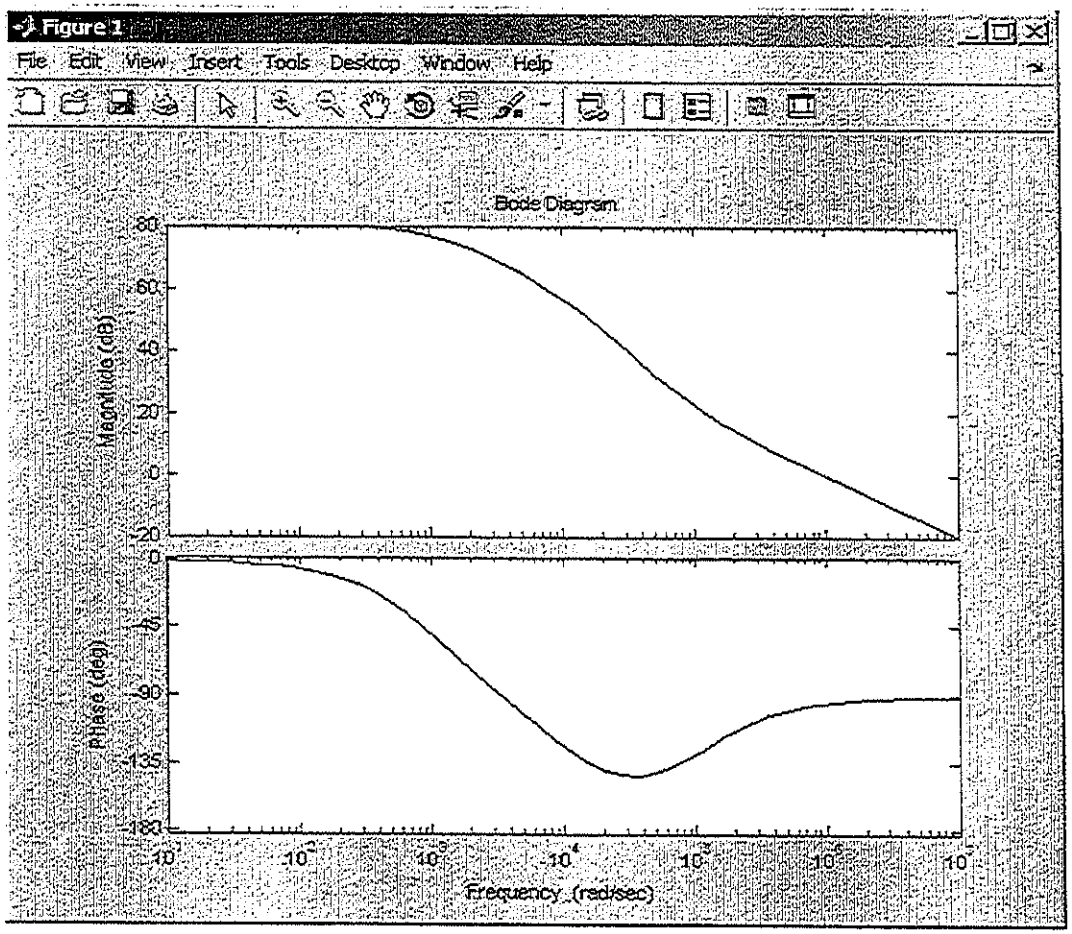
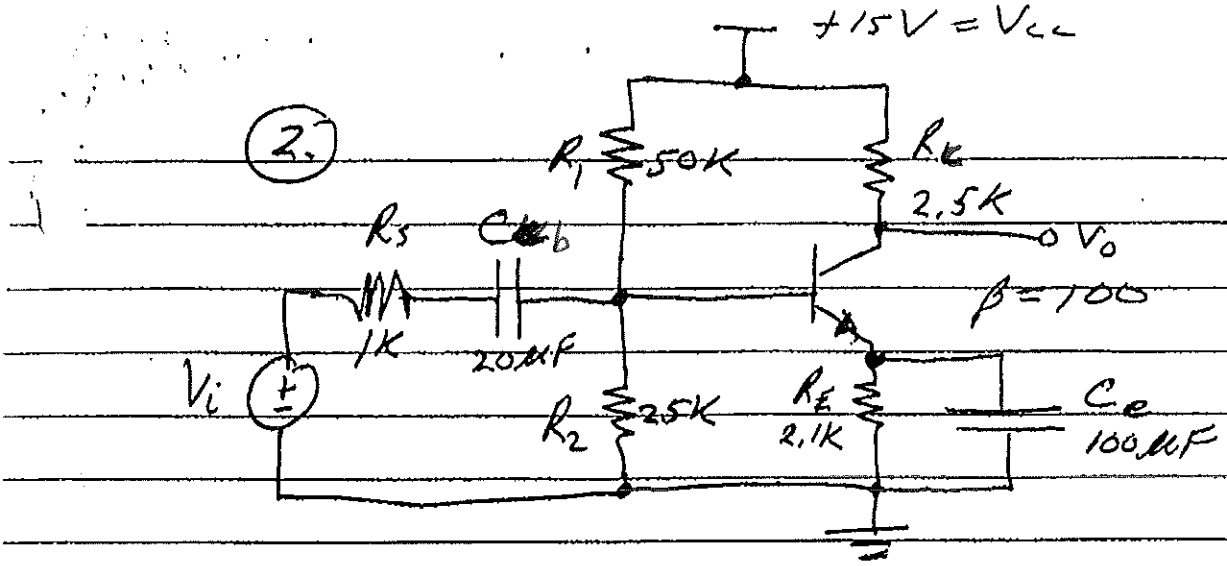
```
>> s=tf('s')

Transfer function:
s

>> T=(1e4*(1+s/1e5))/((1+s/1e3)*(1+s/1e4))

Transfer function:
      0.1 s + 10000
-------------------------
1e-007 s^2 + 0.0011 s + 1

>> bode(T)
>> [mag,phase]=bode(T,1e6)

mag =

    1.0049


phase =

  -95.0804

>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
fx >>
```



