INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY
DELHI

Department
of
Electronics & Communication Engineering

ECE113|Basic Electronics

Lab :4

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Aim: *. Observe the step response of the RLC circuit on LTspice and adjust the parameters so that an
underdamped response of the series RLC circuit is obtained .Observe and trace the response.
* From the traced response, obtain the period of oscillation, time constant and peak overshoot and
compare these values with theoretically calculated values.

* Adjust the parameter values so that a critical response of the series RLC circuit is obtained.
* Compare the critical resistance with theoretically calculated value.
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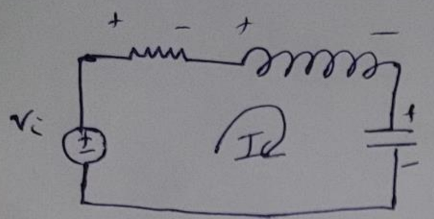
Components: **Resistor, Capacitor, Inductor,wires, Voltage source, ground.**

Software/Tools Used :

- LT Spice

Theoretical Calculation :

Lab-4



$$v_i = Ri + L\frac{di}{dt} + \frac{1}{c} i\int di \quad (1)$$

[Applying laplace transformation
$$\frac{dx}{dt} = \frac{X(s)}{s}$$
]

$$V_i = RI(s) + sLI(s) + \frac{I}{sC}(s) \quad (2)$$

$$V_o(s) = \frac{1}{sC} I(s) \quad — (3)$$

$$(2) \div (3) \Rightarrow \frac{V_o}{V_i} \Rightarrow \frac{1/sC}{R+sL+\frac{1}{sC}} \Rightarrow \frac{1}{s^2LC+RCs+1}$$

$$\simeq \frac{\omega_n^2}{s^2+2\xi\omega_n s+1} \simeq \frac{1/LC}{\frac{s^2LC+RCs+1}{LC}} \simeq \frac{1/LC}{s^2+\frac{R}{L}s+1/LC}$$

$\cancel{\simeq \frac{1}{LC}}$ so, $\omega_n^2 = \frac{1}{LC} \Rightarrow \omega_n = \frac{1}{\sqrt{LC}}$

$2\xi\omega_n = \frac{R}{L} \Rightarrow 2\xi\frac{1}{\sqrt{LC}} = \frac{R}{L}$ [from above $\omega_n = \frac{1}{\sqrt{LC}}$]

$$\xi = \frac{R}{2}\sqrt{\frac{C}{L}}$$

[where ξ is damping ratio]

if $\xi > 1 \longrightarrow$ over damped

$\xi = 1 \longrightarrow$ critically damped

$\xi < 1 \longrightarrow$ underdamped

$\xi = 0 \longrightarrow$ undamped

Case 1) $R = 50\Omega$

$R_{eq} = 50 + 50 = 100\Omega$

$$\xi_e = \frac{100}{2}\sqrt{\frac{6.2\times10^{-8}}{9.6\times10^{-3}}}$$

$\xi_e = 0.126$ so here $\xi_e < 1$

Percentage Peak overshoot

$$\%\ M(p) = \frac{C(t_p) - C_0}{C_0} = \frac{8.32 - 5}{5}$$

$$= 0.664$$

$$M(p)\ \boxed{= 66.4\%}$$

$$\%\ M(p)\ \text{theoretical} = e^{\frac{-n\pi\xi_e}{\sqrt{1-\xi_e^2}}} \times 100$$

$n = 1$ for First peak

$$= e^{\frac{-1\times3.14\times0.126}{\sqrt{1-(0.126)^2}}} \times 100$$

$$= e^{-\frac{0.395}{0.991}} \times 100$$

$$= 0.67$$

$$\simeq 67.1\%$$

Peak time its a time required for the response to reach the peak of the response

$$t_p = \frac{n\pi}{\omega\sqrt{1-\xi^2}} = \frac{1\times3.14}{40989\sqrt{1-(0.126)^2}}$$

