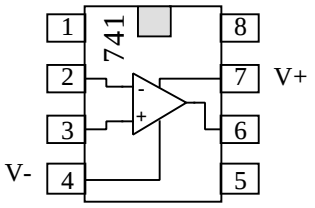
Laboratory 8.1	**Operational Amplifiers**
Name	**Section**

PURPOSE

1. Investigate the non-inverting amplifier.
2. Investigate the inverting amplifier.
3. Build and operate an improved charge pump

SPECIAL EQUIPMENT

ou will need a 741 op amp and two silicon diodes for this lab. If you substitute an improved 741 type op amp, the high frequency studies will become more difficult.



PRELIMINARY

Before you come to lab, use the attached graph sheet to make a log-log Bode plot of the open loop gain of the 741 op amp verses frequency in Hertz. Label the DC gain value and the unity gain frequency.

A. Non-inverting Amplifier

1. Preliminary design work

Before you come to lab, design and sketch a noninverting amplifier with a gain of +10. Don't use any resistor larger than 10 kΩ. Ignore the offset null pins on the op amp.

2. Build and test this circuit.

a. With power off, build this circuit. Be sure that the signal generator ground and the common from your + and - power supplies are all connected to your breadboard ground bus. Apply a small amplitude sine wave and verify the operation of this circuit. Adjust your signal generator so that the op amp's output signal is less than 1 V amplitude and has a near zero DC offset, then find the high frequency corner of this amplifier. You may need to put 100 W across your signal generator output to reduce the amplitude...if you do remember to take it out for the diode-pump section.

f_c = ω_c =

b. Draw a horizontal line on your open-loop plot at a closed-loop gain of 10 and record the frequency where this line intersects the open-loop gain.

$f_{intersect}$ =

c. At a frequency of 5 kHz, increase the amplitude (maintain a zero offset) of your signal generator until the op amp output has a 10 V amplitude, then slowly increase the frequency and note the frequency where the output signal deviates noticeably from a sine wave. Sketch the signal shape in its extreme form.

$f_{distortion\ seen}$= $f_{picture}$=

B. Inverting Amplifier

1. Preliminary design work

Before you come to lab, design and sketch an inverting amplifier with a gain of -10. Your largest resistor should be 10 kΩ. Ignore the offset null pins on the op amp circuit.

2. Build the circuit.

a. Construct this amplifier and verify its operation. Adjust the signal generator until the op amp has a 1 V amplitude output. Locate the high frequency corner.

f_C(10 kΩ) =

b. Now change the feedback resistor to 50 kΩ and measure a new high frequency corner. Use the offset control on your signal generator to maintain a zero volt DC output level

$f_{c(}$50 kΩ) =

c. For both of these amplifiers, sketch the closed loop gain lines on the Bode plot you made before lab.. What corner frequencies do these lines predict?

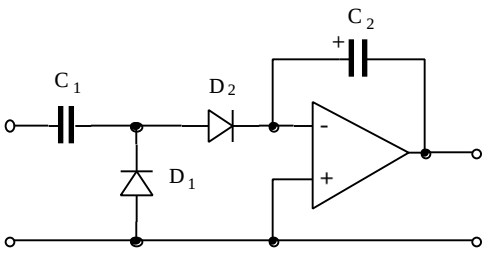
f_c(10 kΩ) = f_c(50 kΩ) =

C. Charge Pump

1. Preliminary design work

Do the work in this section before you come to lab.

a. Add the signal generator to the following schematic. Also locate a shorting switch in a position where it can discharge the charge storage capacitor.



b. Treat the diodes as ideal, take C_2 = 1.0 μF, and determine a value for C_1 so that a 2 V peak-to-peak input square wave signal will generate a 0.1 V step. You can calculate this value by assuming that both capacitors are initially discharged when the square wave is at -1 volts.

C_1 =

2. Build the charge pump.

a. Build the charge pump with C_2 = 1.0 μF and a C_1 value close to that you calculated. If you use a polarized electrolytic for C_2, orient its positive end in the direction shown. Apply a 2 V peak-to-peak input square wave at relatively low frequency and verify your predicted step size.

Remember that you can only expect to ***see a single charging cycle*** each time you flip your switch and allow C_2 to charge. You must take the scope trigger out of the AUTO position and adjust it to start a sweep near the beginning of the charging cycle. The *pn* voltage drop across the diodes will make the output less than you predicted. Record the amplitude of a typical step.

$f_{\text{square wave}}$ = V_{step} =

b. Sketch the shape of a single step, and estimate (50% error is OK) the time constant that produces the rounded edge.

