EE230 Analog Lab

Experiment - 3

BJT Voltage Amplifiers (CE and CC)

Report by Prasann Viswanathan - 190070047

1. Common Emitter Amplifier (Biasing Circuit - DC Analysis)

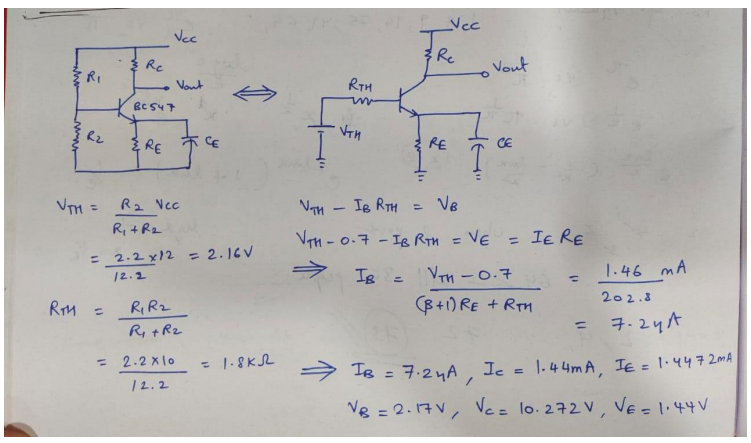
a. ngspice code:

```
Prasann Viswanathan 190070047 Common Emitter

.model bc547a NPN IS=10f BF=200 ISE=10.3f IKF=50m NE=1.3
+ BR=9.5 VAF=80 IKR=12m ISC=47p NC=2 VAR=10 RB=280 RE=1 RC=40
+ tr=0.3u tf=0.5n cje=12p vje=0.48 mje=0.5 cjc=6p vjc=0.7 mjc=0.33 kf=2f

q1 c b e bc547a
vc 3 c 0
vb 2 b 0
ve e 1 0
vcc 4 0 12
re 1 0 1k
rc 4 3 1.2k
r1 4 2 10k
r2 2 0 2.2k

*analysis commands
.op
.control
run

*display commands
print i(vb) i(vc) v(b) v(c) v(e)
.endc
```

b. Results

```
i(vb) = 1.125128e-05
i(vc) = 1.462975e-03
v(b) = 2.143645e+00
v(c) = 1.024443e+01
v(e) = 1.474226e+00
```

c. Learning Outcomes



We see that there are some mismatches between calculated and experimental values, and this is because our assumption of Vbe drop being 0.7 is not accurate, and causes the mismatch.

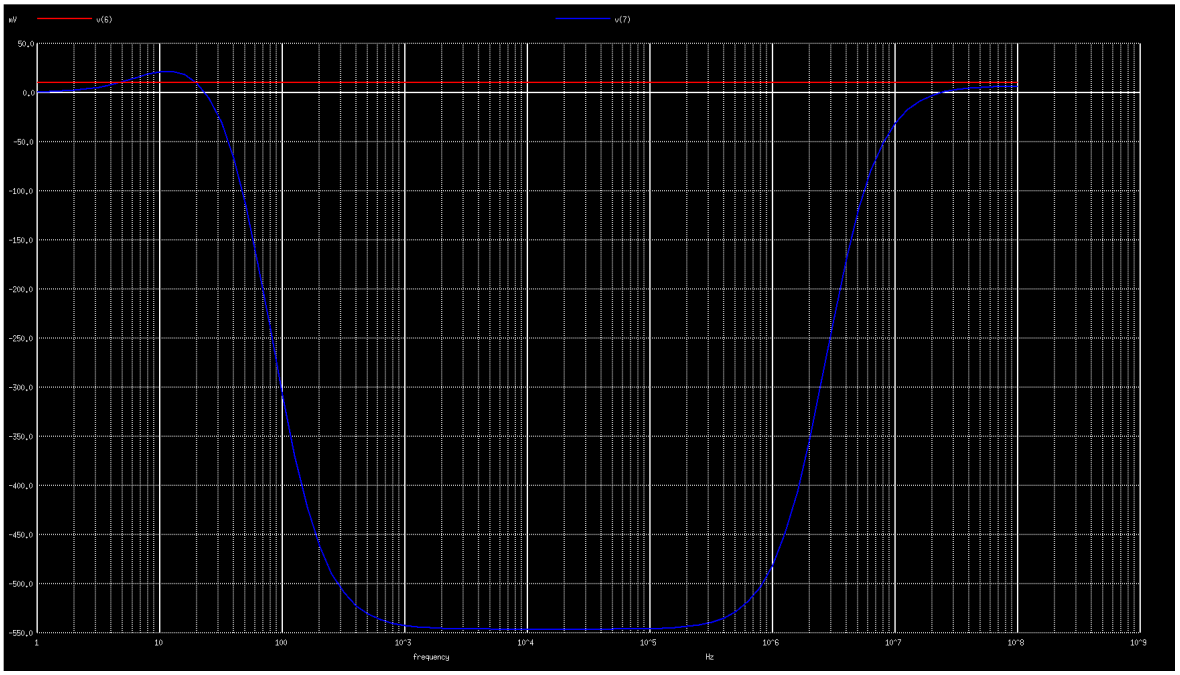
I also learnt to evaluate the DC operating point parameters (Ib , Ic , Ie) and how application of Thevenin's theorem can help.

