<u>PSG COLLEGE OF TECNOLOGY</u>

(AUTONOMOUS INSTITUTION)

COIMBATORE-641 004

TOPIC: RL HIGH PASS FILTER FREQUENCY AND TIME DOMAIN ANALYSIS

BRANCH: ELECTRONICS AND COMMUNICATION ENGINEERING

SUBJECT:CONTROL SYSTEM

SUBJECT CODE:19L504

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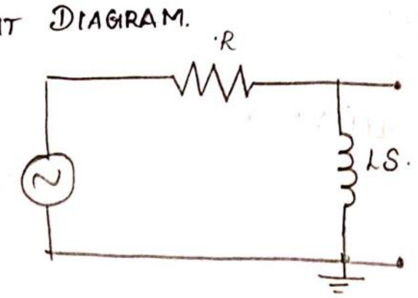
MANUAL CALCULATION:

I MANNUAL CALCULATION:-

(A) Derive the Transfer Function of the Circuit

CIRCUIT DIAGRAM.



Designing RL high pass filter for cut-off frequency 2kHz.

$$f = \frac{R}{2\pi L}$$

Let L = 500mH

R = 6.3 kΩ

$$\frac{R}{L} = 12600$$

By Voltage Divider Rule,

$$V_o = \frac{Ls}{Ls + R} \times V_i$$

$$\frac{V_o}{V_i} = \frac{S}{S + R/L} \Rightarrow \frac{S}{S + 12600}$$

(B) IMPULSE RESPONSE OF THE SYSTEM.

$$\frac{Y(S)}{X(S)} = \frac{S}{S + 12600}$$

$$H(S) = \frac{S}{S + 12600}$$

$$\frac{S}{S + 12600} = A + \frac{B}{S + 12600}$$

$$L^{-1}(H(S)) = L^{-1}\left(1 - \frac{12600}{S + 12600}\right)$$

$$= \delta(t) - 12600\, e^{-12600t}\, u(t)$$

(c) Output of the system for some standard input

Let the standard input be unit step response,

$Y(s) = X(s) \times$ Transfer function,

$$Y(s) = \frac{1}{S} \times \frac{S}{S + 12600}$$

$$= \frac{1}{S + 12600}$$

$$y(t) = e^{-R/L\, t}$$

$$= e^{-12600t} \cdot u(t)$$

$$y(t) = \begin{cases} e^{-12600t}, & u(t) > 0 \\ 0, & \text{otherwise} \end{cases}$$

D Analyse the stability of the system by RH Criterion:-

Transfer function $= \frac{S}{S + 12600}$

No. of poles $= 1$

No. of zeros $= 0$

Poles

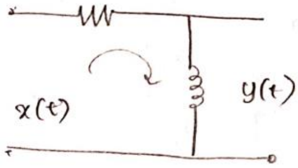
$S = -12600$, (pole lies in the LHS, so the system is stable

$$\left.\begin{array}{ll} S^1 : & 1 \\ S^0 : & 12600 \end{array}\right\} \text{no sign change}$$

(E) Perform Time response analysis of the System.

Transfer Function $= \frac{S}{S+12600}$.

$$T(S) = \frac{S}{S+R/L} = \frac{S}{S+\frac{1}{T}}$$



Applying KVL

$$x(t) = Ri(t) + y(t).$$

$$i(t) = \frac{1}{L}\int y(t)\,dt$$

differential Equation for 1st order System $\Longrightarrow$ $x(t) = \frac{R}{L}\int y(t)\,dt + y(t)$

taking Laplace Transform

$$X(S) = \frac{R}{LS}Y(S) + Y(S)$$

$$\frac{Y(S)}{X(S)} = \frac{LS}{LS+R} \Rightarrow \frac{S}{S+R/L} \Rightarrow \frac{S}{S+12600}$$

$$\boxed{G(S) = \frac{S}{12600}.}$$

(i) Unit step response of 1st order System:

$$T(S) = \frac{C(S)}{R(S)} = \frac{S}{S+12600}.$$

Input is $r(t) = u(t)$.

