Pedro Cabrera

Experiment 9

Bipolar Junction Transistor

Common Collector Amplifier

Introduction:

The objective of this laboratory experiment is to explore the operation and characteristics of a common collector amplifier, also known as an emitter follower, utilizing bipolar junction transistors (BJTs). Our goal is to understand the distinct properties of this amplifier configuration, such as its high input impedance, low output impedance, and a voltage gain of approximately one. By constructing the circuit as per the provided schematic and measuring various DC and AC parameters, we aim to gain practical insights into the behavior of the amplifier under test conditions. We will compare theoretical calculations with actual measurements to evaluate the performance and verify the expected operation of the common collector amplifier. This exercise will not only reinforce our theoretical knowledge from lecture notes and textbooks but also develop our hands-on skills in electronic circuit analysis and troubleshooting.

Bench Parts and Equipment List:

1. Components used:
    - BJT Transistor (2N3904)
    - Resistors: two 10 kΩ, one 100 Ω
    - Capacitor: 100 μF
    - Power supply (Voltage source): Vcc = 10 V
2. Equipment used:
    - Power Supply
    - Function Generator
    - Oscilloscope
    - Multimeter
    - Breadboard and connecting wires
    - Potentiometer

Discussion:

The use of Multisim as a simulation tool provided a strong foundation for understanding the behavior of the common collector amplifier before physical assembly. Simulations are vital in predicting circuit behaviors and identifying potential issues early in the design process. However, the minor discrepancies between the Multisim results and the bench measurements highlighted the limitations of simulation. While Multisim can model ideal conditions, it does not account for all real-world variables such as temperature fluctuations, component tolerances, and parasitic effects. These discrepancies serve as a valuable reminder that while simulations can closely approximate reality, they cannot fully replicate the complexities of physical circuits.

The common collector configuration, often used for its buffering properties, was the focus of our exploration. This circuit is appreciated for its ability to maintain signal integrity, particularly in its role as an impedance matcher. In practice, the common collector lived up to its theoretical reputation. It offered a high input impedance, ensuring that it did not unduly load the signal source, and a low output impedance, which is ideal for driving loads. These characteristics make the common collector an excellent choice for interfacing between circuits with mismatched impedances, validating its common use in real-world applications.

In terms of DC parameters, our bench measurements generally aligned with theoretical expectations. The base-emitter voltage showed the anticipated drop, and the collector-emitter voltage remained consistent with the power supply voltage minus the emitter voltage. The collector current, which we predicted based on the base current and the assumed current gain (β), exhibited only slight variances from the computed values. These small differences in DC measurements could stem from the aforementioned real-world non-idealities not present in the simulation environment.

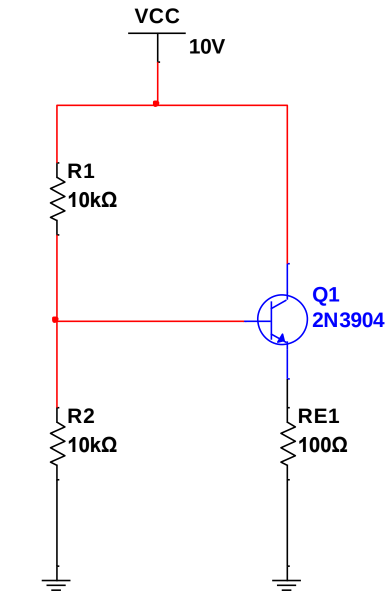

Figure 1

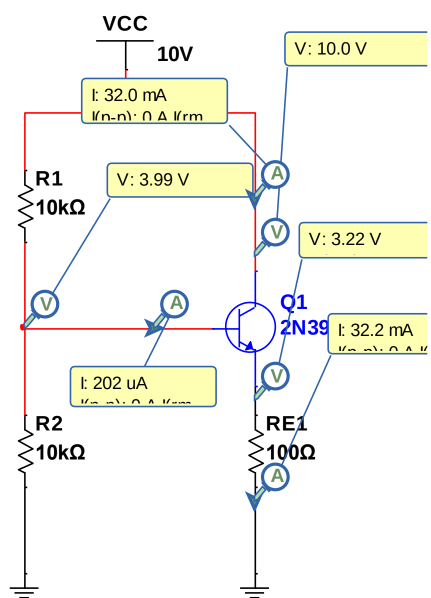

Figure 2

DC Parameters Calculations:

$$R_{INBASE} = \beta_{DC} * R_E$$

$$R_{INBASE} = 150 * 100\Omega = 15k\Omega$$

$$R_{INBASE} \parallel R_2 = \frac{10k\Omega * 15k\Omega}{10k\Omega + 15k\Omega} = 6k\Omega$$

$$V_C = VCC - V_{RC} = VCC - 0 = 10V$$

$$V_B = VCC * \frac{(R_2 \parallel R_{INBASE})}{R_1 + (R_2 \parallel R_{INBASE})} = 10V * \frac{6k\Omega}{10k\Omega + 6\text{k}\Omega} = \; 10V * \; 0.375 = 3.75V$$

$$V_E = V_B - V_{BE} = 3.75V - 0.7V = 3.05V$$

$$I_E = \frac{V_E}{R_E} = \frac{3.05V}{100\Omega} = 30.5mA \approx I_C$$

$$I_B = \frac{I_C}{\beta_{\text{DC}}} = \frac{30.5mA}{150} = 203.33\mu A$$

When we consider the AC parameters, the circuit continued to display its designed functionality. The voltage gain measured across the common collector was indeed close to unity, confirming the theory that this configuration does not amplify voltage significantly. The AC current measurements further substantiated the DC findings, showing the expected trends of the common collector operation. The stability of the output voltage regardless of load changes affirmed the low output impedance of the circuit, demonstrating its effectiveness in real-world signal buffering applications.

