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[AppPhysics 181]: Activity 6: OpAmps I

Objective

1. To observe the responses of OpAmps in circuits harnessing their inversion and amplification properties.

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Solution Proper

1. Application 1: **Inverting OpAmp Amplifier**

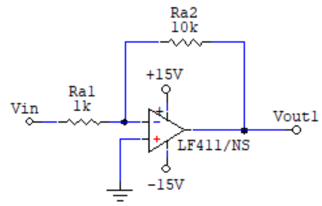

Figure 1: Schematic of Application 1

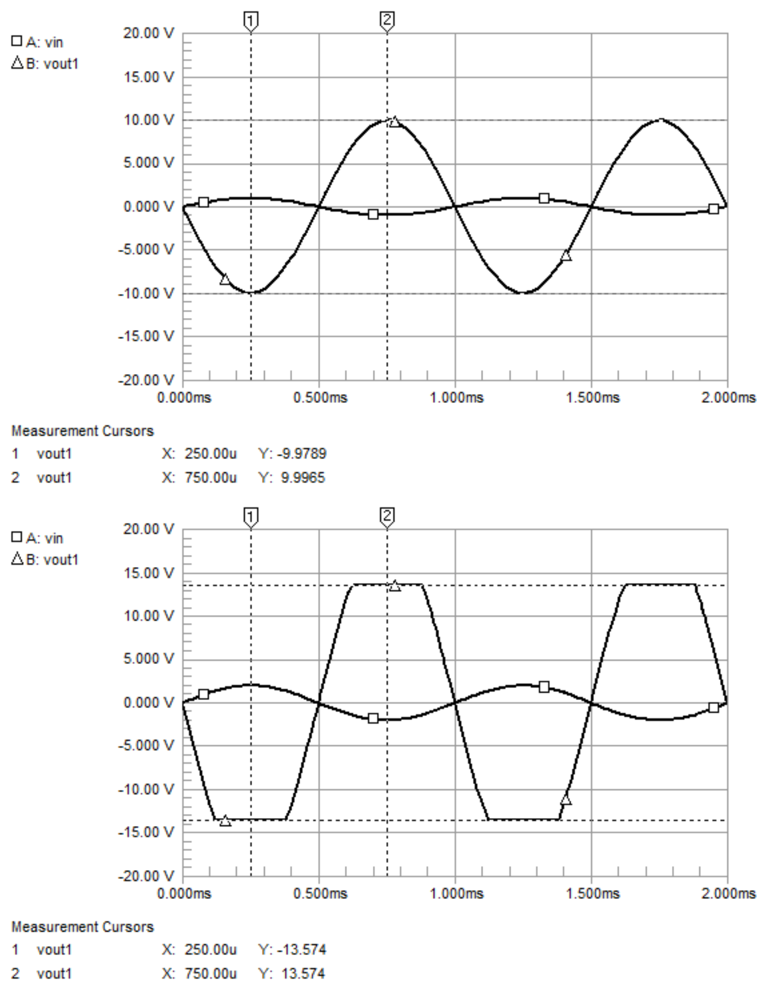

Figure 2: Input and Response of Circuit 1 for an input wave amplitude of 1 V (top) and 2 V (bottom)

The circuit is an **Inverting OpAmp Amplifier** (which redundancy was intentional to differentiate the term from the simpler Transistor Amplifier). Measuring the voltage gain from the peak of the input and the peak of the output, reveals an effective experimental voltage gain of -10, which is exactly the theoretical voltage gain $\frac{\texttt{Ra2}}{\texttt{Ra1}} = \frac{10[\text{k}\Omega]}{1[\text{k}\Omega]} = -10$. This negative value is then observed as the inversion of the output, as seen in Figure 2.

Increasing the input voltage amplitude therefore increases the output voltage, until a limit upon which the output gets clipped, which in this case is around $\pm$13.5V, primarily determined by the supply voltage of the transistor, as shown in the bottom graph of Figure 2. This clipping effect arises when the transistors inside the opamps get overwhelmed, which meant that the internal structure of the said opamp gets more than what it can handle and thus clips the output. Continued usage of the opamps in this mode can cause damage to the said internal structures.

Such circuits will find their use in circuits that demand amplifications of low gain but requires a low input resistance, typically in sound management or signal processing.