Laplace transform $(r(t)) = \frac{1}{S} = R(S)$

$$C(S) = R(S) \times \frac{S}{S+12600}.$$

$$C(S) = \frac{1}{S} \times \frac{S}{S+12600}.$$

$$\Rightarrow \frac{1}{S+12600} =$$

taking Inverse Laplace Transform,

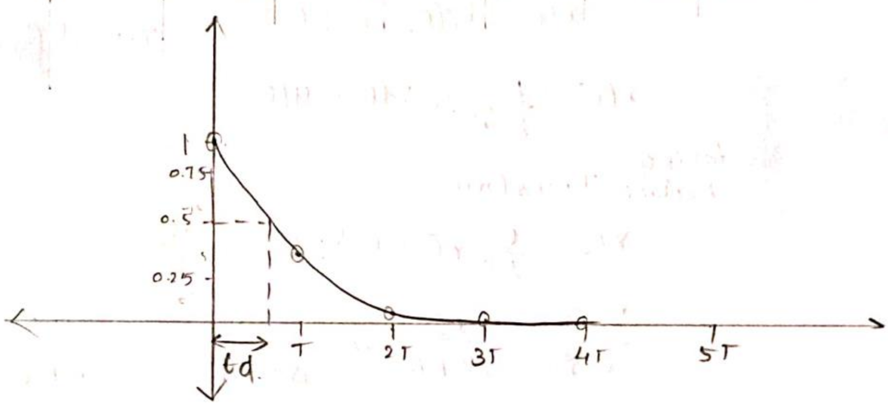
$$\boxed{c(t) = e^{-12600t}\,u(t)} = \begin{cases} e^{-12600t}, & u(t) > 0 \\ 0, & \text{otherwise.} \end{cases}$$

$C_{ss}(t) = 0.$ $\quad C_{tr} = e^{-12600t}$

$$\boxed{C(t) = e^{-12600t}} = e^{-R/L\, t} = e^{-1/(R/L)\, t} = e^{-t/T}$$

For $t > 0$.

t	0	T	$2T$	$3T$	$4T$	$5T$	
$C(t)$	1	0.367	0.135	0.049	0.0183	0.006	



t_d (delay time)

$C(t) = 0.5$

$0.5 = e^{-12600t}$

~~-0.301~~

$-0.693 = -12600\, t$

$0.055\ ms = t_d.$

$$t_d = 0.055\ ms.$$

Time constant T,

At $t = T$, $C(t) = e^{-1} = 0.367.$

(2) UNIT RAMP RESPONSE OF THE FIRST ORDER SYSTEM.

When input is unit ramp function,

$$r(t) = t\,u(t)$$

$$R(s) = \frac{1}{s^2}$$

$$C(s) = R(s) \times \frac{s}{s + R/L}$$

$$= \cancel{R(s)} \times \frac{1}{s(s + R/L)}$$

$$= \frac{1}{s(s+R/L)} = \frac{A}{s} + \frac{B}{s + R/L}$$

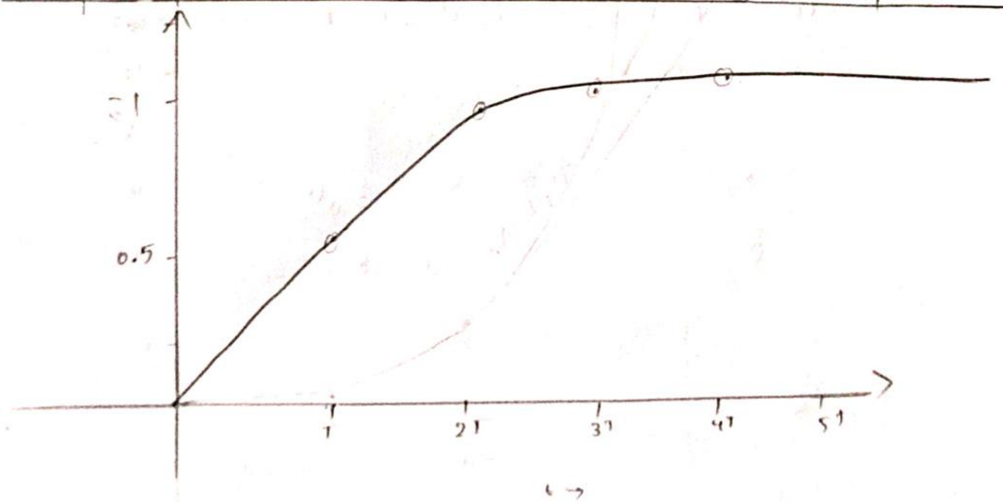
$$= \frac{L}{R}\left(\frac{1}{s}\right) + -\frac{L}{R}\left(\frac{1}{s + R/L}\right)$$

