Expt 3 – BJT Voltage Amplifiers

EE 230 Analog Circuits Lab

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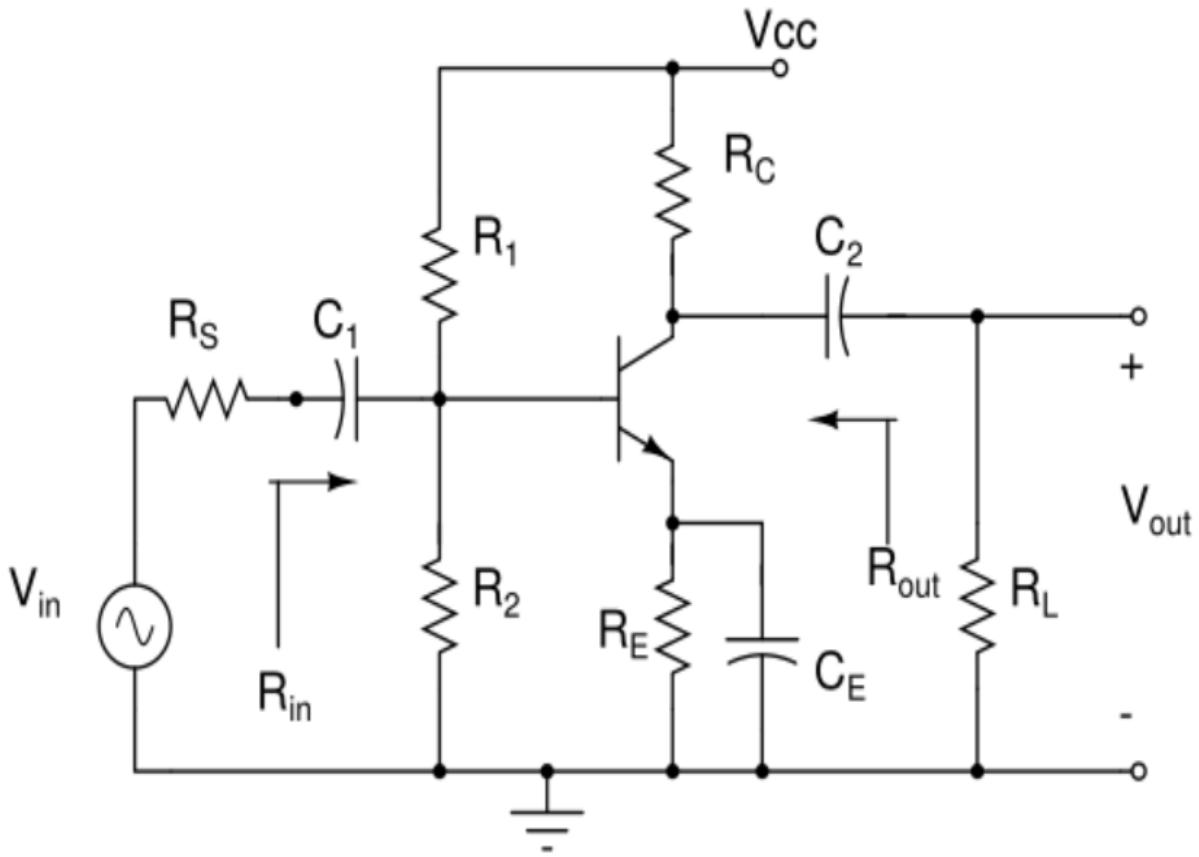
Expt 3 - BJT Voltage Amplifiers

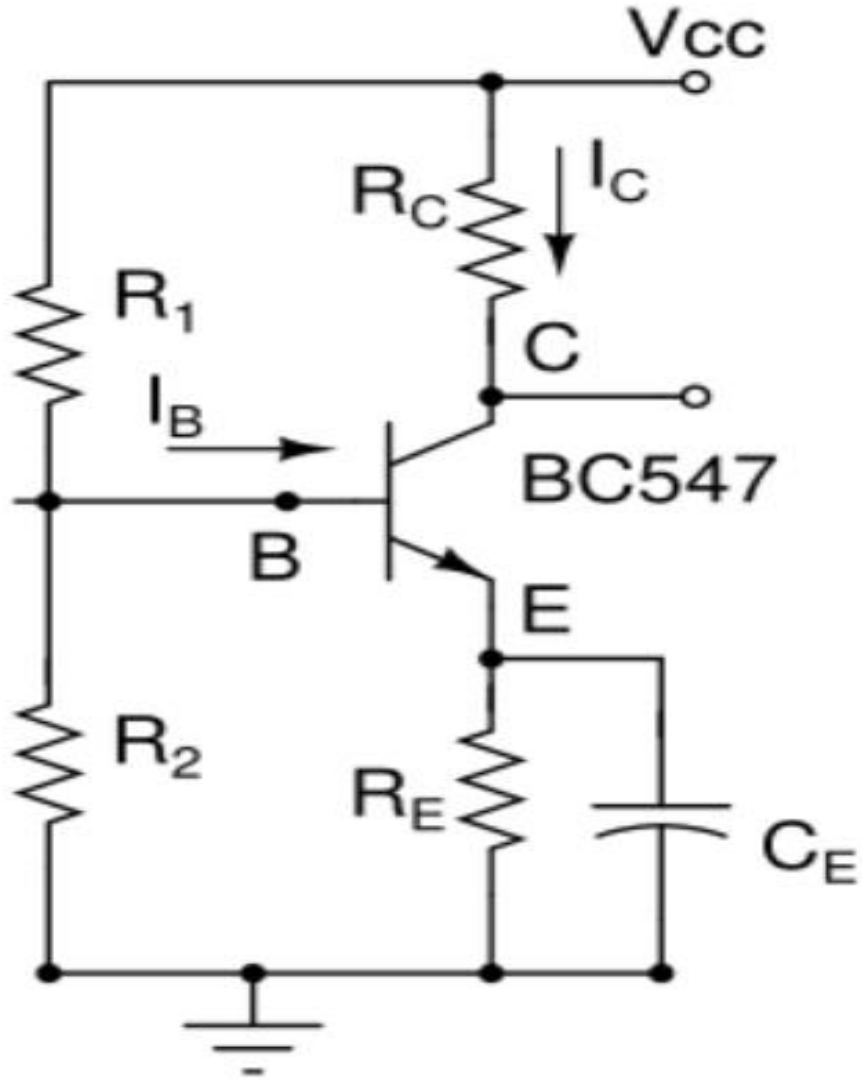
- Part A – Common-Emitter Amplifier
- Part B – Common-Collector Amplifier
- Part C – Two-stage Amplifier (CE + CC)