2. Application 2: **Noninverting OpAmp Amplifier**

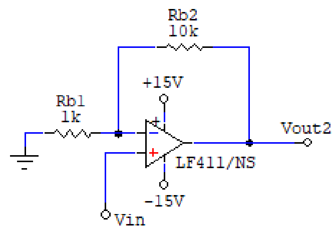

Figure 3: Schematic of Application 2

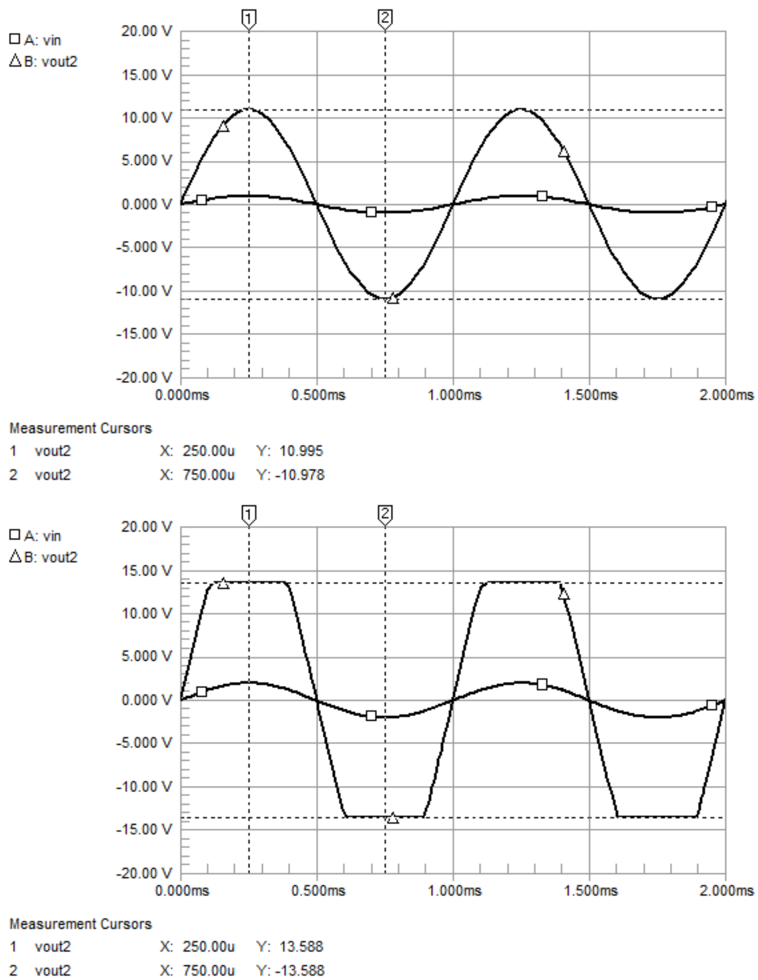

Figure 4: Input and Response of Circuit 3 for an input wave amplitude of 1 V (top) and 2 V (bottom)

The circuit is a **Non-inverting OpAmp Amplifier**. Measuring the voltage gain from the peak of the input and the peak of the output reveals an effective experimental voltage gain of 11 which is exactly the theoretical voltage gain $\frac{\mathtt{Rb2+Rb1}}{\mathtt{Rb1}} = \frac{10[10\ \mathrm{k}\Omega]+1\ [\mathrm{k}\Omega]}{1[\mathrm{k}\Omega]} = 11$. The voltage gain is positive, which meant that there is no inversion in the output as reflected in Figure 4

Note that a similar clipping effect from Application 1 was observed in this circuit.

Such circuits can find their use in circuits that requires higher gain with a small number of circuit components, more common in more practical sound devices.

