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

Numerical 1: In a Hartley oscillator, amplifier components are $R_1 = 100$ kΩ, $R_2 = 18$ kΩ, $R_C = 12$ kΩ, $R_E = 1$ kΩ, $C_{C_1} = 1$ μF, $C_E = 1$ μF, $C_{C_2} = 1$ μF, $V_{CC} = 10$ V. Select the LC tank circuit elements such that frequency of oscillation is close to 30 kHz. Also find frequency of oscillation after finding LC tank circuit elements, time period of oscillations, feedback fraction an phase shift offered by LC tank circuit.
BJT transistor: 2N2222

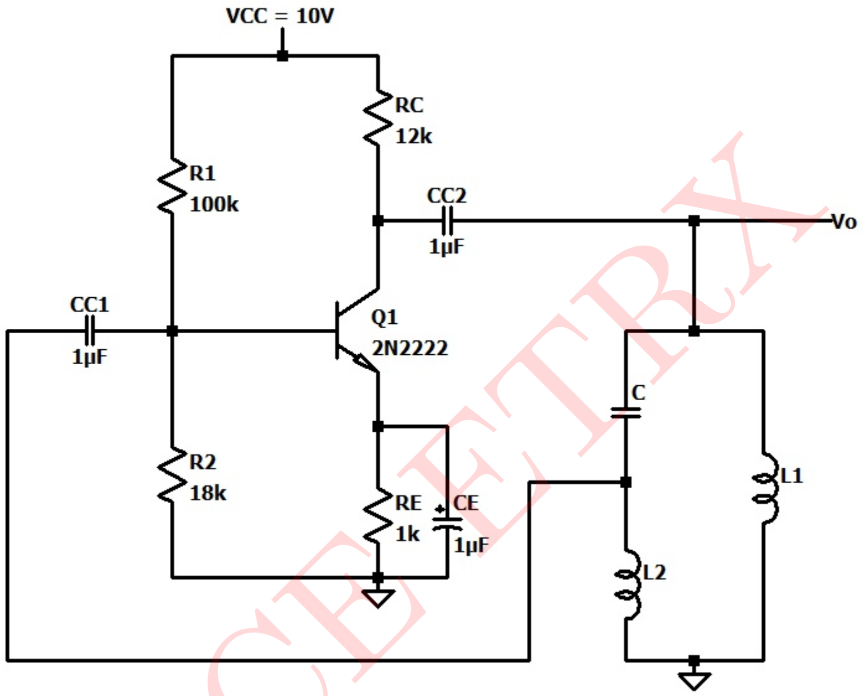

Figure 1: Circuit 1

Solution:

The given circuit 1 is a Hartley oscillator.

Frequency of oscillations is given as,

$$f_o = \frac{1}{2\pi\sqrt{(L_1 + L_2).C}}$$

Let, $L_1 + L_2 = L_{eq}$

$$f_o = \frac{1}{2\pi\sqrt{L_{eq}.C}}$$

Let, C = 47 nF

$$300 \times 10^3 = \frac{1}{2\pi\sqrt{L_{eq}.47 \times 10^{-9}}}$$

Let, $L_{eq} = 5.988$ μH

$L_{eq} = L_1 + L_2$

Let, $L_1 = L_2$

$L_{eq} = 2L_1$ or $L_{eq} = 2L_2$

$$L_1 = L_2 = \frac{L_{eq}}{2} = \frac{5.988 \times 10^{-6}}{2} = \mathbf{2.994}\ \boldsymbol{\mu}\mathbf{H}$$

