EE 230 Experiment 3

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August 4, 2021

1 Common-Emitter Amplifier: Biasing Circuit

NGSPICE code fot the simulation is

```
190020039 Dhruv Shah CE Biasing Circuit

.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

Vcc 1 0 12
R1 2 1 10k
R2 2 0 2.2k
Rc 1 3 1.2k
Re 4 0 1k
Ce 4 0 100u
Q1 5 6 7 bc547a

* //Dummy Voltages
Vb1 2 6 0
Ve1 7 4 0
Vc1 3 5 0
.op

.control
run
print i(Vb1) i(Vc1) i(Ve1)
print V(5) V(6) V(7)
.endc
```

Theoretical analysis

Taking the thevenin equivalent at the base junction gives

$$\begin{aligned} V_{th} &= V_{cc} * \frac{R_2}{R_1 + R_2} \\ &= 2.16V \\ R_{th} &= R_1 || R_2 \\ &= 1.803k\Omega \end{aligned}$$

Now taking $V_{BE} = 0.7V$

$$\begin{aligned} 2.16 - I_B \cdot 1.803 - 0.7 &= (\beta + 1) \cdot I_B \\ \Rightarrow I_B &= 0.007mA \end{aligned}$$

From I_B, all other parameters can be calculated. They are listed below.

Sr no.	Quantity	Theoretical	Simulated
1	V_C	10.32	10.24
2	V_E	1.40	1.47
3	V_B	2.14	2.14

Learning from the experiment

The simualted results from NGSPICE are in line with the calculated theoretical values. The transistor is in active region.

2 Midband gain of CE Amplifier

Code for midband gain simulation is

```
190020039 Dhruv Shah CE gain

.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

Vcc 1 0 12
R1 2 1 10k
R2 2 0 2.2k
Rc 1 3 1.2k
Re 4 0 1k
Ce 4 0 100u
Q1 5 6 7 bc547a
Vin 8 0 dc 0 ac 10
Rs 8 9 0
C1 9 6 10u
C2 5 10 10u
Rl 10 0 100k
* //Dummy Voltages
Vb1 2 6 0
Ve1 7 4 0
Vc1 3 5 0
.ac dec 10 1 100000meg
.control
run
meas ac peak MAX vdb(10)
meas ac fpeak WHEN vmag(10)=peak
let f3db = peak / sqrt(10)
meas ac f1 WHEN vmag(10)= f3db RISE=1
meas ac f2 WHEN vmag(10)= f3db FALL=1
set hcopypscolor=1
hardcopy q1.ps vdb(10)
plot vdb(10)
.endc
```

