|  |  |
| --- | --- |
| Name:Click or tap here to enter text. | Date:Click or tap to enter a date. |

# Operational Amplifiers

Please watch the following short video tutorials (each less than 3 minutes) on operational amplifiers and answer the multiple-choice questions below:

* [Op-Amp Basics: Introduction to the Operational Amplifier](https://www.allaboutcircuits.com/video-tutorials/op-amp-basics-introduction-to-the-operational-amplifier/)
* [Ideal Op-Amp Characteristics](https://www.allaboutcircuits.com/video-tutorials/op-amp-basics-idealized-op-amp-characteristics/)
* [Negative Feedback in Op-Amps](https://www.allaboutcircuits.com/video-tutorials/op-amp-basics-negative-feedback/)
* [Common Operational Amplifier Applications](https://www.allaboutcircuits.com/video-tutorials/op-amp-applications/)
* [Applications of the Op-Amp: The Voltage Follower](https://www.allaboutcircuits.com/video-tutorials/op-amp-applications-voltage-follower/)

One additional topic that isn’t covered well in the videos is the concept of common-mode and difference-mode voltage.

Consider the two signals that are connected to the inputs of our amplifier, call them $V\_{1}$ and $V\_{2}$. These two signals can be written in terms of two other terms called the common-mode signal $V\_{cm}$ and the difference mode signal, $V\_{dm}$ where

$$\begin{matrix}V\_{cm}=\frac{V\_{1}+V\_{2}}{2}&and V\_{dm}=\frac{V\_{2}-V\_{1}}{2}\end{matrix}$$

We can solve these two equations for $V\_{1}$ and $V\_{2}$ to obtain

$$\begin{matrix}V\_{1}= V\_{cm}-V\_{dm}&and V\_{2}= V\_{cm}+V\_{dm}\end{matrix}$$

So $V\_{cm}$ is the portion of the signal that is in common to the two input signals, while $V\_{dm}$ is the difference.

Later, when analyzing the gain of an op-amp we will treat the gain of the common mode signal separately from the gain of the difference mode.  In an op amp, we want to maximize the difference gain and minimize the common mode gain.

## The input impedance of a typical real op-amp is:

[ ]  Infinite

[ ]  Very High

[ ]  Very Low

[ ]  Zero

## The input impedance of an ideal op-amp is:

[ ]  Infinite

[ ]  Very High

[ ]  Very Low

[ ]  Zero

## The output impedance of a typical real op-amp is:

[ ]  Infinite

[ ]  Very High

[ ]  Very Low

[ ]  Zero

## The output impedance of an ideal op-amp is:

[ ]  Infinite

[ ]  Very High

[ ]  Very Low

[ ]  Zero

## A common mode signal is applied to:

[ ]  the non-inverting input.

[ ]  the inverting input.

[ ]  both the inverting and non-inverting inputs.

[ ]  the $+V\_{cc}$ and $-V\_{cc}$ inputs.

## The common-mode voltage gain is:

[ ]  smaller than the differential voltage gain.

[ ]  equal to the differential voltage gain.

[ ]  greater than the differential voltage gain.

[ ]  none of the above.

## An operational amplifier is a:

[ ]  voltage-controlled voltage source (VCVS).

[ ]  voltage-controlled current source (VCCS).

[ ]  current-controlled voltage source (CCVS).

[ ]  current-controlled current source (CCCS).

## The gain of an op-amp voltage follower is:

[ ]  0

[ ]  Unity

[ ]  Infinite

[ ]  Very High

## The op-amp can amplify:

[ ]  AC signals only.

[ ]  DC signals only.

[ ]  both AC and DC signals.

[ ]  neither AC nor DC signals.

## A voltage follower…

[ ]  has a voltage gain of 1.

[ ]  is non-inverting.

[ ]  has no feedback resistor.

[ ]  has all of the above.

## A typical operational amplifier has a:

[ ]  single-ended input and single-ended output.

[ ]  single-ended input and differential output.

[ ]  differential input and single-ended output.

[ ]  differential input and differential output.

## A certain inverting amplifier circuit has a closed-loop voltage gain of 25. The op-amp has an open-loop voltage gain of 100,000. If an op-amp with an open-loop voltage gain of 200,000 is substituted in the for the original op-amp, the closed-loop gain of the circuit:

[ ]  doubles.

[ ]  drops to 12.5.

[ ]  remains at 25.

[ ]  increases slightly.

# Voltage Follower or Unity Gain Buffer

## Output of Unloaded Voltage Divider

Consider the voltage divider shown to the right with each $R=100$ kW.

What will be the voltage at the output of this divider? Justify your answer.

|  |
| --- |
| Click or tap here to enter text. |



## Output of Loaded Divider

Now, suppose that a $1kΩ$ load is attached to the voltage divider output as shown. Each of the divider resistances are still $R=100kΩ$. What will be the resulting voltage across the load? Again, justify your answer with an explanation.

|  |
| --- |
|  |

## Buffered Output with a Voltage Follower

Finally consider the situation where we have placed a voltage follower between the original divider with the two $R=100kΩ$ resistors and the $1kΩ$ load. Describe what voltage will be delivered to the load. In your explanation, use language that describes how this circuit works both in terms of an ideal op-amp and a real op-amp that might have an input impedance on the order of $100MΩ$.

|  |
| --- |
|   |