$t_p = \cancel{7.9}\ 7.91\ \mu sec$

$T = 2t_p \Rightarrow T = 15.8\ \mu sec$

Time Constant

$$\tau = \frac{2L}{R_{eq}} = \frac{2\times9.6m}{100} = 1.92\times10^{-4}\ sec$$

Case 2: when $\xi = 1$, critical damped condition

$$\frac{R_{eq}}{2}\sqrt{\frac{C}{L}} = 1$$

$$R_{eq} = \frac{2 \times \sqrt{9.6m}}{\sqrt{1.2n}}$$

$$\boxed{R_{eq} = 787.4\Omega}$$

so $R = 787.4 - 50 = 737.4\Omega$

$\% M(P)$ simulation $= \frac{5-5}{5} = 0$

$= 0\%$

$$\% M(P) \text{ Theoretical} = \frac{1}{e^{\frac{-n\pi\xi}{\sqrt{1-\xi^2}}}} \times 100$$

$$= \frac{1}{e^{\infty}} \times 100$$

$$= 0\%$$

Peak time $t(p) = \frac{n\pi}{\omega\sqrt{1-\xi^2}} = \infty$

Time constant $\tau = \frac{2L}{R_{eq}} = \frac{2 \times 9.6 \times 10^{-3}}{787.4} = 2.43 \times 10^{-5}$ sec

Case 3) $R = 200\Omega$, $R_{eq} = 200 + 50 = 250\Omega$

$$\xi = \frac{250}{2}\sqrt{\frac{6.27}{9.6}} = \frac{250}{2}\sqrt{\frac{\times 2.53}{10 \times 100}}$$

