

**DEPARTMENT OF ELECTRICAL ENGINEERING**

**ELECTRICAL NETWORK ANALYSIS**

**LIST OF EXPERIMENTS**

<b><u>S.NO</u></b>	<b><u>EXPERIMENTS</u></b>
1.	Introduction to Electronic Workbench
2.	Transient Response analysis of Series RL Circuits
3.	Transient Response analysis of Series RC Circuits
4.	Transient Response analysis of LC Circuits
5.	Transient Response analysis of Series RLC Circuits
6.	Transient Response analysis of Parallel RLC circuits
7.	AC measurements; Amplitude and Phase
8.	Frequency Response analysis of Low Pass Filter
9.	Frequency Response analysis of High Pass Filter
10.	Frequency Response analysis of Band Pass Filter
11.	Frequency Response analysis of Band Stop Filter
12.	Frequency Response analysis of Active Low Pass Filter
13.	Frequency Response analysis of Active High Pass Filter

## **EXPERIMENT#1**

### **INTRODUCTION TO ELECTRONIC WORKBENCH**

#### **OBJECTIVE:**

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#### **THEORY:**

##### **ELECTRONIC WORKBENCH:**

Electronic Workbench (EWB) is a simulation package for electronic circuits. It allows you to design and analyze circuits without using breadboards, real components or actual instruments. EWB's click and drag operations make editing a circuit fast and easy. You can change parameters and circuit components very easily, which make analysis straight forward.

The user interface of EWB consists of the following parts;

- Menu
- Parts bin toolbar
- Circuit window
- Power switch

##### **MENU:**

At the top of the window a menu is provided if we want to create, open or save a file. Furthermore menu contains the cut, paste, rotating and zoom options in order to have an appropriate simulation.

##### **PARTS BIN TOOLBAR:**

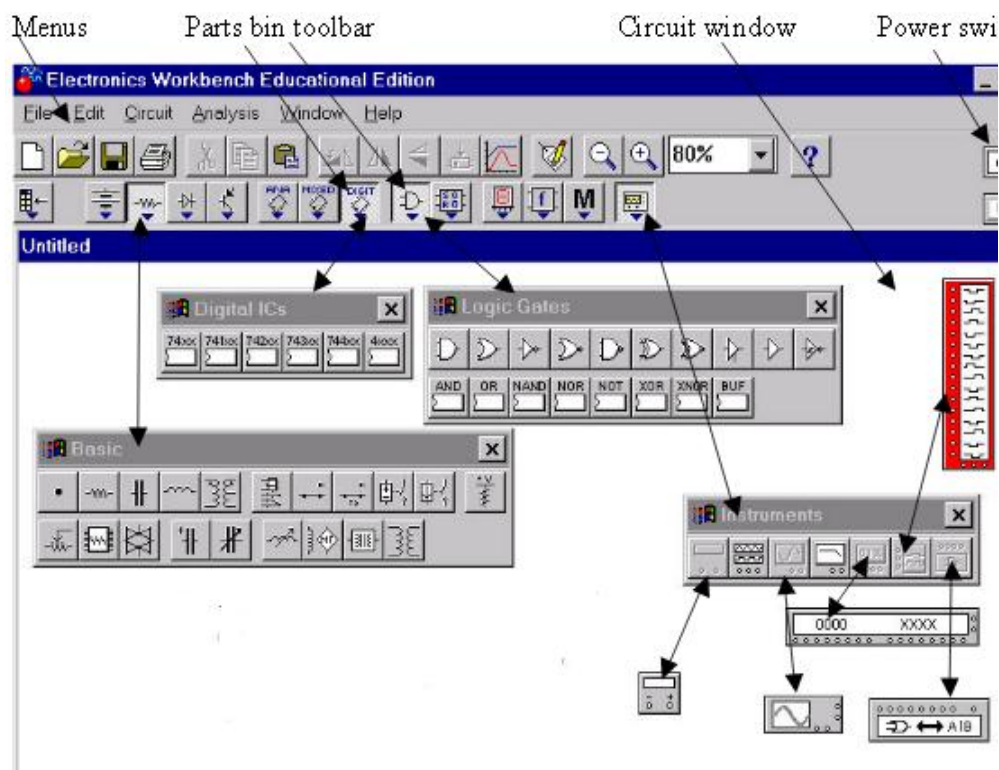
The components and instruments that you need to construct a circuit are grouped into parts bins. Each parts bin has a corresponding button on the Parts Bin toolbar. Clicking one of these buttons displays another toolbar containing buttons representing the components and instruments contained in that parts bin. Instruments toolbar includes a digital meter, a word generator, a logic analyzer, and a logic converter.

## CIRCUIT WINDOW:

The circuit window is where you create your schematics. To place a component or instrument on the circuit window, click the desired part button and drag the component or instrument to the circuit window. The instruments may be dragged onto the circuit window and used to test the circuit that you build just as you would use test instruments in a lab.

## POWER SWITCH:

The final item on the menu bar is a power switch. You need to click on the power switch when you are ready to activate your circuit.



## HOW TO MAKE A CIRCUIT:

### STEP #1: PLACE THE COMPONENTS ON CIRCUIT WINDOW

- Click on file/New to open a new circuit file.
- Click in the Parts Bin toolbar. The basic toolbar should appear.
- Drag the desired components from the toolbar to the circuit window.

## **STEP#2: ARRANGING OF CIRCUIT ELEMENT**

- You can change the orientation of the circuit elements either by rotating them or flipping them over.
- To do this, select the circuit element and either click on the standard rotated/flip icons on the toolbar, or select the desired operation under **circuit**.

## **STEP#3: WIRE THE COMPONENTS**

- Most components have short lines pointing outwards, the terminals. To wire the components together you have to create wires between the components.
- Move the pointer to one end of the component. To make a connection a black dot will appear. Now drag a wire to the end of the other component. Again a black spot will appear, and wire snaps into position.

