

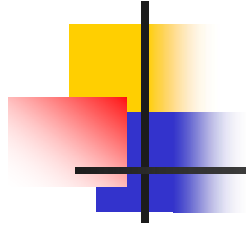


Thapar Institute of Engineering & Technology
(Deemed to be University)
Bhadson Road, Patiala, Punjab, Pin-147004
Contact No. : +91-175-2393201
Email : info@thapar.edu

Engineering Design Project-II (UTA 024)



THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)



Engineering Design Project-II (UTA 024) Buggy Lab

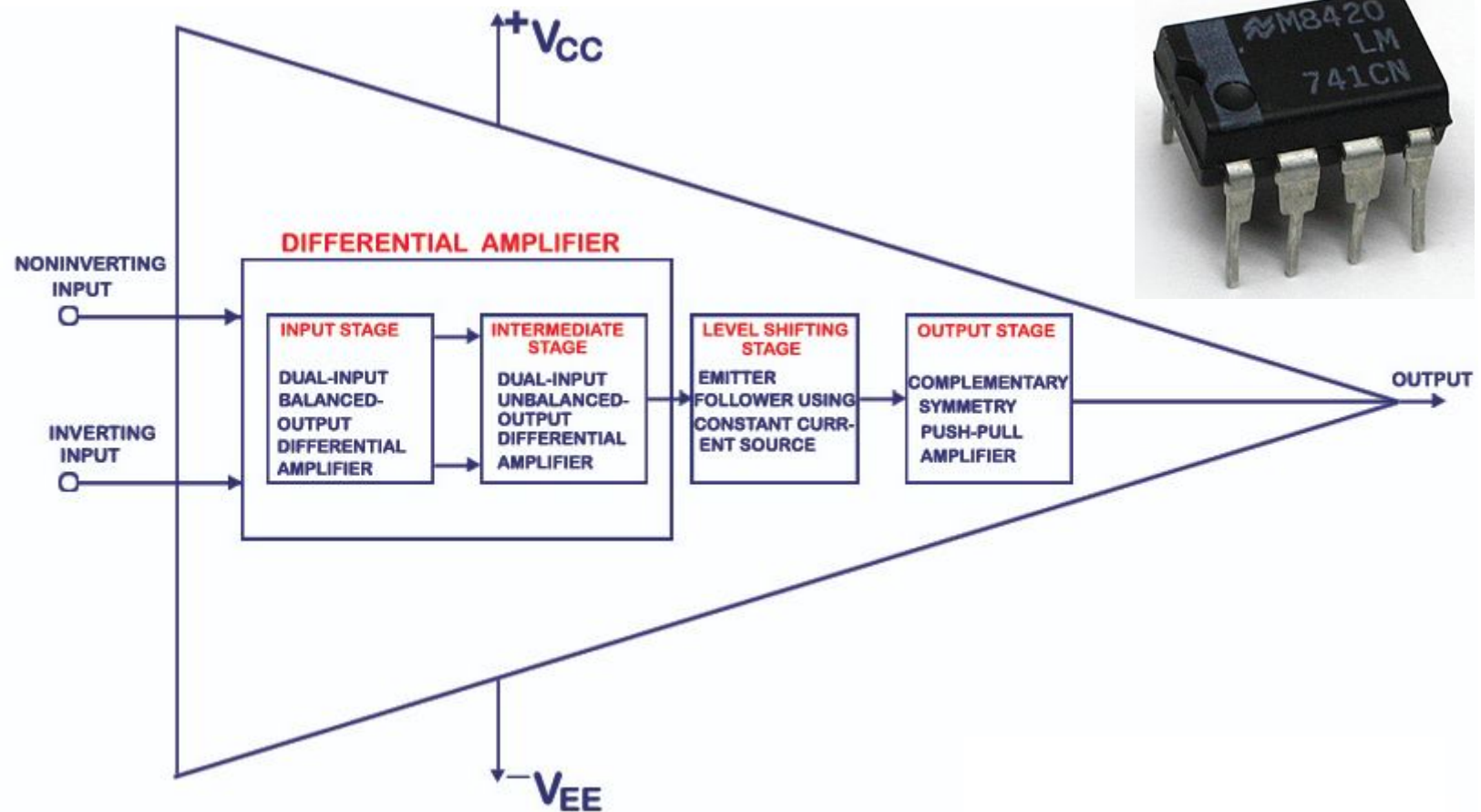
Dr. Amit Mishra



Index

- **Operational amplifier**
- **Ideal Characteristics**
- **Configurations**
- **Applications**
- **References**