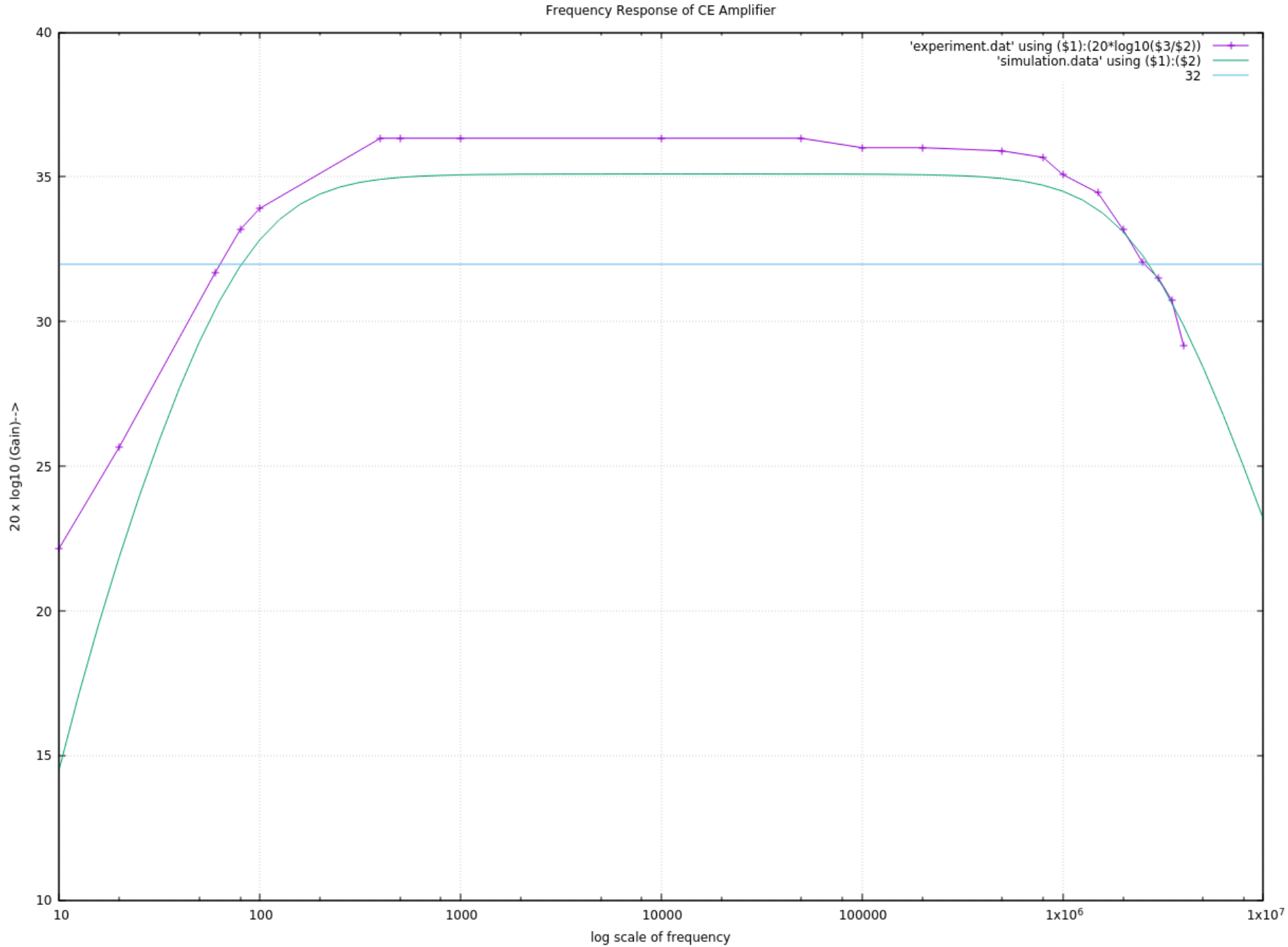
Part A – Common-Emitter Amplifier

- Major Features and Advantages:
  - Single-stage voltage amplifier
  - High voltage gain (50 to 200)
  - Medium input resistance (a few kΩ typ)
  - Medium output resistance (a few kΩ typ)
  - Frequency response – fairly large (tens of Hz to a few MHz)
- Problems
  - Input resistance is low; output resistance is too high
- Applications
  - Can be used as a general purpose voltage amp
  - Most commonly used (because of its simplicity)



- Procedure for analysis
  - Determine IC
  - Determine the small-signal parameters