## **STEP#4: SET VALUE FOR THE COMPONENTS**

Initially, each component comes up with a preset, default value, e.g., the battery voltage is set to 12 V.

You can change all component values to suit your application.

- Double click on the component.
- Select VALUE
- Change its value.
- Click OK

## **STEP#5: SAVE YOUR CIRCUIT**

- Select File/Save.
- Proceed in the normal way for saving files.

## **CONCLUSION:**

## EXPERIMENT#2

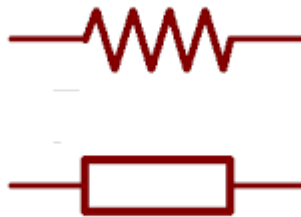
### TRANSIENT RESPONSE ANALYSIS OF SERIES RL CIRCUIT

#### OBJECTIVE:

#### THEORY:

#### RESISTOR:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.



#### INDUCTOR:

An **inductor**, also called a **coil** or **reactor**, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor.



## **CIRCUIT RESPONSE:**

Output response of a circuit is mainly composed of two types.

- Transient response
- Steady state response

## **TRANSIENT RESPONSE:**

In electrical engineering, a **transient response** or **natural response** is the response of a system to a change from equilibrium. The transient response is not necessarily tied to "on/off" events but to any event that affects the equilibrium of the system. The impulse response and step response are transient responses to a specific input. It's a temporary response.

## **STEADY STATE RESPONSE:**

In electronics, **steady state** is an equilibrium condition of a circuit or network that occurs as the effects of transients are no longer important. It's a permanent response.

## **DAMPING:**

The response can be classified as one of three types of damping that describes the output in relation to the steady-state response.

- **UNDER-DAMPED:**

An under-damped response is one that oscillates within a decaying envelope. The more under-damped the system, the more oscillations and longer it takes to reach steady-state. Here damping ratio is always  $<1$ .

- **CRITICALLY DAMPED:**

A critically damped response is the response that reaches the steady-state values the fastest without being under-damped. It is related to critical points in the sense that it straddles the boundary of under-damped and over-damped responses. Here, damping ratio is always equal to one. There should be no oscillation about the steady state value in the ideal case.

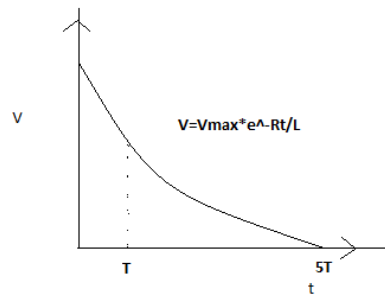
- **OVER-DAMPED:**

An over-damped response is the response that does not oscillate about the steady-state value but takes longer to reach than the critically damped case. Here damping ratio is  $>1$  it is the response of a system with respect to the input as a function of time.

## **TRANSIENT RESPONSE OF SERIES RL CIRCUIT:**

When resistor is connected in series with an inductor, at  $t < 0$  the voltage drop across the inductor is maximum and zero across the resistor. When time is increased  $t \geq 0$  the voltage drop begins to decrease

across inductor and increases across resistor. The inductor allows voltage to jump and prevent jump in current.



### **Time Constant ( $\tau$ )**

It is a measure of time required for certain changes in voltages and currents in RC and RL circuits. Generally, when the elapsed time exceeds five time constants ( $5\tau$ ) after switching has occurred, the currents and voltages have reached their final value, which is also called steady-state response.

The time constant of an RL circuit is the equivalent inductance divided by the resistance as viewed from the terminals of the equivalent inductor.

$$\tau = L / R$$

### **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>Transient>Set to zero>Add nodes and Accept it.
- Now again select Analysis>Transient and Simulate in dialog box.
- This will display the graph of transient response on a screen. You can edit the title, axis and grid from graph dialog box.

**RESISTOR VALUE CHANGED:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**INDUCTOR VALUE CHANGED:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**



**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE ( $\tau$ ):**

$$\tau_1 =$$

$$\tau_2 =$$

$$\tau_3 =$$

$$\tau_4 =$$

**CONCLUSIONS:**

## EXPERIMENT#3

### TRANSIENT RESPONSE ANALYSIS OF SERIES RC CIRCUIT

#### OBJECTIVE:

#### THEORY:

##### RESISTOR:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

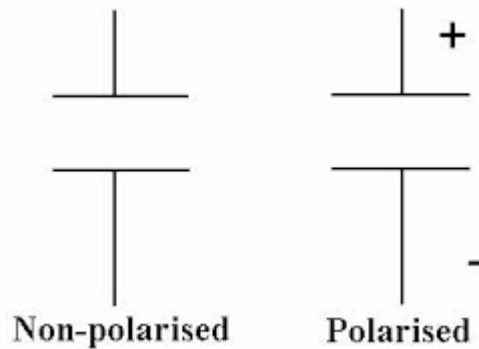


##### CAPACITOR:

A **capacitor** is a passive two-terminal electrical component used to store electrical energy temporarily in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non-conducting dielectric acts to increase the capacitor's charge capacity. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge  $+Q$  to collect on one plate and negative charge  $-Q$  to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage

is applied across the leads of the capacitor, a displacement current can flow.



### **CIRCUIT RESPONSE:**

Output response of a circuit is mainly composed of two types.

- Transient response
- Steady state response

### **TRANSIENT RESPONSE:**

In electrical engineering, a **transient response** or **natural response** is the response of a system to a change from equilibrium. The transient response is not necessarily tied to "on/off" events but to any event that affects the equilibrium of the system. The impulse response and step response are transient responses to a specific input. It's a temporary response.

### **STEADY STATE RESPONSE:**

In electronics, **steady state** is an equilibrium condition of a circuit or network that occurs as the effects of transients are no longer important. It's a permanent response.

### **DAMPING:**

The response can be classified as one of three types of damping that describes the output in relation to the steady-state response.

