ECE 41 FALL 05 COURSE PAGE

Classes T, R 4:00 - 5:15pm B-525, Recitations W 2:00 - 2:50pm B-426
Instructor: **Dr. Reed**, email: **Gregory.Reed@meppi.com**, office hours: T 5:15-6:00pm B-330
TA : **Narayan K**rishnamurthy, email: **nak54@pitt.edu**, office hours W 3:00 - 4:00pm B-1121C
There will be weekly recitations and homeworks for this course.
Homeworks will be assigned on Tuesday's and are due the following Thursday in Krishnamurthy's mailbox, in Room 340
Late submissions will incur 10% deduction.

NOTE: There is a change in the mailbox location, its in Sandy's room Benedum 340.

Home work

HW1: 10.3.1,3.3,3.4, 10.4.1,4.3, 10.5.1,5.3,5.4,5.5,5.6	due on 9/8 hw1 solution
HW2: 10.6.1,6.2, 10.7.2,7.4,7.6 10.8.1,8.2,8.3,8.4	due on 9/15 hw2 solution
HW3: 10.9.1,9.2,9.3,9.4,9.5,9.6,9.8 10.10.1,10.2	due on 9/22 hw3 solution
HW4: 10.10.3,10.4,10.8,10.9,10.11 10.11.1,11.3,11.4,11.5	due on 9/29 hw4 solution
HW5: 10.12.1,12.3, 10.13.1,13.3 13.3.1,3.2,3.4,3.5,3.14	due on 10/13 hw5 solution
HW6: 13.4.1,4.3,4.5,4.7,4.9 NOTE THERE IS A CORRECTION IN PBLM 13.4.5	due on 10/20 hw6 solution
HW7: 11.3.1,3.2,3.3,3.4,3.5 11.4.1,4.3,4.5	due on 10/27 hw7 solution
HW8: 11.5.1,5.2,5.3,5.5,5.7,5.8 11.6.2,6.4,6.5,6.9	due on 11/3 hw8 solution
HW9: 12.3.1,3.2, 12.4.1,4.2,4.4,4.6, 12.5.1, 12.6.1,6.3	due on 11/10 hw9 solution
HW10: 14.3.1,3.3,3.4 14.4.1,4.3,4.5 14.5.1,5.2,5.4,5.5	due on 12/1 hw10 solution
HW11: 14.6.1,6.2,6.3 14.7.1,7.3,7.5 14.8.2 14.9.3	due on 12/8 hw11 solution
HW12: 15.3.1,3.2,3.3 15.4.2,4.6	hw12 solution

Recitation

Exercise 10.3.2 Problems 10.3.2,3.6	recitation 1
Exercise 10.4.1,4.2, 10.5.1,5.2, 10.6.1,6.2,6.4 Problems 10.4.2, 10.5.7	recitation 2
Exercise 10.9.1, 9.2 Problems 10.8.5 10.9.7	recitation 3
Superposition, Thevenin Equivalent Ckt, Mesh Analysis; pblms 1 &3 on 9/21/05, to do pblms 2 and 4 on 9/28	recitation 4
Review Chapter 10 : Phasors, Mesh Analysis, Source Transformation, Impedences in series and parallel	recitation 5
Network Function, Bode Plot	recitation 6
Bode Plot Lecture notes 10/13	lecture_notes
Instantaneous Power, Effective Voltage, Average Power 10/26	recitation 7
Power factor, Complex Power 11/2	recitation 8
Laplace Transform, PFE Inv LT-repeated real roots, Time differentiation, time/frequency shifting, Initial & Final value theorem examples 11/15	lecture notes
Laplace Transform contd, PFE Inv LT-Complex roots, solving differential equations - response of circuits	recitation 9
HAVE A GOOD FINALS WEEK, IT WAS NICE BEING YOUR TA, THIS SEMS	THANK YOU

Bode Plot

My Lecture Notes 10/13/05.
To Dr Reed.
~ Narayanan

(1)

- Quick and dirty frequency response.
- Why do we use Log scale?
  - Compresses, meaningfully depict very small
    Say $0.0001 \xrightarrow{\log_{10}} -4$

    and very large values
    Say $10000 \xrightarrow{\log_{10}} 4$

What is $|H(\omega)| = 5$ correspond to in dB

$$20\log\left(\frac{10}{2}\right) = 20\log 10 + 20\log \tfrac{1}{2}$$
$$= 20 - 6$$
$$= 14\text{ db}.$$

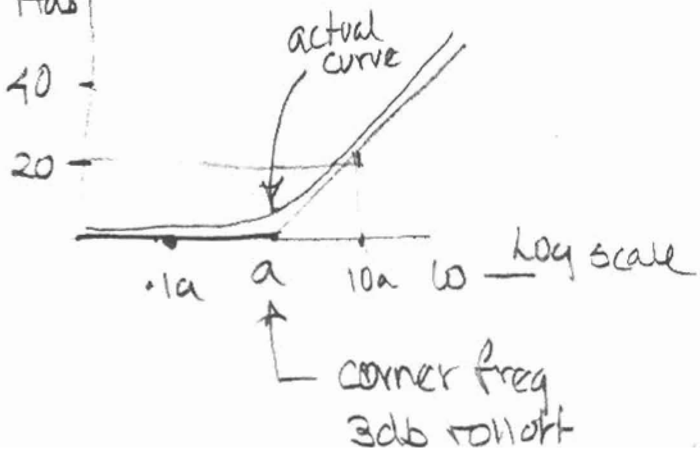
$\lvert H(j\omega)\rvert$	$20\log\lvert H(j\omega)\rvert$
1	0
2	6dB
3	9.54dB
10	20 dB
$\frac{1}{2}$	-6 dB
$\frac{1}{\sqrt{2}}$	-3dB
$\sqrt{2}$	3dB
0.1	-20 dB

