Ex. No : 5

Date : 16/07/2022

RC PHASE SHIFT OSCILLATOR

AIM:

To design and setup an RC phase shift oscillator using BJT and to observe the sinusoidal output waveform.

COMPONENTS REQUIRED:

Transistor, dc power source, capacitors, resistors, potentiometer, breadboard and CRO.

THEORY:

An oscillator is an electronic circuit for generating ac signal using a dc voltage. The frequency of the generated signal is decided by the circuit elements. An oscillator requires an amplifier, a frequency selective network and a positive feedback from the output to the input. The Barkhausen criterion for sustained oscillation is $A\beta = 1$ where A is the gain of the amplifier and β is the feedback factor. This implies the magnitude $|A\beta| = 1$ and the angle $\angle A\beta = 2n\pi$ where n is the integer.

If a common emitter amplifier is used, with a resistive collector load there is a 180° phase shift between the voltages at the base and the collector. Feedback network between the collector and the base must introduce an additional 180° phase shift at a particular frequency.

Three RC sections of phase shift networks are used in the circuit so that each section introduces approximately 60° phase shift at resonant frequency.

By analysis resonant frequency f can be expressed by the equation

$$f = \frac{1}{2\pi RC\sqrt{6 + 4R_C/R}}$$

The three sections of RC network offers a β of 1/29 Hence the gain of the amplifier should be 29 For this the requirement of the h_{FE} on the transistor is

$$h_{FE} \geq 23 + 29\frac{R}{R_C} + \frac{4R_C}{R}$$

This phase shift oscillator is particularly useful in the audio frequency range

DESIGN:

Output requirements

Sine wave with amplitude 10Vpp and frequency 1KHz

Design of amplifier

Select transistor BC107 (minimum h_{FE} = 100)

DC biasing condition:

$V_{CC} = 12V$ $I_C = 2mA$

$V_{RC} = 40\%$ of $V_{CC} = 4.8$

$V_{RE} = 10\%$ of $V_{CC} = 1.2V$

$V_{CE} = 50\%$ of $V_{CC} = 6V$

V_{CC} is taken as 20% additional to the required output peak amplitude

Design of RC:

$V_{RC} = I_C \times R_C = 4.8V$

$R_C = \frac{4.8}{2mA} = 2.4k\Omega$

Taking standard value = $2.2k\Omega$

Design of RE:

$V_{RE} = I_E \times R_E = 1.2V$

$R_E = \frac{1.2}{2mA} = 600\Omega$

Taking standard value $R_E = 680\Omega$

Design of voltage divider R_1 and R_2:

$h_{FE}(min)$ of BC107 = 100 (from data sheet)

$I_B = \frac{I_C}{h_{FE}} = \frac{2mA}{100}$

$= 20\mu A$

Assume that current through $R_1 = 10I_B$ and that through $R_2 = 9I_B$ to avoid loading the potential divider by the base current.

V_{R2} = Voltage across R_2 = $V_{BE} + V_{RE}$

$= 0.7 + 1.2 = 1.9V$

Also $V_{R2} = 9I_B R_2 = 1.9$

$R_2 = \frac{1.9}{9 \times 20 \times 10^{-6}} = 10.6 \times 10^3$

$= 10.6k\Omega$

Taking standard value $R_2 = 10k\Omega$

V_{R1} · Voltage across $R_1 = V_{CC} - V_{R2}$

$= 12 - 1.9$

$= 10.1V$

$V_{R1} = 10 I_B \times R_1 = 10.1$

$$R_1 = \frac{10.1}{10 \times 20 \times 10^{-6}} = 50.5k\Omega$$

Taking standard value $R_1 = 47k\Omega$

Design of frequency selection feedback:

Required frequency of oscillation = 1kHz

$$f = \frac{1}{2\pi RC\sqrt{6 + \frac{4RC}{R}}}$$

Take $R = 4.7k$ to avoid loading of Rc by RC network.

