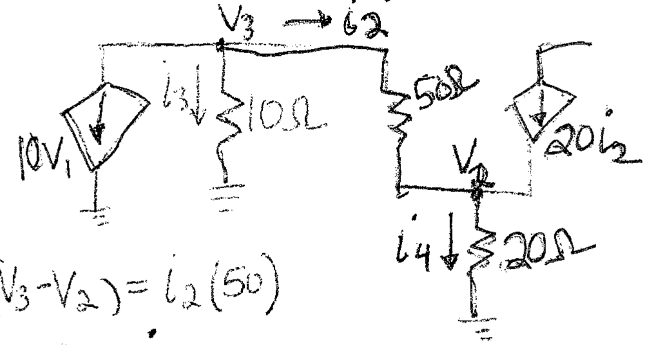
HW #1 sol'n

Spring 2009

1. $V_o = -20i_2(50\|50) = -20i_2(25)$



$(V_3 - V_2) = i_2(50)$

$i_2 + 20i_2 = i_4$

$V_2 = i_4(20) = 21i_2(20)$

$V_3 = i_3(10)$

$10V_1 + i_3 + i_2 = 0$

$i_3 = -10V_1 - i_2$

$\therefore\ V_3 = -10(10)V_1 - 10i_2$

$$i_2 = \frac{V_3 - V_2}{50} = \frac{-10(10V_1 + i_2) - 21(20)i_2}{50}$$

$$\frac{50}{50}i_2 + \frac{10}{50}i_2 + \frac{21(20)}{50}i_2 = -\frac{10(10V_1)}{50}$$

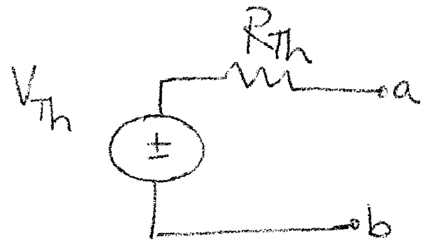
$i_2 = -0.208V_1$

$V_1 = V_g$

$\therefore\ V_o = -20(25)(-.208)(10mV)$

$\Rightarrow$ $\boxed{V_o = 1.04\,V}$

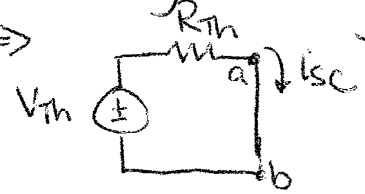
1. (cont.)



$V_{th} = V_o$ (open-circuit voltage between a & b)

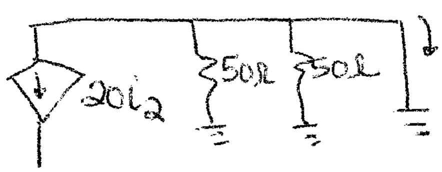
{Note that this is true since no current flows through R_{Th} when a to b is left open}

- R_{Th} can be found by shorting a to b and leaving V_{Th} ⟹



$$R_{Th} = \frac{V_{Th}}{i_{sc}}$$

i_{sc} ⟹



$i_{sc} = -20i_2$

V_{Th} (in terms of i_2) $= V_o = -20i_2(50 \| 50)$

$$\therefore \quad R_{Th} = \frac{-20i_2(25)}{-20i_2} = \boxed{25\Omega}$$

2. Give expressions for the sine-wave voltage signals having:

a. 5V peak amplitude and 1kHz frequency

$\omega = 2*\pi*1k = 6.2832k$ rad/sec => **5sin(6.2832kt) V**

b. 120Vrms and 60Hz frequency

$120*\sqrt{2}\sin(2\pi*60t)$ V

c. 200mV peak-to-peak and 1000-rad/s frequency

0.1sin(1000t) V

d. 0.1V peak and 10ms period

$0.1\sin(2\pi*100t)$ V

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(3) Procedural Steps for Bode Plots.

1. Determine the poles and the zeros.
2. Determine the starting point of the amplitude plot by plugging into the transfer function the first frequency on the plot.
3. Draw the amplitude plot; begin at the starting point. Start with the slope given by poles or zeros at $\omega = 0$; at each zero add 20 dB/decade, and at each pole subtract 20dB/decade. The pole/zero order determines how many 20dB/decade are added or subtracted. Continue drawing, changing the slope until reaching the end of the graph.
4. Draw the phase plot.

Start Value = $0°$ if constants > 0

$180°$ if constants < 0

$+90°$ for each zero at the origin

$-90°$ for each pole at the origin

Each pole/zero contributes a 45° difference in the slope of the Bode Phase Diagram. Mark these on the plot; ~~and~~ the effect begins 1 decade before the pole/zero and ends 1 decade after the pole/zero.

