COMMON EMITTER
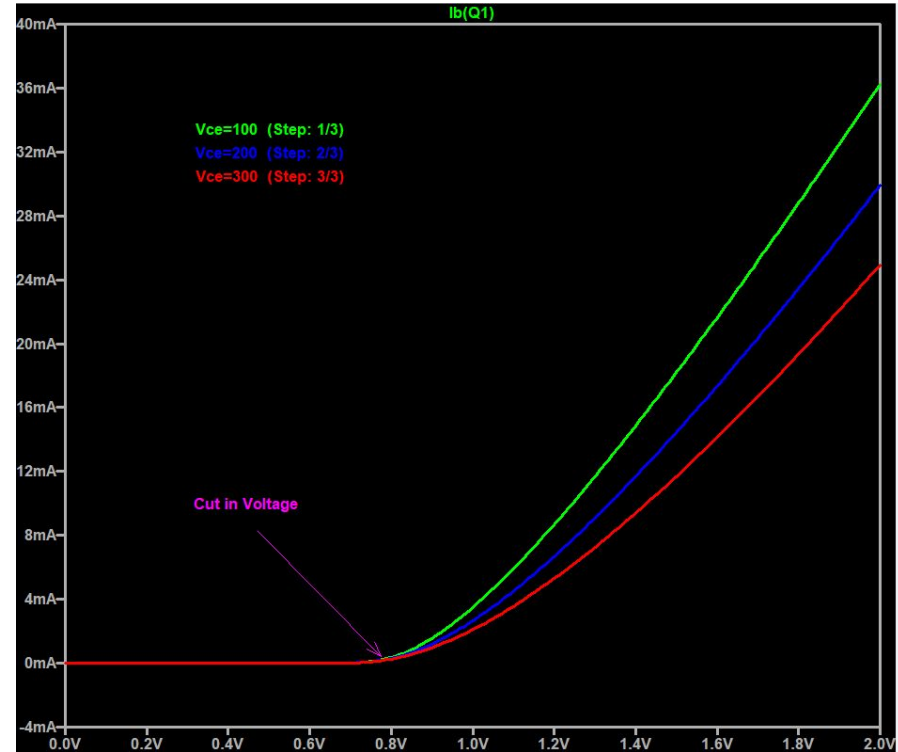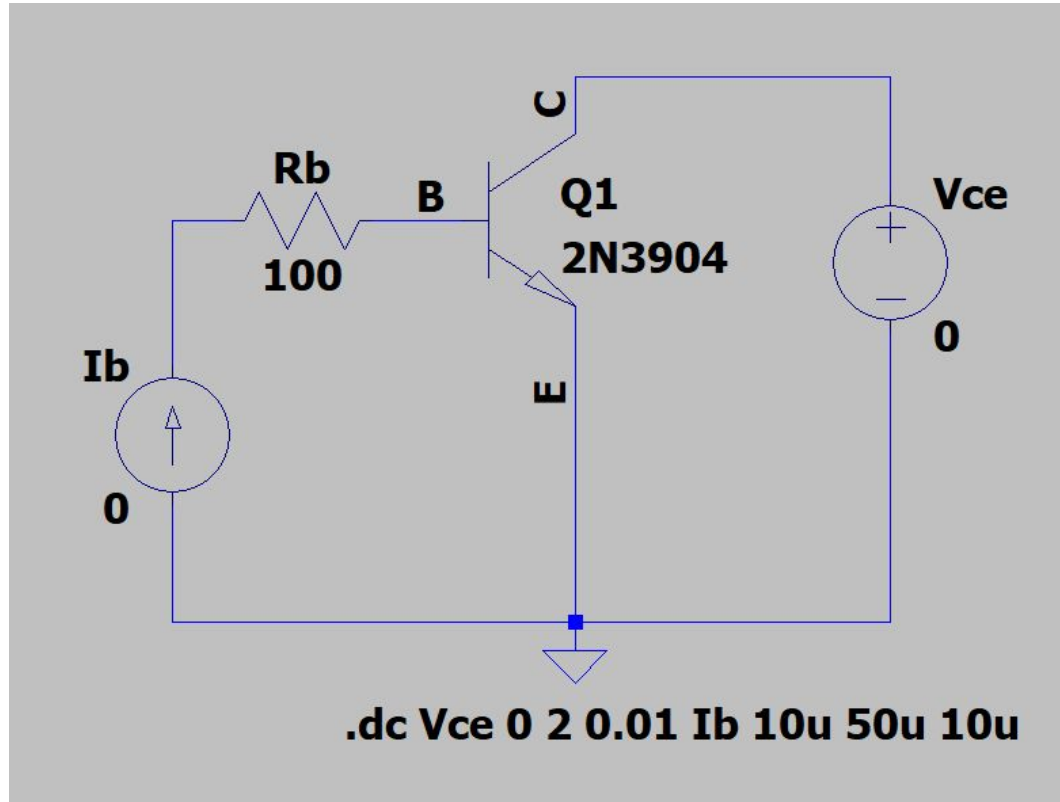
AMPLIFIER