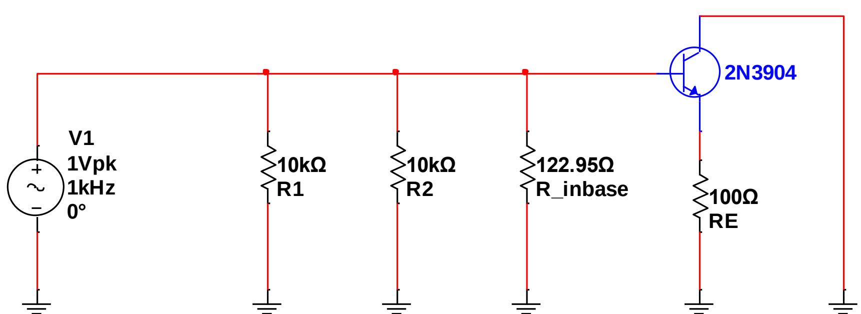

Figure 3

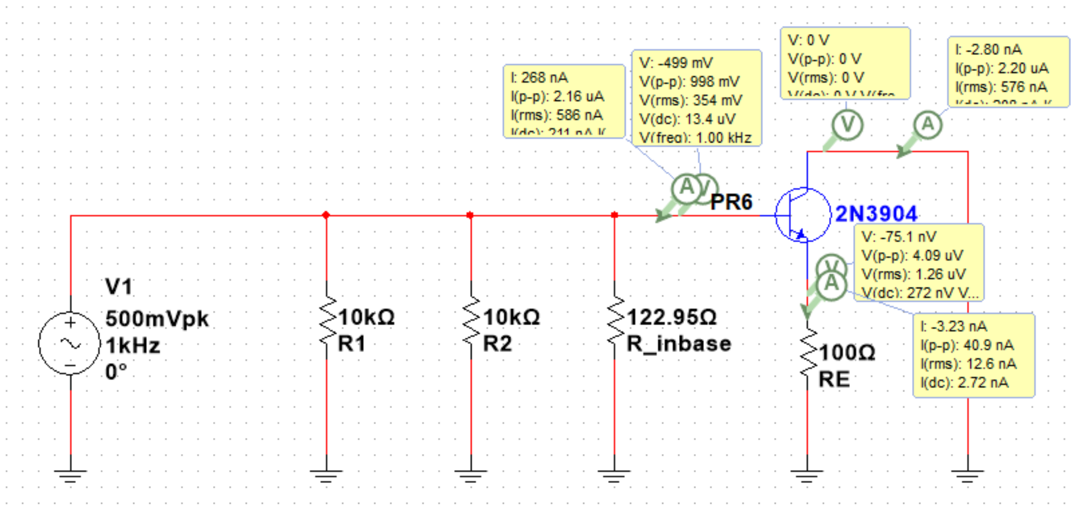

Figure 4

AC Parameter Calculations:

$$r'e = \frac{25mV}{I_E} = \frac{25mV}{30.5mA} = 819.7m\Omega$$

$$R_{inbase} = \beta_{ac} * re' = 150 * 819.7m\Omega = 122.95\Omega$$

$$V_b = V_{in} = 500mVp$$

$$V_c = 0V$$

$$Av = \frac{V_{out}}{V_{in}} = \frac{R_E}{R_E + r'e} = \frac{100}{100 + 819.7E^{-3}} = 991.87E^{-3}$$

$$V_e = Av * V_b = 991.87E^{-3} * 500mVp = 495.93Vp$$

$$I_b = \frac{I_e}{\beta_{ac}} \approx \frac{V_b}{\beta_{ac}(r'e + R_E)} = \frac{495.93Vp}{150\Omega(100 + 819.7E^{-3})\Omega} = 32.79\mu A$$

