Experiment 7

Aim

- ➔ Study of RC lead lag network
- ➔ Construct a Wein Bridge oscillator

Apparatus Required

- Power supply
- Op Amp
- resistors (typically R=15.9K, R2=470 ohm and 1K pot)
- capacitors (typically 0.01 $\lceil F$)
- Diodes
- Electronics voltmeter
- CRO

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PART -1

➔ To study RC lead lag network.

Theory

The series and parallel combination of RC network form a lead-lag circuit. At high frequencies, the reactance of capacitor C1 and C2 approaches zero. This causes C1 and C2 appears short. Here, capacitor C2 shorts the resistor R2. Hence, the output voltage V_O will be zero since output is taken across R2 and C2 combination. So, at high frequencies, circuit acts as a **'lag circuit'**. At low frequencies, both capacitors act as open because capacitor offers very high reactance. Again, output voltage will be zero because the input signal is dropped across the R1 and C1 combination. Here, the circuit acts like a **'lead circuit'**. But at one particular frequency between the two extremes, the output voltage reaches to the maximum value. At this frequency only, resistance value becomes equal to capacitive reactance and gives maximum output. Hence, this frequency is known as **oscillating frequency** (f).

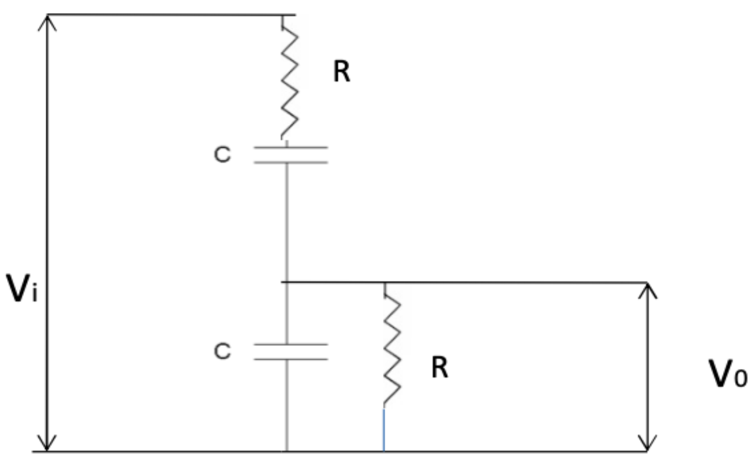


Fig 7.1 RC lead lag network

The relationship between magnitude of output frequency and input frequency is given by the equation:

$$RWC/\sqrt{}((1 - RWC)^2 + (3WRC)^2$$

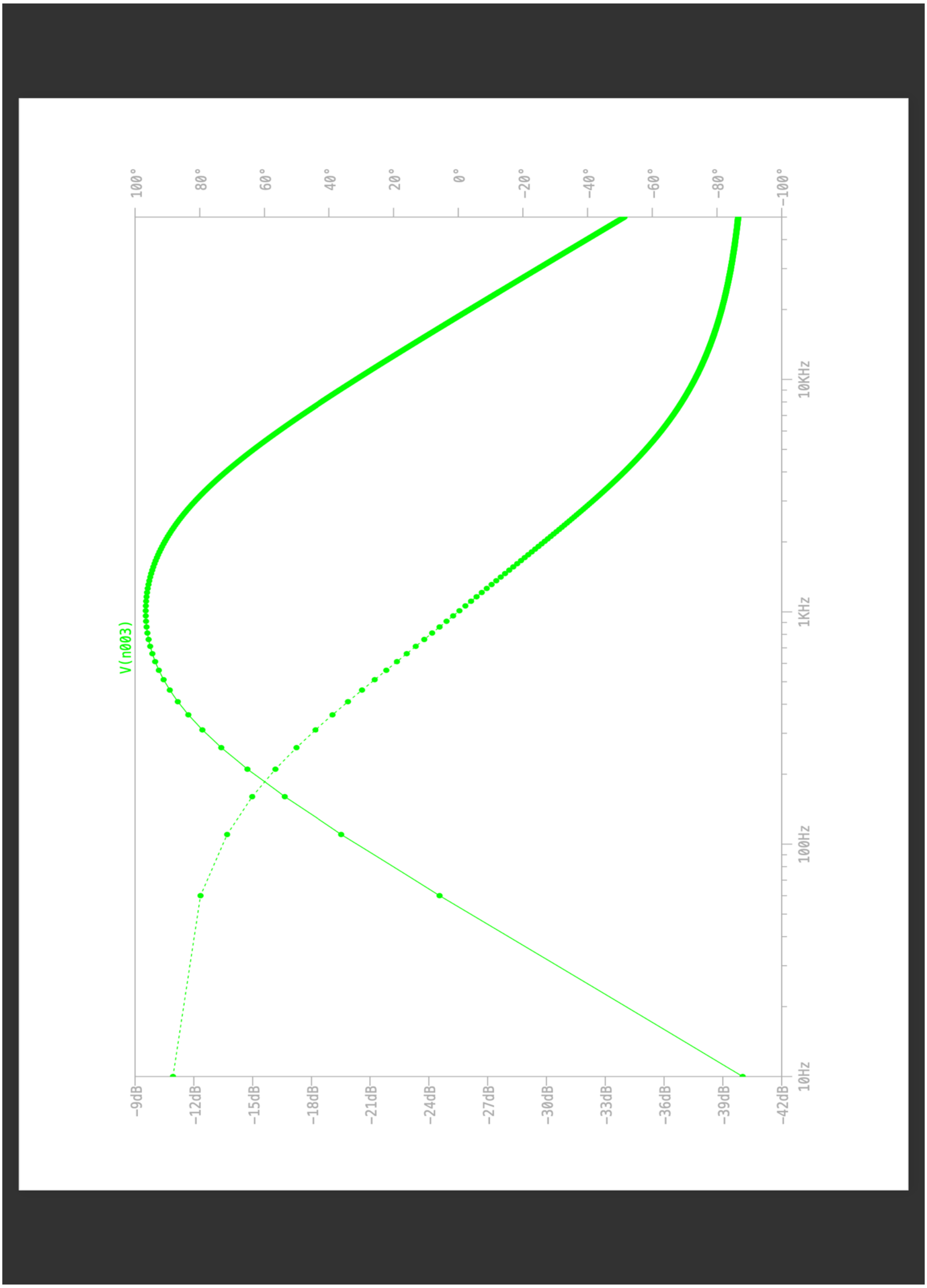
The phase frequency relationship Is given by the equation:

$$\angle\frac{V_{out}}{V_{in}}(s = j\omega) = \frac{\pi}{2} - \tan^{-1}\frac{3RC\omega}{1 - R^2C^2\omega^2},$$

OBSEVERATION TABLE

Frequency	Voltage gain (dB)	Phase shift (degrees)
10Hz	-40.011493dB	88.283143°
60.0Hz	-24.547716dB	79.763036°
110.08Hz	-19.5278dB	71.532864°
160.12Hz	-16.637533dB	63.779987°
210.16Hz	-14.731864dB	56.618616°
310.24Hz	-12.431879dB	44.191546°
360.28Hz	-11.716861dB	38.873353°
510.4Hz	-10.455628dB	25.815404°
610.4Hz	-10.026159dB	18.945025°
660.5Hz	-9.8820098dB	15.917361°
760.6Hz	-9.6891828dB	10.502851°
810.6Hz	-9.6286995dB	8.0621771°
910Hz	-9.5596767dB	3.6099561°
960Hz	-9.545671dB	1.5662807°
1.01KHz	-9.5426093dB	0
1.26KHz	-9.6459605dB	-8.8290059°
1.8KHz	-10.313084dB	-23.780516°
1.9KHz	-10.382631dB	-24.797052°
2.6KHz	-11.527311dB	-37.277475°
3KHz	-12.086381dB	-41.745566°
3.3KHz	-12.642093dB	-45.583526°
4.3KHz	-14.086374dB	-53.654298°
7KHz	-17.547019dB	-66.553245°
10KHz	-20.300941dB	-73.154983°

Combined GRAPH OF Voltage gain(dB) vs FREQUENCY(Hz) and phase(degress) vs frequency



RESULT AND CONCLUTION

We found that the maximum output voltage gain occurs when frequency was equal 1.011KHz. The output voltage was found to 333.32 mV peak to peak. The phase shift was 0 degrees at that frequency.

The frequency at which there is maximum output and minimum phase shift is equal to 1/(R*C) . The practically obtained value was 1.011 Hz which is almost equal to the theoretical value which is 1.014 Khz.

We concluded that at lower frequencies the output voltage was leading and at higher voltage it was lagging.

PART 2

➔ Construct a Wein Bridge oscillator

Theory

To start the oscillation with the constant amplitude, positive feedback is not the only sufficient condition. Oscillator circuit must satisfy the following two conditions known as Barkhausen conditions:

1. Magnitude of the loop gain (A_V β) = 1, where, A_V = Amplifier gain and

   β = Feedback gain.

2. Phase shift around the loop must be 360°

   or 0°.

