SIKSHA 'O' ANUSANDHAN

(DEEMED TO BE UNIVERSITY)

Department of Electrical Engineering,

Institute of Technical Education and Research

CIRCUIT THEORY

(EET2111)

DESIGN PROJECT

SUBMITTED BY

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DECLARATION

I certify that

a. The work contained in this report is original and has been done by me.
b. I have followed the guidelines provided by the Institute in preparing the report.
c. I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.
d. I have tried to complete the work with minimum possible cost.
e. Whenever I have used materials (data, theoretical analysis, figures, and text) from other sources, I have given due credit to them by citing them in the text of the report and giving their details in the references.

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Signature

PROBLEM STATEMENT

Design a circuit which can generate two signals of 10 sin (wt – 45°) and 10 sin (wt + 45°) from a signal of 10 sin (wt).

CIRCUIT OPERATING CONSTRAINTS

- ✓ Value of R_f and R_i should be same else different value of R_f and R_i will differ the results.
- ✓ Connection of capacitor and op-amp should be done carefully else the capacitor will burst out.

THEORETICAL BACKGROUND

➢ Introduction

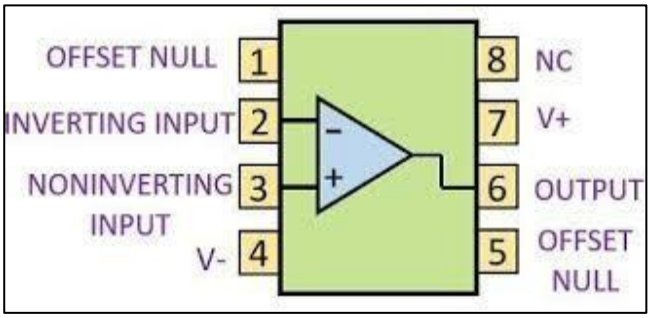
A phase shifter circuit is an electronic circuit that is used to shift the phase of a signal without changing its amplitude. It is a fundamental component in many signal processing systems and is used in applications such as audio processing, frequency synthesis, and phase modulation, AM modulation and demodulation, SSB modulation.

What is Phase and Phase Shift?

Phase is a full cycle period of a sinusoidal wave in a 360-degree reference. A complete cycle is defined as the interval required for the waveform to return its arbitrary initial value. Phase is denoted as a pointed position on this waveform cycle.

RC Phase Shift Oscillator using Op-Amp

When we use op-amp for RC phase shift oscillator, it functions as an inverting amplifier. There are several ways to build a phase shifter circuit, but one common approach is to use a resistor-capacitor (RC) lag network connected to the non-inverting terminal of an op-amp. In this configuration, the phase shift is determined by the ratio of the input signal frequency and the cut-off frequency of the RC lag network, that is, resistance to the capacitance in the network. The op-amp is connected in inverting configuration with unity gain, that is equal resistors on the inverting input. The circuit can ideally shift phase of an input signal from 0 degree to 180 degree without changing the amplitude of the signal.

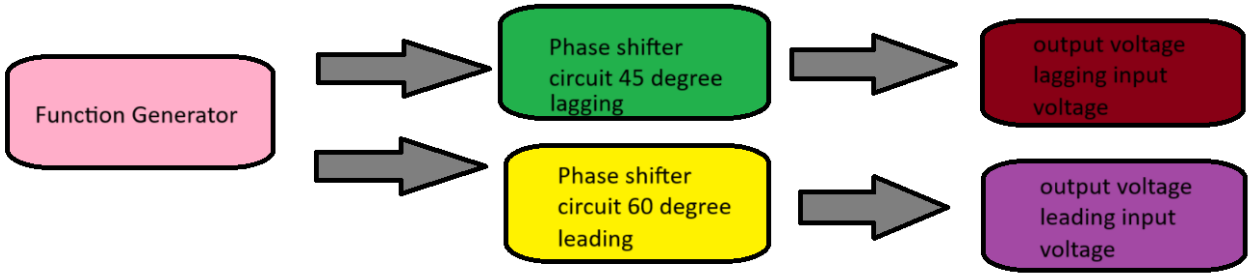


Why use Op-amp for RC Phase Shift Oscillator instead of Transistor?

