PH 211 : Electronics LAB.

Experiment 8: Phase Shift and Wien Bridge Oscillators.

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Experiment: 8

Name of Experiment: Phase Shift & Wien Bridge Oscillators.

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$\frac{48}{50}$

periment 9: Phase Shift & Wien Bridge Oscillators.

Aim: To construct (a) phase shift and (b) Wien bridge oscillator using Opamp

Working Formulae:

1) Phase shift Oscillator:

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

where,
f: oscillation frequency.
R: Resistance
C: Capacitance

$$|A| \geq \frac{1}{|B|} \geq 29$$

where,
A: voltage gain
B: voltage gain (feedback)

2) Wien Bridge Oscillator

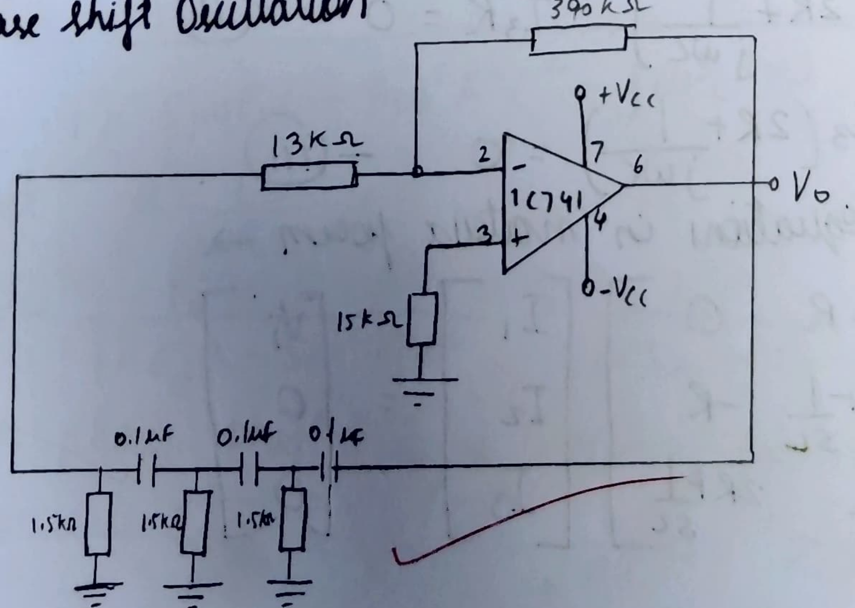
$$f = \frac{1}{2\pi RC}$$

$$T = 2\pi RC$$

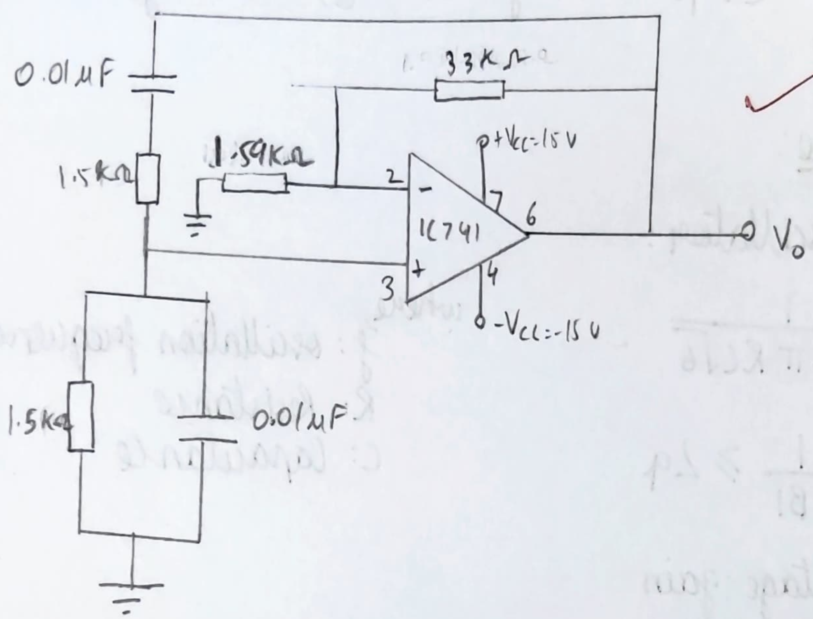
where f: oscillating frequency
R: resistance
C: Capacitance
T: time period.