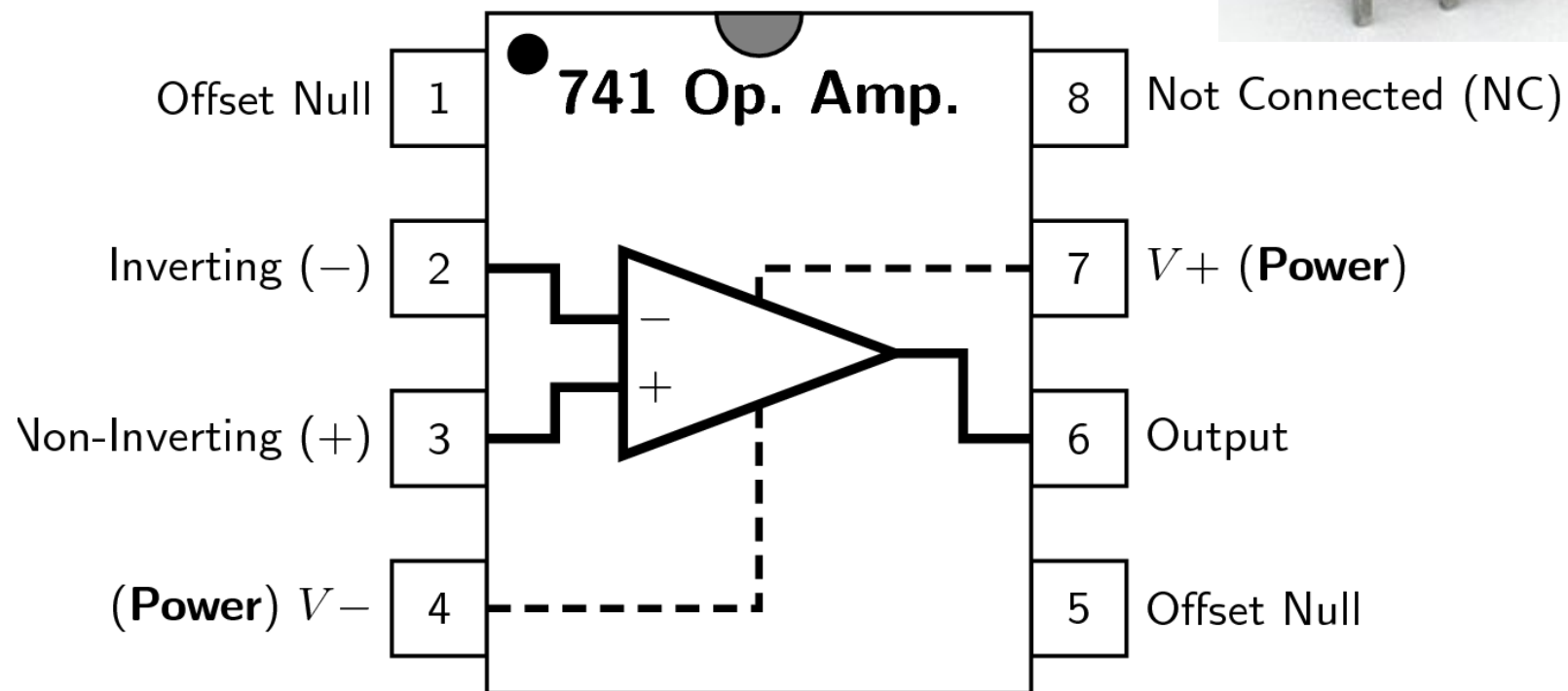
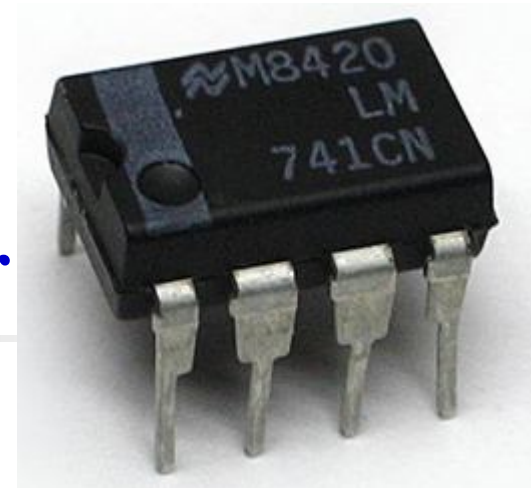
Block diagram of operational amplifier



August 9, 2020

Image source: Google

Pin diagram of operational amplifier





Ideal characteristics of an operational amplifier and typical values

- ❖ Infinite input impedance $\approx 1\text{-}2\text{ M}\Omega$
- ❖ Zero output impedance $\approx 10\text{-}100\ \Omega$
- ❖ Infinite open loop gain $\approx \text{more than } 1,00,000$
- ❖ Infinite slew rate $\approx 0.5\text{ V}/\mu\text{s}$
- ❖ Infinite Bandwidth $\approx 1\text{ MHz}$
- ❖ Infinite Common mode rejection ratio (CMRR) $\approx 10,000$
- ❖ Zero Supply voltage rejection Ratio (SVRR) $\approx 150\ \mu\text{V}/\text{V}$

