Faculty of Engineering and Technology

Electrical and Computer Engineering Department

CIRCUITS AND ELECTRONICS LABORATORY– ENEE2103

Experiment No. 7 Prelab

BJT Transistor as An Amplifier, CE, CC, CB Connection

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Prelab instructions:

1. Simulate the circuits in the procedure section and determine the required values (set the parameters that must be assigned by the instructor in the procedure to proper values).

2. Verify if Simulation Results match the expected results

Procedure and Discussion

Part 1: Common emitter transistor amplifier

1.1: 0 Voltage Ac and Dc (CE amplifier with voltage divider - bias):

First figure shows the CE Amplifier with a Voltage Divider Circuit. The potentiometer (POT) value is set to 10 kHz. The sinusoidal source frequency is set to 1 kHz while the amplitude is set to zero, since v0 connected to nothing as an open circuit, R8 with value 100MEGA has been used as replacement.

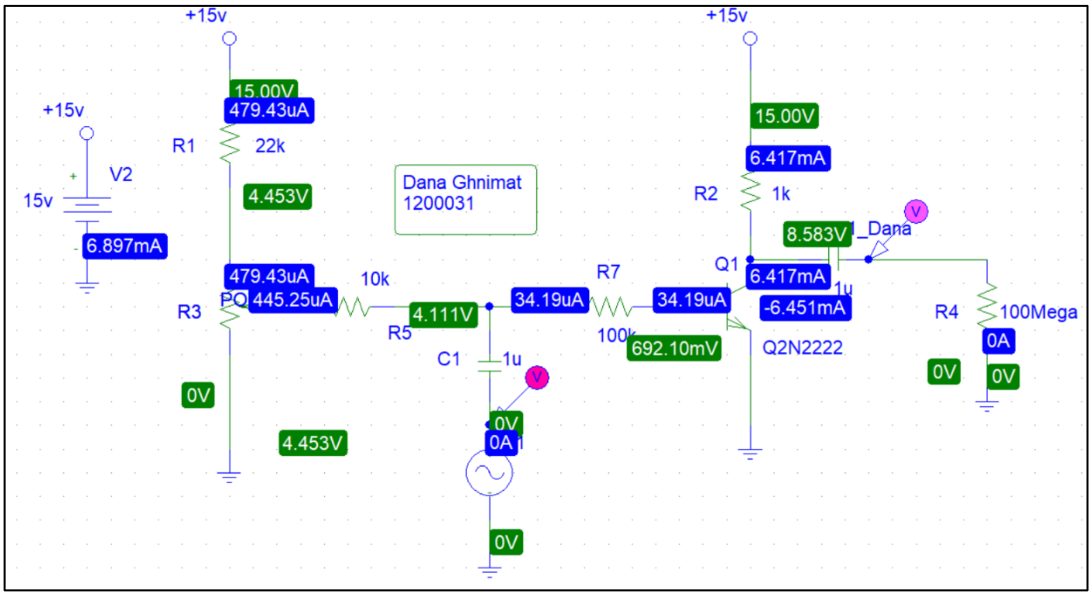

Figure 1 CE amplifier with 0 volt.

1.2: 8 Voltage DC value:

After the base bias potentiometer had been adjusted to 11.05kΩ for a DC collector voltage (VC) for 8 volts.

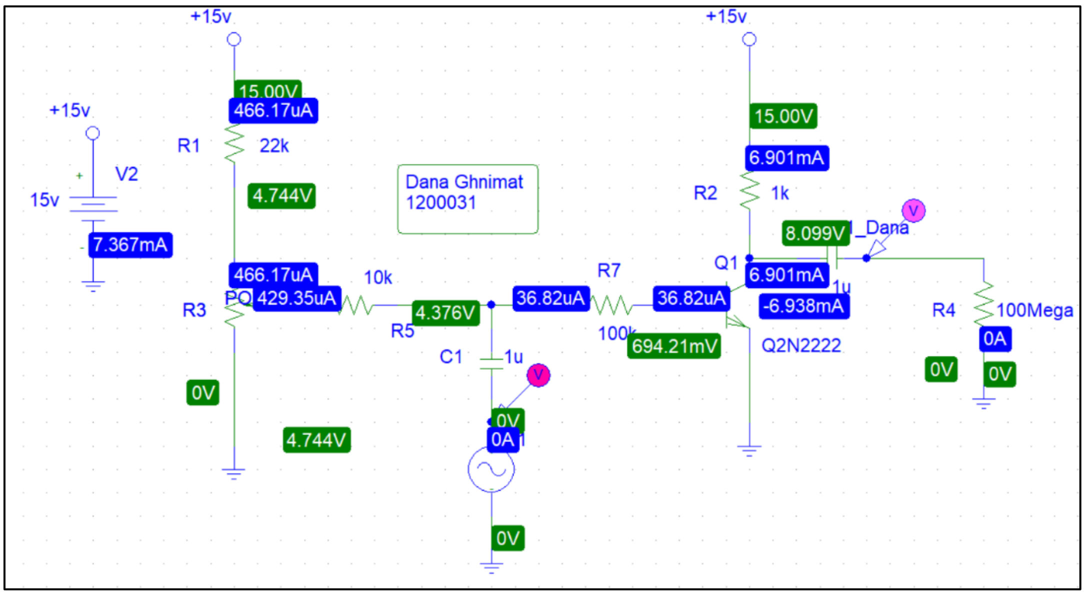

Figure 2 CE amplifier with DC power supply

Table 1 CE Voltage and Current values

IC	IB	VCE	VBE	VBC
6.901mA	36.82µA	8.099V	694.21mV	7.4047V

1.3: When voltage 1V AC:

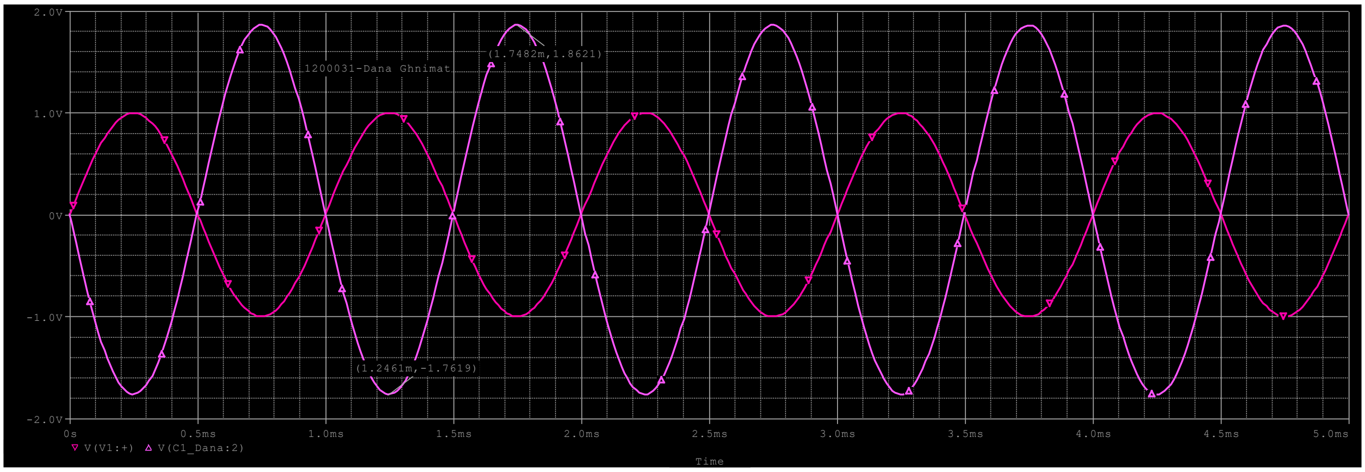

Figure 3 CE Amplifier Vout when VI = 1V

1.4: 8 Voltage DC value and 2.2volt AC:

To get to value of V0 to around 8Vp-p, The Voltage input has been tested to mode around the double of input until it appear into 2.2Volt (4.4 Vp-p).