Vcc
I_C
R_C
R_1
C
I_B
BC547
B
E
R_2
R_E
C_E


Frequency Response of CE Amplifier
'experiment.dat' using ($1):(20*log10($3/$2))
'simulation.data' using ($1):($2)
32
40
35
30
25
20
15
10
20 x log10 (Gain)-->
10
100
1000
10000
100000
1x10^6
1x10^7
log scale of frequency

```
########################################
#  Freq res of CE amplifier            #
#                                      #
########################################
#freq(Hz) Vin(V) Vout(V)
10         0.025    0.32
20         0.025    0.48
60         0.025    0.96
80         0.025    1.14
100        0.025    1.24
400        0.025    1.64
500        0.025    1.64
1000       0.025    1.64
10000      0.025    1.64
50000      0.025    1.64
100000     0.025    1.58
200000     0.025    1.58
500000     0.025    1.56
800000     0.025    1.52
1000000    0.025    1.42
1500000    0.025    1.32
2000000    0.025    1.14
2500000    0.025    1
3000000    0.025    0.94
3500000    0.025    0.86
4000000    0.025    0.720
```

- Midband gain:
  - 65 V/V approx.
  - 36 dB approx.

- Voltage Gain Frequency Response
  - f_L : 80 Hz
  - f_H : 2 MHz

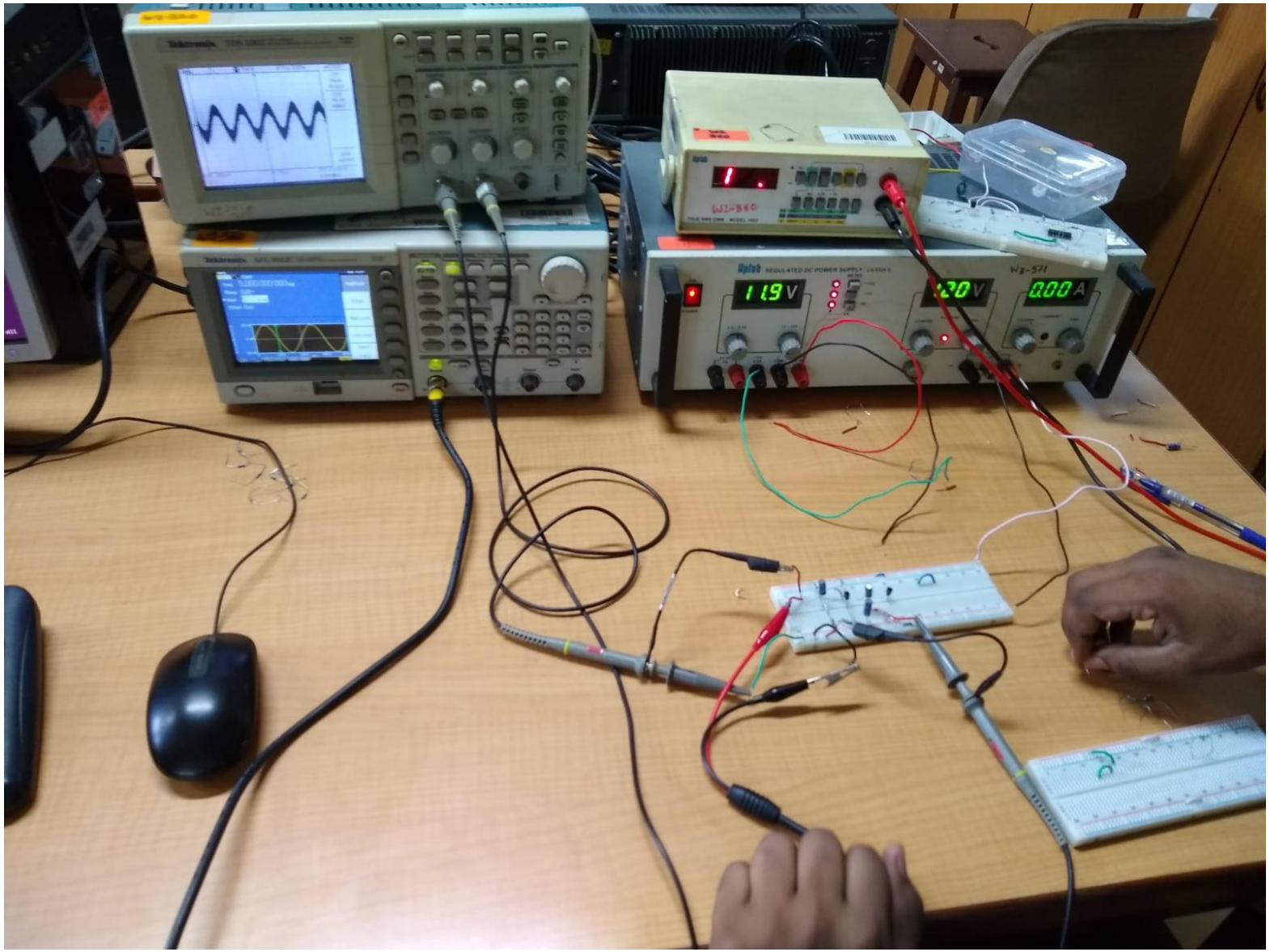
Comparison: Analysis, Simulation and Experiment

- Why there is difference between analysis, simulation and experiment?

