ENSC220 (2015-3) Laboratory 3 – OPAMP Circuits

(A brief formal report is needed for this lab, Due Oct 12, 4:00pm)

Read this lab handout thoroughly and follow the experimental steps carefully

In this lab session, you will experimentally verify the open loop and closed loop characteristics of simple opamp circuits. **All opamp circuits are to be powered using ±10V supply with a current limit set to not more than 50mA.** If you do not set the current limit properly, the opamp will get damaged and you will not be given any replacement opamps.

The supply voltage +10V is Vcc and -10V is Vee. The junction (node) between the two power supplies is the ground for the circuit.

Study the opamp datasheet and familiarize yourself with the various pins of the opamp chip. Identify the input, output and power pins. You have to submit a brief lab report. Therefore, collect as much data in electronic format as possible and e-mail the data/image to yourself.

Reset the FnGen, set the scope probes to 10X and calibrate the scope before you connect these instruments for your experiment. If you don't do this, all your measurements might be wrong

Check the suggested wiring Layout page before you start your experiment.

Also, read the short write-up at the end of this handout on using oscilloscope to measure the comparator circuit voltages.

1. Open loop opamp circuits (50%)

The classical circuit example for opamp in open loop is the voltage comparator. The circuit compares the amplitude of an AC input signal with a DC reference and provides an output indicating if the input signal is below or above the reference voltage level. You will experiment with two circuit configurations, shown in figures 1 and 2 below.

1.1 Experiment-1

- Construct the comparator circuit shown figure 1. Choose resistors Ra and Rb such that the Vref (DC voltage) is between 1.5V and 5V. The smallest resistor in this pair should be at least 1K.
- The resistor R_S can be any value between 500Ω and 5KΩ.
- Set the power supply for ±10V (series mode) and current limit set to not more than 50mA. **The junction between the power supplies will be the ground connection.**
- **The input signal, from the FnGen, to the circuit is to be applied between the Vin and ground. The output is to be measured between the Vout and ground.**
- Set the function generator to output a 10Hz, zero-centered triangular waveform with an amplitude of 0.5V peak.
- Power the circuit and using the DMM measure the DC voltages (Vcc, Vee and Vref) on the bread board and record.
- Connect the function generator signal to the circuit (Vin).
- Increase the amplitude of the signal until you see the comparator output is a nice square wave.
- Display the input and output on the scope screen neatly and measure at what input voltage the output of the opamp changes state. You have to use the Cursor_Measure function of the scope.

- Get a screen capture of the scope trace with the cursors measuring the voltage levels and also displaying the input and output wave form clearly. You should measure at what input voltage the transition occurs and also what is the maximum output peak o peak voltage value is.

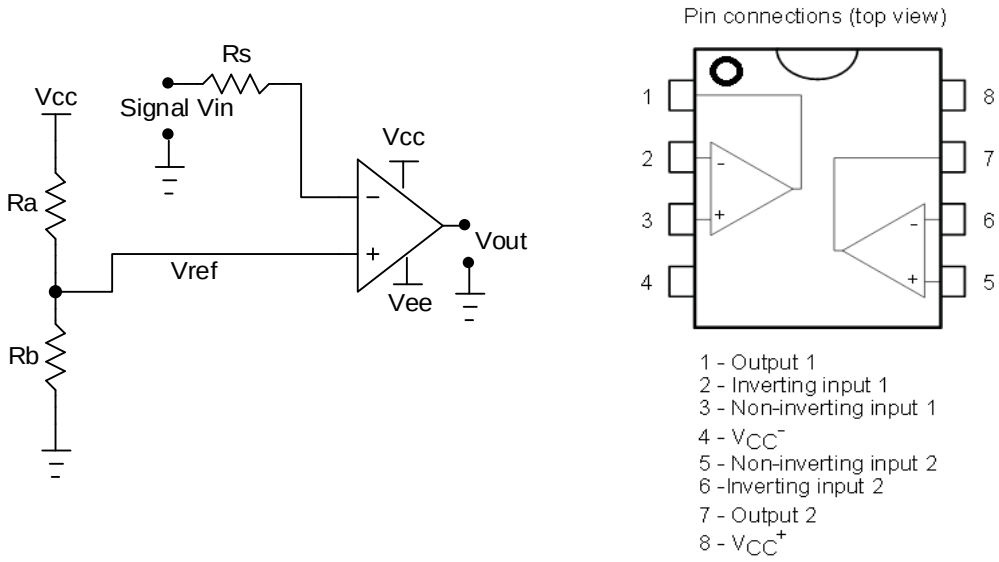

Figure 1. Comparator circuit-1 (Vcc^- is Vee)

1.2 Experiment-2

- Disable the power to the opamp and disconnect the input signal to the circuit.
- Modify the circuit to the configuration in figure 2 and then apply the power and input signal to this new circuit.
- Repeat the experimental steps to characterize the comparator functionality as you did in section 1.1.
- Get a screen capture of the scope.

