<u>Experiment Number</u> : 1

<u>Experiment</u> : RC and RL Transients

Study of Transient Behaviour of RC Circuit.

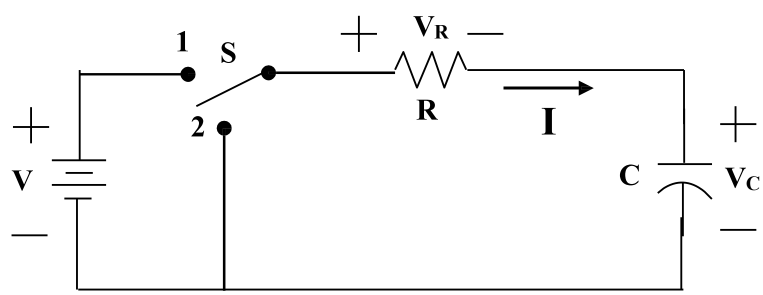
<u>OBJECTIVE</u>:

The objective of this experiment is to study the Transient Response of an RC circuit with a step Input. In this experiment, we shall apply a square wave input to an RC circuit separately and observe the respective wave shapes and determine the time constants.

<u>THEORY:</u>

The transient response is the temporary response that results from a switching operation and disappears with time. The steady state response is that which exists after a long time following any switching operation.

Let us consider an RC circuit shown in the figure.



<u>CHARGING PHASE:</u> When the switch is connected to position 1, applying KVL we can write

$$V = Ri + \frac{1}{C}\int i\,dt \text{ ------------ } (1)$$

If the capacitor is initially uncharged, the solution of equation (1) is----

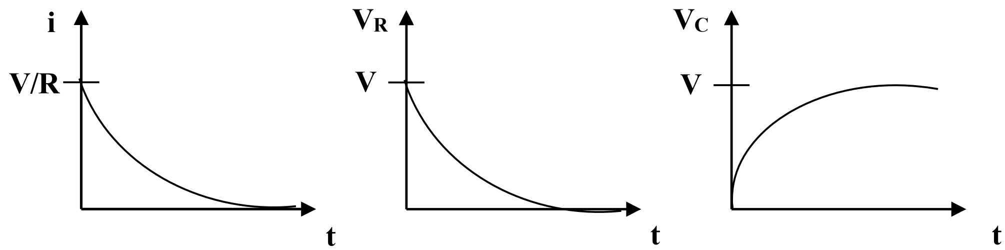
$$i = \frac{V}{R} e^{-\frac{t}{\tau}} \text{ ---------------- } (2)$$

Therefore the voltage across the resistor and capacitor are given by

$$V_R = Ve^{-\frac{t}{\tau}} \text{---------------}(3)$$

$$V_C = V - V_R = V(1 - e^{-\frac{t}{\tau}}) \text{------}(4)$$

Where $\tau = RC$ and is called the time constant of the circuit. Equation (2), (3) & (4) are plotted below:



It is seen from the curves that the voltage across the capacitor rises from zero to V volts exponentially and the charging current is maximum at the start i.e. when C is uncharged, then it decreases exponentially and finally ceases to zero when the capacitor voltage becomes V.

DISCHARGING PHASE: When the switch is connected to position 2,applying KVL we can write

$$0 = Ri + \frac{1}{C}\int idt \text{-------------}(5)$$

Since the voltage across the capacitor is now V, the solution of equation (5)

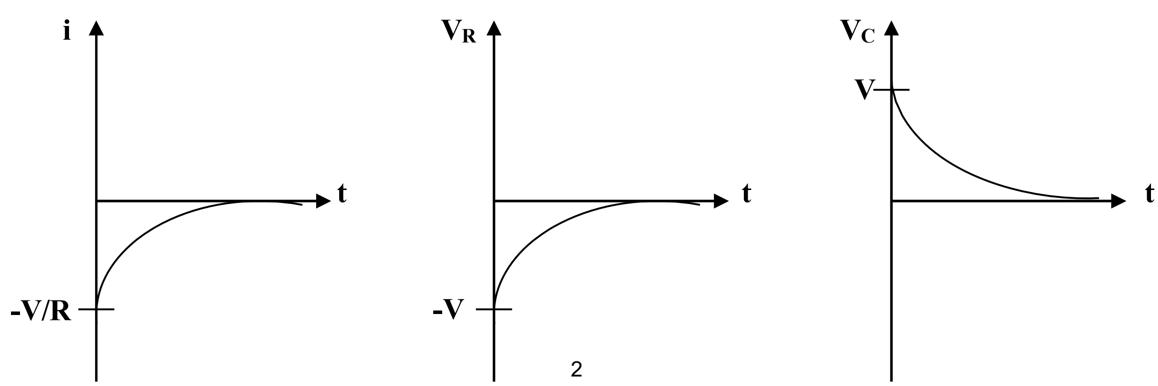
$$i = -\frac{V}{R}e^{-\frac{t}{\tau}} \text{---------------}(6)$$

is therefore the voltage across the resistor and the capacitor is given by

$$V_R = -Ve^{-\frac{t}{\tau}} \text{--------------}(7)$$

$$V_C = Ve^{-\frac{t}{\tau}} \text{---------------}(8)$$

Equation (6), (7) & (8) are plotted below:



It is seen from the curves that the voltage across the capacitor falls from V to zero volts exponentially. The charging current is maximum at the start i.e. when the switch is just thrown to position 2, then it decreases exponentially and finally ceases to zero when the capacitor voltage becomes zero.

APPARATUS:

- Resistance: 1KΩ
- Capacitance: 1μF
- Oscilloscope and Chords
- Signal Generator and Chords
- Wires
- Bread board

EXPERIMENTAL SETUP:

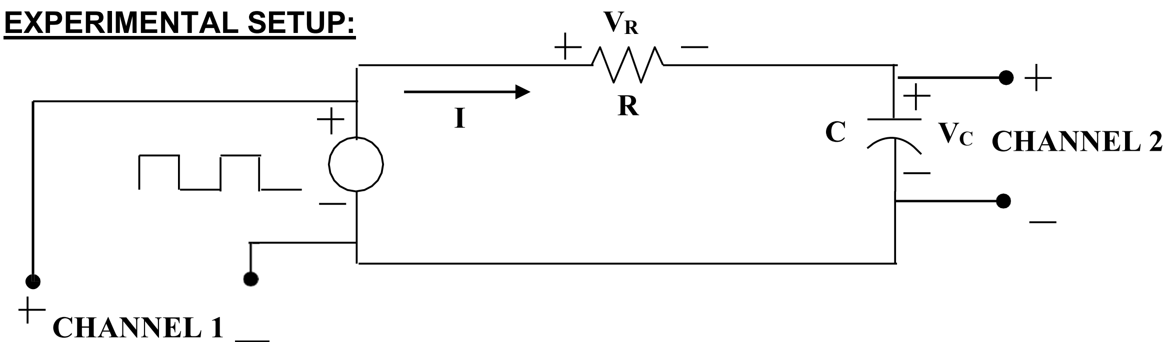


Fig.1

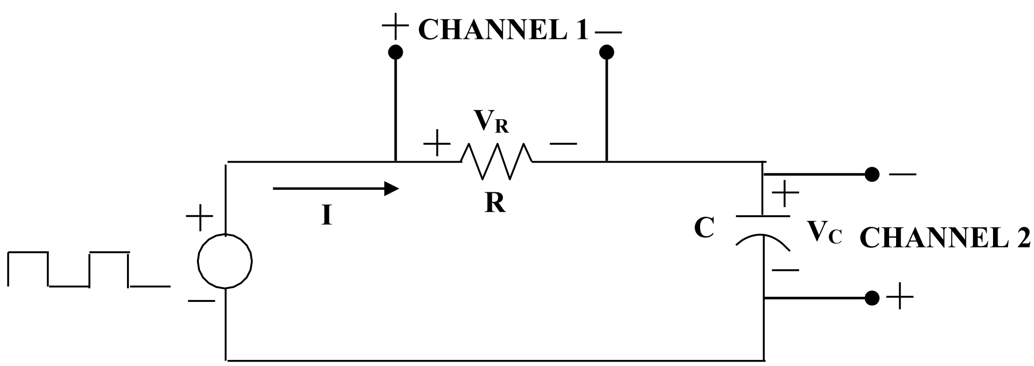


Fig.2

PROCEDURE:

1. Set up the circuit as shown in Figure 1.
2. Apply a 100Hz square wave from the signal generator.
3. Observe the wave shapes at Ch.1 and Ch.2 in DUAL mode and draw them. Find the time constant from the wave shape of V_C.
4. Disconnect Ch.1 and Ch.2 and reconnect them as shown in Figure 2.
5. Observe the wave shapes at Ch.1 and Ch.2 (INV.) in DUAL mode and draw them.