then $C = 0.01\mu F$

Design of emitter bypass capacitor C_E

Assume $f_e = 100Hz$

$$X_{CE} = \frac{R_E}{10} = \frac{1}{2\pi f C_E} \leq \frac{R_E}{10}$$

$$2\pi f C_E \geq \frac{10}{R_E}$$

$$C_E \geq \frac{1}{2\pi f R_E} = \frac{1}{2 \times 3.14 \times 100 \times 680}$$

$= 23.7\mu F$

Take $C_E = 22\mu F$

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PROCEDURE:

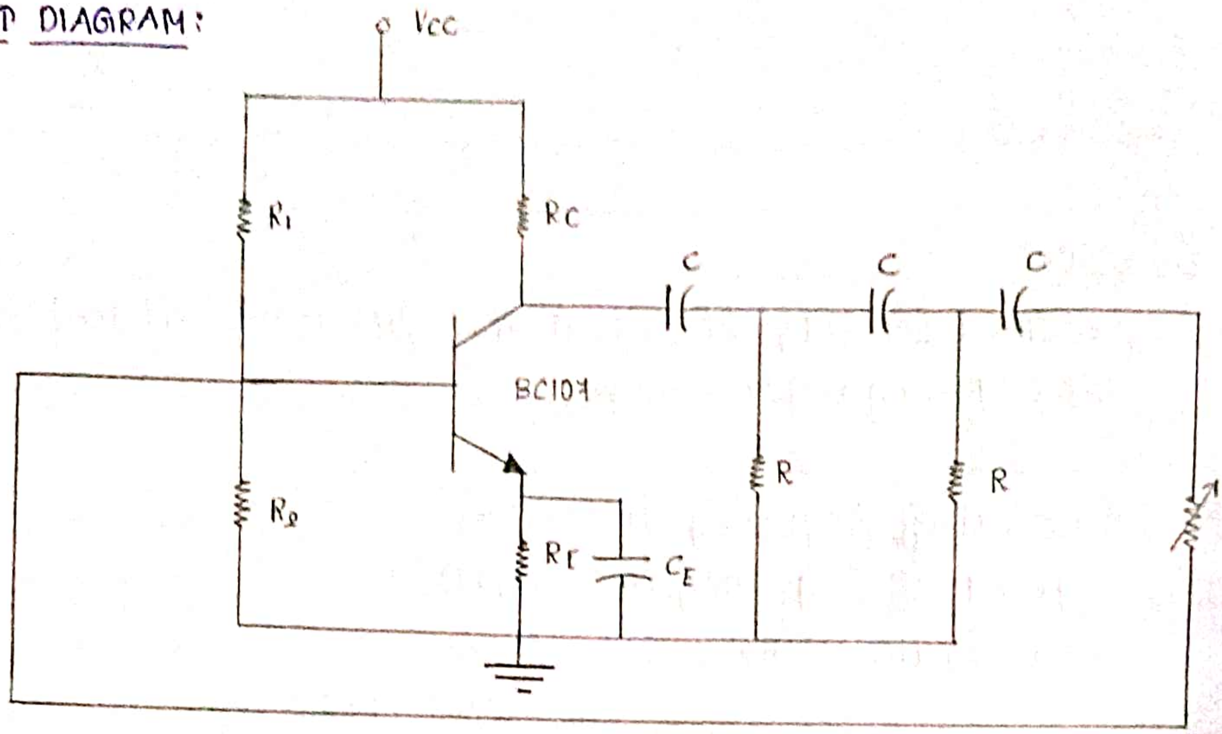
1. Set up the amplifier part of the oscillator and test the dc conditions. Ensure that the transistor is operating as an amplifier with the required gain.
2. Connect the feedback network and observe the sine wave on CRO screen and measure its amplitude and frequency.
3. Observe the waveforms at the base and collector of the transistor simultaneously on CRO screen and notice the phase difference between them.