Determining Asymptodes of poles and zeros

(1) Single Zero @ $s=a$

$$H(s) = 1 + \frac{s}{a} = 1 + \frac{j\omega}{a}$$

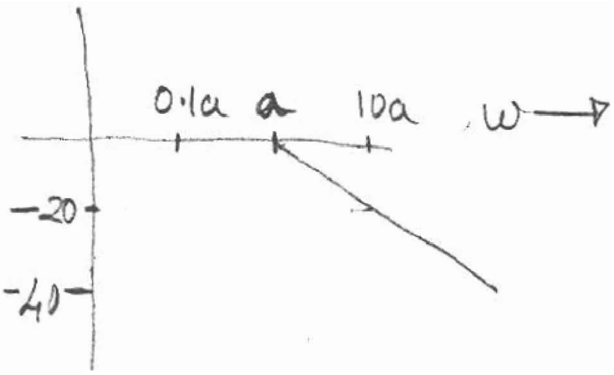
$$|H(s)| = \sqrt{1 + \frac{\omega^2}{a^2}}$$



(2) Single pole @ $s=a$

$$H(s) = \frac{1}{1+\frac{s}{a}} = \frac{1}{1+\frac{j\omega}{a}}$$

$$|H(s)| = \frac{1}{\sqrt{1+\left(\frac{\omega}{a}\right)^2}}$$



Eq

DC offset in freq response

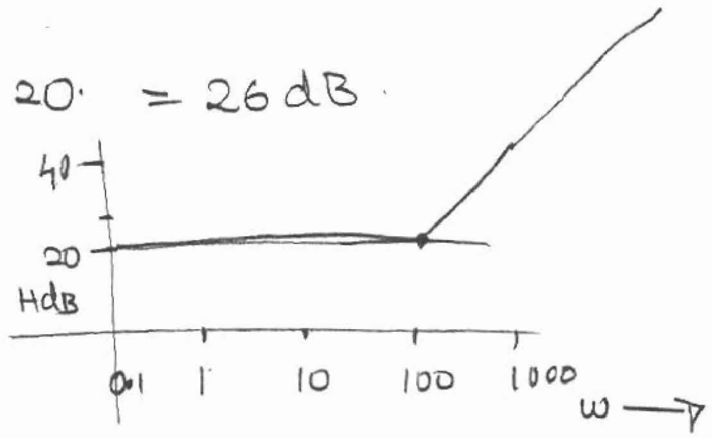
Consider

$$H(s) = 20\left(1+\frac{s}{100}\right)$$

DC offset

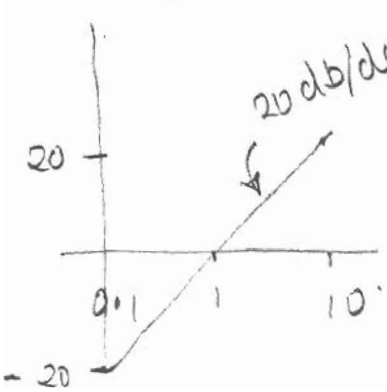
$$20\log H(0) = 20\log 20 = 26\,dB$$

or (0.1) as the case may Be

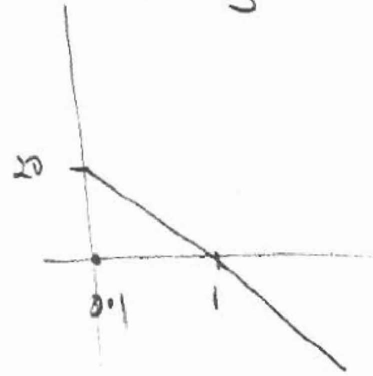


How would the assymptodes look for

$H(s) = s$



$H(s) = \frac{1}{s}$



When poles and zero's are complex conjugate pairs:

$$H(s) = 1 + 2\xi\left(\frac{s}{\omega_0}\right) + \left(\frac{s}{\omega_0}\right)^2 \qquad 0 < \xi < 1$$

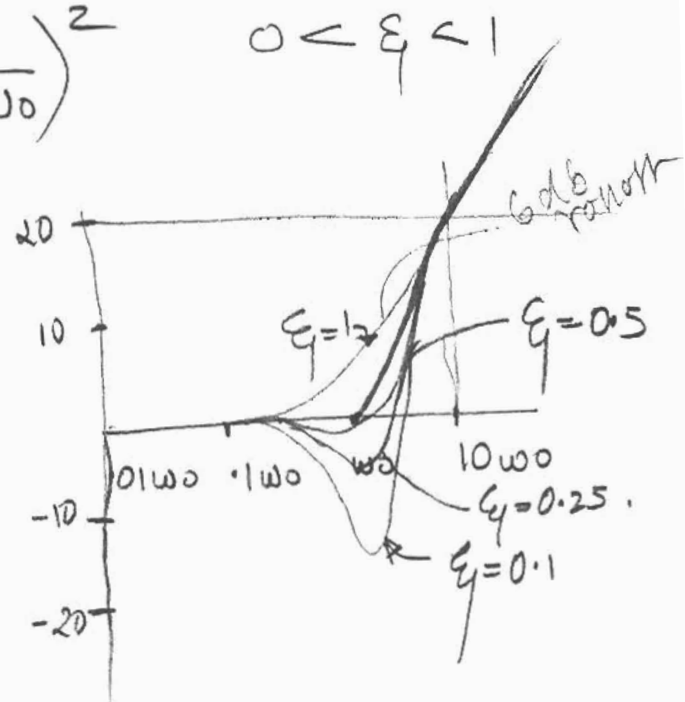
$$= 1 - \left(\frac{\omega}{\omega_0}\right)^2 + 2j\xi\left(\frac{\omega}{\omega_0}\right)$$

$\xi = 1$

at $\omega = \omega_0$

$$H_{db} = 20 \log |0 + 2j|$$

$= 6db$ rolloff



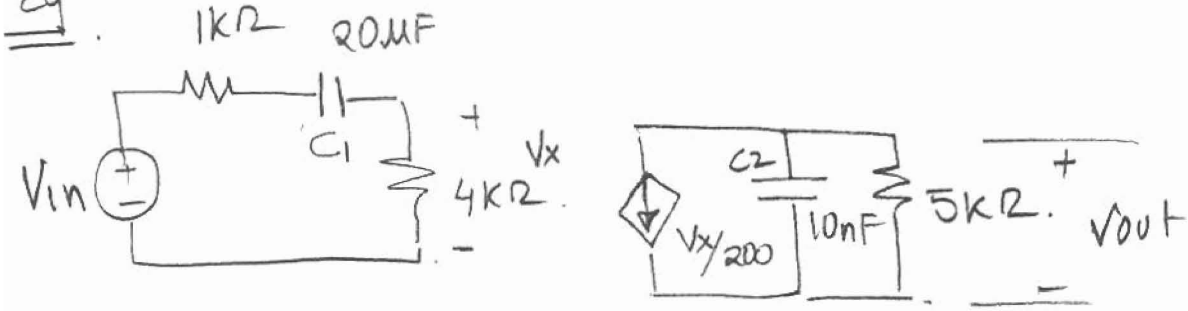
@ $\omega = 0.5\omega_0$

$\xi = 0.25$

$$H_{db} = 20 \log |1 - 0.25 + j2\times0.25\times0.5|$$

$= -2.0db$

Eg.