(3)

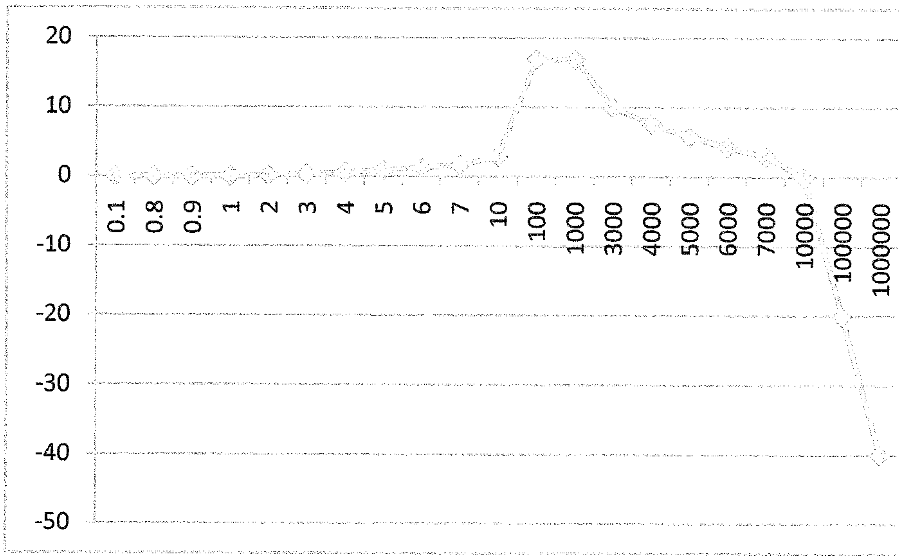
4.a. $H(s)=\dfrac{10{,}000(s+10)}{(s+1{,}000)(s+100)}$

Magnitude => $$H(s)=\frac{10{,}000*10\sqrt{\left(\frac{w}{10}\right)^2+1^2}}{1{,}000*100\sqrt{\left(\frac{w}{100}\right)^2+1^2}\sqrt{\left(\frac{w}{1000}\right)^2+1^2}}$$

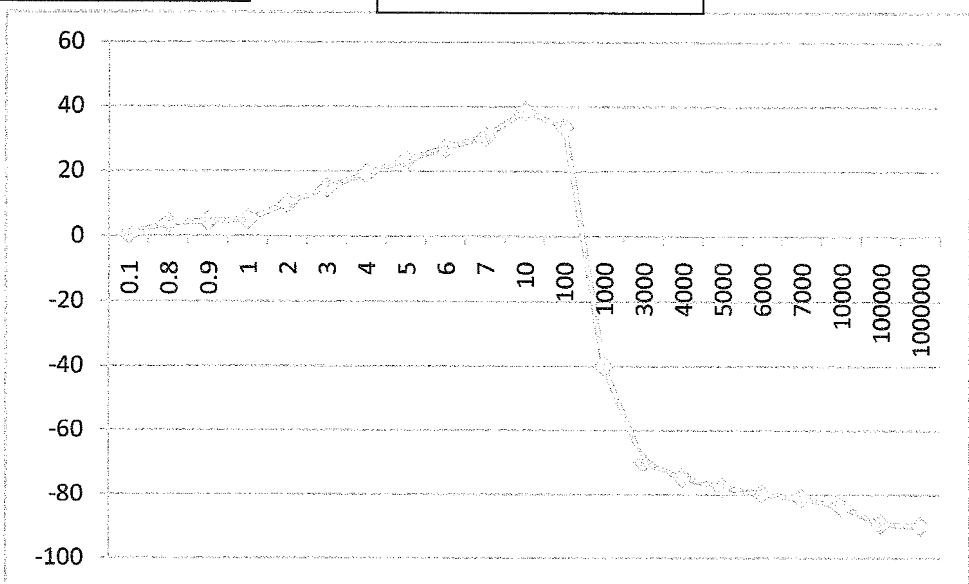
Phase => DEGREES(ATAN(w/10)-ATAN(w/1000)-ATAN(w/100))

ω (rad/sec)	Mag(dB)	Phase(Degrees)
0.1	0.00043	0.509913
0.8	0.027426	4.069728
0.9	0.034681	4.57555
1	0.042775	5.080359
2	0.168579	10.04958
3	0.370319	14.809
4	0.637567	19.28162
5	0.958148	23.41617
6	1.319626	27.18636
7	1.710421	30.58678
10	2.966652	38.71647
100	16.9897	33.57881
1000	16.94692	-39.8623
3000	9.995225	-69.8469
4000	7.692824	-74.6749
5000	5.848547	-77.6589
6000	4.316789	-79.6783
7000	3.009423	-81.1333
10000	-0.04364	-83.7738
100000	-20.0004	-89.3755
1000000	-40	-89.9375