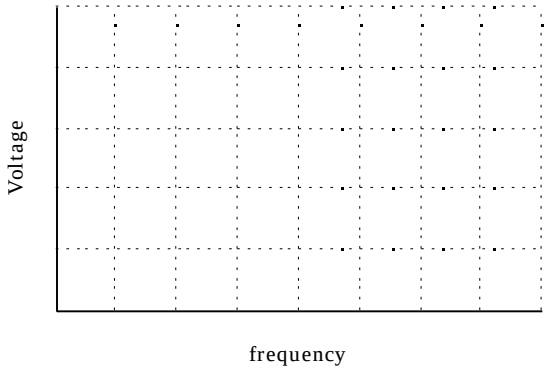
τ =

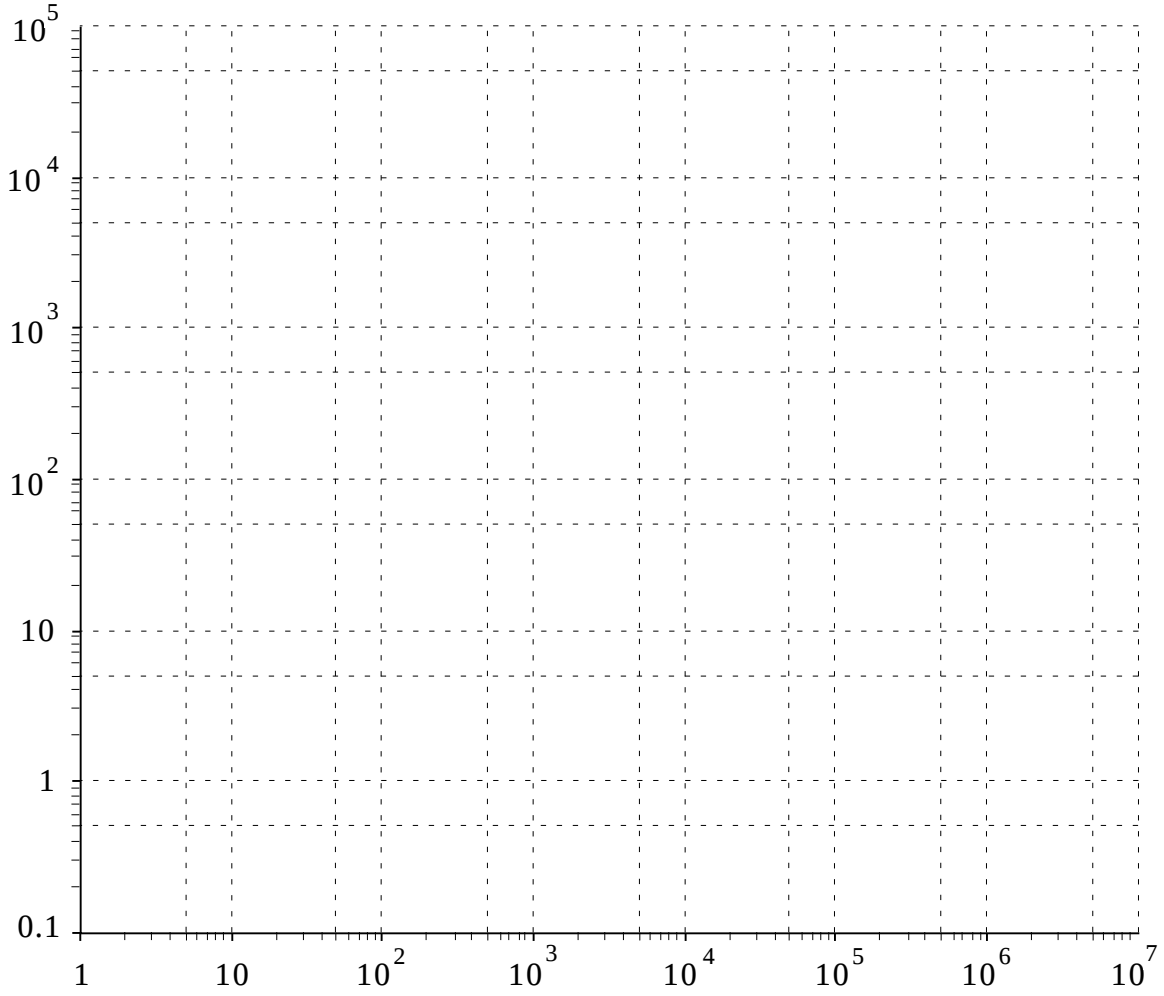
c. Adjust the oscilloscope so that it displays the entire charging cycle, and sketch the display below. Show the scale on both the voltage and time axes.