- **UNDER-DAMPED:**

An under-damped response is one that oscillates within a decaying envelope. The more under-damped the system, the more oscillations and longer it takes to reach steady-state. Here damping ratio is always  $<1$ .

- **CRITICALLY DAMPED:**

A critically damped response is the response that reaches the steady-state values the fastest without being under-damped. It is related to critical points in the sense that it straddles the boundary of under-damped and over-damped responses. Here, damping ratio is always equal to one. There should be no oscillation about the steady state value in the ideal case.

▪ **OVER-DAMPED:**

An over-damped response is the response that does not oscillate about the steady-state value but takes longer to reach than the critically damped case. Here damping ratio is  $>1$  it is the response of a system with respect to the input as a function of time.

**TRANSIENT RESPONSE OF SERIES RC CIRCUIT:**

When resistor is connected in series with a capacitor, at  $t < 0$  the voltage drop across the capacitor is minimum and maximum across the resistor. When time is increased  $t \geq 0$  the voltage drop begins to increase across capacitor since it will start charging and decrease across resistor.

**Time Constant ( $\tau$ )**

It is a measure of time required for certain changes in voltages and currents in RC and RL circuits. Generally, when the elapsed time exceeds five time constants ( $5\tau$ ) after switching has occurred, the currents and voltages have reached their final value, which is also called steady-state response.

The time constant of an RL circuit is the equivalent inductance divided by the resistance as viewed from the terminals of the equivalent inductor.

$$\tau = R * C$$

**PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
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- Now again select Analysis>Transient and Simulate in dialog box.
- This will display the graph of transient response on a screen. You can edit the title, axis and grid from graph dialog box.

**RESISTOR VALUE CHANGED:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**CAPACITOR VALUE CHANGED:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE ( $\tau$ ):**

$$\tau_1 =$$

$$\tau_2 =$$

$$\tau_3 =$$

$$\tau_4 =$$

**CONCLUSIONS:**

## EXPERIMENT#4

### TRANSIENT RESPONSE ANALYSIS OF LC CIRCUIT

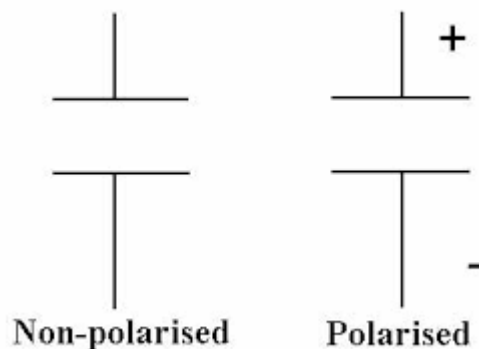
#### OBJECTIVE:

#### THEORY:

##### CAPACITOR:

A **capacitor** is a passive two-terminal electrical component used to store electrical energy temporarily in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non-conducting dielectric acts to increase the capacitor's charge capacity. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge  $+Q$  to collect on one plate and negative charge  $-Q$  to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.





## INDUCTOR:

An **inductor**, also called a **coil** or **reactor**, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor.



## CIRCUIT RESPONSE:

Output response of a circuit is mainly composed of two types.

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## TRANSIENT RESPONSE:

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## STEADY STATE RESPONSE:

In electronics, **steady state** is an equilibrium condition of a circuit or network that occurs as the effects of transients are no longer important. It's a permanent response.

## TRANSIENT RESPONSE OF SERIES LC CIRCUIT:

An **LC circuit**, also called a **resonant circuit**, **tank circuit**, or **tuned circuit**, is an electric circuit consisting of an inductor, represented by the letter L, and a capacitor, represented by the letter C, connected together. The circuit can act as an electrical resonator, an electrical analogue of a tuning fork, storing energy oscillating at the circuit's resonant frequency.

## OPERATION:

A capacitor stores energy in the electric field ( $E$ ) between its plates, depending on the voltage across it, and an inductor stores energy in its magnetic field ( $B$ ), depending on the current through it.

If an inductor is connected across a charged capacitor, current will start to flow through the inductor, building up a magnetic field around it and reducing the voltage on the capacitor. Eventually all the charge on the capacitor will be gone and the voltage across it will reach zero. However, the current will continue, because inductors resist changes in current. The current will begin to charge the capacitor with a voltage of opposite polarity to its original charge. Due to Faraday's law, the EMF which drives the current is caused by a decrease in the magnetic field, thus the energy required to charge the capacitor is extracted from the magnetic field. When the magnetic field is completely dissipated the current will stop and the charge will again be stored in the capacitor, with the opposite polarity as before. Then the cycle will begin again, with the current flowing in the opposite direction through the inductor.

The charge flows back and forth between the plates of the capacitor, through the inductor. The energy oscillates back and forth between the capacitor and the inductor until (if not replenished from an external circuit) internal resistance makes the oscillations die out.

### **RESONANCE FREQUENCY:**

The resonance frequency is defined as the frequency at which the impedance of the circuit is at a minimum. Equivalently, it can be defined as the frequency at which the impedance is purely real (that is, purely resistive). This occurs because the impedances of the inductor and capacitor at resonance are equal but of opposite sign and cancel out.

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

### **SERIES LC CIRCUIT:**

In the series configuration of the LC circuit, the inductor  $L$  and capacitor  $C$  are connected in series, as shown here. The total voltage  $v$  across the open terminals is simply the sum of the voltage across the inductor and the voltage across the capacitor. The current  $i$  into the positive terminal of the circuit is equal to the current through both the capacitor and the inductor.

$$\begin{aligned}v &= v_L + v_C \\i &= i_L = i_C\end{aligned}$$

### **RESONANCE:**

Inductive reactance magnitude ( $X_L$ ) increases as frequency increases while capacitive reactance magnitude ( $X_C$ ) decreases with the increase in frequency. At one particular frequency, these two reactance are equal in magnitude but opposite in sign; that frequency is called the resonant frequency ( $f_0$ ) for the given circuit.