EE 352 HW 3 Solutions

1.



a.) DC Analysis:

$$I_E = \frac{V_{BB} - V_{BE_{on}}}{R_E + \frac{R_B}{1+\beta}} = \frac{5V - .7V}{2.1K + \frac{16.7K}{101}} = (1.9mA)$$

$$I_C = \alpha I_E = \frac{100}{101} I_E = (1.88\,mA)$$

$$I_B = I_C/\beta = (18.8\,\mu A)$$

$$V_E = I_E R_E = (3.94\,V)$$

$$V_B = V_E + V_{BE_{on}} = (4.69\,V)$$

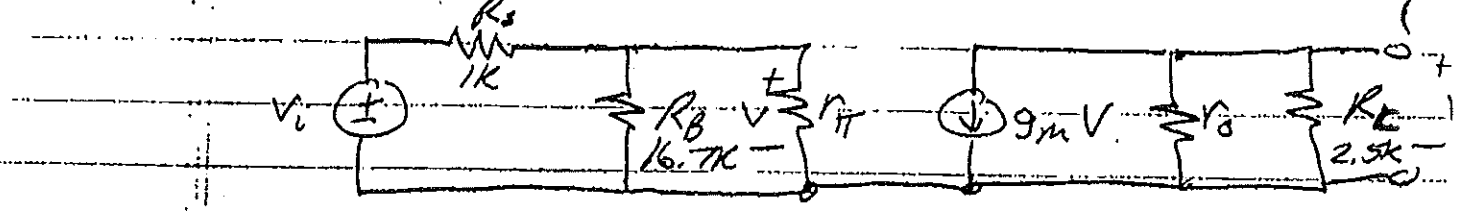
$$V_C = V_{CC} - I_C R_C = 15 - (1.88\,mA)2.5K = (10.3\,V)$$

$$I_{R1} = \frac{V_{CC} - V_B}{R_1} = (.21\,mA)$$

$$I_{R2} = \frac{V_B}{R_2} = (.19\,mA)$$

Yes; Bias Stable to Temp (Beta) due to $V_{BB} >> V_{BE}$; $5V >> .7V$ and to β due to $R_E >> \frac{R_B}{1+\beta}$; $2.1K >> \frac{16.7K}{101}$ ✓

b) AC SS Midband Analysis:



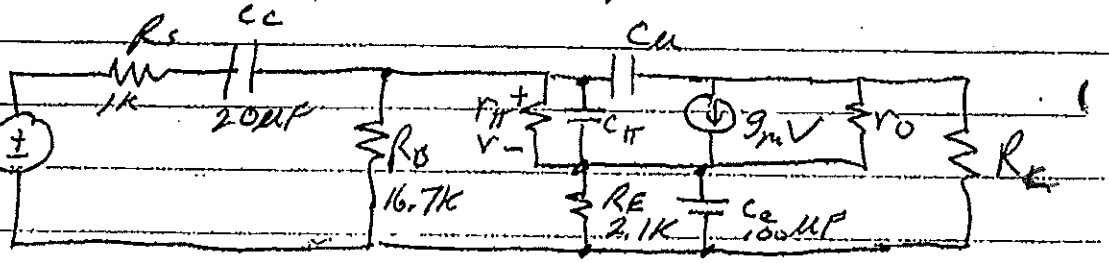
$g_m = \frac{I_c}{V_T} = (.075\ A/V)$; $r_\pi = \frac{\beta}{g_m} = (1330\Omega)$

$r_o = 1/h_{oe} = (66.7K\Omega)$

$A_m \doteq \left|\frac{V_o}{V_i}\right| = \frac{g_m r_\pi // R_B}{r_\pi // R_B + R_s}(r_o // R_c) = (99.7)$

$R_i = R_B // r_\pi = (1.23K\Omega)$ $\quad R_o = r_o // R_c = (2.41K)$

c) AC SS Full Freq Response Analysis:



$C_\mu = C_{obo} = (4pF)$

C_π - recipe

$C_\pi|_{10mA} = \frac{g_m|_{10mA}}{2\pi f_t|_{10mA}} - C_\mu = C_b|_{10mA} + C_{ibe}$

$C_\pi|_{10mA} = \frac{.4\ V/A}{2\pi(300MHz)} - 4pF = 208pF$

$\therefore C_b|_{1mA} = 208pF - 8pF = 200pF$

Scale C_b: $C_b|_{1.88mA} = \frac{1.88}{1.0}(200pF) = 37.6pF$

$\therefore C_\pi|_{1.88mA} = C_\pi = 37.6pF + 8pF = (45.6pF)$

Calculate ω_L using SCTC's:

$$\omega_L \leq \sum \frac{1}{\tau_{js}} = \frac{1}{R_{s_B} C_B} + \frac{1}{R_{c_e} C_e}$$

$$\omega_L \leq \frac{1}{(R_s + r_\pi \| R_B) C_B} + \frac{1}{\frac{R_E (r_\pi + R_s \| R_B) C_e}{r_\pi + R_s \| R_B + (\beta+1) R_E}}$$