Magnitude (dB vs. ω)

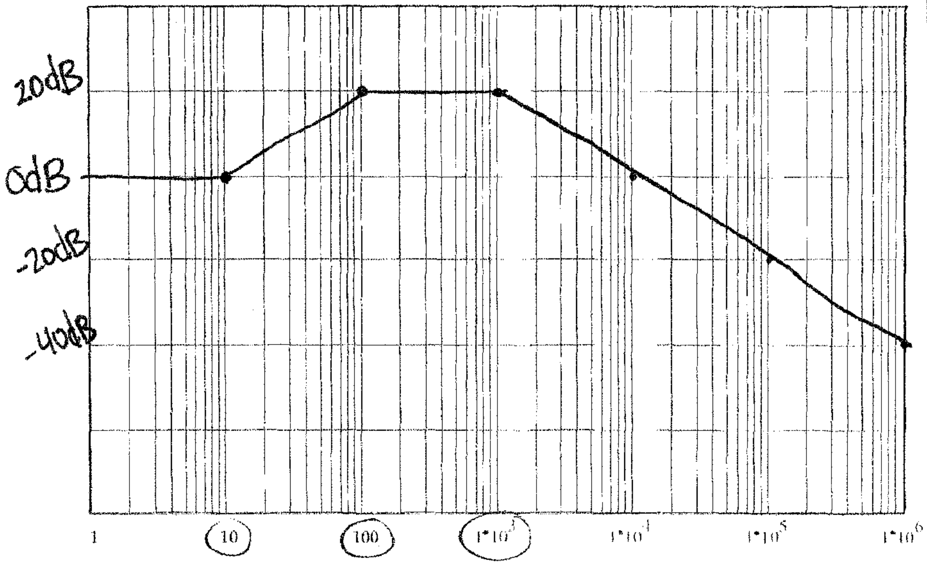


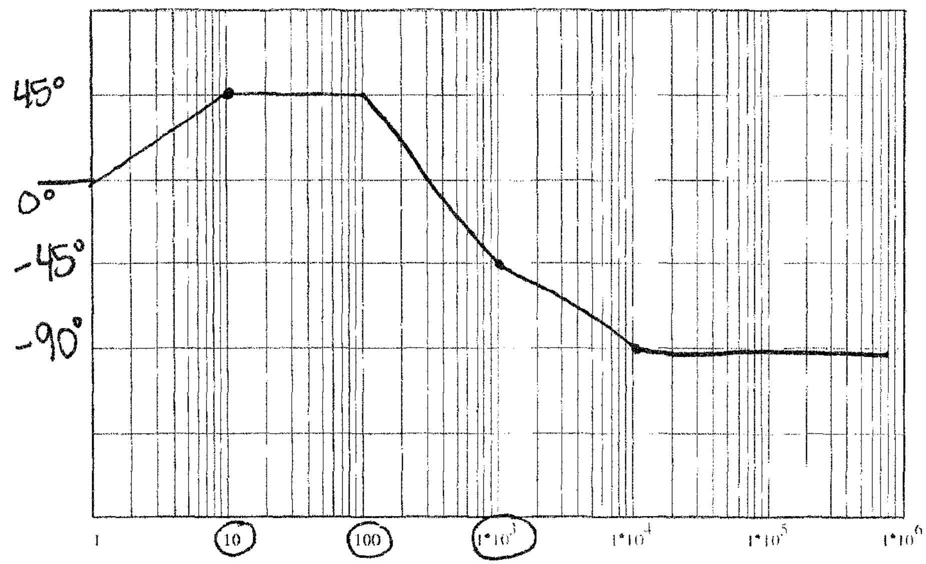
Phase (Degree vs. ω)



(5) 4. b $H(s) = \frac{10k(10)\left(\frac{s}{10}+1\right)}{1k\left(\frac{s}{1k}+1\right)(100)\left(\frac{s}{100}+1\right)} = \frac{\left(\frac{s}{10}+1\right)}{\left(\frac{s}{1k}+1\right)\left(\frac{s}{100}+1\right)}$