2. Common Emitter Amplifier with C_E capacitor (Midband gain)

a. ngspice code:

```
Prasann Viswanathan 190070047 Common Emitter Analysis

.model bc547a NPN IS=10f BF=200 ISE=10.3f IKF=50m NE=1.3
+ BR=9.5 VAF=80 IKR=12m ISC=47p NC=2 VAR=10 RB=280 RE=1 RC=40
+ tr=0.3u tf=0.5n cje=12p vje=0.48 mje=0.5 cjc=6p vjc=0.7 mjc=0.33 kf=2f

q1 3 2 1 bc547a
vin 6 0 dc 0 ac 0.01
vcc 4 0 12
re 1 0 1k
rl 7 0 100k
rc 4 3 1.2k
rs 6 5 0
r1 4 2 10k
r2 2 0 2.2k
c1 5 2 10u
c2 3 7 10u
ce 1 0 100u

*analysis commands
.ac dec 10 1 100000k
.control
run

*display commands
plot v(6) v(7)
.endc
.end
```

b. Results



(We can see that the Midband gain is roughly -54, or 34.6 dB from both the plots.)

c. Learning outcomes

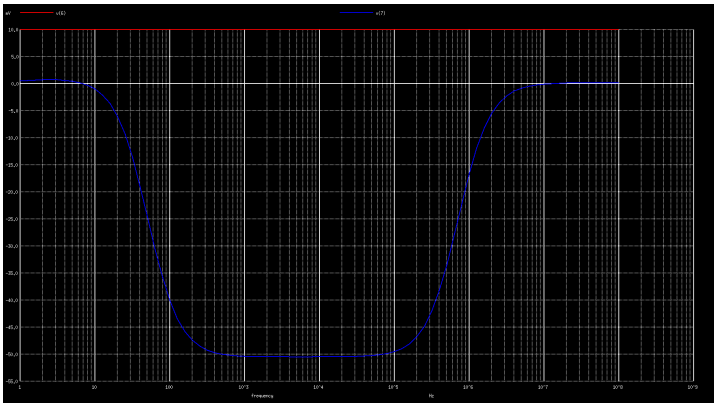
The gain that we calculate using small signal analysis, is only valid over a certain range of frequencies (midband), say from f_L to f_H , and the gain decreases on frequencies less than f_L & greater than f_H

3. Common Emitter effect of Rl Rs on Midband Gain

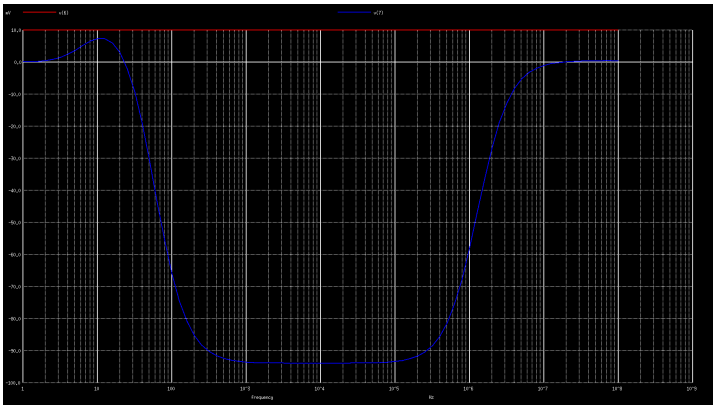
a. ngspice code:

```
Prasann Viswanathan 190070047 Common Emitter RL RS

.model bc547a NPN IS=10f BF=200 ISE=10.3f IKF=50m NE=1.3
+ BR=9.5 VAF=80 IKR=12m ISC=47p NC=2 VAR=10 RB=280 RE=1 RC=40
+ tr=0.3u tf=0.5n cje=12p vje=0.48 mje=0.5 cjc=6p vjc=0.7 mjc=0.33 kf=2f

q1 3 2 1 bc547a
vin 6 0 dc 0 ac 0.01
vcc 4 0 12
re 1 0 1k
rl 7 0 12k
rc 4 3 1.2k
rs 6 5 10k
r1 4 2 10k
r2 2 0 2.2k
c1 5 2 10u
c2 3 7 10u
ce 1 0 100u

*analysis commands
.ac dec 10 1 100000k
.control
run

*display commands
plot v(6) v(7)
.endc
.end
```