$$\xi = 0.31625 \text{ for } \xi \leq 1$$

~~% Peak~~ % M(P) simulated $= \dfrac{6.74 - 5}{5}$

$$\boxed{= 34.8\%}$$

$$\% \text{ M(P) theoretical} = \frac{-n\pi\xi}{e^{\sqrt{1-\xi^2}}} \times 100$$

$$= \frac{-1 \times 3.14 \times 0.316}{e^{\sqrt{1-(0.316)^2}}} \times 100$$

$$= \frac{-0.992}{e^{0.948}} \times 100$$

$$\simeq 35.2\%$$

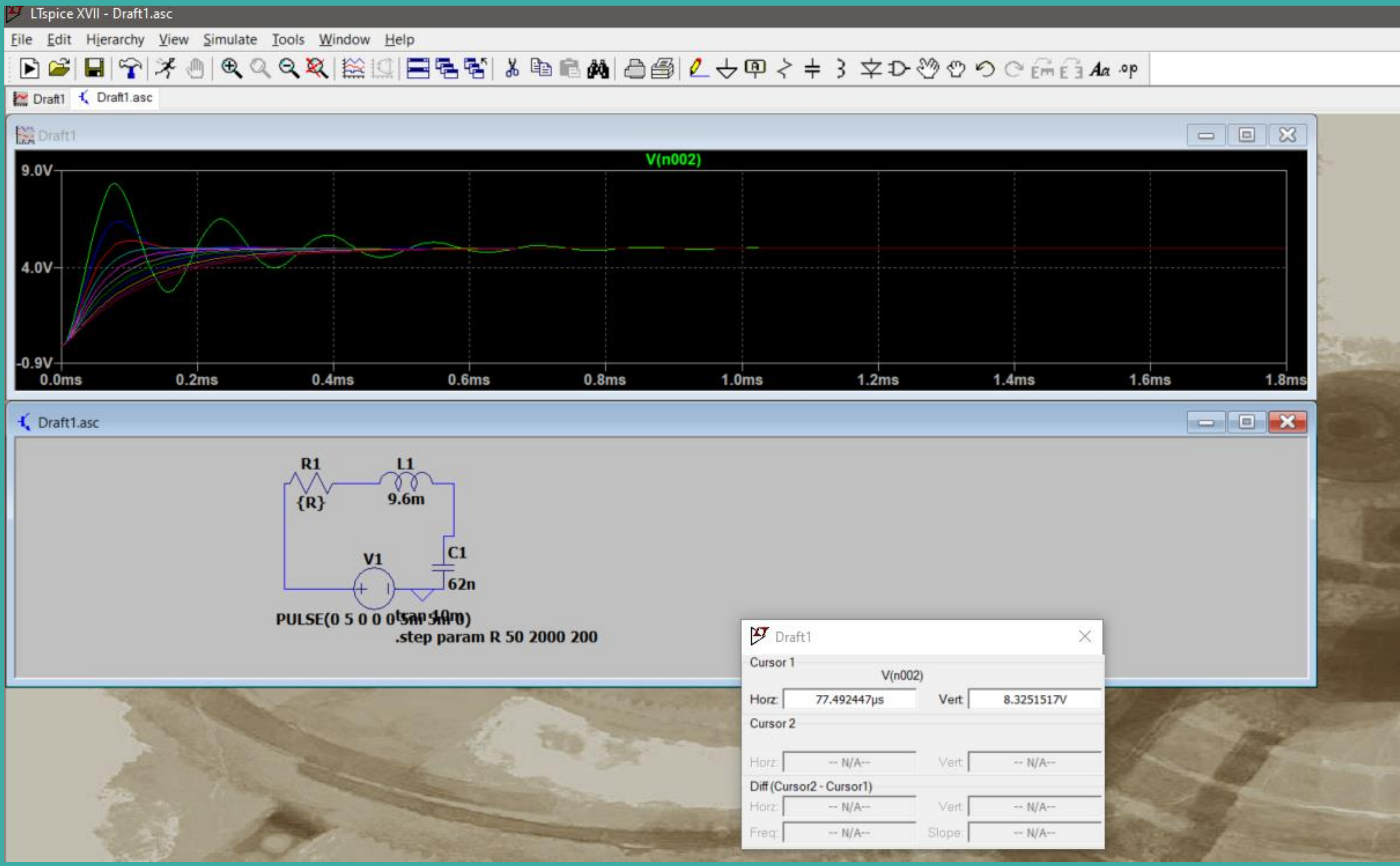
Peak time;

$$t(P) = \frac{n\pi}{\omega\sqrt{1-\xi^2}} = \frac{1 \times 3.14}{40989\sqrt{1-(0.316)^2}} = \frac{3.14}{38857.57}$$