Break freq: $w = 10, 100, 1k$

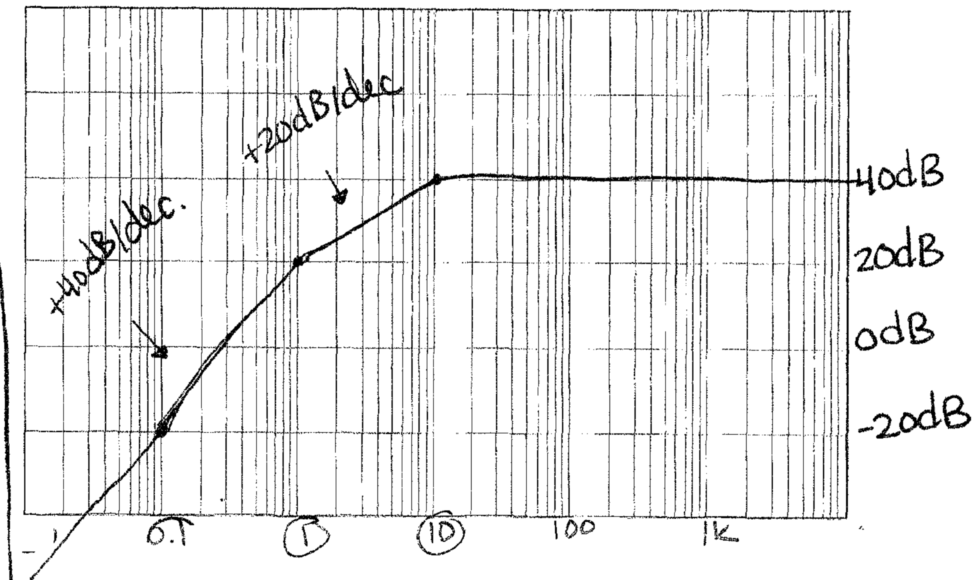


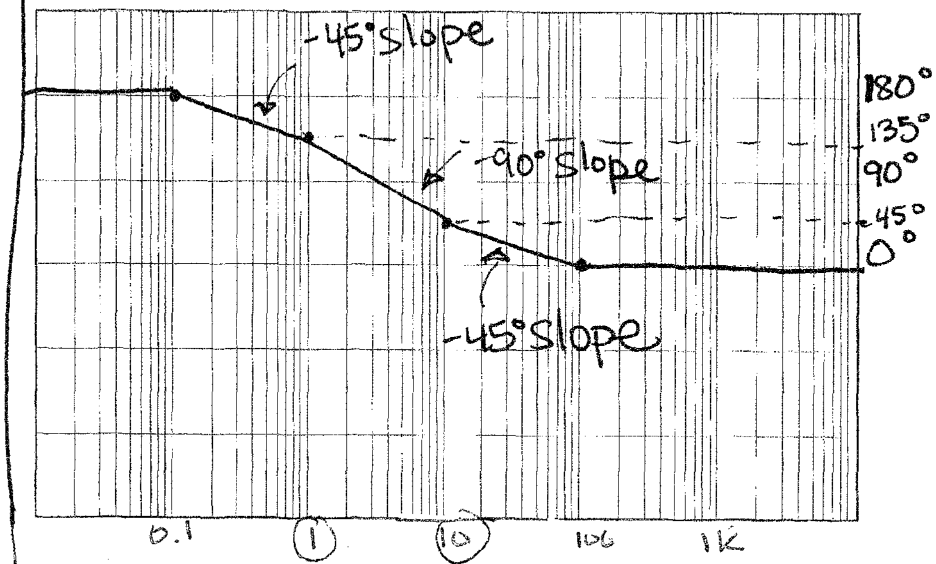


5. $H(s) = \frac{100s^2}{(s+1)10\left(\frac{s}{10}+1\right)} = \frac{10s^2}{(s+1)\left(\frac{s}{10}+1\right)}$

