Indian Institute of Technology Hyderabad

Analog Electronics and Integrated Circuits

Basics of Op Amp

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November 2023

1 Simulating an Open Loop Op-Amp

a) Given that the input signal has a frequency of 10Hz and amplitude of 1mV with bias voltages as 5V.

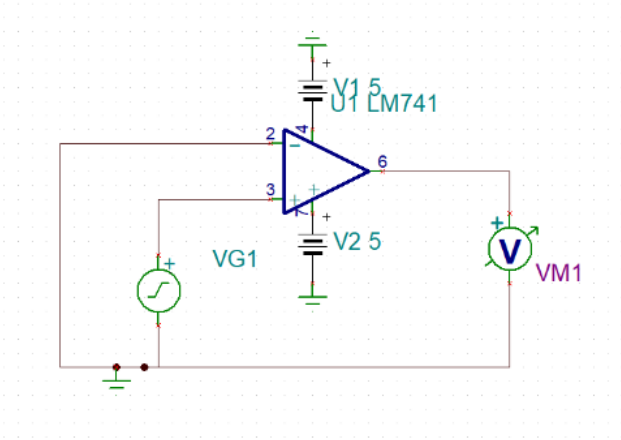

Figure 1: Circuit Simulation of Open Loop Op Amp

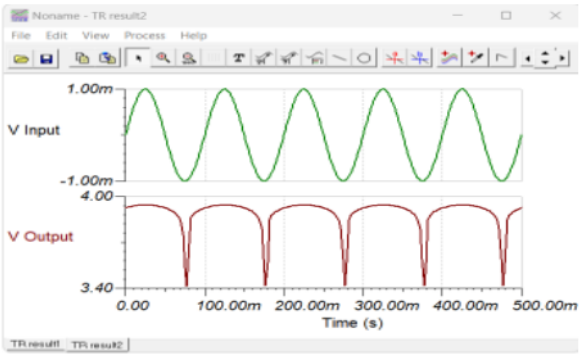

Figure 2: Input-Output Characteristics

b) According to the Data Sheet:

- Open Loop Gain of 714 = 200,000 V/V, which is very high.
- Input resistance $R_i = 2\,\mathrm{M}\Omega$, which is very high.
- Output resistance $R_o = 75\,\Omega$, which is very low.

In the case of an Ideal Op Amp:

- Open Loop Gain of 714 $\rightarrow \infty$
- Input resistance $R_i \rightarrow \infty$
- Output resistance $R_o \rightarrow 0$

c) The Input Output Characteristics are shown above. The reason for the non-linear amplification of the sine wave is due to the DC Transfer Characteristics of the Op Amp.

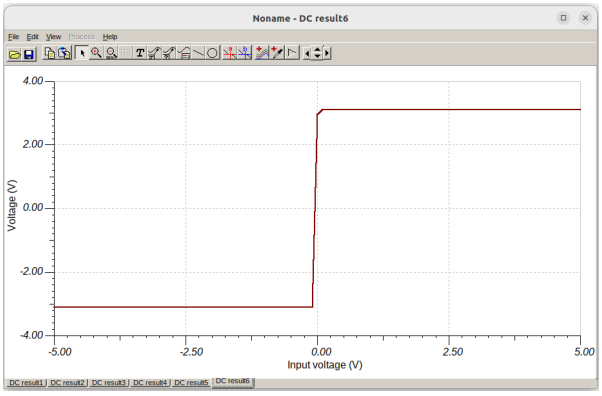

Figure 3: DC Transfer Characteristics for LM714

Since the input signal maps to the constant region of the Transfer Characteristics, the output signal, instead of being an amplified sine wave, looks more like a square wave.

For the Ideal Case:

$$V_{\max} = 200,000 \times 10^{-3} \implies V_{\max} = 200V$$

Since the maximum voltage that the output signal can take is restricted by V_{cc} and V_{ee}, the voltage cannot exceed these values.

d) By looking at the DC Transfer Characteristics, we can infer that the Saturation Voltage is 3V. The Ideal Transfer Voltage is 5V. The difference in the ideal and specific case is due to the internal resistances of the op-amp, which are assumed to be 0 or infinity in ideal cases.

