

# EE 352 HW 2 Solutions

$$(1) \cdot a.) A(s) = \frac{A_0}{1 + s/\omega_H} \approx \frac{\omega_B}{s}$$

$$A_0 = g_{m2} [r_{o2} \parallel r_{o4} \parallel r_{\pi 5}] g_{m5} r_{o5}$$

$$= \frac{50 \mu A}{V_T} \left[ \frac{130 V}{50 \mu A} \parallel \left( \frac{50 V}{50 \mu A} \right) \parallel \left( \frac{50}{100 \mu A} \right) \right] \left( \frac{100 \mu A}{V_T} \right) \left( \frac{50 V}{100 \mu A} \right)$$

$$A_0 = 49,149 \text{ V/V}$$

$$\omega_E = \frac{g_{m2}}{C_C} = 2\pi [1.06 \text{ MHz}]$$

$$\omega_H = \frac{\omega_E}{A_0} = 2\pi [21.6 \text{ Hz}]$$

b.)  $A(s)$  Bode Plots  $\Rightarrow$  See Matlab Printout

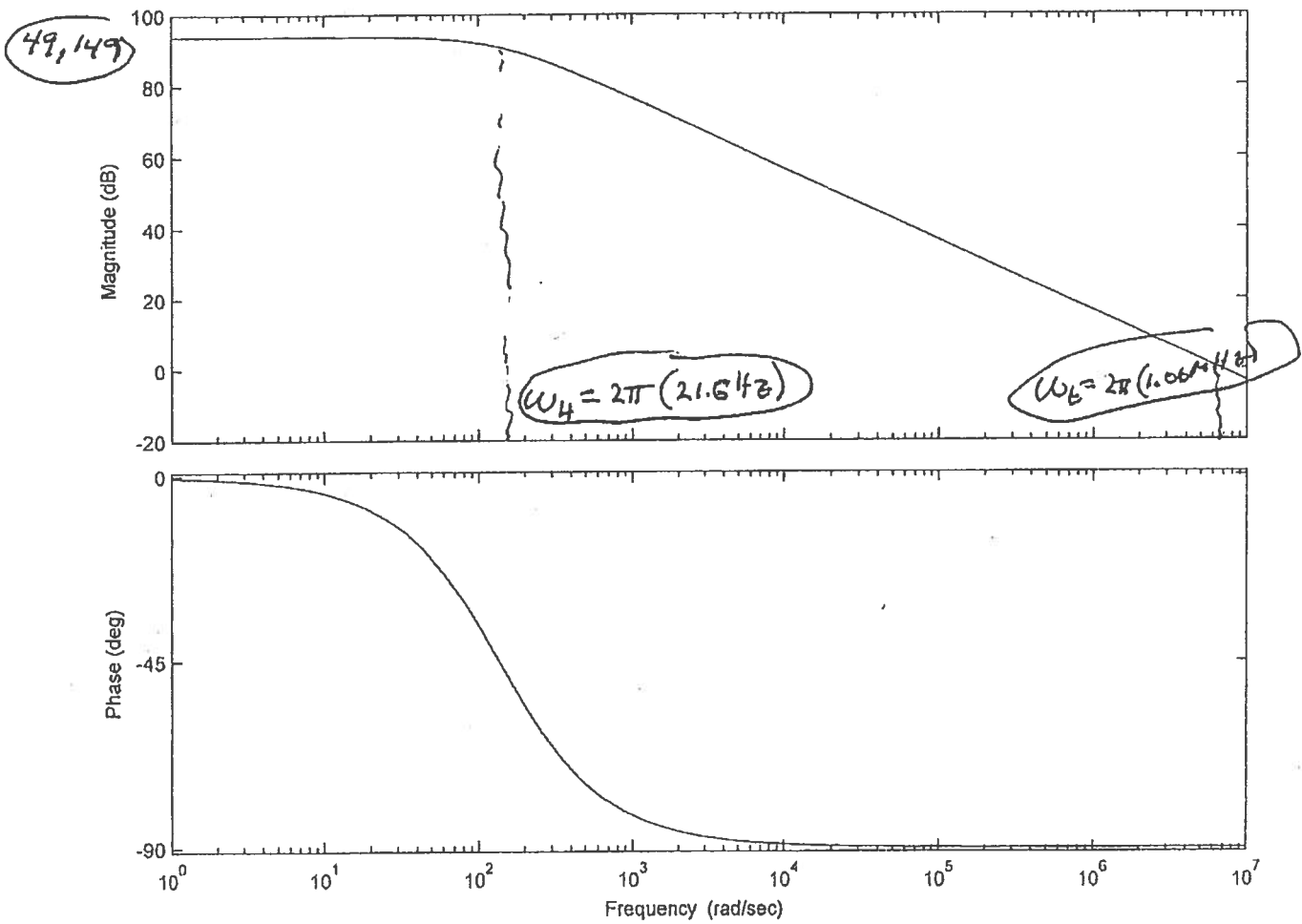
~~$$SR = \frac{A_0}{C_C} = \frac{100 \mu A}{100 \text{ pF}} = 1 \text{ V/}\mu\text{s}$$~~