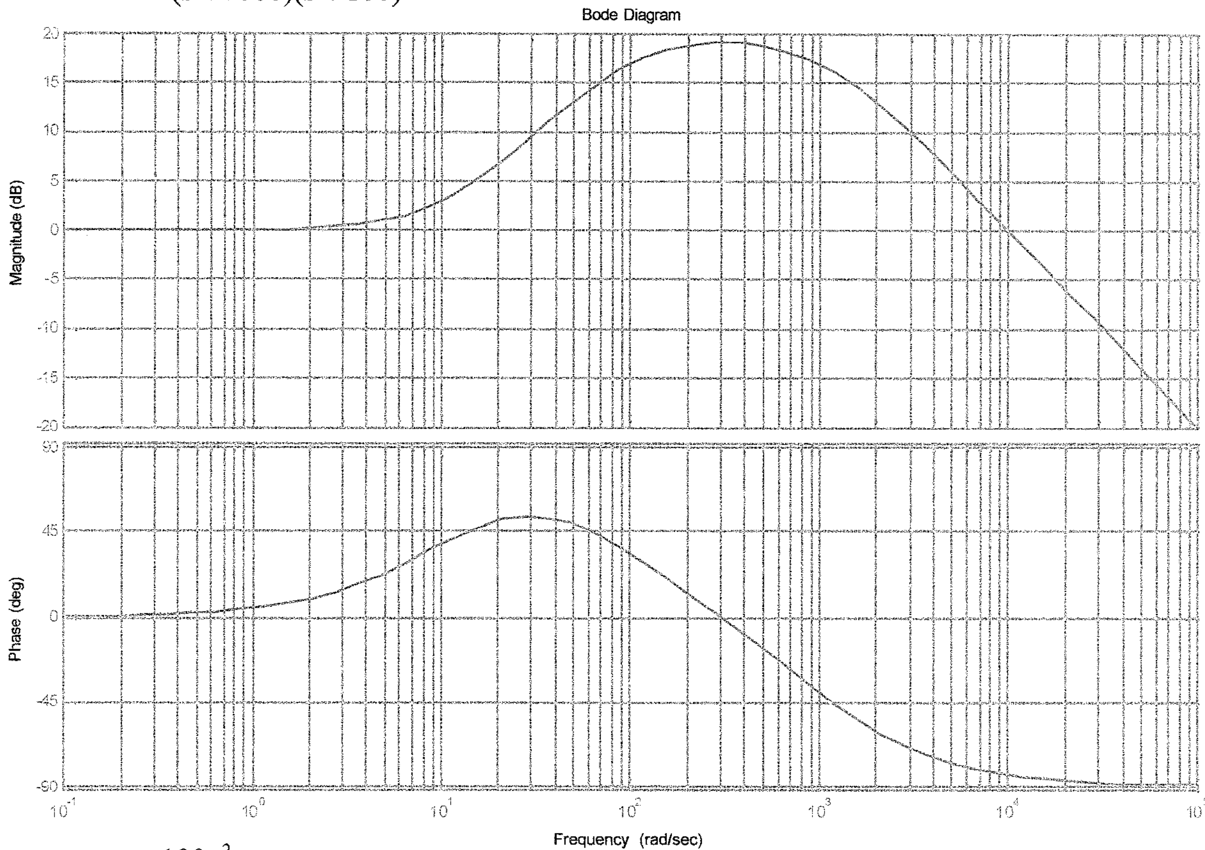
Break freq: $w = 1, 10$

phase starts at 180°
slope starts at +40dB/dec.
@ $w=1 \Rightarrow 20\log(10) = 20dB$

