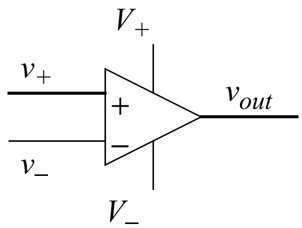
Physics 475, Laboratory 22
Oscillators

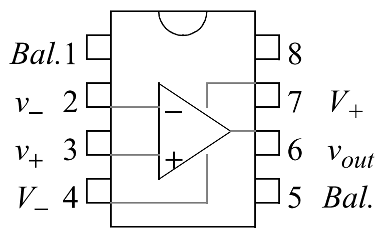
Overview

The purpose of these experiments is to use op-amps in circuits wit positive feedback to create oscillations of fixed frequency and waveform.

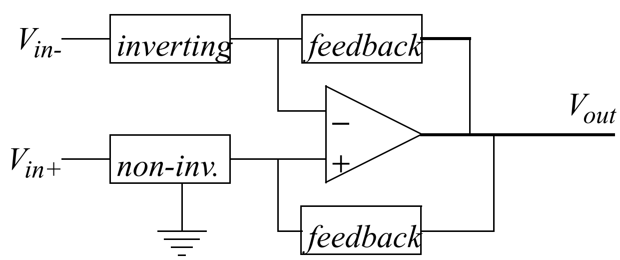
Components

The TL071 op-amp is an integrated circuit based on JFET technology that comes in an 8-pin dual in-line package (DIP). The connections for the chip looking down with the notch facing up is:

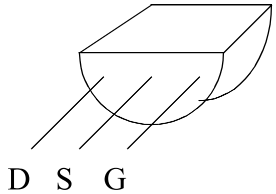




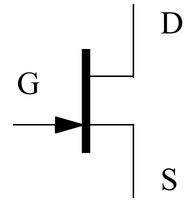
For feedback the general steps for analysis are to find the voltage at the non-inverting input and then to compare that same voltage to the inverting input. Then find the current flowing at the inverting input from any voltage source. All this current is assumed to flow into the feedback network, and generate a voltage drop at the output voltage.



The 2N5485 is an n-channel JFET and comes in a TO-92 plastic case with leads for drain, source and gate.



2N5485



The 2N5485 has maximum ratings as follows:

$V_{DG} < 25$ V, $-V_{GS} < 25$ V

$I_D < 30$ mA, $P = I_D V_{DS} < 300$ mW

1. Wien Bridge Oscillator

Connect a TL071 op-amp as in figure 1 using +/- 15 V for +/-V_{CC}.

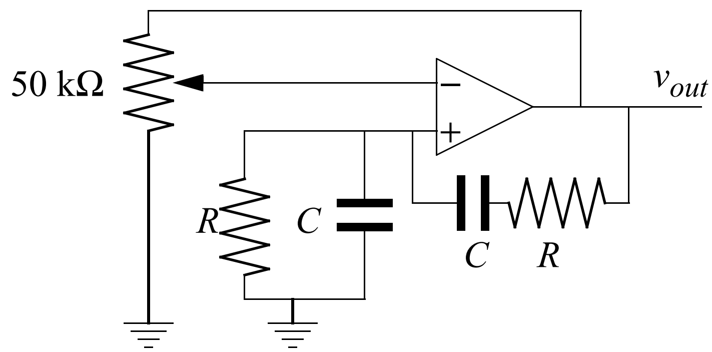


Figure 1: Wien Bridge Oscillator

Use R = 10 kΩ and C = 0.001 μF. Measure v_{out} with the oscilloscope and frequency counter after adjusting the potentiometer to create sinusoidal oscillations. Note the sensitivity of the circuit to a precise ratio of resistance in the potentiometer. Turn off the power and disconnect the potentiometer from the circuit to measure the resistance on both sides with a DMM. What is the ratio of those resistances? Reconnect the potentiometer and measure the period of oscillation with the oscilloscope and compare to the frequency on the counter; do they agree? Compare with the expected value of $\omega_0 = 1/RC$. Measure the frequency for three other values of one resistor (use 22 kΩ, 47 kΩ, and 100 kΩ) and graph the result.

2. Crystal Oscillator

Connect the op-amp as in figure 2 using a crystal of between 100 kHz and 200 kHz as the positive feedback component.

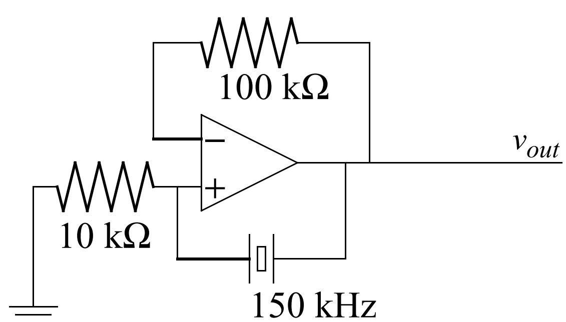


Figure 2: Crystal Oscillator

Measure v_{out} with a scope and find the frequency compared to the frequency printed on the crystal. Do they agree? Observe any non-sinusoidal effects. What might cause the non-sinusoidal behavior?

3. Triangle-Wave Generator

Use two n-channel JFETs to provide a current source for the feedback to a capacitor as in figure 3.

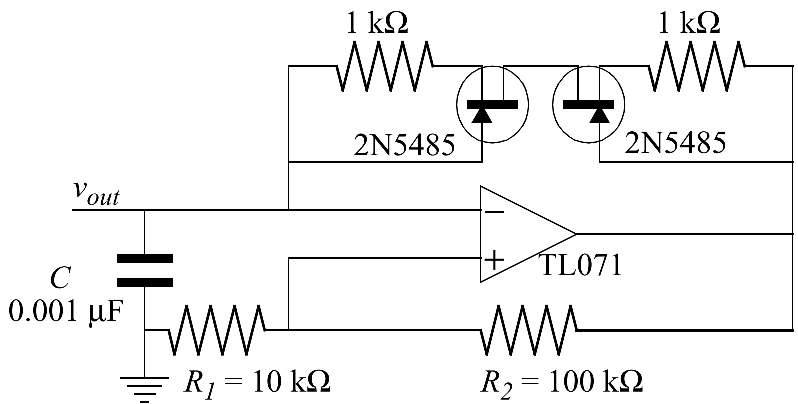


Figure 3: Triangle-Wave Generator

The non-inverting input to the opamp is

$$V_{thr} = \lambda V_{CC} = \frac{R_1}{R_1 + R_2} V_{CC}$$

The current charging the capacitor I_{FET} is given by

$$I_{FET} = C \frac{dV_{out}}{dt}$$

The limits on the charging are from $-V_{thr}$ to $+V_{thr}$ and that will equal one half a period of oscillation. So the current is related to the threshold and period by

$$I_{FET} = C \frac{2\lambda V_{CC}}{T/2} \qquad T = \frac{4\lambda V_{CC}}{I_{FET}}$$

Measure the voltage drop across one 1 kΩ resistor and derive the current flowing from the current source. Measure the charging rate of the capacitor with the oscilloscope and compare with the expected value. Measure the frequency of oscillation and compare it to the expected value. Does evrything agree? How well shaped is the triangle waveform?