Redrawing the oscillator circuit,

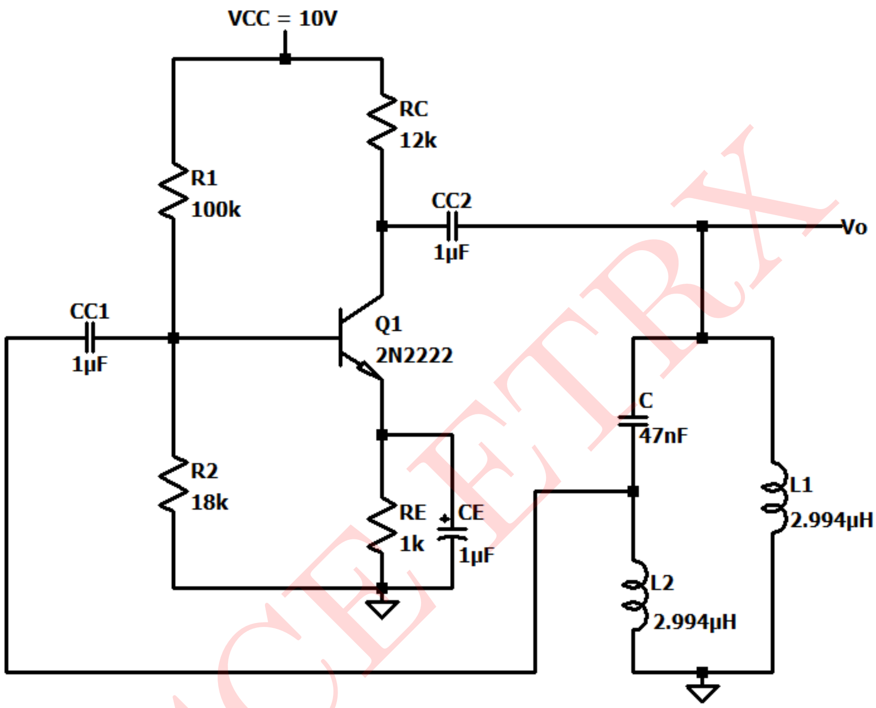

Figure 2: Redrawn circuit 1

Frequency of oscillations,

$$f_o = \frac{1}{2\pi\sqrt{L_{eq}.C}}$$

$$f_o = \frac{1}{2\pi\sqrt{5.988 \times 10^{-6} \times 47 \times 10^{-9}}} = \mathbf{300.006\ kHz}$$

Time period of oscillations,

$$t_o = \frac{1}{f_o}$$

$$t_o = \frac{1}{300.006} = \mathbf{3.3332}\ \boldsymbol{\mu}\mathbf{sec}$$

Feedback fraction,

$$\text{k} = \frac{V_F}{V_o}$$

The voltage developed across L_1 is oscillators output and the voltage develoed across L_2 is the feedback voltage