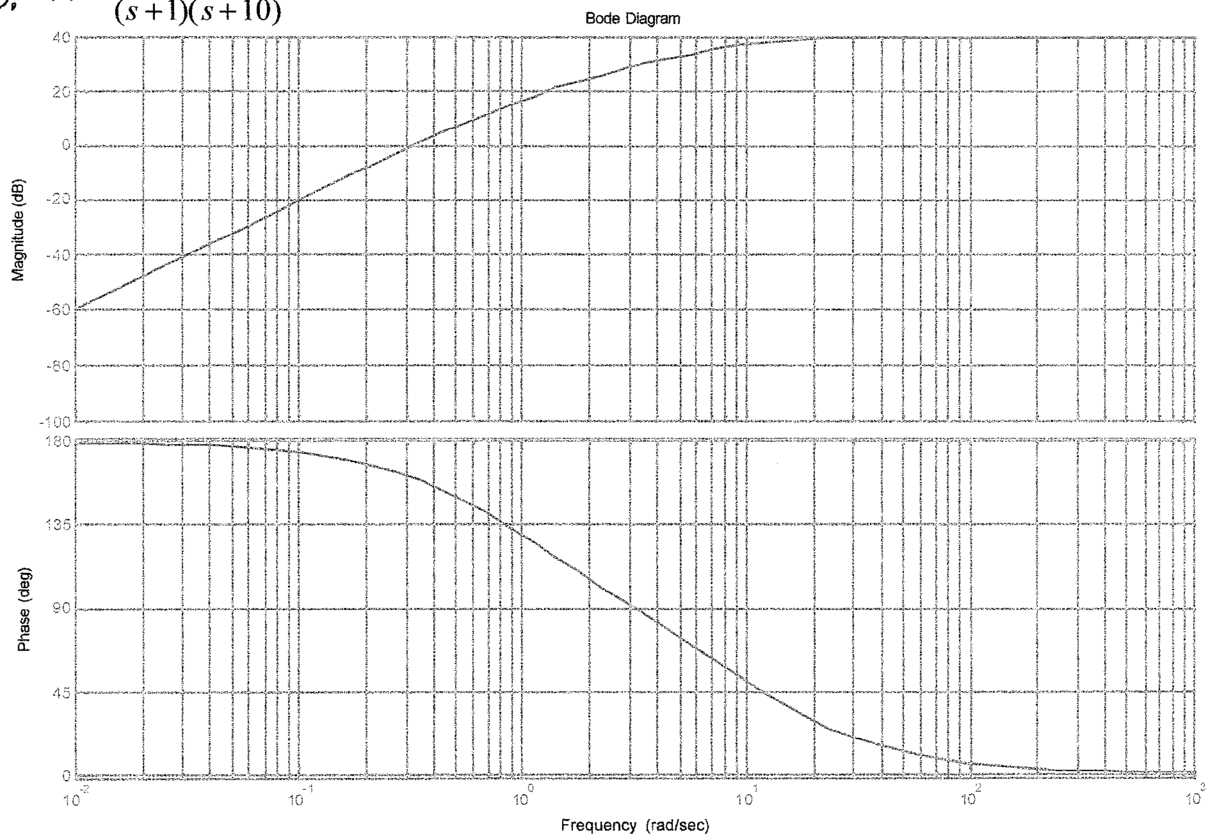




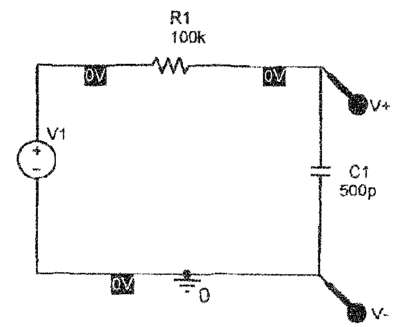
4.C $H(s) = \dfrac{10{,}000(s+10)}{(s+1000)(s+100)}$



5, $H(s) = \dfrac{100s^2}{(s+1)(s+10)}$



6.



Corner Frequency = 1/RC = 20 krad/s = 3.2 kHz

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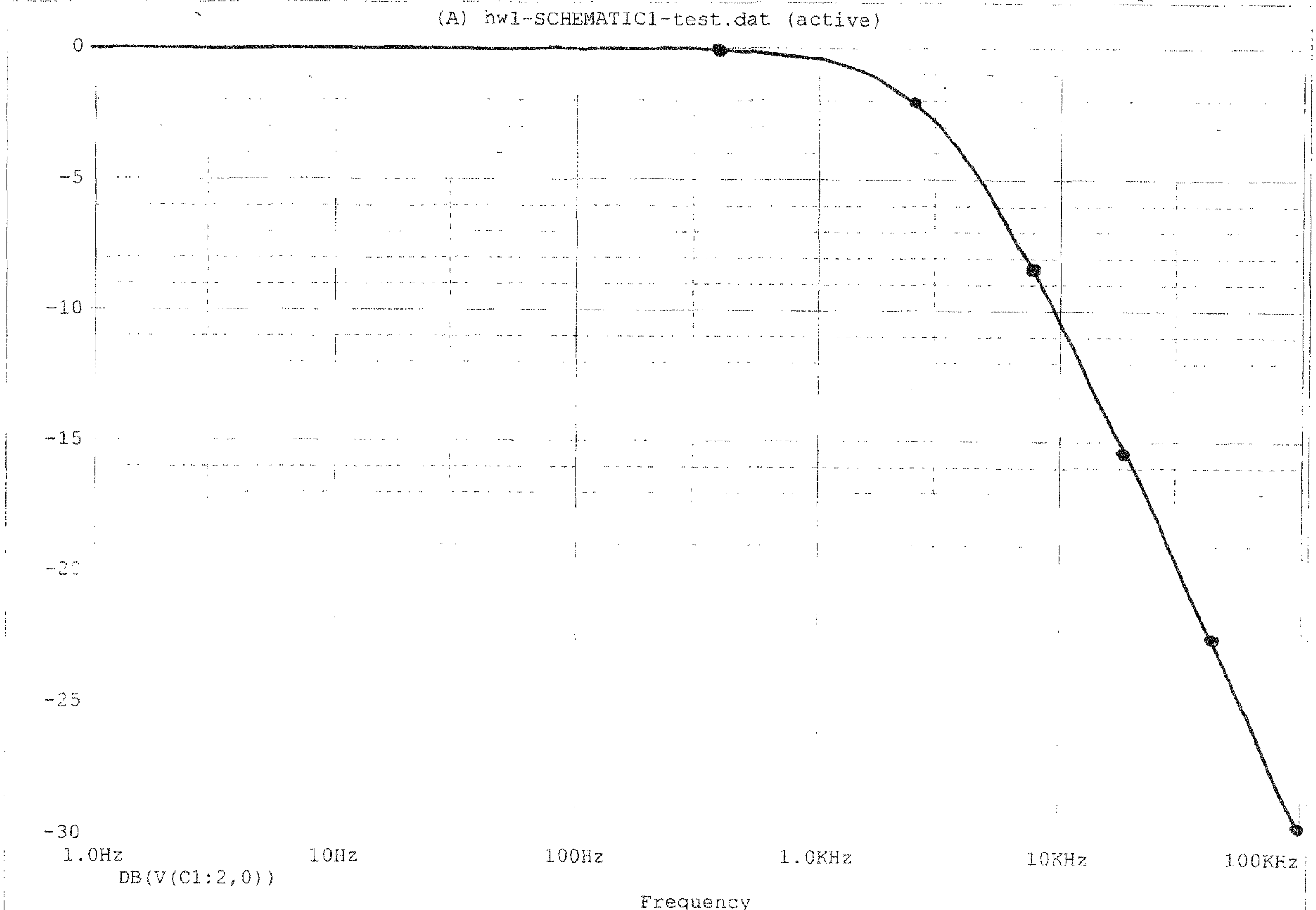
** Profile: "SCHEMATIC1-test" [E:\ECE2280\HW1 Stuff\hw1-schematic1-test.sim]
Date/Time run: 01/09/08 13:25:19 Temperature: 27.0