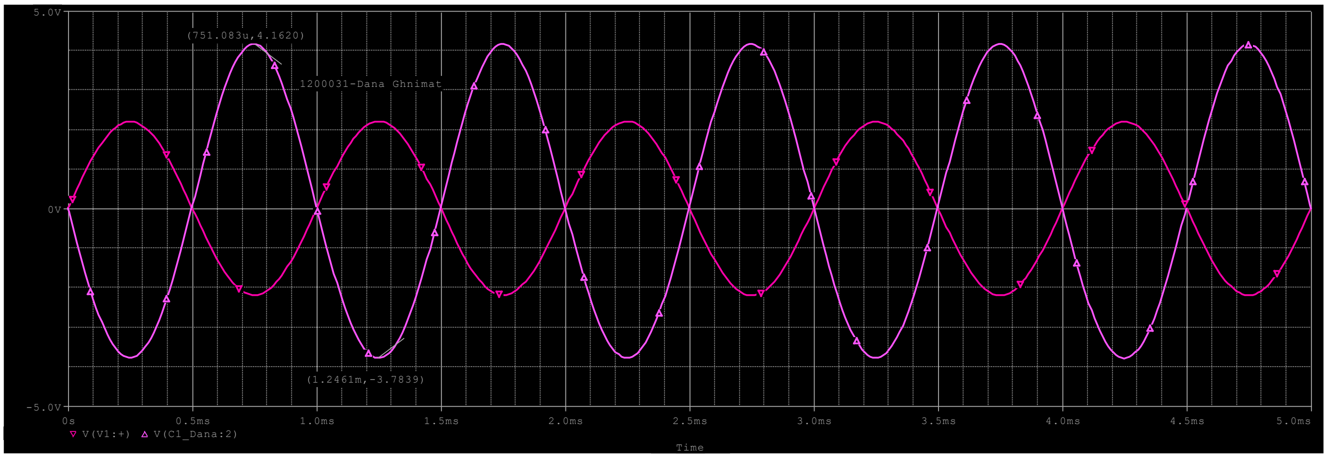

Figure 4 CE amplifier Vout when Vi = 1.05V

Circuit and parameters:

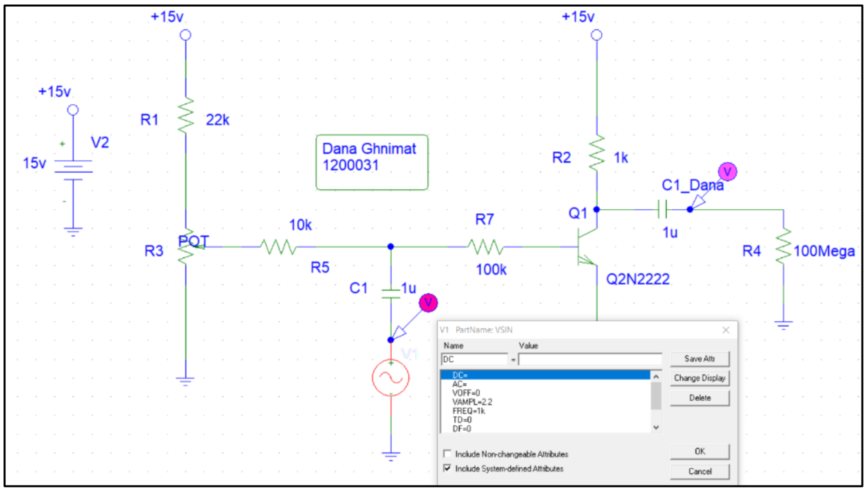

Figure 5 CE amplifier 8 Volts, circuit

$Vo_{p\text{-}p}$ = 7.9459 V, $Vin_{p\text{-}p}$ = 4.4V

$$Av = \frac{Vo}{Vin}$$
$$=7.9459 / 4.4 \text{ V}$$
$$= 1.8058$$

1.5: Gain calculation on Vb and Vo.

First, the oscilloscope connected on Vb.

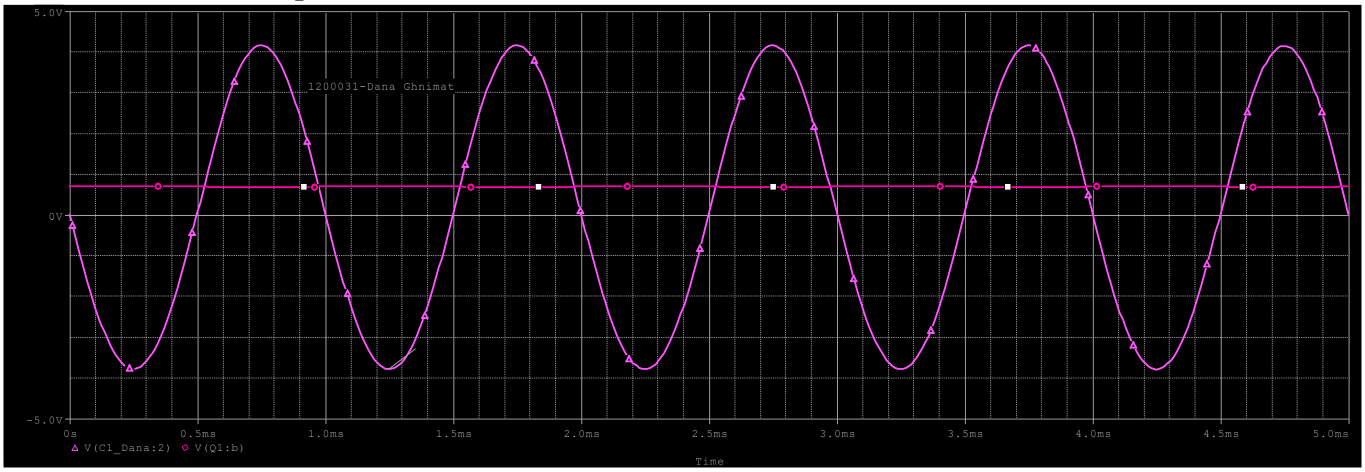

Figure 6 CE amplifier Vb and Vo

Since the values in Figure 6 not cleared, The RMS value is used as shown in Figure 7, Vo_{rms} = 2.8126V, Vin_{rms} = 691.581mV

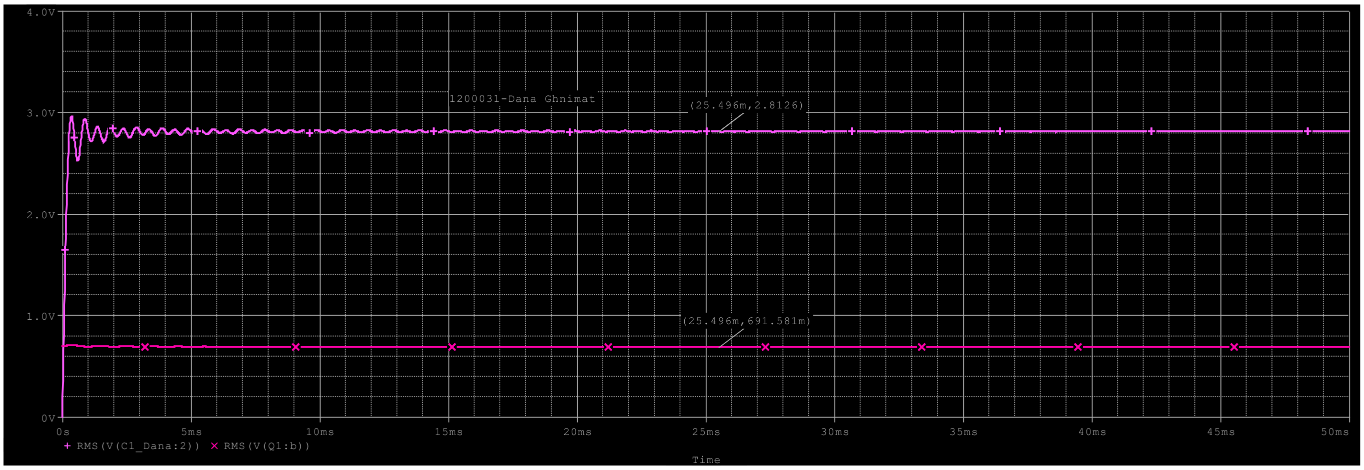

Figure 7 CE Amplifier Vout and VB using RMS

$$Av = \frac{Vo\ rms}{Vin\ rms}$$
$$=2.\ 8126 / 0.6915$$
$$= 4.06691$$

1.6: The effect of the 100 kΩ Resistor

After removing 100k resistor:

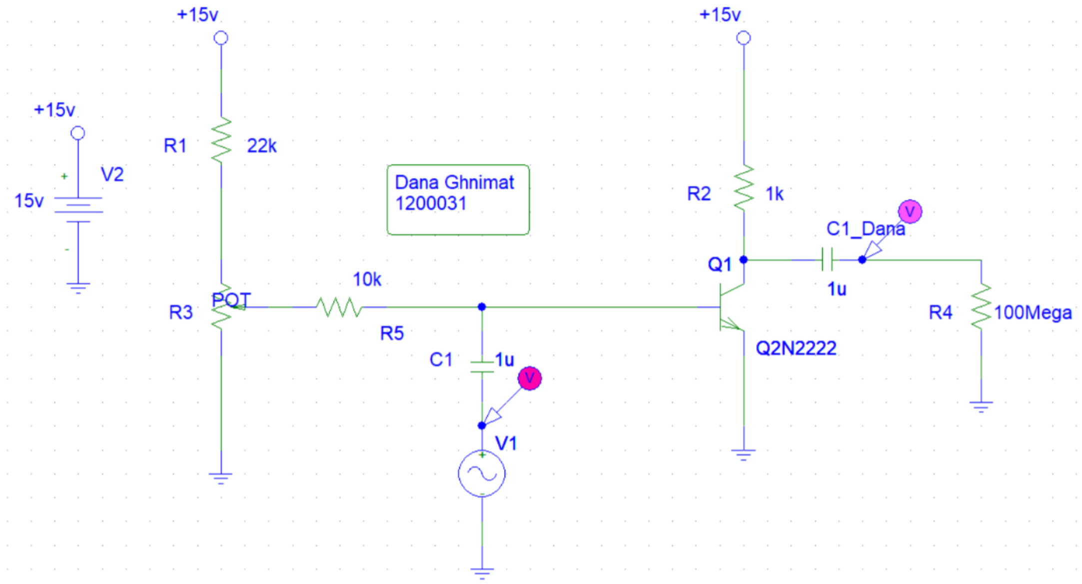

Figure 8 CE Amplifier with Voltage Divider Circuit after shorting the 100 kΩ Resistor Circuit

Simulation:

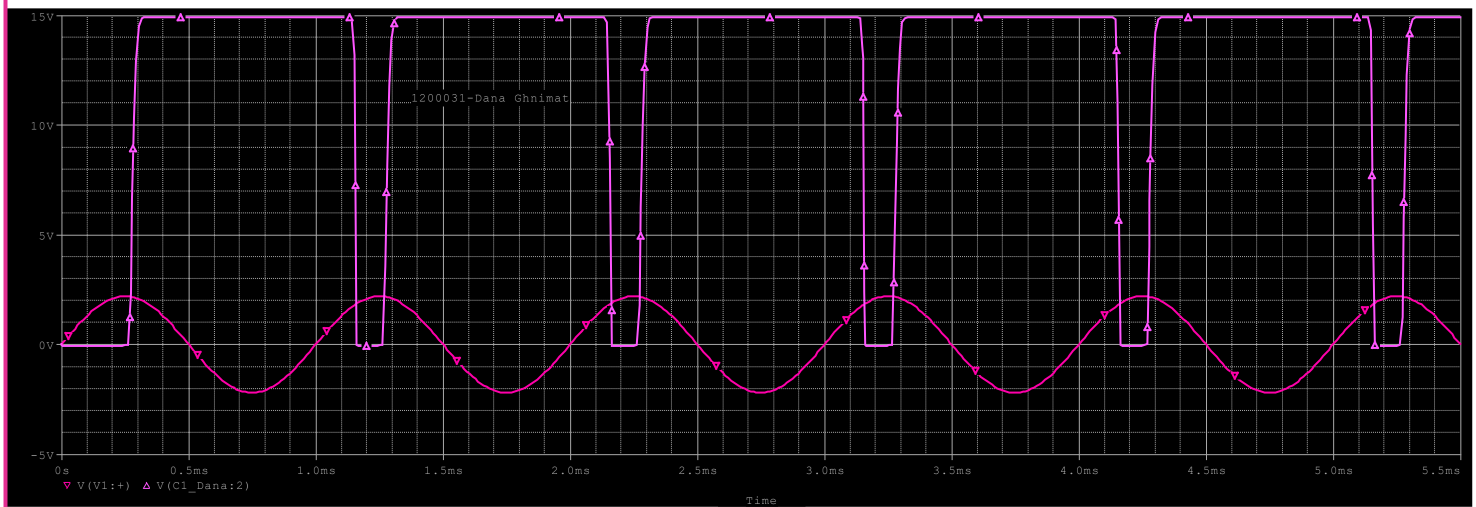

Figure 9 CE Amplifier with Voltage Divider Circuit after shorting the 100 kΩ Resistor Simulation

As shown in Circuit simulation Vo = 15V when Vin = 4.4V.

$$Av = \frac{Vo}{Vin}$$
$$= 15 / 4.4$$
$$= 3.4090$$

The 100 kΩ Resistor have high effect of the voltage gain, which equals to:

$Av_{R100k\ effect} = Av_{,\ old} - Av_{,\ new} = 4.06691 - 3.4090 = 0.65791$.

When replace 100k with 47kΩ

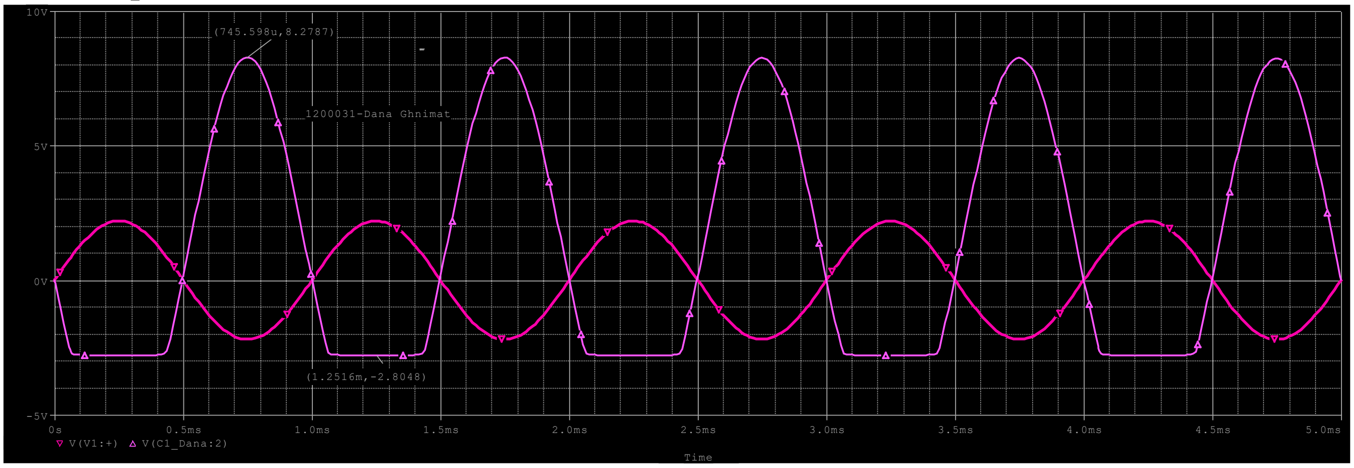

Figure 10 CE Amplifier with Voltage Divider Circuit after replace the 100 kΩ Resistor with 47kΩ Simulation

As shown in Circuit simulation $Vo_{p\text{-}p}$ = 11.0835V when $Vin_{p\text{-}p}$ = 4.4V.

$$Av = \frac{Vo}{Vin}$$

$$=11.0835 / 4.4$$

$$= 2.5189$$

The 100 kΩ Resistor have high effect of the voltage gain, which equals to:

$Av_{R47k\ effect} = Av_{,\ old} - Av_{,\ new}$ = 4.06691-2.5189= 1.54801

Part 2: Common collector transistor amplifier:

2.1: CC Transistor Amplifier Circuit

The figure 11 shows the CC Transistor Amplifier Circuit. The sinusoidal source frequency is set to 1 kHz while the amplitude is set to zero same as first part.