$$k = \frac{I \times L_2}{I \times L_1} = \frac{X_{L_2}}{X_{L_1}}$$

$$k = \frac{2\pi f_o L_2}{2\pi f_o L_1}$$

$$k = \frac{L_2}{L_1}$$

$$k = \frac{2.994 \times 10^{-6}}{2.994 \times 10^{-6}} = \mathbf{1}$$

Phase shift offered by LC tank circuit is 180°

i.e. between V_{out} and V_F

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

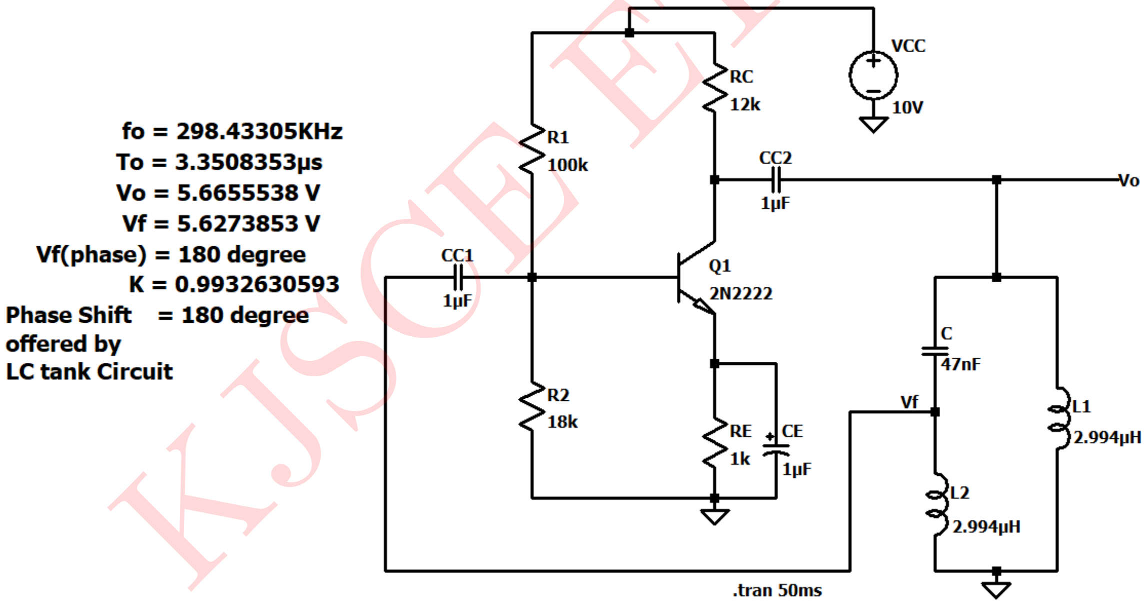

Figure 3: Circuit Schematic 1: Results

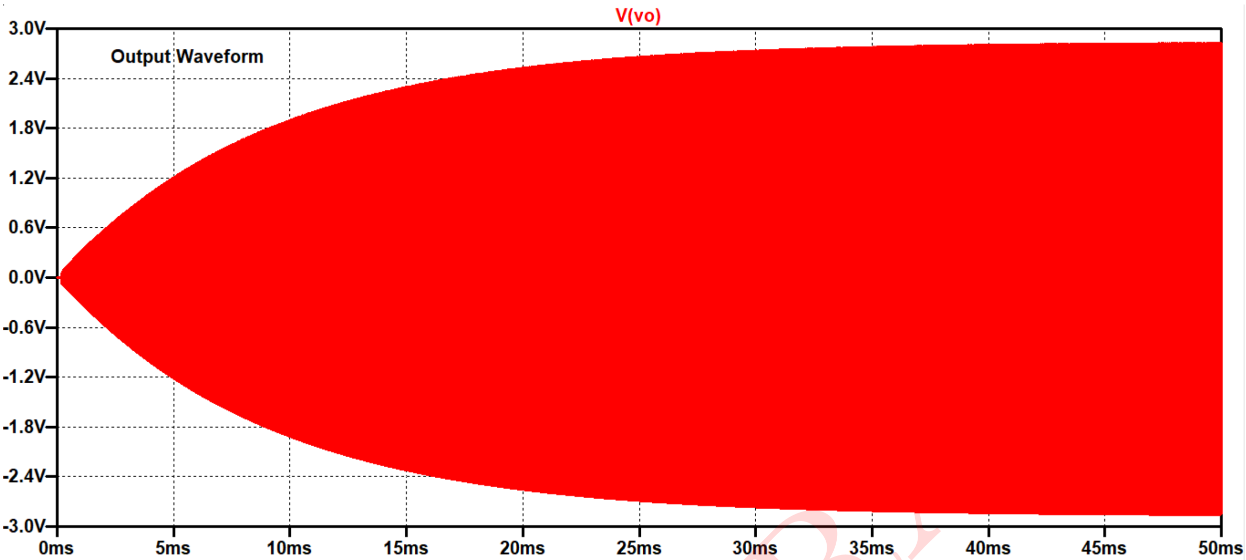

Figure 4: Output waveform for Hartley oscillator

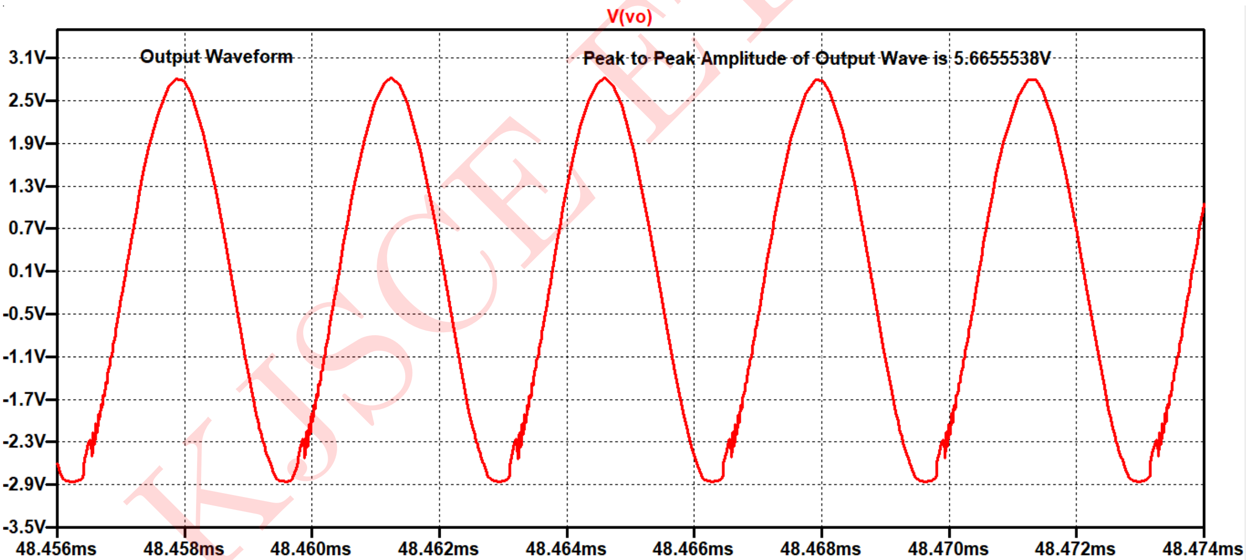

Figure 5: Expanded view of Output waveforms for Hartley oscillator

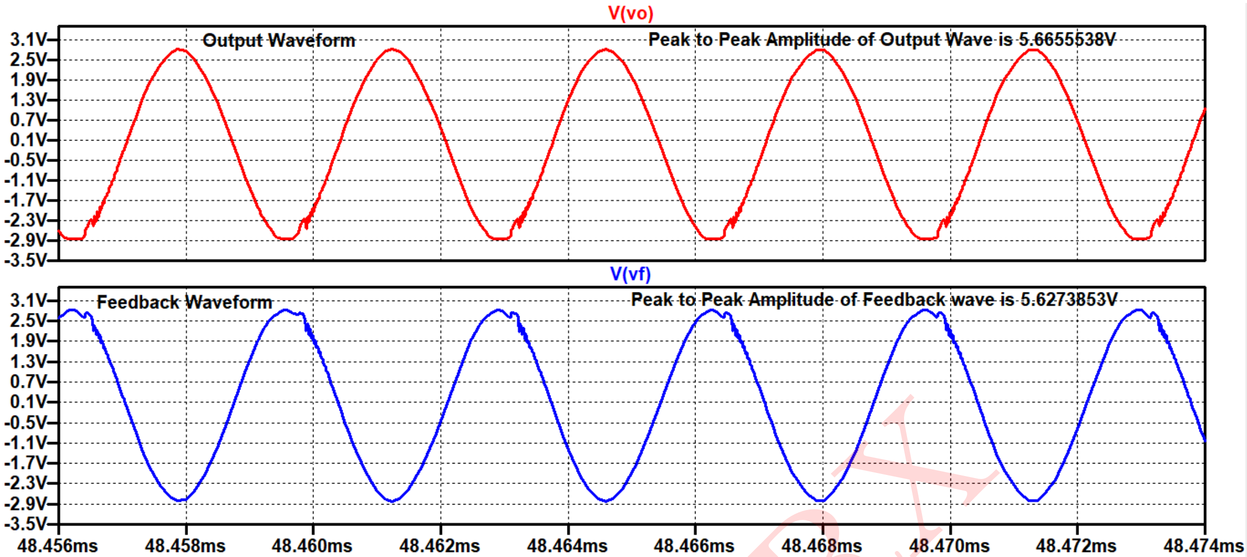

Figure 6: Output & feedback waveform for Hartley oscillator

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
Frequency of oscillation f_o	300.006 kHz	298.4330 kHz
Time period of oscillations	3.3332 μsec	3.3508 μsec
Amplitude of oscillatons	–	5.6655 V
Feedback signal V_F amplitude and phase w.r.t V_{out}	–	5.6273 V, 180°
Feedback Fraction	1	0.9932
Phase shift offered by LC tank	180°	180°

Table 1: Numerical 1

Numerical 2: In a Colpitt's oscillator, amplifier components are $R_1 = 100$ kΩ, $R_2 = 18$ kΩ, $R_C = 12$ kΩ, $R_E = 1$ kΩ, $C_{C_1} = 1$ μF, $C_E = 150$ μF, $C_{C_2} = 1$ μF, $V_{CC} = 10$ V. Select the LC tank circuit elements such that frequency of oscillation is close to 75 kHz. Also find frequency of oscillation after finding LC tank circuit elements, time period of oscillations, feedback fraction and phase shift offered by LC tank circuit.