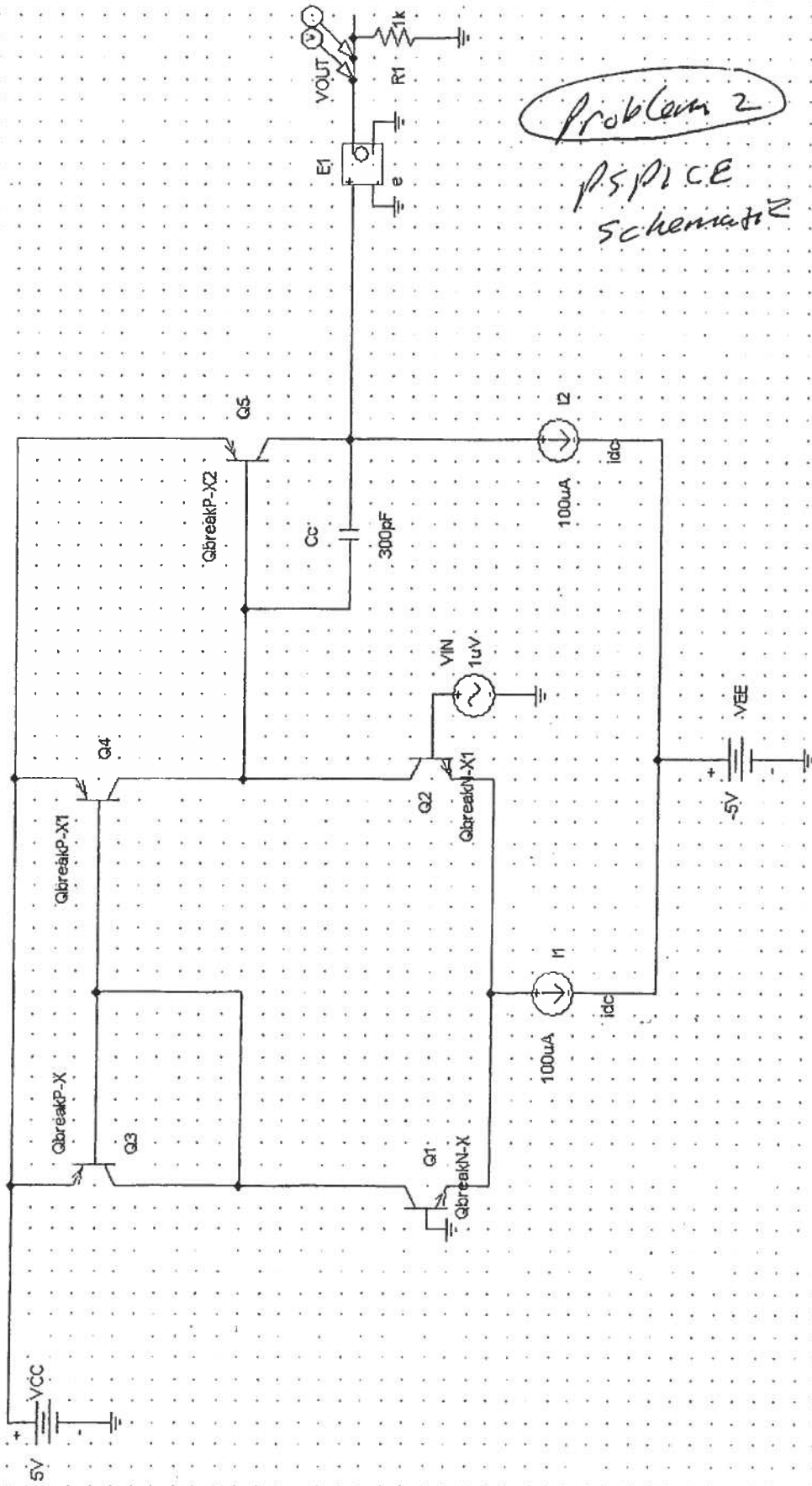
Problem 1. b)

