**ECE 3027 Electronics Laboratory – Lab 2**

**Questions:**

1. When operating in dual supply what voltage is at GND on the board?

* 0 Volts

1. (A) What is the formula for an OP-AMP without feedback in terms of V- and V+. (B) If V+ is greater than V- what is the output? (C) If V+ is smaller than V- what is the output?

* (A) Vout = (V+ - V-)
* (B) Vout > 0 V
* (C) Vout < 0 V

1. What ports set the maximum and minimum output of the OP-AMP? (There are 4 inputs of an OP-AMP and 2 are for the input signals. What are the other two?)

* The power rails, labelled +10V/-10V on the board.

**Preparation:**

**In this lab you will build an astable multivibrator as discussed in the prelab. So please read the prelab if you have not already.**

**Lab:**

**Astable Multivibrator:**

**Please read carefully!**

Power your board in **dual supply** and set up the oscillator / astable multivibrator circuit described in the pre-lab. **You will not need to borrow external parts for this circuit** – you can use all native capacitors and resistors to one type II op amp. This circuit will produce an oscillating output if the board is powered, as this will supply power to the op amp’s rails. **No input is needed from the function generator.** We will derive the mechanism of this circuit quantitatively later, but for now, here is a qualitative explanation. **Please take time to understand the following paragraph, if you are still unsure, ask the instructor after the class!**

Start by assuming that the output Vo is at the negative rail (-9 V). This means that V+ is set through the resistor divider ratio and is equal to -9V\*R1/(R1+R2). Vc will decrease as the capacitor C is discharged through the resistor R. This happens until Vc=V- is lower than V+. Then, V+ - V- will be positive, Vo will swing to the top rail (+9V), and V+ will become positive, at +9V\*R1/(R1+R2). Capacitor C will charge up until Vc is higher than V+, Vo will drop to the bottom rail again, and the cycle will repeat.

The values of R and C will determine the rate of change of Vc. Also note that R1 and R2 will determine the time that passes before Vc is less than V+, as a smaller value of **β=R1/(R1+R2)** will set trip points closer to the middle rail (GND in this case) so that Vc doesn’t need to change as much to cause Vo to swing.

Vary the resistor and capacitor values in the negative feedback path and, keeping everything else constant, record output frequencies for two different R and C combinations.

|  |  |  |  |
| --- | --- | --- | --- |
| R1= 1kΩ  R2= 2k2Ω  β= 0.3125 | R = 1kΩ | C = 0.1 uF | f = 6.69 kHz |
| C = 1 uF | f = 680.15 Hz |
| R = 2k2Ω | C = 0.1 uF | f = 3.28 kHz |
| C = 1 uF | f = 325.70 Hz |

Vary the resistor divider ratio (β = R1 / (R1 + R2)) in the positive feedback path and note the change in oscillation frequency. Note how **changing β** changes the hysteresis points and thus the waveforms:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| R= 1kΩ  C= 0.1 uF | R1 = 10 kΩ | R2 = 1 kΩ | β = 0.909 | f = 1.33 kHz |
| R1 = 2k2Ω | R2 = 10 kΩ | β= 0.167 | f = 11.48 kHz |

**Please read the following section carefully!**

In the oscillator circuit, change the capacitor C ground connection to “-10V” on the board. Write down any change in the behavior of the oscillator. Next change the resistor R1 ground connection to -10. Write down any change in the behavior of the oscillator. Note that these two changes, ***if successful***, would allow the oscillator circuit as is to operate in single supply mode. Comment on operations with these two changes:

Return your C and R1 connections to “GND.”

Take pictures of waveforms from the oscilloscope and paste them here.

Note that the picture should show

1. Horizontal and vertical markers.
2. Probe setup (1X and 10X values on oscilloscope screen)

The team made a mistake and saved our oscilloscope pictures as .XML files. The team went after class on Friday to try and get the proper file, but the lab was locked. The team has both .XML files and can attach them if necessary.

**Simulation (optional)**

Download the TopSPICE schematic file from Lab2 folder in Carmen and change the resistors and capacitor values to the actual values you considered while performing bench experiment. Recreate two tables available above for simulation part.

NOTE1: Paste schematic output waveform on this sheet.

NOTE2: There is initial condition set on schematic. Try to change its value and observe changes, if any.

Save this worksheet and upload it on carmen.

A screenshot of a computer

Description automatically generated