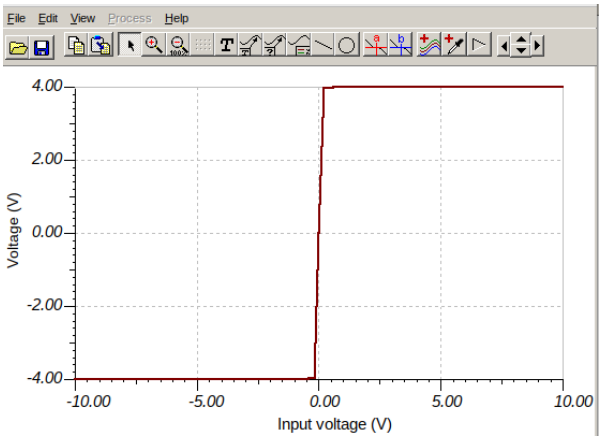

Figure 4: DC Transfer Characteristics for LM776

The change in the DC Transfer Characteristics is due to the different internal resistances of the op amp. The output resistance in LM776 is 5Ω, which is closer to ideal.

e) Bandwidth of Ideal Op Amp is infinite.
Bandwidth of LM714 is 5.7 kHz. This implies that the op amp can show the full power output within the range of 5.7 kHz.

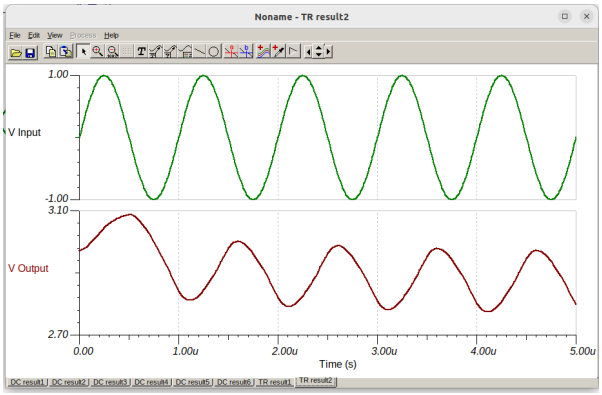

Figure 5: Input Output Characteristics for $f = 1$ MHz

The Non-Ideal Nature of the sine wave is because 1 MHz is way beyond the bandwidth of the Op Amp.

2 Voltage Follower Circuit

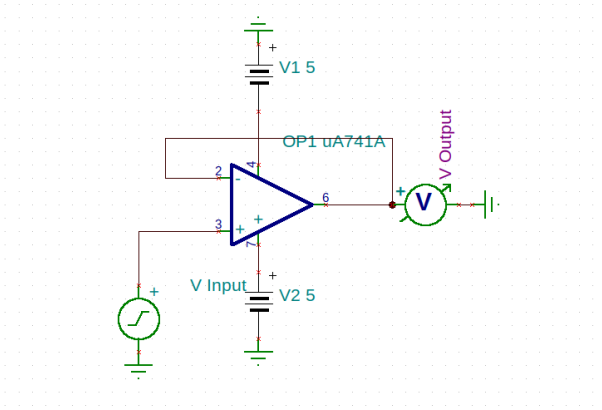

Figure 6: Voltage Follower Circuit

a) As we can observe from the input-output graphs

$$v_o = v_i$$

b) Such a circuit is called a buffer circuit or an amplifier with unit gain.

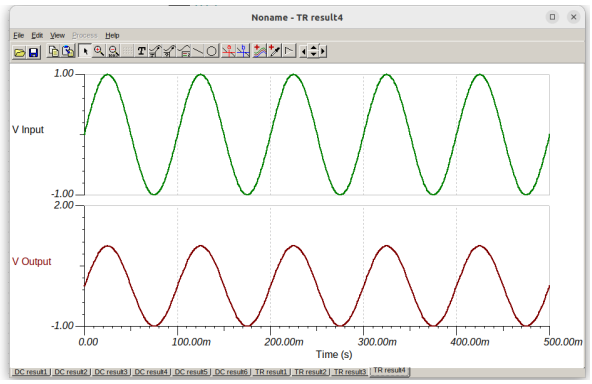

Figure 7: Input Output Characteristics

c) A buffer circuit is used to create isolation between two components of a circuit due to the high input impedance and low output impedance characteristics of the op-amp. The voltage follower circuit is used to provide high current gain in the op-amp.

d)

