EXPERIMENT 10

CHARACTERIZATION OF OP-AMP CIRCUITS

OBJECTIVE

To study the performance of some typical op-amp circuits.

PROCEDURE

Connect the following circuits:

1) Comparator (Fig. 1). Apply a 1 kHz sine wave signal of about 1 volt p-p to the noninverting (+) input, with the inverting (-) input grounded. Observe this signal on the oscilloscope, triggering on external. Sketch the output. *Does it change if you reduce the input voltage to 0.1 volt? What is the effect of grounding the + input and connecting the signal to the - input?*

2) Follower (Fig. 2). Apply the same signal to the input as in part (1). Note that with negative feedback (to the inverting input) the op-amp adjusts its output so that the inverting input is at the same voltage as the noninverting input. *What is the signal at the output? What is the input impedance of the circuit? What happens with a square wave input?*

3) Non inverting amplifier (Fig. 3). The two 1 kΩ resistors divide the signal at the output of the amplifier by a factor of two. In order for the voltages at the two inputs to the amplifier to be equal the circuit must have a gain of two. Apply the same signal as in part (1) to the input. *What is the signal at the output? What is the signal at the inverting input? What is the gain of the amplifier? What happens when the input voltage is too large? What happens with a square wave input? How would you change the circuit to make the gain equal to 10?*

4) Inverting amplifier (Fig. 4). In this circuit the noninverting input is at ground. In order to keep the inverting input near ground the amplifier must "balance" a positive input with a negative output, and *vice versa*. Measure the voltage at the inverting input. The inverting input is said to be at a "virtual ground." Observe the performance of the amplifier on the oscilloscope. *What is the gain of the amplifier? What happens if you connect the inverting input to a "real" ground?*

The input impedance of a circuit is the ratio of the input voltage to the input current. With a 1 volt input, calculate the current flowing through the 1 kΩ input resistor. *What is the input impedance of the circuit? How would you change the circuit to make the gain equal to -10?*

5) Differentiator (Fig. 5). This circuit differentiates the input voltage. Since the inverting input is at a virtual ground, the current flowing through the 1 kΩ resistor, and hence the output voltage, is proportional to the derivative of the voltage across the 0.2 μF capacitor.

$$I(1k\Omega) = C\frac{dV}{dt} \qquad (10-1)$$

Apply the same signal as in part (1) to the input. *What is the signal at the output?* (**Careful** - be sure to trigger the scope on external or you may miss the 90° phase shift!) *What is the output with a <u>triangular</u> wave input?*

6) Integrator (Fig. 6). In this circuit the capacitor and the resistor are interchanged and the signal is integrated instead of differentiated. In addition, a 100 kΩ resistor has been added to prevent any input offset voltage that might be present from driving the output of the op-amp to one of its extreme limits. Apply the same signal as in part (1) to the input. *What is the signal at*

the output? (Better trigger the scope on external again!) *What is the output with a square wave input?*

7) D/A converter (Fig. 7). The op-amp in this circuit is effectively an inverting amplifier with four separate inputs. Because the inverting input is held at a virtual ground, currents from the four inputs are added and flow together into the output resistor. The values of the four input resistors have been chosen so that each one causes approximately twice as much current to flow as the previous one. Measure the output voltage as a function of the digital input, using the following series:

0	0000	all inputs grounded
1	0001	1st input at 5 Volts
2	0010	2nd input at 5 Volts
3	0011	1st and 2nd inputs at 5 Volts
	etc.	
10	1010	?

ASSIGNMENT

Using your measurements of the D/A converter, plot the **output voltage** (Y axis) as a function of the **digital input** (X axis). Draw a straight line fit to the data.

Figures

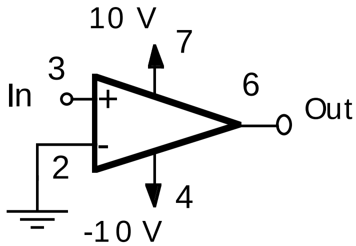

Figure 1

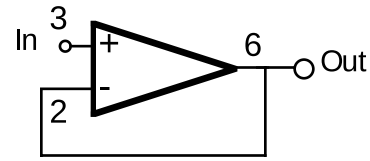

Figure 2

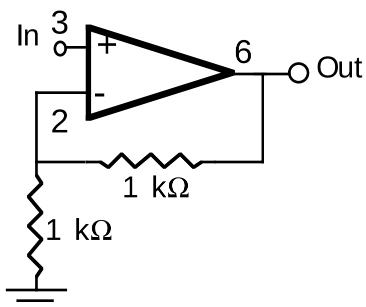

Figure 3

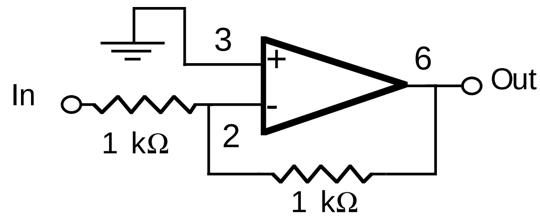

Figure 4

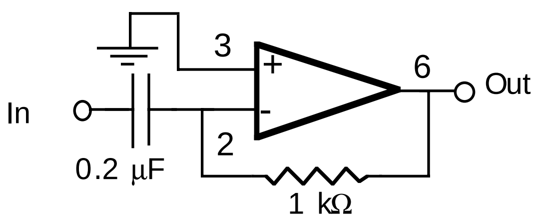

Figure 5

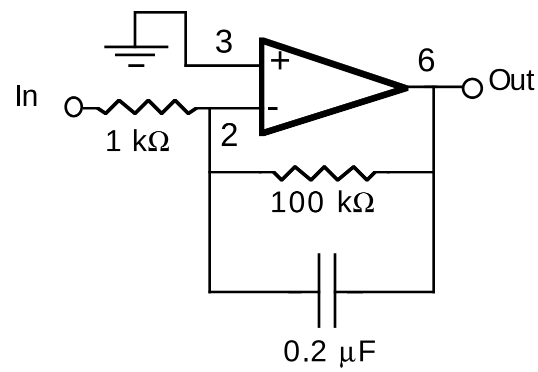

Figure 6

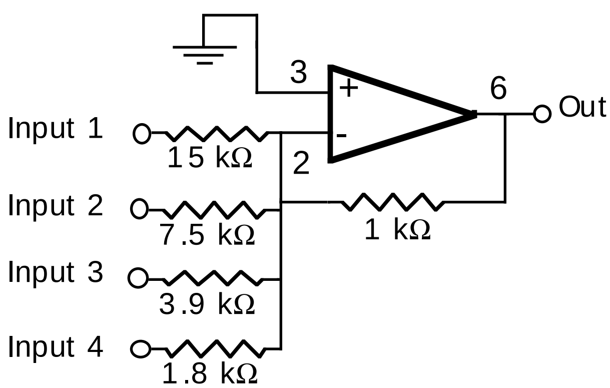

Figure 7