REPORT:

1. Draw all the wave shapes on graph paper.

Part B Continued: `Study of Transient Behaviour of RL Circuit.`

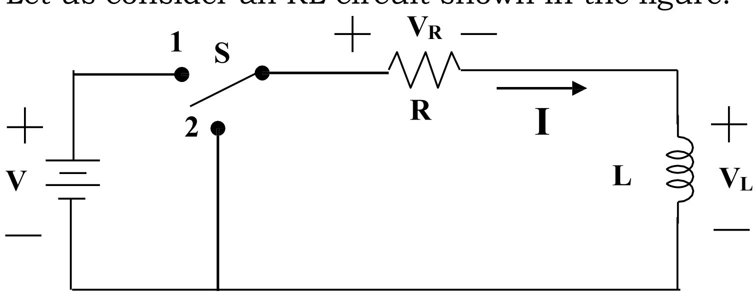
OBJECTIVE:

The objective of this experiment is to study the Transient Response of an RL circuit with a step input. In this experiment, we shall apply a square wave input to an RL circuit and observe the wave shapes and determine the time constant.

THEORY:

The transient response is the temporary response that results from a switching operation and disappears with time. The steady state response is that which exists after a long time following any switching operation.

Let us consider an RL circuit shown in the figure.



STORAGE PHASE: When the switch is connected to position 1, applying KVL we can write

$$V = Ri + L\frac{di}{dt} \text{------------} (1)$$

If the inductor is initially relaxed, the solution of equation (1) is----

$$i = \frac{V}{R}(1 - e^{-\frac{t}{\tau}}) \text{----------------} (2)$$

$$V_R = V(1 - e^{-\frac{t}{\tau}}) \text{--------------} (3)$$

$$V_L = V - V_R = Ve^{-\frac{t}{\tau}} \text{------} (4)$$

Therefore, the voltage across the resistor and inductor is given by
Where $\tau = L/R$ and is called the time constant of the RL circuit. Equations (2), (3) & (4) are plotted below:

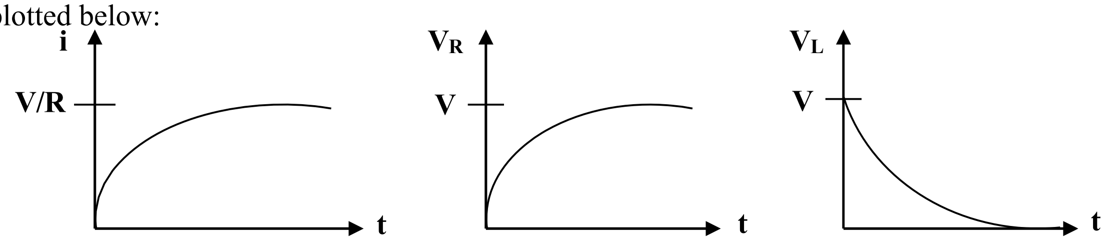


Fig.1

It is seen from the curves that the voltage across the inductor falls from V to zero volts exponentially. The current is zero at the start i.e. when the switch is just thrown to position 1, then it increases exponentially and finally reaches V/R amps when the inductor voltage becomes zero.

DECAY PHASE: When the switch is connected to position 2, applying KVL, we can write

$$0 = Ri + L\frac{di}{dt} ------------(5)$$

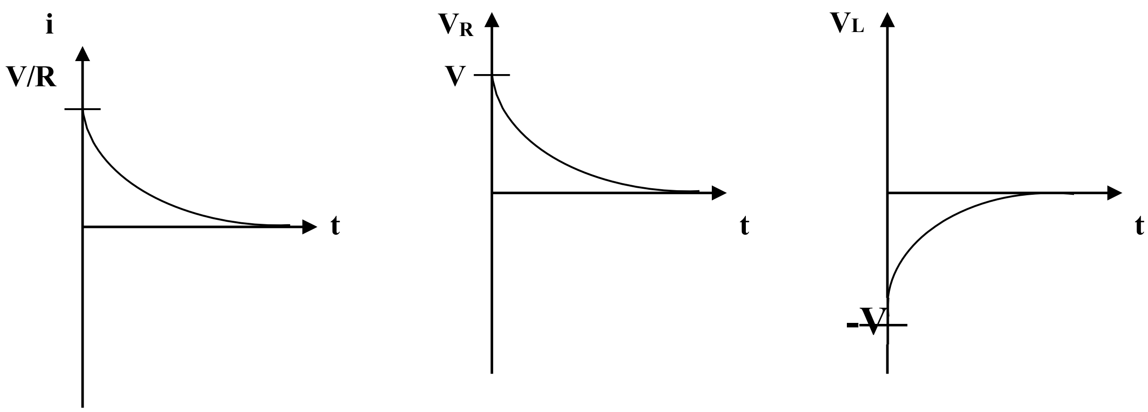
The solution of equation (5) is
Therefore, the voltage across the resistor and inductor is given by

$$i = \frac{V}{R}e^{-\frac{t}{\tau}} -------------(6)$$

$$V_R = Ve^{-\frac{t}{\tau}} -------------(7)$$

$$V_L = -Ve^{-\frac{t}{\tau}} -------------(8)$$

Equations (6), (7) & (8) are plotted below:



It is seen from the curves that the voltage across the inductor rises from -V to zero volts exponentially. The current is maximum at the start i.e. when the switch is just thrown to position 2, then it decreases exponentially and finally ceases to zero when the inductor voltage becomes zero.

APPARATUS:

- Resistance:460 Ω
- Inductance: 2.7mH
- Oscilloscope and Chords
- Signal Generator and Chords
- Wires
- Bread Board

EXPERIMENTAL SETUP:

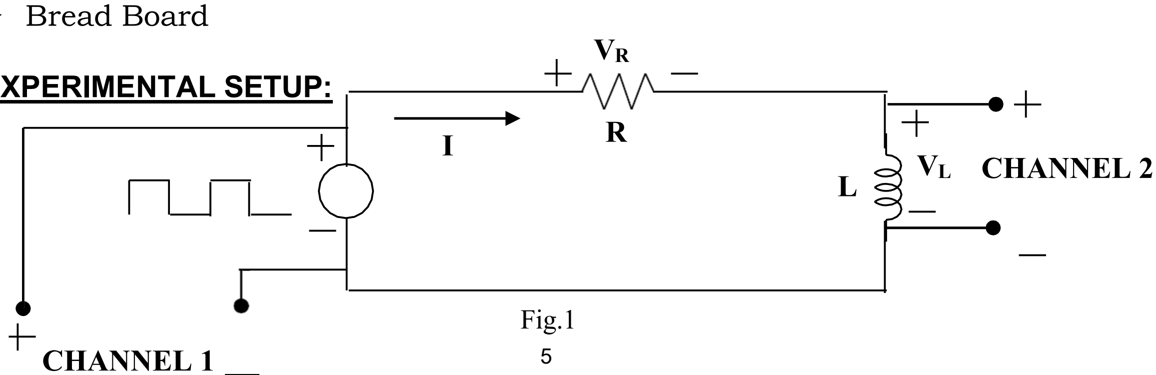


Fig.1

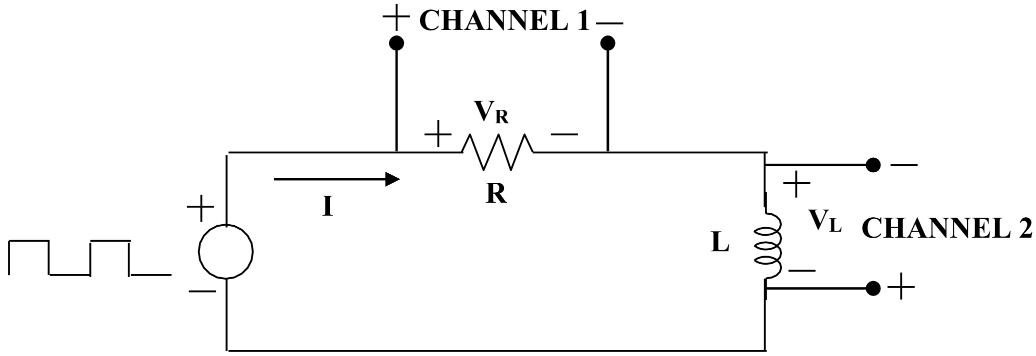


Fig.2

PROCEDURE:

6. Set up the circuit as shown in Figure 1.
7. Apply a 14 kHz square wave from the signal generator.
8. Observe the wave shapes at Ch.1 and Ch.2 in DUAL mode and draw them. Find the time constant from the wave shape of V_L.
9. Disconnect Ch.1 and Ch.2 and reconnect them as shown in Figure 2.
10. Observe the wave shapes at Ch.1 and Ch.2 (INV.) in DUAL mode and draw them.