Wien bridge oscillator is an audio frequency sine wave oscillator of high stability and simplicity. The feedback signal in this circuit is connected to the non-inverting input terminal so that the op-amp is working as a non-inverting amplifier. Therefore, the feedback network need not provide any phase shift. The circuit can be viewed as a Wien bridge with a series combination of R1 and C1 in one arm and parallel combination of R2 and C2 in the adjoining arm. Resistors R3 and R4 are connected in the remaining two arms. The condition of zero phase shift around the circuit is achieved by balancing the bridge.

The series and parallel combination of RC network form a lead-lag circuit. At high frequencies, the reactance of capacitor C1 and C2 approaches zero. This causes C1 and C2 appears short. Here, capacitor C2 shorts the resistor R2. Hence, the output voltage V_O will be zero since output is taken across R2 and C2 combination. So, at high frequencies, circuit acts as a 'lag circuit'. At low frequencies, both capacitors act as open because capacitor offers very high reactance. Again, output voltage will be zero because the input signal is dropped across the R1 and C1 combination. Here, the circuit acts like a 'lead circuit'. But at one particular frequency between the two extremes, the output voltage reaches to the maximum value. At this frequency only, resistance value becomes equal to capacitive reactance and gives maximum output. Hence, this frequency is known as oscillating frequency (f).

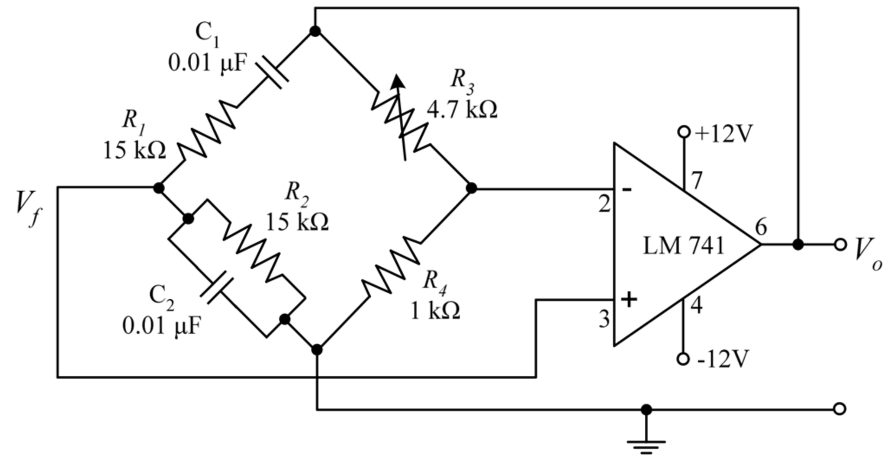


Fig 2 Circuit diagram of Wien bridge oscillator using opamp.

V (s)

To follow the Barkhausen condition the product feedback from the RC oscillator and the non-inverting voltage gain from the operational amplifier should equate to 1.

$$\left(1+\frac{R_3}{R_4}\right)\left(\frac{RsC}{(RsC)^2+3RsC+1}\right)=1$$

Substitute $s = j\omega$

$$\left(1+\frac{R_3}{R_4}\right)\left(\frac{j\omega RC}{-R^2C^2\omega^2+3j\omega RC+1}\right)=1$$

$$\left(1+\frac{R_3}{R_4}\right)j\omega RC=\left(-R^2C^2\omega^2+3j\omega RC+1\right)$$

$$j\omega\left[\left(1+\frac{R_3}{R_4}\right)RC-3RC\right]=1-R^2C^2\omega^2$$

By equating the imaginary and real part to zero , we get the following results.

1.

$$1-R^2C^2\omega^2=0$$

$$\omega=\frac{1}{RC}$$

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

2.

$$j\omega\left[\left(1+\frac{R_3}{R_4}\right)RC-3RC\right]=0$$

$$j\omega\left(1+\frac{R_3}{R_4}\right)RC=j\omega 3RC$$

$$\left(1+\frac{R_3}{R_4}\right)=3\quad (gain\ of\ the\ amplifier)$$

$$\frac{R_3}{R_4}=2$$

For this experiment the value of resistor and capacitors used are :-

We are building a oscillator capable of producing sinusoid signal of frequency 1Khz. We are given a capacitor of value 0.01 micro farad.

So by the formula f=1/(2*pi*R*C)

We get R= 15.9 kilo Ohms.

R3/R4 = 2.

So let R3=2 Ohms and R4=1ohms.