H(ω) can be found using Voltage division

$$V_x = \frac{V_{in} \cdot 4000}{5000 + \frac{1}{j\omega C_1}} \Rightarrow V_x(s) = \frac{V_{in}(s) \cdot 4000\, s \times 20e^{-6}}{1 + \frac{s}{10}}$$

$$V_{out} = \frac{V_x}{200} \cdot \frac{\frac{5000 \times 1}{j\omega C_2}}{5000 + \frac{1}{j\omega C_2}} \Rightarrow V_{out}(s) = \frac{V_x(s)}{200} \cdot \frac{5000}{1 + \frac{s}{20000}}$$

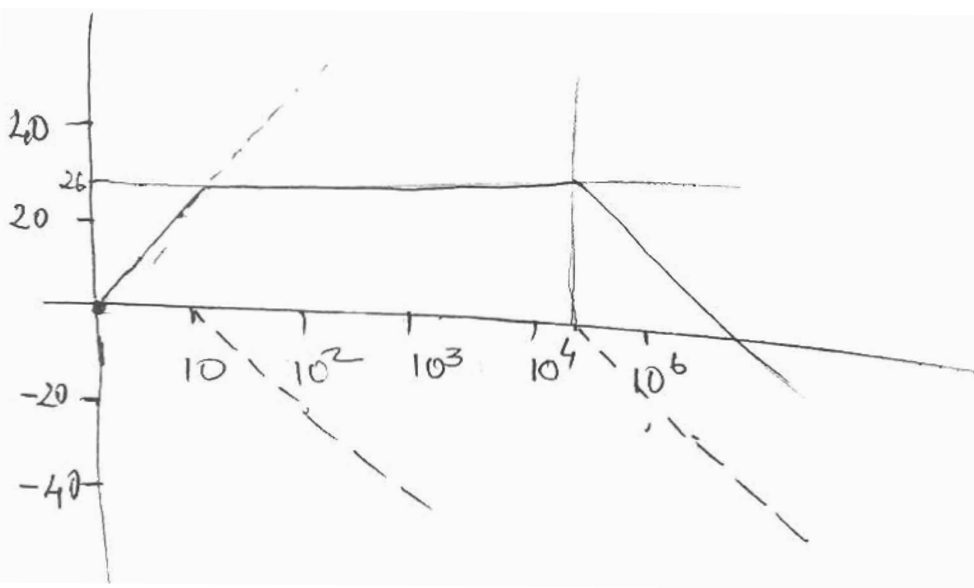
$$V_{out} = \frac{V_{in}(s)\ 4000\, s \times 20e^{-6}}{\left(1 + \frac{s}{10}\right)} \frac{\times 5000}{200\left(1 + \frac{s}{20000}\right)}$$

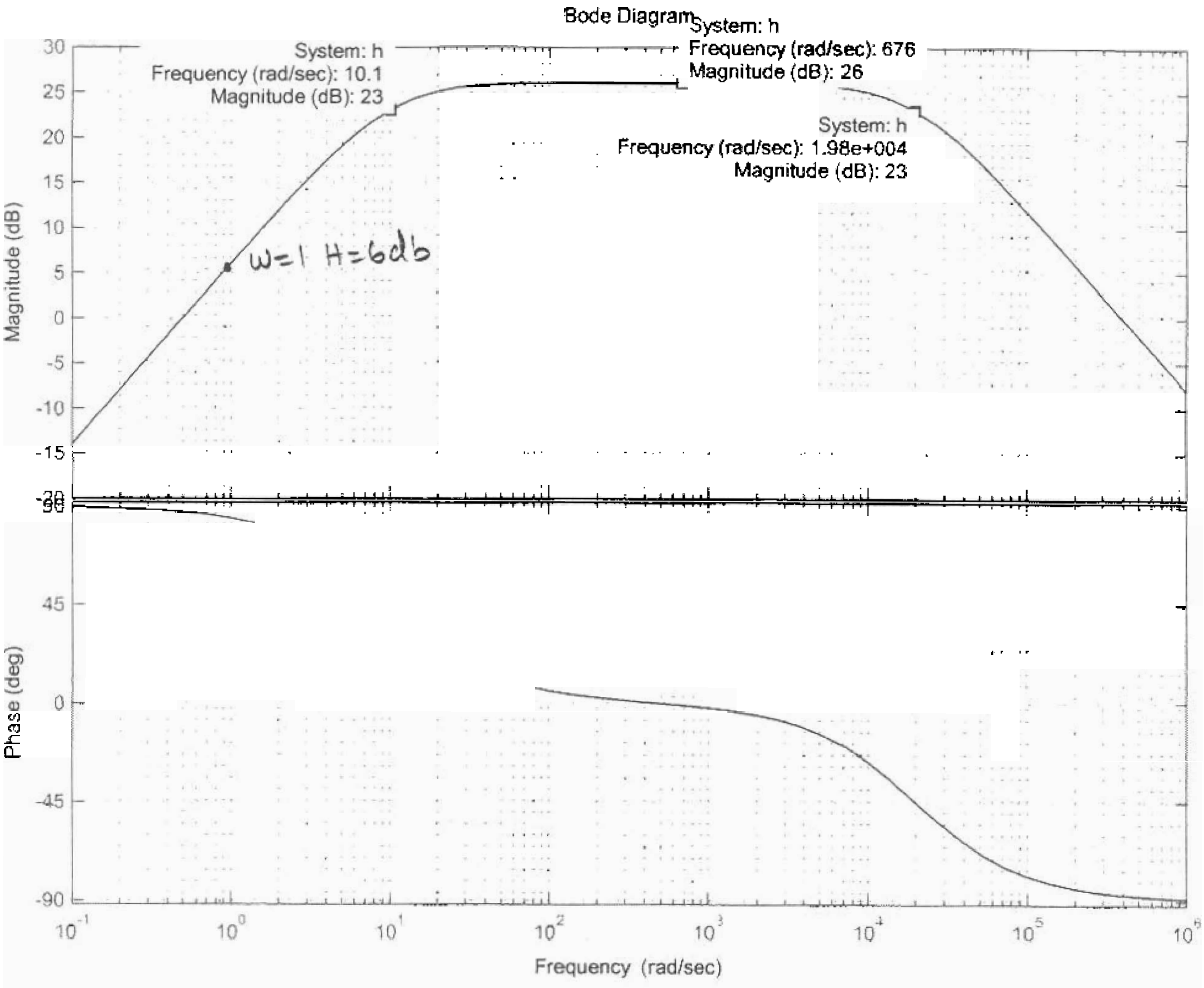
$$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{\frac{400}{200}\ s}{\left(1 + \frac{s}{10}\right)\left(1 + \frac{s}{20000}\right)} = \frac{2s}{\left(1 + s/10\right)\left(1 + \frac{s}{20000}\right)}$$