- DC biasing
- AC analysis and mesurements

CE Amp - Biasing	Beta=100		
	Analysis	NGSPICE	Expt
VC	10.28		10.1 V
VB	2.13 V		2.15 V
VE	1.43 V		1.51 V

- Naveen and Sarvesh at work in WEL-4 Lab

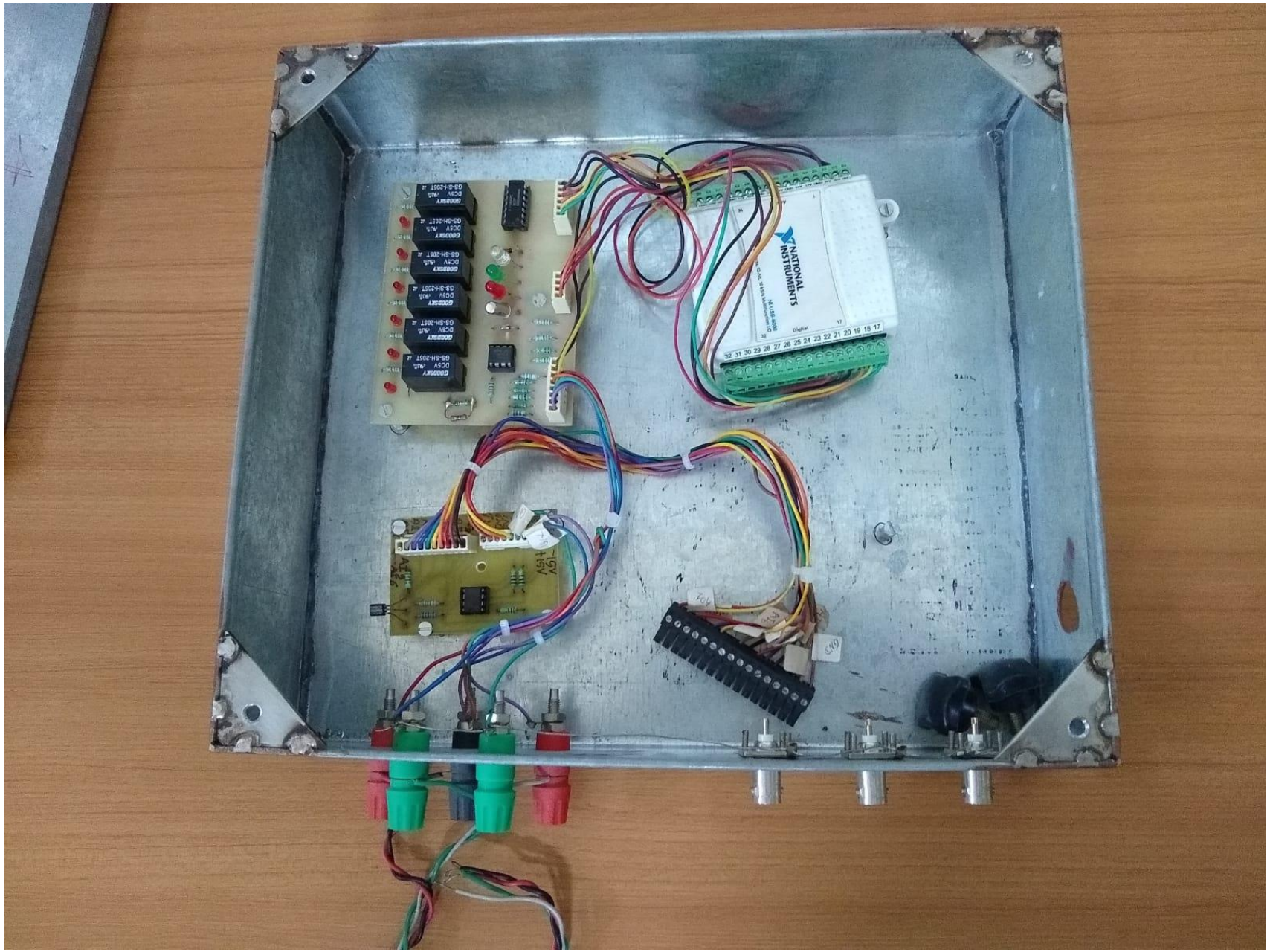


- Common-Emitter Amplifier Experiment

- Note the noisy signals on the DSO

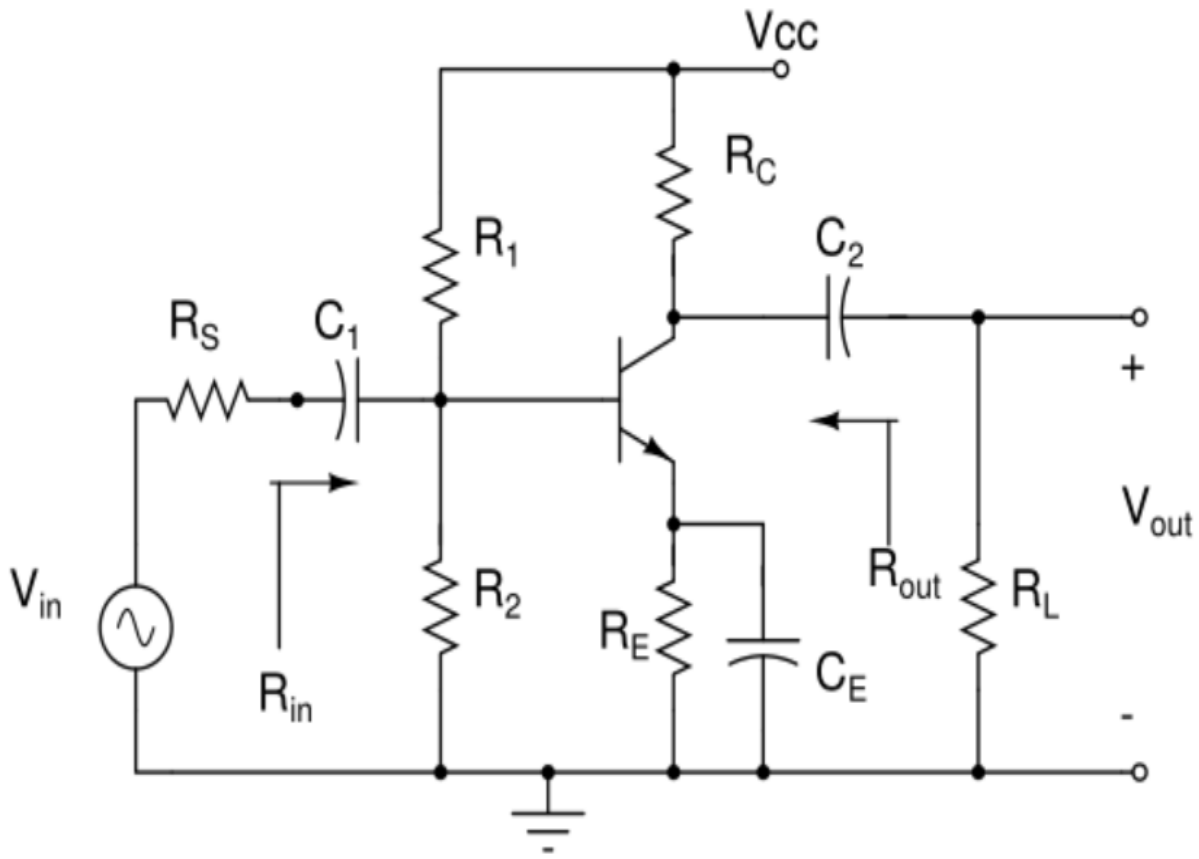
- Vin = 25 mV (p-to-p)
- Vout = 1.6 V (p-to-p)