Hence, at resonance:

$$X_L = -X_C$$

$$\omega L = \frac{1}{\omega C}$$

Solving for  $\omega$ , we have

$$\omega = \omega_0 = \frac{1}{\sqrt{LC}}$$

Which, is defined as the resonant angular frequency of the circuit

Converting angular frequency (in radians per second) into frequency (in hertz), one has

$$f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$$

In a series configuration,  $X_C$  and  $X_L$  cancel each other out. In real, rather than idealized components, the current is opposed, mostly by the resistance of the coil windings. Thus, the current supplied to a series resonant circuit is a maximum at resonance.

- In the limit as  $f \rightarrow f_0$  current is maximum. Circuit impedance is minimum. In this state, a circuit is called an *acceptor circuit*.
- For  $f < f_0$ ,  $X_L \ll (-X_C)$ . Hence, the circuit is capacitive.
- For  $f > f_0$ ,  $X_L \gg (-X_C)$ . Hence, the circuit is inductive.

### **PARALLEL LC CIRCUIT:**

In the parallel configuration, the inductor  $L$  and capacitor  $C$  are connected in parallel, as shown here. The voltage  $v$  across the open terminals is equal to both the voltage across the inductor and the voltage across the capacitor. The total current  $i$  flowing into the positive terminal of the circuit is equal to the sum of the current flowing through the inductor and the current flowing through the capacitor.

$$v = v_L = v_C$$
$$i = i_L + i_C$$

### **RESONANCE:**

Let  $R$  be the internal resistance of the coil. When  $X_L$  equals  $X_C$ , the reactive branch currents are equal and opposite. Hence they cancel out each other to give minimum current in the main line. Since total current is minimum, in this state the total impedance is maximum.

Resonant frequency given by;  $f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$

Note that any reactive branch current is not minimum at resonance, but each is given separately by dividing source voltage (V) by reactance (Z). Hence  $I=V/Z$ , as per Ohm's law.

- At  $f_0$ , line current is minimum. Total impedance is maximum. In this state a circuit is called a rejecter circuit.
- Below  $f_0$ , circuit is inductive.
- Above  $f_0$ , circuit is capacitive.

### **PROCEDURE:**

- Open the software and add new file.
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- Connect all the components with the help of cursor. When the cursor selects the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>Transient>Set to zero>Add nodes and Accept it.
- Now again select Analysis>Transient and Simulate in dialog box.
- This will display the graph of transient response on a screen. You can edit the title, axis and grid from graph dialog box.

**SERIES LC CIRCUIT:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**PARALLEL LC CIRCUIT:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CONCLUSIONS:**

## EXPERIMENT#5

### TRANSIENT RESPONSE ANALYSIS OF SERIES RLC CIRCUIT

#### OBJECTIVE:

#### THEORY:

##### RESISTOR:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.



##### INDUCTOR:

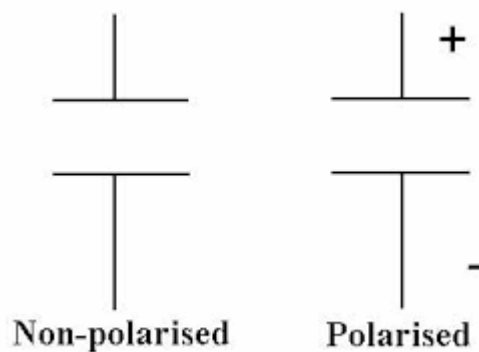
An **inductor**, also called a **coil** or **reactor**, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor.



## CAPACITOR:

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When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge  $+Q$  to collect on one plate and negative charge  $-Q$  to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.



## CIRCUIT RESPONSE:

Output response of a circuit is mainly composed of two types.

- Transient response
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## TRANSIENT RESPONSE:

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### **STEADY STATE RESPONSE:**

In electronics, **steady state** is an equilibrium condition of a circuit or network that occurs as the effects of transients are no longer important. It's a permanent response.

### **DAMPING:**

The response can be classified as one of three types of damping that describes the output in relation to the steady-state response.

- **UNDER-DAMPED:**

An under-damped response is one that oscillates within a decaying envelope. The more under-damped the system, the more oscillations and longer it takes to reach steady-state. Here damping ratio is always  $<1$ .

- **CRITICALLY DAMPED:**

A critically damped response is the response that reaches the steady-state values the fastest without being under-damped. It is related to critical points in the sense that it straddles the boundary of under-damped and over-damped responses. Here, damping ratio is always equal to one. There should be no oscillation about the steady state value in the ideal case.

- **OVER-DAMPED:**

An over-damped response is the response that does not oscillate about the steady-state value but takes longer to reach than the critically damped case. Here damping ratio is  $>1$  it is the response of a system with respect to the input as a function of time.

### **TRANSIENT RESPONSE OF SERIES RC CIRCUIT:**

A RLC circuit is an electrical circuit consisting of a resistor (R), an inductor (L), and a capacitor(C), connected in series.

The circuit forms a harmonic oscillator for current, and resonates in a similar way as an LC circuit. Introducing the resistor increases the decay of these oscillations, which is also known as damping. The resistor also reduces the peak resonant frequency. An important property of this circuit is its ability to resonate at a specific frequency, the resonance frequency.

### **RESONANCE FREQUENCY:**

The resonance frequency is defined as the frequency at which the impedance of the circuit is at a minimum. Equivalently, it can be defined as the frequency at which the impedance is purely real (that is, purely resistive). This occurs because the impedances of the inductor and capacitor at resonance are equal but of opposite sign and cancel out.

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

**DAMPING RATIO:**

The damping ratio is a dimensionless measure describing how oscillations in a system decay after a disturbance.