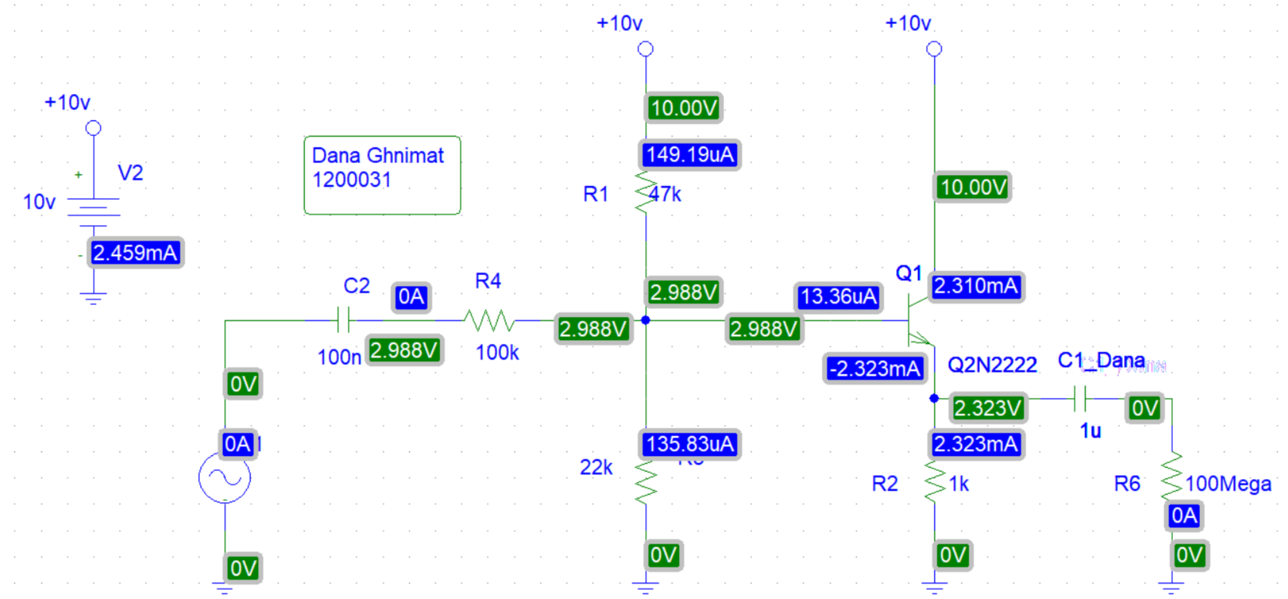

Figure 11 Common Collector Transistor Amplifier Circuit and simulation

Table 2 CC Voltage and Current Values

IC	IB	VC	VB	VE
2.310mA	13.36µA	10V	2.988mV	2.323V

2.2: Vo is about 2 volts peak-to-peak

To obtain Vo at around 0.9990 +1.0182 = 2.0172$V_{p\text{-}p}$, Vin is measured at 8.39V.

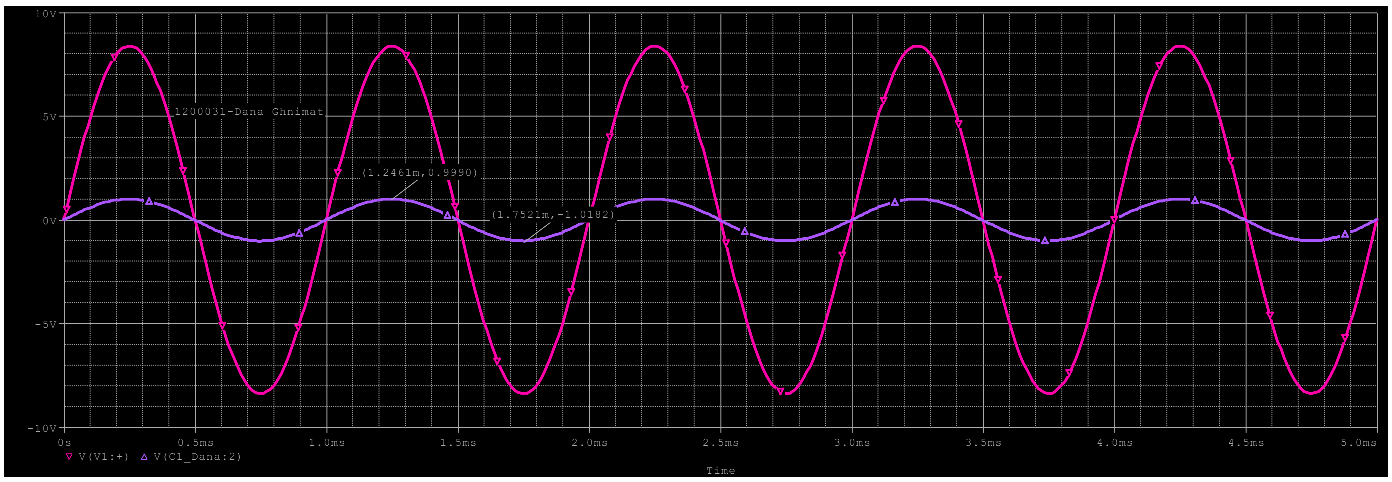

Figure 12 Common Collector Transistor Amplifier Vo, p-p ≈ 2V

$$Av = \frac{Vo}{Vin}$$
$$= 0.9990 / 8.39$$
$$= 0.1190$$

2.3: Calculating Ai and Zi:

To measure Ai and Zi I on the input and I on R2 resistor:

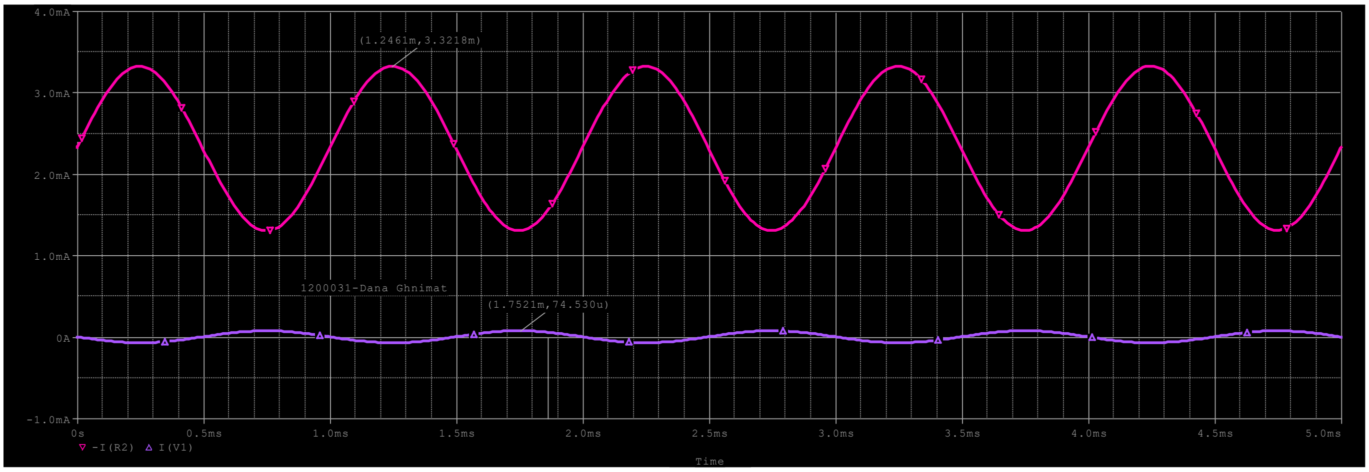

Figure 13 Common Collector Transistor Amplifier Ii and Iout

As the figure 13 shows that $I_{o,\,peak} = 3.3218mA$, while $I_{in,\,peak} = 74.530\mu A$

$$Ai = \frac{Io}{Iin}$$
$$= 3.3218/\ 74.530\mu$$
$$= 44.5699$$

Since Vin = 8.39V, and Iin = 74.530µA. Then

$$Zi = \frac{Vin}{Iin}$$
$$= 3.3218/\ 74.530\mu$$
$$= 112.57k\Omega$$

2.4: Calculating Zout:

As shown in figure 14, to measure Zout, a generator on the output is connected and removed the original sine wave generator is replaced with short circuit.

