Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**EEE 202 Lab 5 Data Sheet**

**Operational Amplifiers**

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| --- | --- | --- |
| **Part 0: Waveform Generators and Oscilloscopes** | | |
| 1. **What is the maximum voltage rating on your Waveform Generator?** | |  |
| 1. **Adjust the WFG to output a 1V (peak to peak) sine wave with a frequency of 2 kHz. Take a screenshot or photo of your waveform on the oscilloscope and include it here:** | | |
| 1. **What is the input impedance of the oscilloscope?** | |  |
| 1. **What is the maximum acceptable input voltage for the oscilloscope? (Hint: read the manual or watch the supplier’s video here:** [**https://youtu.be/HUAy0J3XqaU**](https://youtu.be/HUAy0J3XqaU)**)** | |  |
| 1. **What is the voltage resolution of the oscilloscope? Hint: resolution=**   **[Do not forget the units]** | |  |
| **Part 1: Voltage Reference** | | |
| **Connect the circuit in Part 1 of the manual. In each case below, record relationship between RA and RB, their actual values, and VRef measured at the junction between them based on a multimeter measurement.**  **Include a photo of your hardware circuit here - only include that of one of the five following cases (Have a look at an example photo at the end of this document):** | | |
| **Resistor Values (kOhms)** | **Multimeter measurement** | |
| **1) RA = \_\_\_\_\_\_\_\_ RB = \_\_\_\_\_\_\_\_** | **VRef \_\_\_\_\_\_\_\_\_**  **reason for discrepancy with 2 V expectation:** | |
| **2) RA = \_\_\_\_\_\_\_\_\_\_\_\_\_** | **IA = \_\_\_\_\_\_\_\_ IB = \_\_\_\_\_\_\_\_ IC = \_\_\_\_\_\_\_\_** | |
| **3) RA = \_\_\_\_\_\_\_\_\_\_\_\_\_** | **IA = \_\_\_\_\_\_\_\_ IB = \_\_\_\_\_\_\_\_ IC = \_\_\_\_\_\_\_\_** | |
| **4) RA = \_\_\_\_\_\_\_\_ RB = \_\_\_\_\_\_\_\_** | **VRef = \_\_\_\_\_\_\_\_\_**  **reason for discrepancy with 2 V expectation:** | |
| **5) RA = \_\_\_\_\_\_\_\_ RB = \_\_\_\_\_\_\_\_** | **VRef = \_\_\_\_\_\_\_\_\_**  **reason for discrepancy with 2 V expectation:** | |
| **Part 2: Simulation of Inverting Op-Amp in LTSpice** | | |
| **Assume a gain of 2 V/V and the input voltage vI being a sine wave with 2Vpp**     1. **Determine RA & RB. Show your steps. Does R1 impact this?** 2. **Determine R1 and R2. Show your steps.**   **Resistor values RA = \_\_\_\_\_\_\_\_\_\_, RB = \_\_\_\_\_\_\_\_\_\_\_\_, R1 = \_\_\_\_\_\_\_\_\_\_\_\_, R2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** | | |
| **With the same gain and input voltage, build your circuit in LTSpice and run a Transient Simulation (use OP07 as your Op Amp). Plot the output and input waveforms of your op-amp circuit. You should show at least one period and the voltage scale of your graph (i.e. the range of the y-axis) should be 0 to 4 V.**  **Screenshot of LTSpice schematic circuit. Make sure your circuit nodes are labeled (Have a look at an example screenshot at the end of this document):**  **Screenshot of LTSpice Plot - output and input voltage on the same plot (Make sure that your computer’s date and time are showing up in your screenshot):**  **Repeat for a 4V/V gain:**  **Screenshot of LTSpice schematic circuit. Make sure your circuit nodes are labeled (Have a look at an example screenshot at the end of this document):**  **Screenshot of LTSpice Plot - output and input voltage on the same plot (Make sure that your computer’s date and time are showing up in your screenshot):** | | |
| **Part 3: Physical Validation Inverting Configuration of the Op-Amp** | | |
| **Build the Physical Prototype of the circuit and include an image (use OP484 or MCP6022). Your Inverting Configuration design on the prototype board, should contain resistors, connection wires, and the Op-Amp. (Attach the image of your physical circuit to the lab data sheet.)**  **Include a photo of your hardware circuit here (Have a look at an example photo at the end of this document):** | | |
| **Capture the screenshot of your oscilloscope waveforms showing the channel 1 input from the waveform generator and the channel 2 output of the Op-Amp. You should display a stable image triggered on channel 1 with at least one period of the sinusoid and a voltage range of 0 – 4V.**  **Include a screenshot of your waveforms here (Have a look at an example photo at the end of this document):** | | |
| **Is your Op-Amp a “rail-to-rail” Op-Amp? If not, what are the upper and lower clipping voltages?** | | |
| **Discussion (don’t disassemble your circuit yet, as you may need it to answer the questions):**   1. **Is your op-amp a “rail-to-rail” op-amp? If so, are you still seeing some “clipping” of the output for a 2 V/V gain and why? When you increase the gain of your configuration to 4 v/v, what are the upper and lower clipping voltages?** 2. **How do your calculation, simulation, and measurement results compare? Did the “ideal op-amp” calculations closely match what was seen in the physical circuit?** 3. **What advantages/disadvantages do you see in using op-amps?** 4. **Which did you like better, simulation of the circuit, or physically building it? Which one would you prefer to do in your career design, simulation verification, or physical implementation?**   **LTSpice Screenshot Example (Note your name, date and time, readable circuit, and labelled nodes – screenshots might vary based on the operating system you are using) – This applies to screenshots of circuits only. Screenshots of graphs/plots/anything else can include only the date and time.**    **Hardware Image Example. Note your name:**   1. **on a piece of paper; OR** 2. **typed electronically (must be typed on the breadboard WITHOUT any “text background”. Breadboard must show up in the background of your name.)** | | |