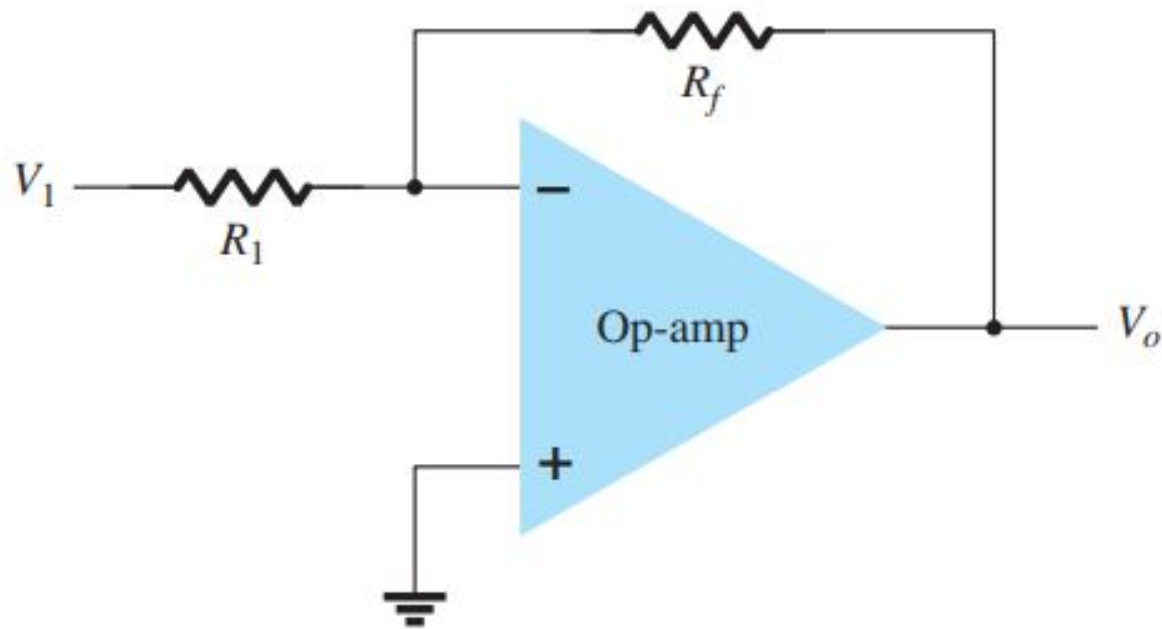


Configurations of operational amplifier

- ❖ **Inverting amplifier**
- ❖ **Non inverting amplifier**

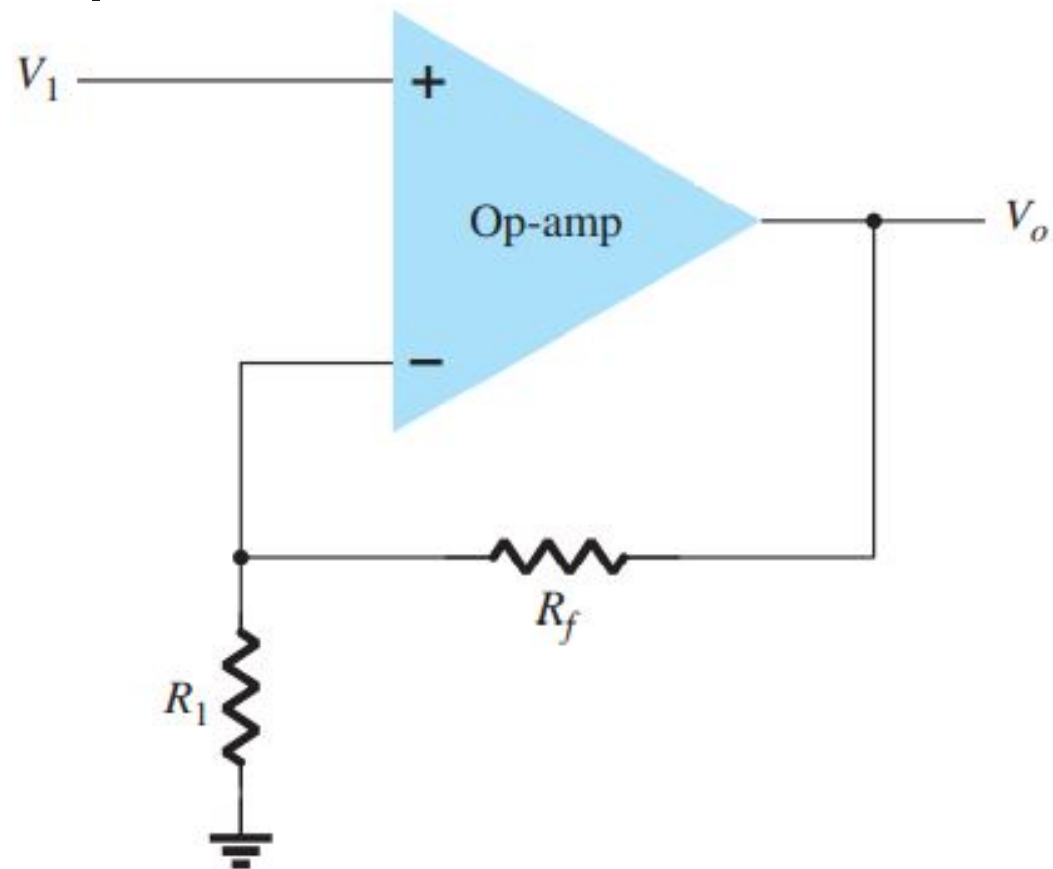


Inverting amplifier



