K. J. SOMAIYA COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
ELECTRONIC CIRCUITS
Oscillator Circuits

Design 1:
Design a RC phase shift oscillator to oscillate at 1100Hz, DC supply voltage is 10V

Solution:

Step 1:- Selection of transistor and circuit diagram

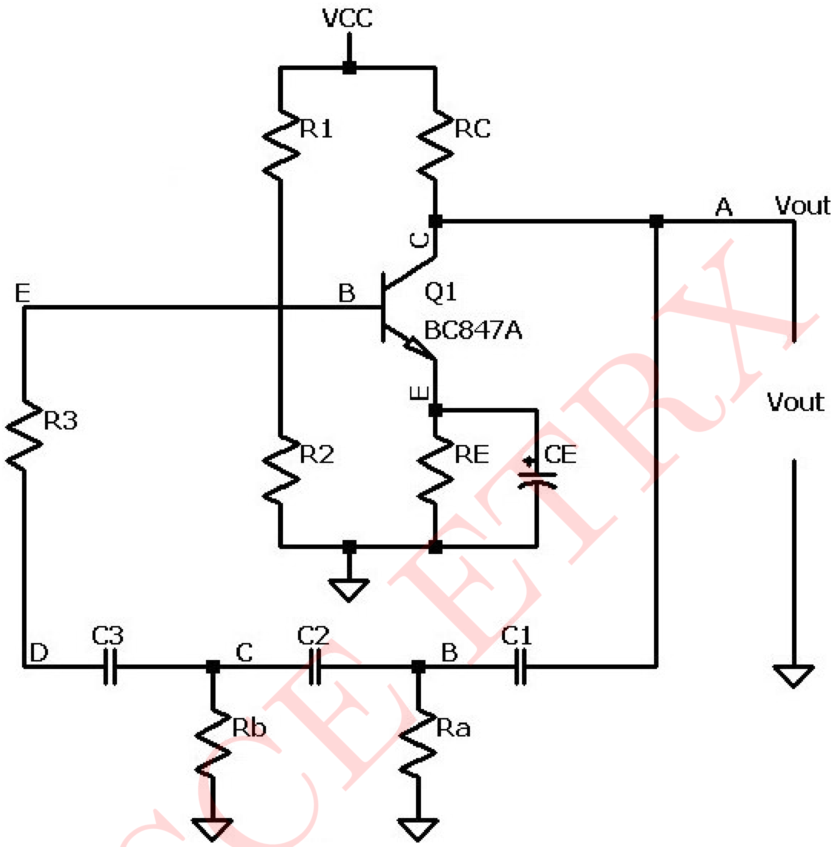

Figure 1: Circuit 1

Select BC147A $\rightarrow h_{fe} = 220$, $h_{fE} = \beta = 180$, $h_{ie} = 2.7k\Omega$ and $V_{CE} = 0.25V$

Step 2:- Selection of R & C

$R = R_a = R_b$; $C = C_1 = C_2 = C_3$

For RC phase- shift oscillator,

$$f = \frac{1}{2\pi R_C} = \frac{1}{\sqrt{6+4k}}$$

Where, $k = \frac{R_C}{R}$

Minimum value of k is 2.7

i.e. $11 \times 10^2 = \frac{1}{2\imath RC(\sqrt{6+4\times 2.7})}$

$$RC = \frac{1}{2\pi \times 11 \times 10^2 \times \sqrt{6 + 4 \times 2.7}} = 35.299 \times 10^{-6}$$

let, $C = 0.01\mu F$

$$R = \frac{3.53 \times 10^{-6}}{0.01 \times 10^{-6}} = 3.52k\Omega$$

Select $\boldsymbol{R = 3.90k\Omega, 1/4W = R_a = R_b}$

Step 3:- Selection of $\boldsymbol{R_C}$

$$k = \frac{R_C}{R}$$

$$R_C = k \times R = 2.7 \times 3.90k = 10.53k\Omega$$

Select $\boldsymbol{R_C = 12k\Omega, 1/4W}$

Step 4:- Selection of $\boldsymbol{R_E}$

$V_{R_E} = 10\%$ of $V_{CC} \approx 0.1V_{CC} = 0.1 \times 10 = 1V$[For good stability]