BJT transistor: 2N2222

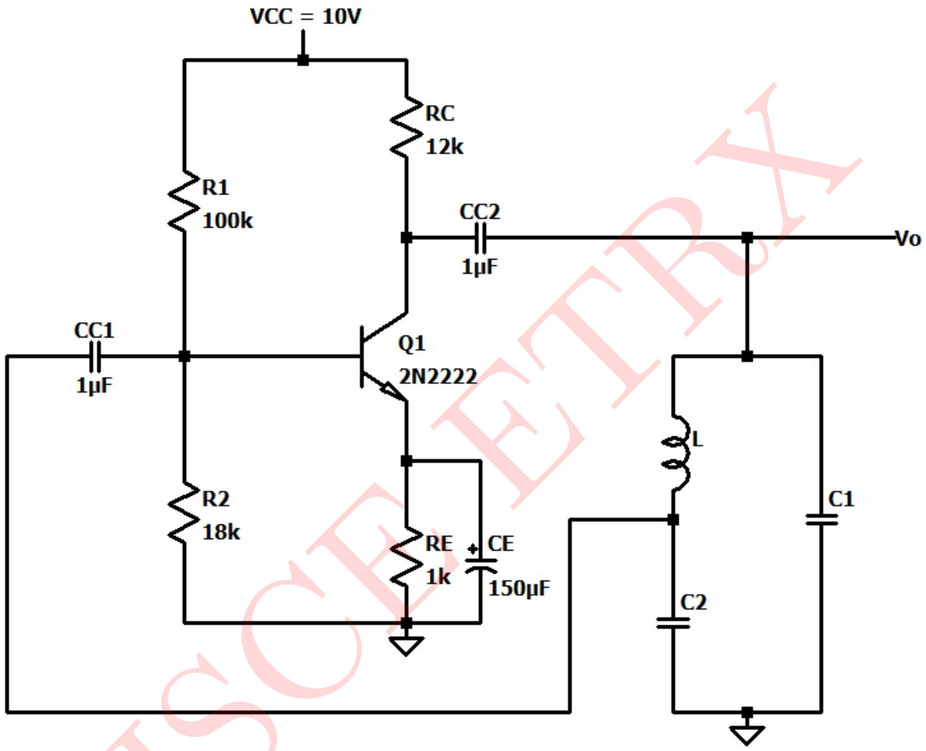

Figure 7: Circuit 2

Solution:

The given circuit 2 is a Colpitt's oscillator.

