1430
TRANSISTORS
EXPERIMENT 7
THE COMMON-BASE AMPLIFIER

For more courses visit www.cie-wc.edu
OBJECTIVE

1. To measure the voltage, current and power gains of a typical common-base amplifier.

2. To measure the input and output impedances of a typical common-base amplifier.
INTRODUCTION

• The next slide illustrates a common-base amplifier.

• The base is biased by a voltage divider and the emitter is biased through an emitter resistor.
SCHEMATIC OF A COMMON-BASE AMP.
• The input signal is injected at the emitter, and the output signal is measured at the collector.

• The capacitors are used, in the circuit, to block the DC bias currents and pass only the AC signal currents.
• In this experiment, we will be calculating, using measured values, the Voltage Gain $A_V$, Current Gain $A_I$ and the Power Gain $A_P$.

• The following slide illustrates the formulas for the gains mentioned above,

• Later we will use these formulas to compare the three basic amplifier configurations.
BASIC AC GAIN FORMULAS

\[ A_v = \frac{\text{AC output voltage}}{\text{AC input voltage}} \]

AC Voltage Gain Formula
$A_I = \frac{\text{AC output current}}{\text{AC input current}}$

AC Current Gain Formula
\[ A_P = \frac{\text{AC output power}}{\text{AC input power}} \]

AC Power Gain Formula
REQUIRED PARTS

1. 330Ω ½ Watt resistor (orange-orange-brown)
2. 1000Ω ½ Watt resistor (brown-black-red)
2. 1200Ω ½ Watt resistor (brown-red-red)
1. 6800Ω ½ Watt resistor (blue-gray-red)
2. 10 kΩ ½ Watt resistor (brown-black-orange)
1. MPSA-20 silicon transistor
3. 10 μF electrolytic capacitor
PROCEDURE

1. Construct the circuit, for Experiment 7, which is shown on the next slide
   a) Turn on the trainer and adjust the positive power supply to +15 V.
   b) Measure the voltages on the emitter, base and collector to make sure they are approximately the same as shown on the Experiment 7 schematic.
EXPERIMENT 7 SCHEMATIC

- **$R_6$: 10kΩ**
- **$R_7$: 1200Ω**
- **$R_4$: 1200Ω**
- **$R_5$: 6800kΩ**
- **$C_1$: 10μF**
- **$C_2$: 10μF**
- **$C_3$: 10μF**
- **$Q_1$: MPSA20**
- **$V_i$: Voltage**
- **$V_o$: Voltage**
- **$I_i$: Current**
- **$R_2$: 330Ω**
- **$R_3$: 1000Ω**
- **$1\,kΩ$ Potentiometer $R_1$**

Denotes DC voltages with respect to ground.
c) If you have trouble obtaining a voltage in step 2, increase $R_2$ until you get the necessary voltage.

1. Try the following resistor values: 470 Ω, 560 Ω, 680 Ω, 820 Ω, or 910 Ω.

2. Adjust the frequency control so the sine output is 1 kHz and adjust $R_1$ so that the AC output voltage $V_0$ is 2V rms. (Be sure to use the correct scale on your meter.)
3. Measure $V_i'$, and record the rms value in the experiment book.

4. Use the below voltage-divider formula to calculate the actual input voltage $V_i$.

$$V_i = V_i' \left( \frac{R_3}{R_2 + R_3} \right)$$
a) Record the calculated rms value in the experiment book.

5. Calculate the voltage gain of the amplifier using the formula $V_o/V_i$.
   a) Record the calculated value of the voltage gain in the experiment book.
6. Remove the $1000 \Phi$ resistor $R_3$, and short the $330 \Phi$ resistor $R_2$ with a jumper wire.

   a) Add a $1000 \Phi$ resistor ($R_{10}$) in series with $R_1$, as shown in the diagram of the 1st modification of Experiment 7 schematic diagram. The schematic is on the next slide.

   b) Adjust $R_1$ so that $V_0$ is 2.0 V rms.
1\textsuperscript{st} MODIFICATION OF EXP. 7 SCHEMATIC
EXP. 7, 1ST MOD. CIRCUIT PICTORIAL
7. Remove the jumper wire across \( R_2 \), and measure the output voltage \( V_0 \).
   a) Record the rms value in the experiment book.

8. Determine the input voltage required to get the output voltage you recorded in step 7.
   a) Use the voltage gain you recorded in step 5.
b) Record the input voltage (rms value) in the experiment book.