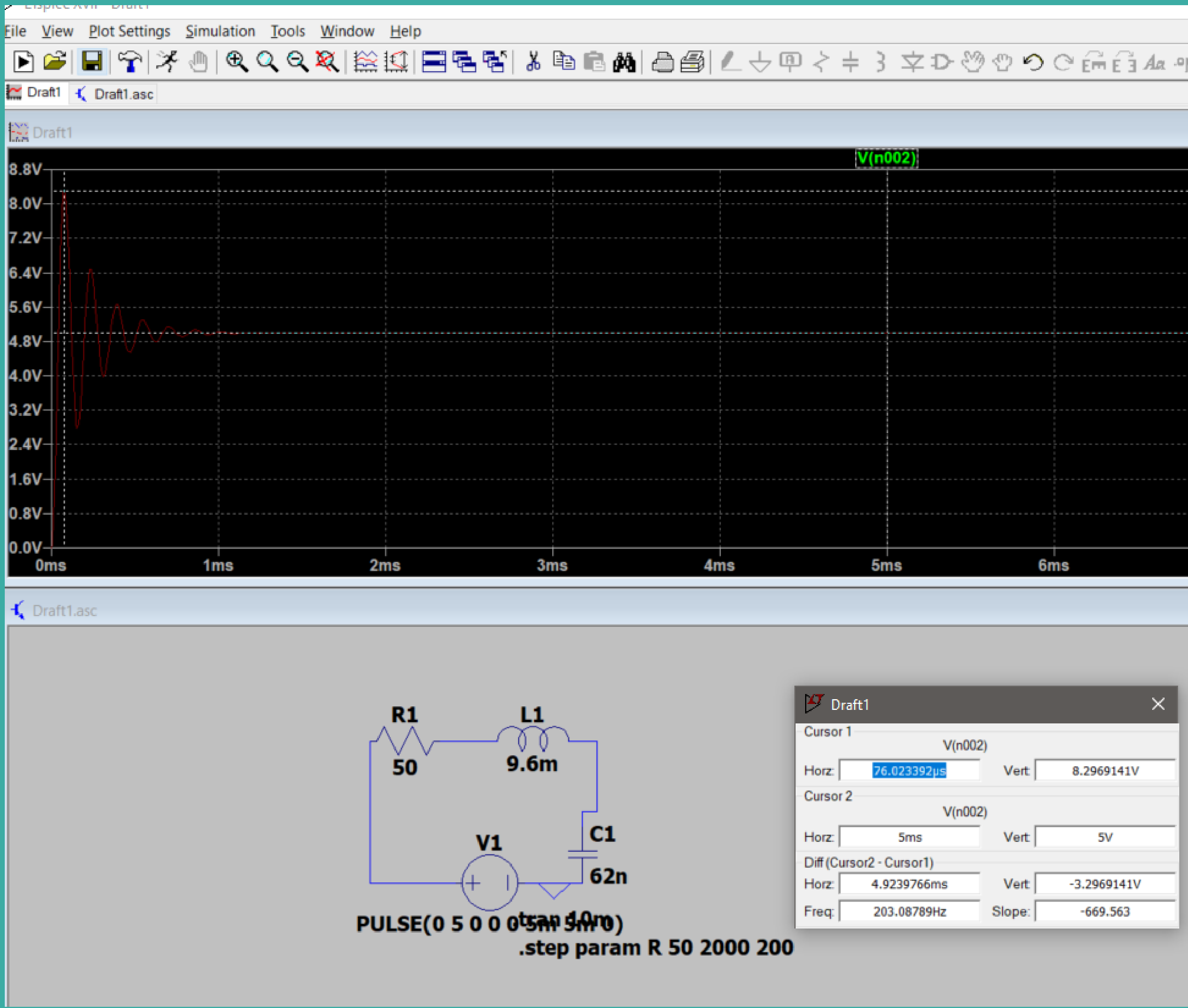
$$\boxed{t(P) \simeq 80.87 \times 10\ \mu s}$$

