Laboratory Goals

- Design and construct a non-inverting amplifier using the op-amp
- Measure and record input and output waveforms
- Compare measured and theoretical values

Pre-lab reading

- *Student Reference Manual for Electronic Instrumentation Laboratories* by Stanley Wolf and Richard Smith, Copyright 1990.
- LM348 datasheet at the website

Equipment needed

- Lab notebook, pen
- Agilent E3631A Triple DC Power Supply
- Agilent 54621A Digital Oscilloscope
- 2 oscilloscope probes (attached to the oscilloscope)
- Agilent 33120A Function Generator/Arbitrary Waveform Generator
- 1 test lead, BNC/EZ Hook
- 2 test leads, red, banana/EZ Hook
- 1 test lead, black, banana/EZ Hook

Parts needed

- Circuit breadboard
- Lab parts kit
- IC, Quad Operational Amplifier, LM 348N (in lab parts kit)
- Resistors (2), 1k Ohm, ¼ Watt
- Resistor, ¼ Watt (to be determined by the circuit gain)
- Jumper wires (found in the parts kit)

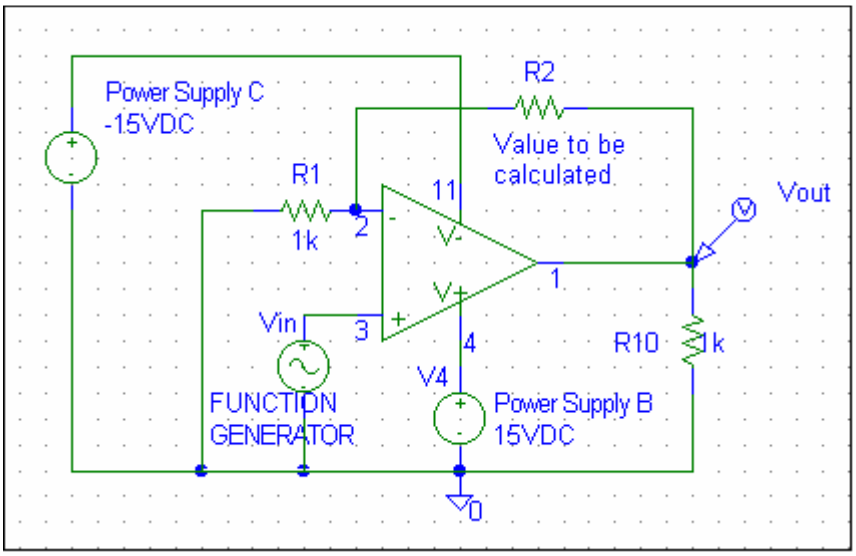
Lab safety concerns

- Make sure all circuit connections are correct, and no shorted wires exist.
- Adjust the power supply to the proper voltages before connecting it to the circuit
- Adjust signal generator to the proper level before connecting it to the circuit

1. Pre-Lab Amplifier Design

- Refer to the LM 348 datasheet on the EECE website for the 14-pin diagram before wiring the circuit. Each of the pins you will use are labeled on the schematic below

- Design the non-inverting op amp shown below, but with a gain of 1.5 times your lab station number (e.g., if your station number is 6, design the circuit to have a gain of +9)



- Create a table in your lab notebook similar to the one below for the amplifier (an example column is shown). The test points are 100Hz, 300Hz, 1kHz, 3kHz, 10kHz, 30kHz, 100kHz, 300kHz, 1MHz input frequencies.

V_{in}		V_{out}		
Frequency (Hz)	Amplitude (Vpp)	Amplitude (Vpp)	Phase shift	Gain (V_{out}/V_{in})
100				
1k	1.05	2.43	3 degrees	2.31

2. Circuit Construction and Signal Measurement

- Use the schematic to build the amplifier circuit.
- For resistor R2, use the closest available resistor value (found in the cabinet) to your calculated R2.

- Set the Agilent power supply:
  - Press the **Output On/Off** button to enable the power supply output
  - Press the **+25V** button to select the +/- 25V power supply
  - Adjust the power supply output to +15VDC
  - Press and hold the **Track** button (this allows the negative supply to automatically track the positive supply voltage setting)
  - Press the **Output On/Off** button to disable the power supply output

- Connect a **red** banana/EZ Hook test lead between the **+** output (+/-25V terminals) and the circuit +15 V connection
- Connect a another **red** banana/EZ Hook test lead between the **-** output (+/-25V terminals) and the circuit -15 V connection
- Connect a **black** banana/EZ Hook test lead between the **COM** power supply ground and the circuit ground connection
- Press the **Output On/Off** button to enable the power supply output

- Set the Agilent oscilloscope:
  - Press the **Save/Recall** button
  - Press the **Default Setup** softkey to return the oscilloscope to a known state
  - Briefly test the **CH1** and **CH2** oscilloscope probes using the **Probe Comp** test point (always make sure the probes are working correctly before using them!)

- Set the Agilent function generator:
  - Use **RECALL 1** to set the instrument for high impedance circuits
  - Sine waveform
  - Amplitude = 1Vpp
  - Frequency = 100Hz

- Connect the BNC/EZ Hook test lead to the function generator **OUTPUT**
- Connect the **red** and **black** ends of the EZ Hook test lead to the circuit input and ground connections respectively

- Connect the **CH1** oscilloscope probe and ground clip to the circuit input and ground connections respectively
- Connect the **CH2** oscilloscope probe and ground clip to the circuit output and ground connections respectively

- Using the **Auto-Scale** and **Quick Meas** options, record the circuit input voltage, output voltage, and phase shift in your table. Remember, for phase shift measurements:

    - You must first select **Source 1** from the **Quick Meas** menu
    - Press the → softkey to find the **Phase 1→2** option
    - Press the **Phase 1→2** softkey to make an automatic phase measurement

- Repeat the voltage and phase shift measurements for the required input frequencies
- Calculate the gain for each frequency, and record it on your table
- After all the measurements have been recorded, disable the power supply output
- Unclip all of the test leads from the circuit, and turn off the equipment

Before leaving the lab, take a few minutes to make sure all equipment and test leads are returned to your cabinet, and that you have cleaned up your work space.

3. Analysis

Write a summary report combining both parts 4a and 4b. Be sure to also include the following topics:

Create an Excel(or any software that you would like to use) graph of the gain vs. input frequency for each amplifier. (Make the gain (y-axis) a linear scale, and the frequency (x-axis) a log scale from 10Hz to 10MHz)

What applications can you think of for these circuits?

Compare theoretical vs. measured values. Explain how/where you got the theoretical results. Are there differences? If so, why? Analyze the differences.

Explain any difficulties you had with these labs. (Please include suggestions to improve the labs, if you have them).