REPORT:

2. Draw all the wave shapes on graph paper.

Experiment Number: 2

STUDY OF THE CHARACTERISTICS OF SERIES RESONANCE AND THE FREQUENCY RESPONSE OF RC FILTERS

Part A: Series Resonance

Theory: A series resonant circuit containing R, L, and C are in series and is said to be in resonance when the total reactance is zero. Since the capacitive reactance and the inductive reactance are of opposite sign so a series circuit will be in resonance when X_L is equal to X_C in magnitude. Thus, for series resonance,

$$X_L = X_C$$

$$2\pi f L = \frac{1}{2\pi f C}$$

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

Where f is the resonance frequency. Thus, series resonance can be obtained by adjusting L, C or f. In this experiment, we will vary C to obtain the resonance condition. It is obvious that at the resonance, the power factor of the combined load will be unity, and the total impedance is the value of the resistance R and will be minimum, so that the current is maximum. This is the criterion that will be used to detect the resonance condition.

Circuit Diagram

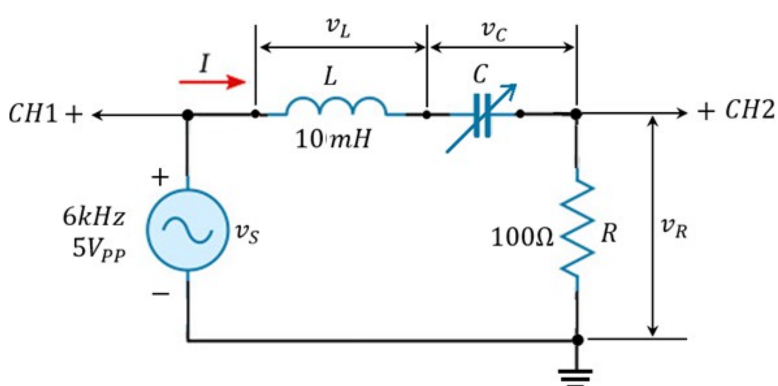


Figure 1

Equipment

1. Resistor : 100 Ω
2. Decade inductance box
3. Decade capacitance box
4. Voltmeter
5. Oscilloscope
6. Signal generator
7. Breadboard

Procedure

1. Complete the RLC circuit by setting 100Ω resistance, 10mH inductance and 30nF capacitance as shown in Figure 1.
2. Select the function generator in sinewave 5 V_{PP}, 6.0 kHz, across the RLC resonator circuit and measure the input voltage by using channel 1 of the oscilloscope. Connect channel 2 of the oscilloscope to measure the current in the circuit by measuring the voltage across the 100 Ω resistance.
3. Observe the wave shape in both channels separately by selecting the oscilloscope in dual mode. Measure the values of the series current I by measuring the voltage v_R and the phase difference between v_R and the input voltage v_S.
4. Also measure the voltage across the inductor and capacitor.
5. Increase the capacitance gradually 10nF steps until 120nF. Repeat the measurements of steps 3 and 4 for different capacitor settings. At each step, adjust the signal generator output so that v_S remains constant. Record all the measurements in Table 1.

Table-1: $f = 6.0$ kHz and $R = 100\Omega$

Obs.	v_i (Vpp)	C (nF)	v_R (Vpp)	v_L (Vpp)	v_C (Vpp)	$I = v_R/100$ (mA)	Phase (Degrees)
1	5	30					
2	5	40					
3	5	50					
4	5	60					
5	5	70					
6	5	80					
7	5	90					
8	5	100					
9	5	110					
10	5	120					

Report 1.

Plot and the following curves in a semi-Log graph

1. I versus C
2. Phase versus C
3. v_L, v_C, and v_R versus C

Part B: FREQUENCY RESPONSE OF RC FILTER

THEORY:

Low Pass Filter: An ideal low pass filter passes all signals below its cutoff frequency with zero attenuation but blocks all signals above that frequency. A simple first-order RC low pass filter is shown in Figure 2(a). The transfer function of this filter is given by:

$$T(j\omega) = \frac{v_O}{v_i} = \frac{1}{1 + j\omega CR}$$

The corner or cutoff frequency ω_C is defined as the frequency where the magnitude of the transfer function is $1/\sqrt{2}$ times the maximum value. For this low-pass filter, cut-off frequency,

$$\omega_C = 1/(RC)$$

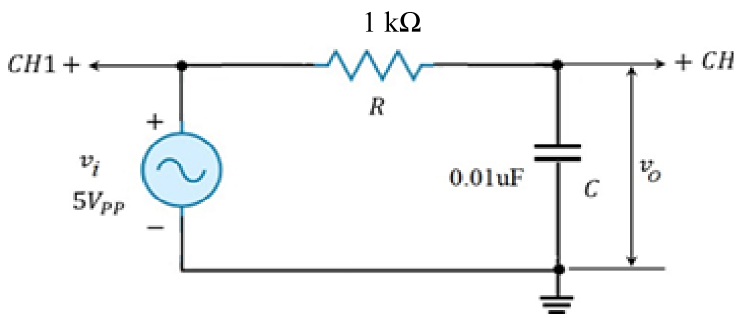


Figure 2(a): RC low-pass filter

High Pass Filter: An ideal high pass filter blocks all signals below its cutoff frequency but passes all signals above the cutoff with no attenuation. A simple first-order RC high-pass filter is shown in Figure 2(a). The transfer function of this filter is given by:

$$T(j\omega) = \frac{v_O}{v_i} = \frac{j\omega CR}{1 + j\omega CR}$$

For this high-pass filter, cut-off frequency,

$$\omega_C = 1/(RC)$$

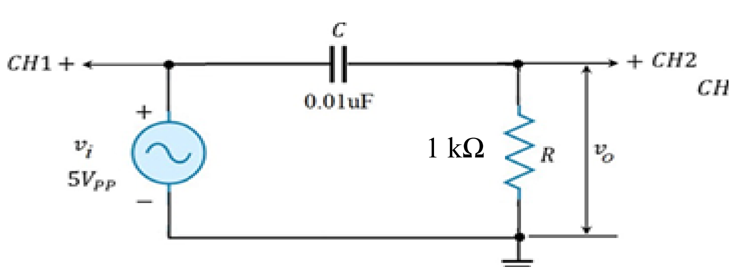


Figure 2(a): RC high-pass filter

EQUIPMENT USED

1. Resistor 1 kΩ
2. Capacitors 0.01 μF
3. Oscilloscope
4. Signal Generator

Procedure:

1. Construct the circuit as shown in Figure 2(a). Connect v_i to Channel 1 and v_O to Channel 2 of the oscilloscope. Set the input starting frequency to 100 Hz and $v_i = 5\ Vpp$. Measure the peak-to-peak voltage of v_O and phase angle between v_i and v_O and record in Table 2 and Table 3 for low pass and high pass filters, respectively.
2. Gradually increase the frequency up to 200kHz, record the value of v_O and phase angle in Table 2. Remember to adjust the signal generator amplitude so that v_i remains constant.
3. Now construct the circuit of Figure 2(b) and repeat steps 1 and 2.