3. Application 3: **Unity Gain OpAmp Amplifier**

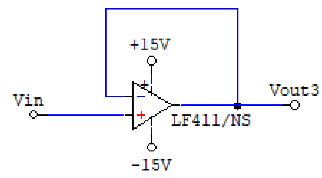

Figure 5: Schematic of Application 3

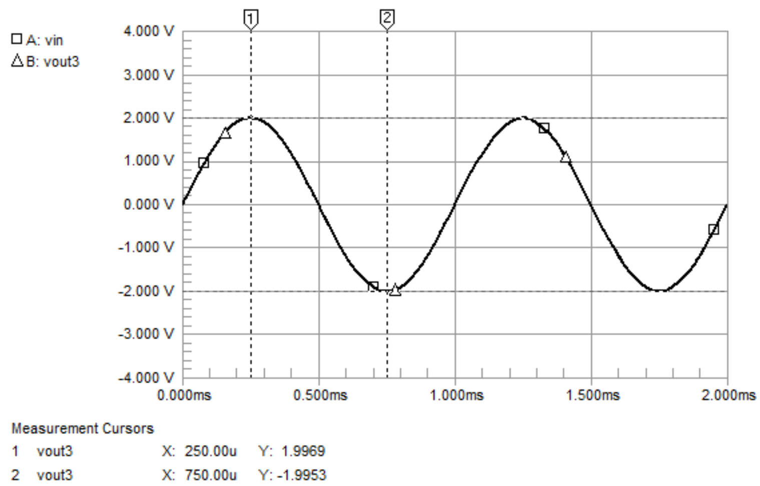

Figure 6: Input and Response of Circuit 5

This circuit is a **Unity Gain OpAmp Amplifier** or **Voltage Follower**. As shown in Figure 6, no voltage gain and inversion is observed in the output wave - the output wave is exactly the input wave (assuming ideal materials). This meant experimental voltage gain is 1, which is exactly the theoretical voltage gain.

While doing essentially nothing to the input voltage, this circuit provides a system upon which impedances (which are in essence, just resistances) change, giving the ability to control the current responses. One good example for this is on dividing sections of circuits: certain disturbances in one circuit won't necessary affect the other circuit using this technique.

4. Application 4: **OpAmp Current Source**

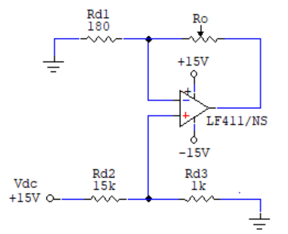

Figure 7: Schematic of Application 4

This circuit is an **OpAmp Current Source** . Ideal current sources provide an output current independent of the input voltage, being highly dependent instead on the load resistance Ro integrated with it.

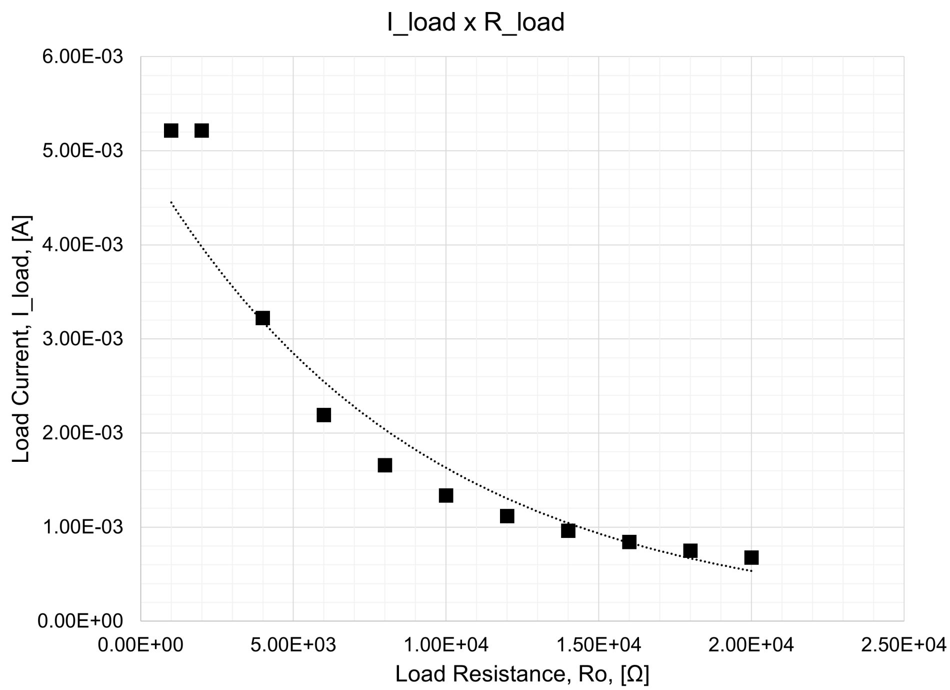

Figure 8: $I_{\texttt{Ro}} \times$ Ro plot

The current supplied or the load current $I_{\texttt{Ro}}$ follows an almost exponential curve down. At the limit of an infinite resistance, it should be expected that the circuit will imitate an open circuit and as such must have zero current flowing, which the circuit seemed to observe as shown in Figure 8.

A similar behavior is also seen in Transistor Current Sources. In the previous paper, a transistor current source shows the same behavior but requires a very smaller number of components than the OpAmp current source.