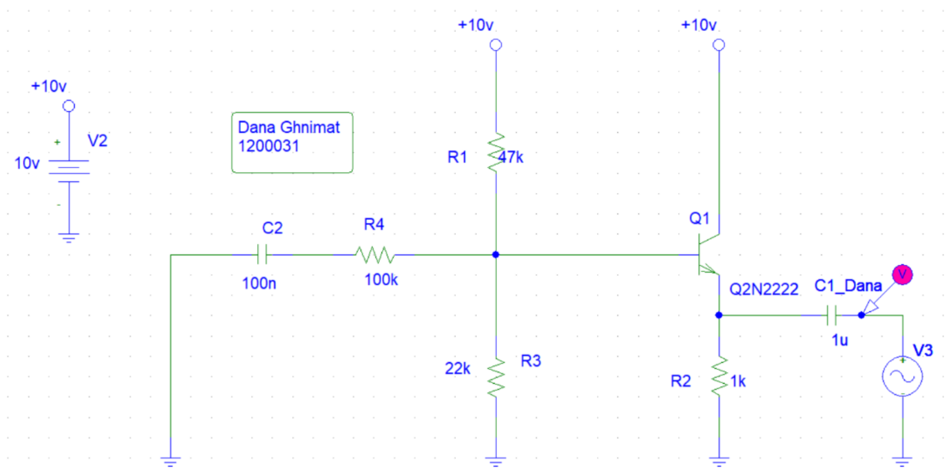

Figure 14 Common Collector Transistor Amplifier Zout circuit

in the simulation to find mean value to find Vrms, Zout: which is 5.9413V

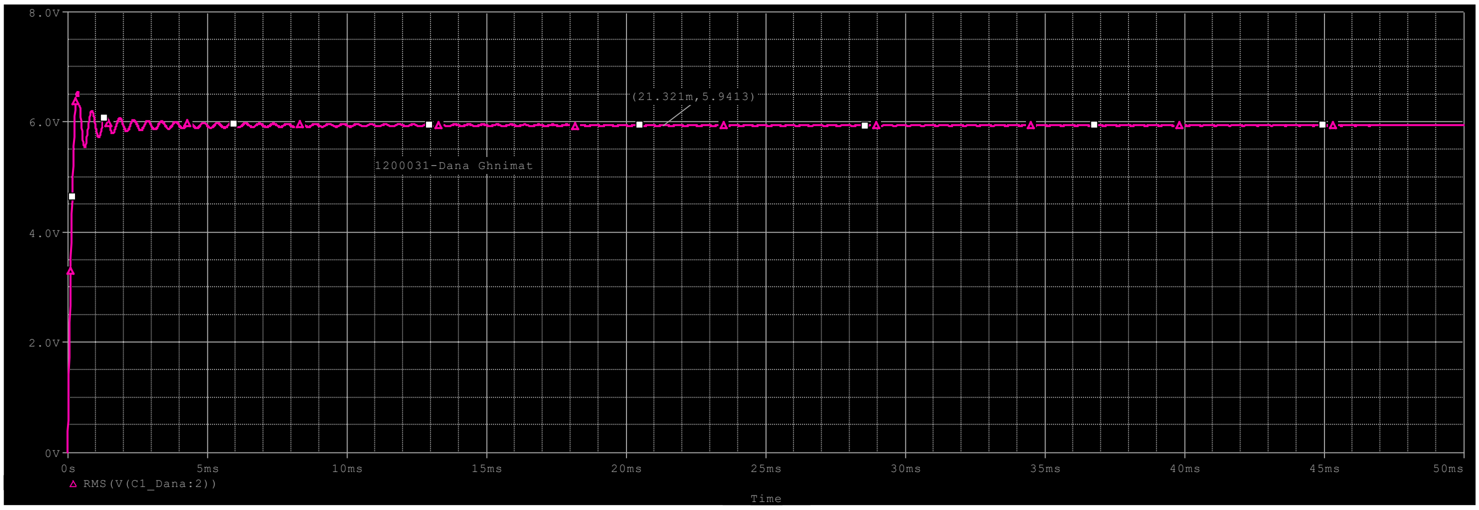

Figure 15 Common Collector Transistor Amplifier V, Zout

Simulation for Irms, Zout which is 16.485mA.

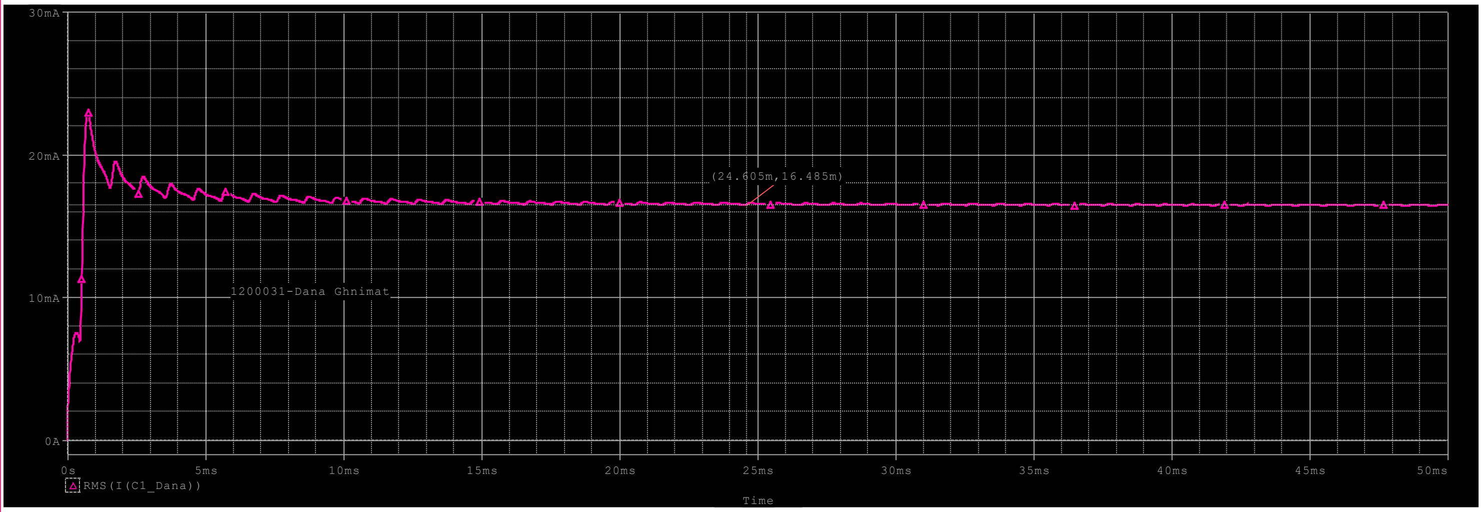

Figure 16 Common Collector Transistor Amplifier I, Zout

$$\text{Zout} = \frac{\boldsymbol{Vo}}{\boldsymbol{Io}}$$

= 5.9413/ 16.485m

= 36.0406

2.5: I_{in} for 100kΩ Register:

Vrms is used for R2, $V_{100k,\ rms}$ = 3.0749

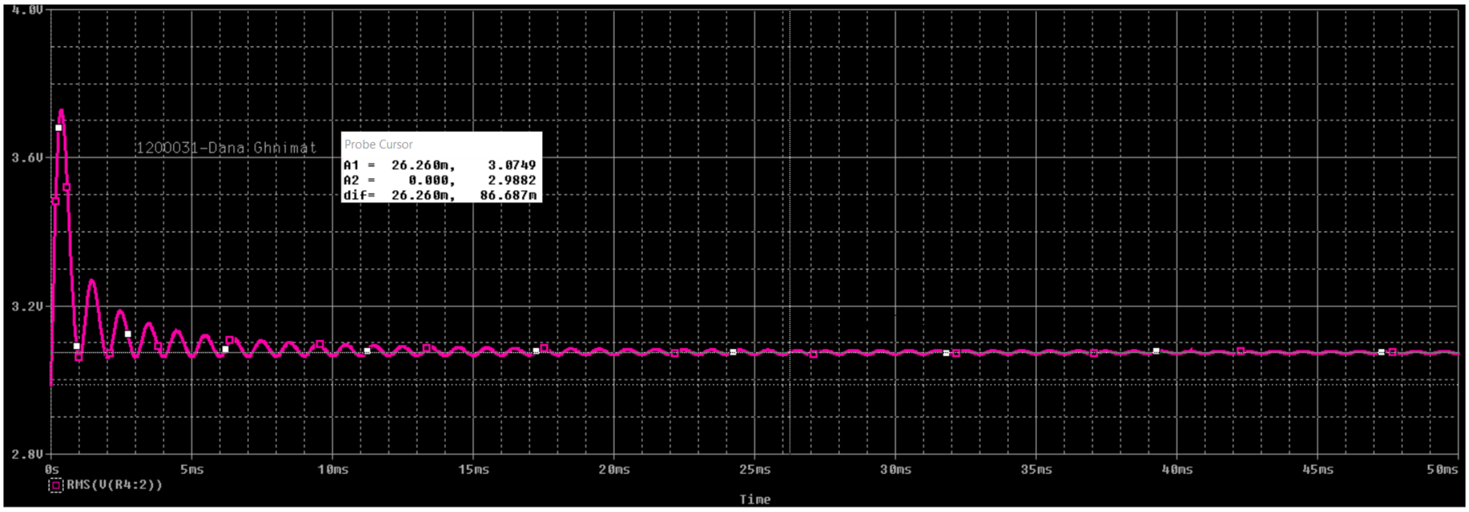

Figure 17 Common Collector Transistor Amplifier Vrms for R2

$$I_{100K,R} = \frac{Vrms}{R}$$
$$= 3.0749/\ 100k$$
$$= 3.0749 * 10^{-5}\ A$$
$$= 30.749\ \mu A$$

Table 3 Common Collector Transistor Amplifier Resulted Values

Quantity	Measured values
V_{in}	8.39V
V_{out}	$2V_{P-P}$
$V_{100k,\ RMS}$	3.0749V
$I,_{out}$	16.485mA
Calculated values	
$A_V=V_{out}/V_{in}$	0.1190
$I_{in} = V_{100k\_RMS}/100k$	30.749 µA
$Ai=I_{out}/I_{in}$	44.5699
$Z_{in}=V_{in}/I_{in}$	112.57kΩ
$Z_{out}=V_T/I_T$	36.0406Ω

A common collector amplifier is used as a buffer. This means the input impedance of this amplifier is very high, while the output impedance is low.