Table-2: For Low pass filter, $R = 1\ \text{k}\Omega$ and $C = 0.01\mu F$

Obs.	f (kHz)	v_i (Vpp)	v_O (Vpp)	Practical $\lvert T \rvert$ (dB)	Theoretical $\lvert T \rvert$ (dB)	Phase (Degrees)
1	0.3					
2	0.6					
3	1.2					
4	1.6					
5	1.8					
6	3.0					
7	6.0					
8	15.0					
9	30.5					
10	50					
11	80					
12	100					
13	160					
14	200					

Table-2: For high pass filter, $R = 1\ \text{k}\Omega$ and $C = 0.01\mu F$

Obs.	f (kHz)	v_i (Vpp)	v_O (Vpp)	Practical $\|T\|$ (dB)	Theoretical $\|T\|$ (dB)	Phase (Degrees)
1	0.3					
2	0.6					
3	1.2					
4	1.6					
5	1.8					
6	3.0					
7	6.0					
8	15.0					
9	30.5					
10	50					
11	80					
12	100					
13	160					
14	200					

REPORT

1. Determine the theoretical corner frequencies of low-pass and high-pass filters.
2. Plot the magnitude of the transfer function versus frequency curves on a log graph paper. Determine the corner frequencies from the graphs and compare these with the theoretical values.
3. Plot the magnitude of the phase angle versus frequency curves on a log graph paper and find the angle at corner frequencies from the graph directly.

EXPERIMENT NO.: 3

NAME OF THE EXPERIMENT: STUDY OF COMMON EMITTER AMPLIFIER.

OBJECTIVE: To know the effect of the frequency on the gain of a common emitter amplifier and also to measure the input impedance, output impedance, and phase relationships of a CE amplifier.

EQUIPMENTS:

• (i) n-p-n transistor C828	one piece
• (ii) 10k,100K potentiometer	one piece each
• (iv)resistors	100Ω ,470Ω, 560Ω,5KΩ,33KΩ
• (v)capacitors	10µF,10µF,47µF
• (vi) multimeter	one piece
• (vii) breadboard	one piece
• (vii)power supply	one piece
• (viii)signal generator	one piece
• (ix)oscilloscope	one piece

CIRCUIT DIAGRAM:

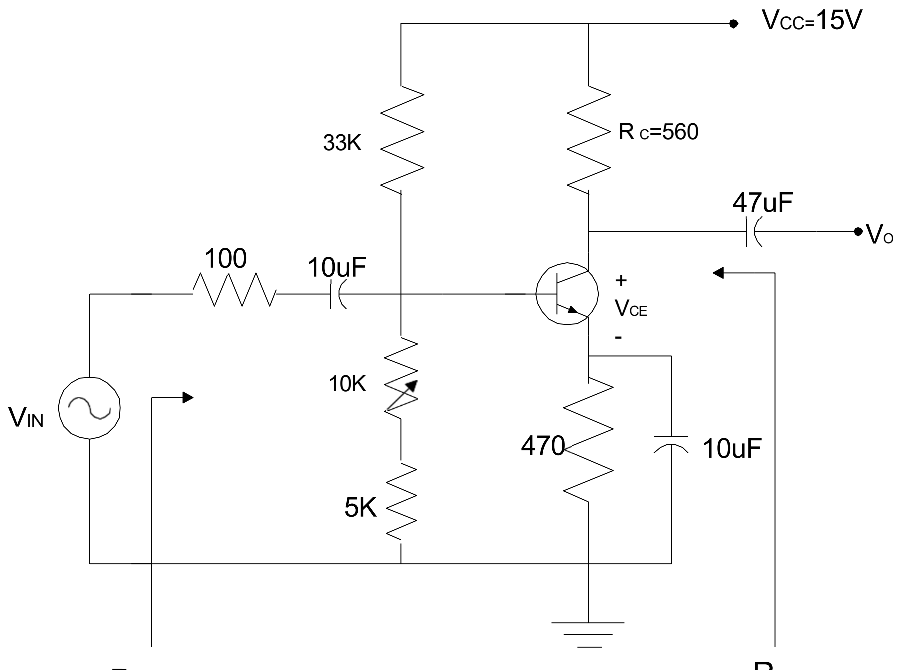


Fig. CE emitter

PROCEDURE:

1. Construct the circuit as shown in the figure and adjust 10K potentiometer until V_{CE} is approximately equal to $V_{CC}/2$ measured by a multimeter.
2. Set the signal generator frequency at 5KHz. Ch.2 is connected to V_O . Increase the input signal until the output is not distorted. Connect V_{IN} to ch.1. Measure the peak value of both V_{in} and V_O .

3. Set the oscilloscope in dual mode. Observe the phase relationship between input and output.
4. Connect the 100KΩ potentiometer from V_O to ground. Adjust the 100 KΩ potentiometer until V_O is half the open circuit value. Measure the output impedance from the potentiometer.
5. Disconnect ch.2 and connect ch.1 across 100Ω and measure peak value.
6. Disconnect the bypass capacitor and observe the effect on gain.
7. Reconstruct the circuit as shown in the figure. Set the signal frequency at 50 Hz. Measure the input and output.
8. Repeat step 7 for frequency 100Hz, 200Hz, 500Hz,800Hz,1KHz,2KHz etc, until a higher cutoff frequency is found, ensuring the input remains constant for all steps, or measure the input and make sure that they are close..
9. Observe the phase relationships between input and output below the lower cutoff and higher cutoff frequency.

REPORT:

1. Plot the gain in dB as a function of frequency on a semi-log paper.
2. From the graph paper, determine the lower cutoff frequency, higher cutoff frequency and midband gain for this common emitter amplifier.
3. What is the input impedance, output impedance and phase relationship between input and output for the CE amplifier and comment on them?
4. What is the function of the bypass capacitor and the DC blocking capacitor?
5. What are the advantages and disadvantages of a common emitter amplifier ?.
6. How can frequency response be improved in the CE amplifier for what cost?

Experiment No.- 4

SECOND ORDER ACTIVE FILTER DESIGN

Objective: The objective of this experiment is to investigate the characteristics of three different types of active filter, namely

i) Low-pass filter
ii) High-pass filter

Introduction: A filter is a frequency-sensitive circuit. It passes some frequencies, but blocks or attenuates others. In this experiment, you will build the above two different types of filters and plot a response curve for each type. In these experiments, the Sallen-Key filter topology is used. The cut-off frequency and gain of the filter can be calculated as:

$$f_C = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

$$\frac{R_3}{R_4} = 0.586$$

(Ex. $R_3 = 5.86k, R_4 = 10k$)
(Ex. $R_3 = 33k, R_4 = 56k$)

Instruments and Components Required

Instruments:
Power supply, Signal generator, Oscilloscope

Components:
741 Operational amplifier – 1 pc
0.01µF – 2 pcs
33kΩ resistor – 1 pc
56kΩ resistor – 1 pc
1kΩ resistor – 2 pcs

ACTIVE LOW-PASS FILTER:

Theory:

$$|A_v|_{dB} = \frac{1.586}{\sqrt{1 + (f/f_C)^4}}$$

Procedure:

1. Construct the circuit as shown in Figure 1.

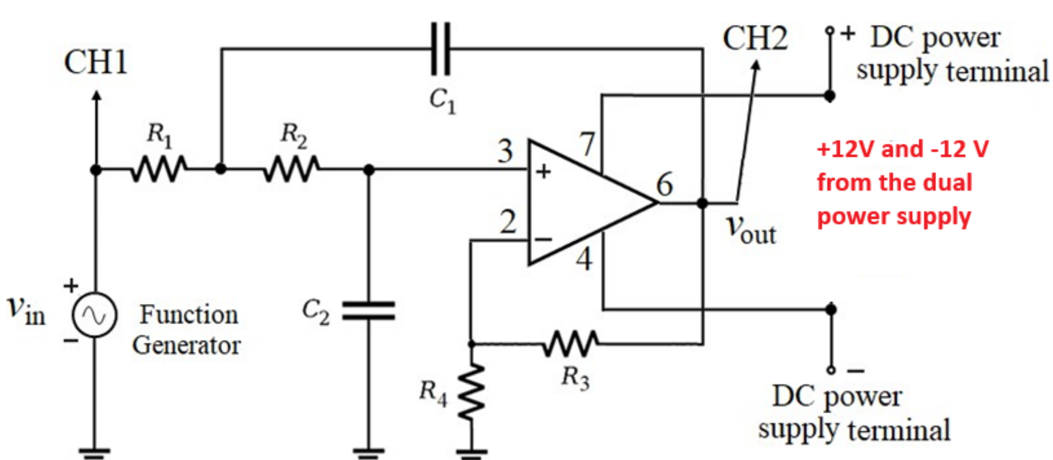


Figure 1: Active Low Pass Filter

2. Set the function generator to the sinusoidal wave with a frequency of 0.1 kHz.

3. Observe the output waveform at pin 6 of the op-amp. Adjust the input peak-to-peak voltage until the output voltage at pin 6 of the op-amp is approximately 6.0V peak-to-peak.

