

ELEC-313
Lab 1: Amplifier Models

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1 Objective

The objective is to verify the equivalence of four circuits used to model an amplifier, shown in Figure 3.

2 Schematics

Circuit Tested

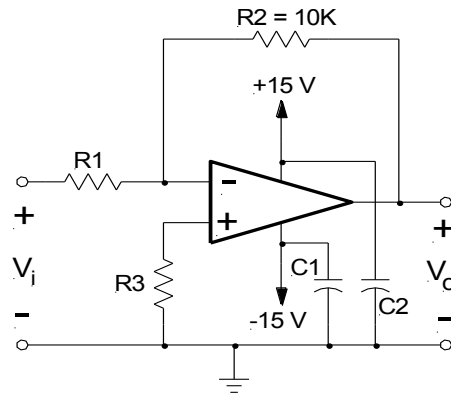


Figure 1: Circuit being tested. $C_1 = C_2 = 1 \mu\text{F}$

Test Configuration

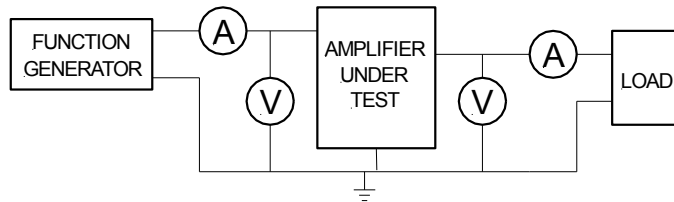


Figure 2: Test Configuration

3 Procedure

First, resistors R_1 , R_2 , and R_3 measured with a multimeter and recorded in Table 1. Then the circuit in Figure 1 was built on a breadboard. A function generator was programmed to output a sine wave at 1 kHz. The test configuration was constructed as shown in Figure 2 using Fluke multimeters as the

ammeters and an oscilloscope as both voltmeters. The function generator was added to the circuit as the voltage input (V_i) and, with the oscilloscope measuring the voltage generator, the amplitude was adjusted to $200V_{\text{rms}}$. The input voltage, input current, and output voltage were taken and recorded in Table 2 with the open circuit across the load terminals. Finally, the decade box was added to the output terminals (V0 in Figure 1) of the circuit and, set to 200Ω , and the output voltage was measured and recorded in (Table 2).

4 Results

Name	Nominal ($k\Omega$)	Measured ($k\Omega$)	% Error
R_1	1	0.986	1.40
R_2	10	9.88	1.20
R_3	1	0.983	1.70

Table 1: Comparison of labelled and actual resistance.

	Voltage		Current	
	V_i (mV_{rms})	V_o (V_{rms})	I_i (mA_{rms})	I_o (mA_{rms})
No Load	200	1.98	0.2	nil
Load	200	1.98	0.2	9.52

Table 2: Comparison of electrical characteristics of the amplifier under load.

	Load			No Load	
	Nominal	Measured	% Error	Nominal	Measured
R_o (Ω)	200	207.98	3.99%	∞	∞
R_i ($k\Omega$)	1	1	0.00%	1	1
A_v	10	9.9	1.00%	10	9.9
A_i	50	47.6	4.80%	nil	nil
G_m (S)	0.05	0.0495	1.00%	0	0
R_m ($k\Omega$)	10	9.9	1.00%	10	9.90

Table 3: Comparison of values determined from amplifier models in Figure 3

5 Conclusion

As seen in Table 3, the measured results of the circuit were very close to the calculated values using nominal values of the resistors. This shows that the four amplifier models shown in Figure 3 are closely representative of the operational

amplifier circuit seen in Figure 1. The highest % difference when comparing the measured with the nominal theoretical value was only 4.8% (current gain [Ai] Table 3)!

6 Appendix

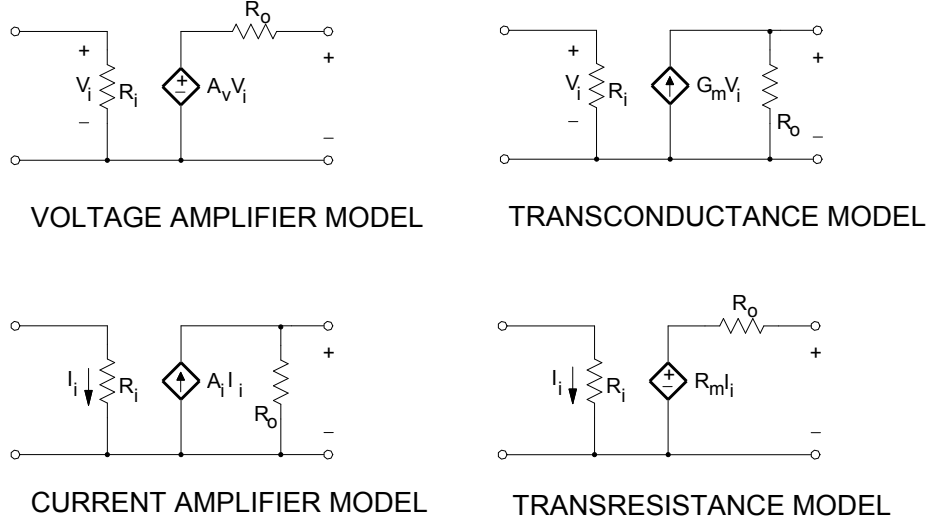


Figure 3: Four equivalent models of an amplifier

Equations

$$\%_{error} = \frac{|measured - nominal|}{nominal} \times 100\% \quad (1)$$

$$R_o = \frac{V_{noload} - V_{load}}{I_{load}} \quad (2)$$

$$R_i = \frac{V_i}{I_i} \quad (3)$$

$$A_v = \frac{V_o}{V_i} \quad (4)$$

$$A_i = A_v \left(\frac{R_i}{R_o} \right) \quad (5)$$

$$G_m = \frac{A_v}{R_o} \quad (6)$$

$$R_m = A_v R_i \quad (7)$$