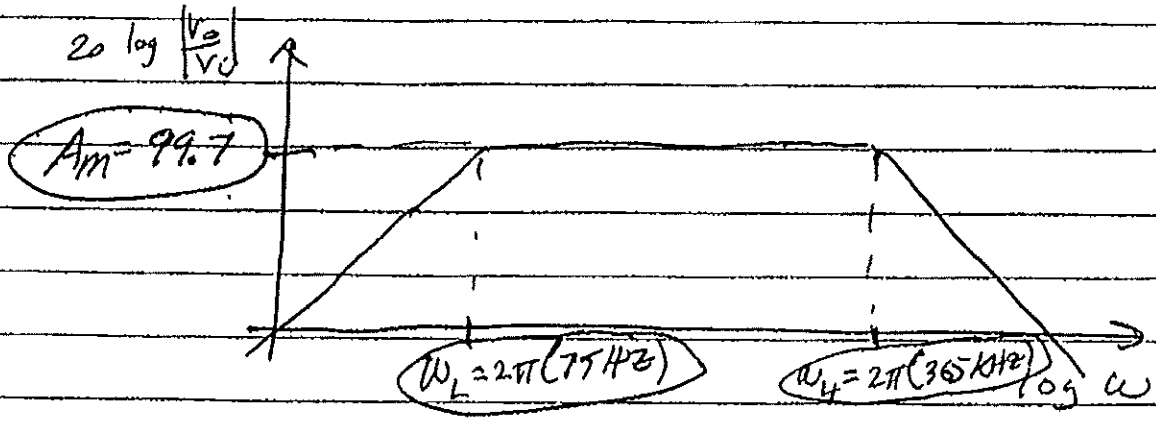
$$\omega_L \approx 2\pi (75\ Hz)$$

$$\omega_H \geq \frac{1}{\sum \tau_{j0}} = \frac{1}{R_{c_\mu} C_\mu + R_{c_\pi} C_\pi}$$

$$\omega_H \approx \frac{1}{(r_\pi \| R_B \| R_s) C_\pi + [r_o \| R_L + r_\pi \| R_B \| R_s (1 + g_m r_o \| R_L)] C_\mu}$$

$$\omega_H \approx 2\pi (365\ KHz)$$

Bode Plot:

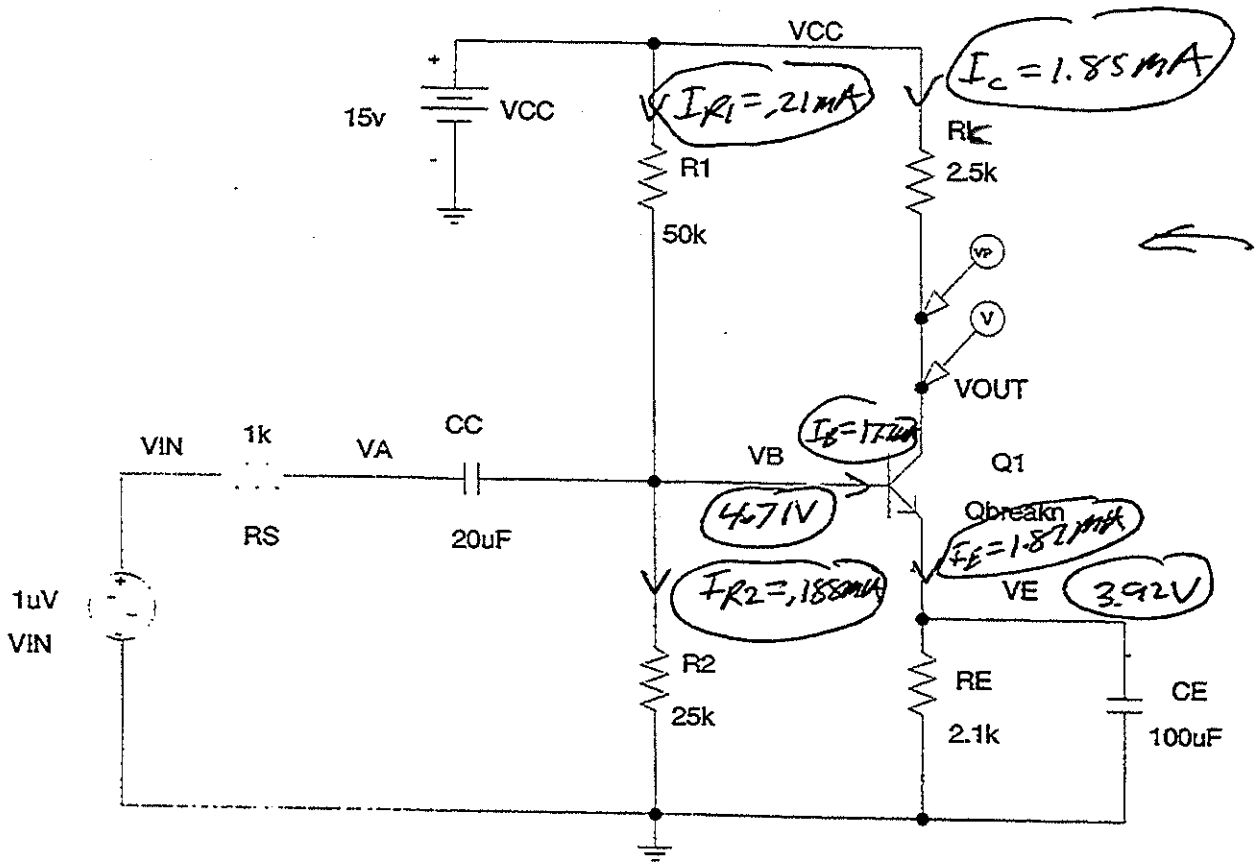


c) $f_t = f_t|_{1.88mA} = \frac{g_m|_{1.88mA}}{2\pi (C_\pi|_{1.88mA} + C_\mu)} = 241\ MHz$

d) $R_{IN} = R_B \| r_\pi = 2.2\ k\Omega$

$R_{OUT} = R_C \| R_L = 2.7\ k\Omega$

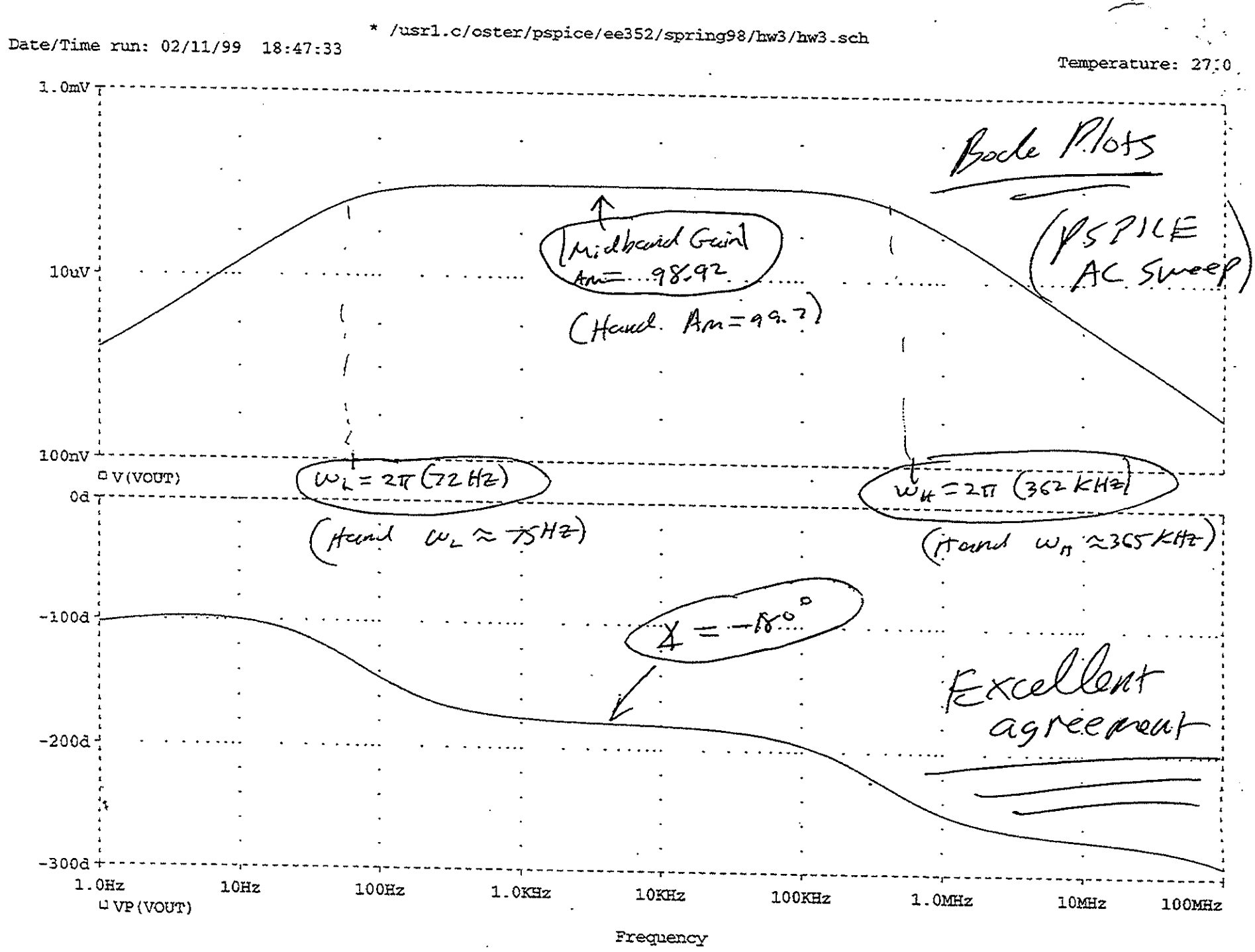
e) $\frac{V_A}{I_C} = \frac{1}{h_{oe}} \Rightarrow V_A = 125\ V$



