EN313 Power Electronics
Basic OpAmp Configurations & Loading Effects

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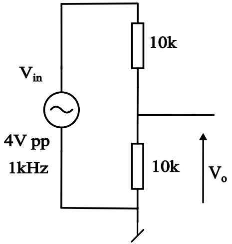

Figure 1: Potential divider

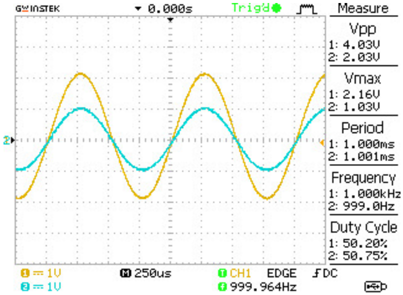

Figure 2: V_{in} and V_o

- Output voltage

$$V_o = \frac{10k}{10k + 10k} * V_{in} = 2\text{V (pk-pk)} \qquad (1)$$

Potential divider: Loading effects

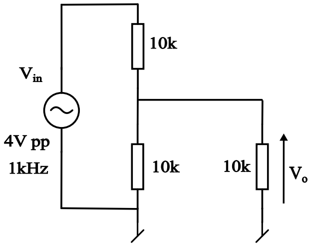

Figure 3: Potential divider: loading

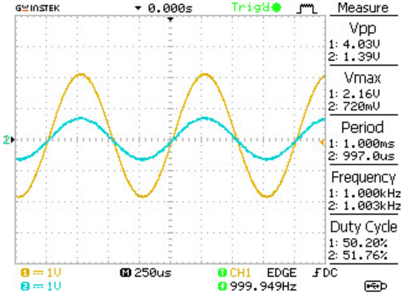

Figure 4: V_{in} and V_o

- Due to loading, output voltage (V_o) dips !!
- How to take care of this?
- One must ensure that negligible current is drawn from output of potential divider to address loading effects.

Buffer/Unity-gain Amplifier

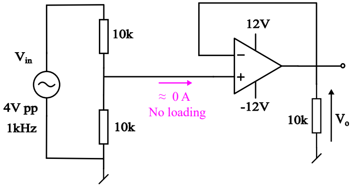

Figure 5: Opamp buffer

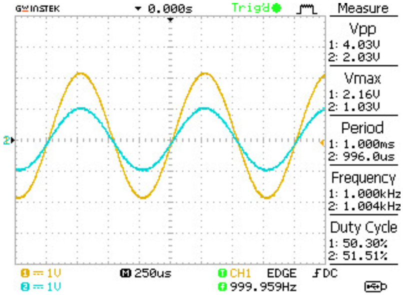

Figure 6: V_{in} and V_o

Buffer/Unity-gain Amplifier/Voltage Follower

- Opamp buffer can be used at the output stage of potential divider to get rid of loading effects.
- Input resistance of opamp buffer is very high.

$$\mathrm{R_{in}} \approx R_i\ (1 + \mathrm{A}_v)$$

- Output resistance of opamp buffer is very low.

$$\mathrm{R_{out}} \approx \frac{R_o}{(1 + \mathrm{A}_v)}$$

- A_v: Open-loop gain of opamp ($2 * 10^5$ V/V for LM741)
  R_i: Input resistance of opamp (2 MΩ for LM741)
  R_o: Output resistance of opamp (75 Ω for LM741)

Non-inverting Amplifier

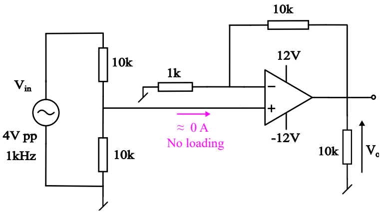

Figure 7: Non-inverting configuration

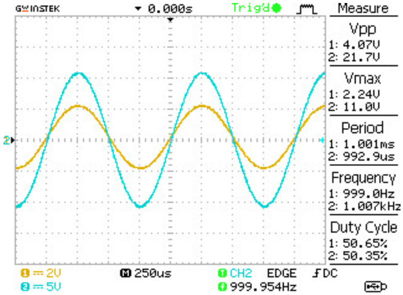

Figure 8: V_{in} and V_o

Non-inverting Amplifier

- In this configuration, opamp gets its input directly at the inverting terminal.
- Thus, it is not prone to loading effects because of very high input impedance.
- The input resistance for this configuration is given by

$$\mathrm{R_{in}} \approx R_i \; \mathrm{A}_v \; \frac{R_1}{R_1 + R_2}$$

Inverting Amplifier

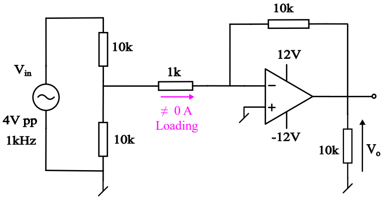

Figure 9: Inverting configuration: loading

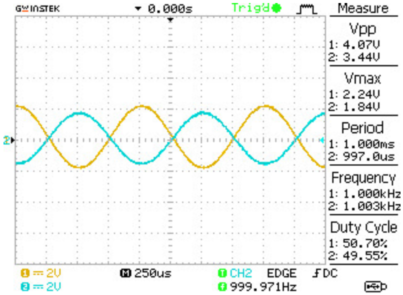

Figure 10: V_{in} and V_o

Inverting Amplifier: Loading effects

- Inverting amplifier configuration is prone to loading effects (on the input side).
- This is because the input resistance of this configuration is low as compared to that of non-inverting configuration.