INPUT CHARACTERISTICS
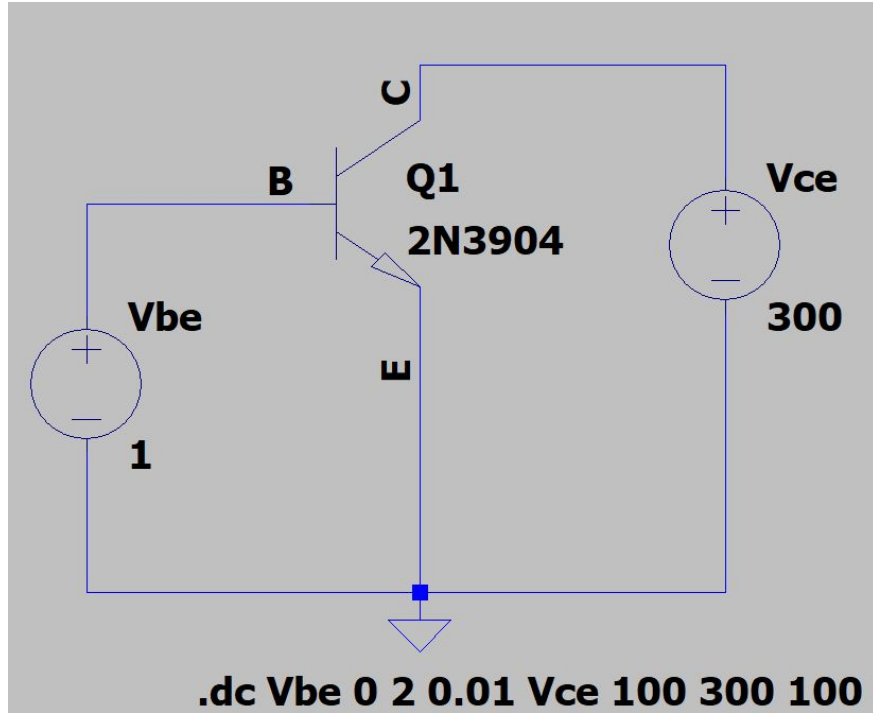
INPUT CHARACTERISTICS
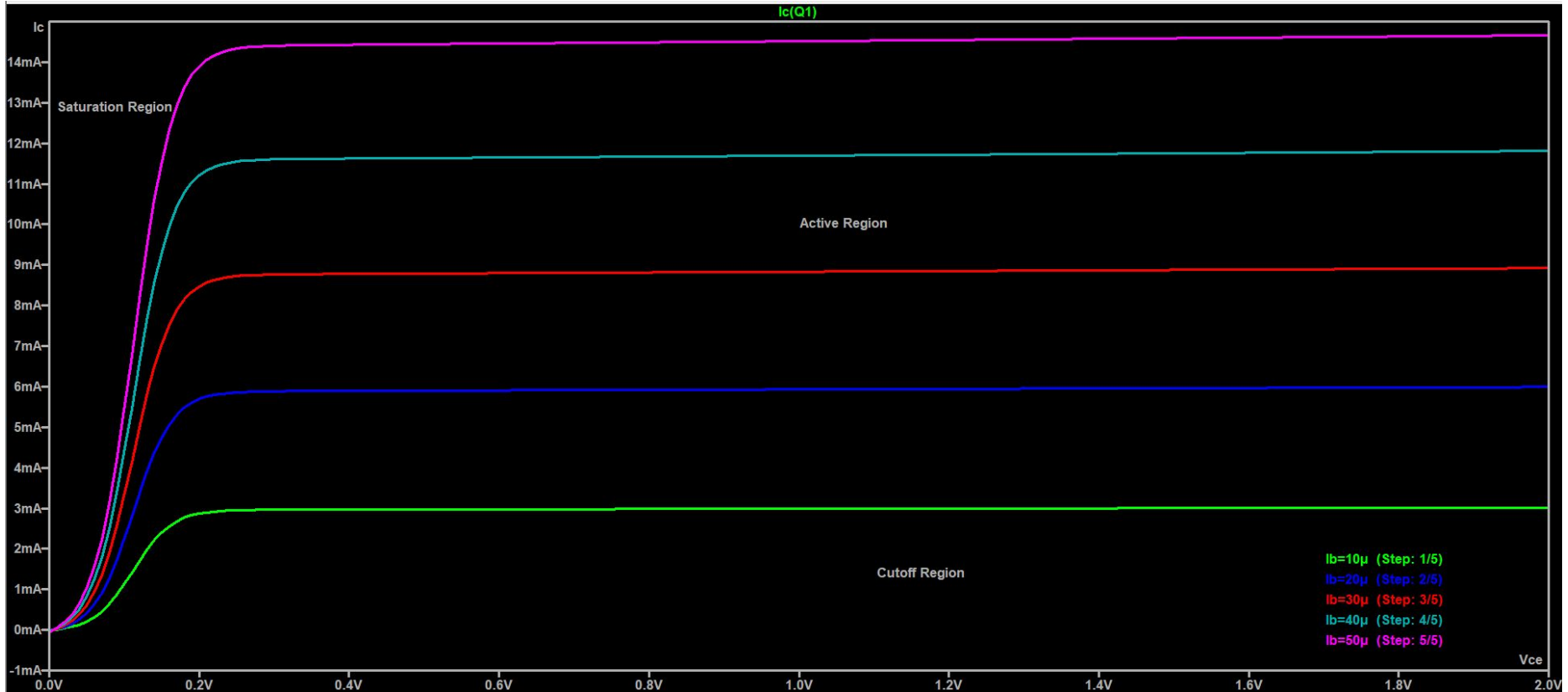
Observation	Explanation
Exponential Current curve	The base current curves for different Vce are exponential (similar to forward biased diode) when Vbe is greater then cut in voltage
Vce dependence	Increasing Vce means increasing reverse bias voltage Vcb cause the effective base width to shrink, leading to less recombination and thus a slightly lower base current for the same Vbe
Early effect	VAF(early voltage) of 2n39004 is 100, and so the ratio Vce/Vaf has to be large for us to see distinction in plots for different Vce