$$H(j\omega) = \begin{cases} 2j\omega & 1 < \omega < 10 \\ \dfrac{2j\omega}{\dfrac{j\omega}{10}} = 20 & 10 < \omega < 20 \\ \dfrac{2j\omega}{\dfrac{j\omega}{10} \cdot \dfrac{j\omega}{20000}} & \omega > 20000 \end{cases}$$

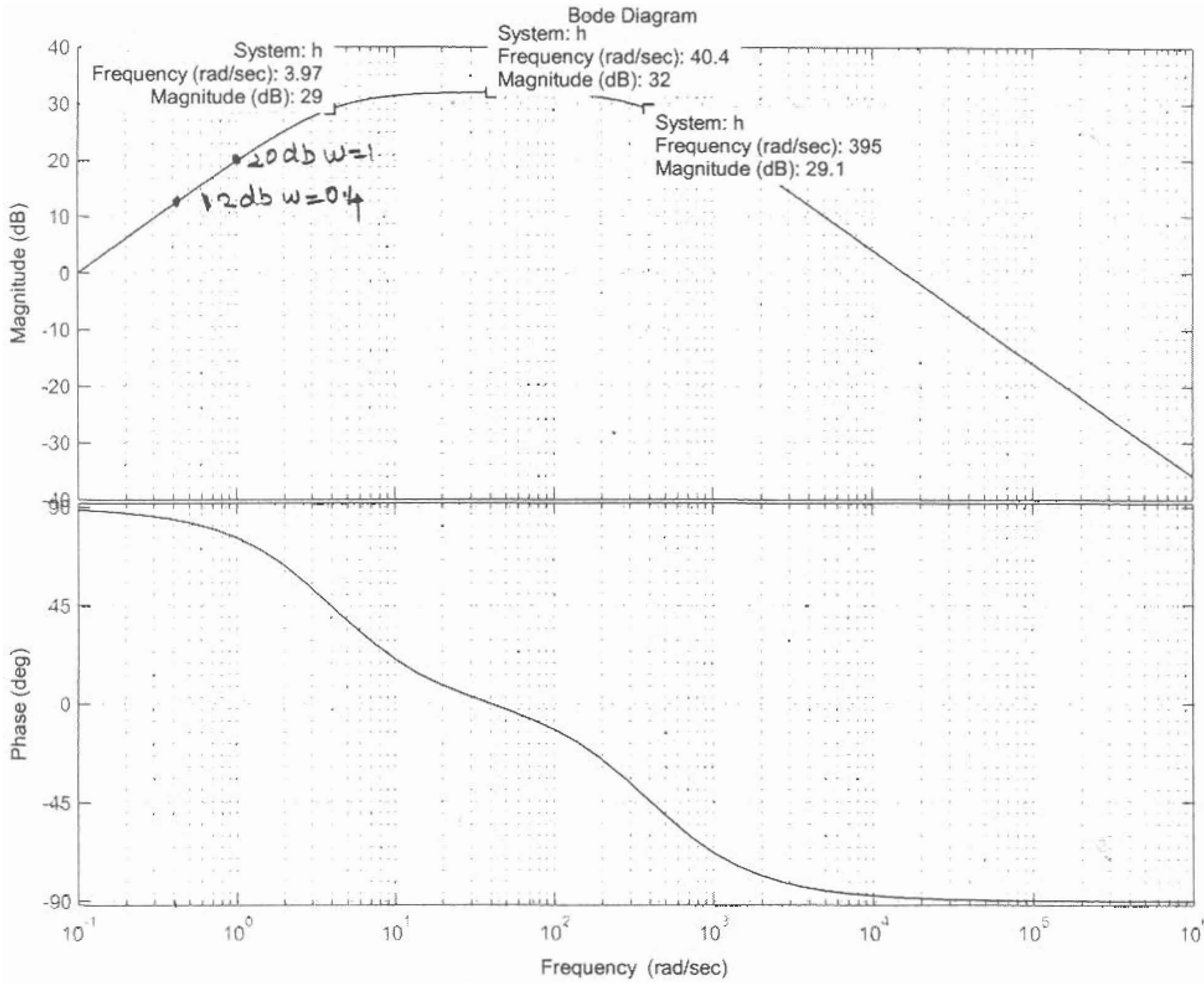
$$20 \log 20 = 26 \text{ db}$$

$$20 \log (10 \times 2)$$





Bode Diagram
System: h
Frequency (rad/sec): 10.1
Magnitude (dB): 23
System: h
Frequency (rad/sec): 676
Magnitude (dB): 26
System: h
Frequency (rad/sec): 1.98e+004
Magnitude (dB): 23
ω=1 H=6db
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)


Bode Diagram
System: h
Frequency (rad/sec): 3.97
Magnitude (dB): 29
System: h
Frequency (rad/sec): 40.4
Magnitude (dB): 32
System: h
Frequency (rad/sec): 395
Magnitude (dB): 29.1
20db w=1
12db w=0.4
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)

```
wmin = 0.1
wmax = 10e5
w = logspace(log10(wmin),log10(wmax))
k = 0.05
z = 1
p1 = 40
p2 = 400
for i= 1:length(w)
    h(i) = k*j*w(i)/((1 + j*w(i)/p1) * (1 + j*w(i)/p2));
end
subplot(211)
semilogx(w, 20*log10(abs(h)))
subplot(212)
semilogx(w, angle(h).*180/pi)


wmin = 0.1
wmax = 10e5
w = logspace(log10(wmin),log10(wmax))

%corrected 13.4.5
h = tf([10 0],[6.25e-4 .2525    1.0000]);
figure(1)
bode(h,w)
grid on


%pblm 16.9 pp581
h = tf([2 0],[5e-6 .10005 1])
figure(2)
bode(h,w)
grid on
```