For maximum symmetrical output voltage swing, select Q-Point at center of DC load line

$$V_{CE} = \frac{1}{2}V_{CC} = 5V$$

$$I_{C_Q} = \frac{V_{CC} - V_{CE} - V_{R_E}}{R_C} = \frac{10 - 5 - 1}{12k} = 0.333mA$$

$$I_C = \alpha I_E; \qquad \alpha = \frac{1}{1+\beta} = \frac{180}{181} = 0.994$$

$$I_E = \frac{I_C}{\alpha} = \frac{0.333mA}{0.994} = 0.335mA$$

$$V_{R_E} = I_E R_E$$

$$R_E = \frac{V_{R_E}}{I_E} = \frac{1}{0.335mA} = 2.98k\Omega$$

Select $\boldsymbol{R_E = 2.7k\Omega, 1/4W}$

Step 5:- Selection of $\boldsymbol{R_1}$ and $\boldsymbol{R_2}$

$$S = \frac{1+\beta}{1 + \beta\left(\frac{R_E}{R_B + R_E}\right)} \qquad [\beta = 180, \text{ Assume } S = 8]$$

$$8 = \frac{1+180}{1 + 180\left(\frac{330}{R_B + 330}\right)}$$

$$1 + \frac{190 + 330}{R_B + 330} = \frac{181}{8}$$

$$\frac{180 \times 330}{R_B + 330} = \frac{173}{8}$$

$$R_B = \frac{180 \times 2.7k - (2.7k \times 173)}{173} = 19.774k\Omega$$

$$R_B = \frac{R_1 R_2}{R_1 + R_2} \qquad \text{.........(1)}$$

$$V_B = \frac{R_2}{R_1 + R_2} \times V_{CC} \qquad \text{.........(2)}$$

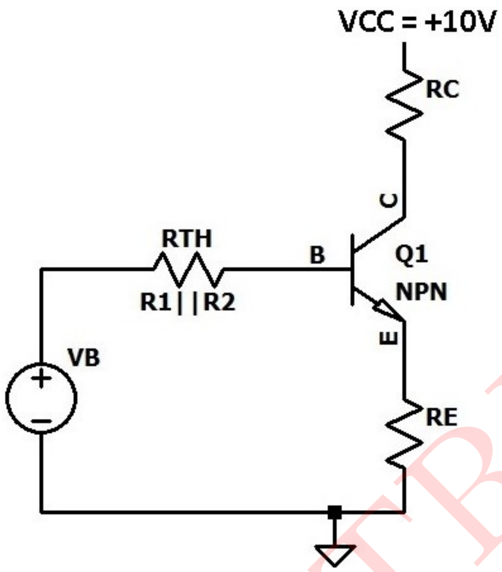

Figure 2: DC Equivalent circuit

Applying KVL to the base-emitter loop,

$V_B - I_B R_B - V_{BE} - I_E R_E = 0$

$V_B = 0.7 + \dfrac{0.333mA}{180} \times 19.77k\Omega + (2.7k \times 0.335mA) = 1.641V$

From 2,

$V_B = 1.641 = \dfrac{R_2}{R_1 + R_2} = 10$

$\dfrac{R_2}{R_1 + R_2} = 0.1641$ ....(3)

Put (3) in (1),

$(0.1641)R_1 = 19.774k\Omega$

$R_1 = 120.5k\Omega$

Select $\boldsymbol{R_1 = 150k\Omega, 1/4W}$

From 3, $\dfrac{R_2}{R_1 + R_2} = 0.1641$

$R_2 = \dfrac{0.1641 \times 150k}{1 - 0.1641} = 29.447k\Omega$

Select $\boldsymbol{R_2 = 27k\Omega, 1/4W}$

Step 6:- Selection of $\boldsymbol{C_E}$

$X_{CE} \leq \dfrac{R_E}{10} \leq 0.1R_E$ [to ensure complete bypass of R_E]

Consider $f_L = 11kHz$ of R_E

$$\frac{1}{2\pi f_L C_E} = 0.1R_E$$

$$C_E = \frac{1}{2\pi f_L 0.1R_E} = \frac{1}{2\pi \times 1100 \times 0.1 \times 2.7k} = 0.535\mu F$$