OUTPUT CHARACTERISTICS

Added Rb for
simulation stability

OUTPUT CHARACTERISTICS

OUTPUT CHARACTERISTICS

Cutoff region	The bottom most curve where Ib=0, here Ic is essentially zero (or only small leakage current). The transistor acts as an **Open Switch.**
Active region	The flat, nearly horizontal region. This is the **amplifier region**.For a constant Ib, the collector current Icis nearly constant, following the relationship Ic = □*Ib. The slope in this region is small but non-zero. This slope is the manifestation of the Early Effect.
Saturation region	The region where Vce is small.In this area, all the curves bunch up and rise sharply. The C-B junction is also forward-biased. The transistor acts as a closed switch.
	Therefore BJT in common emitter configuration act as a **current amplifier** or a **current controlled source**, since small input current controls large output current.

OUTPUT CHARACTERISTICS

Current gain (β)	296.51 (300 theoretical)
Small-Signal Output Resistance (ro)	16909.32Ω
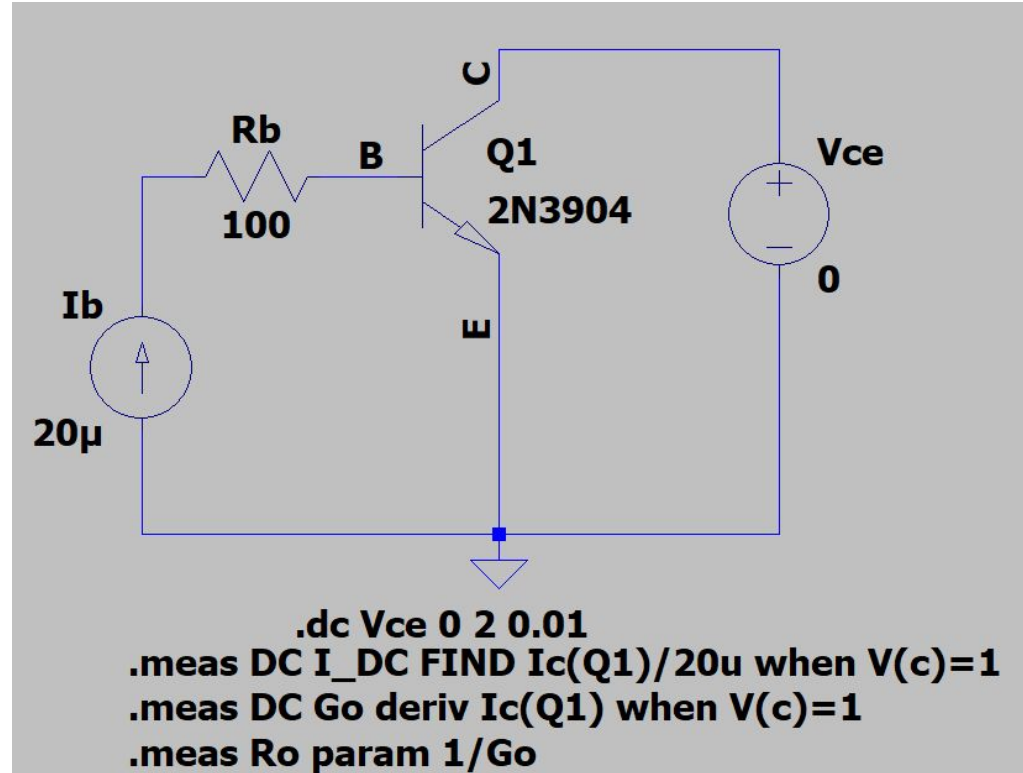
DESIGN

BIASING

BIASING POINT: PRE DESIGN VALUES

Parameter	Value
Supply voltage (Vcc)	12V
Collector current (Ic)	1mA
Emitter voltage (Ve)	1V (~10% of Vcc for stability)
Base emitter voltage (Vbe)	0.7V
Current gain (β)	300

Automatic calculator:
https://github.com/SushantSingh-23-01/EE_LTspice_Simulations/blob/main/BJT_Amplifiers/bjt_amplifier_designer.ipynb

BIASING POINT: PARAMETERS

Parameter	Value
Re	1.2kΩ
Rc	4.8kΩ
R1	303.0kΩ
R2	57.0kΩ
Cin	1.22uF
Cout	0.54uF
Ce	322.84uF
Av	-129.73
Vin(max)	25mV