Compared to the common emitter stage, the DC configuration provides less than a unite voltage gain, high input impedance similar to the common emitter stage, low output impedance, and an in-phase relationship between the input and output signals.

The Emitter followers are typically used when high input impedance and low output impedance are required, so they are used for matching impedances.

Part3: Common base transistor amplifier:

3.1: Common Base Transistor Circuit:

Common Base amplifier Circuit has been built as in figure 18. As The sinusoidal source frequency sat to 1 kHz and amplitude to zero volt.

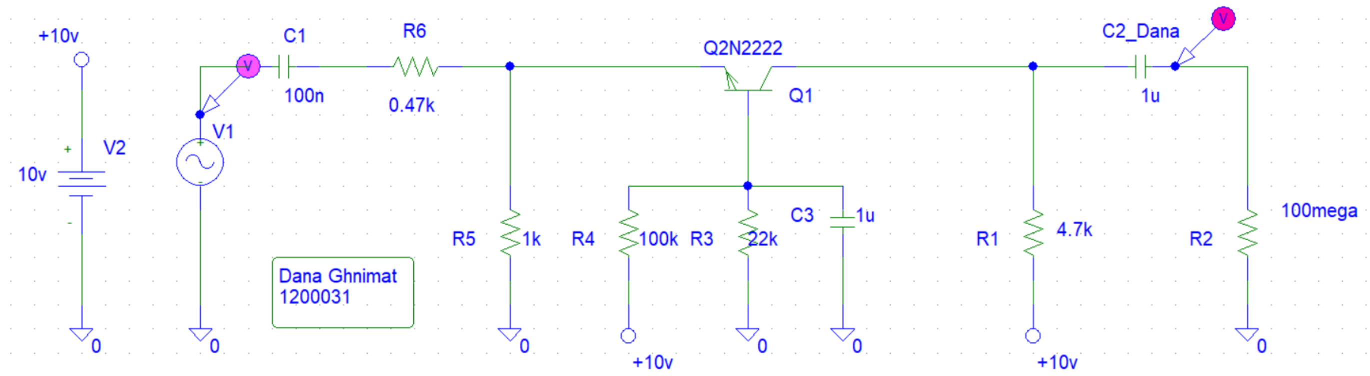

Figure 18 Common Base amplifier Circuit

Simulation:

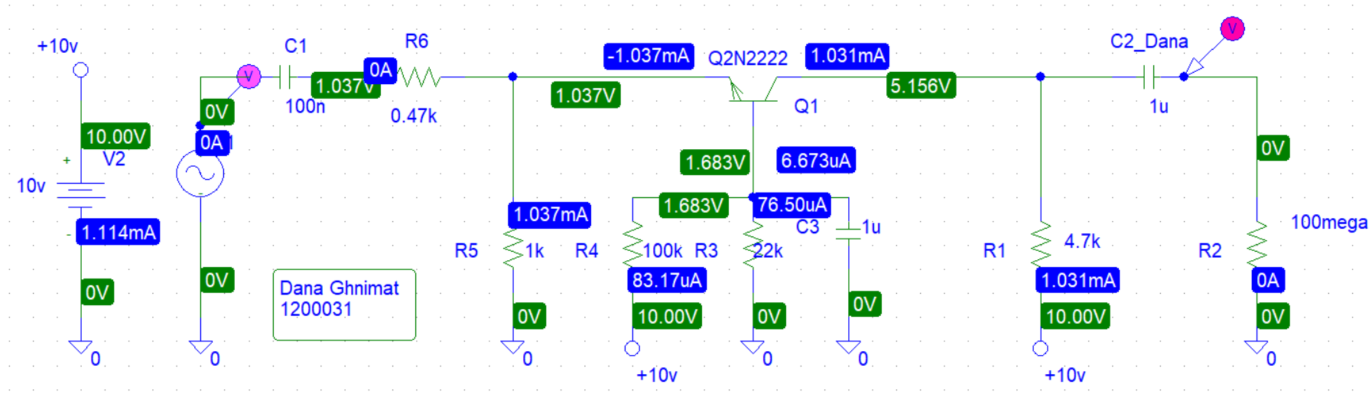

Figure 19 Common Base amplifier Circuit simulation

Table 4 Common Base amplifier values

IC	IB	VC	VB	VE
1.037mA	6.673µA	1.037V	1.683V	5.156V

$$VBE = VB - VE = 1.683 - 1.037 = 0.646V$$
$$VBC = VB - VC = 1.683 - 5.156 = -3.473V$$
$$VCE = VC - VE = 5.156 - 1.037 = 4.119V$$

3.2: Setting $V_{out,\ p\text{-}p}$ to 2V:

To get $V_{out,\ p\text{-}p} \approx 2V$.i.e. $V_{out,\ peak} \approx 1V$. is by V_{in} is sat to 0.37v as shown below:

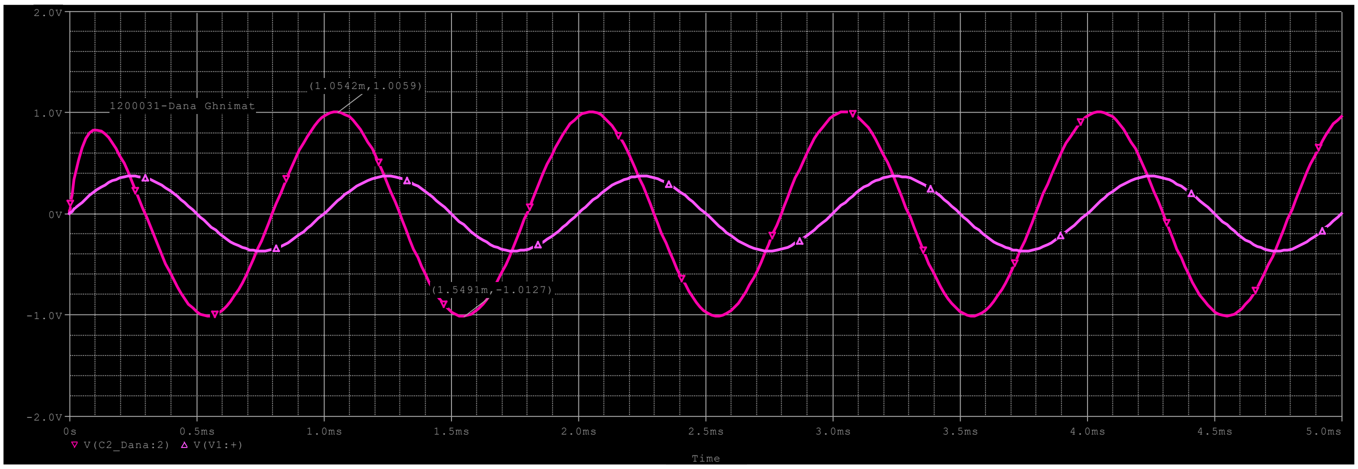

Figure 20 Common Base amplifier Vout, p-p = 2V

$$Av = \frac{Vo}{Vin}$$
$$= 1.0059 / 0.37$$
$$= 2.7186$$

3.3: Calculating Zi and Ai:

To measure Ai, we get $I_{i,\ peak}$ = 230.814µA and $I_{out,\ peak}$ = 1.2547mA as shown in figure 21