For series RLC circuit damping ratio is given as;

$$\alpha = \frac{R}{2L}$$

Under damped

$$\alpha = \frac{R}{2L} < \omega_0 = \frac{1}{\sqrt{LC}}$$

Critically damped

$$\alpha = \frac{R}{2L} = \omega_0 = \frac{1}{\sqrt{LC}}$$

Over damped

$$\alpha = \frac{R}{2L} > \omega_0 = \frac{1}{\sqrt{LC}}$$

**DAMPED RESONANCE FREQUENCY:**

$$\omega_d = \sqrt{\omega_0^2 - \alpha^2}$$

## **PROCEDURE:**

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- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>Transient>Set to zero>Add nodes and Accept it.
- Now again select Analysis>Transient and Simulate in dialog box.
- This will display the graph of transient response on a screen. You can edit the title, axis and grid from graph dialog box.

## **SERIES RLC CIRCUIT:**

### **SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

### **SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$\alpha =$$

$$\omega_0 =$$

$$\omega_d =$$

**CONCLUSIONS:**

## EXPERIMENT#6

### TRANSIENT RESPONSE ANALYSIS OF PARALLEL RLC CIRCUIT

#### OBJECTIVE:

#### THEORY:

##### RESISTOR:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.



##### INDUCTOR:

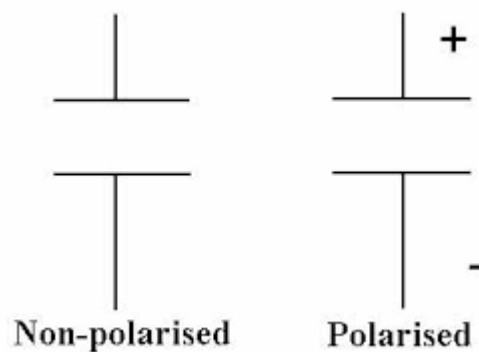
An **inductor**, also called a **coil** or **reactor**, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor.



## CAPACITOR:

A **capacitor** is a passive two-terminal electrical component used to store electrical energy temporarily in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non-conducting dielectric acts to increase the capacitor's charge capacity. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge  $+Q$  to collect on one plate and negative charge  $-Q$  to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.



## CIRCUIT RESPONSE:

Output response of a circuit is mainly composed of two types.

- Transient response
- Steady state response

## TRANSIENT RESPONSE:

In electrical engineering, a **transient response** or **natural response** is the response of a system to a change from equilibrium. The transient response is not necessarily tied to "on/off" events but to any event that affects the equilibrium of the system. The impulse response and step response are transient responses to a specific input. It's a temporary response.

## **STEADY STATE RESPONSE:**

In electronics, **steady state** is an equilibrium condition of a circuit or network that occurs as the effects of transients are no longer important. It's a permanent response.

## **DAMPING:**

The response can be classified as one of three types of damping that describes the output in relation to the steady-state response.

- **UNDER-DAMPED:**

An under-damped response is one that oscillates within a decaying envelope. The more under-damped the system, the more oscillations and longer it takes to reach steady-state. Here damping ratio is always  $<1$ .

- **CRITICALLY DAMPED:**

A critically damped response is the response that reaches the steady-state values the fastest without being under-damped. It is related to critical points in the sense that it straddles the boundary of under-damped and over-damped responses. Here, damping ratio is always equal to one. There should be no oscillation about the steady state value in the ideal case.

- **OVER-DAMPED:**

An over-damped response is the response that does not oscillate about the steady-state value but takes longer to reach than the critically damped case. Here damping ratio is  $>1$  it is the response of a system with respect to the input as a function of time.

## **TRANSIENT RESPONSE OF PARALLEL RLC CIRCUIT:**

A RLC circuit is an electrical circuit consisting of a resistor (R), an inductor (L), and a capacitor(C), connected in parallel.

The circuit forms a harmonic oscillator for current, and resonates in a similar way as an LC circuit. Introducing the resistor increases the decay of these oscillations, which is also known as damping. The resistor also reduces the peak resonant frequency. An important property of this circuit is its ability to resonate at a specific frequency, the resonance frequency.

## **RESONANCE FREQUENCY:**

The resonance frequency is defined as the frequency at which the impedance of the circuit is at a minimum. Equivalently, it can be defined as the frequency at which the impedance is purely real (that is, purely resistive). This occurs because the impedances of the inductor and capacitor at resonance are equal but of opposite sign and cancel out.

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

### **DAMPING RATIO:**

The damping ratio is a dimensionless measure describing how oscillations in a system decay after a disturbance.

For series RLC circuit damping ratio is given as;

$$\alpha = \frac{1}{2RC}$$

Under damped

$$\alpha = \frac{1}{2RC} < \omega_0 = \frac{1}{\sqrt{LC}}$$

Critically damped

$$\alpha = \frac{1}{2RC} = \omega_0 = \frac{1}{\sqrt{LC}}$$

Over damped

$$\alpha = \frac{1}{2RC} > \omega_0 = \frac{1}{\sqrt{LC}}$$

### **DAMPED RESONANCE FREQUENCY:**

$$\omega_d = \sqrt{\omega_0^2 - \alpha^2}$$



## **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>Transient>Set to zero>Add nodes and Accept it.
- Now again select Analysis>Transient and Simulate in dialog box.
- This will display the graph of transient response on a screen. You can edit the title, axis and grid from graph dialog box.

## **PARALLEL RLC CIRCUIT:**

### **SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

### **CHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$\alpha =$$

$$\omega_0 =$$

$$\omega_d =$$

**CONCLUSIONS:**

## EXPERIMENT#7

### AC MEASUREMENTS; AMPLITUDE AND PHASE

#### OBJECTIVE:

#### THEORY:

##### RESISTOR:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

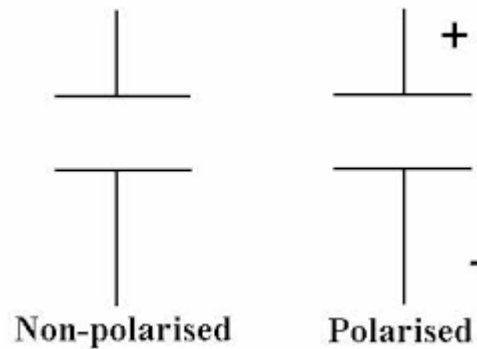


##### CAPACITOR:

A **capacitor** is a passive two-terminal electrical component used to store electrical energy temporarily in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non-conducting dielectric acts to increase the capacitor's charge capacity. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge  $+Q$  to collect on one plate and negative charge  $-Q$  to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage

is applied across the leads of the capacitor, a displacement current can flow.