- A Metal box with the circuit shielded from external interferences
- (Faraday Cage)



- Inside the Faraday cage
- Extremely clean signals
- Required esp for low-level signal measurements

Influence of Load Resistance and Source Resistance

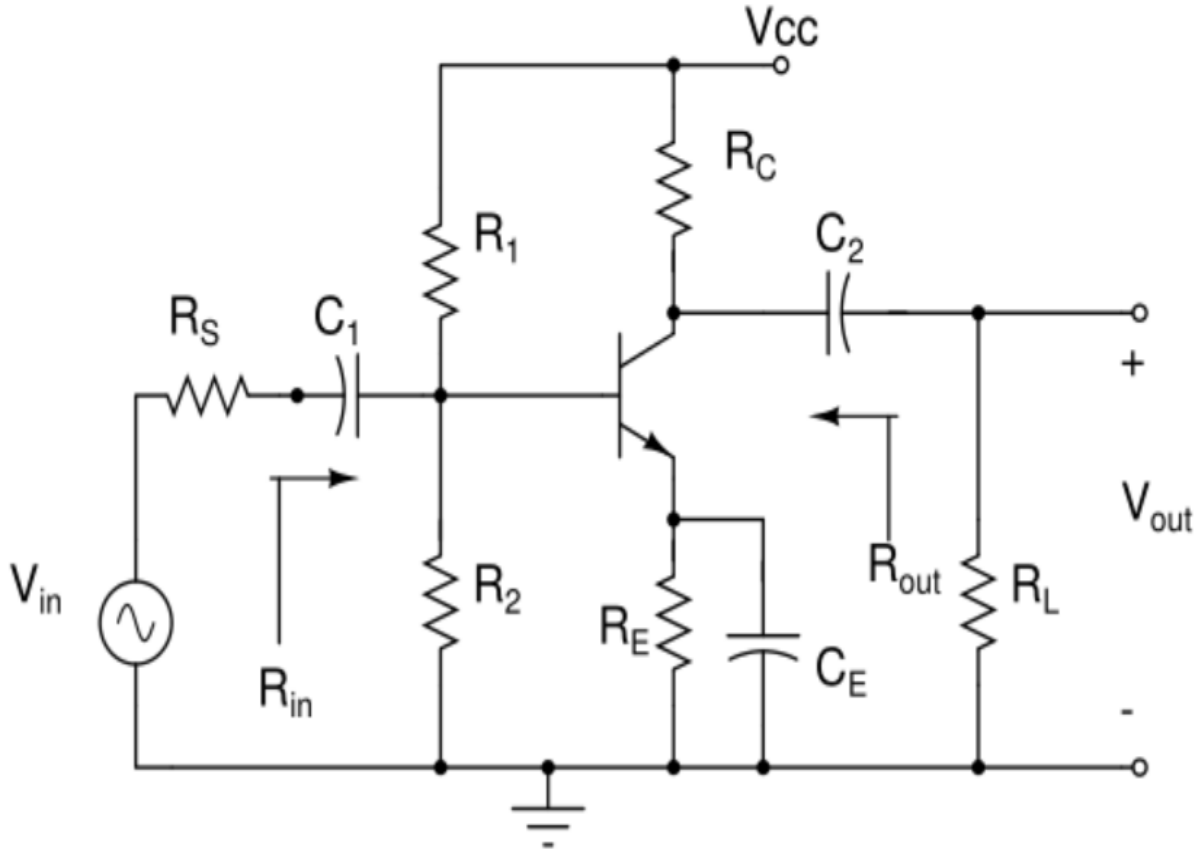


- Amplifier is a Controlled Source
- CE Amp (VCVS)

