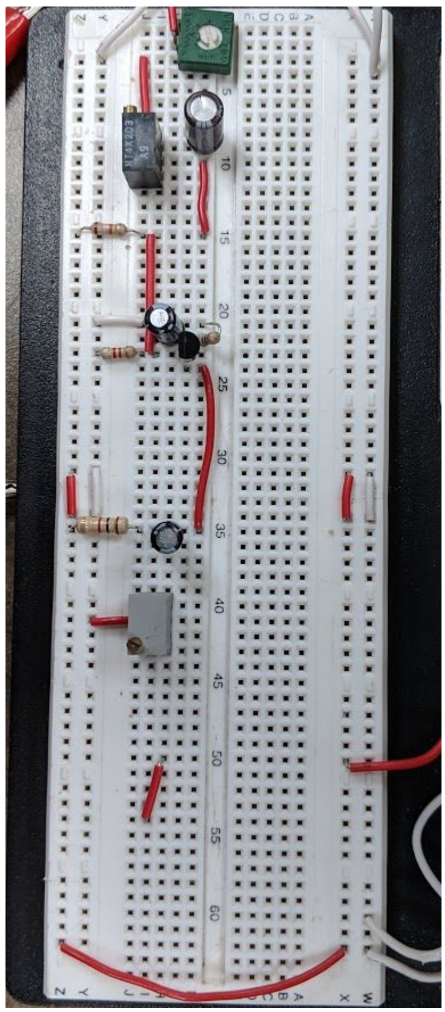
Experiment 15

Common-Emitter Amplifier Impedance, Power, And Phase Relationships



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Objectives:

1. The objectives of this lab are to measure both the input and output impedance of a CE amplifier
2. Determine decibel power gain of a CE amplifier
3. To observe the phase of both input and output voltages with an oscilloscope

Materials:

- **0-30 V variable power source**
- **A Digital Multimeter**
- **An Oscilloscope**
- **An AF sine-wave generator**
- **470 Ω, 4700 Ω, 8200 Ω, 1000 Ω(*2), 18000 Ω resistors**
- **5000 Ω 2-Watt Potentiometer**
- **A 100 µf-50 V and two 25 µf-50 V electrolytic capacitors**
- **A 2N3904 NPN Transistor**
- **A SPST switch**
- **Computer with Multisim**
- **Breadboard and Wires**

Procedure:

1. **Figure 15-6** should be constructed as shown in multisim while a physical version should also be constructed as shown in **figure 15-3** and the following steps should be done on both circuits.
2. R_X should be adjusted to 1000 Ω and the sine-wave generator should be set to 1000 Hz and the output should be set to 70% of the maximum undistorted output as observed with an oscilloscope across the output.
3. Measure the peak to peak voltage values of V_{AC}, V_{BC} which is voltage input, and V_{OUT}. record each value in **table 15-4** for multisim data and **table 15-1** for real world data.
4. Measure V_X, I_{IN}, and R_{IN} and record each value in figure 15-4 for multisim data and figure 15-1 for real world data.
5. Adjust R_{out} so the output signal voltage is half of the measured output in step 3.
6. Remove R_{out} and measure its resistance and record it for R_{out} in figures 15-1 and 15-4.
7. Calculate the voltage gain and the power gain (in decibels) and record the values in **tables 15-4 and 15-1** using the equations shown below.

8. Remove C_3 from the circuit and repeat steps 3-7 and record in section 8 of **tables 15-1 and 15-4**.

9. Re-insert C_3 and graph the input and output waveforms in **tables 15-2 and 15-5**.

Real World Calculations

Equation 1: Voltage Gain	$= V_{Out}/V_{In}$	$= 5.48/0.076$	$= 72.1$
Equation 2: Power Out	$= V_{Out}^2/R_{Out}$	$= 5.48^2/958$	= 31 mW
Equation 3: Power In	$= V_{In}^2/R_{In}$	$= 0.076^2/3238$	= 1.67 uW
Equation 4: Power Gain	$= P_{Out}/P_{In}$	$= 0.031/0.00000167$	$= 18562.87$
Equation 5: Power Gain (dB)	$= 10 \log(P_{Out}/P_{In})$	$=10 \log(0.031/0.00000167)$	= 42.68 dB

Table 15-1 Real World Data

	V p-p, V							Gain	
Steps	V_{AC}	$\frac{V\,bc}{V\,in}$	V_{out}	$\frac{V\,x}{V\,ac - V\,bc}$	I_{in} ,uA	R_{in} , Ω	R_{out} , Ω	Voltage	Power db
2-7	0.15	0.076	5.48	.076	22.1	3238	958	72.1	42.68
8	0.728	0.215	1.06 V	0.513	42.3	5083	907	1.93	21.34

Table 15-2

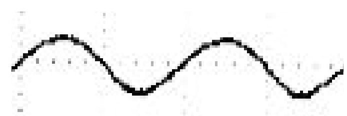
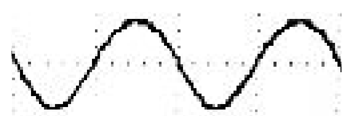
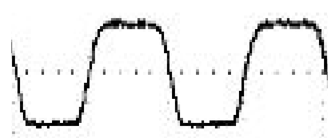
Input Waveform	
Output Waveform	
Distorted Output Waveform	