### **INDUCTOR:**

An **inductor**, also called a **coil** or **reactor**, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor.



### **AC SIGNALS:**

An AC voltage is continually changing between positive (+) and negative (-). The rate of changing direction is called the frequency of the AC and it is measured in hertz (Hz) which is the number of forwards-backwards cycles per second.

An electrical signal is a voltage or current which conveys information, usually it means a voltage. The term can be used for any voltage or current in a circuit.

The voltage-time graph on the right shows various properties of an electrical signal. In addition to the properties labeled on the graph, there is frequency which is the number of cycles per second.

$$x(t) = A \cdot \cos(2\pi ft + \varphi)$$

$$y(t) = A \cdot \sin(2\pi ft + \varphi) = A \cdot \cos\left(2\pi ft + \varphi - \frac{\pi}{2}\right)$$

### **AMPLITUDE:**

It is the maximum voltage reached by the signal. It is measured in volts, V

### **TIME PERIOD:**

It is the time taken for the signal to complete one cycle. It is measured in seconds(s), but time periods tend to be short so milliseconds (ms) and microseconds ( $\mu\text{s}$ ) are often used.  $1\text{ms} = 0.001\text{s}$  and  $1\mu\text{s} = 0.000001\text{s}$ .

### **FREQUENCY:**

It is the number of cycles per second. It is measured in hertz (Hz), but frequencies tend to be high so kilohertz (kHz) and megahertz (MHz) are often used.  $1\text{kHz} = 1000\text{Hz}$  and  $1\text{MHz} = 1000000\text{Hz}$ .

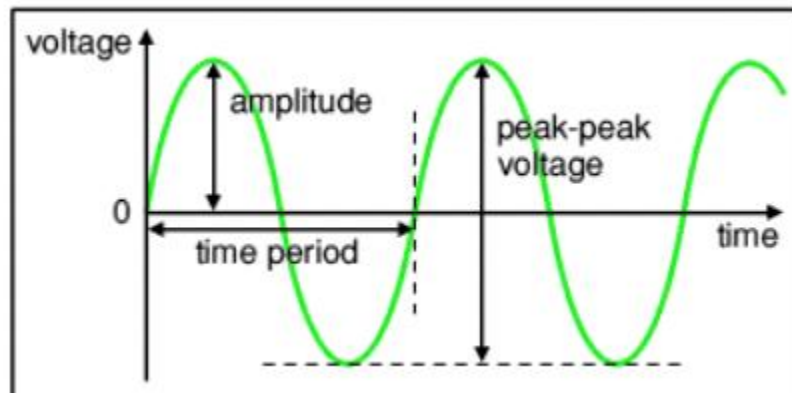
Frequency =  $1/\text{time period}$

Time period =  $1/\text{frequency}$

### **PHASE SHIFT:**

Phase shift is any change that occurs in the phase of one quantity, or in the phase difference between two or more quantities.

$\varphi$  Is sometimes referred to as a phase shift or phase offset, because it represents a "shift" from zero phase.



### **PROCEDURE:**

- Open the software and add new file.

- From the tool bar select the desired components. In this experiment resistor, inductor, capacitor ground, oscilloscope and ac power supply is used. Set the frequency to 10kHz
- Connect all the components with the help of cursor. When the cursor selects the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Connect the source with the oscilloscope and the across the inductor. After that with the capacitor
- Now when the circuit is complete. Run the simulation and measure the amplitude and phase difference.

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CONCLUSIONS:**

## **EXPERIMENT#8**

### **FREQUENCY RESPONSE ANALYSIS OF LOW PASS FILTER**

#### **OBJECTIVE:**

#### **THEORY:**

#### **FILTERS:**

**Filters** are circuits which are used to remove unwanted frequency components from the signal, to enhance wanted ones, or both. Filters can be active, high-pass, low-pass, band-pass, band-stop etc.

#### **PASSIVE FILTERS:**

Passive implementations of linear filters are based on combinations of resistors (R), inductors (L) and capacitors (C). These types are collectively known as *passive filters*, because they do not contain active components such as transistors.

Inductors block high-frequency signals and conduct low-frequency signals, while capacitors do the reverse. Resistors on their own have no frequency-selective properties, but are added to inductors and capacitors to determine the *time-constants* of the circuit, and therefore the frequencies to which it responds.

#### **ACTIVE FILTERS:**

Active filters are implemented using a combination of passive and active (amplifying) components, and require an outside power source. Operational amplifiers are frequently used in active filter designs.

#### **LOW PASS FILTER:**

A **low-pass filter** is a filter that passes signals with a frequency lower than a certain cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. The amount of attenuation for each frequency depends on the filter design

An ideal low-pass filter completely eliminates all frequencies above the cutoff frequency while passing those below unchanged; its frequency response is a rectangular function. The transition region present in practical filters does not exist in an ideal filter.

One simple low-pass filter circuit consists of a resistor in series with a load, and a capacitor in parallel with the load. The capacitor exhibits reactance, and blocks low-frequency signals, forcing them through the load instead. At higher frequencies the reactance drops, and the capacitor effectively functions as a short circuit. The combination of resistance and capacitance gives the time constant of the filter



The break frequency, also called the turnover frequency or cutoff frequency (in hertz), is determined by the time constant:

$$f_c = \frac{1}{2\pi\tau} = \frac{1}{2\pi RC}$$

Or equivalently (in radians per second)

$$\omega_c = \frac{1}{\tau} = \frac{1}{RC}$$

### **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>AC frequency>Add nodes and Accept it.
- Now again select Analysis>AC frequency and Simulate in dialog box.
- This will display the graph of frequency response on a screen. You can edit the title, axis and grid from graph dialog box.