Onesided Laplace transform — useful for analysis of ckts in Tx domain, especially when forcing function is applied at say $t = t_0$.

$$F(s) = \int_{-\infty}^{\infty} f(t)\,u(t)\,e^{-st}\,dt = \int_{0^-}^{\infty} e^{-st} f(t)\,dt$$

Find LT of:

$f(t) = 2u(t-3)$

$$F(s) = \int_{-\infty}^{\infty} f(t)\,e^{-st}\,dt = \int_{3}^{\infty} 2e^{-st}\,dt = \frac{-2}{s}e^{-st}\Big|_{3}^{\infty} = \underline{\underline{\frac{2e^{-3s}}{s}}}$$

Find LT of

$$f(t) = te^{-t}u(t)$$

$$F(s) = \int_{-0}^{\infty} te^{-t}\cdot e^{-st}\,dt$$

$$= \frac{-t\cdot e^{-(s+1)t}}{s+1} + \int \frac{e^{-(s+1)t}}{s+1}$$

$$= \cancel{\frac{-t\cdot e^{-(s+1)t}}{s+1}} - \frac{1\cdot e^{-(s+1)t}}{(s+1)^2}\Bigg|_{-0}^{\infty} = \frac{1}{(s+1)^2}$$

|||ly

$$f(t) = t^n e^{-t}u(t). \quad F(s) = \frac{n!}{(s+1)^{n+1}}$$

$$\mathcal{L}(u(t)) = \int_{0^-}^{\infty} e^{-st}\,dt = \frac{-1}{s} e^{-st}\Big|_0^{\infty} = \frac{1}{s}$$

$$\mathcal{L}(\delta(t-t_0)) \overset{0^-}{=} \int_{-\infty}^{\infty} e^{-st}\,\delta(t-t_0)\,dt = e^{-st_0}$$

$$\mathcal{L}(e^{-\alpha t}u(t)) = \int_{-0}^{\infty} e^{-st} e^{-\alpha t}\,dt = \frac{-1}{s+\alpha} e^{-(s+\alpha)t}\Big|_{-0}^{\infty} = \frac{1}{s+\alpha}.$$

Inverse transforms for Rational funtions.

$$H(s) = \frac{N(s)}{D(s)} \begin{array}{l} \text{— zeros} \\ \text{— poles.} \end{array}$$

Use Partial fraction expansion

$$H(s) = \frac{2}{s^3 + 12s^2 + 36s} = \frac{2}{s(s+6)^2}$$

$$\frac{a_1}{s} + \frac{a_2}{s+6} + \frac{a_3}{(s+6)^2} = \frac{2}{s(s+6)^2}$$

$$a_1(s+6)^2 + a_2(s+6)s + a_3 s = 2.$$

$$a_1(s^2 + 12s + 36) + a_2(s^2 + 6s) + a_3 s = 2.$$

substituting a_1

$$\begin{array}{c} s^2 \\ s \\ \text{Const} \end{array} \underbrace{\begin{bmatrix} 1 & 1 & 0 \\ 12 & 6 & 1 \\ 36 & 0 & 0 \end{bmatrix}}_{S} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

$$\begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} = S^{-1} * \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} = \begin{bmatrix} 1/18 \\ -1/18 \\ -1/3 \end{bmatrix}$$

$$V(s) = \frac{-1/3}{(s+6)^2} + \frac{-1/18}{s+6} + \frac{1/18}{s}$$

$$v(t) = \left[-\tfrac{1}{3} t e^{-6t} - \tfrac{1}{8} e^{-6t} + \tfrac{1}{18}\right] u(t)$$

time differentiation:

What is

$$\mathcal{L}\left\{\frac{df}{dt}\right\} = \int_{0^-}^{\infty} e^{-st}\frac{df}{dt}\,dt$$

$$= e^{-st}f(t) - \overbrace{\int -se^{-st}f(t)\,dt}^{sF(s)}$$

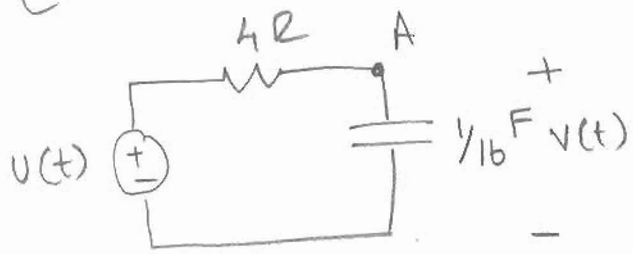
$$= e^{-st}f(t)\Big|_{0^-}^{\infty} + sF(s) = sF(s) - f(0^-)$$

IIIly

$$\mathcal{L}\left\{\frac{d^2f}{dt^2}\right\} = s^2F(s) - sf(0^-) - f'(0^-)$$

$$\mathcal{L}\left\{\frac{d^3f}{dt^3}\right\} = s^3F(s) - s^2f(0^-) - sf'(0^-) - f''(0^-)$$

Example



KCL @ A

$$\frac{v(t) - u(t)}{4} + \frac{1}{16}\frac{\partial v}{\partial t} = 0$$

$v(0^-) = 9V$ Taking LT

$$\frac{V(s)}{4} - \frac{U(s)}{4} + \frac{1}{16}sV(s) - \frac{1}{16}v(0^-) = 0$$

$$V(s)\left[1 + \frac{s}{4}\right] = \frac{9}{4} + \frac{1}{s} = \frac{9s+4}{4s}$$

$$V(s) = \frac{9s+4}{4s} \times \frac{4}{(4+s)} = \frac{A}{s} + \frac{B}{s+4}$$

$$\boxed{v(t) = (1 + 8e^{-4t})u(t)}$$

PFE

$A = 1$

$B = \frac{-36+4}{-4} = 8$

$\mathcal{L}\{\sin\omega t\, u(t)\} = \dfrac{\omega}{s^2+\omega^2}$ $\qquad$ $\mathcal{L}\{\cos\omega t\, u(t)\} = \dfrac{s}{s^2+\omega^2}$

Initial Value & Final Value theorem.