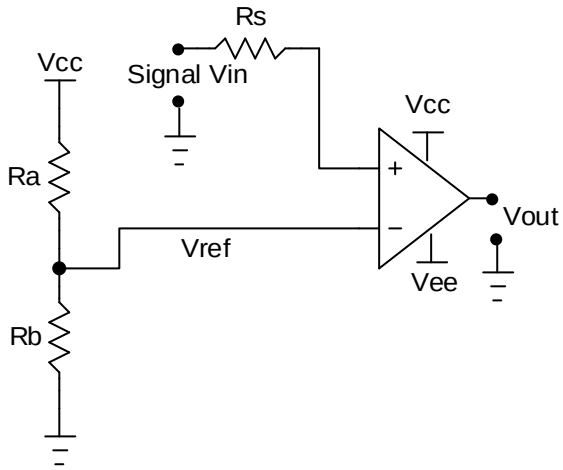

Figure 2. Comparator circuit-2

2. Closed Loop linear opamp amplifiers (50%)

The next two circuits will be the experimental characterization of linear opamp circuits.

2.1 Inverting amplifier

- Disable the power and disconnect the input signal from the bread board.
- Construct the inverting amplifier circuit shown in figure 3. Choose the resistors R1 and R2 such that the gain of the amplifier is around -5. The smallest resistor in this pair should be at least 1K. Measure the exact resistor values. Based on the measured resistor values, estimate the gain.
- Make sure the function generator is set to output a 1kHz, zero-centered sinusoidal waveform with an amplitude of 0.5V peak.
- Power the circuit and connect the function generator signal to the circuit (Vin).
- Display the input and output on the scope screen neatly. Using the cursors measure the input and output signals' pk-pk value on the scope to compute the circuit's functional gain and compare the actual and estimated gain.
- Get a scope screen capture for your report.

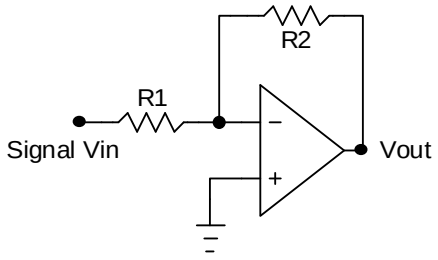

Figure 3. Inverting amplifier circuit

2.2 Non-Inverting amplifier

- Disable the power and disconnect the input signal from the bread board.
- Modify the circuit to non-inverting amplifier circuit shown in figure 4. The resistors R1 and R2 should be the same value as in section 2.1. Based on the resistor values estimate the gain.
- Power the circuit and connect the function generator signal to the circuit (Vin).
- Display the input and output on the scope screen neatly. Using the cursors measure the input and output signals' pk-pk value to compute the circuit's functional gain and compare the actual and estimated gain.
- Get a scope screen capture for your report.

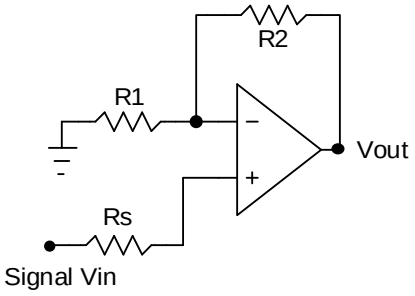

Figure 4. Non-Inverting amplifier circuit

Write a brief report (one report per lab group) and address the following

1. Functional characteristics of opamp comparator circuits.
   - Measured DC voltage of the Vref
   - Scope cursor measured transition voltage. Compare the two
   - Based on measured Vcc and Vee, what would be the estimated output peak to peak voltage and what was the cursor measured output peak to peak voltage from scope?
   - Attach scope screenshots to validate your observation and record.
2. Functional characteristics of opamp liner amplifiers.
   - What are the measured resistor values?
   - What would be the estimated gain based on resistor values?
   - What was the cursor measured input and output signal amplitudes and the calculated gain of the amplifiers?
   - Attach scope screenshots to validate your observation and record.

The report should be less than 6 pages maximum. A good portion of the marks will be devoted to organization of results and quality of presentation.

Hints for how to measure various voltages of a functional comparator circuit using oscilloscope.

1. Calibrate the scope.
2. Set both the channels to GND and bring the zero line for both channels to the center of the screen. Be very critical to make sure both the traces are one on top of the other. Now the center of the scope screen is 0V. (See Illustration A).
3. Set both the channels to DC coupling. Use CH1 to measure the input and CH2 to measure output signals. Never touch the vertical position knob anymore. Use only Time/Div and Volts/Div to adjust the display on the scope screen.
4. After you have adjusted the input signal and also adjusted the scope to display the comparator functionality, you can measure the transition voltage and the output peak to peak voltage as shown in Illustration B. Use Cursor_Measure function. Choose appropriate channel to read the correct voltage values.
5. Vr is the input transition voltage and this should be equal to DC Vref.
6. $V_{Pk\text{-}Pk}$ is the output signal peak to peak value

Illustration A

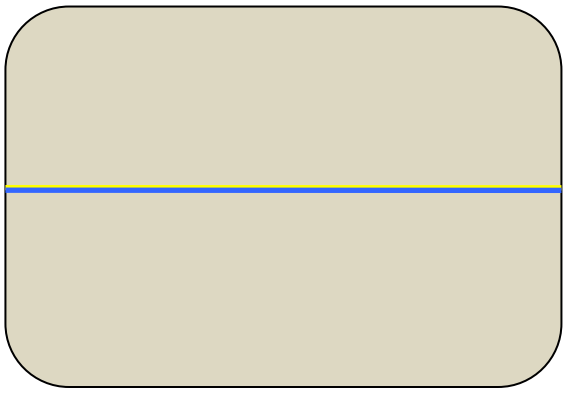

Illustration B