**LOW PASS FILTER:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$F_{C1} =$$

$$F_{C2} =$$

**CONCLUSIONS:**

## **EXPERIMENT#9**

### **FREQUENCY RESPONSE ANALYSIS OF HIGH PASS FILTER**

#### **OBJECTIVE:**

#### **THEORY:**

#### **FILTERS:**

**Filters** are circuits which are used to remove unwanted frequency components from the signal, to enhance wanted ones, or both. Filters can be active, high-pass, low-pass, band-pass, band-stop etc.

#### **PASSIVE FILTERS:**

Passive implementations of linear filters are based on combinations of resistors (R), inductors (L) and capacitors (C). These types are collectively known as *passive filters*, because they do not contain active components such as transistors.

Inductors block high-frequency signals and conduct low-frequency signals, while capacitors do the reverse. Resistors on their own have no frequency-selective properties, but are added to inductors and capacitors to determine the *time-constants* of the circuit, and therefore the frequencies to which it responds.

#### **ACTIVE FILTERS:**

Active filters are implemented using a combination of passive and active (amplifying) components, and require an outside power source. Operational amplifiers are frequently used in active filter designs.

#### **HIGH PASS FILTER:**

**High-pass filter** is an electronic filter that passes signals with a frequency higher than a certain cutoff frequency and attenuates signals with frequencies lower than the cutoff frequency. The amount of attenuation for each frequency depends on the filter design.

The simple first-order electronic high-pass filter shown in Figure 1 is implemented by placing an input voltage across the series combination of a capacitor and a resistor and using the voltage across the resistor as an output. The product of the resistance and capacitance ( $R \times C$ ) is the time constant ( $\tau$ ); it is inversely proportional to the cutoff frequency  $f_c$ , that is,

$$f_c = \frac{1}{2\pi\tau} = \frac{1}{2\pi RC}$$

Where  $f_c$  is in hertz,  $\tau$  is in seconds,  $R$  is in ohms, and  $C$  is in farads.

### **CUTOFF FREQUENCY:**

Cutoff frequency applies to an edge in a low pass, high pass, band pass, or band-stop characteristic –A frequency characterizing a boundary between a pass band and a stop band.

### **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>AC frequency>Add nodes and Accept it.
- Now again select Analysis>AC frequency and Simulate in dialog box.
- This will display the graph of frequency response on a screen. You can edit the title, axis and grid from graph dialog box.

**HIGH PASS FILTER:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$F_{C1} =$$

$$F_{C2} =$$

**CONCLUSIONS:**

## **EXPERIMENT#10**

### **FREQUENCY RESPONSE ANALYSIS OF BAND PASS FILTER**

#### **OBJECTIVE:**

#### **THEORY:**

#### **FILTERS:**

**Filters** are circuits which are used to remove unwanted frequency components from the signal, to enhance wanted ones, or both. Filters can be active, high-pass, low-pass, band-pass, band-stop etc.

#### **PASSIVE FILTERS:**

Passive implementations of linear filters are based on combinations of resistors (R), inductors (L) and capacitors (C). These types are collectively known as *passive filters*, because they do not contain active components such as transistors.

Inductors block high-frequency signals and conduct low-frequency signals, while capacitors do the reverse. Resistors on their own have no frequency-selective properties, but are added to inductors and capacitors to determine the *time-constants* of the circuit, and therefore the frequencies to which it responds.

#### **ACTIVE FILTERS:**

Active filters are implemented using a combination of passive and active (amplifying) components, and require an outside power source. Operational amplifiers are frequently used in active filter designs.

#### **BAND PASS FILTER:**

A band-pass filter is a device that passes frequencies within a certain range and rejects (attenuates) frequencies outside that range.

Band-pass filter is an RLC circuit (a resistor–inductor–capacitor circuit). These filters can also be created by combining a low-pass filter in series with a high-pass filter.

A band-pass filter can be characterized by its Q factor. The Q-factor is the inverse of the fractional bandwidth. A high-Q filter will have a narrow pass band and a low-Q filter will have a wide pass band.

An ideal band pass filter would have a completely flat pass band (e.g. with no gain/attenuation throughout) and would completely attenuate all frequencies outside the pass band. In practice, no band



pass filter is ideal. The filter does not attenuate all frequencies outside the desired frequency range completely; in particular, there is a region just outside the intended pass band where frequencies are attenuated, but not rejected.

### **CUTOFF FREQUENCY:**

Cutoff frequency applies to an edge in a low pass, high pass, band pass, or band-stop characteristic – A frequency characterizing a boundary between a pass band and a stop band.

### **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor selects the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>AC frequency>Add nodes and Accept it.
- Now again select Analysis>AC frequency and Simulate in dialog box.
- This will display the graph of frequency response on a screen. You can edit the title, axis and grid from graph dialog box.

**BAND PASS FILTER:**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$F_{C1} =$$

$$F_{C2} =$$

**CONCLUSIONS:**

# **EXPERIMENT#11**

## **FREQUENCY RESPONSE ANALYSIS OF BAND STOP FILTER**

### **OBJECTIVE:**

### **THEORY:**

#### **FILTERS:**

**Filters** are circuits which are used to remove unwanted frequency components from the signal, to enhance wanted ones, or both. Filters can be active, high-pass, low-pass, band-pass, band-stop etc.

#### **PASSIVE FILTERS:**

Passive implementations of linear filters are based on combinations of resistors (R), inductors (L) and capacitors (C). These types are collectively known as *passive filters*, because they do not contain active components such as transistors.