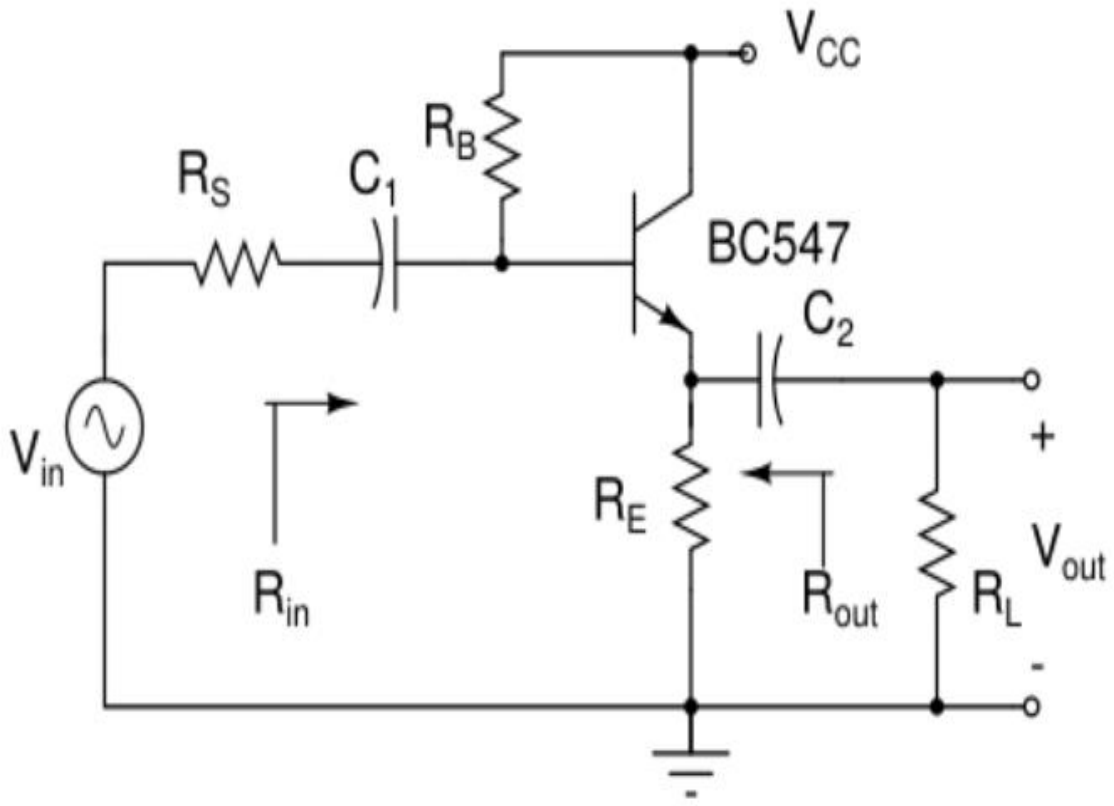
- V_{in} – could be from a sensor
  - R_S could be up to 1 MΩ
- V_{out} may be driving a load
  - R_L could be < 100 Ω

Common-Emitter Amplifier – with CE (bypass Capacitor Open) – Negative Feedback

- Features
  - Gain reduced drastically
- Advantages?
  - Much higher R_{in}
  - Much higher bandwidth

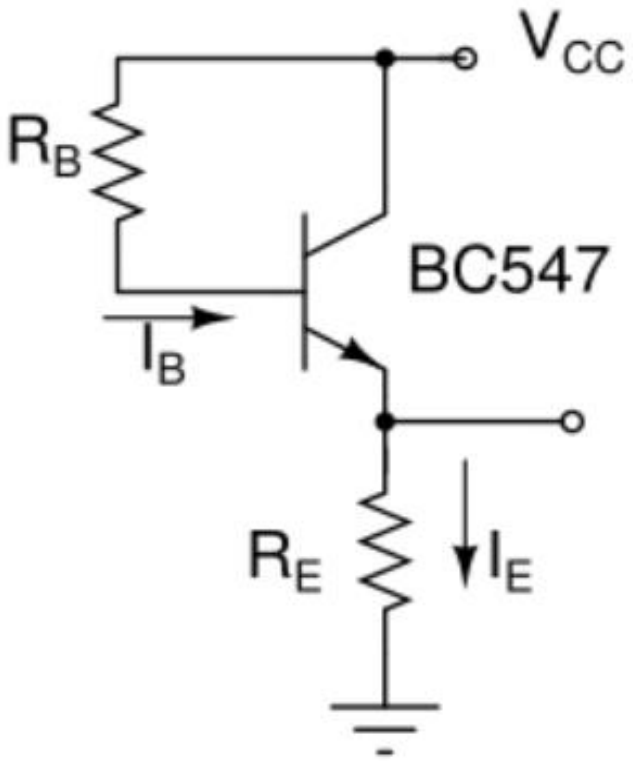


Part B : Common-Collector Amplifier



- Midband Voltage Gain
  - Unity
- Why used?
  - High R_{in}
  - Low R_{out}
- Excellent buffer
- Problems of the CE Amp?

