

# Differential amplifier

This article was checked by pedagogue



This article was checked by pedagogue, but later was changed.

OK I HAVE IMPROVED IT - REMEMBER IN THE FUTURE WRITE FOR MEDICAL STUDENTS NOT PHYSICS STUDENTS.



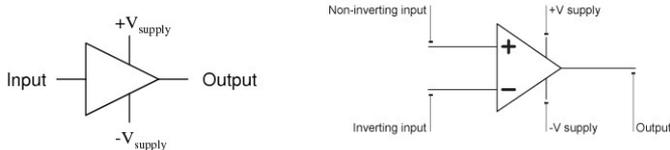
## 1. Introduction to operational amplifiers

Operational Amplifiers or Op-amps are one of the basic elements of Analogue Electronic Circuits. They are used in signal AMPLIFYING, conditioning, filtering or in mathematical operations for example adding, subtracting, integrating or differentiating.

This three-terminal device consists also of two high impedance inputs: Inverting Input (-), Non-inverting Input (+) and output port which can either sinks or sources voltage and current. There can be four different classifications of operational amplifier gain:

- Voltage - Voltage "in" and Voltage "out"
- Current - Current "in" and Current "out"
- Transconductance - Voltage "in" and Current "out"
- Transresistance - Current "in" and Voltage "out"

General amplifier circuit symbol

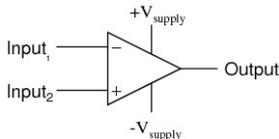


## 2. Differential Amplifiers

Why use integrated fully-differential amplifiers?

- Immunity to external noise is increased E.G., NOISE PICKED UP BY THE BODY FROM THE ENVIRONMENT WHEN MEASURING BIOPOTENTIALS
- Best for AMPLIFYING low-voltage systems E.G., BIOPOTENTIALS

Differential amplifier



The differential amplifier has a unique feature that is, it amplifies the voltage difference between two input signals unlike the single-ended which amplify a single input signal.

A principle application is to eliminate the noise (common-mode fluctuating voltage). It may be also configured to operate as a single-ended amplifier by grounding one of the inputs. An integrated, fully-differential amplifier architecturally resembles a standard, voltage-feedback operational amplifier. Both have differential inputs, however a standard operational amplifier's output is single-ended and the other's is differential. Due to the above mentioned fact, in the differential amplifier the output common-mode voltage can be controlled independently of the differential voltage and in a standard one the signal and output common-mode voltage are the same thing. It is also worth mentioning that a fully-differential amplifier has multiple feedback paths. Below there is a figure presenting differences between a fully-differential and a standard operational amplifier.

Gain of an amplifier is defined as  $V_{out}/V_{in}$ . For the special case of a differential amplifier, the OUTPUT  $V_{out}$  is PROPORTIONAL TO the difference between its two input terminals, which is equal to  $(V1-V2)$ .

$$V_{out} = A_d (V_{+in} - V_{-in})$$

Where:

- $V_{out}$  = output voltage
- $V_{+in}$  = input voltage on the NON-INVERTING input
- $V_{-in}$  = input voltage on the INVERTING negative input
- $A_d$  = differential gain

## 3. Differential amplifiers and medicine

We use differential amplifiers when we need TO MEASURE DIFFERENCES BETWEEN TWO VARIABLES AND TO minimize noise and amplify the signal.

FOR EXAMPLE THE FOLLOWING BIOSIGNALS REQUIRE THE MEASUREMENT OF THE DIFFERENCE IN ELECTRICAL POTENTIAL BETWEEN DIFFERENT PARTS OF THE BODY

- ECG/EKG - (Electrocardiography is the process of recording the electrical activity of the heart over a period of time)
- EMG - (Electromyography - technique for evaluating and recording the electrical activity produced by skeletal muscles)
- EEG - (Electroencephalography - is an electrophysiological monitoring method to record electrical activity of the brain)

How?

There are two input, one reference and one ground electrodes attached to the skin. It is very important because it amplifies the differential signal of interest and rejects the common mode voltages at the same time.

REFERENCES:

[http://www.electronics-tutorials.ws/opamp/opamp\\_5.html](http://www.electronics-tutorials.ws/opamp/opamp_5.html)

[https://books.google.pl/books?id=0yJ3blal7b8C&pg=PA157&lpg=PA157&dq=Differential+amplifier+for+dummies&source=bl&ots=13mLh\\_I9y&sig=KNT9CqYcrmd1tX5PGW0MxgRzZuc&hl=pl&sa=X&ved=0ahUKEwjv37CysKr](https://books.google.pl/books?id=0yJ3blal7b8C&pg=PA157&lpg=PA157&dq=Differential+amplifier+for+dummies&source=bl&ots=13mLh_I9y&sig=KNT9CqYcrmd1tX5PGW0MxgRzZuc&hl=pl&sa=X&ved=0ahUKEwjv37CysKr)

[https://en.wikipedia.org/wiki/Differential\\_amplifier#Long-tailed\\_pair](https://en.wikipedia.org/wiki/Differential_amplifier#Long-tailed_pair)

<http://www.allaboutcircuits.com/textbook/semiconductors/chpt-8/negative-feedback/>

<http://www.ecircuitcenter.com/Circuits/opdif/opdif.htm>

[https://en.wikipedia.org/wiki/Operational\\_amplifier](https://en.wikipedia.org/wiki/Operational_amplifier)

<http://www.radio-electronics.com/info/circuits/transistor/long-tailed-pair.php>

<https://wiki.analog.com/university/courses/electronics/text/chapter-12>

<http://www.ti.com/lit/an/sloa054d/sloa054d.pdf>

<http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/integratedrev3.shtml>

<https://www.youtube.com/watch?v=Dq7Jzc9Rgkg>

<https://www.youtube.com/watch?v=voEjKClpGs>