$$V_o = -\frac{R_f}{R_1} V_1$$

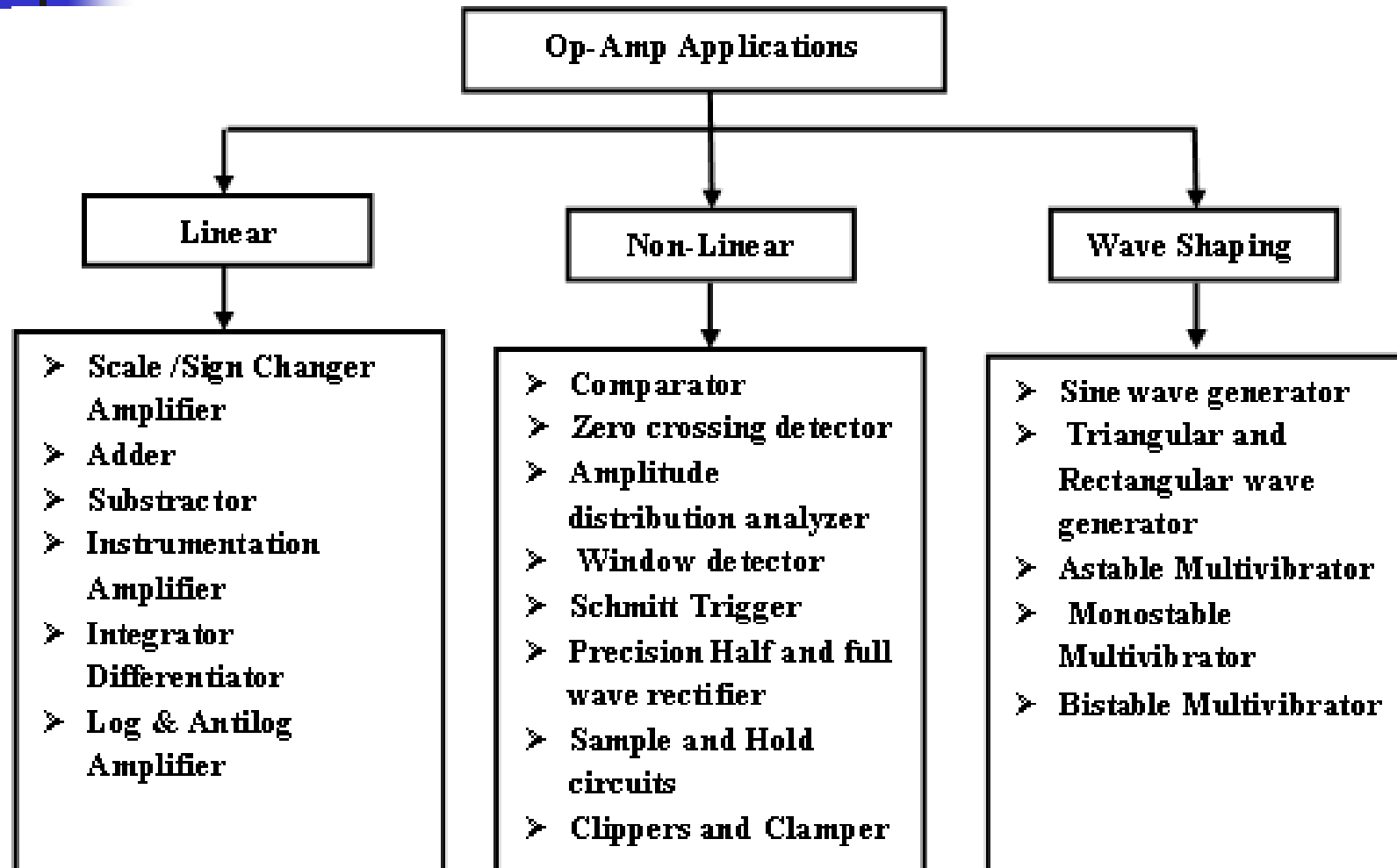
Non inverting amplifier



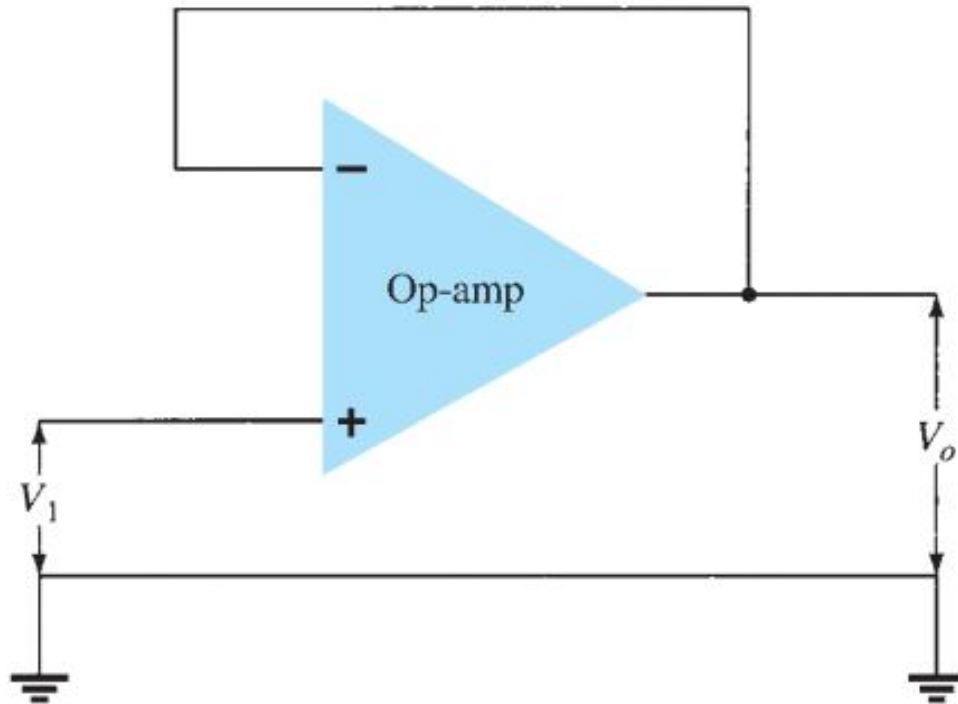
$$V_o = \left(1 + \frac{R_f}{R_1} \right) V_1$$