There are some limitations in using Transistor for Building RC Phase Shift Oscillator:

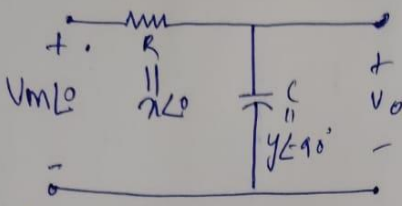
1. It is stable for low frequencies only.
2. RC phase shift oscillator requires additional circuitry to stabilize the amplitude of the waveform.
3. Frequency accuracy is not perfect and it is not immune to noisy interference.
4. Adverse Loading effect. Due to cascade formation the second pole's input impedance change the resistors resistance properties of the first pole filter. More the filters cascaded more the situation worsen up as it will affect the accuracy of calculated phase shift oscillator frequency.

BLOCK DIAGRAM



CALCULATION

Lagging Circuit



Being series, we apply VDR,

$$V_o = \frac{y\angle -90^\circ}{x\angle 0 + y\angle -90^\circ} Vm\angle 0$$

$$= \frac{Vm\, y\angle -90^\circ + 0}{x - yj}$$

$$= \frac{Vm \cdot y\angle -90^\circ}{z\angle -\theta \ (\text{say})}$$

$$= \frac{Vmy}{z}\angle -90 - (-\theta)$$

$$= \frac{Vmy}{z}\angle 0 - 90^\circ$$

RC phase shifter-

$$\theta = \tan^{-1}\left(\frac{Xc}{R}\right) = \tan^{-1}\frac{1}{2\pi fRC}$$

R_1 and R_2 = 1kΩ

C_1 and C_2 = 1MF

$$f = \frac{1}{2\pi RC\tan\theta} = \frac{10^6}{2\pi \times 1000 \times \tan 15} = 159.15Hz$$

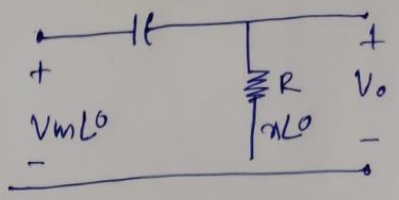
$$V_{rms} = \frac{10}{\sqrt{2}} = 7.07$$

$$\therefore 7.07 \times \sqrt{2}(1.414) = 9.996 \approx 10$$

$$V_o = \left(1 + \frac{R_f}{R_i}\right) v_i = 1.4 \times v_i$$

$\frac{R_f}{R_i} = 0.4$, so, $R_f = 4k\Omega$, $R_i = 10k\Omega$. $\therefore \frac{R_f}{R_i} \to 0.4$

leading Circuit



$$V_o = \frac{x\angle 0\ (Vm\angle 0)}{x\angle 0 + y\angle -90^\circ}$$

$$= \frac{x \cdot Vm\angle 0}{x - yj}$$

$$= \frac{x \cdot Vm\angle 0}{z\angle -\theta}$$

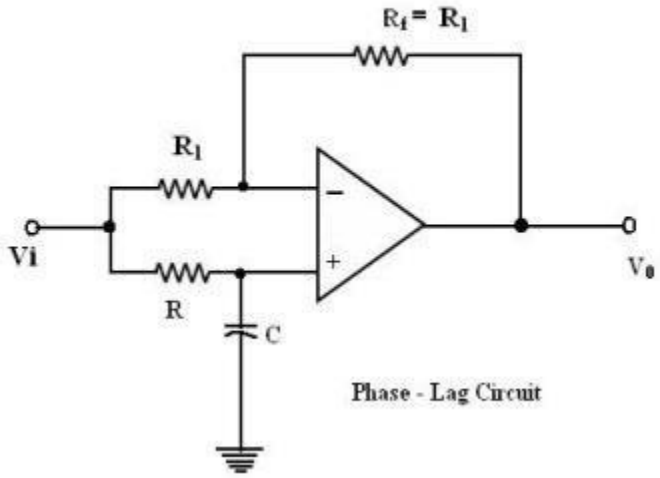
$$= \frac{x \cdot Vm}{z}\angle 0 - (-\theta)$$

$$= \frac{x \cdot Vm}{z}\angle \theta$$

MATHEMATICAL MODELLING / ANALYSIS

Phase-lag circuit :

$1+\frac{R_f}{R_1} = 1+1 = 2$ Since R f =R1.