← PSPICE DC values shown (All agree well with Hand)

2.

PSPICE xxx.sch Schematic


* /usr1.c/oster/pspice/ee352/spring98/hw3/hw3.sch
Date/Time run: 02/11/99 18:47:33
Temperature: 27.0
Bode Plots
(PSPICE AC Sweep)
Midband Gain
Am = 98.92
(Hand. Am = 99.7)
ωL = 2π (72 Hz)
(Hand ωL ≈ 75Hz)
ωH = 2π (362 KHz)
(Hand ωH ≈ 365 KHz)
X = -88°
Excellent agreement
1.0mV
10uV
100nV
V(VOUT)
0d
-100d
-200d
-300d
1.0Hz
10Hz
100Hz
1.0KHz
10KHz
100KHz
1.0MHz
10MHz
100MHz
VP(VOUT)
Frequency

```
**** 02/11/99 18:47:33 ******** PSpice 6.2 (April 1995) ******* ID# 83989 ****
 ****     CIRCUIT DESCRIPTION
********************************************************************************
* Schematics Version 6.2 - April 1995
* Thu Feb 11 18:47:26 1999
** Analysis setup **
.ac DEC 10 1 100MEG
.OP
Q_Q1          VOUT VB VE Qbreakn
R_RL          VOUT VCC  2.5k
R_RE          0 VE  2.1k
R_R2          0 VB  25k
R_R1          VB VCC  50k
R_RS          VA VIN  1k
C_CC          VA VB  20uF
C_CE          0 VE  100uF
V_VIN          VIN 0 DC 0V AC 1uV
V_VCC          VCC 0 15v
.probe
.END
```

PSPICE xxx.out file

```
 ****     BJT MODEL PARAMETERS
********************************************************************************
               Qbreakn
               NPN
          BF   100
         VAF   126
         CJE     8.000000E-12
         MJE     0
         CJC     4.000000E-12
         MJC     0
          TF   500.000000E-12
```

NPN Model Parameters

```
 ****     SMALL SIGNAL BIAS SOLUTION       TEMPERATURE =   27.000 DEG C
********************************************************************************
 NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE
(   VA)     0.0000 (   VB)     4.7054 (   VE)     3.9164 (  VCC)    15.0000
(  VIN)     0.0000 ( VOUT)    10.3820

    TOTAL POWER DISSIPATION   3.08E-02  WATTS

**** BIPOLAR JUNCTION TRANSISTORS
NAME             Q_Q1
MODEL            Qbreakn
IB               1.77E-05
IC               1.85E-03
VBE              7.89E-01
VBC             -5.68E+00
VCE              6.47E+00
BETADC           1.05E+02
GM               7.14E-02
RPI              1.46E+03
RX               0.00E+00
RO               7.13E+04
CBE              4.37E-11
CBC              4.00E-12
CBX              0.00E+00
CJS              0.00E+00
BETAAC           1.04E+02
FT               2.38E+08
```

All agree with Hand

All Agree with Hand values