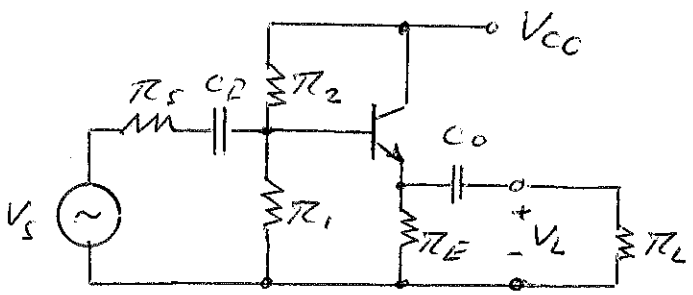
CC Amplifier



Transistor

$\beta = 150$

$V_A = \infty$

$V_{BEQ} \cong 0.7V$

$@ V_T \cong 30mV$

$R_1 = R_2 = 2.2k\Omega$ $\quad R_S = 1k\Omega$ $\quad C_I = 15\mu F$

$R_E = R_L = 100\Omega$ $\quad C_O = 33\mu F$

Find:

- Q-point (I_{CQ}, V_{CEQ}) — DC Analysis
- $A_V = \frac{V_L}{V_S}$ — Ac Analysis
- $A_I = \frac{i_L}{i_b}$ — Ac Analysis

Step 1: DC Analysis

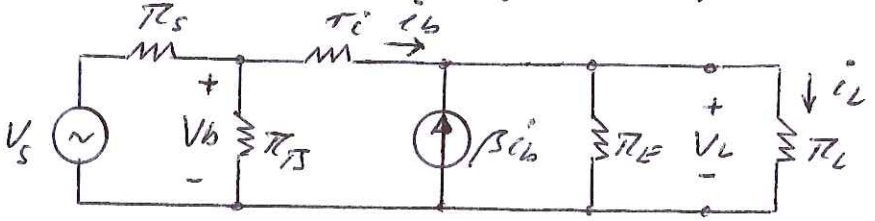
$$I_{CQ} = \frac{V_{CC}\frac{R_1}{R_1+R_2} - V_{BEQ}}{\frac{R_B}{\beta} + (1+\frac{1}{\beta})R_E} \cong 39.8mA$$

$$V_{CEQ} = V_{CC} - I_{CQ}(1+\tfrac{1}{\beta})R_E \cong 6V$$

$$R_B = R_1 \| R_2 = 1.1k\Omega$$

Step 2: AC Analysis (caps act as shorts)

Small signal eq. Circuit



$r_i = \frac{\beta}{g_m} \cong 113\,\Omega$

Equations

(1) $V_b = i_b r_i + (1+\beta) i_b \tilde{R}_L$

(2) $V_L = (1+\beta) i_b \tilde{R}_L$

$\tilde{R}_L = R_E \| R_L = 50\,\Omega$

$\therefore \quad \frac{V_L}{V_b} = \frac{(1+\beta)\tilde{R}_L}{r_i + (1+\beta)\tilde{R}_L}$

Def $r_{in} = R_B \| \frac{V_b}{i_b}$

$\therefore \; r_{in} = R_B \| (r_i + [1+\beta]\tilde{R}_L) \cong 962\,\Omega$

Thus $V_b = V_s \frac{r_{in}}{R_s + r_{in}}$ (voltage divider)