$$I_e = I_b * \beta_{ac} = 32.79\mu A * 150 = 4.91mA \ \approx I_c$$

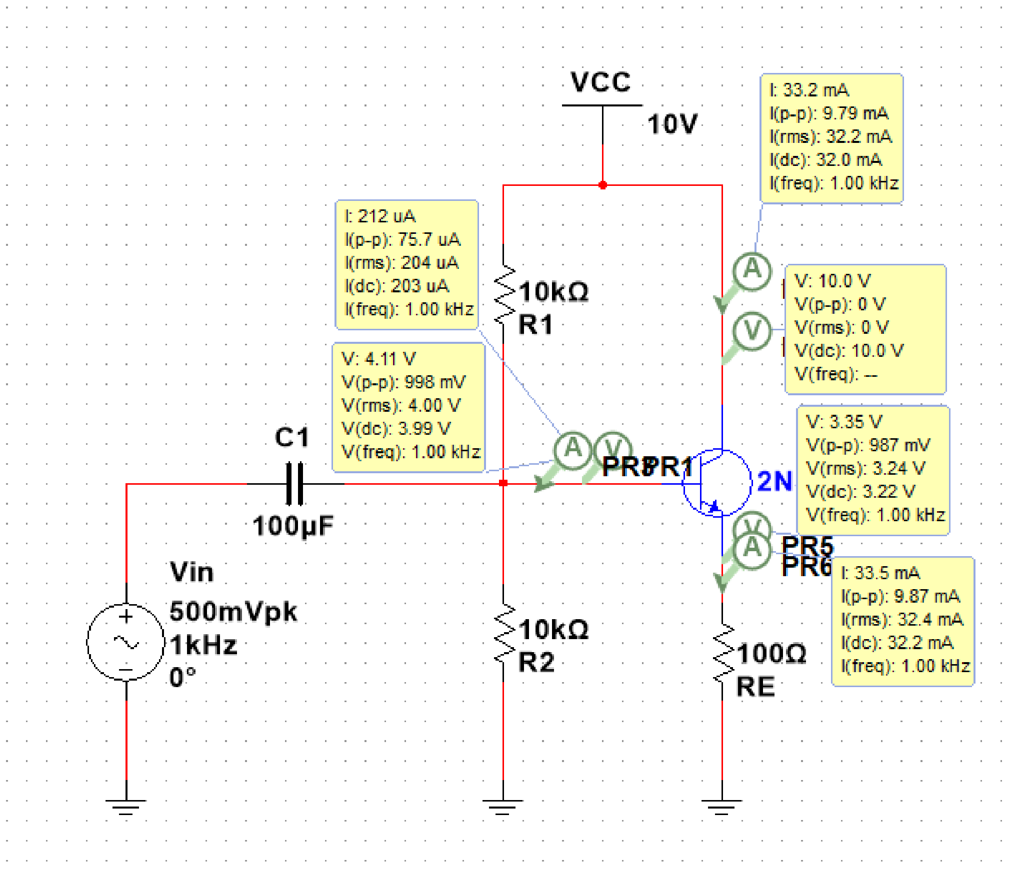

Figure 5

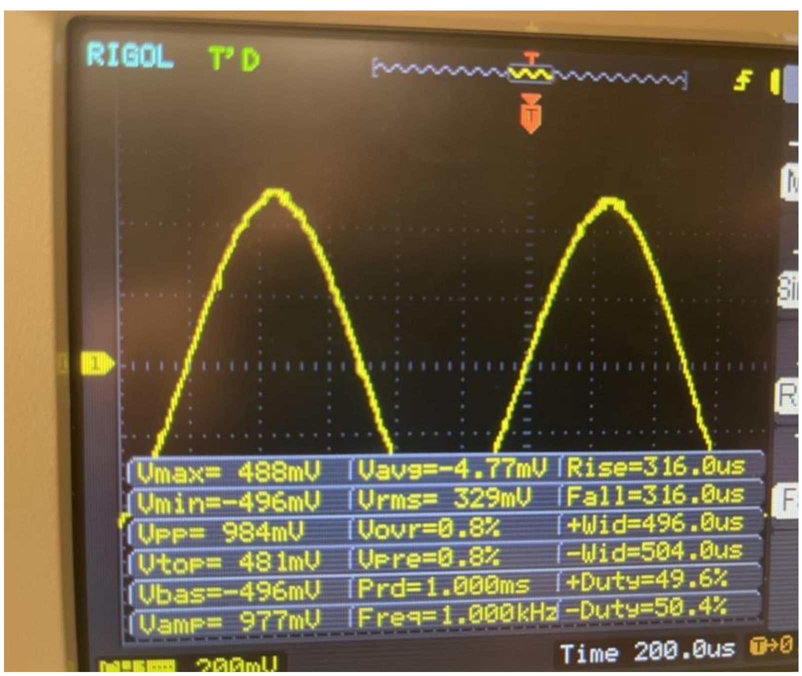

Figure 6 - Validating the Voltage pk

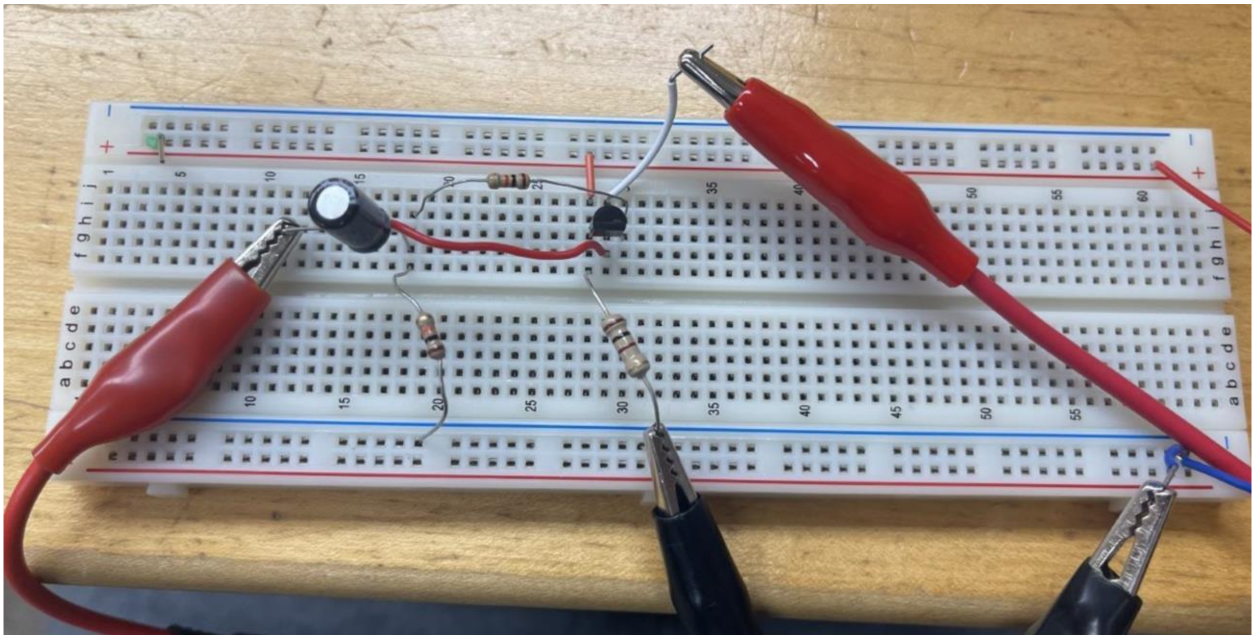

Figure 7- Fully built circuit.