5. Application 5: **Inverting Summing Amplifier**

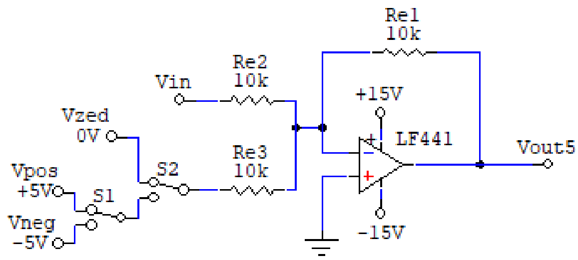

Figure 9: Schematic of Application 5

This circuit is an **Inverting Summing Amplifier** . As observed in Figure 10, these circuits add the voltages input voltages as they enter and then inverts the sum.

Figure 10 shows three of the possible cases for adding ACs and DCs in this circuit. The bottom graph, in particular shows that this circuit can also act a general signal inverter.

This kind of circuit can find their use in compound circuits that implement some degree of logic and circuits that connects to multiple voltage sources.

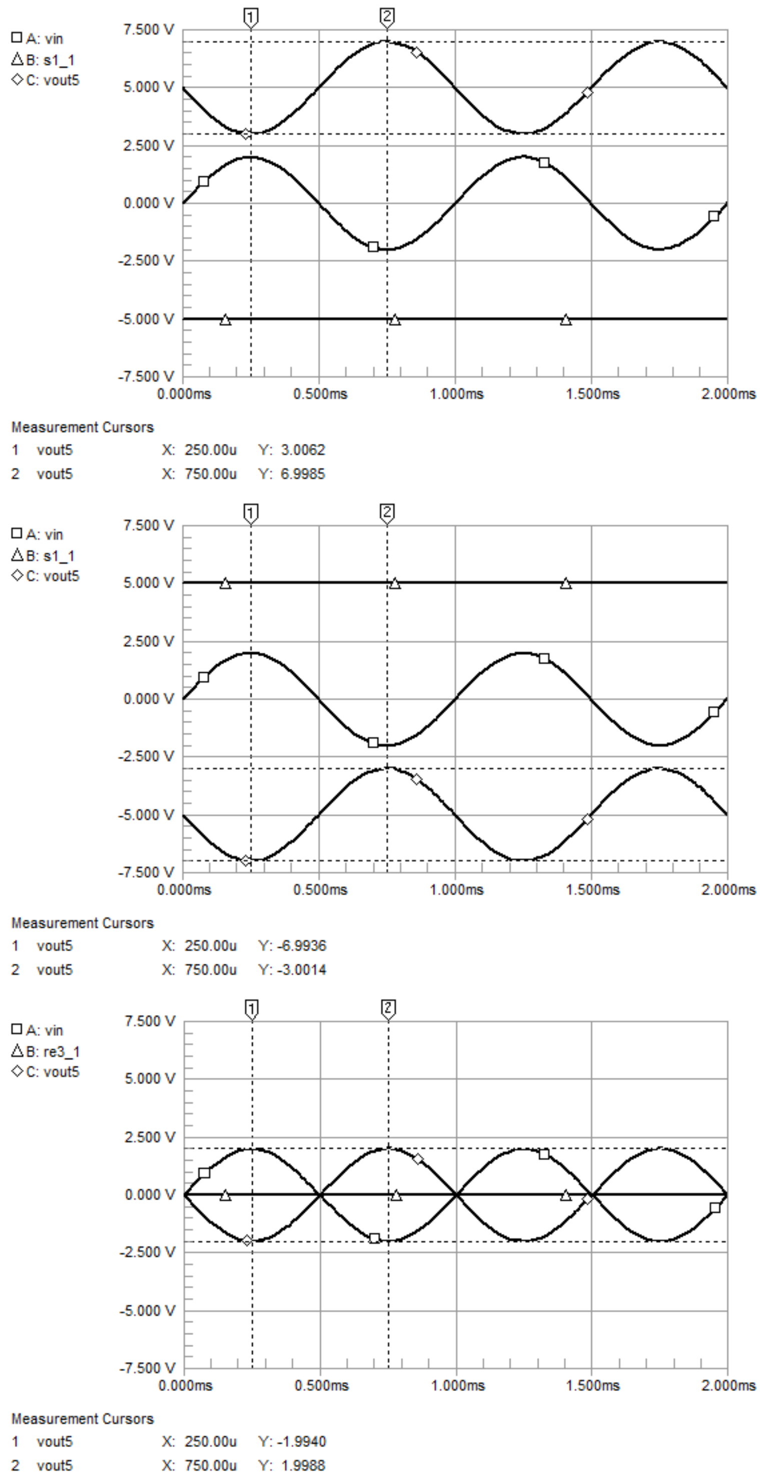

Figure 10: Input and Response of Circuit 9 when the circuit is toggled to `Vpos` (top), `Vneg` (middle), and `Vzed` (bottom).