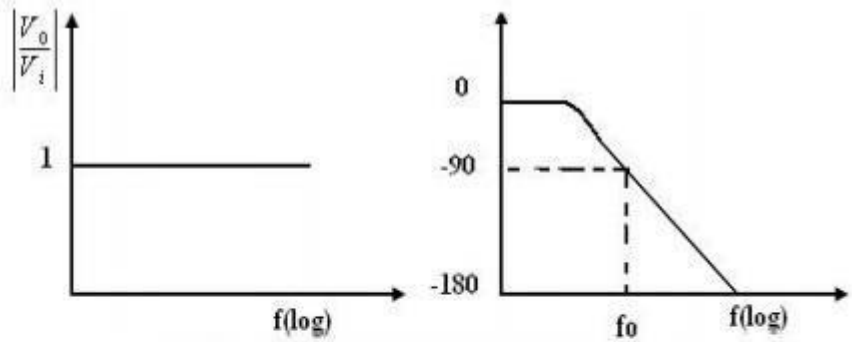


Fig 2.3 Bode plot of phase lag circuit

For the circuit fig 2.2, it can be written as

$$V_O(jw) = -V_i(jw)\left(-1+\frac{2}{1+jwRC}\right)$$

and the relationship between output and input can be expressed by

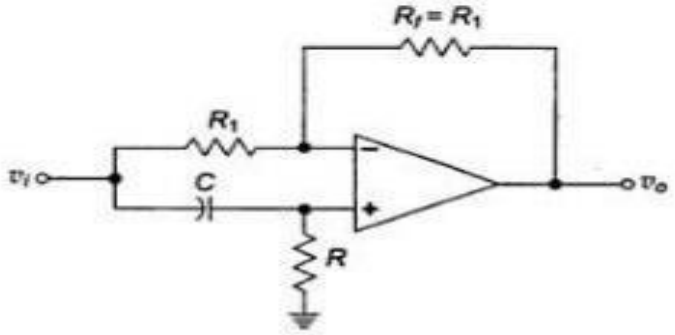
$$\frac{V_O(jw)}{V_i(jw)} = \frac{(1-jwRC)}{(1+jwRC)}$$

Phase-lead circuit :