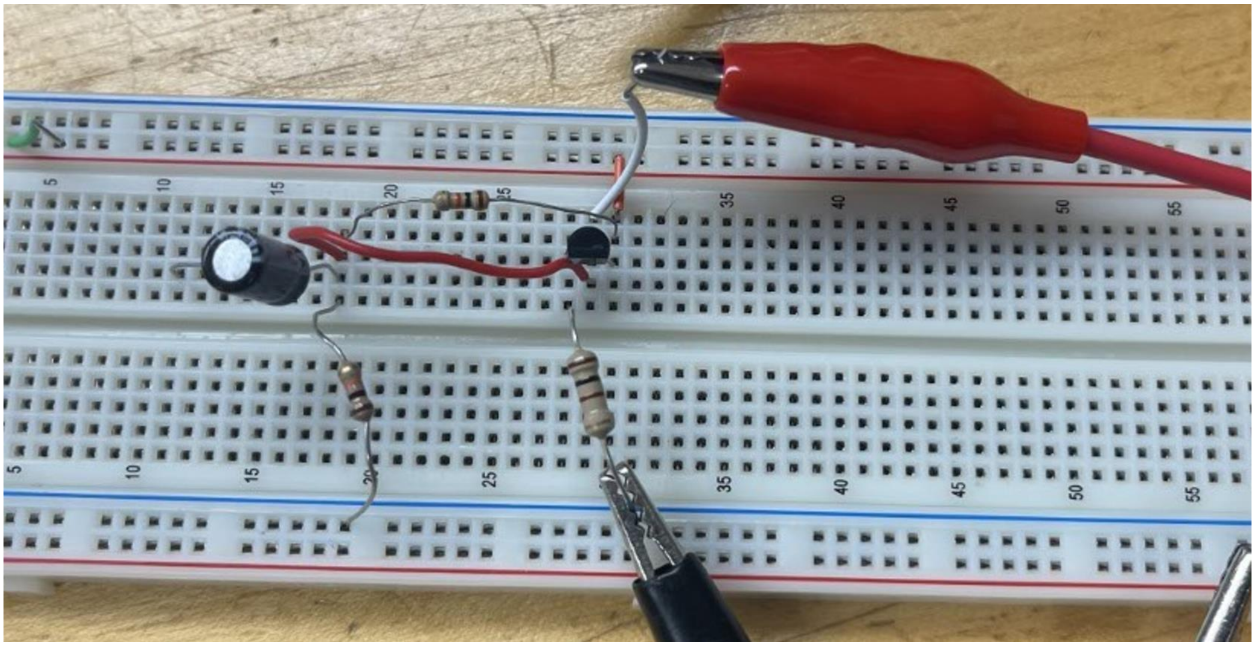

Figure 8 - Measuring Base Voltage

Figure 9 - Base Voltage DC

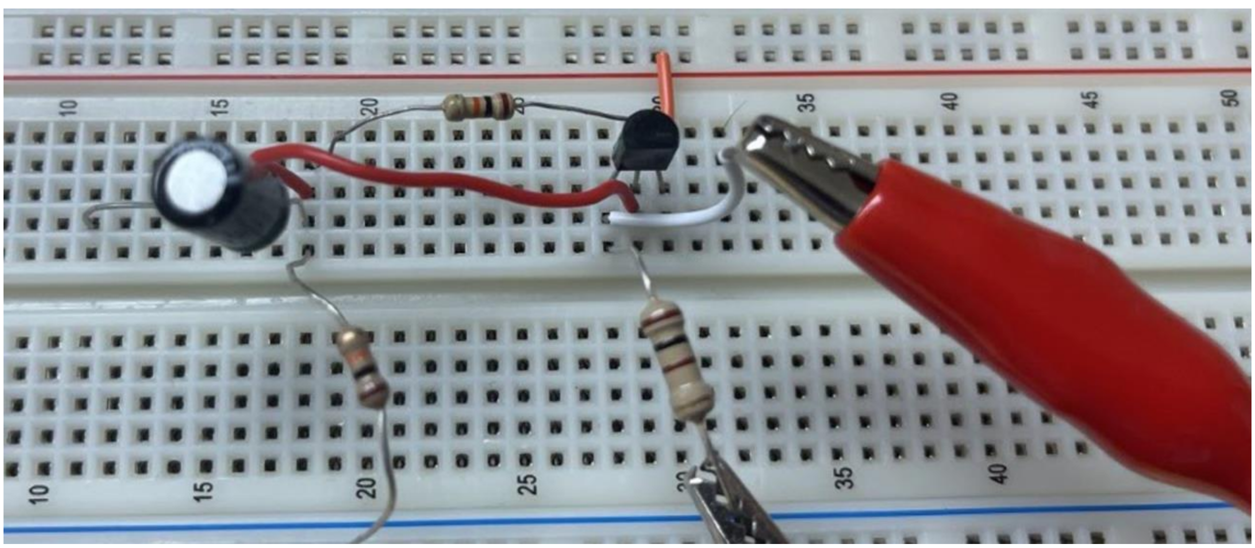

Figure 10 - Measuring Emitter Voltage

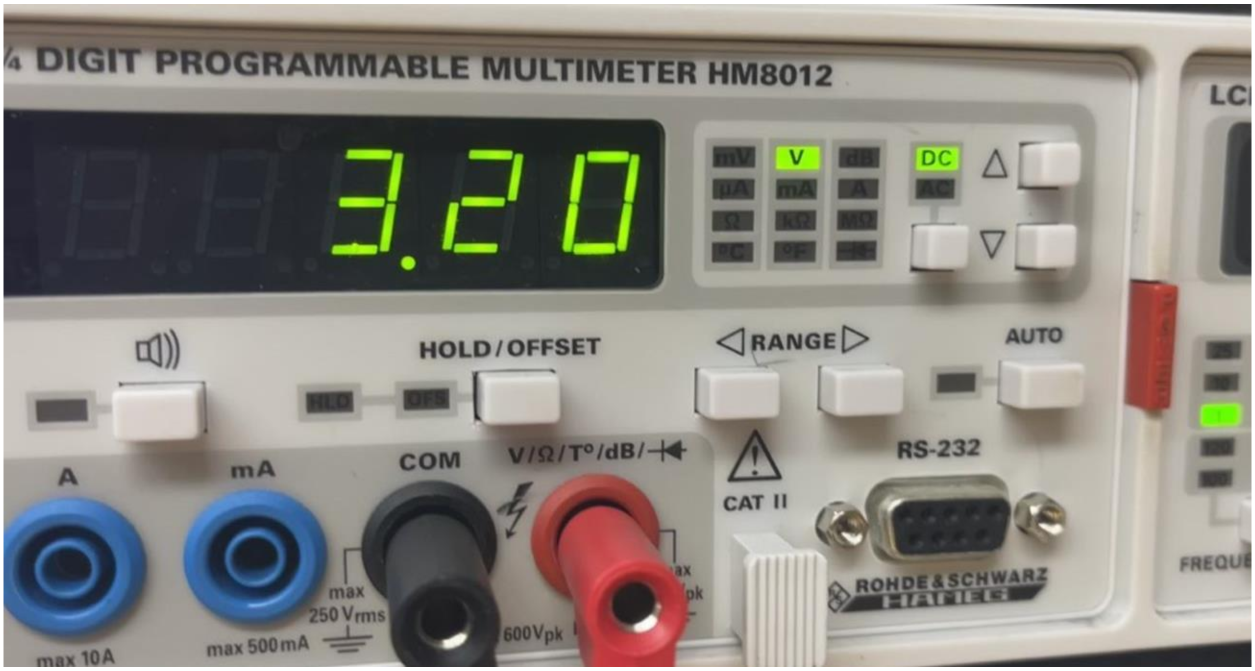

Figure 11 - Emitter Voltage DC

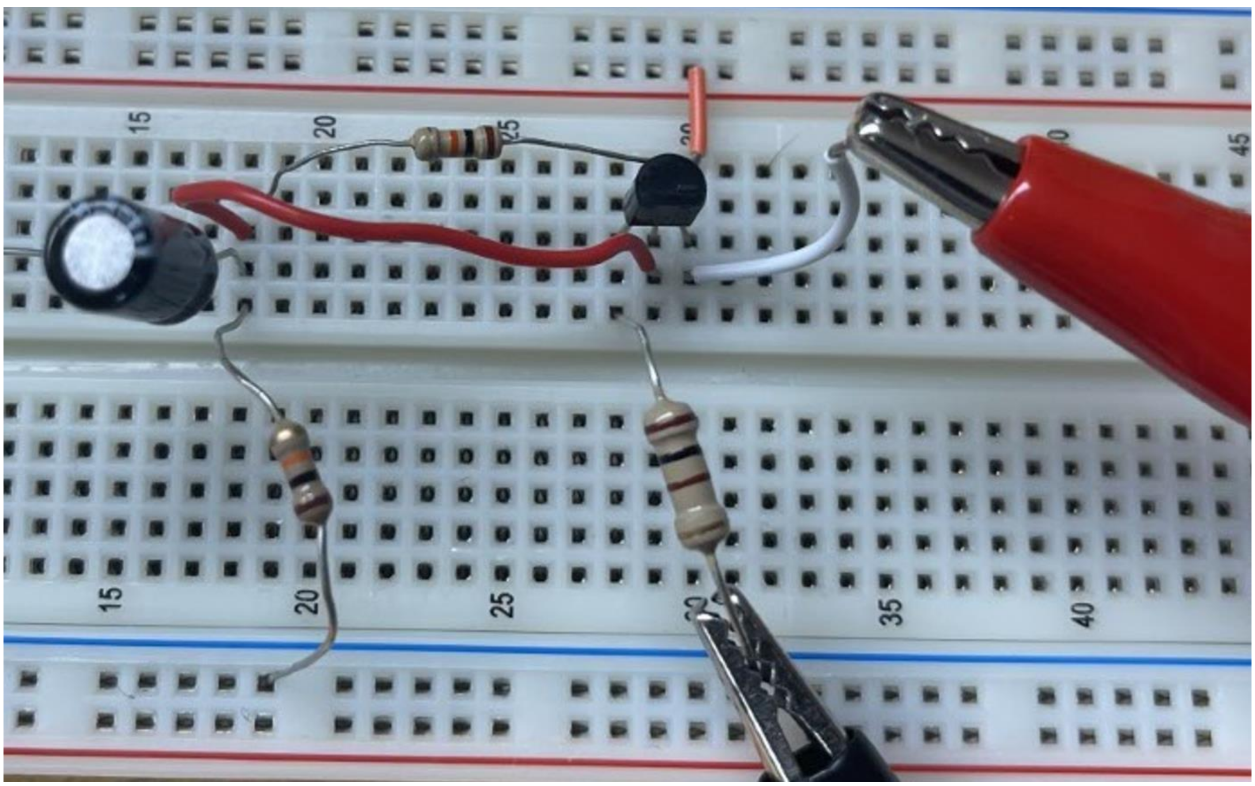

Figure 12 - Measuring collector Voltage.