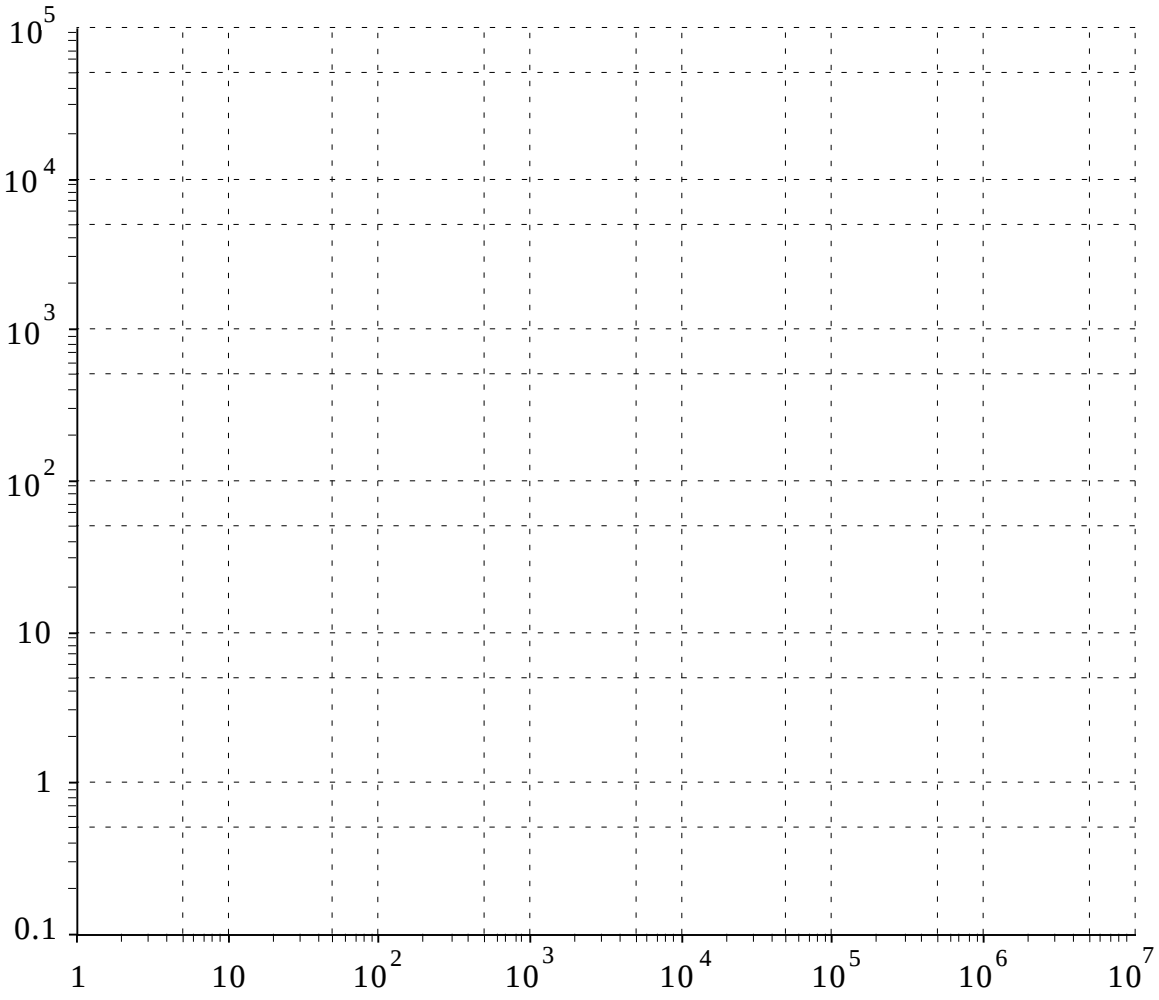
d. Other than the inversion of the output, what is the most significant difference in the output signal compared to that of the passive charge pump?

3. Frequency to voltage converter.

Add a 10 kΩ resistor in parallel with C_2, open your switch, and observe the variation of the average output signal as you change the frequency of the input square wave. Starting at 100 Hz, plot the magnitude of the output voltage against the frequency on the linear plot given. Label the scales.






10^5
10^4
10^3
10^2
10
1
0.1
1
10
10^2
10^3
10^4
10^5
10^6
10^7