$$\theta = -2\ \tan^{-1} RC\omega$$

$$\frac{V_O(jw)}{V_i(jw)} = -\frac{(1 - jwRC)}{(1 + jwRC)}$$

$$\theta = 180° - 2\ \tan^{-1} RC\omega$$



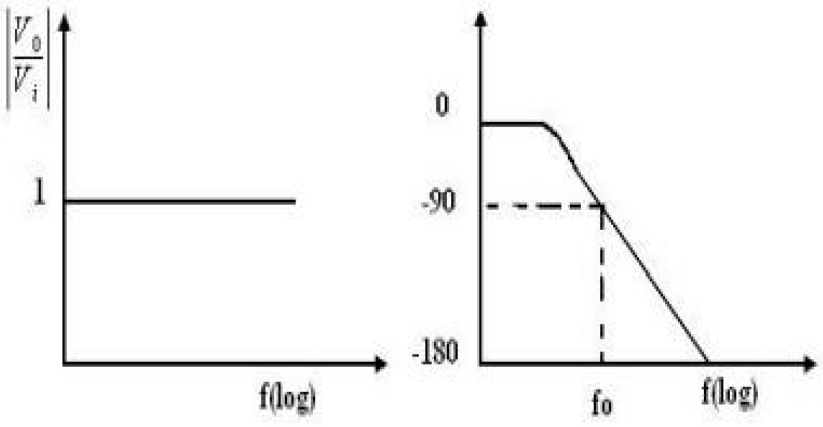
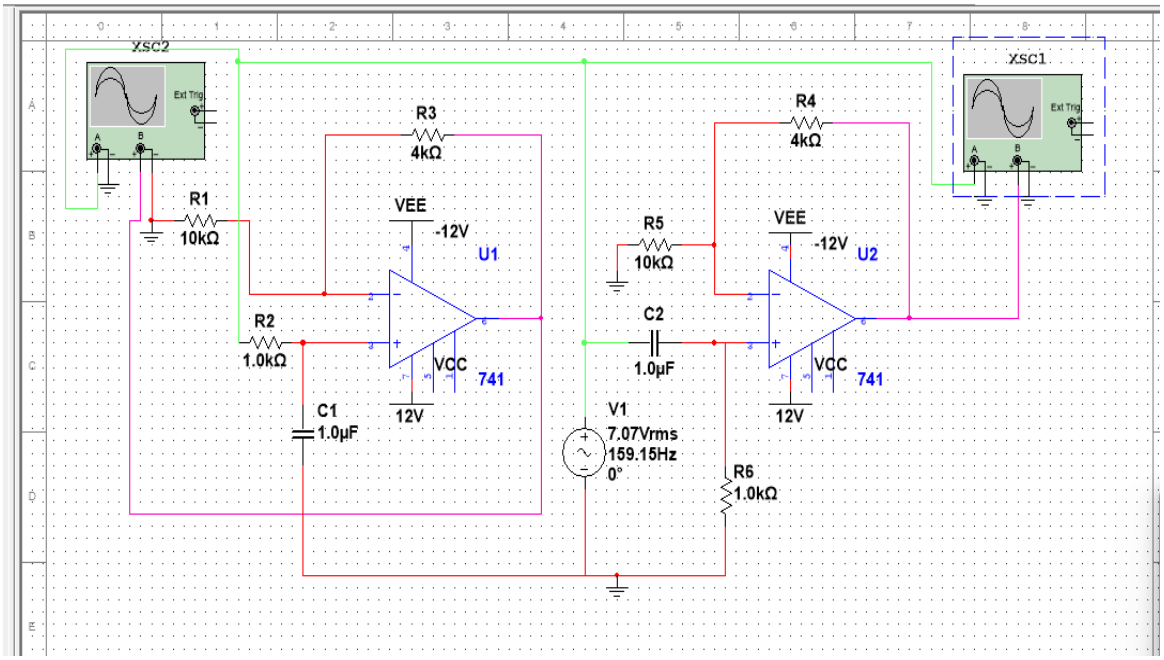