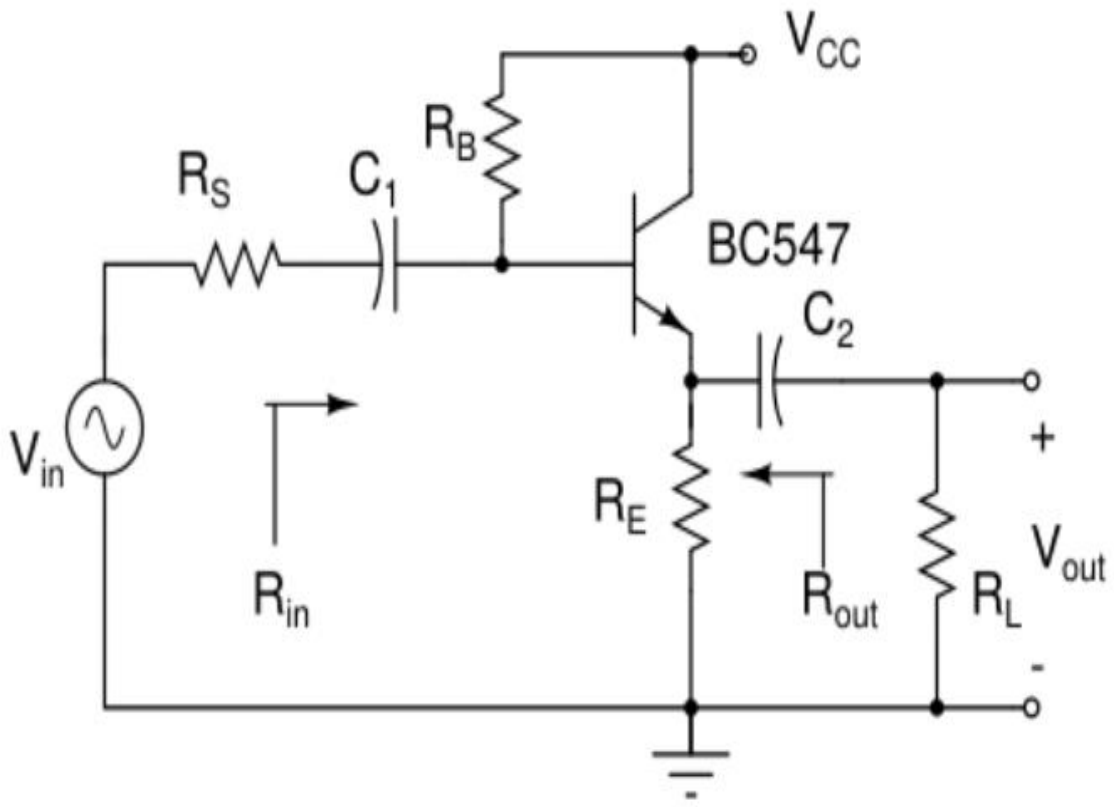
Comparison: Analysis, Simulation and Experiment



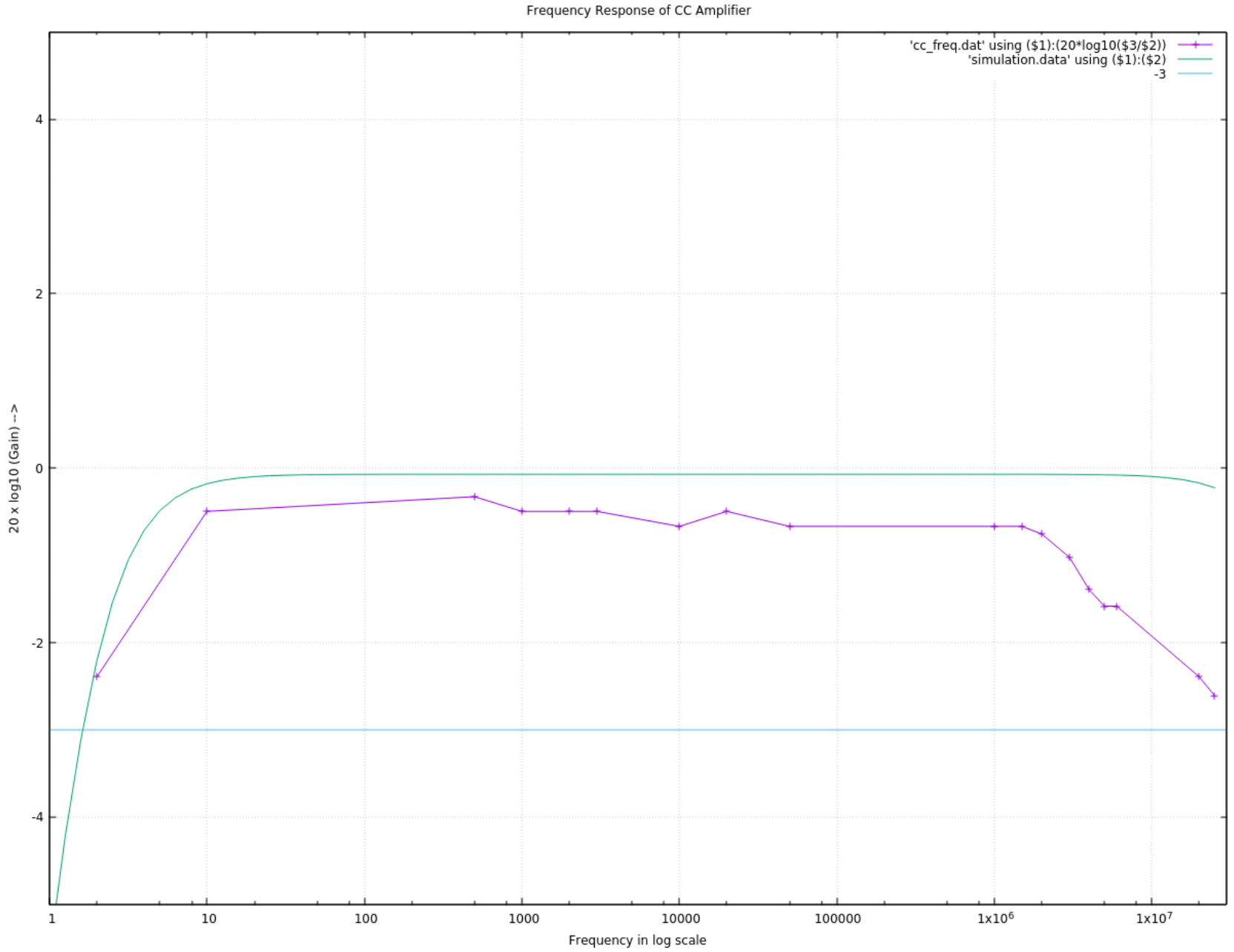
CC Amp - Biasing	Beta=200		
	Analysis	NGSPICE	Expt
VB	8.25 V		7.66 V
VE	7.55 V		7.56 V

- Why there is difference (between experiment and analysis)?