Select, $C_E = 1\mu F/25V$

Step 7:- Selection of R_3

To avoid loading effect by input impedance of BJT towards R_3,

$R_3 = R + R_i$

$R_i = R_1 \mid\mid R_2 \mid\mid r_\pi = 150k \mid\mid 27k \mid\mid 2.7k = 2.415k\Omega$

$R_3 = 3.9k + 2.415k = 6.315k\Omega$

Select $R_3 = 6.8k\Omega, 1/4W$

Step 8:- Compete designed circuit

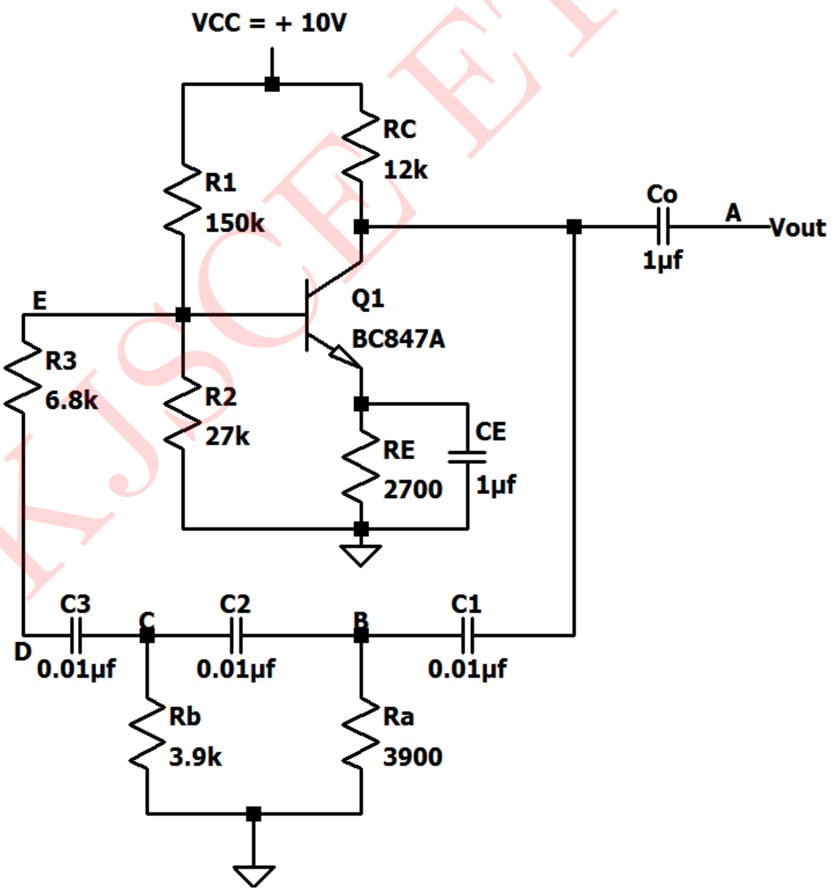

Figure 3: Designed RC Phase shift oscillator, oscillating at 11kHz

SIMULATED RESULTS:

Above circuit was simulated in LTSpice and results are presented below:

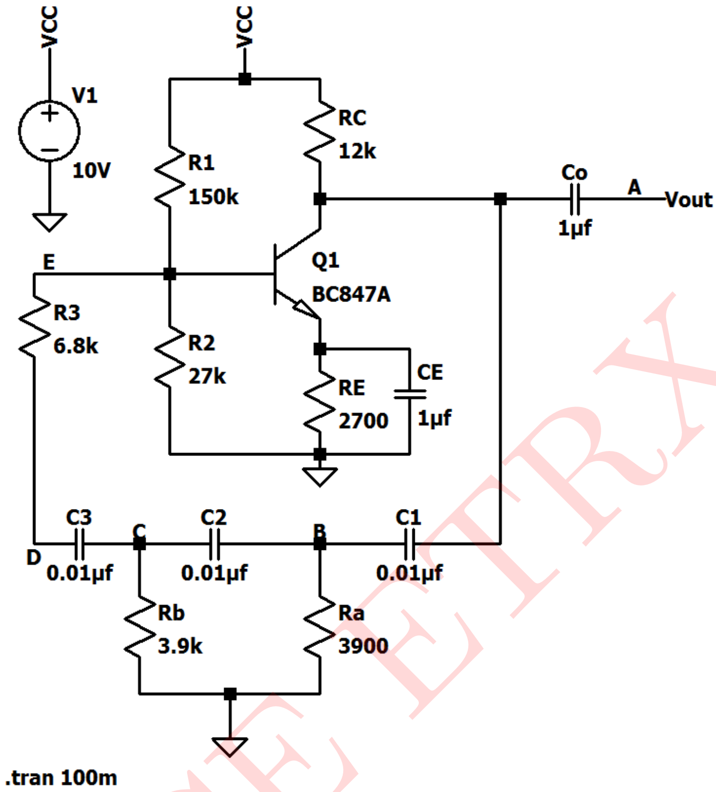

Figure 4: Circuit Schematic 1

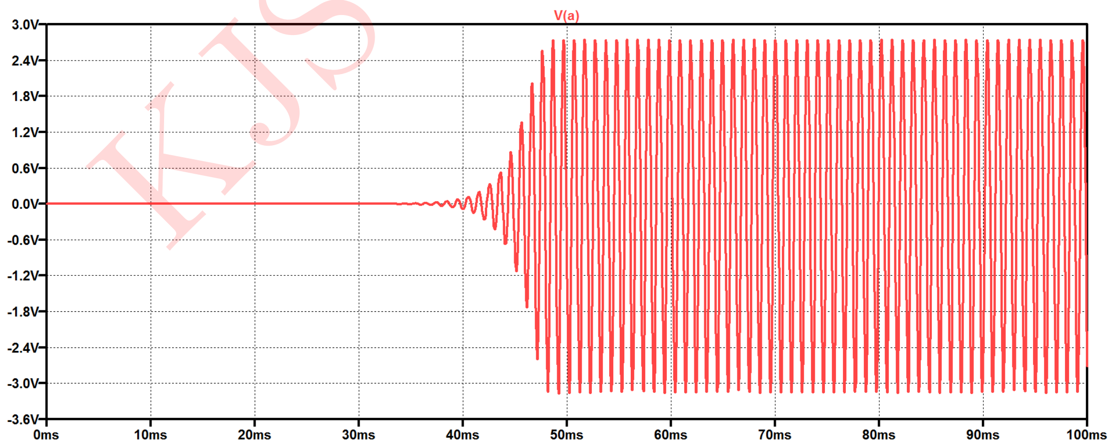

Figure 5: RC Phase shift oscillator output waveforms

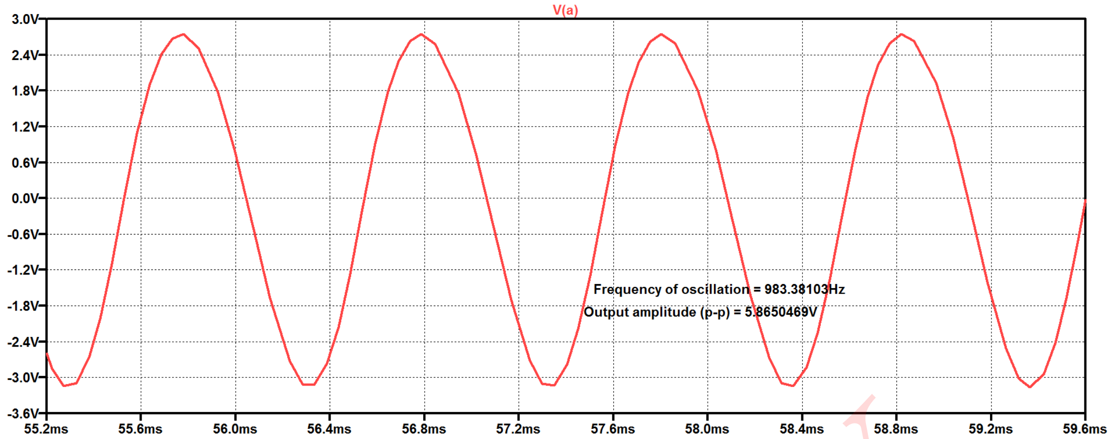

Figure 6: Expanded view of output waveforms

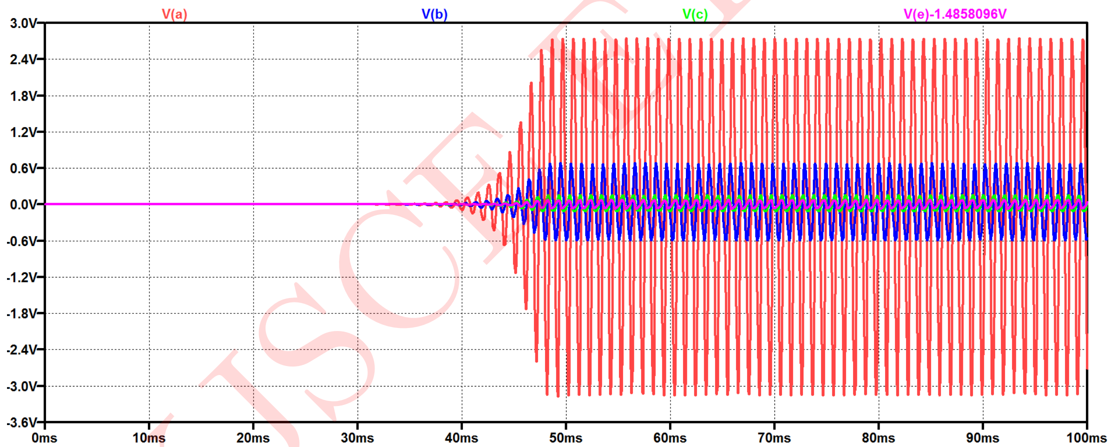

Figure 7: Waveforms of oscillator output and feedback network

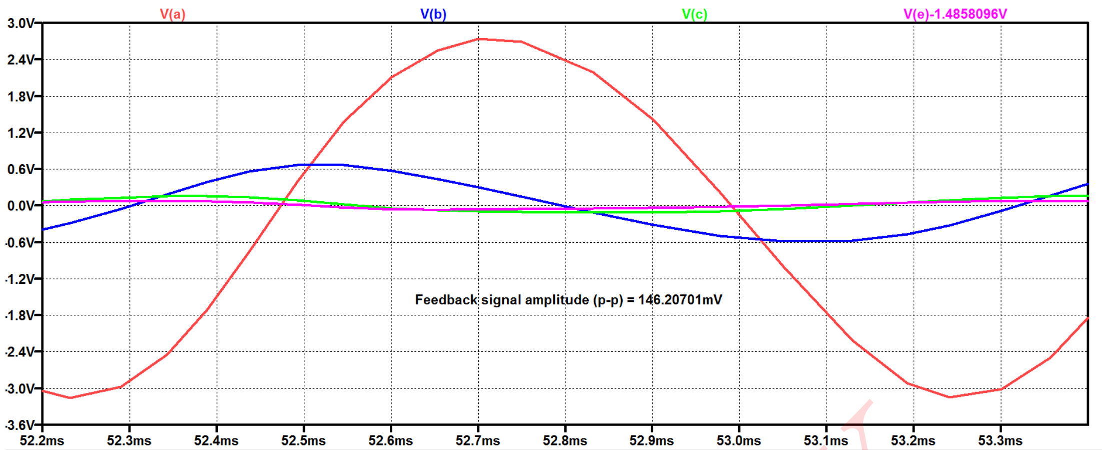

Figure 8: Expanded view of output and feedback waveforms

Comparison of Theoretical and Simulated Values:

Parameters	Theoretical	Simulated
Frequency of oscillator	$1100Hz$	$983.38Hz$
Time period of oscillator	$0.91ms$	$1.01ms$
Amplitude of oscillator	—	$5.865V$
Feedback signal amplitude	—	$146.21mV$
Feedback fraction	0.034	0.025
Phase shift offered by feedback network	180°	180°

Table 1: Design 1

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