Time constant $(\tau) = 7.68 \times 10^{-5}$ sec

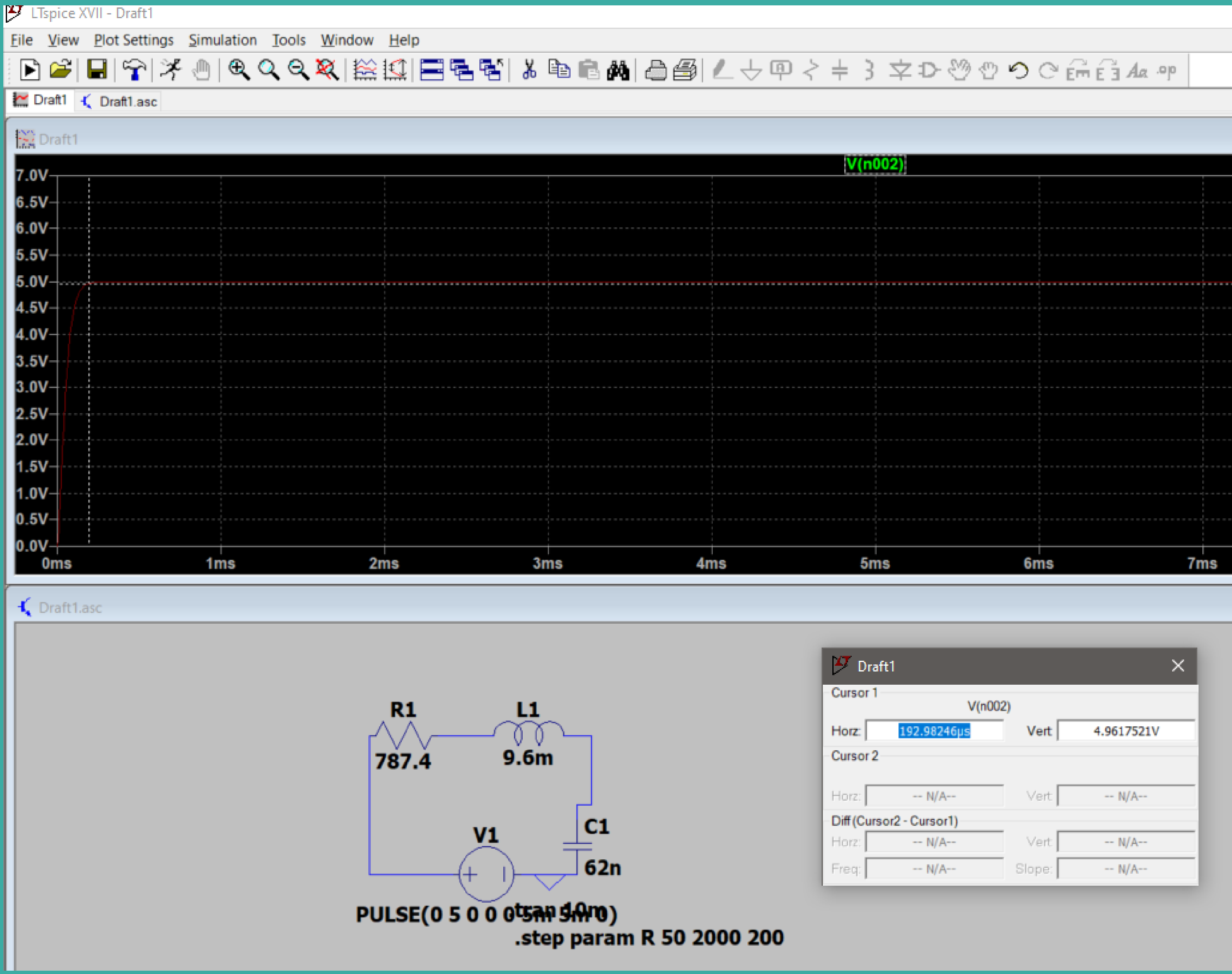
Circuit Diagram and Link:



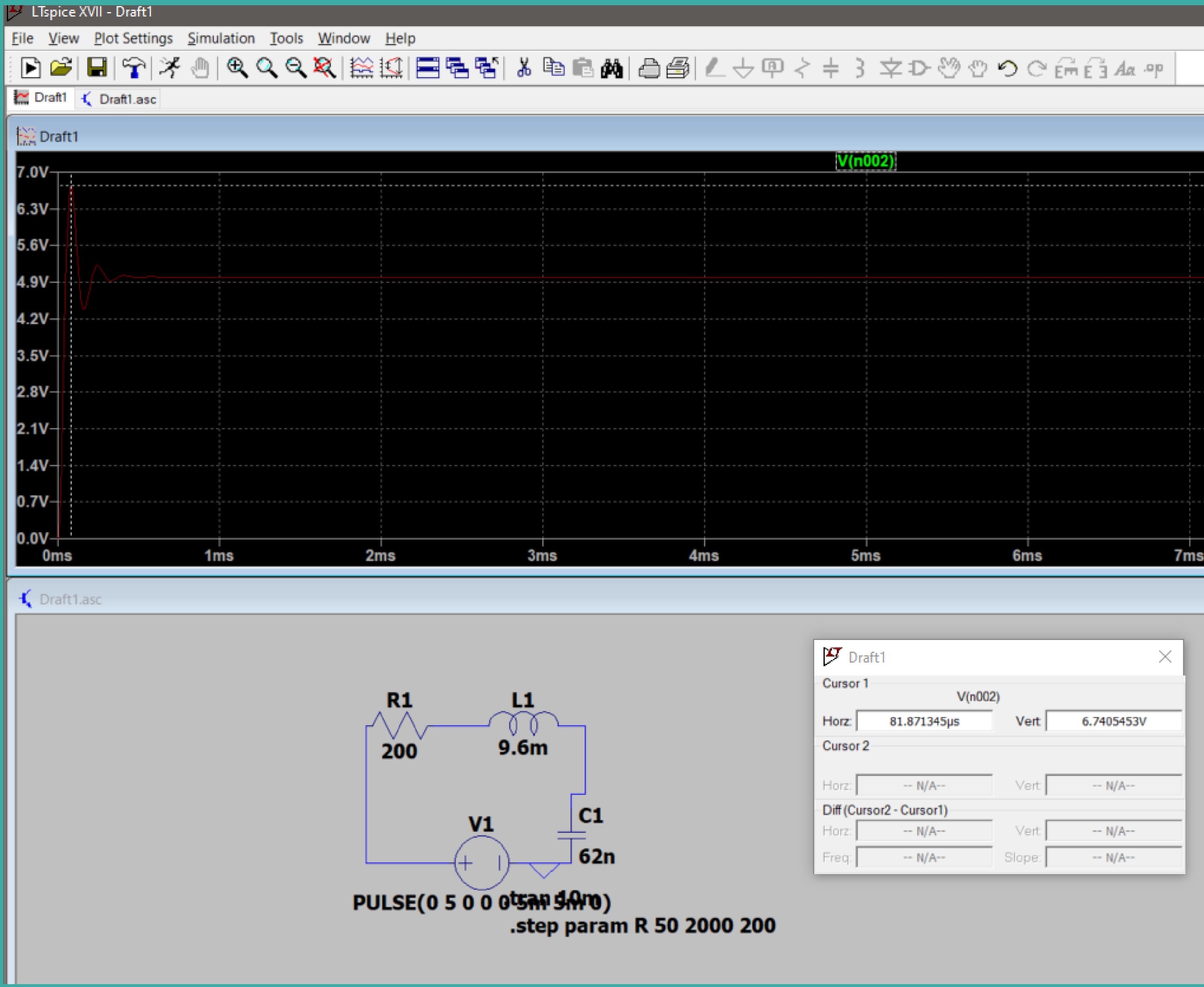
R=50ohm


File View Plot Settings Simulation Tools Window Help
Draft1
Draft1.asc
V(n002)
8.8V
8.0V
7.2V
6.4V
5.6V
4.8V
4.0V
3.2V
2.4V
1.6V
0.8V
0.0V
0ms
1ms
2ms
3ms
4ms
5ms
6ms
R1
50
L1
9.6m
C1
62n
V1
PULSE(0 5 0 0 0 5m 5m 0)
.tran 10m
.step param R 50 2000 200
Cursor 1
V(n002)
Horz: 76.023392µs
Vert: 8.2969141V
Cursor 2
V(n002)
Horz: 5ms
Vert: 5V
Diff (Cursor2 - Cursor1)
Horz: 4.9239766ms
Vert: -3.2969141V
Freq: 203.08789Hz
Slope: -669.563

R= 787.4ohm


LTspice XVII - Draft1
File View Plot Settings Simulation Tools Window Help
Draft1
Draft1.asc
V(n002)
7.0V
6.5V
6.0V
5.5V
5.0V
4.5V
4.0V
3.5V
3.0V
2.5V
2.0V
1.5V
1.0V
0.5V
0.0V
0ms
1ms
2ms
3ms
4ms
5ms
6ms
7ms
R1
787.4
L1
9.6m
C1
62n
V1
PULSE(0 5 0 0 0 5m 5m 0)
.tran 10m
.step param R 50 2000 200
Draft1
Cursor 1
V(n002)
Horz: 192.98246µs
Vert: 4.9617521V
Cursor 2
Horz: -- N/A--
Vert: -- N/A--
Diff (Cursor2 - Cursor1)
Horz: -- N/A--
Vert: -- N/A--
Freq: -- N/A--
Slope: -- N/A--

R= 200ohm



Observations/Results:

After doing observing period of oscillation, time constant and peak overshoot and comparing this value with theoretically calculated values we found they are nearly same

Applications:

- It is used to detect the frequencies of the narrow range in the broad spectrum of radio waves.
- It is used to tune radio frequency of AM/FM radio