4. Measure and record the input voltage at pin 2 by CH1 of an oscilloscope and keep it constant during the experiment.

1. Change the frequency of the function generator and measure and record the output voltage from pin 6 of the op-amp. Also measure and record the phase difference between the output and input voltages.

5. Plot the voltage gain and phase data on a separate semi-log paper with frequency on the log scale. This will give the response curve of the low-pass filter. Take data at sufficient points so that the response curve can be drawn with sufficient accuracy. Try to plot at least 15 different points across the frequency range.

No. Obs.	Frequency (kHz)	Input Voltage (mV)	Output Voltage (V)	Phase (Degree)	Voltage gain (dB)	
					Practical	Theoretical
1	0.1					
2	1.0					
3	2.0					
4	4.0					
5	8.0					
6	10.0					
7	12.0					
8	14.0					
9	16.0					
10	18.0					
11	25.0					
12	30.0					
13	60.0					
14	100.0					
15	500.0					

Report:

1. Plot the magnitude and phase response curves for this filter.
2. Explain the operation of the circuit and determine the cut-off frequency theoretically. Compare this cutoff frequency with that obtained from the response curve.
3. From the response curve, find the roll-off in db/decade.

<u>ACTIVE HIGH-PASS FILTER:</u>

A simple active high-pass filter is shown in Figure 2. C_1, R_1, C_2, R_2 now form a high-pass filter. At low frequencies, the X_C of the capacitor is high. Thus, the signal applied at the non-inverting input of the op-amp is very weak. However, at high frequencies, X_C decreases and allows more signal to reach the op-amp.

Theory:

$$|A_v|_{dB} = \frac{1.586}{\sqrt{1 + (f_C/f)^4}}$$

Procedure:

2. Construct the circuit as shown in Figure 1.

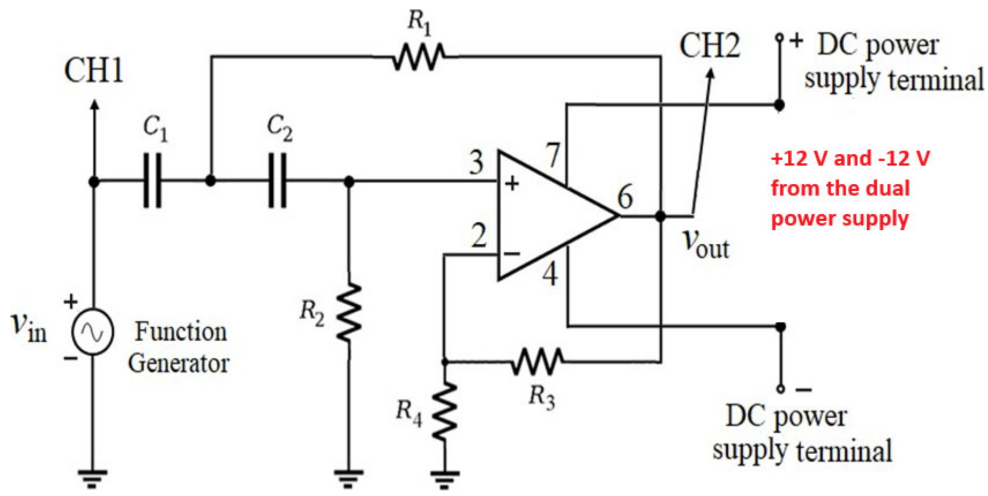


Figure-2: Active High Pass Filter

3. Set the function generator to the sinusoidal wave with a frequency of 1 kHz.

4. Observe the output waveform at pin 6 of the op-amp. Adjust the input peak-to-peak voltage until the output voltage at pin 6 of the op-amp is approximately 5.0V peak-to-peak.

5. Measure and record the input voltage at pin 2 by CH1 of an oscilloscope and keep it constant during the experiment.

6. Change the frequency of the function generator and measure and record the output voltage from pin 6 of the op-amp. Also measure and record the phase difference between the output and input voltages.

7. Plot the voltage gain and phase data on a separate semi-log paper with frequency on the log scale. This will give the response curve of the high-pass filter. Take data at sufficient points so that the response curve can be drawn with sufficient accuracy. Try to plot at least 20 different points across the frequency range.

No. Obs.	Frequency (kHz)	Input Voltage (mV)	Output Voltage (V)	Phase (Degree)	Voltage gain (dB)	
					Practical	Theoretical
1	1.0					
2	2.0					
3	4.0					
4	8.0					
5	10.0					
6	12.0					
7	14.0					
8	16.0					
9	18.0					
10	25.0					
11	30.0					
12	60.0					
13	100.0					
14	500.0					
15	1000.0					

Report:

1. Give a plot of the response curve for this filter.
2. Explain the operation of the circuit and determine the cut-off frequency theoretically. Compare this cutoff frequency with that obtained from the response curve.
3. From the response curve, find the roll-off in db/decade.

EXPERIMENT NO. 5
NAME OF THE EXPERIMENT: STUDY OF A RC COUPLED TWO-STAGE AMPLIFIER

OBJECTIVE:

To know the effect of frequency on the gain of RC coupled amplifier and to measure the input impedance, output impedance and phase relationship of the amplifier.

THEORY:

$$g_m = 40I_{CQ}$$

$$r_\pi = \frac{\beta}{40\ _{CQ}}$$

$$r_0 = \frac{V_A + V_{CEQ}}{I_{CQ}}$$

$$R_{ib} = r_\pi + (1+\beta)R_E$$

$$R_{in} = r_\pi \| R_{ib}$$

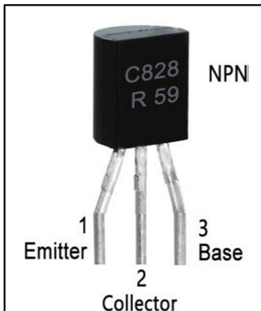
$$R_0 = r_0 \| R_C$$

$$A_v = -40I_{CQ}(R_C \| r_0 \| R_L)$$

$$A_{vT} = A_{v1} \times A_{v1}$$

Components and Equipment

Description	*Quantity and value*
Transistor C828	2
Resistor	1kΩ (2), 470Ω (2), 560Ω (2), 33KΩ (2), 68KΩ (2)
Variable Resistor	1kΩ (1)
Capacitor	0.1µF (1), 10µF (3)
Breadboard	1
Digital Multimeter	1
DC Power Supply	1
Function Generator	1
Dual trace oscilloscope	1



Pin Configuration

CIRCUIT DIAGRAM:

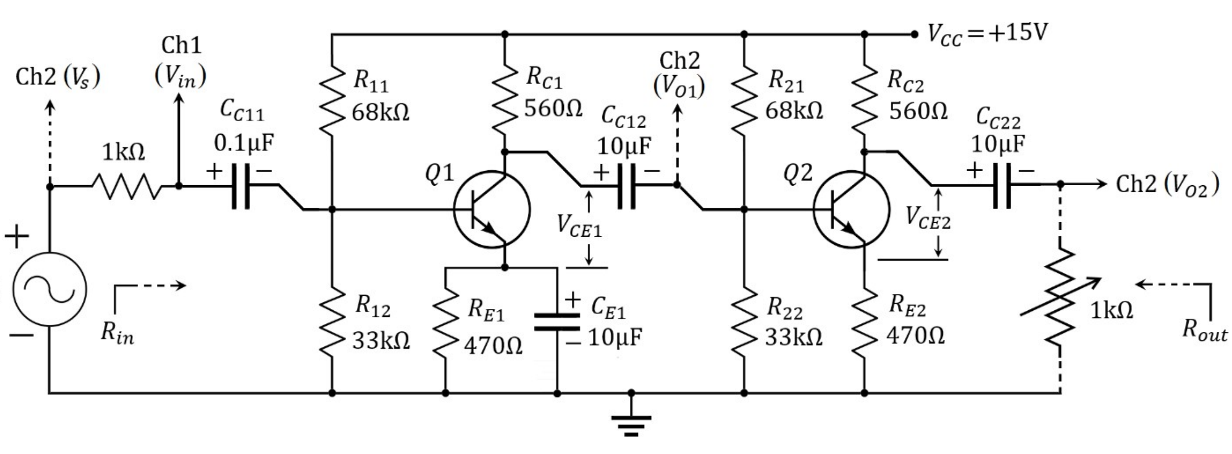


Figure 1: RC-coupled 2-stage common-emitter amplifier

PROCEDURE:

1. Construct the circuit as shown in **Figure 1**. Verify that both the transistors are properly biased in the active region, i.e., $V_{CE1} = V_{CE2} \approx V_{CC}/2$.