Fig 2.5 Bode plot of Phase lead circuit

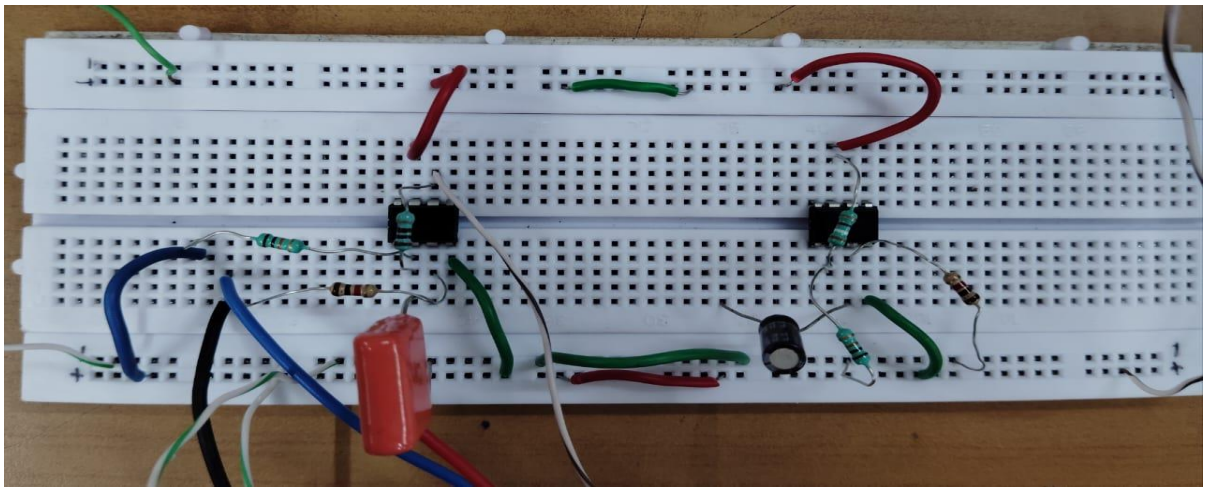
CIRCUIT DIAGRAM

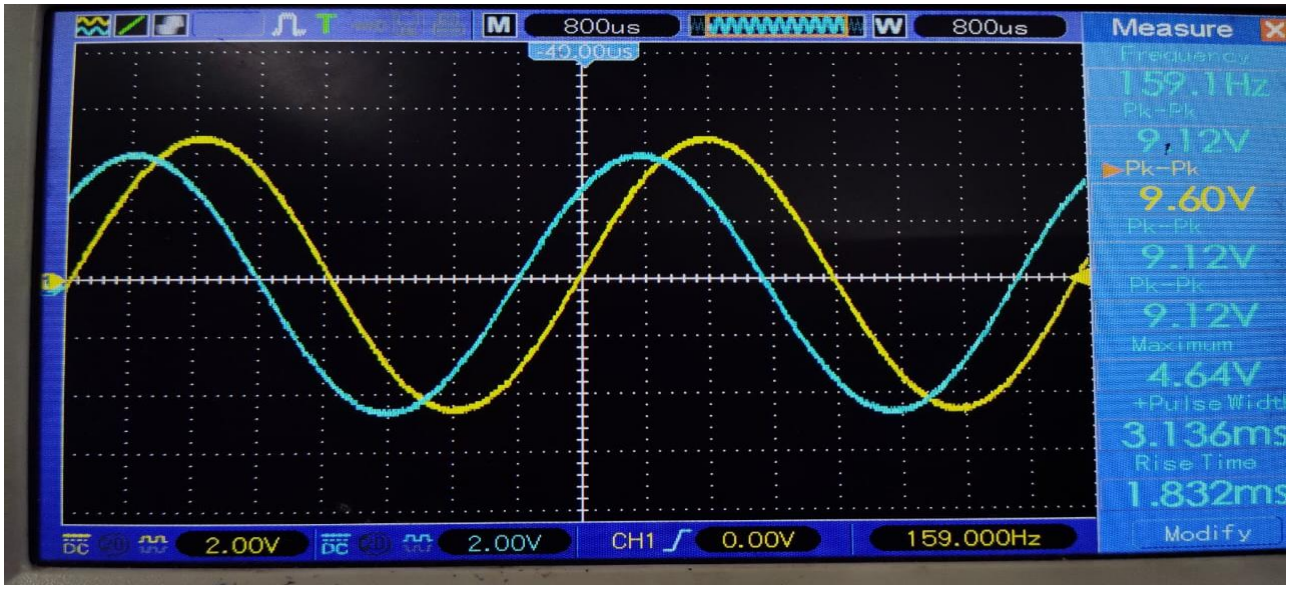


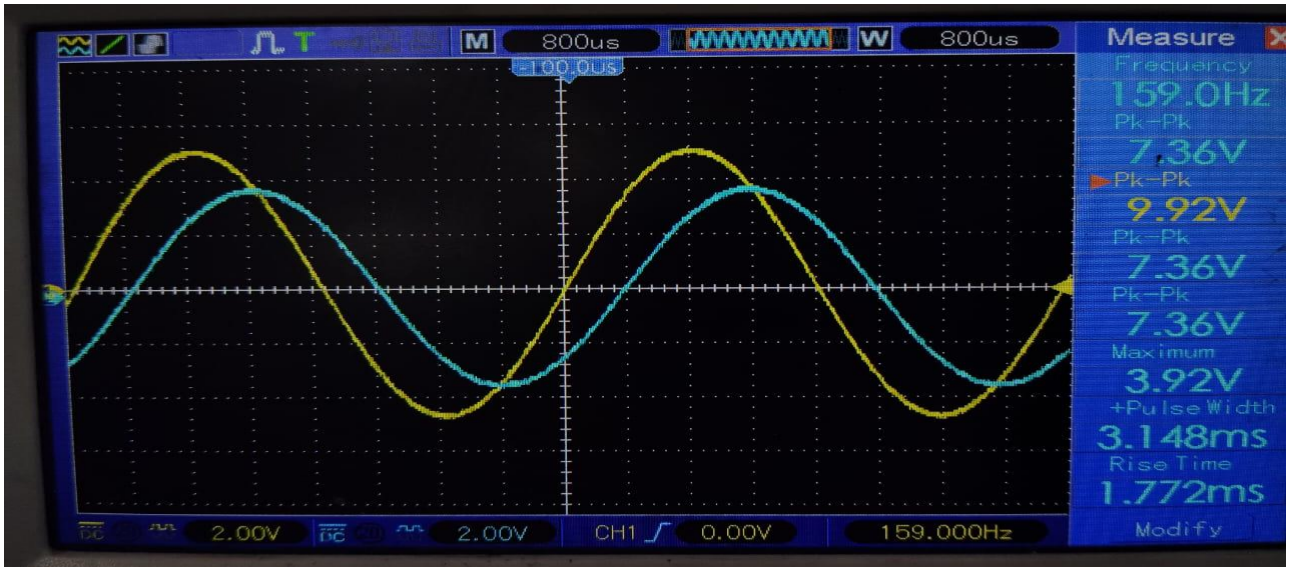
DESIGN SPECIFICATION

Sl. No.	Component Name	Specification	No. of units
1.	Resistors	4kΩ, 10kΩ, 1kΩ	6
2.	Capacitors	1 µF	2
3.	Op-amp	UA741CP	2
4.	Breadboard	Mb102	1
5.	Connecting Wires	23 SWG	As per required