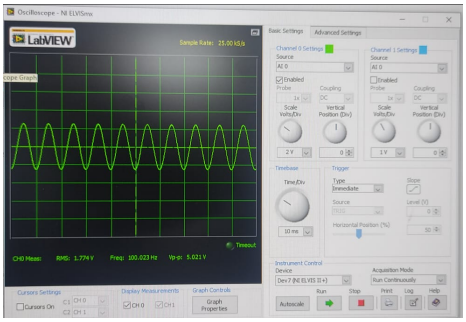

Figure 8: Voltage Follower Circuit

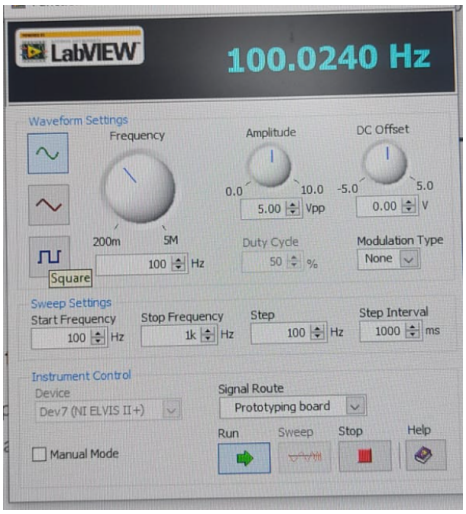

Figure 9: Input by function Generator

3 Adder Circuit

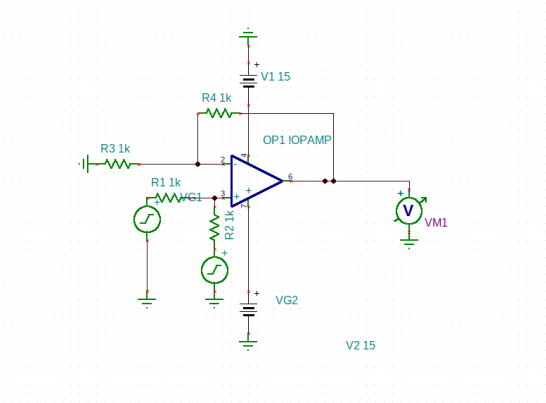

Figure 10: Input by function Generator

By Using an Op Amp, two sine waves can be added.
In the Elvis board implementation, a sine wave is being added with a constant source voltage of 5V.

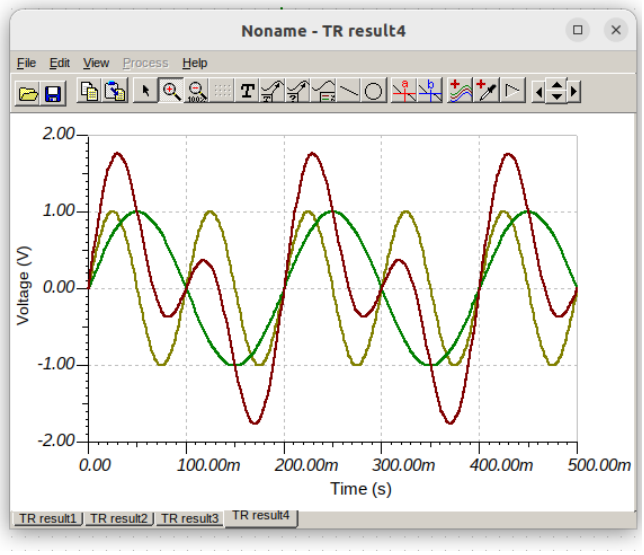

Figure 11: Input Output Characteristics

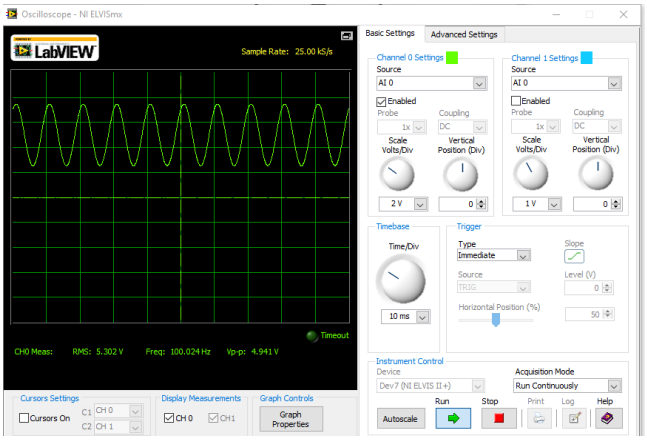

Figure 12: Adder Circuit