Figure 15-3

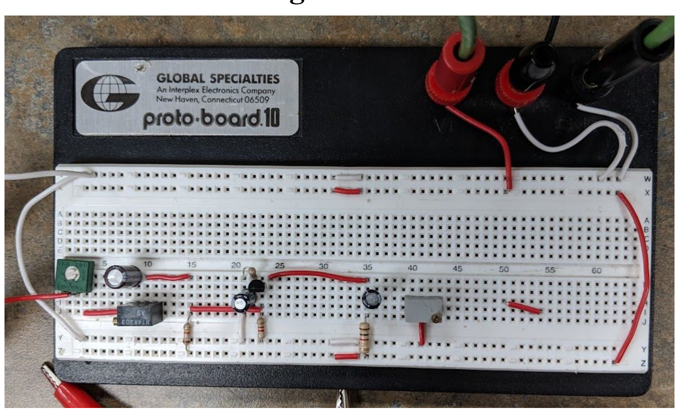


Table 15-4 Multisim Data

Steps	V p-p, V				I_{in}, uA	R_{in}, Ω	R_{out}, Ω	Gain	
	V_{AC}	$\frac{V\,bc}{V\,in}$	V_{out}	$\frac{V\,x}{V\,ac - V\,bc}$				Voltage	Power db
2-7	0.090	0.049	5.31	0.041	41.5	1183	950	108.37	41.65
8	0.596	0.574	1.00	0.022	108	5315	990	1.74	12.12

Table 15-5

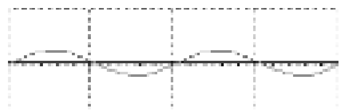
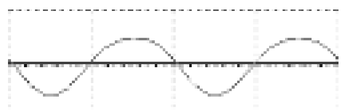
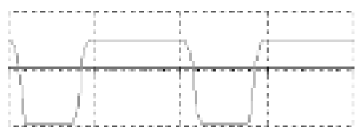
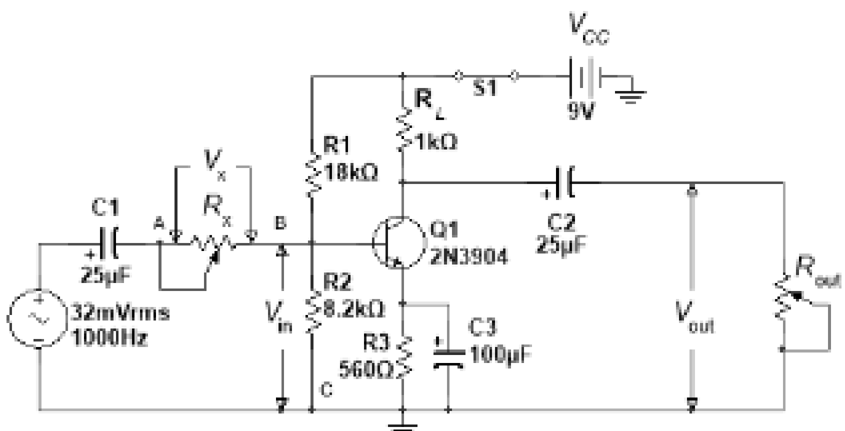
Input Waveform	
Output Waveform	
Distorted Output Waveform	

Figure 15-6



Questions:

1. **(a)If you wished to measure V_X, (voltage across Rx) directly, why would it be necessary to use a "floating" oscilloscope, that is, an oscilloscope whose case is not grounded to the electrical system?**
    - A floating oscilloscope would only measure R_X directly instead of the entire input.

    (b) Why is the use of a floating instrument generally not recommended?
    - A floating instrument isn't recommended for general use due to the fact that it would have nothing to reference to as it would not be grounded and it creates a shock hazard.
2. **What is the effect on input impedance of removing bypass capacitor C_3 in Fig. 15-6? Refer to your data to substantiate your answer.**
    - The input impedance increases as shown in table 15-4 when before the capacitor was removed the input was 1183 Ω and after the capacitor was removed from the circuit the input impedance rose to 5284 Ω.
3. **(a) What is the phase relationship between the input and output signals of a CE amplifier?**
    - The output signal is 180 degrees out of phase with the input signal.

    (b) Was this relationship confirmed by the results of your experiment? Explain how.
    - The relationship was confirmed due to the fact that the measured input voltage was 180 degrees out of phase with the output as shown in table 15-2 or 15-5.
4. **Is the output impedance of a CE amplifier a fixed quantity? Confirm your answer by referring specifically to any substantiating data in this experiment.**
    - No, as shown in table 15-4 when the capacitor was removed from the circuit the output impedance did change a little, from 950 Ω to 990 Ω.

Discussion:

When calculating the power gain valves for both the real world and multisim data tables, the values were originally incorrect. The values were far too high, but this was not found out until we had recalculated the values for a seperate part of the lab. These new values were much smaller and more realistic to what they should be.

Conclusion:

1. The input impedance can be measured by first measuring the input voltage and current then using the equation R=V/
I to find the input impedance. To find the output impedance the voltage of the output should be measured without a load then a potentiometer should be hooked up as the load and adjusted until the voltage reads ½ of the initial output. Take out and measure the potentiometers resistance and it will be equal to the output impedance.

2. The decibel gain is calculated by first finding the power gain as shown in equations 15-2 and 15-3 then using equation 15-5 to find the power gain in decibel units.

3. The input voltage will be 180 degrees out of phase with the output voltage as shown in tables 15-2 and 15-5 due to forward biasing of the input being opposite to the reverse biasing of the output.

Real World Calculations

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