BIASING POINT: SIMULATION

```
--- Operating Point ---

V(b):           1.78499         voltage
V(c):           7.56667         voltage
V(e):           1.1329          voltage
V(n001):        12              voltage
I(R1):          3.39369e-05     device_current
I(R2):          3.09894e-05     device_current
I(Rc):          0.000933332     device_current
I(Re):          0.000936279     device_current
I(Vcc):         -0.000967269    device_current
Ib(Q1):         2.94755e-06     device_current
Ic(Q1):         0.000933332     device_current
Ie(Q1):         -0.000936279    device_current
Is(Q1):         0               device_current
```
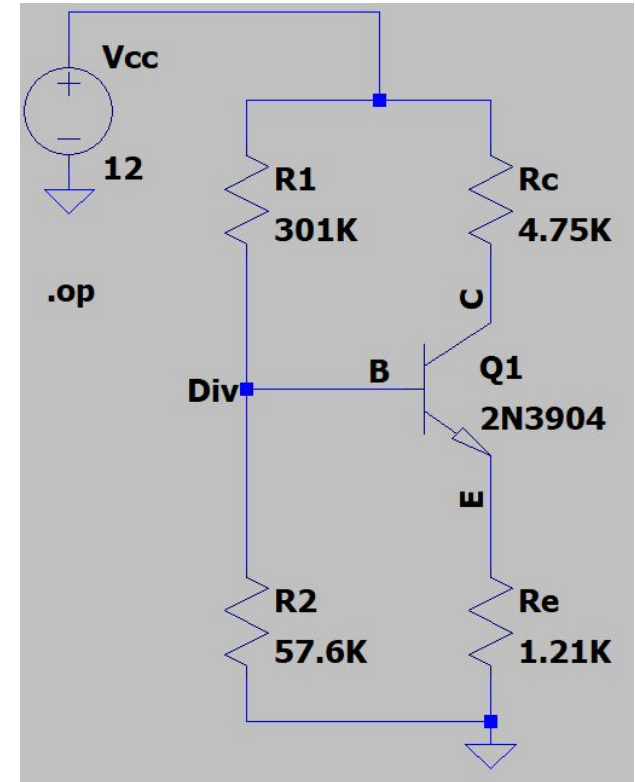

Note: Replaced calculated Resistance values with standard ones with 1% tolerance.

BIASING POINT: RESULTS

Parameter	Simulated Value	Expected value	Error%
Vce	(Vc-Ve) = 6.43377	6V	7.23
Ic	0.933332e-3	1e-3	6.67
☐	Ic / Ib = 316.646707	300	5.55

Note:10-15% error is workable based on assumptions and standard resistance replacements.

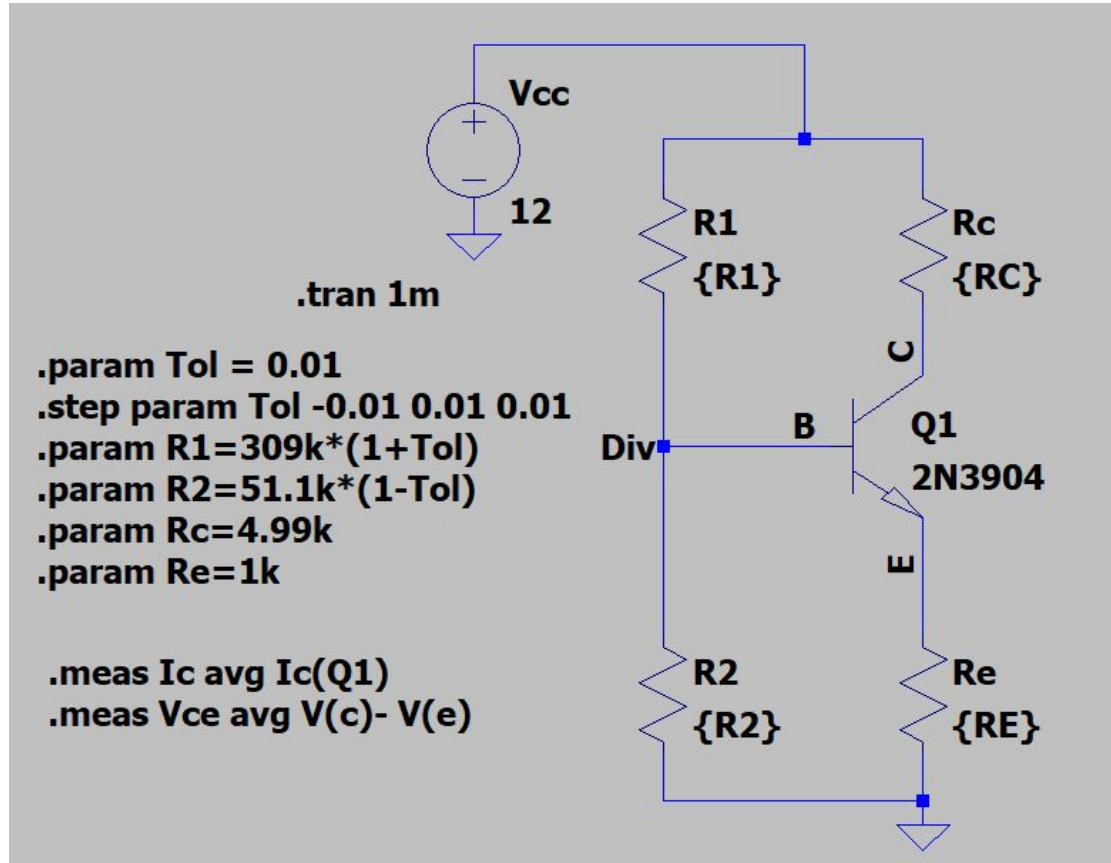# BIASING POINT: TOLERANCE ANALYSIS


```
Measurement: ic
  step                  AVG(Ic(Q1))
    1                   0.000944959290791
    2                   0.000920782389585
    3                   0.000896934710909

Measurement: vce
  step                  AVG(V(c)- V(e))
    1                   6.33670675755
    2                   6.4816069603
    3                   6.62453383207
```
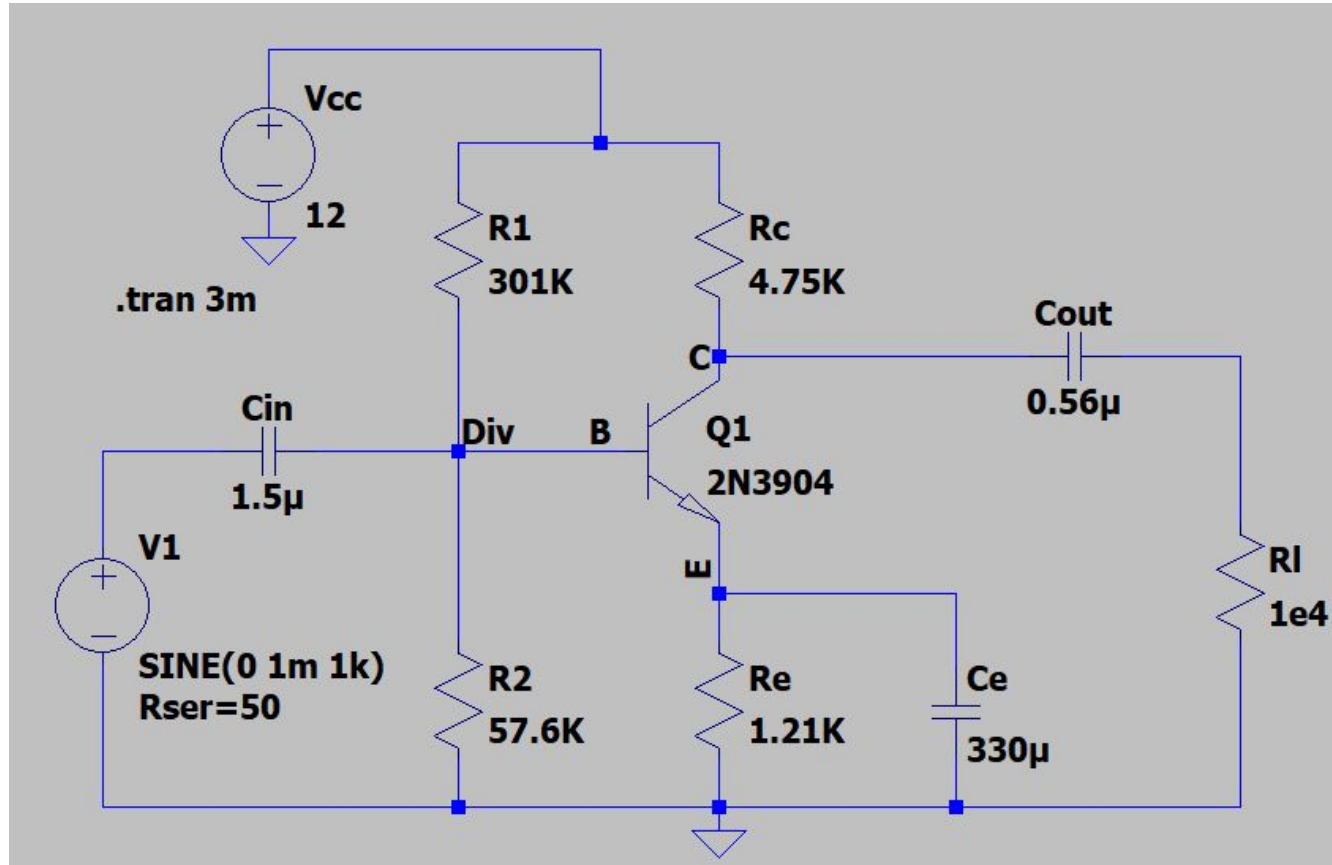
Note: Worst case scenario is selected, i.e.:
(R1 + Tol, R2 - Tol)