Figure 13 - collector Voltage DC

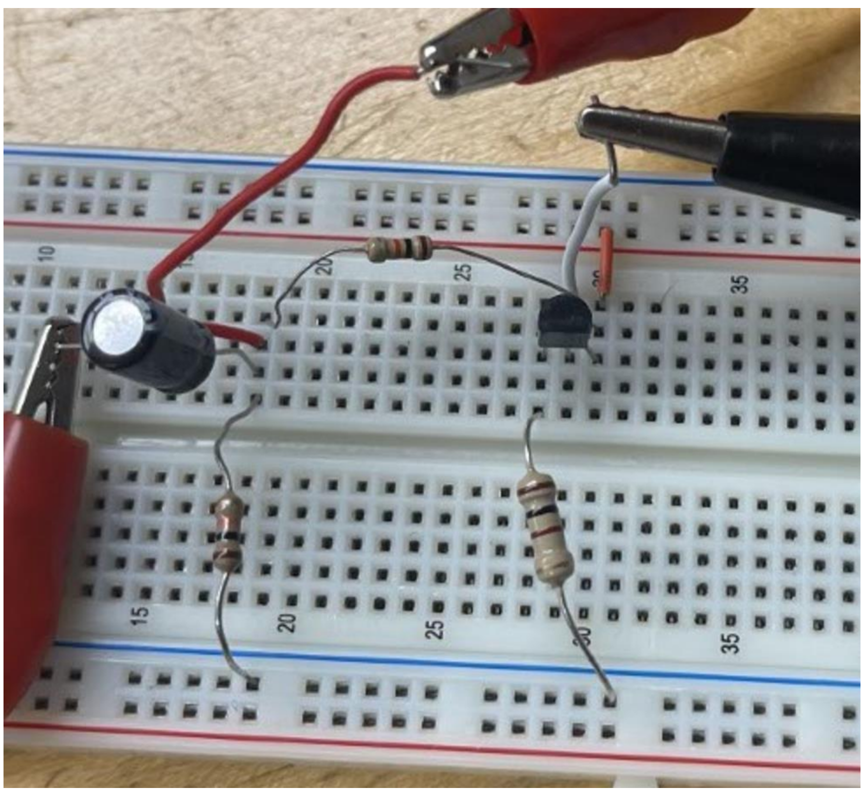

Figure 14 - Measuring Base Current

Figure 15 - Base Current Value

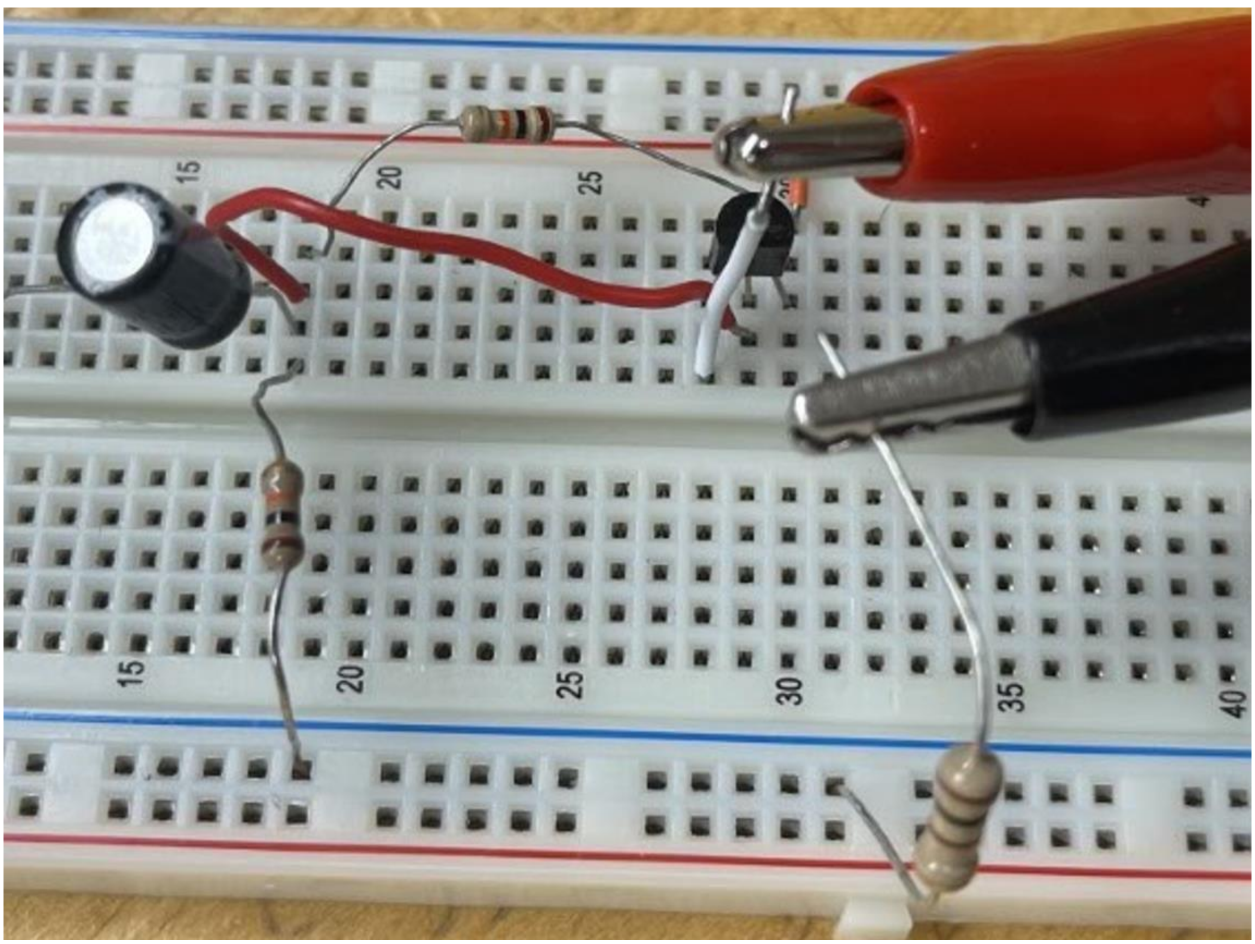

Figure 16 - Emitter Current Measuring

