EE2303 Introduction to Integrated Circuits

Introduction to Integrated Circuits

Equipment Required
Function generator
DC power supply
Multimeter
Oscilloscope
1 MΩ, 10 kΩ, 51 kΩ, 560 kΩ, 820 kΩ, 220 kΩ
LM741 Op Amp (or equivalent)
Bread board

Learning Outcomes

The student should learn to implement and use various circuits that are applicable to real-time analog signal processing using monolithic integrated circuits. Using operational amplifier circuits and continuous time signals, the student should be able to demonstrate basic principles of amplification, summation, and gain adjustment.

Note: You will be using signals with very low-frequency spectral content (often including DC). Use a direct-coupled (DC) input to the NI 5102 oscilloscope since using the AC coupling will attenuate and shift the phase of low-frequency signals.

Prelab
2. Define the following terms common in operational amplifier component specifications: Common Mode Rejection Ratio, Slew Rate. What are common test conditions for determining these component characteristics?

Procedure

Inverting Amplifier

1. Set up an inverting amplifier, as shown in Fig 1, using the 741 Op Amp on your breadboard.
   a. Connect the 8102 power supply to provide a "dual ended" voltage of ±15 V DC.
   b. Verify the power supply output with the NI 4060 Multimeter before you energize your circuit.

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c. Using the NI 5411 Function Generator DC Offset control, set the input DC voltage $V_1$, to \[0.50 \text{ V}\] (verify this with the NI 4060 Multimeter)

d. Set the coupling of the NI 5102 Oscilloscope to “DC” Make sure that the Power Supply (8102), Oscilloscope, NI 4060 Multimeter, and NI 5411 Function Generator have a common reference (ground)

e. View $V_1$ on Ch 1 of the NI5102 and $V_2$ with Ch 2 of the NI 5102 oscilloscope. Determine if you obtain the expected output $V_2$, and repeat with several gain factors by changing the resistance ratio $R_2/R_1$. See the attached data sheet for values of $R_1$ and $R_2$

Note: Linear operation of the Op Amp is limited to an output voltage that is slightly less than the DC supply voltages to the Op Amp (±15 volts). The NI 5102 oscilloscope is limited to a maximum of 5 volts on its display. In order to observe this "clipping" characteristic it will be necessary to reduce both sides of the "dual ended" power supply simultaneously before reapplying the power to the Op Amp. Reduce the input voltage to ±5 V DC. Verify the voltage with the NI 4060 Multimeter prior to reapplying the power to the Op Amp. Observe the input and output simultaneously.

2. Replace the source $V_1$ with a 5 kHz, 0.5 $V_{pk}$ sinusoid using the NI 5411 Function Generator and recheck the result.
   a. Use $R_1 = 560 \text{ k}\Omega$, $R_2 = 1 \text{ M}\Omega$
   b. Set the Timebase on the NI 5102 oscilloscope to 50ms/div
   c. Set Ch1, Ch2 volts/div to 500mV
   d. View V1 on Ch1 and V2 on Ch2
   e. Read the MAX values of Ch1, and Ch2 for gain measurements (Measure → Ch 1(Ch 2) → MAX

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Inverted Summing Amplifier

3. Using the schematic for a summing amplifier shown in Fig 2, revise the circuit to sum two inputs (one DC input and one sinusoid input from the NI 5411 function generator). Verify the summing operation.
   a) Input A: 2V DC from the adjacent NI 5411 Function Generator (Note: Make sure all systems have a common reference i.e. ground)
   b) Input B 0.5 V $V_{pk}$, 5 HZ sinusoid
   c) $R_1 = 10k\Omega$, $R_2 = 10k\Omega$, $RF = 51k\Omega$
   d) Adjust the NI 5102 Oscilloscope Volts/div: Ch1 = 200 mV, Ch2 = 2 V
   e) View the sinusoid input on Ch1 and the summing output $V_{out}$ on Ch 2 of the NI 5102 Oscilloscope
   f) Repeat this procedure with $V_1 = .5 \sin 200\pi t$ and $V_2 = .25 \sin 4000\pi t$
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Challenge Circuit:
Build the circuit below and measure the output magnitude and frequency. Note that this circuit has no input signal. It relies on both positive and negative feedback. The negative feedback is time delayed by the capacitor in the feedback loop, which causes the output to switch back and forth between the maximum voltage inputs at a predictable frequency given by

\[ f_0 = \frac{1}{2 R_f C \ln \left( \frac{2R_1}{R_2} + 1 \right)} \]
Amplification and Summation

Adjust v1 to .25 V

<table>
<thead>
<tr>
<th>R1</th>
<th>R2</th>
<th>V2</th>
<th>Ideal gain (-R2/R1)</th>
<th>Measured Gain (V2/V1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>820K</td>
<td>1M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>1M</td>
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<td></td>
</tr>
<tr>
<td>10K</td>
<td>1M</td>
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</tr>
</tbody>
</table>

b) Use the 5 Hz 1V $V_{pk}$ sinusoid as v1, Ideal gain=_______, measured gain=_________. Attach a hardcopy of the oscilloscope output showing v1 and v2.

c) Input A is 2V DC, input B is a 0.5V $V_{pk}$ sinusoidal wave. Feedback resistor $R_1 = 10k\Omega$, $R_2 = 10k\Omega$, $RF = 51k\Omega$. Attach a hard copy of the input B and the output showing peak values.

d) Input A is .5 sin 200$\pi$t and Input B is .25 sin 4000$\pi$t. Attach a hard copy of the input B and the output showing peak values.

e) Challenge circuit: Calculated Amplitude_______ Frequency__________

Observed Amplitude _______ Frequency__________