Frequency of oscillations is given as,

$$f_o = \frac{1}{2\pi\sqrt{\frac{C_1 C_2}{C_1 + C_2} L}}$$

Let, $\frac{C_1 C_2}{C_1 + C_2} = C_{eq}$

$$f_o = \frac{1}{2\pi\sqrt{C_{eq}.L}}$$

Let, L =1 mH

$$75 \times 10^3 = \frac{1}{2\pi\sqrt{1 \times 10^{-3} \times C_{eq}}}$$

C_{eq} = **4.503 nF**

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

Let, $C_1 = C_2$

$$C_{eq} = \frac{C_1 C_1}{C_1 + C_1} = \frac{C_1^2}{2C_1} = \frac{C_1}{2}$$

$$C_{eq} = \frac{C_1}{2} \text{ or } C_{eq} = \frac{C_2}{2}$$

$$C_1 = C_2 = 2C_{eq}$$

$C_1 = C_2 = 2 \times 4.503 \times 10^{-9}$ = **9.006 nF**

Redrawing the oscillator circuit,

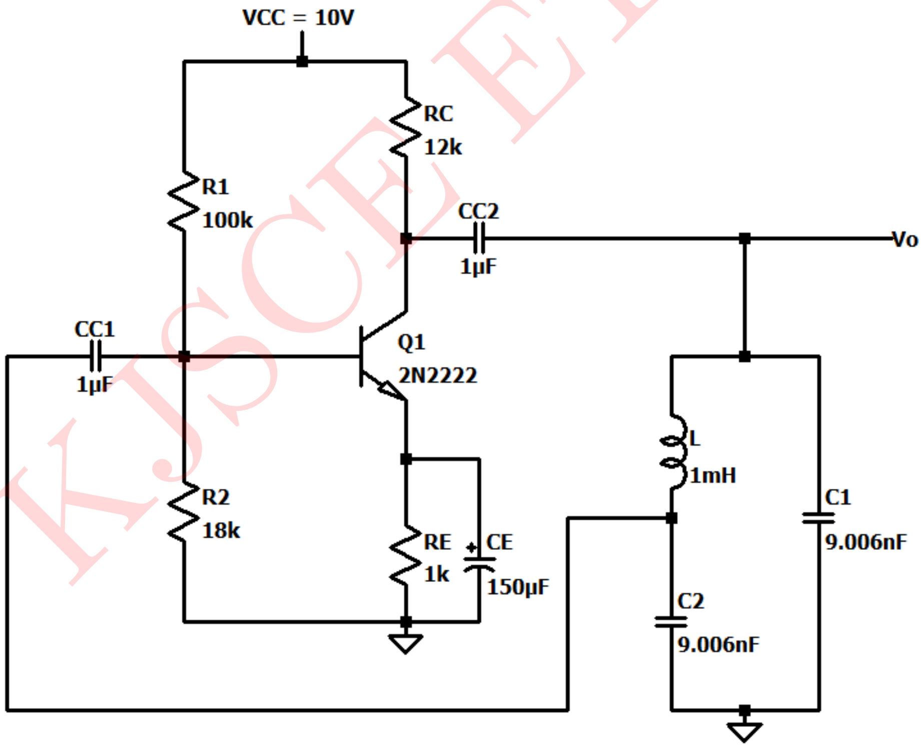

Figure 8: Redrawn circuit 2

Frequency of oscillations,

$$f_o = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

$f_o = \dfrac{1}{2\pi\sqrt{1 \times 10^{-3} \times 4.503 \times 10^{-9}}}$ = **75.001 kHz**

Time period of oscillations,

$$t_o = \frac{1}{f_o}$$

$$t_o = \frac{1}{75.001} = \mathbf{13.333}\ \mu\mathbf{sec}$$

Feedback fraction,

$$\text{k} = \frac{V_F}{V_o}$$

The voltage developed across C_1 is oscillator's output voltage and the voltage developed across C_2 is the feedback voltage

$$\text{k} = \frac{IX_{C_2}}{IX_{C_1}}$$

$$\text{k} = \frac{X_{C_2}}{X_{C_1}}$$

$$\text{k} = \frac{\frac{1}{2}\pi f_o C_2}{\frac{1}{2}\pi f_o C_1}$$

$$\text{k} = \frac{C_1}{C_2} = \frac{9.006 \times 10^{-9}}{9.006 \times 10^{-9}} = \mathbf{1}$$