$$L^{-1} \quad = \frac{L}{R}\,u(t) - \frac{L}{R}\,e^{-R/L\,t}\,u(t)$$

$$= T - Te^{-t/T}$$

$$\boxed{c(t) = T\left(1 - e^{-t/T}\right)} \quad \text{for } u(t) > 0.$$

t	0	T	2T	3T	4T	5T	6T	7T
c(t)	0	~~1.11T~~ 0.632T	~~6.369T~~ 0.86 T	~~-19.08T~~ 0.95 T	~~-53.5T~~ 0.981T	~~-147.413T~~ 0.99T	0.99 T	0.99 T



Unit parabolic response of first order System:-

$$r(t) = \frac{t^2}{2}u(t)$$

$$R(s) = \frac{1}{s^3}.$$

$$C(s) = \frac{1}{s^{\cancel{3}2}} \times \frac{\cancel{s}}{s + R/L}.$$

$$= \frac{1}{s^2(s+R/L)} = \frac{A}{s^2} + \frac{B}{s} + \frac{C}{s+R/L}$$

After solving we get,

$$A = T, \quad B = -T^2, \quad C = T^2.$$

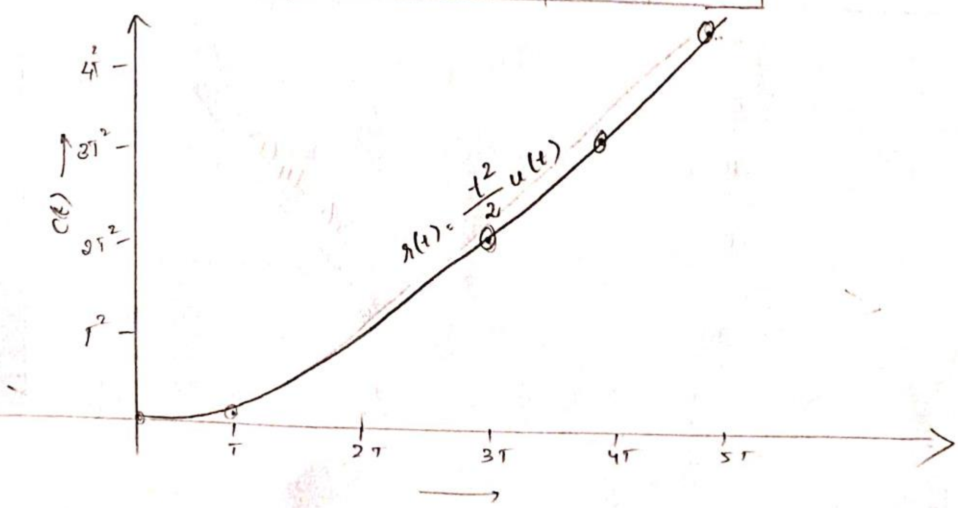
$$C(s) = T\left(\frac{1}{s^2}\right) - T^2\left(\frac{1}{s}\right) + T^2\left(\frac{1}{s+R/L}\right)$$

$$= T\, r(t) - T^2 u(t) + T^2 e^{-t/T} u(t)$$

$$= T \times t u(t) - T^2 u(t) + T^2 e^{-t/T} u(t)$$

$$\boxed{c(t) = \left(tT - T^2 + T^2 e^{-t/T}\right)} \text{ for } u(t) > 0.$$

t	0	T	$2T$	$3T$	$4T$	$5T$
$c(t)$	0.	$0.36T^2$	$1.135T^2$	$2.049T^2$	$3.018T^2$	$4.006T^2$.