$A(s)$  Bode Plots

$$A(s) = \frac{49,149}{1 + s/2\pi(21.6\text{Hz})}$$

Bode Diagram





Problem 2  
PSpICE .out file

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**** 04/02/12 11:38:11 ***** Evaluation PSpice (Nov 1999)
*****
* U:\electrical_engineering\oster\pspice\ee352\spring12\hw7\hw7.sch
****   CIRCUIT DESCRIPTION
*****
* Schematics Version 9.1 - Web Update 1
* Mon Apr 02 11:38:04 2012
** Analysis setup **
.ac DEC 10 1 100MEG
.TF V([VOUT]) V_VIN
.OP
.LIB "U:\electrical_engineering\oster\pspice\ee352\spring12\hw7\hw7.lib"
* Schematics Netlist *
R_R1      0 VOUT 1k
V_VIN     $N_0001 0 DC 0V AC 1uV
I_I1     $N_0002 $N_0003 DC 100uA
I_I2     $N_0004 $N_0003 DC 100uA
V_VEE    $N_0003 0 -5V
V_VCC    $N_0005 0 5V
E_E1     VOUT 0 $N_0004 0 1
Q_Q3     $N_0006 $N_0006 $N_0005 QbreakP-X
Q_Q4     $N_0007 $N_0006 $N_0005 QbreakP-X1
Q_Q5     $N_0004 $N_0007 $N_0005 QbreakP-X2
Q_Q1     $N_0006 0 $N_0002 QbreakN-X
Q_Q2     $N_0007 $N_0001 $N_0002 QbreakN-X1
C_Cc     $N_0007 $N_0004 300pF
.probe
.END

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****   BJT MODEL PARAMETERS
*****
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	QbreakP-X	QbreakP-X1	QbreakP-X2	QbreakN-X
	PNP	PNP	PNP	NPN
IS	100.000000E-18	100.000000E-18	100.000000E-18	
100.000000E-18				
BF	50	50	50	200
VAF	50	50	50	130
TF	30.000000E-09	30.000000E-09	30.000000E-09	
500.000000E-12				
	QbreakN-X1			
	NPN			
IS	100.000000E-18			
BF	200			
VAF	130			
TF	500.000000E-12			

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****   SMALL SIGNAL BIAS SOLUTION   TEMPERATURE = 27.000 DEG C
*****
*****

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NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE
( VOUT)	1.3926	(\$N_0001)	0.0000			(\$N_0002)	
-.6958							
(\$N_0003)	-5.0000			(\$N_0004)	1.3926		
(\$N_0005)	5.0000			(\$N_0006)	4.3044		
(\$N_0007)	4.2868						

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VOLTAGE SOURCE CURRENTS
NAME          CURRENT

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V\_VIN -2.408E-07  
 V\_VEE 2.000E-04  
 V\_VCC -1.995E-04