b. Results



Rs = 10k, Rl = 12k



Rs = 2.2k, Rl = 1.2k

We can see that as we increase the value of R_L , the midband gain increases. On the other hand, as we increase the value of R_S , the midband gain decreases.

c. Learning outcomes

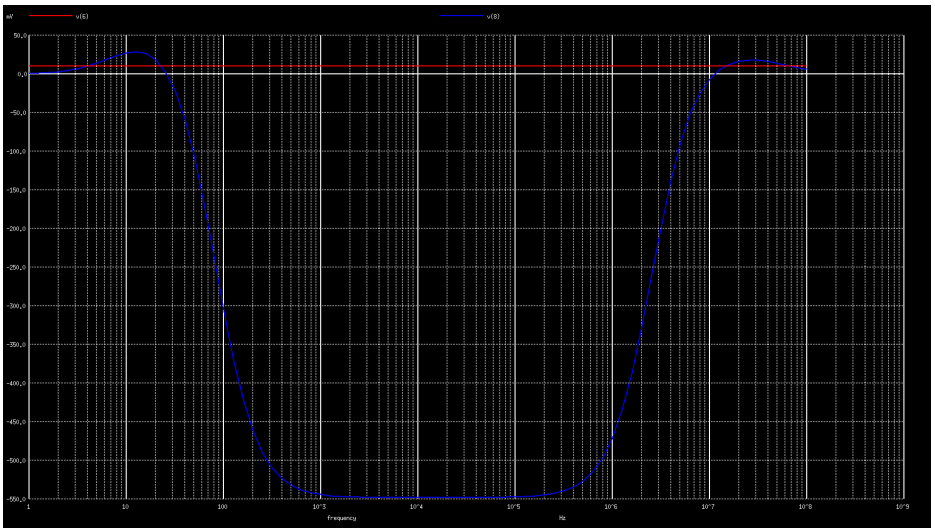
Ideally, R_L should be infinity and R_S should be zero. However, practically, $R_L < \infty$ & $R_S > 0$.

4. Two-stage Amplifier (CE and CC)

a. ngspice code:

```
Prasann Viswanathan 190070047 TwoStage CECC Amplifier

.model bc547a NPN IS=10f BF=200 ISE=10.3f IKF=50m NE=1.3
+ BR=9.5 VAF=80 IKR=12m ISC=47p NC=2 VAR=10 RB=280 RE=1 RC=40
+ tr=0.3u tf=0.5n cje=12p vje=0.48 mje=0.5 cjc=6p vjc=0.7 mjc=0.33 kf=2f

q1 3 2 1 bc547a
q2 4 b2 9 bc547a
vin 6 0 dc 0 ac 0.01
vcc 4 0 12
re 1 0 1k
rl 8 0 10k
rc 4 3 1.2k
rs 6 5 0
r1 4 2 10k
r2 2 0 2.2k
c1 5 2 10u
c2 9 8 10u
ce 1 0 100u
vb2 3 b2 0
ve2 9 7 0
re2 7 0 10k

*analysis commands
*.op
.ac dec 10 1 100000k
.control
run

*display commands
*print i(vb2) i(ve2)
plot v(6) v(8)
.endc
.end
```

b. Results



c. Learning outcomes

For reasonable R_L values, the gain of the amplifier comes out to be the product of the gains of the two independent amplifiers. Cascading the two amplifiers gives us the benefit of both of the amplifiers, high gain from the CE amplifier and low output resistance from the CC amplifier.