Circuit Diagram:

1) Phase shift Oscillation

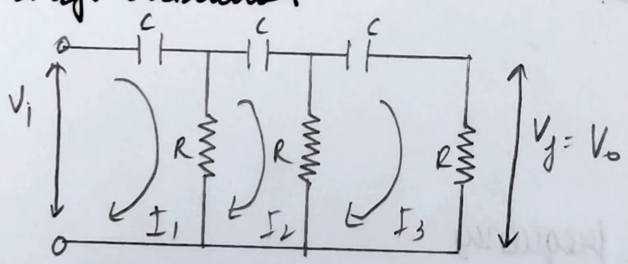


2) Wien Bridge Oscillator



Circuit Analysis

1) Phase shift oscillator



Applying KCL to loops 1, 2, 3

$$I_1\left(R+\frac{1}{j\omega C}\right) - I_2 R - V_i = 0 \quad -(i)$$

$$-I_1 R + I_2\left(2R+\frac{1}{j\omega C}\right) - I_3 R = 0 \quad -(ii)$$

$$0 - I_2 R + I_3\left(2R+\frac{1}{j\omega C}\right) = 0 \quad -(iii)$$

Let $j\omega = s$, equations in matrix form →

$$\begin{bmatrix} R+\frac{1}{sC} & -R & 0 \\ -R & 2R+\frac{1}{sC} & -R \\ 0 & -R & 2R+\frac{1}{sC} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} V_i \\ 0 \\ 0 \end{bmatrix}$$

Using Cramers rule to find I_3

$$D = \begin{bmatrix} R+\frac{1}{sC} & -R & 0 \\ -R & 2R+\frac{1}{sC} & -R \\ 0 & -R & 2R+\frac{1}{sC} \end{bmatrix} = \frac{1+5sRC+6s^2R^2C^2+s^3C^3R^3}{s^3C^3}$$

$$D_3 = \begin{bmatrix} R+\frac{1}{sC} & -R & V_i \\ -R & 2R+\frac{1}{sC} & 0 \\ 0 & -R & 0 \end{bmatrix} = V_i R^2$$

$$I_1 = \frac{D_3}{D} = \frac{V_i R^2 s^3 C^3}{1+5sRC+6s^2R^2C+\underline{s^3C^3R^3}}$$

$$V_o = V_f = I_3 R$$

$$\beta = \frac{V_o}{V_i}$$

Putting $s = j\omega$.

$$\beta = \frac{-j\omega^3R^3C^3}{1+5j\omega RC-6\omega^2R^2C^2-j\omega^3C^3R^3}$$

Let $\alpha = \frac{1}{\omega RC}$.

$$\beta = \frac{1}{1+6j\alpha-5\alpha^2-j\alpha^3} = \frac{1}{1-5\alpha^2-j(\alpha^3-6\alpha)}$$

For phase shift to be $180°$, $j(\alpha^3-6\alpha)=0$

$\Rightarrow \alpha = \sqrt{6} \Rightarrow \sqrt{6} = \frac{1}{\omega RC} \Rightarrow \frac{1}{RC\sqrt{6}} = \omega$.

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

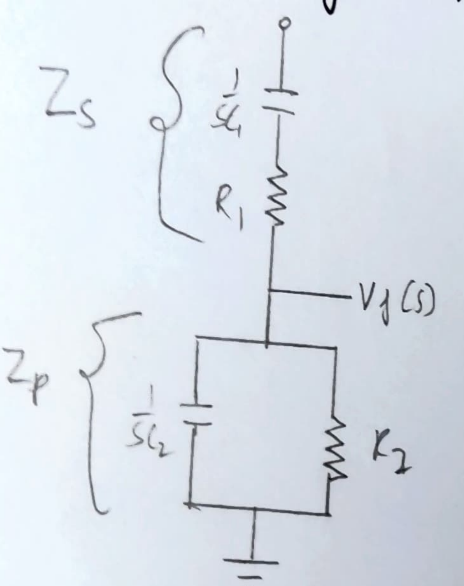
At this frequency, $\beta = -\dfrac{1}{29}$

whose negative sign implies a phase shift of 180°

$|\beta| = \dfrac{1}{29}$

for oscillations, $|A||\beta| \geq 1 \Rightarrow |A| \geq \dfrac{1}{|\beta|} > 29.$

(2) Wien Bridge Oscillator.