HARDWARE SETUP

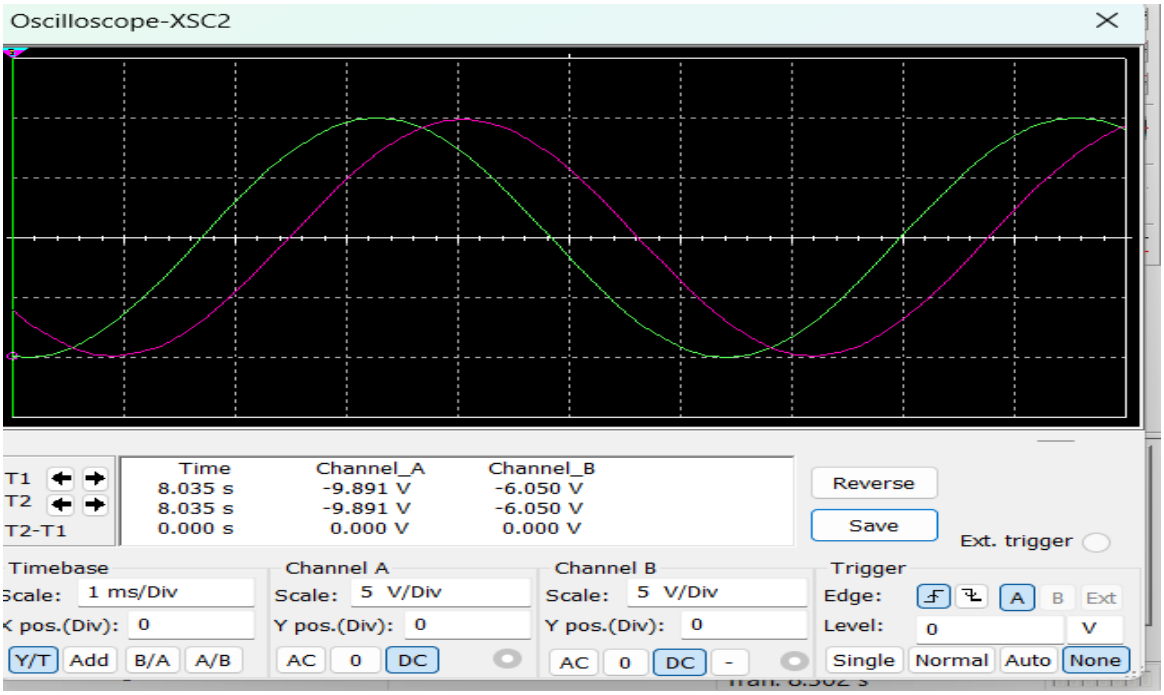




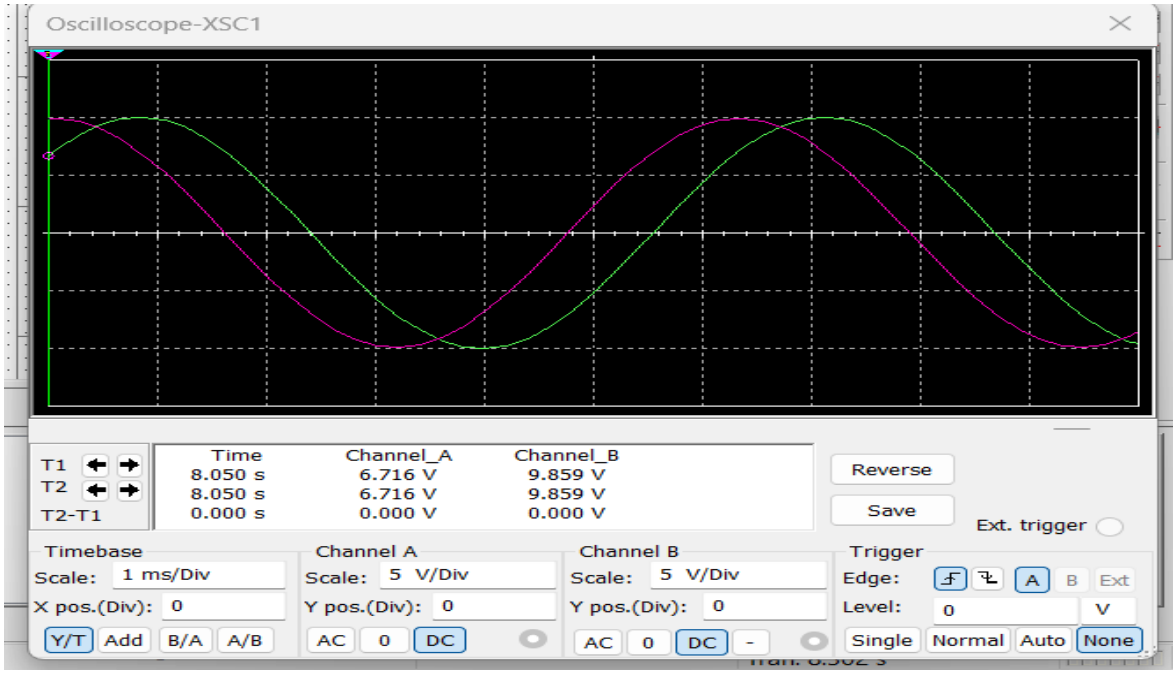


RESULT

45° leading



45° lagging



COMMENTS

- The phase shift depends on the value of R, C and the operating frequency.
- Here, inverting Op-Amp is used and negative feedback is used as it's the most stable circuit compared to positive feedback systems.
- The phase angle between input and output waveform were leading 45° leading and 45° lagging which was in accordance to the given problem statement.
- The output if taken across the capacitor always gives a lagging circuit.
- The output if taken across the resistor always gives a leading circuit.

REFERENCE

- https://ieeexplore.ieee.org/document/1489861
- https://www.researchgate.net/publication/372497209_Design_Construction_and_Study_of_a_Phase_Shifter_Circuit_Using_OP-AMP741
- https://www.brainkart.com/article/Phase-Shift-Circuits_36000/