Name ______________________

Date ______________________

Instructor ______________________

EXPERIMENT

28

Linear Op-Amp Circuits

OBJECTIVE

To measure DC and AC voltages in linear op-amp circuits.

EQUIPMENT REQUIRED

Instruments

Oscilloscope
DMM
Function generator
DC power supply

Components

Resistors

(1) 20-kΩ
(3) 100-kΩ

ICs

(1) 741 Op-amp

EQUIPMENT ISSUED

Item	*Laboratory serial no.*
DC power supply	
Function generator	
Oscilloscope	
DMM	

RÉSUMÉ OF THEORY

The op-amp is a very high gain amplifier with inverting and noninverting inputs. It can be used to provide a much smaller but exact gain set by external resistors or to sum more than one input, each input having a desired voltage gain.

As an inverting amplifier the resistors are connected to the inverting input as shown in Fig. 28.1 with output voltage

$$V_o = -\frac{R_o}{R_i} V_i \qquad (28.1)$$

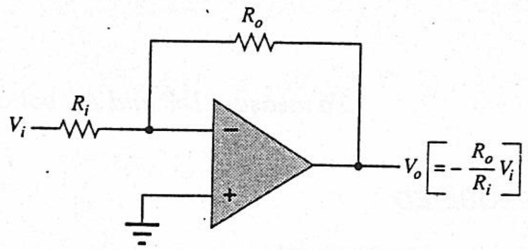


Figure 28-1

A noninverting amplifier is provided by the circuit of Fig. 28.2 with output voltage given by

$$V_o = \left(1 + \frac{R_o}{R_i}\right) V_i \qquad (28.2)$$

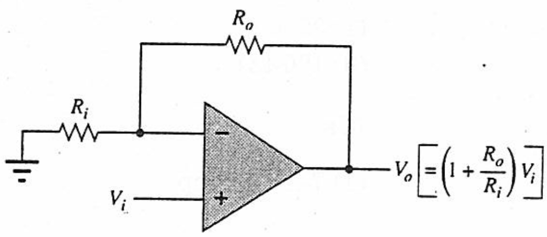


Figure 28-2

Connecting the output back to the inverting input as in Fig. 28.3 provides a gain of exactly unity:

$$V_o = V_i \qquad (28.3)$$

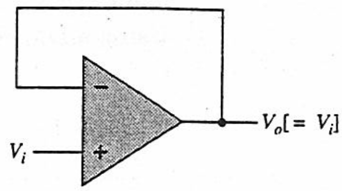


Figure 28-3

More than one input can be connected through separate resistors as shown in Fig. 28.4, with the output voltage then

$$V_o = -\left(\frac{R_o}{R_1}V_1 + \frac{R_o}{R_2}V_2\right) \tag{28.4}$$

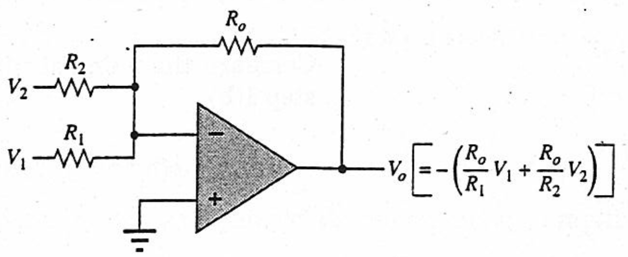


Figure 28-4

PROCEDURE

Part 1. Inverting Amplifier

a. Calculate the voltage gain for the amplifier circuit of Fig. 28.5.

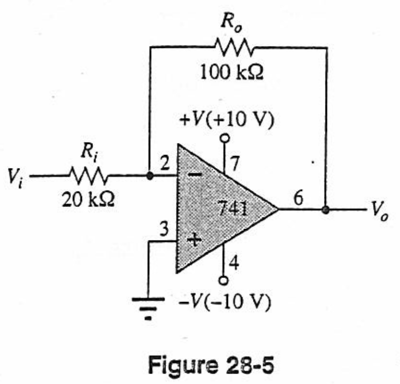


Figure 28-5

V_o/V_i (calculated) = ____________

b. Construct the circuit of Fig. 28.5. (Measure and record resistor values in Fig. 28.5.) Apply an input of V_i = 1 V, rms (f = 10 kHz). Using a DMM measure and record the output voltage.

V_o (measured) = ____________

Calculated voltage gain using measured values:

A_v = ____________

Compare the gain calculated in step 1(**a**) with that measured in step 1(**b**).

c. Replace R_1 with a 100-kΩ resistor. Calculate V_o/V_i.

V_o/V_i (calculated) = ____________

For input of V_i = 1 V, rms measure and record V_o.