$$\mathrm{R_{in}} \approx R_i$$

Buffer + Inverting Amplifier

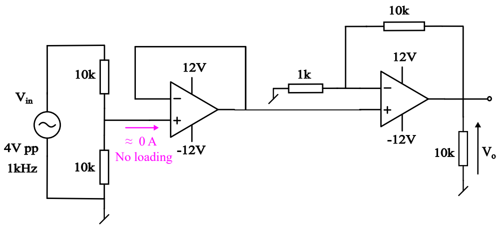

Figure 11: Buffer with inverting config.

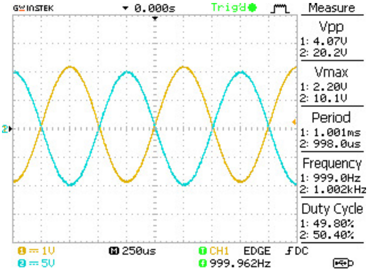

Figure 12: V_{in} and V_o

- A buffer can be placed at the front-end of inverting amplifier to get rid of loading effects.

Saturation effects in Opamp

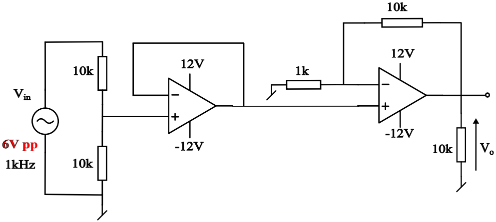

Figure 13: Buffer with inverting config.

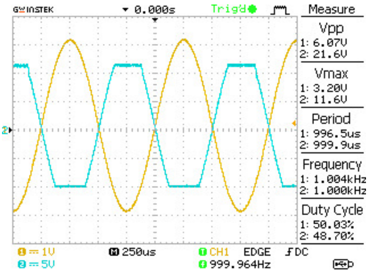

Figure 14: V_{in} and V_o

- Input is 6V (pk-pk), expected o/p voltage is 6*0.5*10 = 30V (pk-pk).
- Opamp supply is +/- 12V, output voltage saturates at 21.6 V pp.
- The remaining drop (24-21.6 V) is due to saturation voltages of transistors present in opamp.

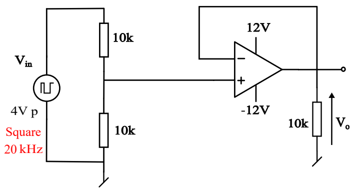

Figure 15: Buffer: slew rate effect on output with 20 kHz square input

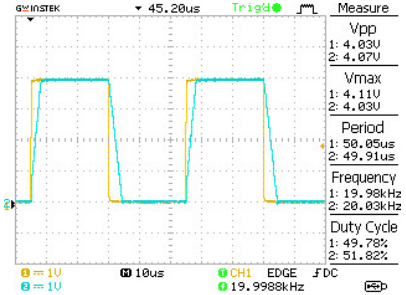

Figure 16: V_{in} and V_o

Slew rate in Opamp: 100kHz input source

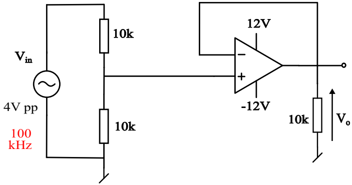

Figure 17: Buffer: slew rate effect on output with 100 kHz input

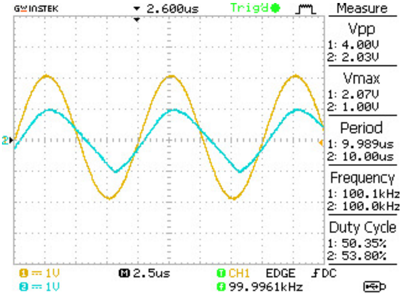

Figure 18: V_{in} and V_o

Slew rate in Opamp: 500kHz input source

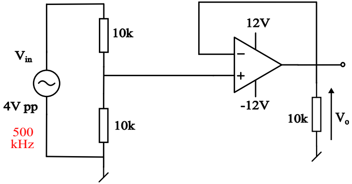

Figure 19: Buffer: slew rate effect on output with 500 kHz input

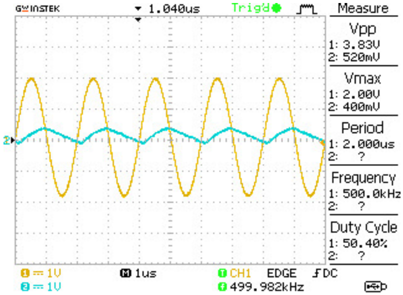

Figure 20: V_{in} and V_o

THANK YOU