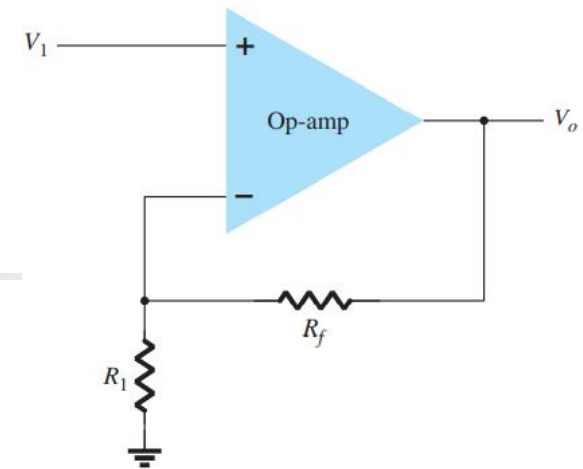
Applications



Unity follower

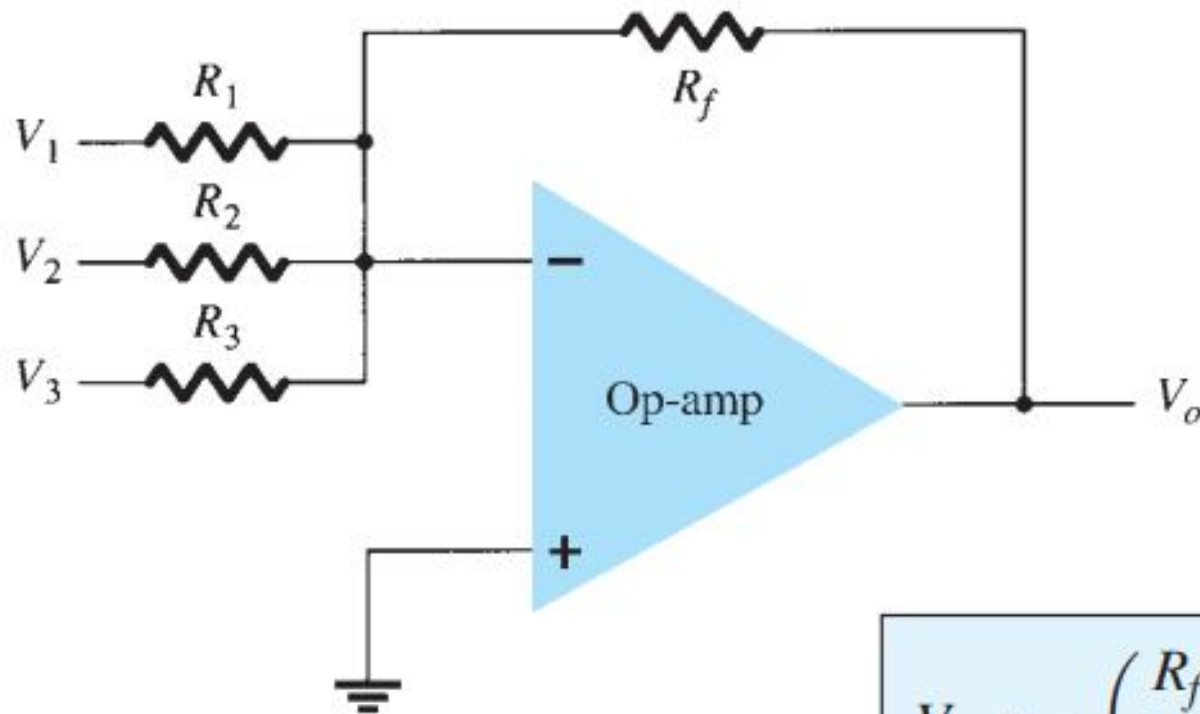


Non inverting amplifier



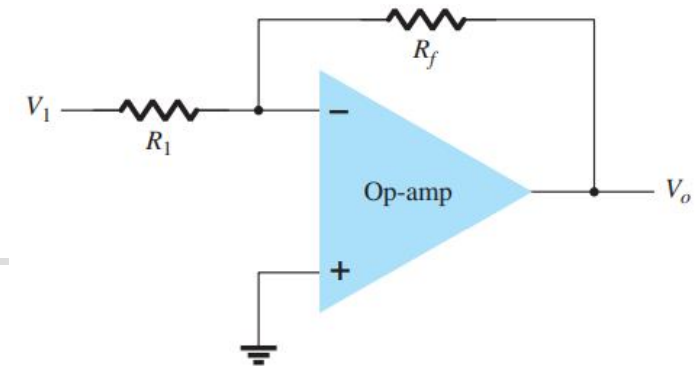
$$V_o = V_1$$

Summing amplifier