Part B : CC Amplifier – Full Circuit



- R_L and R_S included
- Influence of R_S
- Influence of R_L



- Frequency Response
  - NGSPICE and Experiment
- Why the expt f_H << simulated f_H?

```
#######################################
#  Frequency Response of CC           #
#                                     #
#######################################
# Our Function Generator is limited to 25MEG Hz
#
#Freq    Vin(pk-pk volts)    Vout(pk-pk volts)
2                1.08              0.820
10               1.08              1.02
500              1.08              1.04
1000             1.08              1.02
2000             1.08              1.02
3000             1.08              1.02
10000            1.08              1.00
20000            1.08              1.02
50000            1.08              1.0
1000000          1.08              1.0
1500000          1.08              1.0
2000000          1.08              0.990
3000000          1.08              0.960
4000000          1.08              0.920
5000000          1.08              0.900
6000000          1.08              0.900
20000000         1.08              0.820
25000000         1.08              0.800
```

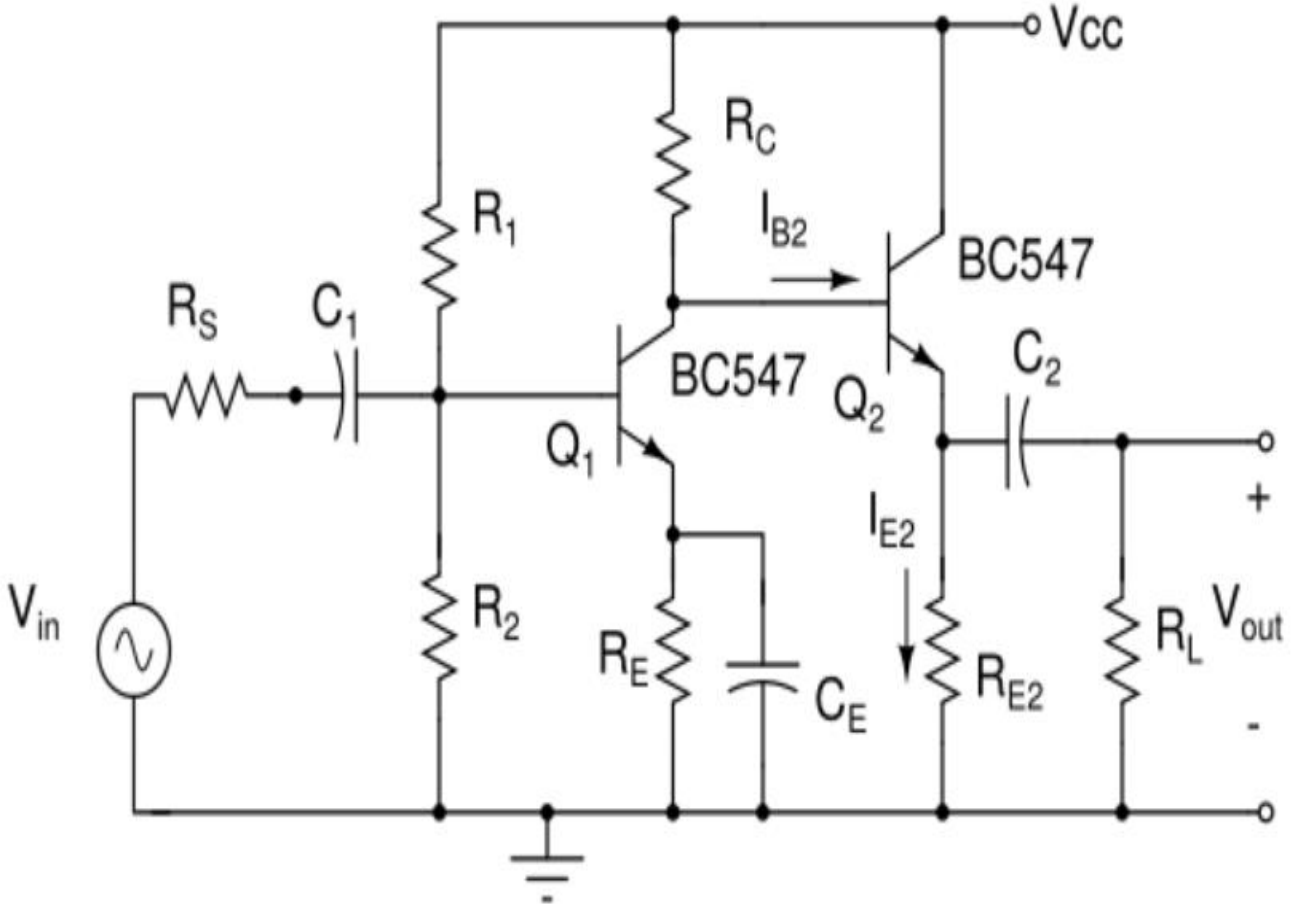
- Frequency Response
  - Experimental Data
- Could not measure beyond 25 MHz

Part C – Two-stage Amplifier (CE + CC)

- Why multistage Amplifiers?
  - Single stage amps cannot fulfill all the required parameters
  - Eg. CE Amp – high Av, but poor Rin and Rout parameters

- Multistage Amplifiers
  - Choose the appropriate amp to cascade
  - CE + CC is a good idea (though incomplete)

Two-stage Amplifier: CE + CC



- CE stage is directly coupled to the CC stage
- Any advantage?

Questions?