TOTAL POWER DISSIPATION 2.00E-03 WATTS

\*\*\*\* OPERATING POINT INFORMATION TEMPERATURE = 27.000 DEG C  
 \*\*\*\*\*  
 \*\*\*\*\*

\*\*\*\* VOLTAGE-CONTROLLED VOLTAGE SOURCES

NAME E\_E1  
 V-SOURCE 1.393E+00  
 I-SOURCE -1.393E-03

\*\*\*\* BIPOLAR JUNCTION TRANSISTORS

NAME	Q_Q3	Q_Q4	Q_Q5	Q_Q1	Q_Q2
MODEL	QbreakP-X	QbreakP-X1	QbreakP-X2	QbreakN-X	QbreakN-X1
IB	-9.57E-07	-9.57E-07	-1.89E-06	2.41E-07	2.41E-07
IC	-4.78E-05	-4.79E-05	-1.00E-04	4.98E-05	4.98E-05
VBE	-6.96E-01	-6.96E-01	-7.13E-01	6.96E-01	6.96E-01
VBC	0.00E+00	1.76E-02	2.89E+00	-4.30E+00	-4.29E+00
VCE	-6.96E-01	-7.13E-01	-3.61E+00	5.00E+00	4.98E+00
BETADC	5.00E+01	5.00E+01	5.29E+01	2.07E+02	2.07E+02
GM	1.85E-03	1.85E-03	3.86E-03	1.92E-03	1.92E-03
RPI	2.70E+04	2.70E+04	1.37E+04	1.07E+05	1.07E+05
RX	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RO	1.05E+06	1.05E+06	5.29E+05	2.70E+06	2.70E+06
CBE	5.55E-11	5.55E-11	1.16E-10	9.62E-13	9.62E-13
CBC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CJS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BETAAC	5.00E+01	5.00E+01	5.29E+01	2.07E+02	2.07E+02
CBX/CBX2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FT/FT2	5.30E+06	5.30E+06	5.30E+06	3.18E+08	3.18E+08

\*\*\*\* SMALL-SIGNAL CHARACTERISTICS

V(VOUT)/V\_VIN = 5.181E+04  $\leftarrow$   $A_o$   
 INPUT RESISTANCE AT V\_VIN = 2.137E+05  $\leftarrow$   $R_{in}$   
 OUTPUT RESISTANCE AT V(VOUT) = 0.000E+00  $\leftarrow$   $R_{out}$

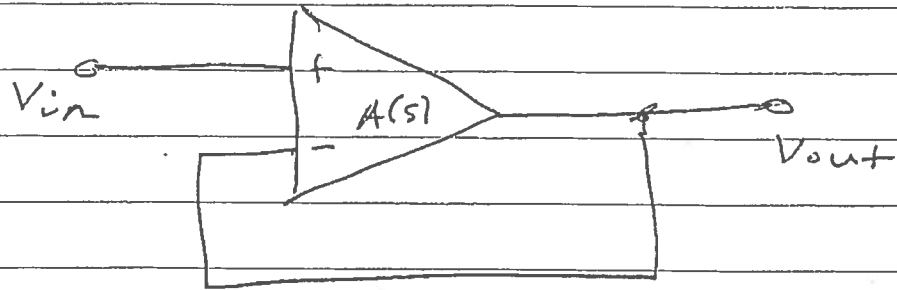
JOB CONCLUDED  
 TOTAL JOB TIME

.03

↑  
TF Analysis



3.