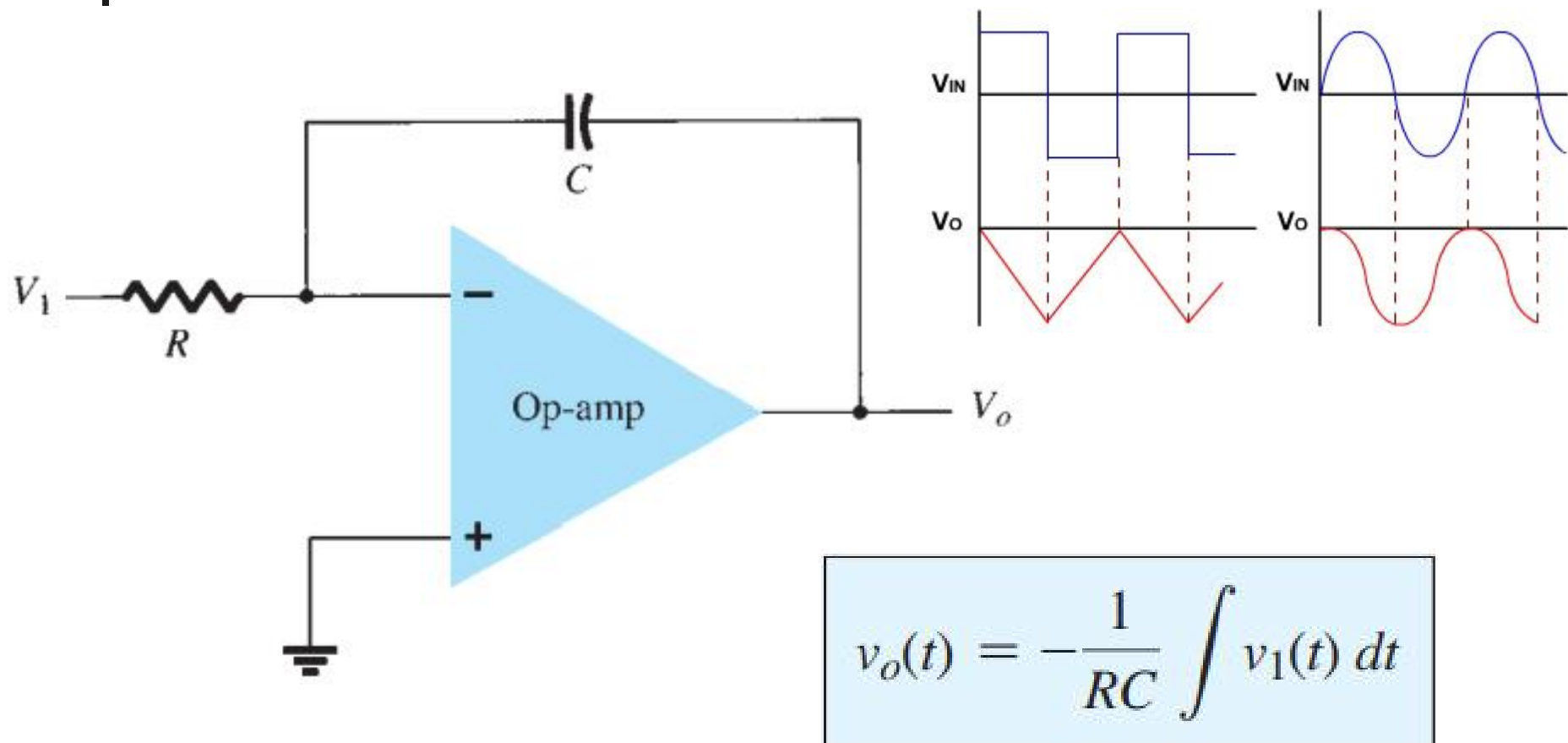


$$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$

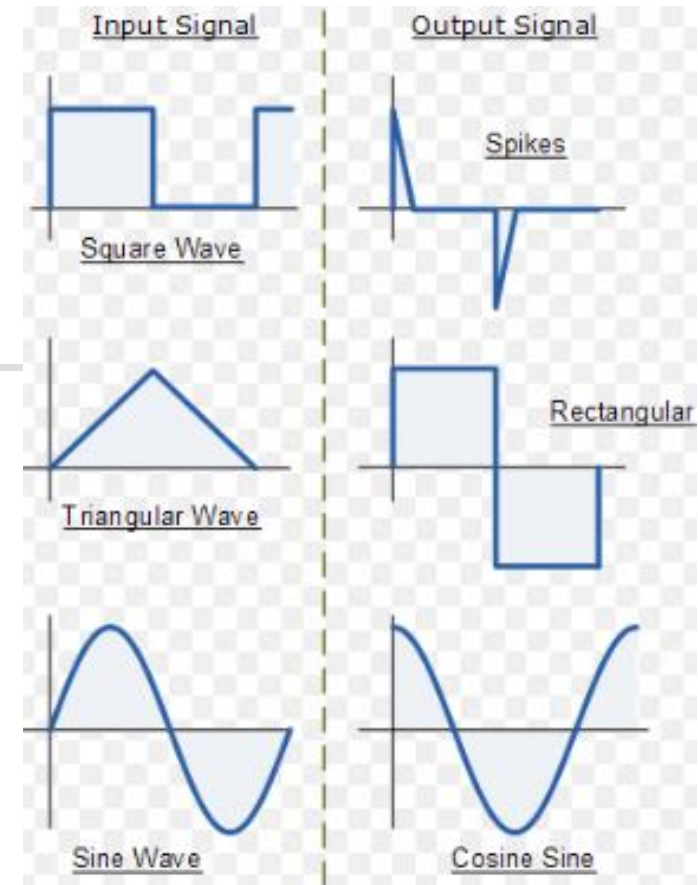
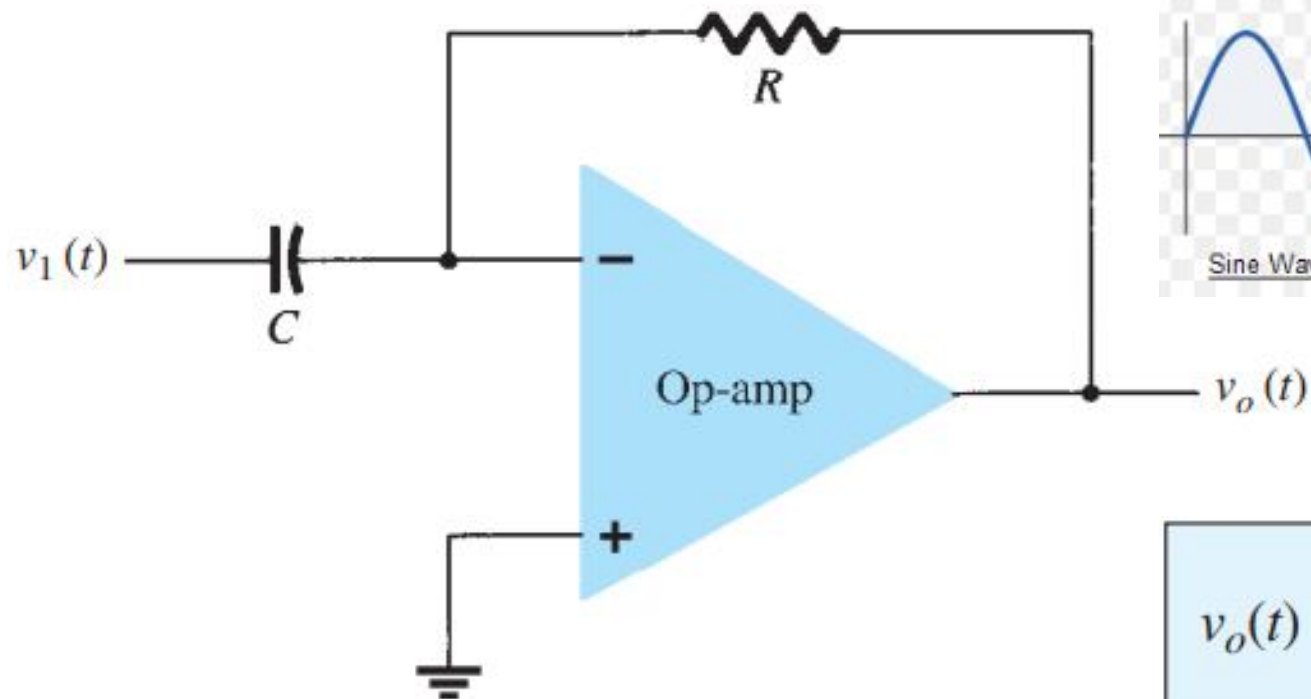
Inverting amplifier