Figure 17 - Emitter Current Value

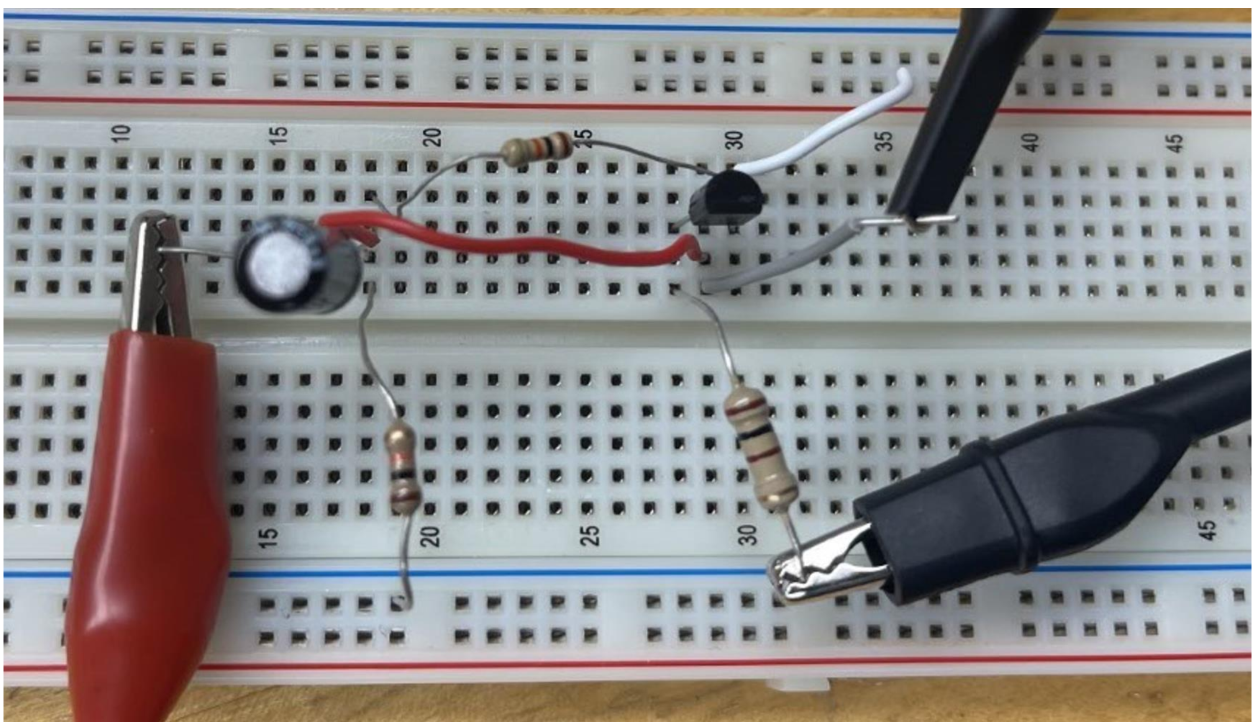

Figure 18 - Measuring Base Voltage AC

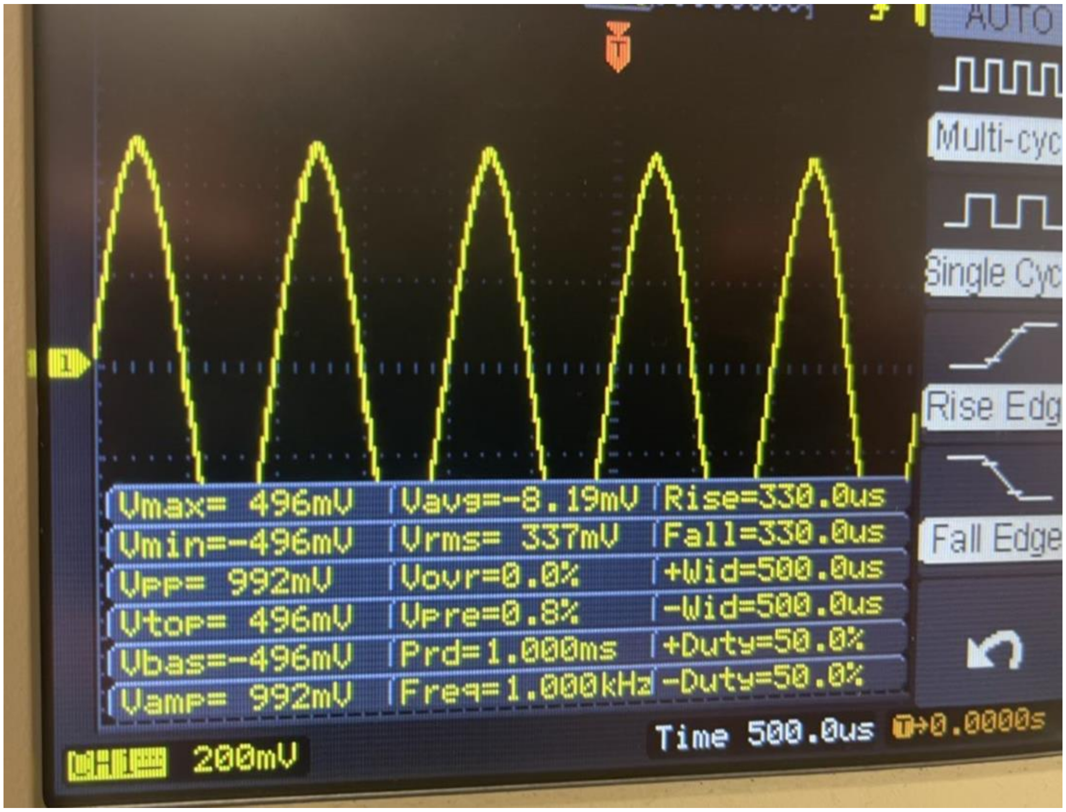

Figure 19 - Base Voltage AC

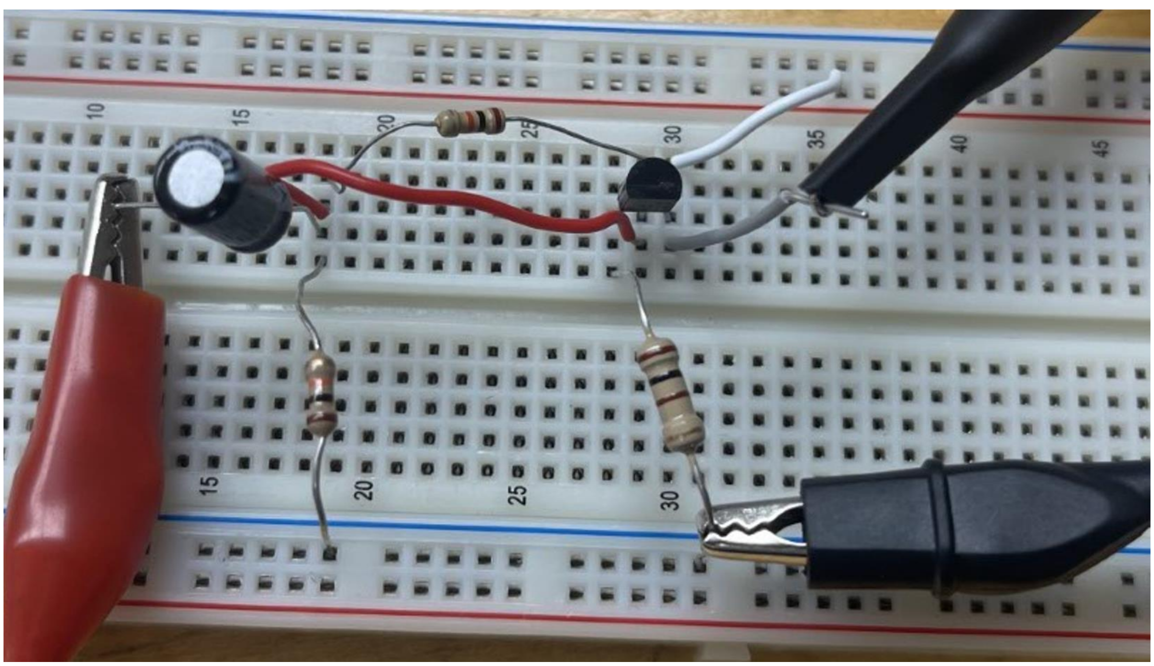

Figure 20 - Measuring Collector Voltage AC