$$a.) A_f(s) = \frac{A(s)}{1 + A(s)} = \frac{1}{1 + s/\omega_E}$$

$$A_f(s) = \frac{1}{1 + s/2\pi(1.06\text{MHz})}$$

b.) SS - step response  $\Rightarrow$

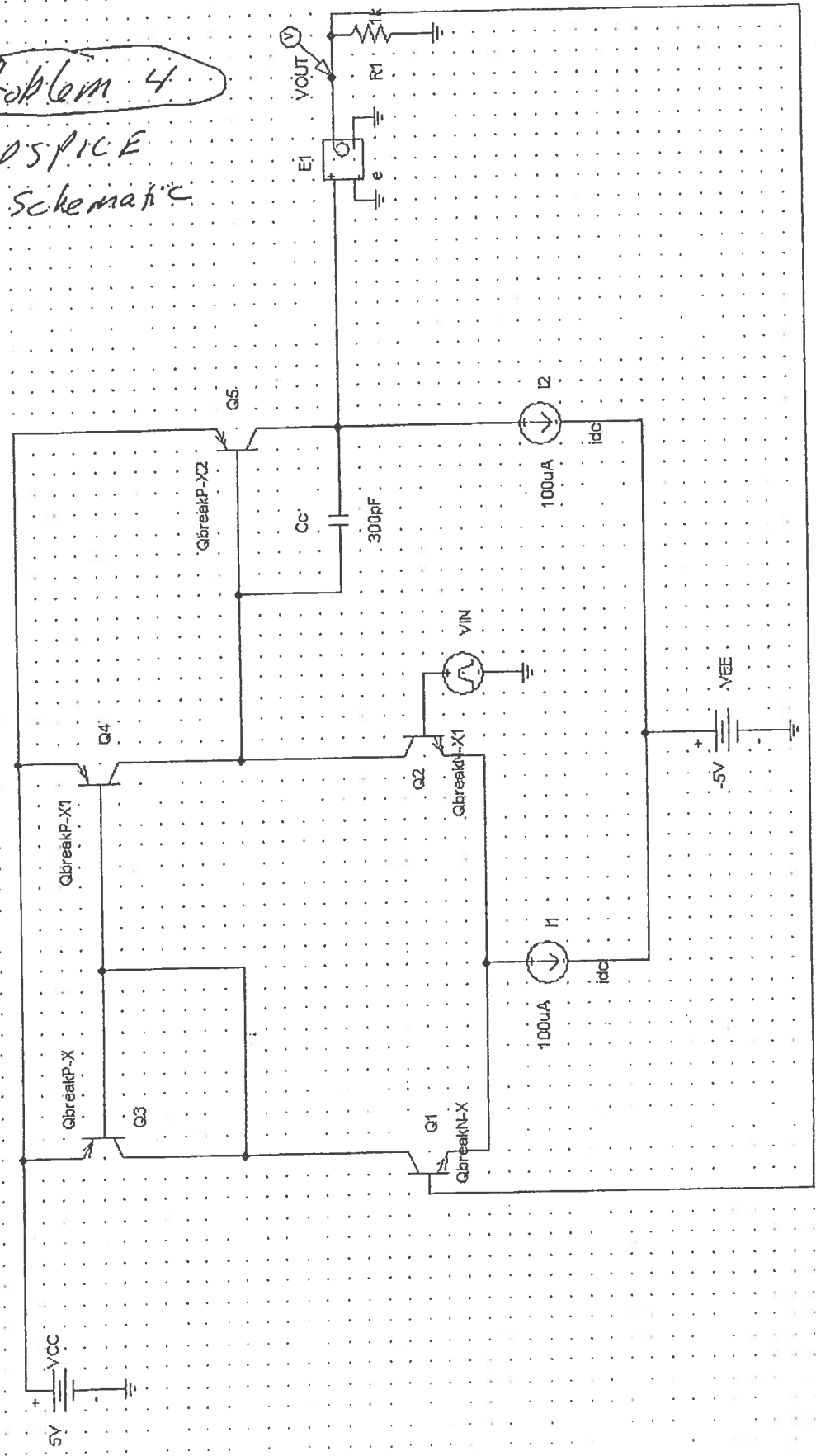
$$\tau = \frac{1}{\omega_E} = .15 \mu\text{s}$$