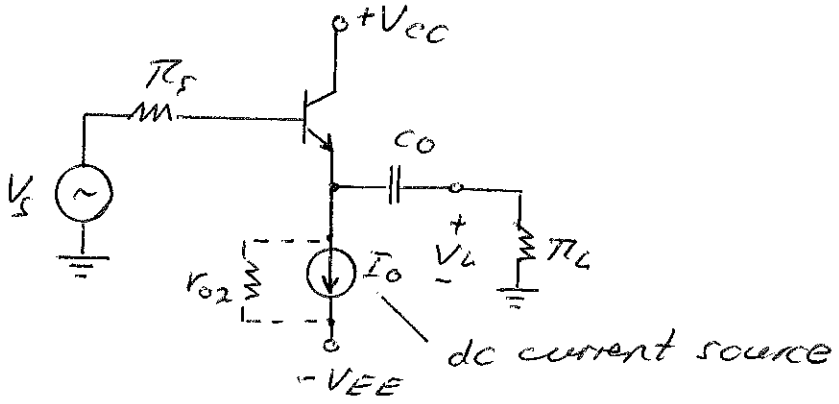
and $A_V = \frac{V_L}{V_s} = \underbrace{\frac{r_{in}}{R_s + r_{in}}}_{0.49} \times \underbrace{\frac{(1+\beta)\tilde{R}_L}{(r_i + [1+\beta]\tilde{R}_L)}}_{0.99} \cong 0.48$

Note: Most of the voltage loss occurs in the voltage divider stage between r_{in} and R_s.

$$\| A_I = \frac{i_L}{i_b} = (1+\beta)\frac{r_E}{r_E + r_L} \cong 76 \|$$

Conclusions:
- To improve voltage gain (i.e. reduce loss), we have to increase r_{in} over r_s
- To increase current gain, we have to increase r_E over r_L

Improved Circuit:



Note: This circuit requires a bipolar supply (e.g. ±5V for V_{CC} and V_{EE}, respectfully)

The current source I_o establishes the Q-point current I_{EQ}, that is $I_{CQ} = I_o\left(1 - \frac{1}{\beta}\right)$. The source resistor r_{o2} acts as r_E.

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CC Amplifier with active Load

.model mod1 npn (bf=180 is=100f nf=1.2 va=80)
.model mod2 pnp (bf=180 is=100f nf=1.2 va=40)

.MODEL Q2N3904 NPN (Is=6.734f Xti=3 Eg=1.11 Vaf=74.03 Bf=416.4 Ne=1.259
+       Ise=6.734f Ikf=66.78m Xtb=1.5 Br=.7371 Nc=2 Isc=0 Ikr=0 Rc=1
+       Cjc=3.638p Mjc=.3085 Vjc=.75 Fc=.5 Cje=4.493p Mje=.2593 Vje=.75
+       Tr=239.5n Tf=301.2p Itf=.4 Vtf=4 Xtf=2 Rb=10)

.MODEL Q2N3906 PNP ((Is=1.41f Xti=3 Eg=1.11 Vaf=18.7 Bf=180.7 Ne=1.5 Ise=0
+       Ikf=80m Xtb=1.5 Br=4.977 Nc=2 Isc=0 Ikr=0 Rc=2.5 Cjc=9.728p
+       Mjc=.5776 Vjc=.75 Fc=.5 Cje=8.063p Mje=.3677 Vje=.75 Tr=33.42n
+       Tf=179.3p Itf=.4 Vtf=4 Xtf=6 Rb=10)

VCC 1   0  dc  5
VEE 6   0  dc -5

*Current source for Ie=37mA
RB2   0   4   330
RB1   4   6   100
RE2   5   6   10
Q2    3   4   5   q2n3904

Vs   8   0  dc 0 ac 1 sin(0,3.5,1k)
Rs   8   2  1k
Co   3   7  15u
RL   7   0  100