Integrator



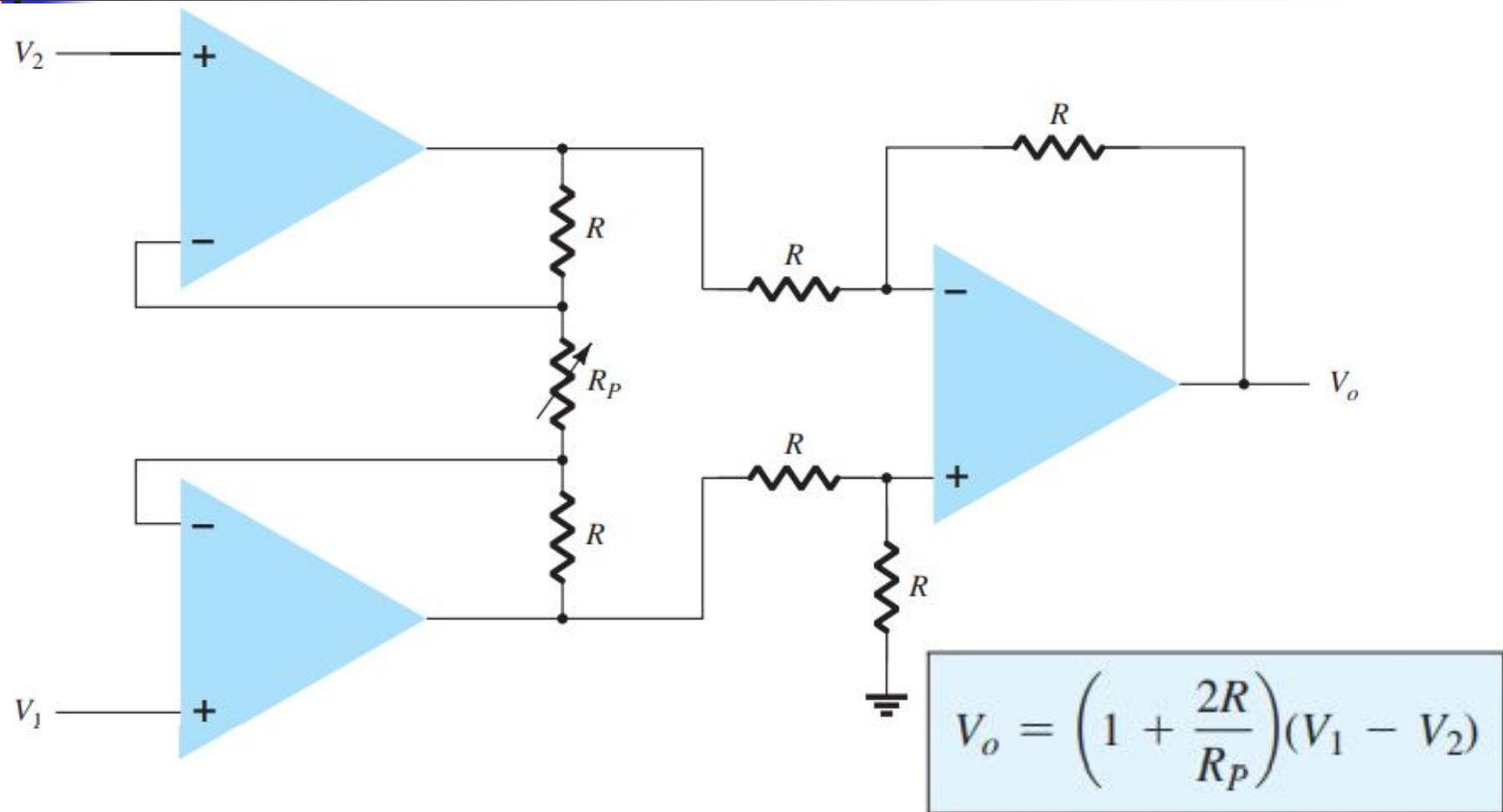
Differentiator



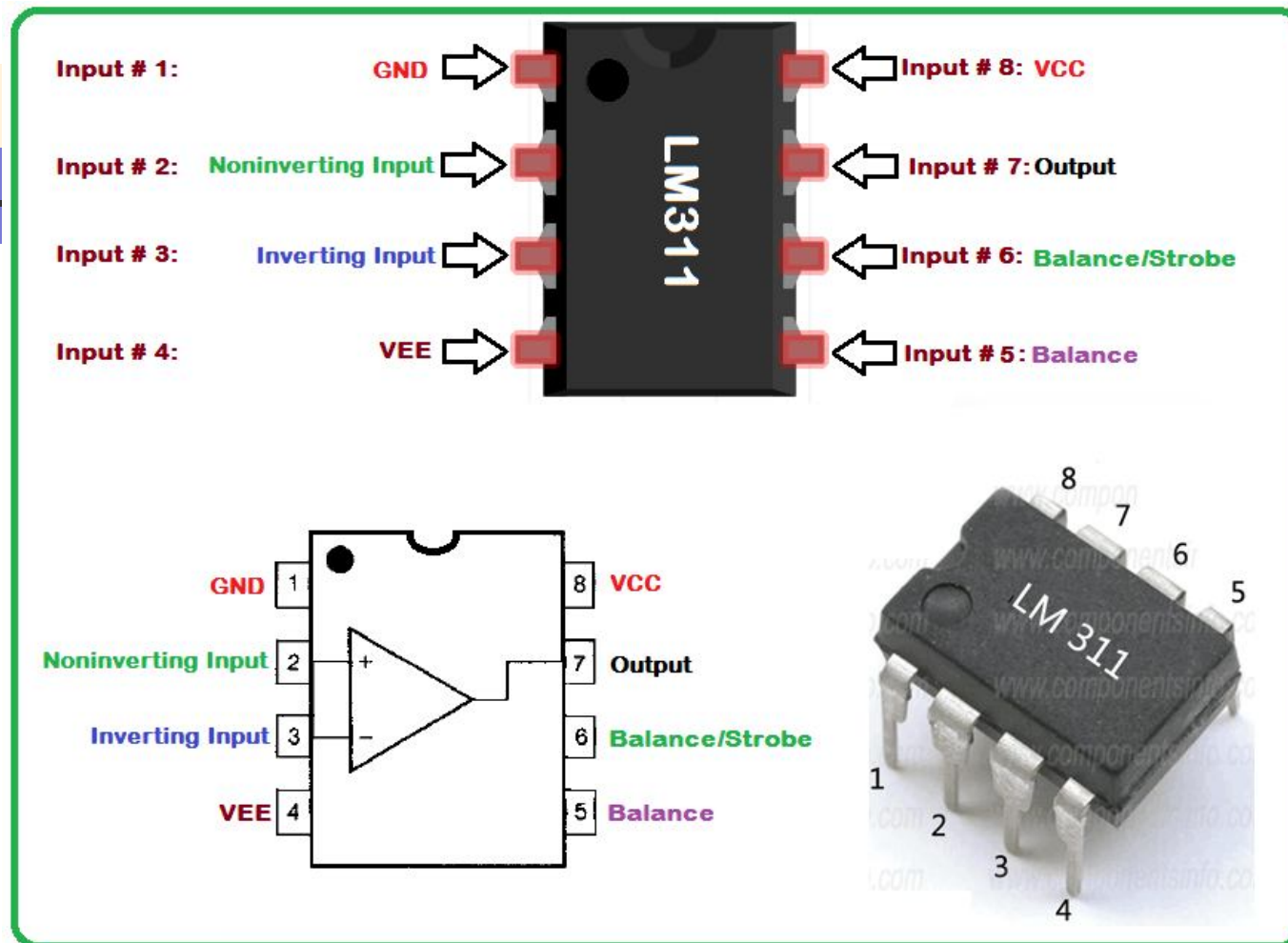
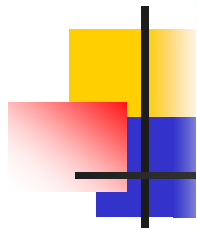
$$v_o(t) = -RC \frac{dv_1(t)}{dt}$$

Instrumentation amplifier

An *instrumentation amplifier* is a differential op-amp circuit providing high input impedances with ease of gain adjustment through the variation of a single resistor.



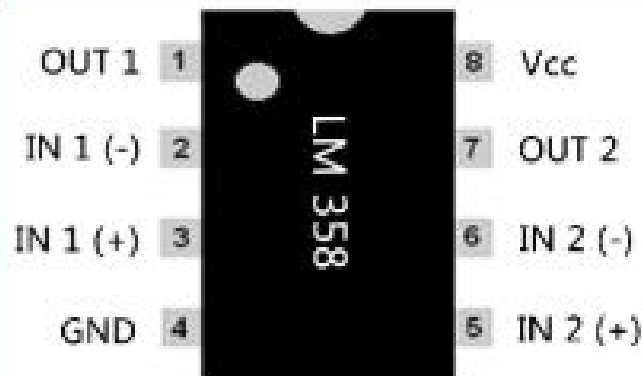
LM311-Differential amplifier IC



Balance: This pin can be used to turn off the DC-offset voltage