$\lim_{t\to 0^+} f(t) = \lim_{s\to\infty} sF(s)$ $\qquad$ $\lim_{t\to\infty} f(t) = \lim_{s\to 0} sF(s)$.

Example

$f(t) = \cos(\omega_0 t) \cdot u(t)$

$f(0^+) = 1$ clearly by substitution.

From IVT

$\lim_{s\to\infty} \dfrac{s^2}{s^2+\omega_0^2}$ $\quad s^2 \gg \omega_0^2$

$\to 1$

Confirmed $f(0^+) = \lim_{s\to\infty} sF(s)$

$f(t) = \left(1-e^{-at}\right) u(t)$

$f(\infty) = 1$ clear from substitution

From FVT

$\lim_{s\to 0} s \cdot \left[\dfrac{1}{s} - \dfrac{1}{s+a}\right]$

$\lim_{s\to 0} \dfrac{a}{s+a} = \dfrac{a}{a} = 1$

Confirmed

$f(\infty) = \lim_{s\to 0} sF(s)$

Use of time shifting Property

find LT of $f(t) = 3\,u(t-3)$ $\qquad \mathcal{L}\{u\} = \frac{1}{s}$

$$F(s) = \boxed{\frac{3}{s} e^{-3s}}$$

Direct Method

LT of $8e^{2t}\left[u(t+3) - u[t-3]\right]$

$$\frac{8}{s-2}\left[e^{3(s-2)} - e^{-3(s+2)}\right]$$

Alternative Method

$$\int_{-3}^{3} 8e^{2t} e^{-st}\, dt = 8\int_{-3}^{3} e^{-(s-2)t}\, dt$$

$$= \frac{-8}{s-2} e^{-(s-2)t}\Big|_{-3}^{3}$$

$$= \frac{-8}{s-2}\left[e^{-3(s-2)} - e^{+3(s-2)}\right]$$

Find V_1 & V_2 By Superposition Theorem.

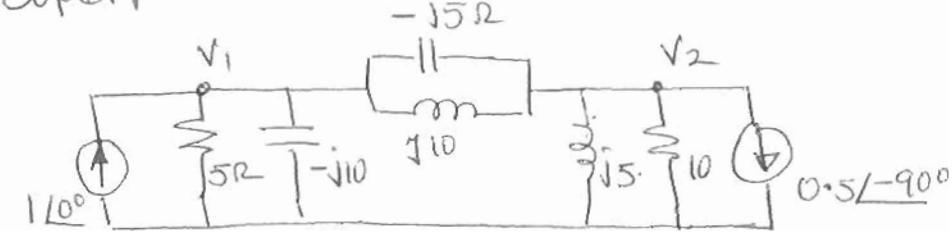
RECITATION-4

9/21/05.

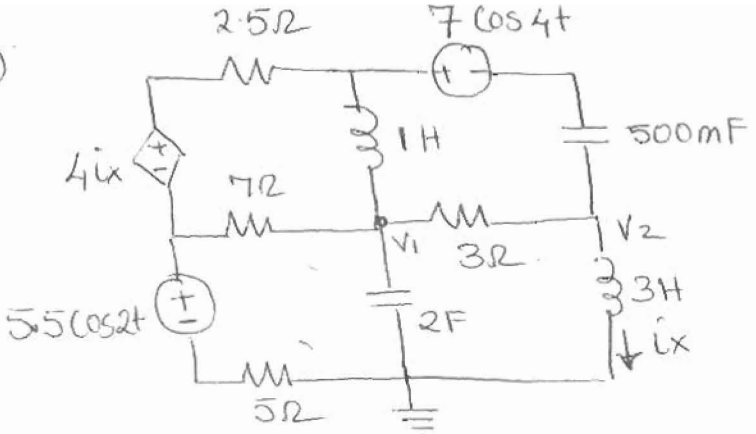
ANS:- $V_1 = 1 - j2$

$V_2 = -2 + j4$

(1)



(2)

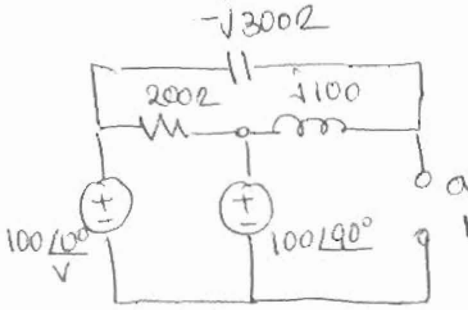


Note: Superposition of sources

i - Short ckt V sources

ii - Open ckt i sources.

(3) Find the thevenin Equivalent of the ckt.



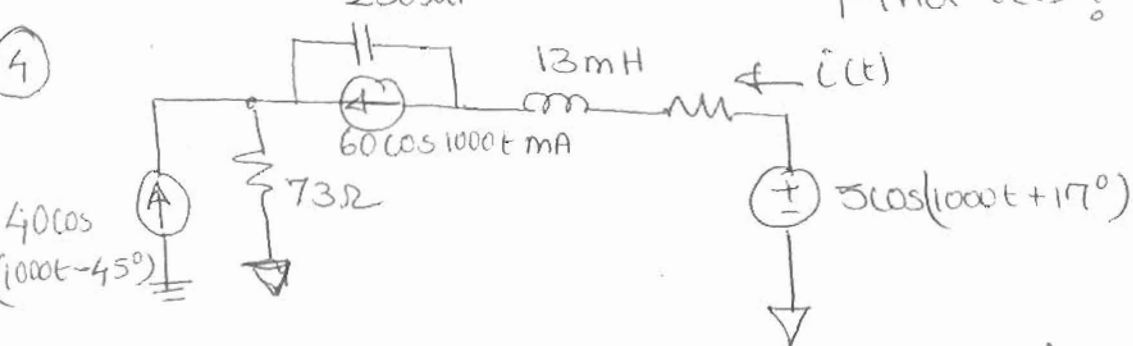
ANS

Z_{TH} :- $j150\Omega$

$V_{TH} = 158.11\angle 108.43°$

Find $i(t)$?

(4)



ANS:

$i(t) = 82.62\angle -13.21°$ mA

Chapter 10 - Review - RECITATION 5 - 9/28.