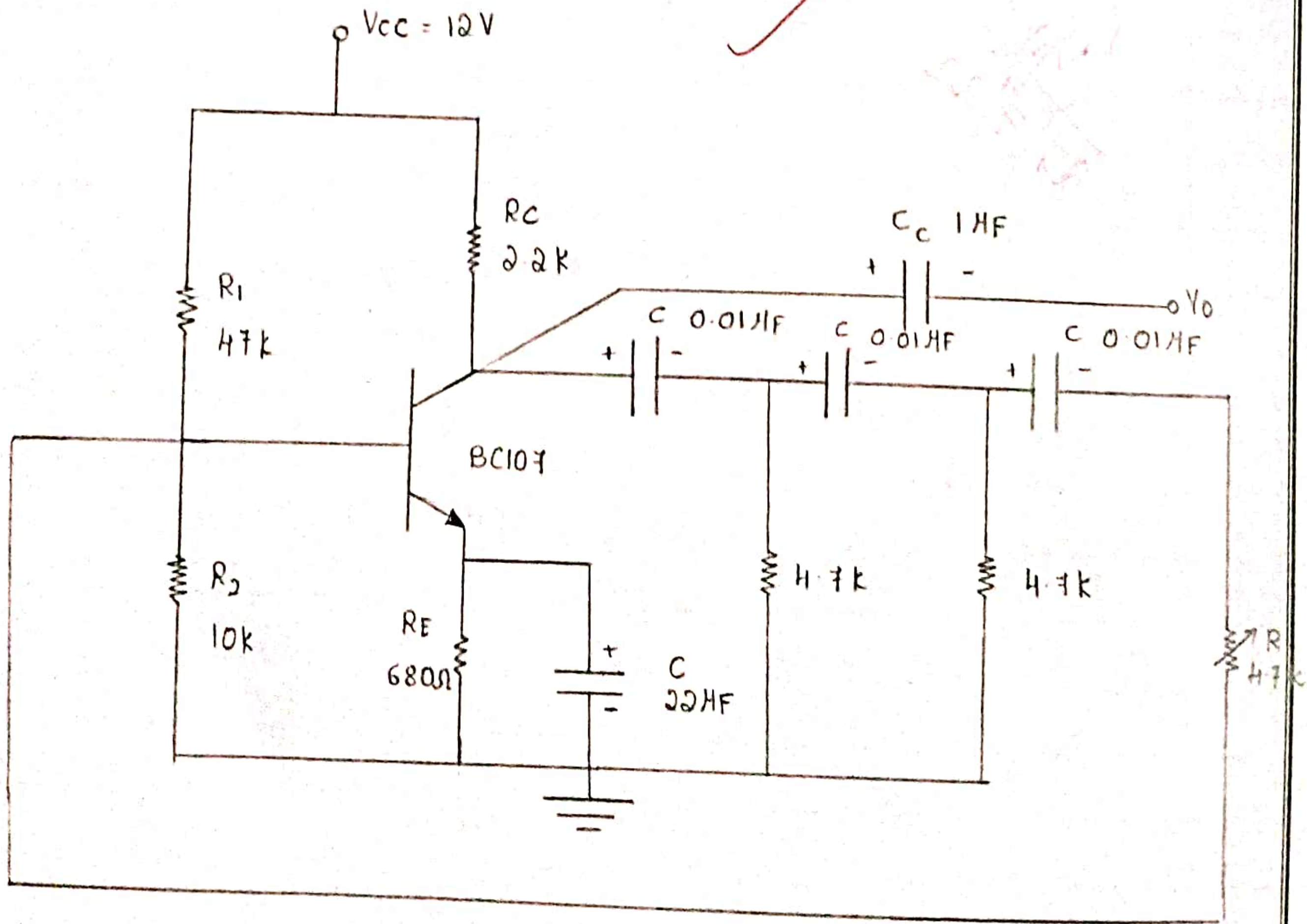
RESULT:

Designed and setup an RC phase shift oscillator for frequency of 1.1kHz using BJT and obtained the output sinewave with Vpp = 8.48 V

29/07/22

CIRCUIT DIAGRAM:





Frequency = 1.1 kHz

Time Period = 899.9849 = 0.899 ms

Vpp = 8.48 V

Scale

X axis - 20 div - 0.5 ms

Y axis - 10 div - 2V