9. The voltage drop of $R_2$ is the difference between the voltage you recorded in step 4 and the voltage you calculated in step 8.

a) Record the input voltage (rms value) in the experiment book.
10. The input current is the voltage across resistor $R_2$ divided by the resistance value of $R_2$.

a) Calculate the input current, using the voltage you recorded in step 9.

b) Record the current value in the experiment book. $I_i = ____ m\text{\textdegree}$ rms
11. The output voltage is the output voltage $V_0$ divided by the load resistance $R_L$ (10kΩ).

a) Calculate the output current, using the voltage you recorded in step 7.

b) $I_0 = \underline{\hspace{2cm}}$ mA rms. (Value may be in mA rms.)
12. The current gain is the ratio of the output current to the input current.

a) This means divide the output current by the input current.

b) Use the values you recorded in steps 10 and 11 and calculate the current gain.

c) Record this calculation in your experiment/lab book.
13. The power gain is the current gain (step 12) times the voltage gain (step 5).
   a) Record this calculation in your experiment/lab book.

14. The input impedance is the input voltage (step 8) divided by the input current (step 10).
a) Use the values you recorded in steps 8 and 10 and calculate the input impedance.

b) Record this calculation in your experiment/lab book.
15. To measure $Z_0$, remove the 10kΩ resistor $R_8$ and replace it with the 100kΩ pot on your trainer. Look at the following schematic and pictorial diagrams.

a) When $R_9$ is adjusted to a value equal to $Z_0$, only half the voltage will appear across the output.
EXP. 7, 2\textsuperscript{nd} MOD. CIRCUIT PICTORIAL
b) Lift (disconnect) the ground wire on $R_9$, and adjust $R_1$ so the output voltage is 2V.

c) Reconnect the ground wire to $R_9$, and adjust $R_9$ so that the output voltage is 1V.

d) Turn the trainer off, and disconnect $R_9$ without disturbing its setting.

e) Using the X 1KΩ scale of your multimeter, measure the resistance between points 1 and 2 of $R_9$. Record the value in Lab book.
CIE RESULTS

3. 0.2 V

4. 0.15 V...2.0 V x \( \frac{1\,\text{k}Ω}{(1\,\text{k}Ω + 330Ω)} \) =

\[
0.2 \,\text{V} \times 0.7519 = 0.15 \,\text{V}
\]

5. 13.33...\( A_v = \frac{V_o}{V_i} = \frac{2.0 \,\text{V}}{0.15 \,\text{V}} = 13.33 \)

7. 0.95 V

8. 0.07 V...\( V_i = \frac{V_o}{A_v} = \frac{0.95 \,\text{V}}{13.33} = 0.07 \,\text{V} \)
9. \(0.08 \text{ V} \ldots 0.15 - 0.17 = 0.08 \text{ V}\)

10. \(0.24 \text{ mA} \ldots 0.08 \text{ V/330} \Phi = 0.24 \text{ mA}\)

11. \(95 \Omega \ldots 0.95 \text{ V/10k} \Phi = 95 \Omega\)

12. \(0.40 \ldots \text{A}_l = I_0/I_i\)

13. \(5.33 \ldots \text{A}_p = A_v \times \text{A}_l\)

14. \(292 \Phi \ldots Z_i = 0.07\text{V/}0.24 \times 10^{-3} \text{ A} = 292 \Phi\)

15. 5000 \(\Phi\)
Since the voltage gain of the amplifier was so high, it was not possible to measure the input voltage directly. Thus we used a voltage divider consisting of the $330 \, \Omega$ resistor $R_2$ and the $1000 \, \Omega$ resistor $R_3$. 
Then we could measure the voltage going into the divider Vi’ (step 3), and the voltage coming out of the divider, Vi (step 4). We were then able to calculate the voltage gain (step 5).

- We then measured the input current indirectly.
• We first adjusted the input voltage so the output voltage was 2V (step 6).
• Then we inserted a 330 Ω resistor in series with the input (step 7), and measured the output voltage. This let us use the voltage gain, of the amplifier, to calculate the voltage drop across the 330 Ω resistor (steps 8 and 9).
• We could then calculate the current through the 300 Ω resistor (step 10), since we knew the voltage across the 300 Ω resistor.

• Since the 330 Ω resistor was in series with the input of the amplifier, the current through the 330 Ω resistor was the same as the current through the input of the amplifier (step 10).
• The previous steps of this experiment gave us the voltage gain, input voltage, output voltage and input current.

• We were then able to calculate the current gain (step 12), power gain (step 13), and the input impedance (step 14).
We measured the output impedance by simply loading the output with the 100kΩ potentiometer until the output voltage was half its unloaded value.

At this point, half the voltage was across the output impedance of the amplifier and half was dropped across the load resistor (the 100 kΩ potentiometer).
The measured resistance of the 100 kΩ potentiometer at this setting was equal to the output impedance of the amplifier. While your results may differ substantially from ours (due to variations from one transistor to another), your conclusions should be in the same general range as those reached in the lab at CIE.
To summarize our results, we recorded the following: a voltage gain of 13.3; a current gain of 0.4; a power gain of 5.33; an input impedance of 292 Ω; and an output impedance of 5000 Ω.
QUESTIONS?
RESOURCES