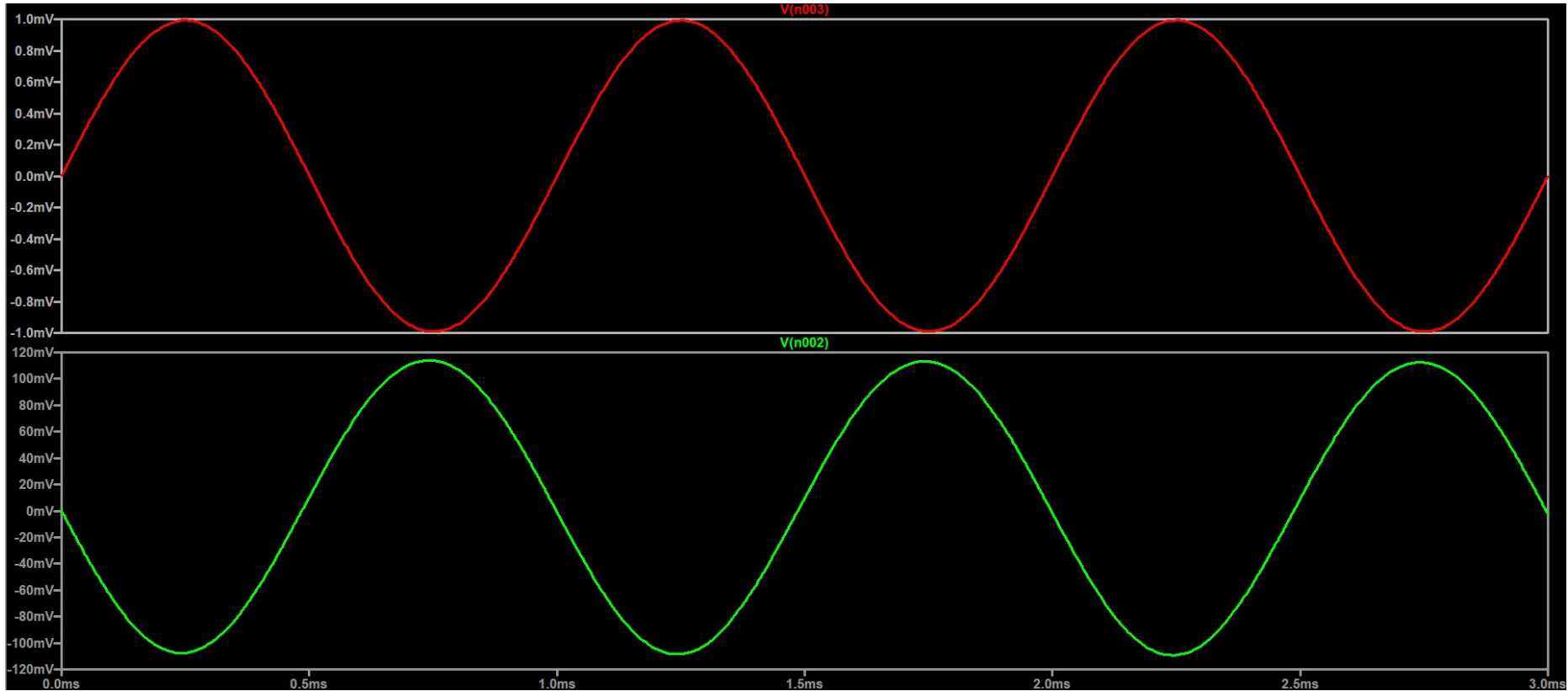The Q-point seems stable as there is 2.2%
change om Vce and 2.6% change in Ic