Inductors block high-frequency signals and conduct low-frequency signals, while capacitors do the reverse. Resistors on their own have no frequency-selective properties, but are added to inductors and capacitors to determine the *time-constants* of the circuit, and therefore the frequencies to which it responds.

#### **ACTIVE FILTERS:**

Active filters are implemented using a combination of passive and active (amplifying) components, and require an outside power source. Operational amplifiers are frequently used in active filter designs.

#### **BAND STOP FILTER:**

A band-stop filter or band-rejection filter is a filter that passes most frequencies unaltered, but attenuates those in a specific range to very low levels. It is the opposite of a band-pass filter. A notch filter is a band-stop filter with a narrow stop band (high Q factor)

#### **CUTOFF FREQUENCY:**

Cutoff frequency applies to an edge in a low pass, high pass, band pass, or band-stop characteristic –A frequency characterizing a boundary between a pass band and a stop band.

## **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>AC frequency>Add nodes and Accept it.
- Now again select Analysis>AC frequency and Simulate in dialog box.
- This will display the graph of frequency response on a screen. You can edit the title, axis and grid from graph dialog box.

## **BAND STOP FILTER:**

### **SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$F_{C1} =$$

$$F_{C2} =$$

**CONCLUSIONS:**

## EXPERIMENT#12

### FREQUENCY RESPONSE ANALYSIS OF ACTIVE LOW PASS FILTER

#### OBJECTIVE:

#### THEORY:

#### FILTERS:

**Filters** are circuits which are used to remove unwanted frequency components from the signal, to enhance wanted ones, or both. Filters can be active, high-pass, low-pass, band-pass, band-stop etc.

#### ACTIVE FILTERS:

The main disadvantage of Passive Filters is that the amplitude of the output signal is less than that of the input signal, i.e., the gain is never greater than unity and that the load impedance affects the filters characteristics.

With passive filter circuits containing multiple stages, this loss in signal amplitude called “Attenuation” can become quite severe. One way of restoring or controlling this loss of signal is by using amplification through the use of **Active Filters**.

As their name implies, **Active Filters** contain active components such as operational amplifiers, transistors or FET's within their circuit design. They draw their power from an external power source and use it to boost or amplify the output signal.

Filter amplification can also be used to either shape or alter the frequency response of the filter circuit by producing a more selective output response, making the output bandwidth of the filter narrower or even wider. Then the main difference between a “passive filter” and an “active filter” is amplification.

#### ACTIVE LOW PASS FILTER:

The most common and easily understood active filter is the **Active Low Pass Filter**. Its principle of operation and frequency response is exactly the same as those for the previously seen passive filter; the only difference this time is that it uses an op-amp for amplification and gain control.

This first-order low pass active filter consists simply of a passive RC filter stage providing a low frequency path to the input of a non-inverting operational amplifier. The amplifier is configured as a voltage-follower (Buffer) giving it a DC gain of one,  $A_v = +1$  or unity gain as opposed to the previous passive RC filter which has a DC gain of less than unity.

## **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor select the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>AC frequency>Add nodes and Accept it.
- Now again select Analysis>AC frequency and Simulate in dialog box.
- This will display the graph of frequency response on a screen. You can edit the title, axis and grid from graph dialog box.

## **HIGH PASS FILTER:**

### **SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**



**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$F_{C1} =$$

$$F_{C2} =$$

**CONCLUSIONS:**

## EXPERIMENT#13

### FREQUENCY RESPONSE ANALYSIS OF ACTIVE HIGH PASS FILTER

#### OBJECTIVE:

#### THEORY:

#### FILTERS:

**Filters** are circuits which are used to remove unwanted frequency components from the signal, to enhance wanted ones, or both. Filters can be active, high-pass, low-pass, band-pass, band-stop etc.

#### ACTIVE FILTERS:

The main disadvantage of Passive Filters is that the amplitude of the output signal is less than that of the input signal, i.e., the gain is never greater than unity and that the load impedance affects the filters characteristics.

With passive filter circuits containing multiple stages, this loss in signal amplitude called “Attenuation” can become quite severe. One way of restoring or controlling this loss of signal is by using amplification through the use of **Active Filters**.

As their name implies, **Active Filters** contain active components such as operational amplifiers, transistors or FET's within their circuit design. They draw their power from an external power source and use it to boost or amplify the output signal.

Filter amplification can also be used to either shape or alter the frequency response of the filter circuit by producing a more selective output response, making the output bandwidth of the filter narrower or even wider. Then the main difference between a “passive filter” and an “active filter” is amplification.

#### ACTIVE HIGH PASS FILTER:

A first-order (single-pole) **Active High Pass Filter** as its name implies, attenuates low frequencies and passes high frequency signals. It consists simply of a passive filter section followed by a non-inverting operational amplifier. The frequency response of the circuit is the same as that of the passive filter, except that the amplitude of the signal is increased by the gain of the amplifier and for a non-inverting amplifier the value of the pass band voltage gain is given as  $1 + R_2/R_1$ , the same as for the low pass filter circuit.

## **PROCEDURE:**

- Open the software and add new file.
- From the tool bar select the desired components. In this experiment resistor, inductor, ground and dc power supply is used.
- Connect all the components with the help of cursor. When the cursor selects the terminal a black spot will appear. Hold it by clicking the left mouse button and join it with the required component.
- Now when the circuit is complete go to Circuit>Schematic option>show nodes. This will select the nodes and number it.
- Now go to Analysis>AC frequency>Add nodes and Accept it.
- Now again select Analysis>AC frequency and Simulate in dialog box.
- This will display the graph of frequency response on a screen. You can edit the title, axis and grid from graph dialog box.

## **ACTIVE HIGH PASS FILTER:**

### **SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (1):**

**SCHEMATIC DIAGRAM AND ANALYSIS GRAPH (2):**

**OBSERVATIONS AND CALCULATIONS:**

**CALCULATE:**

$$F_{C1} =$$

$$F_{C2} =$$

**CONCLUSIONS:**