 Henry and an internal resistance of 100R. It is serially connected with a 1µf capacitor

1- Find the resonance difference of parallel circuit.
2- Find the circuit impedance at resonance frequency.

Solution:

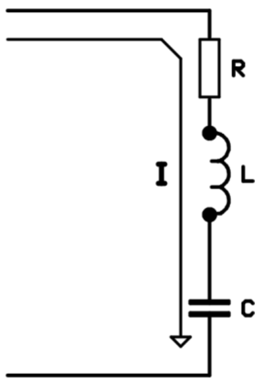

Figure 9.12

1- Resonance frequency:

$$fo = \frac{1}{2\pi\sqrt{LC}}$$

$$fo^2 = \frac{1}{4\pi^2.L.C} = \frac{1}{4.9,85.2.100.10^{-9}} = 126903$$

$$fo = \sqrt{126903} = 356Hz$$

2- Circuit impedance is equal to the internal resistance of the inductor.

$$Z = R = 100R$$