Q1   1   2   3   q2n3904

.opt probe post=1
.op
.ac dec 20 10 10meg
.tran 2u 4m 2m
.four 1k v(7)
.print tran v(2) v(3) v(7)
.print ac  vm(7) vp(7)
.end
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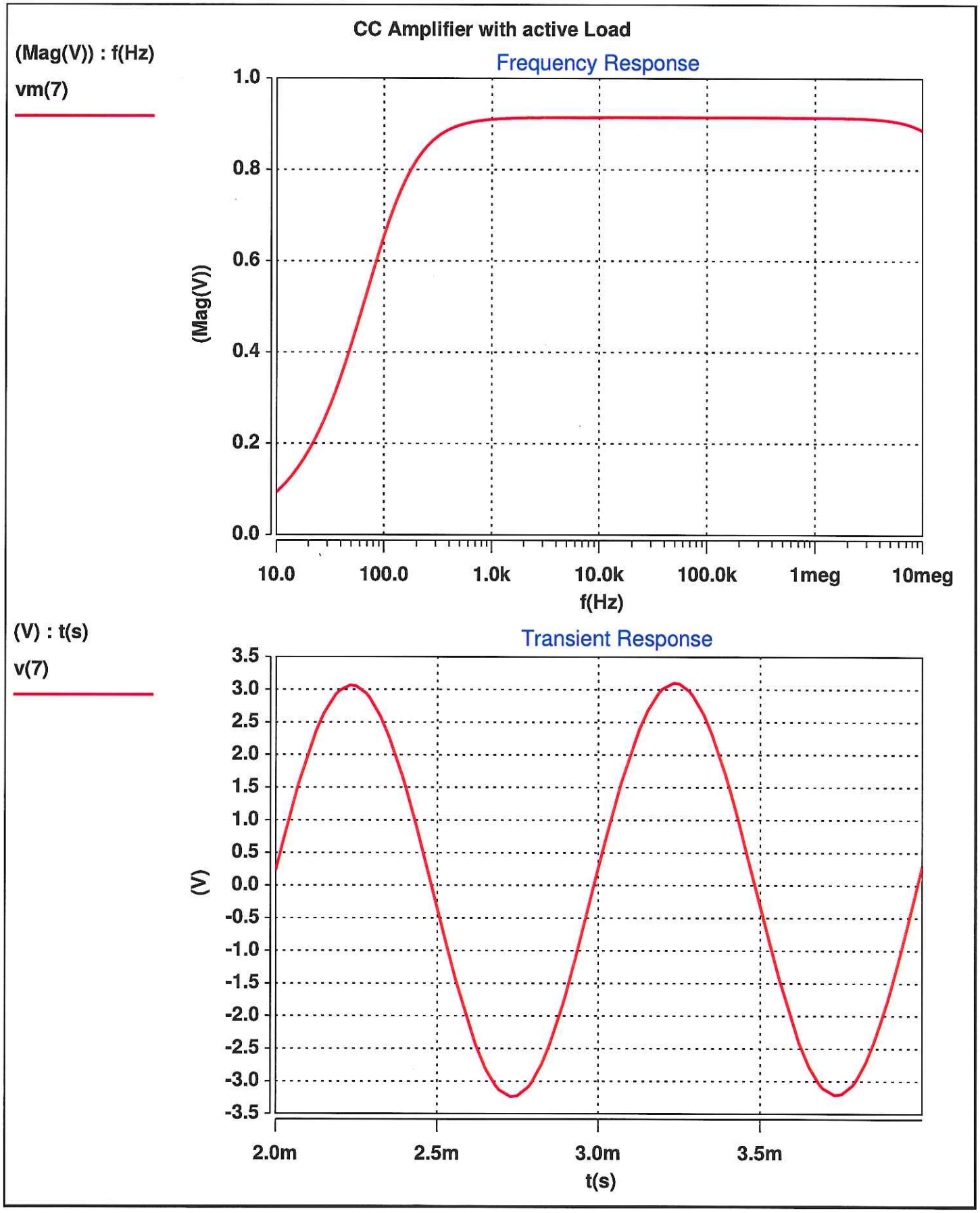
CC Amplifier with active Load
(Mag(V)) : f(Hz)
vm(7)
Frequency Response
1.0
0.8
0.6
0.4
0.2
0.0
(Mag(V))
10.0
100.0
1.0k
10.0k
100.0k
1meg
10meg
f(Hz)
(V) : t(s)
v(7)
Transient Response
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
(V)
2.0m
2.5m
3.0m
3.5m
t(s)