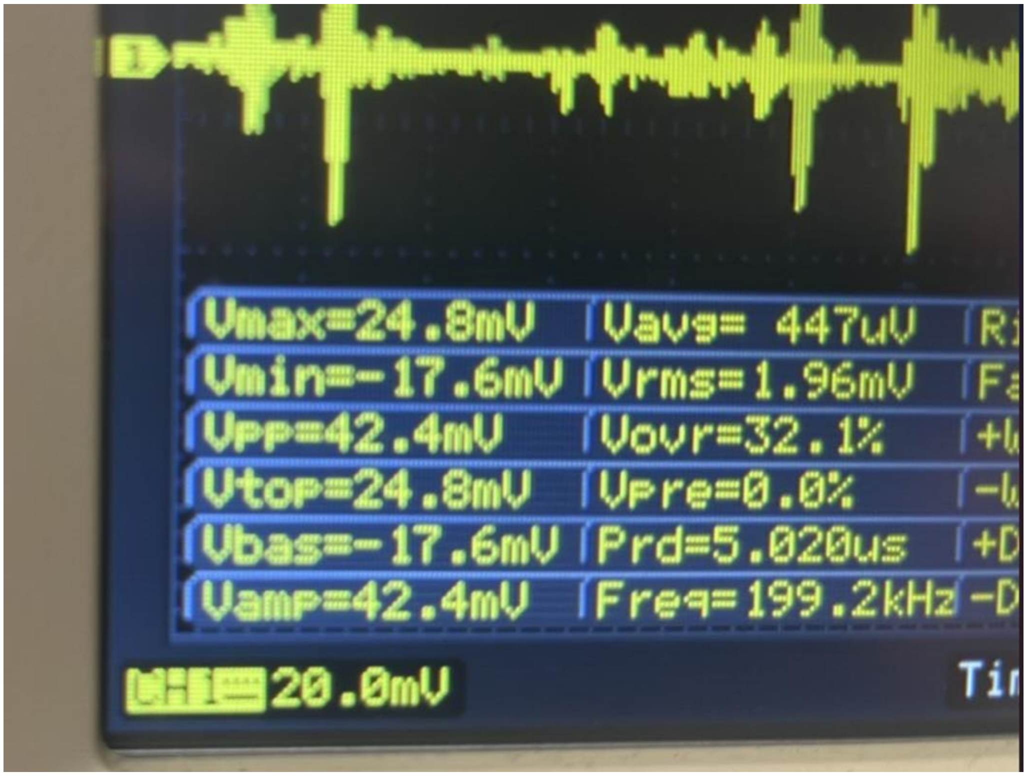

Figure 21 - Collector Voltage, should be 0 V but it was picking up some noise.

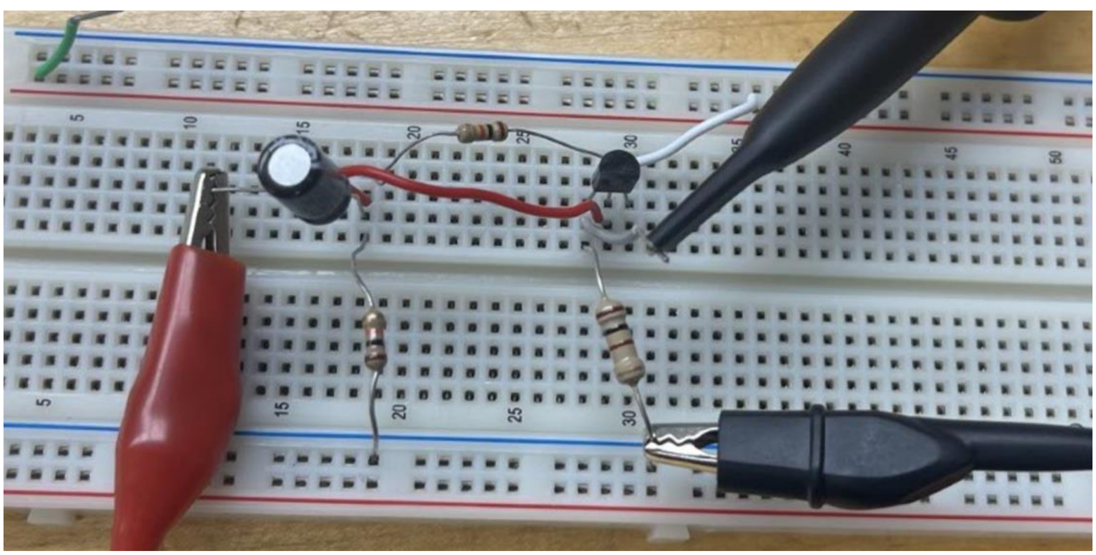

Figure 22 - Measuring Emitter Voltage AC Version 1.