2. Set the function generator frequency at 5 kHz sine wave. Adjust the input signal go obtain the output wave is undistorted (better to start initially from 10mV)

3. Set the oscilloscope in dual mode. Observe the phase relationships of both input and output. Measure peak value of Vs, Vin, V_{01} and the open circuit voltage V_{02} using oscilloscope's probes.

4. Open and reconnect the emitter bypass capacitor C_{E1} and observe the effect.

5. Connect the 1kΩ potentiometer from V_{02} to ground. Adjust the 1.0 kΩ potentiometer until V_{02} is half of the previously measured open circuit voltage. Measure the potentiometer resistance and determine the output resistance of the amplifier.

6. Disconnect Ch2 and connect it to the source output terminal and measure peak value.

7. Change the frequency of the function generator and measure the V_{01} and V_{02} output voltages using Ch2 of the oscilloscope and record the data in **Table 1.** Measure the phase between input voltage Vin and output voltage V_{02} for the corresponding frequencies and also record in Table 1. In this case Try to keep the input voltage constant at each frequency.

Table 1: Data for Experiment no. 6

Obs.	**Frequency (kHz)**	**Vin (mV)**	**Output Voltage (V)**		**Phase Betn. Vin & V02 (Degree)**	**Voltage gain (dB)**			
						Theoretical		**Experimental**	
			V01	**V02**		**V01/Vin**	**V02/V01**	**V01/Vin**	**V02/V01**
1	0.05								
2	0.1								
3	0.5								
4	1.0								
5	2.0								
6	4.0								
7	10.0								
8	20.0								
9	50.0								
10	100.0								
11	200.0								
12	300.0								
13	600.0								
14	1000.0								
15	2500.0								

REPORT:

1. Plot the amplifier's frequency versus overall gain (in dB) on a semi-log graph paper. Measure the -3dB corner frequencies and bandwidth from the plot.
2. Plot the amplifier's frequency vs phase (in degrees) on a separate semi-log graph paper. Measure the -3dB corner frequency's phases from the plot.

3. What is the measured mid-band gain of each stage of the amplifier and the overall gain of the amplifier?
4. Calculate the mid-band gain of each stage and the overall gain and compare it to the experimental value.
5. What is the calculated and experimental input resistance and output resistance of the amplifier?
6. Discuss the phase relationship of each stage of amplifier.
7. What are the advantages and disadvantages of RC coupled common emitter amplifier?
8. Why does the gain decrease at higher frequency?
9. What is the effect of emitter bypass capacitor C_{E1} on gain and frequency response?
10. Why has the bypass capacitor been omitted from the second stage?

EXPERIMENT NO. 6

NAME OF THE EXPERIMENT: STUDY OF FEEDBACK AMPLIFIER CIRCUIT

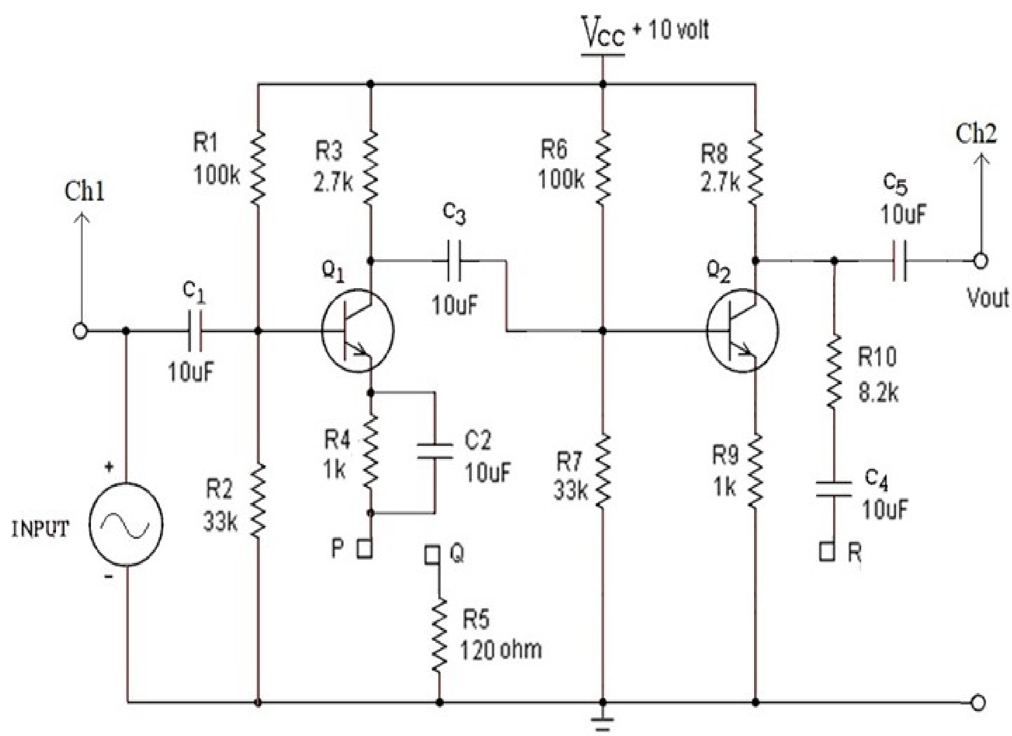
OBJECTIVE

Study of voltage gain, bandwidth, input/ output impedance under current series and voltage series feedback conditions of a two-stage CE amplifier configuration.

EQUIPMENT

Transistor C828 or C829	2 pieces
Resistors	
100k, 33 k, 1k, 2.7k, 8.2k, 120 Ω	2 pieces each
Potentiometer 10 k	1 piece
Capacitors 10 μF	4 pieces
Signal generator	1 unit
Oscilloscope	1 unit
DC power supply	1 unit

CIRCUIT DIAGRAM



PROCEDURE

1. Connect the point P to ground.

2. Apply input signal at 1 kHz, V_{in} should be 10mV to 20 mV (P-P)

3. Keep the input constant during the experiment

4. Keeping the input voltage constant, increase the frequency of the input

5. Measure the output voltage V_{out} , and find the 3 db point

6. Connect the 10kΩ potentiometer to the output terminal. Vary the potentiometer until the voltage is half of the open circuit voltage.

7. Apply **current series feedback** in the first stage of the amplifier. To do this ***connect*** **P and Q**. Repeat steps 2,4,5, and 6 respectively.