Equivalent circuit

Applying voltage

$$V_f(s) = \frac{V_o(s)\, Z_p(s)}{Z_p(s) + Z_s(s)}$$

where, $Z_s = R_1 + \dfrac{1}{sC_1}$

$Z_p = R_2 \parallel \dfrac{1}{sC_2}$

Let $R = R_1 = R_2$ & $C_1 = C_2 = C$.

$$\beta = \frac{V_f(s)}{V_o(s)} = \frac{R_sC}{(R_sC)^2 + 3R_sC + 1}$$

Since the OP-AMP is operating in non inverting configuration

$$A_v = \frac{V_o(s)}{V_f(s)} = 1 + \frac{R_3}{R_4}$$

$A_v \cdot \beta = 1$ (for sustained oscillation

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

$\Rightarrow (1 - R^2C^2W^2) - jw\left(\left(1 + \frac{R_3}{R_4}\right)RC - 3RC\right) = 0$

Equating real part to zero we get.

$1 - R^2w^2C^2 = 0$

$\Rightarrow \omega = \dfrac{1}{RC}$

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

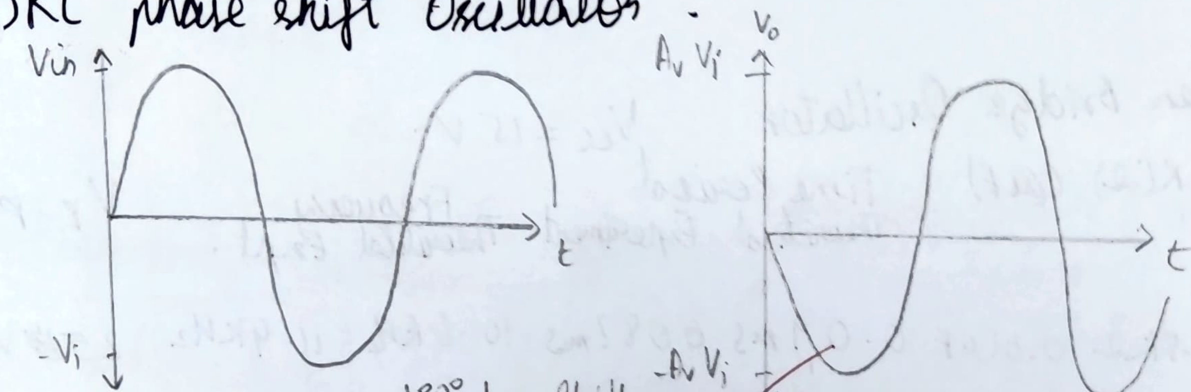
Simplified design.

$f = \dfrac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$ when $R_1 = R_2$ & $C_1 = C_2$.

$f = \dfrac{1}{2\pi RC}$.