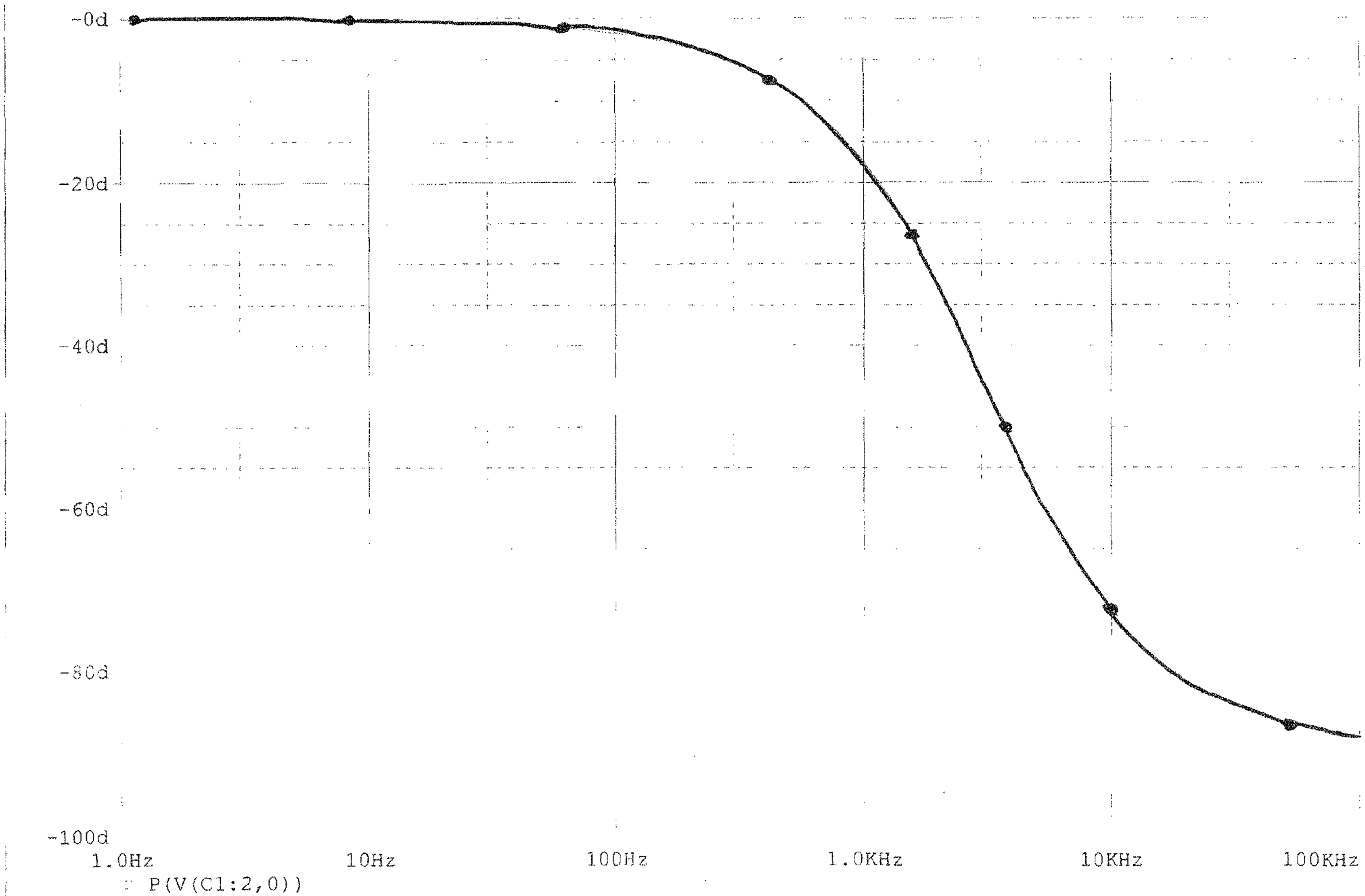
Date: January 09, 2008 Page 1 Time: 13:26:00