Phase shift offered by LC tank circuit is 180°

i.e. between V_o and V_F

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

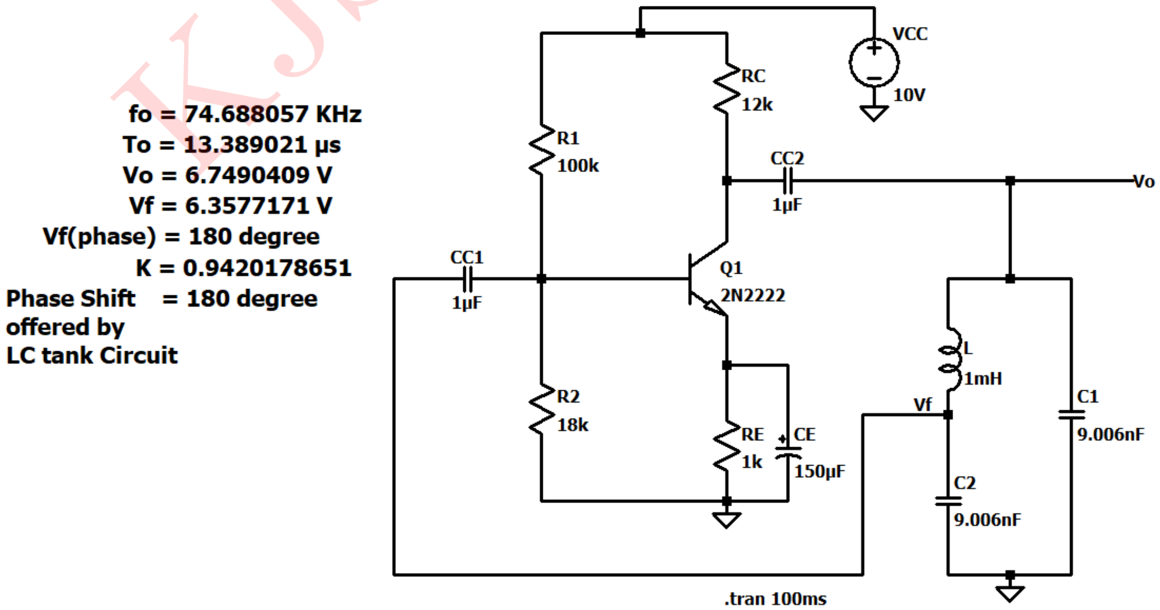

Figure 9: Circuit Schematic 2: Results

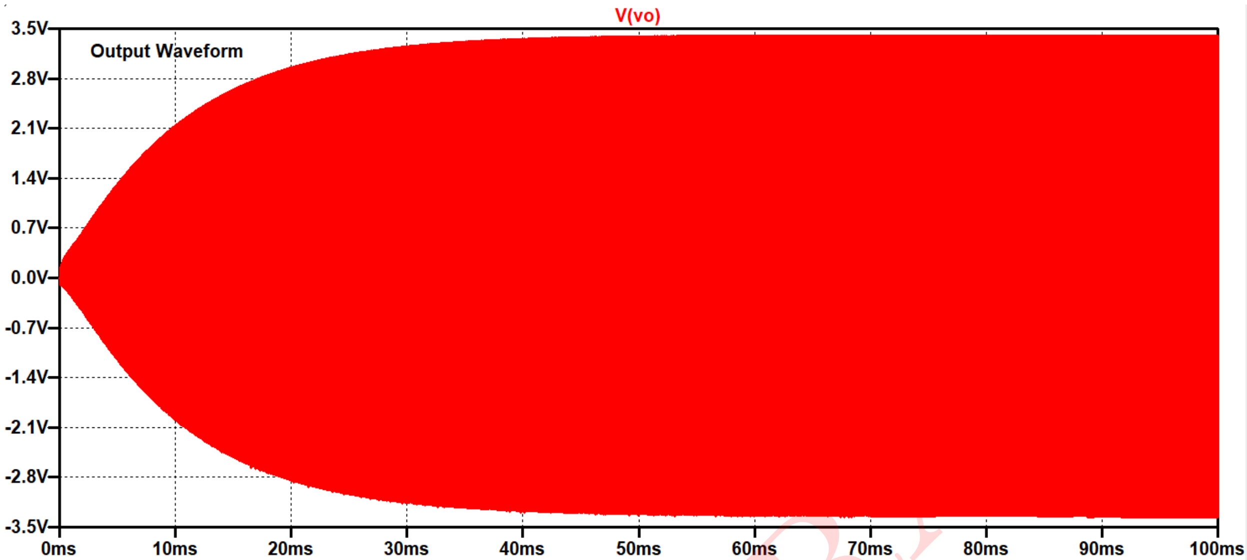

Figure 10: Output waveform for colpitt oscillator

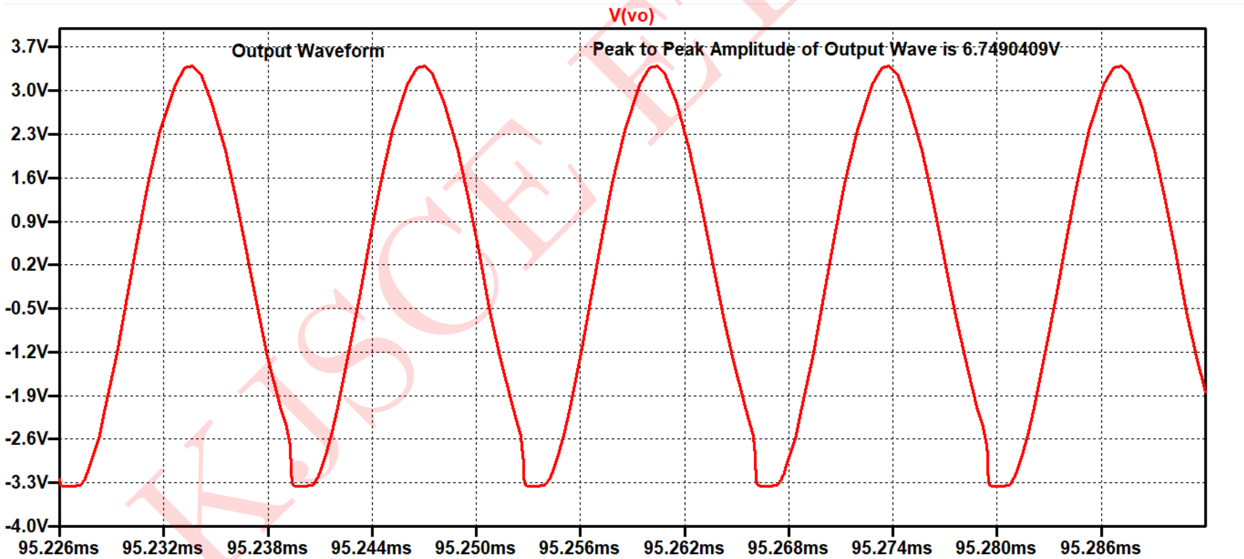

Figure 11: Expanded view of Output waveforms for colpitt oscillator

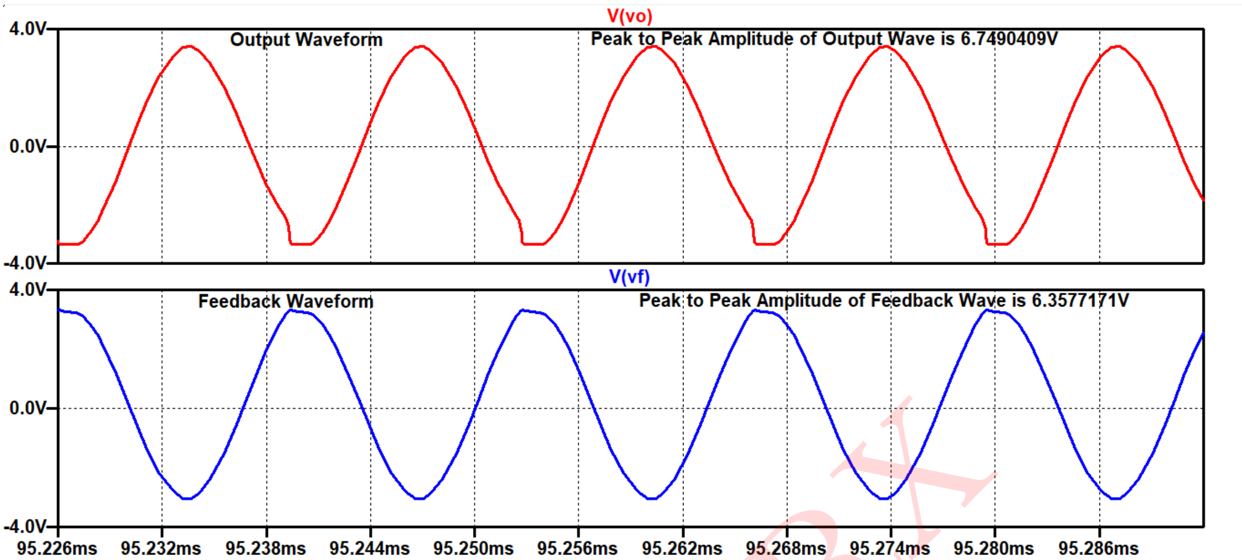

Figure 12: Output & feedback waveform for colpitt oscillator

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
Frequency of oscillation f_o	75.001 kHz	74.6880 kHz
Time period of oscillations	13.333 μsec	13.3809 μsec
Amplitude of oscillatons	–	6.7490 V
Feedback signal V_F amplitude and phase w.r.t V_{out}	–	6.3577 V, 180°
Feedback Fraction	1	0.9420
pase shift offered by LC tank	180°	180°

Table 2: Numerical 2

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