8. Apply **voltage series feedback**. To do this, ***connect*** **P, Q, and R**. Repeat steps 2,4,5, and 6 respectively.

REPORT

- What is feedback? Why is it used?
- Classify and explain feedback topologies briefly and mention their advantages.
- Calculate gain A and plot frequency response characteristics for the different amplifier configurations
- Find out the bandwidth with the current series and the voltage series feedback
- Relate the output impedances obtained from different amplifier configurations
- Why is a coupling capacitor used between the two stages of the amplifier?
- Why is the emitter bypass capacitor omitted from the second stage?
- Is it possible that an amplifier without feedback may oscillate at high frequency? If so, why?
- Discussion

DATA SHEET:-

Frequency	Without F/B		Current Series F/B		Voltage Series F/B	
Hz	**V_{in}**	**V_{out}**	**Vin**	**Vout**	**Vin**	**Vout**
1k to 5 M	mv	mv	mv	mv	mv	mv

Output Resistance, R_o	
Without F/B	
Current Series F/B	
Voltage Series F/B	

EXPERIMENT NO. 7

NAME OF THE EXPERIMENT: DESIGN OF A WIEN BRIDGE OSCILLATOR

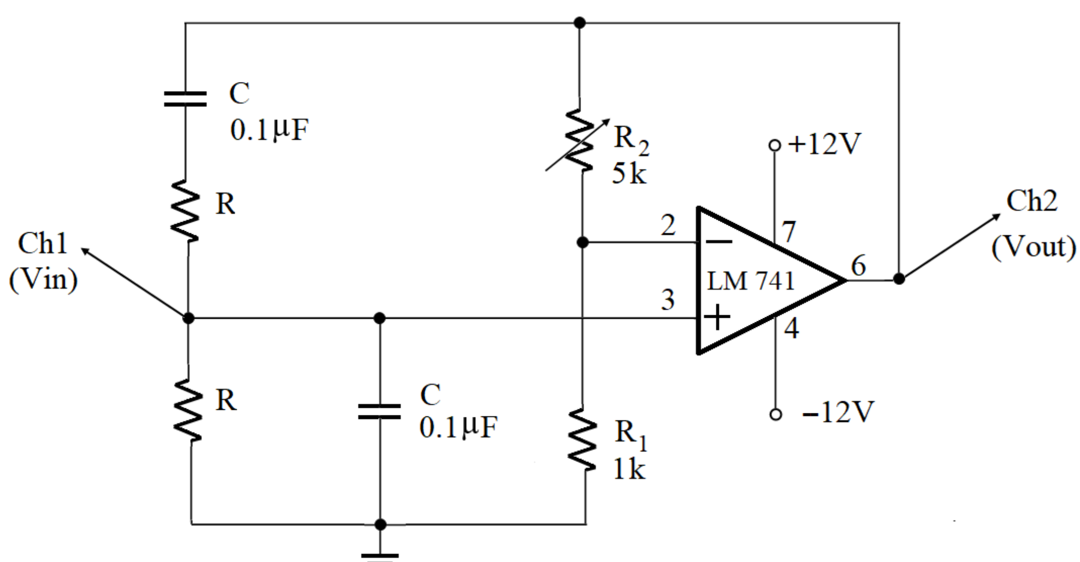
OBJECTIVE

An oscillator circuit in which a balanced bridge is used as the feedback network is the Wien bridge oscillator. The objective of this experiment is to study the operation of the Wien bridge.

EQUIPMENT

1.	OPAMP 741	1 piece
2.	Trainer Board	1 unit
3.	Regulated power supply	1 unit
4.	Oscilloscope	1 unit
5.	Resistor 1kΩ	1 unit
6.	5kΩ (POT)	1 unit
7.	Capacitor 0.1µF, 0.01uf, , 0.001uF	2 unit each
8.	Resistor Need to find from the initially chosen capacitor 0.1µF	

CIRCUIT DIAGRAM



PROCEDURE

1) Set up the circuit based on the designed frequency. Initially, choose a 0.1uF capacitor for designing the oscillator.

2) Connect the oscilloscope lead to the output of the amplifier. Adjust the potentiometer to obtain a sinusoidal waveform that is just maintained. Measure the ratio of R_2/R_1 and the frequency of oscillation.

3) Theoretically, the frequency of oscillation is given by $f = 1/2\pi RC$ (here R=100K). Oscillation is maintained when the R_2/R_1 ratio is approximately 2. Notice that if R_2 is made appreciably greater than $2R_1$, a square wave oscillation is produced and if R2 is made less than $2R_1$, the oscillation decays and ceases.

4) Observe and measure the frequency and amplitude of the designed circuit and then replace the capacitor with the given values and measure frequency and amplitude and make sure that it satisfies the oscillation condition.

Data Table:

Capacitor (μF)	Resistor (kΩ)	Frequency (kHz)	Phase (Deg.)	Vin (V)	Vout (V)	R_F/R_3	Gain	
							Measured	Theoretical
0.1								
0.01								
0.001								

REPORT

1) Compare the observed frequency with the theoretical one.
2) Draw the output wave shape.
3) Describe the significance of the R_2/R_1 ratio.
4) What are the methods of changing the frequency of the Wien bridge oscillator?

EXPERIMENT NO. 8

NAME OF THE EXPERIMENT: STUDY OF AN RC-PHASE SHIFT OP-AMP OSCILLATOR

OBJECTIVE:

A typical RC phase op-amp shift oscillator will be constructed and studied in this experiment. The theoretical frequency of oscillation is:

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

When, $R_1 = R_2 = R_3 = R$ and $C_1 = C_2 = C_3 = C$

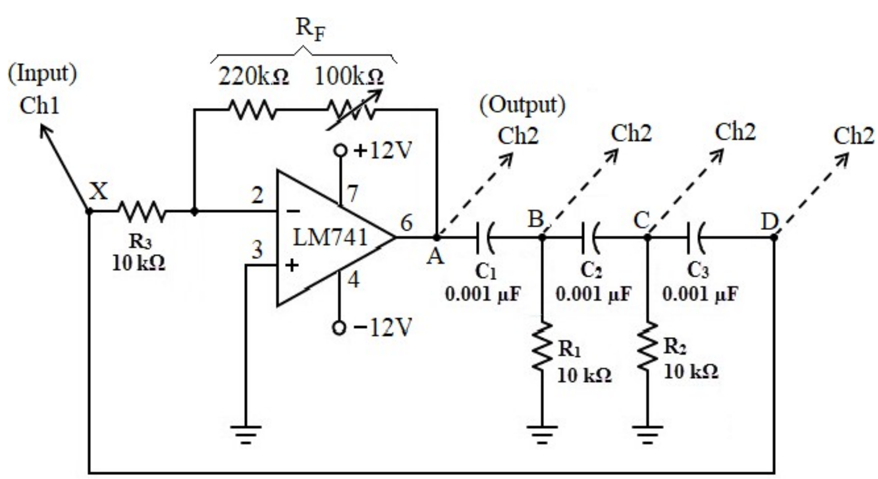
Minimum gain:

$$A_v = \frac{R_F}{R} = 29$$

INSTRUMENT & COMPONENTS:

Description	*Quantity*
Dual-Trace Oscilloscope	1
Dual Polarity DC Power Supply	1
Bread Board	1
Op-Amp (LM741)	1
Variable Resistor, 100k	1
Resistor, 220k	1
Resistor, 10k	3
Capacitor 0.001μF	3

CIRCUIT DIAGRAM:



PROCEDURE

1. Connect the circuit as shown in the figure for Op-amp RC phase shift oscillator.
2. Vary the 100kΩ potentiometer to have the undistorted sine wave at the output terminal.
3. Determine the output frequency and verify it with the theoretical frequency.
4. Determine the phase shift at points "A," "B," "C" and "D" with respect to the input voltage at point "X." To do this, connect the Ch1 at point "X" and fixed it. Then connect the Ch2 at point "A", point "B", point "C" and "D" respectively and record the data in the Table.
5. Reconnect the circuit for CR oscillator by interchanging the R and C elements.
6. Repeat steps 2, 3 and 4.

$$\boldsymbol{A_v} = \frac{\boldsymbol{v_{ch2}}\ (\boldsymbol{at\ point\ A})}{\boldsymbol{v_{ch1}}\ (\boldsymbol{at\ point\ X})}$$

$R_1 = R_2 = R_3 = R =$ $\qquad$ $C_1 = C_2 = C_3 = C =$

Data Table:

Condition	Phase at point				Frequency (kHz)		Gain A_v	
	A	B	C	D	Theoretical	Practical	v_{Ch2}/v_{Ch1}	R_F/R
Circuit 1 (RC)								
Circuit 2 (CR)								

REPORT

1. Why is RC oscillator called phase shift oscillator?
2. Why is there a discrepancy between the observed and theoretical frequency?
3. How can the amplitude and the frequency of the oscillator be changed?
4. What type of feedback is used in the oscillator circuit?
5. What is the frequency range of the RC oscillator?
6. What is the criterion to be followed in obtaining oscillator output?
7. Derive the above two equations.
8. Compare RC phase shift oscillator and Wien bridge oscillator using Op-amp as active element.