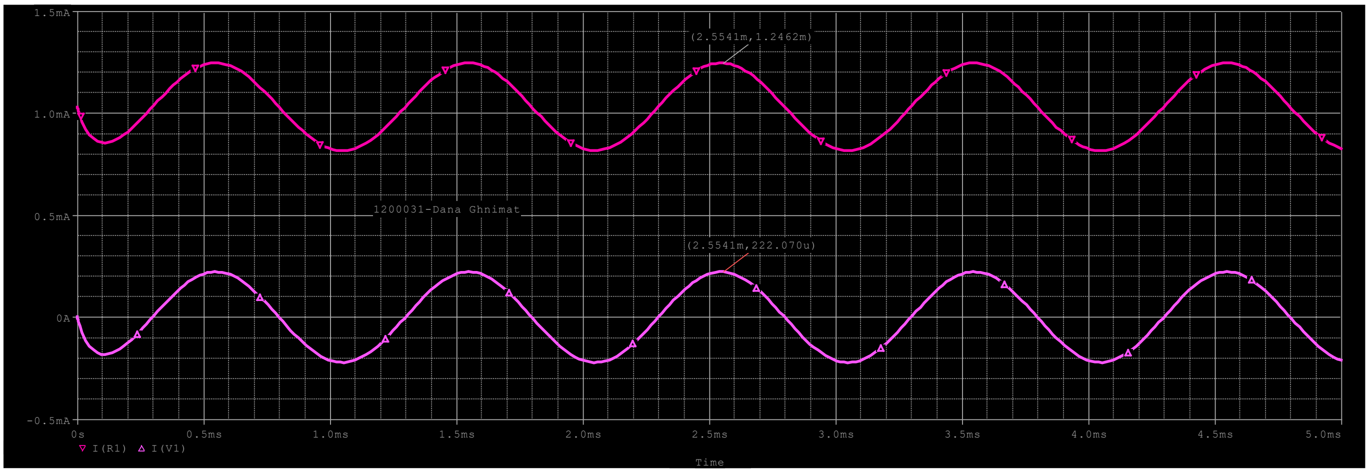

Figure 21 Common Base amplifier Ii and Iout

$$Ai = \frac{Io}{Iin}$$
$$= 1.2462m / 222.070\mu$$
$$= 5.6117$$

Since V_{in} = 0.37V, and, $I_{i,\ peak}$ = 222.070 µA, Then

$$Zi = \frac{Vin}{Iin}$$
$$= 0.37 / 222.070\ \mu$$
$$= 1.66614k\Omega$$

3.4: V across 0.47kΩ Resistor:

To value the Voltage across R= 0.47kΩ, RMS values has been taken.

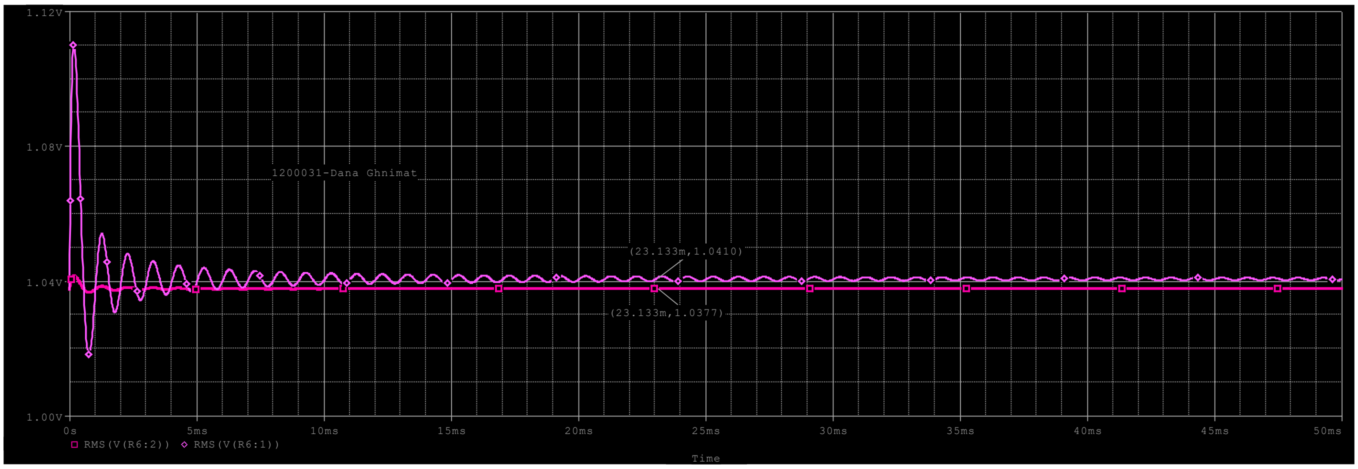

Figure 22 Common Base amplifier V(rms) for 0.47k resistor

V = 1.0410 - 1.0377 = 0.0033V

3.5: I_{in} for 10kΩ resistor:

To measure Iin for 10k resistor, the 0.47k resistor is replaced with with 10k:

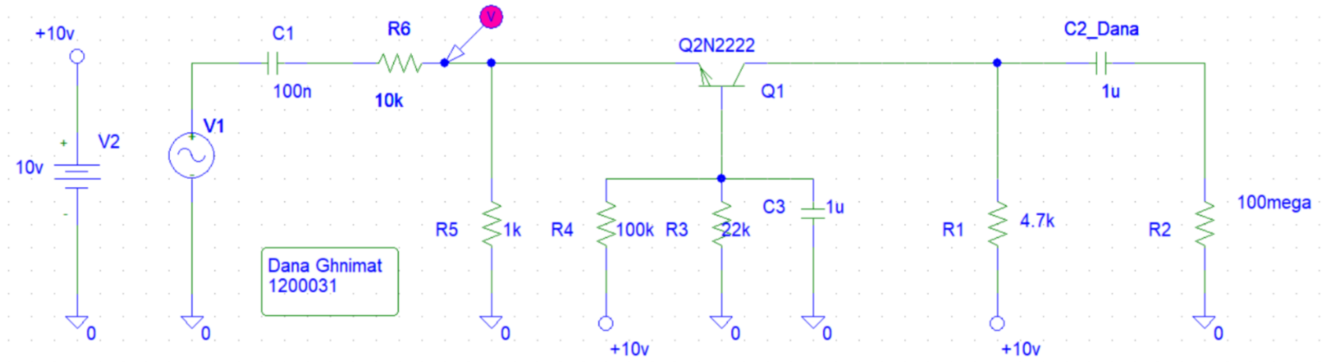

Figure 23 Common Base amplifier with 10k resistor

Simulation using RMS value of V: 1.0374V

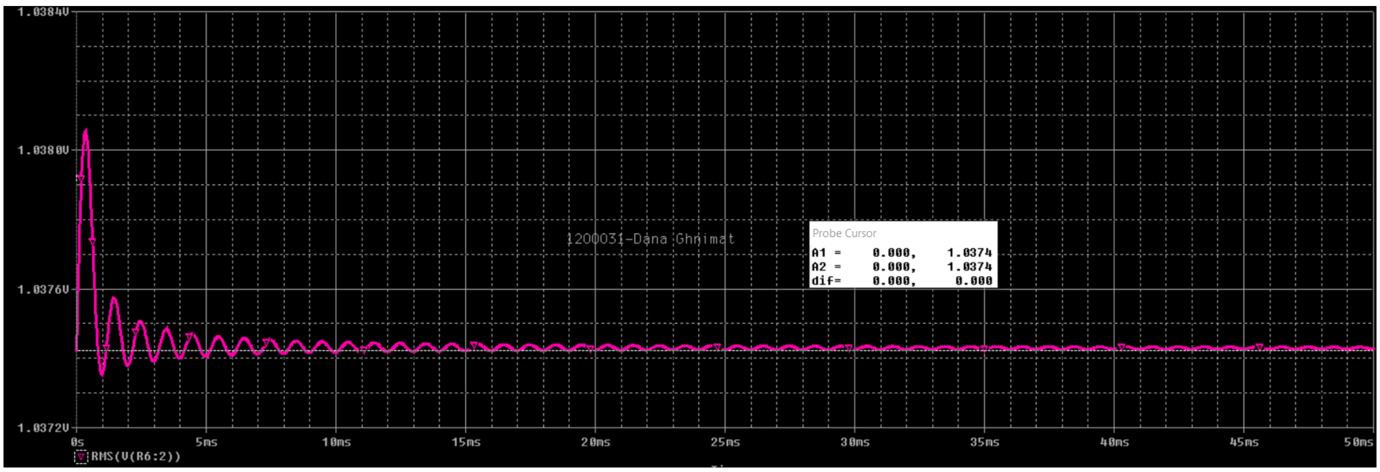

Figure 24 Common Base amplifier with 10k resistor VRMS simulation

$$I_{10K,\,R} = \frac{\boldsymbol{Vrms}}{\boldsymbol{R}}$$

$$= 1.0374/\ 10k$$

$$= 103.74\ \mu A$$

3.6: Calculating Zout:

To measure Zout, the input sine wave generator is replaced with a short circuit, then the generator connected to the output (emitter) via a capacitor, as shown in figure 25.