Vcc

12

.tran 1m

.param Tol = 0.01
.step param Tol -0.01 0.01 0.01
.param R1=309k*(1+Tol)
.param R2=51.1k*(1-Tol)
.param Rc=4.99k
.param Re=1k

.meas Ic avg Ic(Q1)
.meas Vce avg V(c)- V(e)

R1 {R1}   **Rc** {RC}

C

Div **B**   **Q1** 2N3904

E

R2 {R2}   **Re** {RE}

AC ANALYSIS

AC ANALYSIS: CIRCUIT

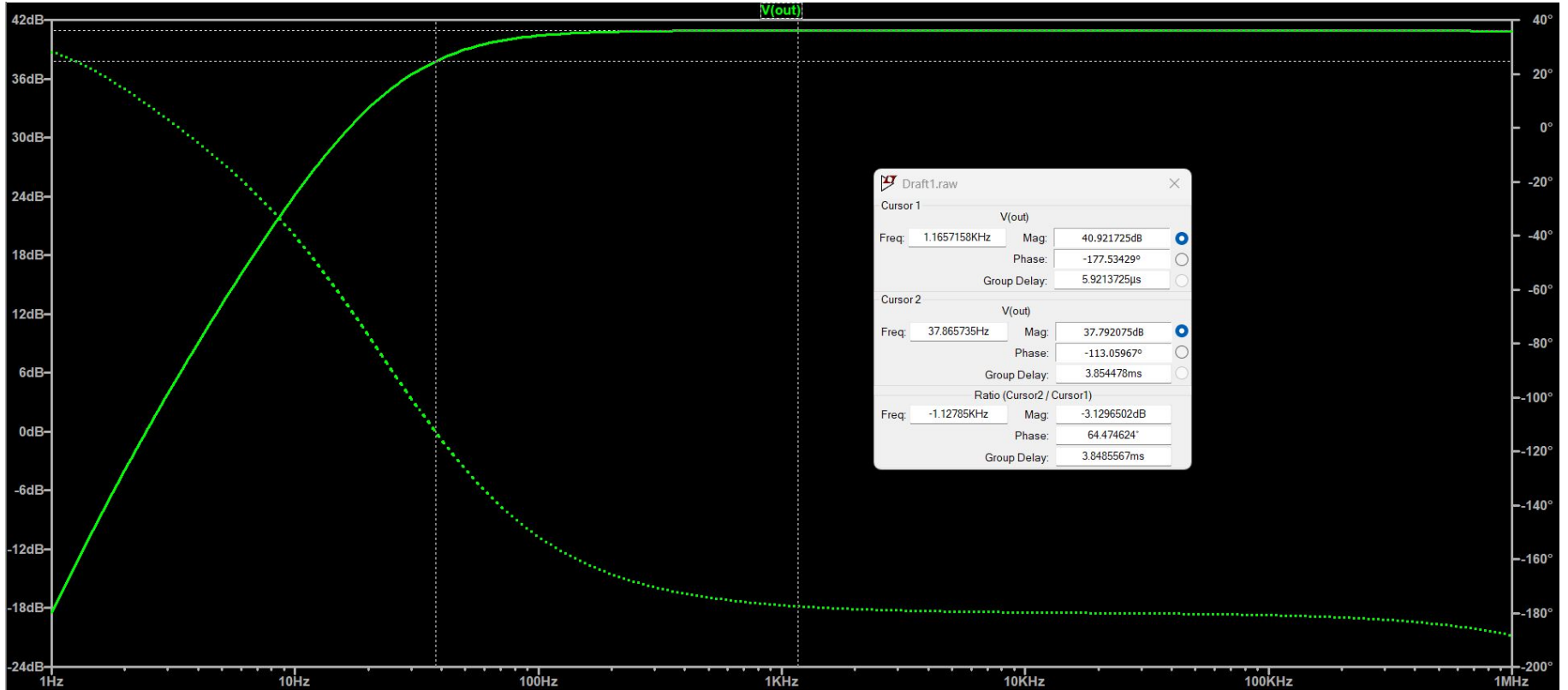# AC ANALYSIS: SIMULATION

Visual estimate of Av: 110e-3/1e-3 = 110
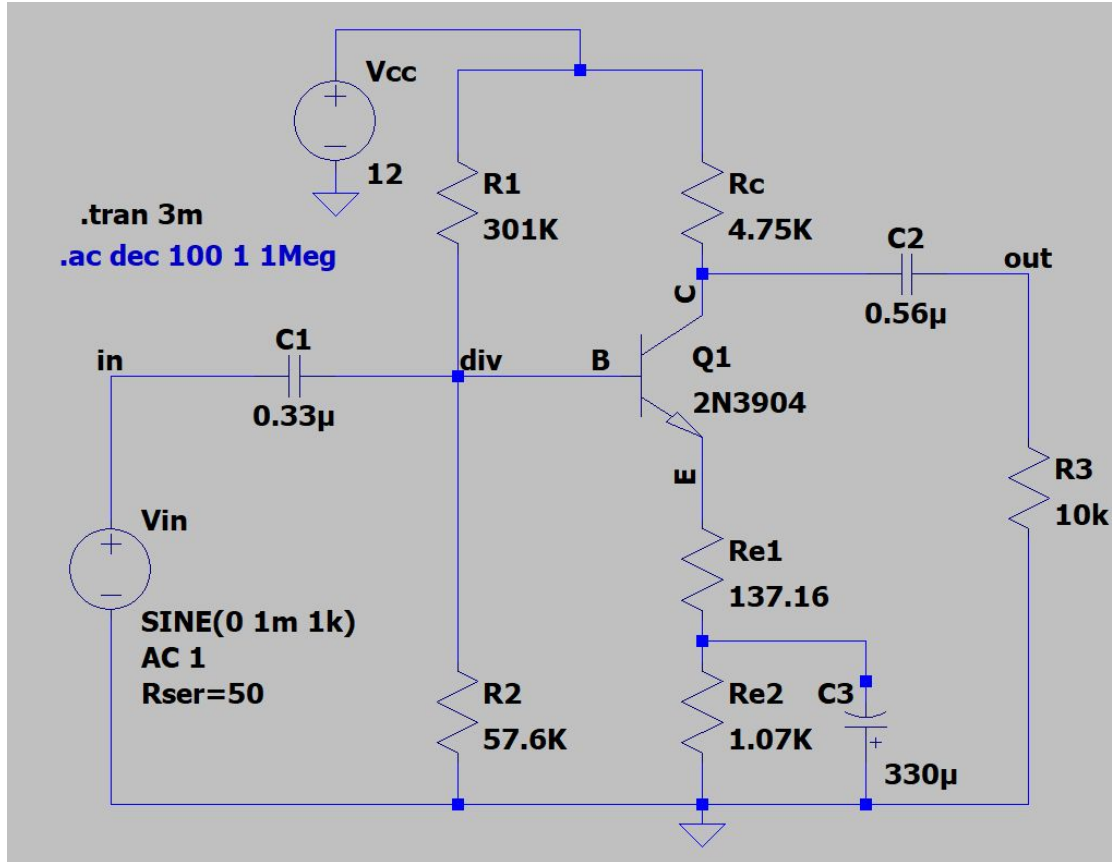
AC ANALYSIS: FREQUENCY PLOT

Theoretical: Cutoff frequency: 34.64Hz, Midband gain: 42.26 dB
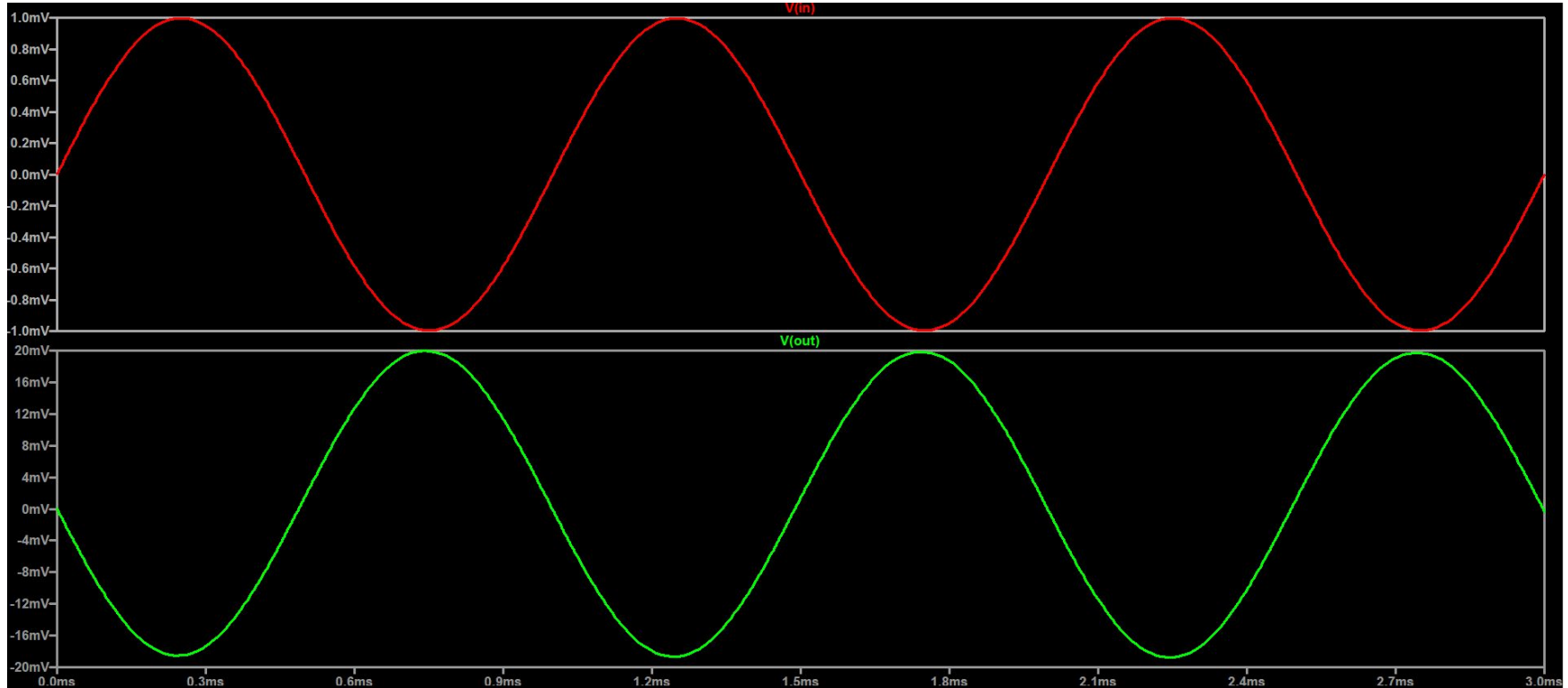Observation:Cutoff frequency: 37.87Hz, Midband gain: 40.92dB