c.) LS - step response  $\Rightarrow$

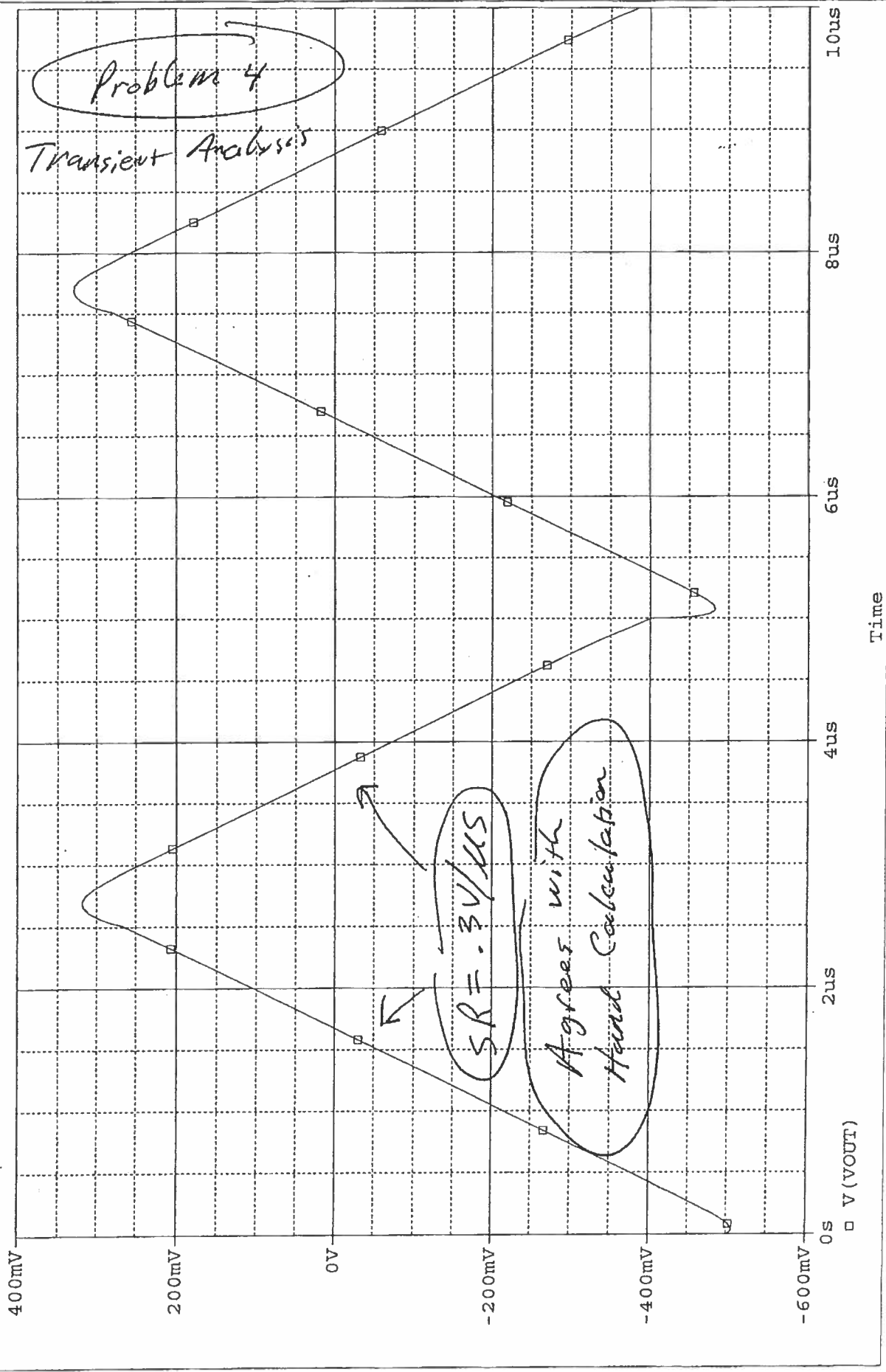
$$SR = \frac{I_{ol}}{C_c} = .33 \text{V}/\mu\text{s}$$



Problem 4  
PSPICE  
Schematic



(A) hw7.dat (active)



\* U:\electrical\_engineering\oster\pspice\ee352\spring12\hw7\hw7.sch  
Date/Time run: 04/02/12 11:52:16

Temperature: 27.0

(A) hw7.dat (active)