(ii) Unit Impulse response, $r(t) = \delta(t)$ $\quad R(s) = 1$

$$C(s) = \frac{s}{s + R/L}$$

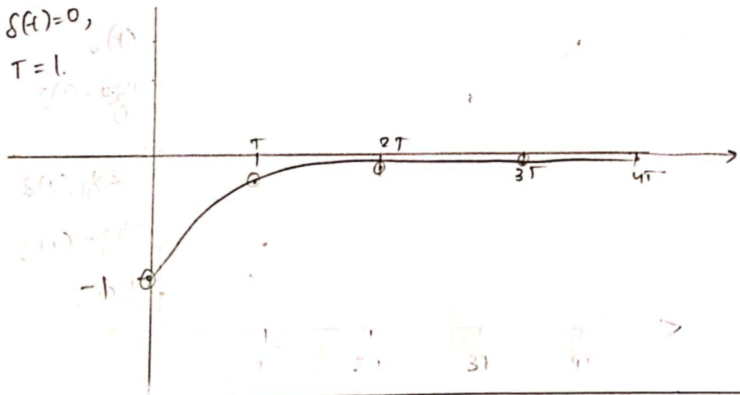
$$C(t) = L^{-1}\left(\frac{s}{s + R/L}\right)$$

$$= \delta(t) - \frac{R}{L} e^{-R/L\, t}$$

$$\boxed{C(t) = \delta(t) - \frac{1}{T} e^{-t/T}}$$

t	0	T	2T	3T	4T
c(t)	$\delta(t) - \frac{1}{T}$	$\delta(t) - \frac{0.367}{T}$	$\delta(t) - \frac{0.135}{T}$	$\delta(t) - \frac{0.049}{T}$	$\delta(t) - \frac{0.018}{T}$

If $\delta(t) = 0$,
$T = 1$.

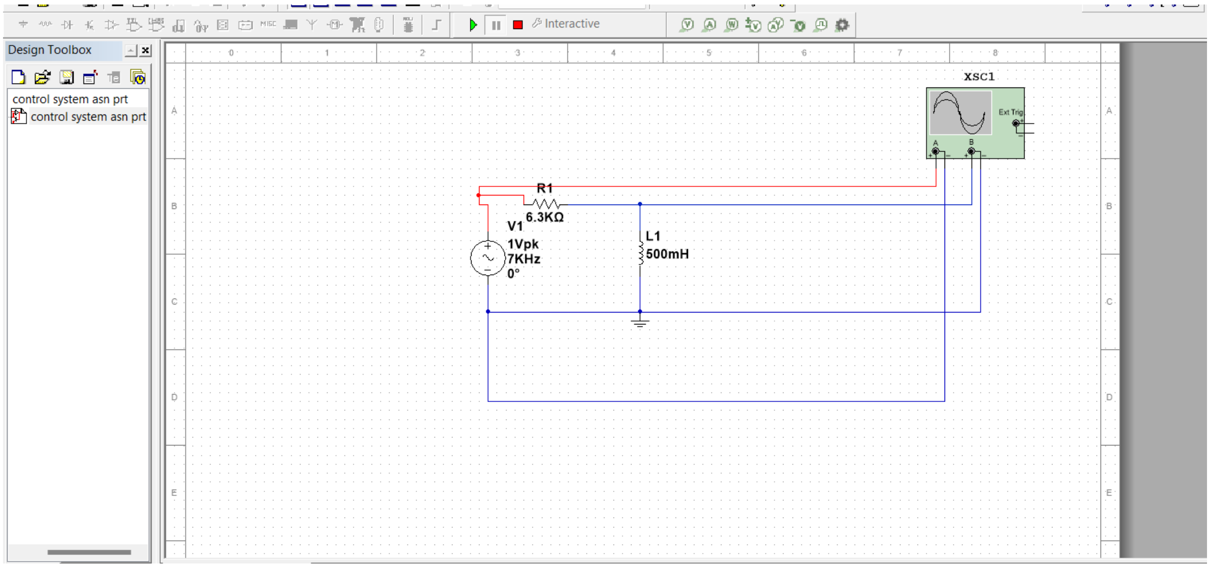


r(t)	c(t)
Unit step, : $u(t)$	$e^{-t/T}$
Unit ramp : $tu(t)$	$T(1 - e^{t/T})$
Unit parabola : $\frac{t^2}{2}u(t)$	$tT - T^2 + T^2 e^{-t/T}$
Unit Impulse : $\delta(t)$	$\delta(t) - \frac{1}{T} e^{-t/T}$

SIMULATION OF THE CIRCUIT:

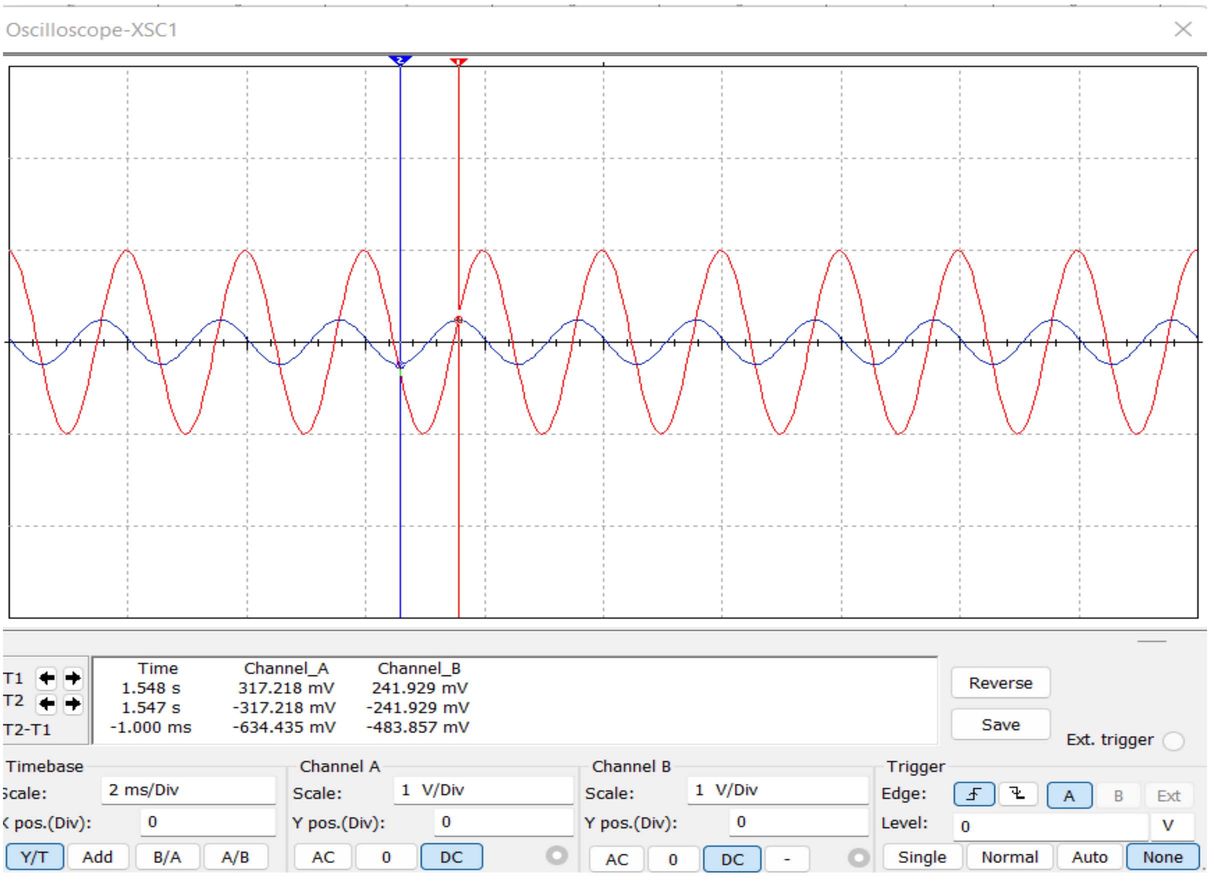
SOFTWARE USED:MULTISIM:

CUT-OFF FREQUENCY=2KHZ



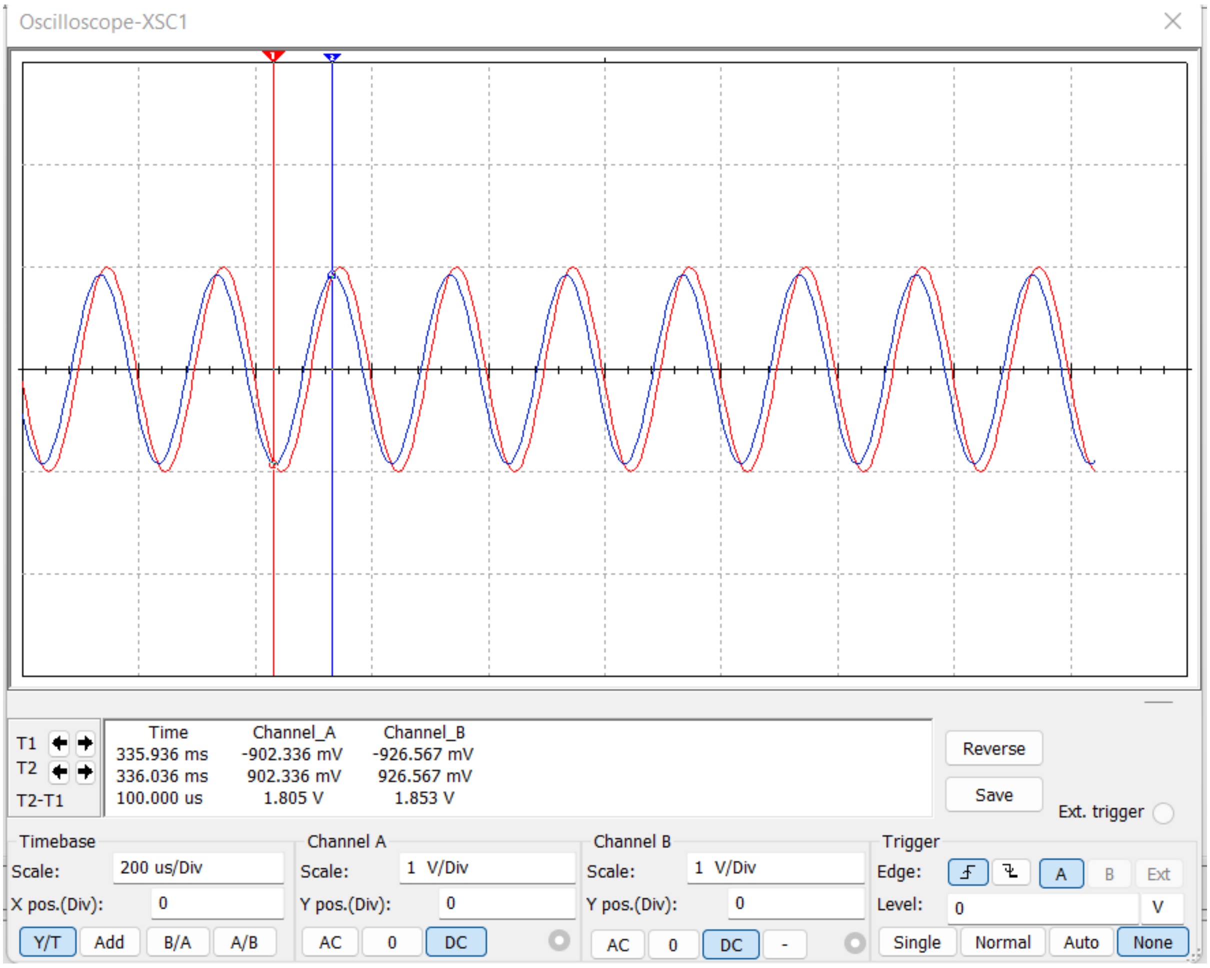
WHEN FREQUENCY <2KHZ

VOUT(P-P)=0.48V VIN(P-P)=2V



WHWN FREQUENCY >2KHZ

VOUT(P-P)= 1.85V VIN(P-P)= 2V



MATLAB IMPLEMENTATION:

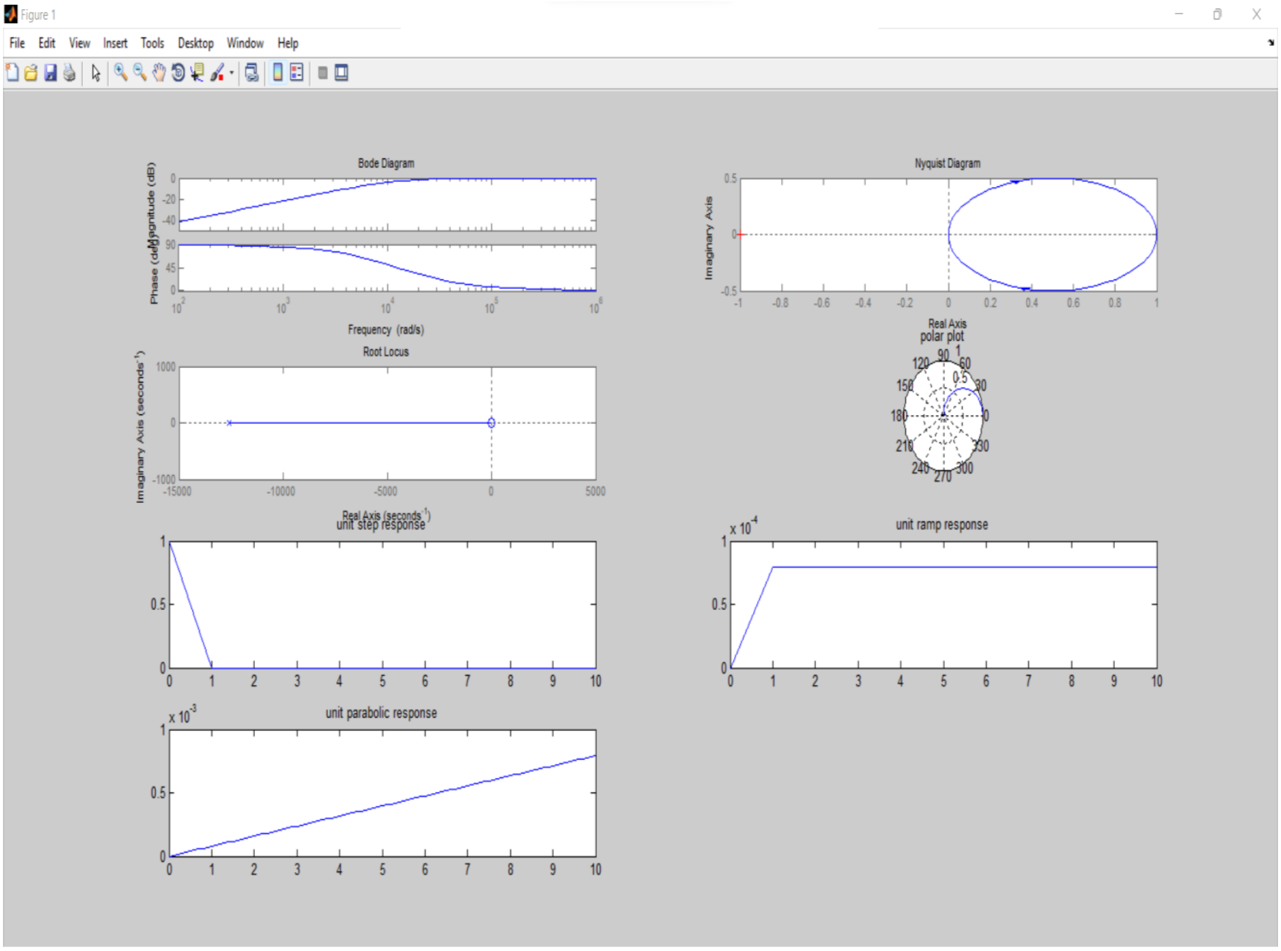
Code:

```
l=tf([1,0],[1,12600]);%defining transfer function
subplot(421);
bode(l);      %bode plot
subplot(422);
nyquist(l);  %nyquist plot
subplot(423);
rlocus(l);  %root locus
[a,b]=bode(l)
b=b(1,:);
a=a(1,:);
subplot(424); %polar plot
polar(b*pi/180,a);
title('polar plot');

disp(l);
%time response analysis
R=6300;
L=0.5;
T=L/R;
%unit step function
c=1;s=[];
for t=0:1:10
    s(c)=exp(-t*(1/T));
    c=c+1;
end
t=0:1:10;
subplot(425);
plot(t,s);
title('unit step response');
%unit ramp
c=1;s=[];
for t=0:1:10
    s(c)=T*(1-exp(-t*(1/T)));
    c=c+1;
end
t=0:1:10;
subplot(426);
plot(t,s);
title('unit ramp response');

%unit parabolic
c=1;s=[];
for t=0:0.1:10
    s(c)=t*T-(T*T)+((T*T)*exp(-t*(1/T)));
    c=c+1;
end
t=0:0.1:10;
subplot(427);
plot(t,s);
title('unit parabolic response');
```

OUTPUT:



The system is stable.

CONCLUSION:

Thus time response analysis and frequency response analysis for RL high pass filter is been done and polar,Nyquist ,bode and time response plots have been done using matlab.