EXPERIMENT NO. 8

NAME OF THE EXPERIMENT: STUDY OF A R-C OSCILLATOR

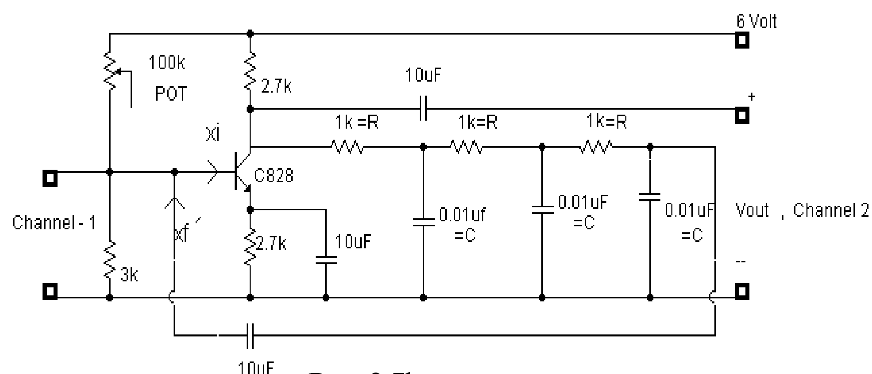
OBJECTIVE

A typical R-C phase shift oscillator will be constructed and studied in this experiment. The theoretical frequencies of oscillation are:

$$\frac{\sqrt{6}}{2\pi RC} \quad \text{for R - C} \quad \text{Oscillator}$$

$$\frac{1}{2\pi RC}\frac{1}{\sqrt{6+4(R_c/R)}} \quad \text{for C - R Oscillator}$$

CIRCUIT DIAGRAM



$R_c = 2.7k$

PROCEDURE

1. Connect the circuit as shown in the figure for the R-C phase shift oscillator.
2. Vary the 100k pot to have the undistorted sine wave at the output terminal
3. Determine the frequency of output and verify it with the theoretical frequency
4. Determine the phase shift of the input and output signal. To do this, connect both channels and operate the oscilloscope in XY mode.
5. Reconnect the circuit for the C-R oscillator by interchanging the R and C elements
6. Repeat steps 2,3 and 4.

REPORT

1. Why is the R-C oscillator called a phase shift oscillator?
2. Why is there a discrepancy between the observed and theoretical frequency?
3. How can the amplitude and the frequency of the oscillator be changed?

4. What type of feedback is used in the oscillator circuit?
5. What is the frequency range of the R-C oscillator?
6. What is the criterion to be followed in obtaining oscillator output?
7. Derive the above two equations
8. Make a comparison between the RC phase shift oscillator and the Wien bridge oscillator using the OPAMP as an active element.

Exp. No. 9
Study of Mutual Inductance

Introduction

When the magnetic flux produced in one circuit links a second circuit, the two circuits are magnetically coupled. Mutual inductance between the two circuits determines the coupling between the circuits and the energy that can be transferred from one circuit to another. In this experiment, we will determine the mutual inductance M and the coefficient of coupling K. K is defined by

$$K = \frac{M}{\sqrt{L_1 L_2}}$$

Where L_1 and L_2 are the self-inductances of the first and second coil, respectively.

Circuit Diagram

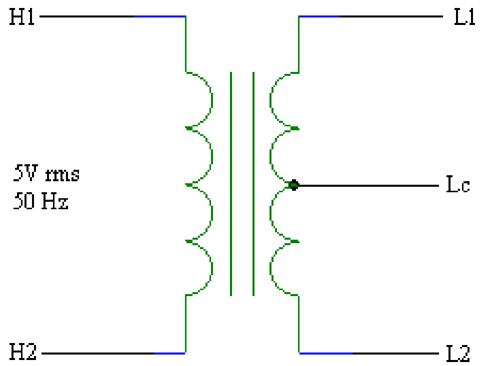


Figure 1:

Equipment

1. 220v/9v transformer
2. Voltmeter
3. Ammeter
4. Multimeter
5. SPST switch
6. Signal Generator

Procedure

1. Connect the circuit as shown in the diagram. Energize the HV side of the transformer with a 5V rms, 50 Hz supply from the signal generator. Measure the current flowing in the primary and the voltage induced in the open-circuited LV side. The LV side voltage is to be measured between the end terminals, not with respect to the center-tap.
2. Disconnect the circuit and set the signal generator to give 1V rms, 50 Hz supply and connect across the two end terminals of the LV side. Measure the current flowing in the circuit and the voltage induced in the open-circuited HV side.
3. Disconnect the circuit and measure the DC resistance of the HV and LV winding with a multimeter. Though the effective ac resistance of the transformer winding is higher than the dc resistance, for simplicity, we still take them equal.
4. Connect the two coils of the transformer in series. Apply a 5V, 50 Hz supply across the series-connected coils and measure the current.

5. Reverse the connection of any one of the two coils and measure the applied voltage and line current.

Table

For HV side Energized

V_1	I_1	I_2

For LV side Energized

V_1	V_2	I_2

For dc resistance measurement and polarity of the coil

R_1	R_2	I_{1S}	I_{2S}

Report

1. From the readings taken in steps 1, 2 and 3 calculate L_1, L_2 and M_{12} and M_{21}. Compare M_{12} and M_{21}. If the two values are not equal, an effective M can be obtained by taking the geometric mean of the two. Calculate the coefficient of coupling.
2. From the readings of steps 4 & 5, label the appropriate terminals on the HV and LV side with dot marks. Also, calculate M from these readings. Compare the value of M with the one determined in the previous step.

Exp No. 10
Study of Power Factor Correction

Introduction

In all manufacturing plants (large or small), the power factor is usually low and lagging (due to the usage of induction motors). This low power factor causes extra line loss, which is not registered at the consumer's meter. For this reason, the power system authority penalizes the consumer if power is consumed below a certain power factor (normally, if less than 0.85). So it is the consumer's duty to improve the power factor. Lagging power factor (usually, industrial loads are lagging) is improved by adding capacitors in parallel to the load. In this experiment, we shall study how the power factor can be corrected by varying the parallel capacitance.

Equipment

1. One rheostat (120Ω)
2. Decade capacitor box
3. Decade inductance box
4. Oscilloscope
5. Ammeter
6. Signal generator

Circuit Diagram

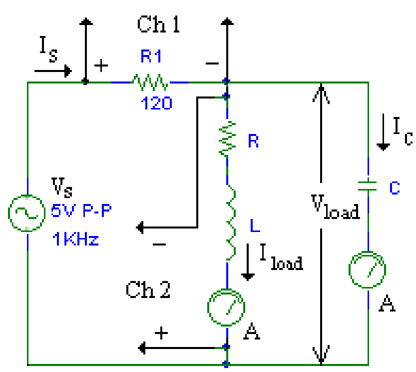


Figure 1:

Procedure

1. Complete the RL circuit by setting 500Ω resistance and 100mH inductance. Keep capacitance at zero.
2. Connect the probe across the RL load as input to channel 2 of the oscilloscope, and the voltage across the 120 Ω resistance as input to channel 1, accordingly as shown in the diagram. Remember to connect the grounds of both oscilloscope probes to the same point and to pull the inverter knob of channel 2.
3. With capacitance zero, observe the wave shapes in both channels separately and in dual mode. Measure the value of current I_s (by dividing the voltage of channel 1 by the value of the 120 Ω resistor) and voltage V_{load}, and the phase difference between V_{load} and I_s. *To measure the phase difference, observe the two waveforms in dual mode. Determine the time delay Δt between the*

waves. The phase difference is then calculated from $\theta = \frac{\Delta t}{T}360$ *degrees. Also* note which wave leads.

4. Set the capacitor to 10nF. Then repeat measurements of step 3. Also measure currents I_{load} and I_c from the ammeter.
5. Increase the capacitance gradually until a unity pf between V_{load} and I_s is obtained.
6. Continue to increase the capacitance gradually until a leading pf of about 45 degrees is obtained. Repeat all measurements in each step.

Report

1. Plot the pf vs. C curve and show the capacitance for which the f is unity.
2. Draw the vector diagram for 45° lag, unity, and 45° lead pf.
3. Sketch the wave shapes of V_{load} and I_s for the three cases mentioned above.
4. Discuss the overall system performance, power absorbed without and with pf correction.