① $V_1 = A_1 \cos(5t + 10°)$ $V_2 = A_2 \sin(5t - 30°)$

What is the relationship bet V_1 & V_2 - ?

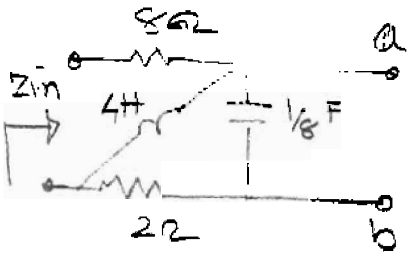
ANS: V_1 leads V_2 by 130°

V_1 lags V_2 by 230°

② Equivalent Impedence - series / parallel.

a)

When a-b open, ab sckt



$\omega = 4$.

Ans: ab open. ab sckt

$Z_{in} = 10.56 - 1.92j$ $Z_{in} = 9.97 + 0.246j$

Note 1: Phasors

$I(t) = I_m \cos(\omega t + \phi)$

$\downarrow$

$I(t) = \mathrm{Re}\{I_m e^{j(\omega t + \phi)}\}$

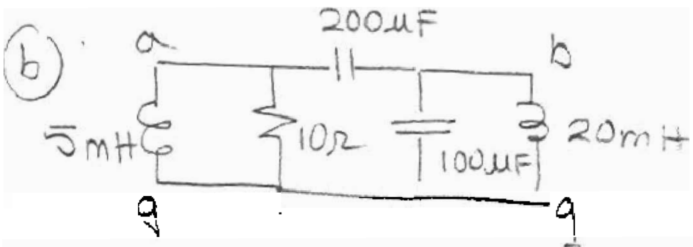
$\downarrow$

$I = I_m e^{j\phi} = I_m \angle\phi$

Note 2: KCL & KVL

Become vector addition of phasors

b)

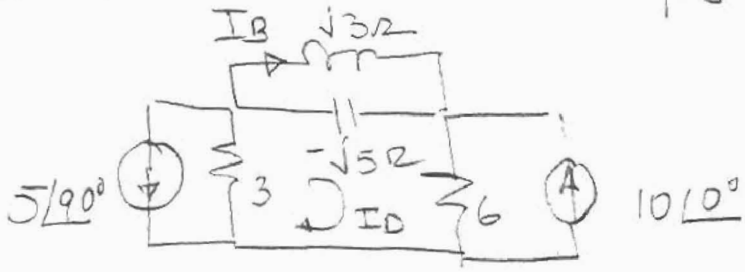


$\omega = 1000$ rad/s

Find Z_{ag}, Z_{bg}, Z_{ab}

ANS $Z_{ag} = 2.8 + j4.5\,\Omega$ $Z_{bg} = 1.8 - j1.12\,\Omega$ $Z_{ab} = 0.11 - j3.8\,\Omega$

③ Phasors & MESH analysis.



Find I_B & I_D ?

ANS:-

$I_B = 13.19 \angle 154.23°$

$I_D = 5.28 \angle 154.23°$

10/6/05

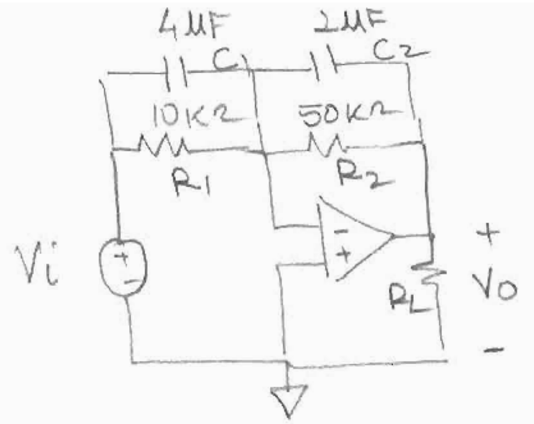
Recitation 6

What is

① 200mW is ____ in dBmW — Ans 23 dBmW.

50 W in ____ dBW — Ans 17 dBW.

② Pblm. 13.3.9



Find gain $|H(\omega)|$ & Phase shift. at freq = 200 Hz

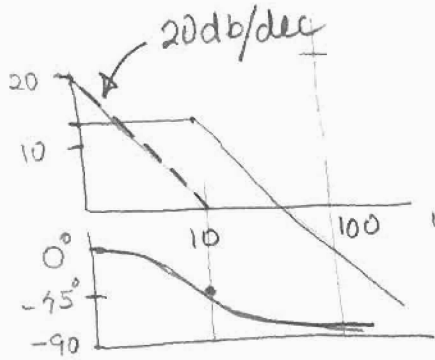
ANS: gain = 2.003

$\angle H\omega = 140.7^\circ$

③ Ex 13.4-4

PP - 586

④ Ex 13.4.6



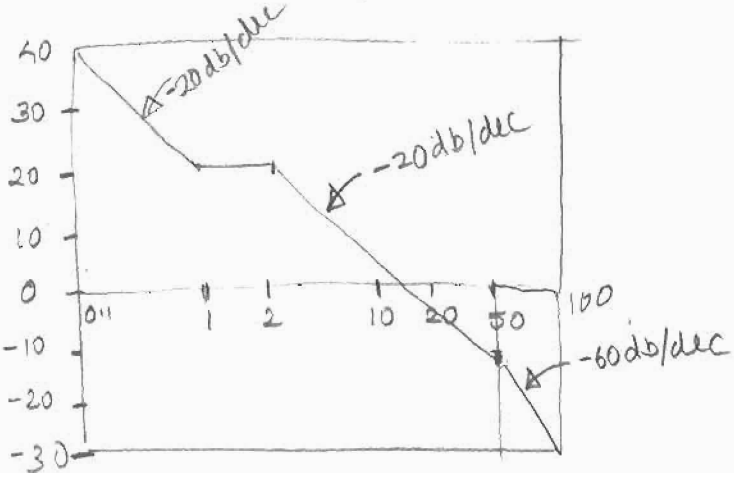
$\omega \rightarrow$ ANS $H(\omega) = \left(1 + \frac{R_1}{R_2}\right)\frac{1}{1+j\omega CR}$