Simulation graph obtained is

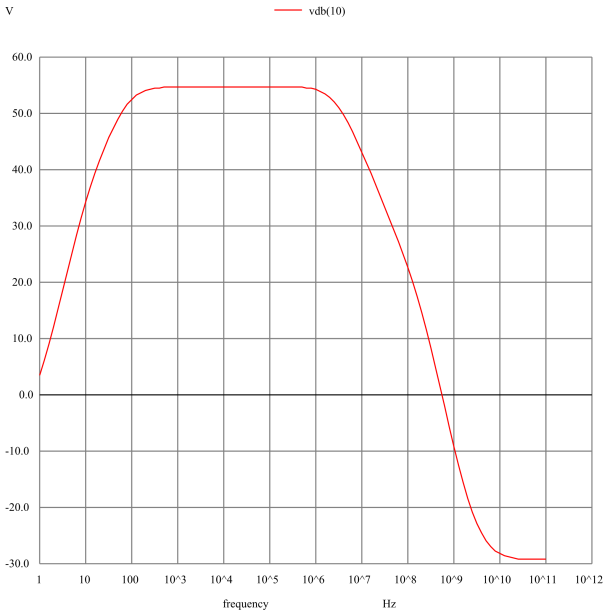


Figure 1: $R_s = 0$ and $R_l = \infty$

Learning from the experiment

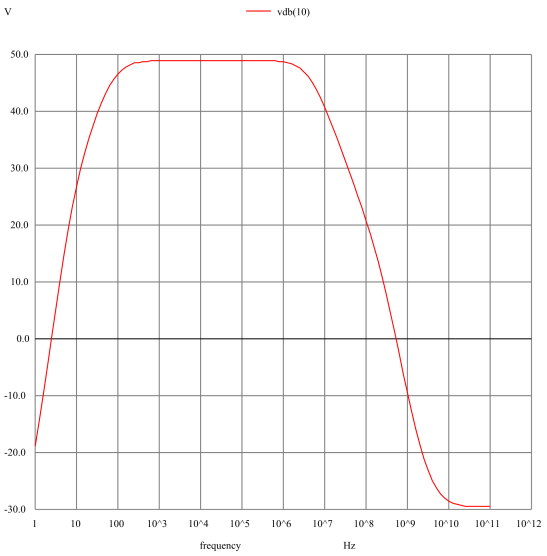
It can be seen that Midband gain is 34dB, f_l is 8 Hz and f_h is 38.1 MHz.

3 Effects of R_s and R_l in midband gain

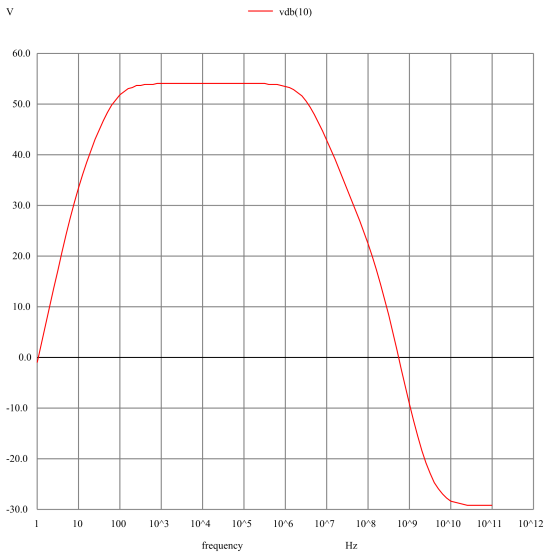
Code for simulation

```
190020039 Dhruv Shah CE_with cap
.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

Vcc 1 0 12
R1 2 1 10k
R2 2 0 2.2k
Rc 1 3 1.2k
Re 4 0 1k
Ce 4 0 100u
Q1 5 6 7 bc547a
Vin 8 0 dc 0 ac 10
C1 9 6 10u
C2 5 10 10u

* Case 2
Rs 8 9 0k
Rl 10 0 12k
* //Dummy Voltages
Vb1 2 6 0
Ve1 7 4 0
Vc1 3 5 0
.ac dec 10 1 100000meg
.control
run
meas ac peak MAX vdb(10)
meas ac fpeak WHEN vmag(10)=peak
let f3db = peak / sqrt(10)
meas ac f1 WHEN vmag(10)= f3db RISE=1
meas ac f2 WHEN vmag(10)= f3db FALL=1
set hcopypscolor=1
hardcopy CE_withcap_case2.ps vdb(10)
plot vdb(10)
.endc
```