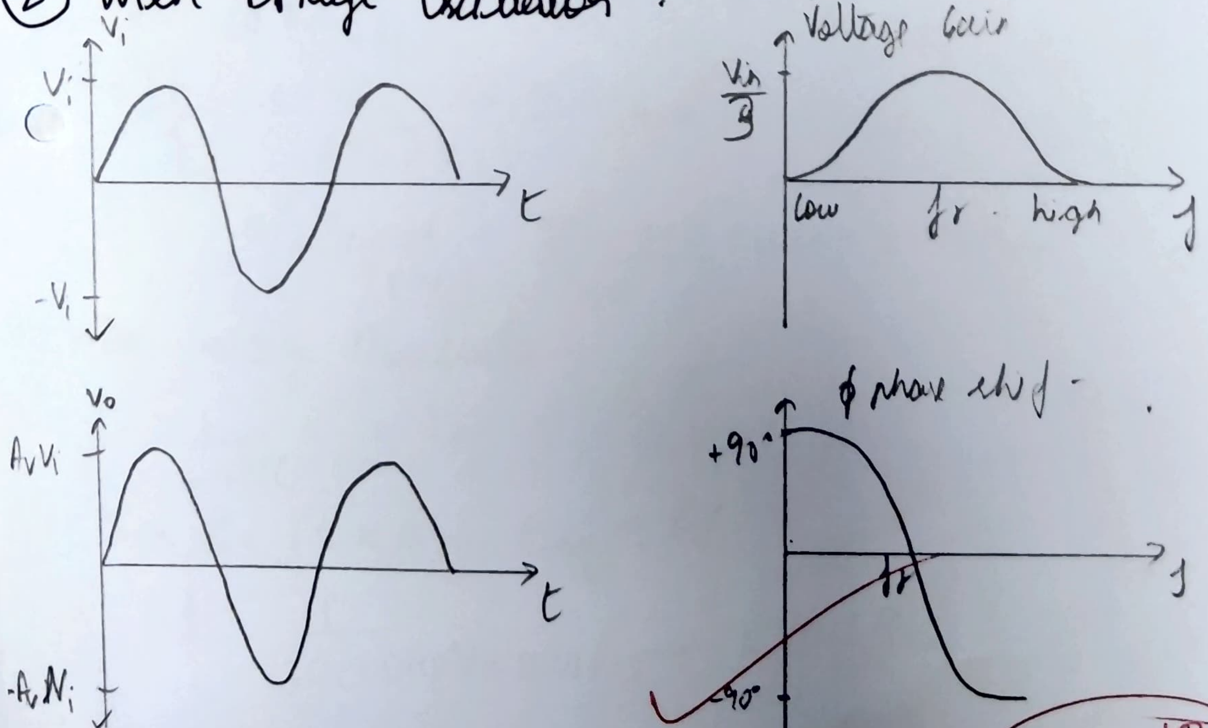
Expected Waveform:

① RC phase shift Oscillator.



180° phase shift.

② Wien Bridge Oscillator.



0°/360° phase shift

IP = 10/10

Observation:

1) Phase shift oscillator $V_{cc} = 15V$

Sr. No	R(Ω)	C(µF)	Time Period Theoritical	Time Period Experiment	Frequency Theoritical	Frequency Expt.	V_{P-P} (
1.	1.5kΩ	0.1µF	2.309 ms	2.6 ms	433 Hz	382.7 Hz	27.4
2.	1.5kΩ	0.01µF	230 µs	~~1~~ 250 µs	4.33 kHz	~~4.0kHz~~ 4.0 kHz	27.6.
3.	2.2kΩ	0.1µF	340 µs	~~4~~ 350 µs	2.95 kHz	2.8 kHz	27.6.

2) Wien Bridge Oscillator $V_{CC} = 15V$

Sr. No.	R(Ω)	C(µF)	Time Period Theoritical	Time Period Experiment	Frequency Theoritical	Frequency Expt.	V_{P-P}
1	1.5kΩ	0.01µF	0.09 ms	0.087 ms	10.6 kHz	11.4 kHz	25.[illegible] V

Calculation:

(Theoritical Calculation)

a1) Phase shift oscillator

a) $R = 1.5K\Omega$ $C = 0.1\mu F$

$$f = \frac{1}{2\pi RC\sqrt{6}} = \cancel{433.2Hz} \frac{1}{2\pi \times 1.5\times10^3 \times 0.1\times10^{-6}\times\sqrt{6}} = 433.2Hz$$

$$T = \frac{1}{f} = \frac{1}{433.2} = 2.3ms$$

$\Rightarrow$ % Error (T%) $= \frac{2.609-2.3}{2.309} \times 100 = 12.99\%$

b) $R = 1.5k\Omega$ $C = 0.01\mu F$

$$f = \frac{1}{2\pi RC\sqrt{6}} = 4331\,Hz$$

$$T = \frac{1}{f} = \frac{1}{4331\,Hz} = 0.23ms.$$

~~2) Wien Bridge Oscillator.~~ ~~% Error =~~ % Error (T%) $= \frac{4.0-4.3}{4.3} \times 100 = 6.97\%$