$H(\omega) = 4.867 - 1.0026 e^{j2^\circ}$

$\omega = 0.01$ rad/s

gain = 100 ⇒ 40 db

$\angle H(\omega) = -87^\circ$



$$H(\omega) = \frac{10(1+s)}{s(1+0.5s)(12.5 - j48.4 + s)(12.5 + j48.4 + s)}$$

Recitation 7

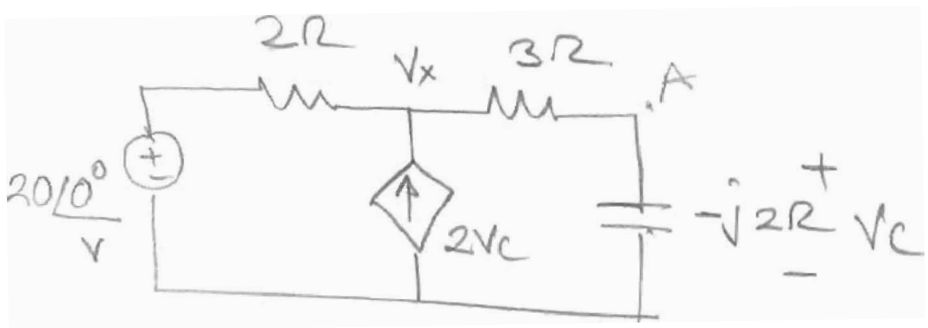
(1) $i = 2t^2 - 1 \qquad 1 < t < 3$

(a) 4H inductor what energy is delivered in $1 < t < 3$ ANS 576

(b) 0.2F capacitor given $V(1) = 2$ what power is delivered at $t = 2$. ANS 142.331

Instantaneous power / energy.

(2) What is the avg power supplied by the dependent source.



ANS = 26.23 W

(3) (a) Calculate effective value of

$v(t) = 10 + 9\cos 100t + 6\sin 100t$

ANS: 12.59 V

(b) Find effective value of f where f is :

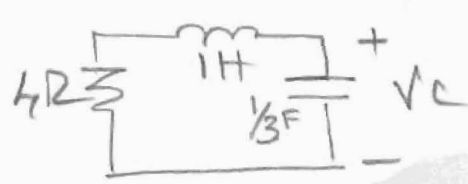
ANS :- 12.247

(c) find avg of f ANS: 10

(4) If $v_C(0) = -2V$, $i(0) = 4A$ find Power absorbed by C @

(a) $t = 0^+ s$ (b) 0.2s (c) 0.4 s.

ANS :- −8W −0.554W 0.422W

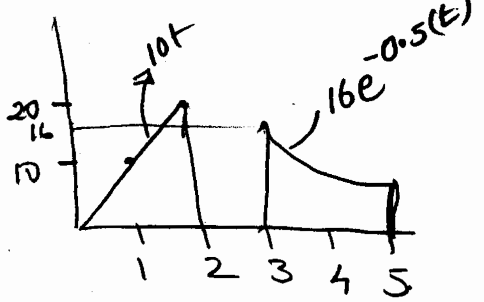


Recitation 8

2/11/05.

1. Find the effective value of waveform with $T = 5s$

$$v(t) = 10t\left[u(t) - u(t-2)\right] + 16e^{-0.5(t-3)}\left[u(t-3) - u(t-5)\right]$$



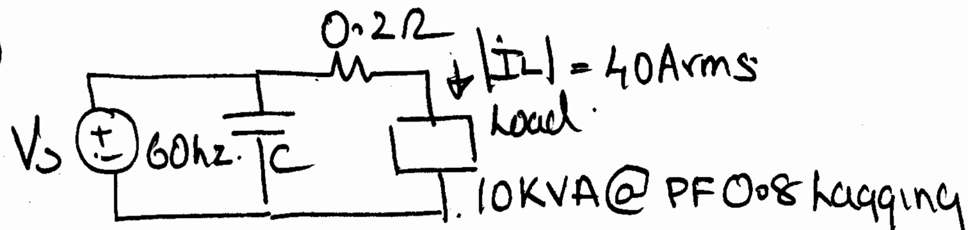
V_{eff}

$$= \sqrt{\frac{1}{5}\left[\int_0^2 100t^2\,dt + \int_3^5 256\,e^{-(t-3)}\,dt\right]}$$

$= 9.879$. ANS

2. A Series combination of inductor and Resistor must not dessipate more than 250mW, assuming sinusoidal i, $\omega = 500$ rad/s. What is the largest rms current in the ckt? ANS = 10.18mA rms

3.



What value of 'C' should cause the source to lag with PF 0.9. ?

ANS: $C = 79.5\mu F$

4. A Load operates at 2300 Vrms, draws 28 A rms, with PF = 0.812 lagging.

Find ANS)

a) Peak Current. (39.6 A)

b) Instantaneous Power @ t = 2.5ms, f = 60hz (105.79 KW)

c) Real Power taken by Load (52.29 KW)

d) Complex power ($64.4\angle 35.7^\circ$ KVA)

e) Apparent power (64.4 KVA)

f) Impedence of Load ($82.14\angle 35.7^\circ$)

g) Reactive Power (37.59 KVAR)

Recitation 9 – 11/30

① Find the $\mathcal{L}^{-1}[F(s)]$

where

$$F(s) = 2 - \frac{1}{s} + \frac{25s^3 + 120s^2 + 220s + 240}{s^4 + 5s^3 + 8s^2 + 20s + 16}$$

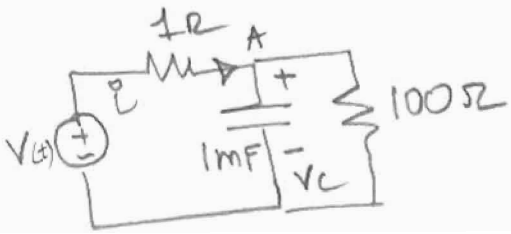
ANS:-

$$f(t) = 2\delta(t) - u(t) + \frac{23}{3}e^{-t} + \frac{16}{3}e^{-4t} + 12\cos 2t + 12\sin 2t$$

② Pblm:-

14.7.2

Find $i(t)$ for the ckt using LT



$V(t) = 160\cos 400t$

$V_C(0) = 0$

$$\therefore i(0) = \frac{160\cos(0)}{1\Omega} = 160\,A$$

ANS:-

$$i(t) = 136.9e^{-1010t} + 23\cos 400t - 54.4\sin 400t$$