AC ANALYSIS: PARAMETERS (NEGATIVE FEEDBACK)

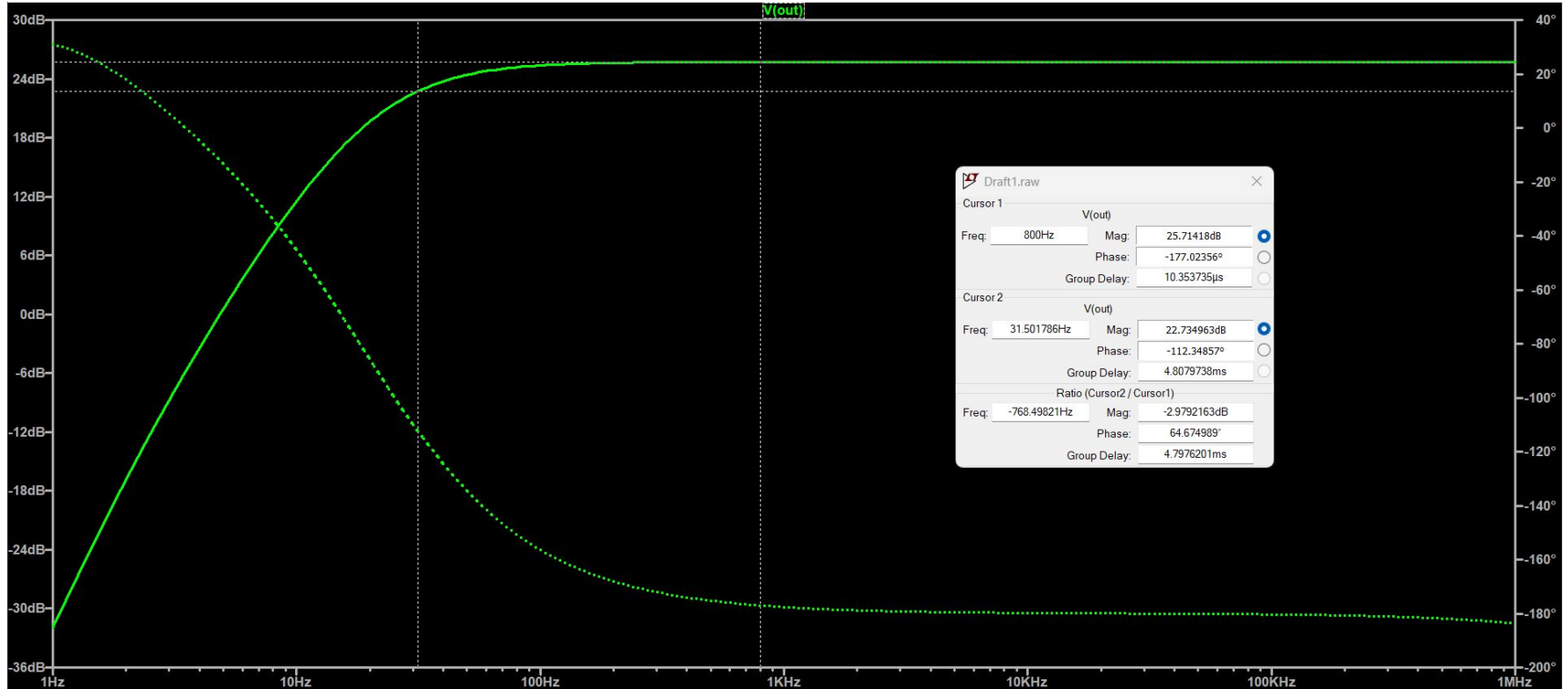| Parameter	Value
Av(new)	20
Re1	137.16Ω
Re2	1062.84Ω
Rc	4.8kΩ
R1	303.0kΩ
R2	57.0kΩ
Cin	0.33uF
Cout	0.54uF
Ce	323.7uF
Av	-192.0

AC ANALYSIS: CIRCUIT (NEGATIVE FEEDBACK)

AC ANALYSIS: SIMULATION

Visual estimate of Av: 20e-3 / 1e-3 = 20

FREQUENCY ANALYSIS: SIMULATION

Expected: Av: 26.02 dB, fL: 34.64Hz,   Simulated: Av: 25.71 dB, fL: 31.5Hz