(C) $R = 2.2k\Omega$ $C = 0.01\mu F$.

$$f = \frac{1}{2\pi RC\sqrt{6}} = 2953.4\,kHz$$

$$T = \frac{1}{f} = \frac{1}{2953.4} = 0.34ms$$

% Error (T%) $= \frac{350-340}{340} \times 100 = 2.94\%$

2) Wien Bridge Oscillator.

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

For $R = 1.5k\Omega$ $C = 0.01\mu F$.

$$f = \frac{1}{2\pi(1.5\times10^3)\times0.01\times10^{-6}} = 10.6Hz.$$

$$T = \frac{1}{F} = 0.09ms.$$

$$T\% = \frac{0.087-0.09}{0.09} = 3.33\%$$

Summary of Result :

1) In RC phase shift oscillator .

i) Observed frequency for

- R = 1.5kΩ C = 0.1μF was : 382.7Hz
- R = 1.5kΩ C = 0.01μF was 4.0kHz
- R = 2.2kΩ C = 0.01μF was 2.8kHz

was

(ii) Error in time period was found to be

R = 1.5kΩ C = 0.01μF ⇒ %Error = 12.9%

R = 1.5kΩ C = 0.01μF ⇒ %Error = 6.9%

R = 2.2kΩ C = 0.01μF ⇒ %Error = 2.9%

2) In Wien Bridge Oscillator

i) Observed

R = 1.5kΩ C = 0.01μF .

T = 0.087 Frequency = 11.4kHz

%

(ii) Error in time Period was observed to be .

% Error in Time Period = 3.33%

3) The peak to peak voltage achieved in

Part 1	Part 2 .
(i) V_{p-p} = 27.4 V	V_{p-p} = 25.2 V .
(ii) V_{p-p} = 27.6 V	
(iii) V_{p-p} = 27.6V	

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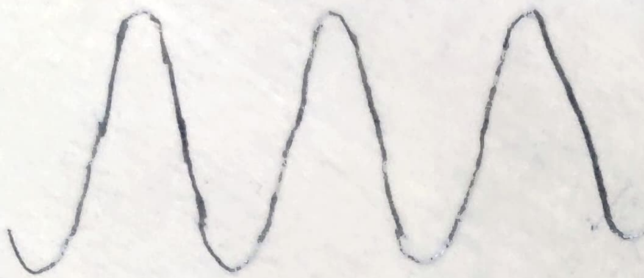
Phase shift Oscillator



$R = 1.5\,k\Omega$ $C = 0.1\,\mu F$ $V_{cc} = 15.0V$

$\phi = 180°$

$f_R = ?$

$V_{p-p} = ?$

Wien Bridge Oscillator

$R = 15\,k\Omega$ $C = 0.01\,\mu F$ $V_{cc} = 15V$.

$\phi = 0°/360°$

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4) The errors in reading of both the oscillator frequency and time period was low for both RC phase shift oscillator and wien bridge oscillator.

5) There was an expected phase shift which was observed in the 1st experiment but the circuit was very sensitive to movement & loose connections.

6) Wien bridge worked as expected with 0°/360° phase shift and there was very low error but the circuit was very sensitive to loose connections and slight movements of the circuit board.

7) For phase shift we changed the circuit since the expected output was not observed in the given circuit.
The change was - (i) The 13KΩ resistor was removed.
(ii) The 1.5KΩ resistor was connected to pin 2 and disconnected from ground

Precaution:

- Make sure the IC741 is not shorted.
- Avoid using rusted crocodile clips & connectors.
- Ensure that there are no loose connection.
- Shut of the power supply if it beeps because this means there is a short circuit which may damage the component
- Use appropriate feedback resistors in order to get a correct output
- The given circuits are very sensitive to loose connections and movement of the components. So care must be taken while the readings are taken.