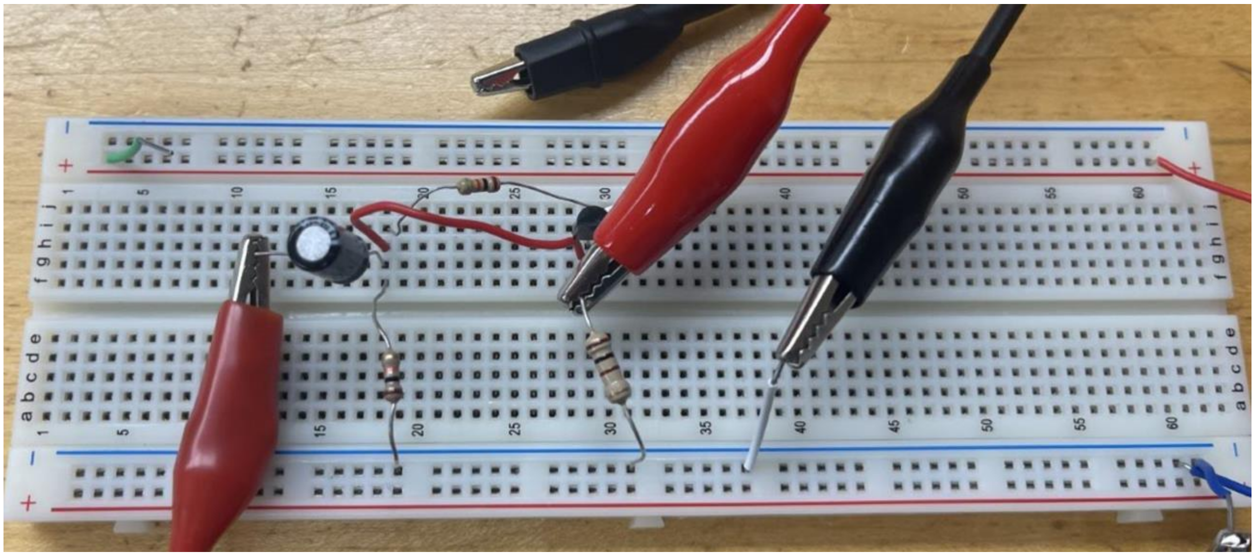

Figure 23 - Measuring emitter voltage with DMM

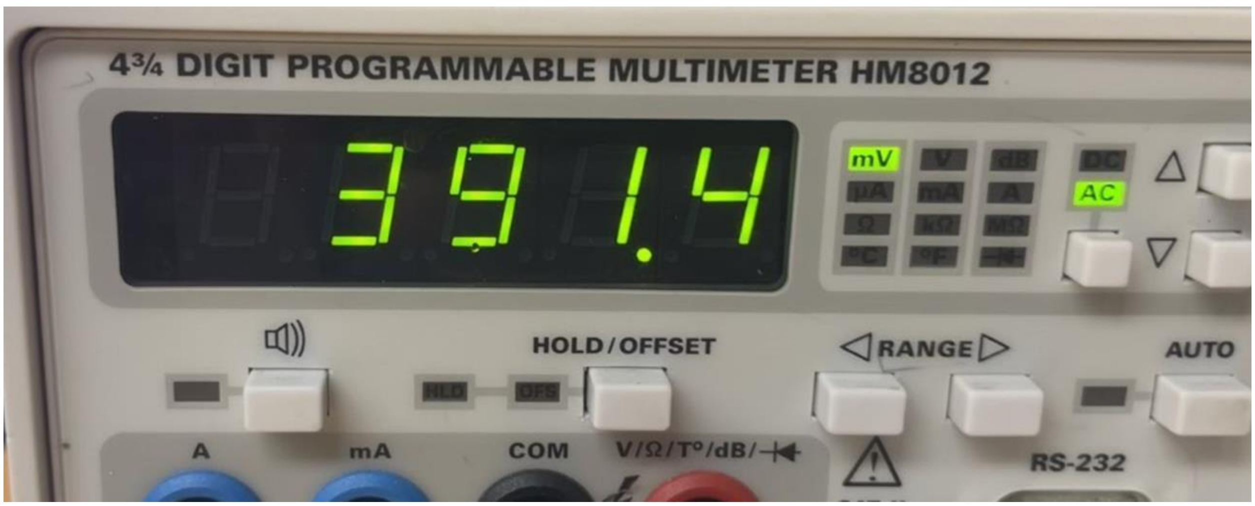

Figure 24 - Emitter Voltage AC

Table 1

	DC Parameters		AC Parameters	
	Computed	Measured	Computed	Measured
Base Voltage	3.75 V	3.93V	500 mVpk	498 mVpk
Emitter Voltage	3.05 V	3.20V	495.93 mVpk	391 mV_{RMS}
Collector Voltage	10 V	10.01 V	0V	0V
Base Current	203.33 μA	162.1 μA	32.79 μA	
Emitter Current	30.5 mA	28.22 mA	4.91 mA	
Collector Current	30.5 mA	31.03 mA	4.91 mA	

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Experiment 9
Bipolar Junction Transistors
Common Collector Amplifier

Common Collector Amplifier. Common Collector amplifier also known as emitter follower is widely used in class B power amplifiers. It has a voltage gain of approximately 1 which makes it to act as a buffer, isolating two circuits. Common collector amplifier has relatively high input impedance and very low output impedance.

Objective: To investigate the operation of a common collector amplifier.

Materials
- Power Supply, Function Generator
- BJT Transistor (2N3904)
- 10 kΩ (2), 100 Ω, 100 μF

Input: Function Generator
Output: Oscilloscope

Procedure:

1- Build the amplifier circuit shown in figure 1. Assume $ß_{ac} = ß_{DC} = 150$.

2- Apply 1 Vp-p @ 1 KHz AC signal to the base of the amplifier through the input coupling capacitor.

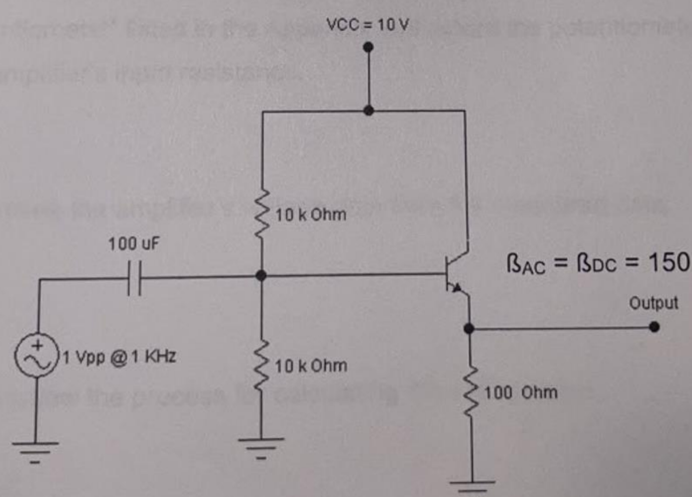

Figure 1

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R 4.03.24

3- Measure and record the amplifier's DC and AC currents and voltages in Table 1.

	DC parameter		AC parameter	
	Computed	Measured	Computed	Measured
Base Voltage	3.75 v	3.93 v	500 mVp	498 mv
Emitter Voltage	3.05 v	3.20 v	495.93 vp	550 mVp
Collector Voltage	10 v	10.01 v	0 v	0 v
Base Current	203.33 μA	162.1 μA	32.79 μA	
Emitter Current	30.5 mA	28.22 mA	4.91 mA	
Collector Current	30.5 mA	31.03 mA	4.91 mA	

4- Determine the AC resistance of the emitter diode, r_e'.

$$r'e = \frac{25 mV}{I_E} = \frac{25 mV}{30.5 mA} = 819.7 m\Omega$$

5- Measure the amplifier's input resistance. (Use a potentiometer).
Note: Follow the steps for "Measuring Rin of the Amplifier with a Potentiometer" listed in the Appendix and record the potentiometer value as the amplifier's input resistance.

$14.6 k\Omega$

6- Determine the amplifier's voltage gain from the measured data.

$$A_V = \frac{V_{out}}{V_{in}} = 1.1$$

7- Show below the process for calculating the voltage gain.

$$A_V = \frac{V_{out}}{V_{in}} = \frac{R_E}{R_E + r'e} = \frac{100}{100 + 819.7 E^{-3}} = 991.8 E^{-3}$$

8- Elaborate on the results of the calculated and measured voltage gains.

Since Voltage gain is < 1 that means we're loosing Voltage.
41 However somehow in the measurements my Vout kept jumping between really low and slightly higher than Vin

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Conclusion:

The primary objective of this lab was to investigate the operational characteristics of a common collector amplifier and to validate the theoretical concepts through practical experimentation. The lab was successful in meeting its objectives, as we were able to construct the circuit, perform measurements, and observe the behavior of the common collector amplifier in action. Through this process, we learned the significance of the common collector configuration as a buffer and an impedance matcher, reaffirming its role in circuit design. We observed the high input impedance and low output impedance firsthand, which were in alignment with the theory. Despite minor discrepancies between simulation and actual measurements, we learned the importance of accounting for real-world conditions when designing and testing circuits. Additionally, this lab emphasized the value of simulations as a preliminary step in the design process, setting expectations and providing a baseline for actual testing. Overall, the lab was an invaluable hands-on experience that bridged the gap between theoretical study and practical application.