The plots are

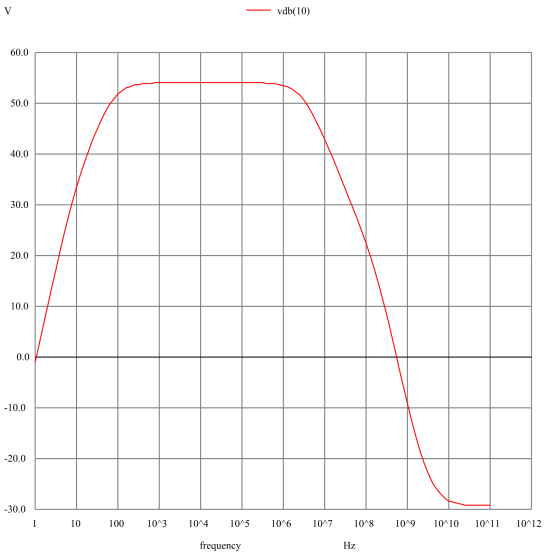


(a) $R_l = 1.2k\Omega$ and $R_s = 0$

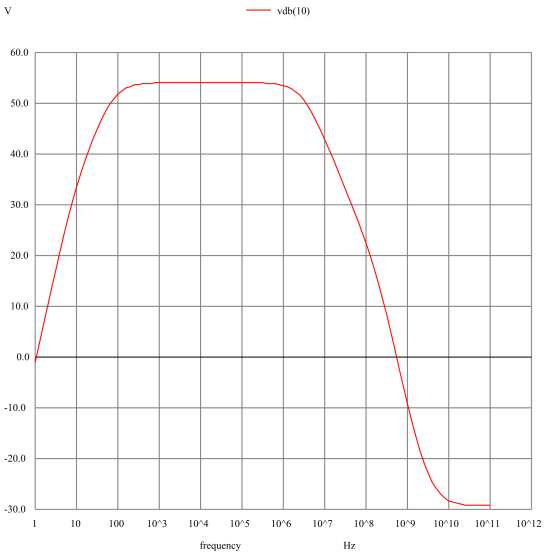


(b) $R_l = 12k\Omega$ and $R_s = 0$

Figure 2: Varying R_l



(a) $R_l = \infty$ and $R_s = 2.2k\Omega$



(b) $R_l = \infty$ and $R_s = 10k\Omega$

Figure 3: Varying R_s

Learning from the experiment

CE amplifiers have low R_{in} and high R_{out} which is not expected behaviour from voltage controlled voltage sources sources.

4 Two stage amplifier

```
190020039 Dhruv Shah Two stage
* //Include models
.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

Vcc 1 0 12
Rc 1 2 1.2k
R1 1 3 10k
R2 3 0 2.2k
Q1 2 3 5 bc547a
Q2 1 2 6 bc547a
Re 5 0 1k
Re2 6 0 10k
Rs 7 4 0
C1 4 3 10u
C2 6 8 10u
RL 8 0 5k
Ce 5 0 100u
Vin 7 0 dc 0 ac 1
.ac dec 10 1 100000meg
.control
run
meas ac peak MAX vdb(8)
meas ac fpeak WHEN vmag(8)=peak
let f3db = peak / sqrt(2)
meas ac f1 WHEN vmag(8)= f3db RISE=1
meas ac f2 WHEN vmag(8)= f3db FALL=1
set hcopypscolor=1
hardcopy two_stage.ps vdb(8)
plot vdb(8)
.endc
```

The circuit parameters obtained from simulation are

Sr no.	Quantity	Simulated Value
1	I_{b2}	0.008 mA
2	I_{e2}	0.95 mA
3	V_{out}	9.5 V

The simulation graph for midband gain is

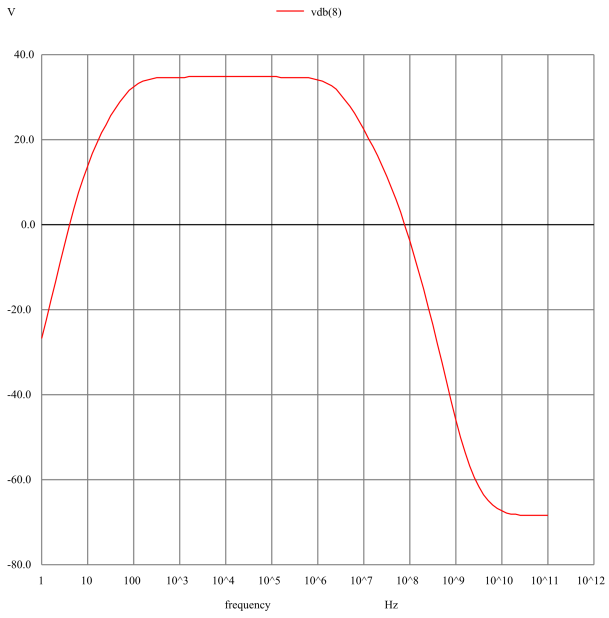


Figure 4: Midband gain of the amplifier

Learning from the experiment

Double stage amplifier performs better than the previous amplifier. It has high R_{in}, low R_{out} and average gain.