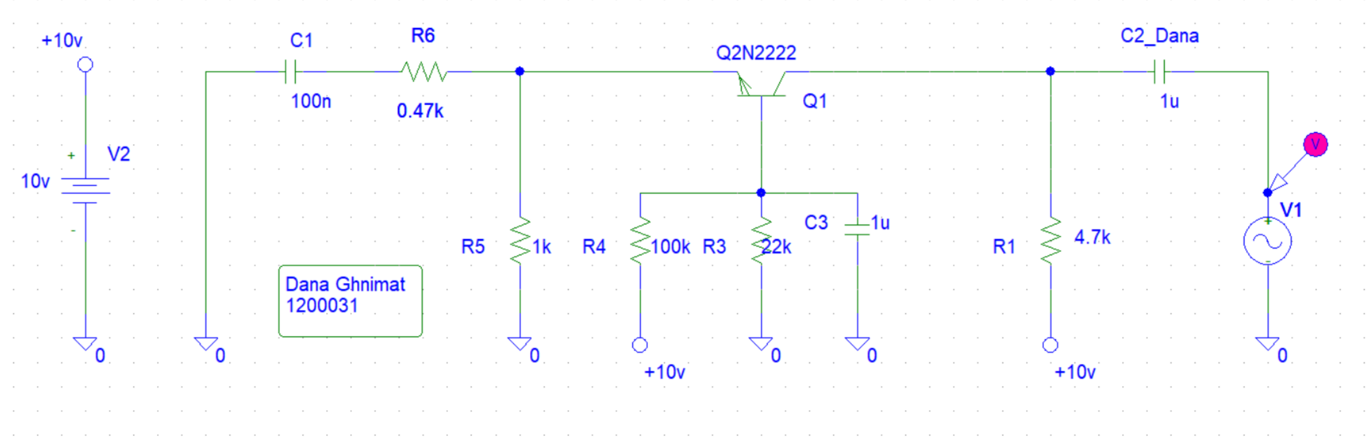

Figure 25 Common Base amplifier Zout

Simulation for Vrms: Vout, rms =261.625mV.

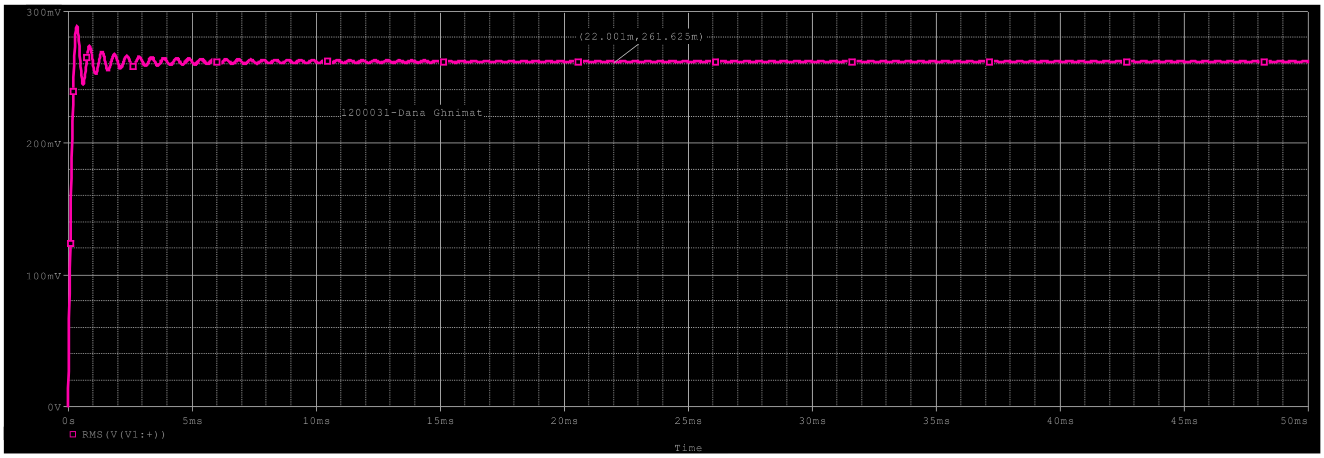

Figure 26 Common Base amplifier Vrms for Zout

Simulation for Irms: Iout, rms =55.735µA

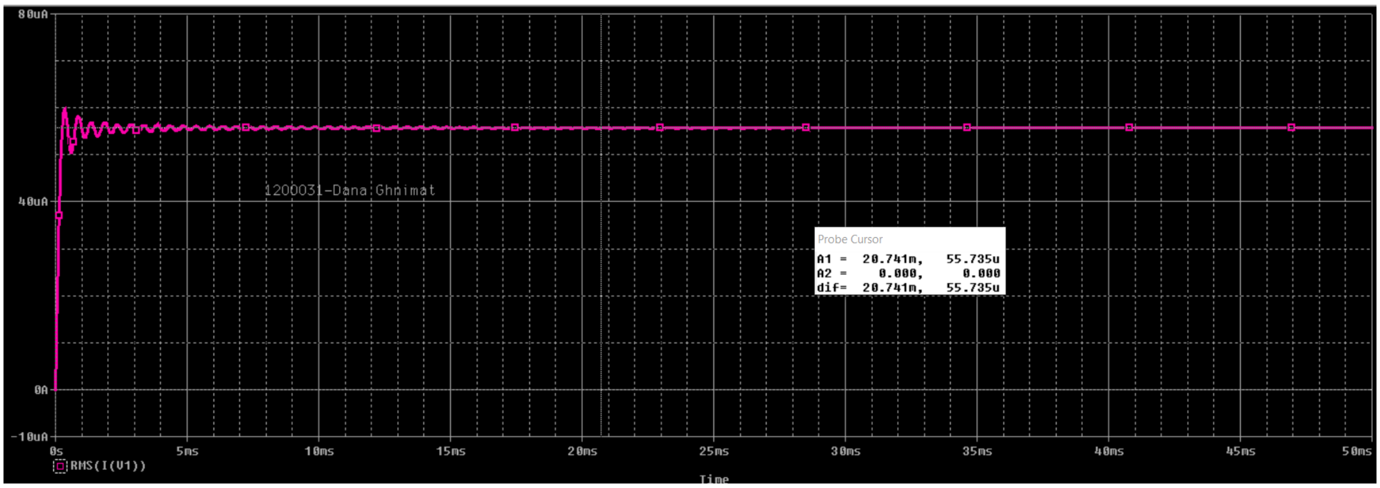

Figure 27 Common Base amplifier Irms for Zout

$$\text{Zout} = \frac{Vo}{Io}$$

$$= 261.625\text{mV} / 55.735\mu\text{A}$$

$$= 4.6941\text{k}\Omega$$

Table 5 Common Base amplifier results

Quantity	Measured values
V_{in}	0.37V
V_{out}	$2V_{P-P}$
$V_{10k, RMS}$	1.0374V
Calculated values	
$A_V=V_{out}/V_{in}$	0.1190
I_{out} = Vout /4.7k	0.2127mA
I_{in} = V_{10k_RMS} /10k	103.74 µA
$Ai=I_{out}/I_{in}$	5.6117
$Z_{in}=V_{in}/ I_{in}$	1.6661kΩ
$Z_{out}=V_T/I_T$	4.6941kΩ

In a common base (CB) amplifier, the output static voltage, determined by the bias of the transistor, as it is influenced by the input AC signal, due to configuration common basis the output roughly following the input.

Compared to the common emitter amplifier, the CB configuration typically shows lower voltage gain with lower input impedance and lower output impedance.

The common emitter amplifier provides both voltage and current amplification, resulting in higher voltage gain, while the common base stage primarily provides current amplification.