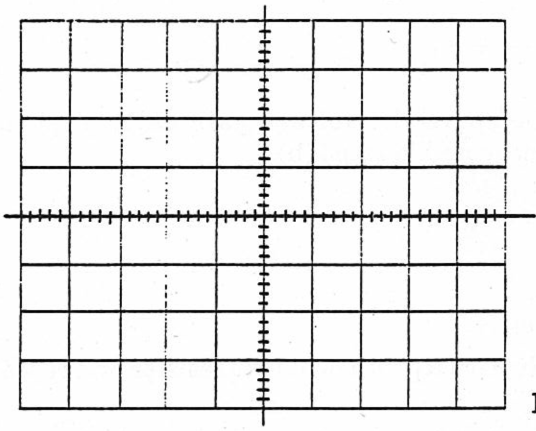
V_o (measured) = ____________

Calculate A_v.

A_v = ____________

Compare the calculated and measured values of the voltage gain.

d. Using the oscilloscope, observe and sketch the input and output waveforms in Fig. 28.6.



Vertical sensitivity = __________

Horizontal sensitivity = __________

Figure 28-6

Part 2. Noninverting Amplifier

a. Calculate the voltage gain of the noninverting amplifier in Fig. 28.7.

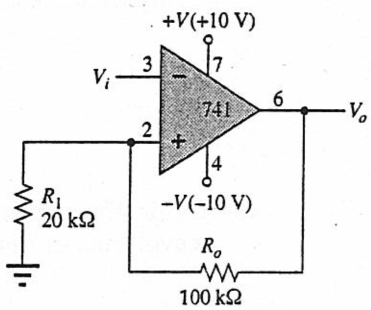


Figure 28-7

A_v (calculated) = __________

b. Construct the circuit of Fig. 28.7. Apply an input of V_i = 1 V, rms (f = 10 kHz). Using a DMM, measure and record the output voltage.

V_o (measured) = __________

Calculate the voltage gain of the circuit using measured voltages.

V_o/V_i = ________

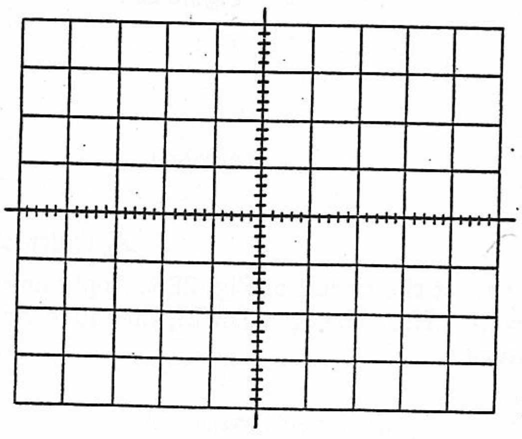
Compare the voltage gain calculated in step 2(**a**) with that measured in step 2(**b**).

c. Replace R_1 with a 100-kΩ resistor and repeat steps 2(**a**) and 2(**b**).

A_v (calculated) = ________
V_o (measured) = ________
V_o/V_i = ________

Compare the calculated voltage gain with that measured.

d. Using the oscilloscope, observe and sketch the input and output waveforms in Fig. 28.8.



Vertical sensitivity = ________
Horizontal sensitivity = ________

Figure 28-8

Part 3. Unity-Gain Follower

a. Construct the circuit of Fig. 28.9. Apply an input signal of $V_i = 2$ V, rms ($f = 10$ kHz). Using a DMM, measure and record the input and output voltages.

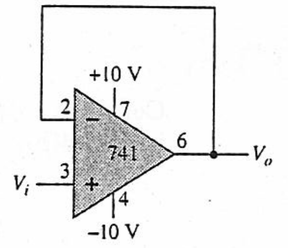


Figure 28-9

V_i (measured) = ____________

V_o (measured) = ____________

Compare the circuit voltage gain, V_o/V_i with the theoretical unity gain.

Part 4. Summing Amplifier

a. Calculate the output voltage for the circuit of Fig. 28.10 (see Fig. 28.4) with inputs of $V_1 = V_2 = 1$ V, rms.

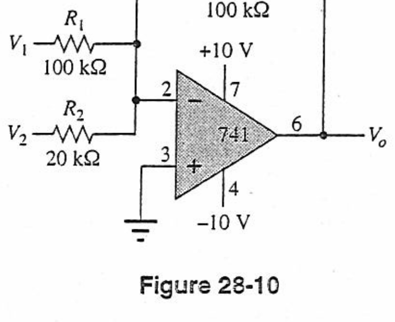


Figure 28-10

V_o (calculated) = ____________

b. Construct the circuit of Fig. 28.10. Apply inputs of $V_1 = V_2 = 1$ V, rms ($f = 10$ kHz). Measure and record the output voltage.

V_o (measured) = ____________

Compare output voltage calculated in step 4(**a**) and that measured in step 4(**b**).

c. Change R_2 to 100 kΩ. Repeat steps 4(**a**) and 4(**b**).

V_o (calculated) = ____________

V_o (measured) = ____________

Compare the calculated output voltage with that measured.