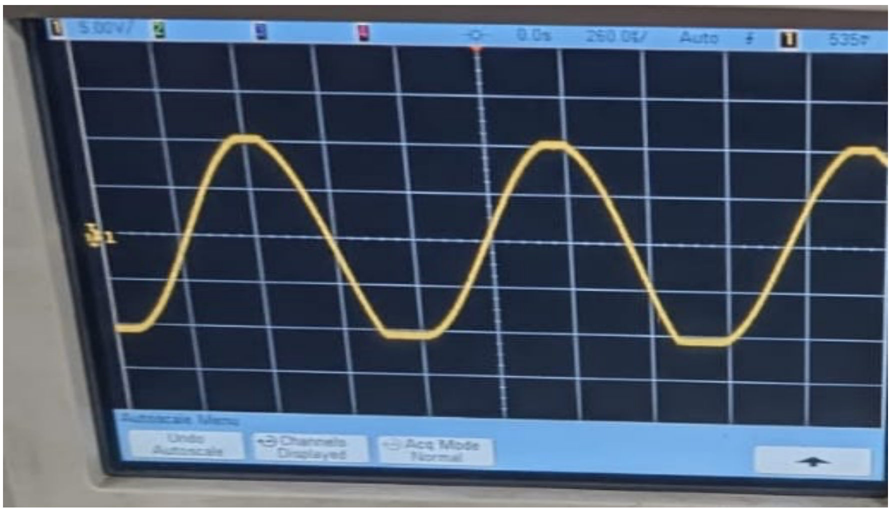
Or we can also use a potentiometer to fine tune R3 so that the ratio becomes equal to 2.

PROCEDURE:

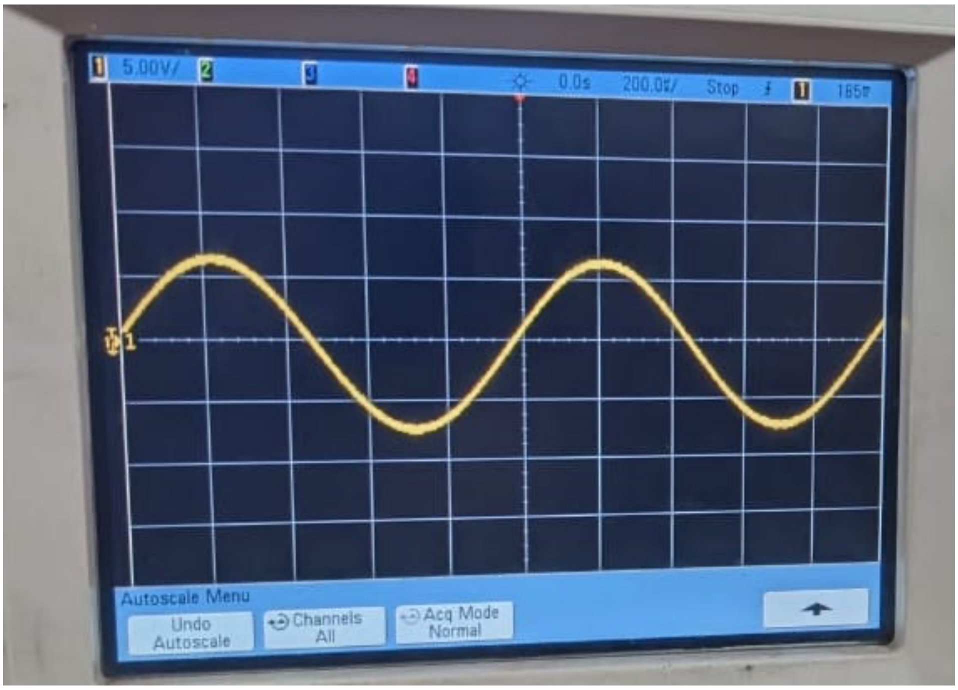
- ➔ Test the op-amp by giving a sine wave at the inverting terminal, ground at the non-inverting terminal to obtain a square wave at the output.
- ➔ Set up the circuit as shown in the figure.
- ➔ Obtain the sine wave at the output. Check for the frequency obtained.

OBSERVATION

The output signal obtained is shown here :



After fine tuning the signal obtained is shown below :



Result and Conclusion

In the above activity we successfully created the Wein Bridge oscillator to obtain a sinusoid of 1 Kilo Hertz frequency.

PRECAUTIONS

- ➔ Make sure all the components of the Wein Bridge circuit are properly connected and securely fastened.
- ➔ Ensure that the power supply voltage is within the specified limits.
- ➔ Use high-quality resistors and capacitors with low tolerance values to ensure accurate results.

➔ Make sure the circuit is properly grounded to prevent electrical interference.

➔ Use a high-quality oscilloscope to accurately measure the output waveform.

➔ Avoid touching any of the components while the circuit is powered on.

➔ Keep the experiment area clean and free of clutter to prevent accidental shorts or other problems.