(9)

** Profile: "SCHEMATIC1-test" [E:\ECE2280\HW1 Stuff\hw1-schematic1-test.sim]

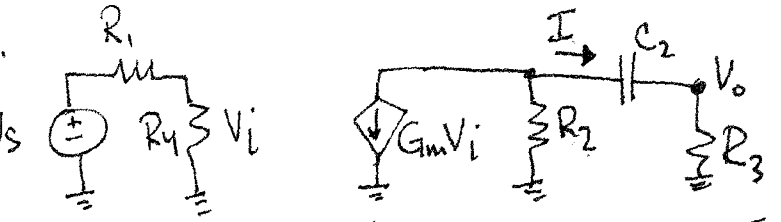
Date/Time run: 01/09/08 13:25:19 Temperature: 27.0

(A) hw1-SCHEMATIC1-test.dat (active)



Date: January 09, 2008 Page 1 Time: 13:26:11

7.



$R_1 = 100$, $R_4 = 1M$, $G_m = 40m^{A}/V$, $R_2 = 20K$, $C_2 = 100nF$, $R_3 = 20K$

$$V_o = I \cdot R_3$$

$$I = \left[\frac{-G_m V_i \cdot R_2}{R_2 + \frac{1}{C_2 s} + R_3}\right]\frac{C_2 s}{C_2 s} = \frac{-G_m R_2 (V_i) \cdot C_2 s}{((R_2 + R_3)C_2 \cdot s + 1)}$$

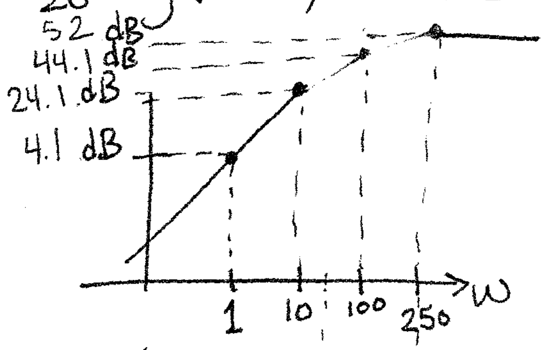
$$V_i = \frac{R_4 \cdot V_s}{R_1 + R_4}$$

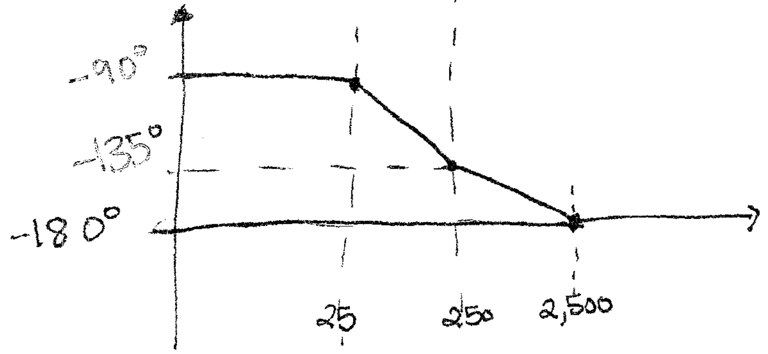
$$\therefore \quad \frac{V_o}{V_s} = \frac{-G_m R_2 C_2 s \cdot R_4 \cdot V_s \cdot R_3}{(R_1 + R_4)((R_2 + R_3)C_2 s + 1)} = \frac{-80\mu \cdot s \cdot 20K}{\left(\frac{s}{250} + 1\right)}$$

$20 \log(1.6) \cong 4.1$ dB @ $\omega = 1$; because of s in numerator, starting slope = 20 dB/dec until 250 rad/sec (the pole value) $\Rightarrow$ [add on the 3dB]

$\omega = 250$:

$$20 \log\left[\frac{(1.6)(250)}{\sqrt{2}}\right] = 49\text{ dB} + 3\text{dB} \approx 52\text{ dB}$$





- This circuit operates at frequencies above 250 rad/sec.
- phase starts at -180° because of negative sign. Add the s in top to -180° to start at -90°