Balance/Strobe: This pin can be used to turn off the output stage

LM358-Low Power Dual Operational Amplifier IC



LM358 DETAILED PIN DESCRIPTION

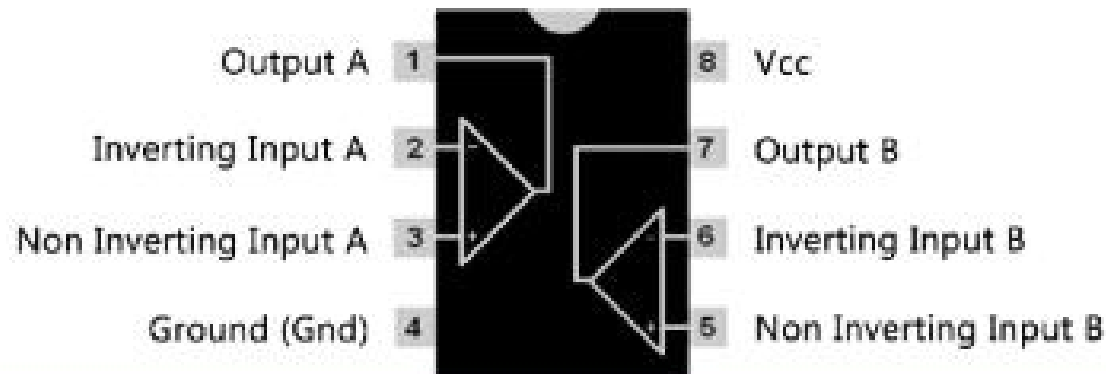
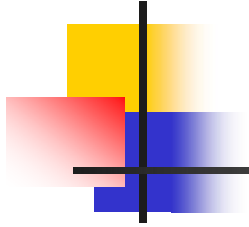


Image source : Google



References

- ❖ Boylestad, R. L., & Nashelsky, L. (1978). Electronic devices and circuit theory. Englewood Cliffs, N.J: Prentice-Hall.
- ❖ https://www.electronics-tutorials.ws/opamp/opamp_1.html
- ❖ <https://www.circuitstoday.com/introduction-to-ua-741-op-amp>
- ❖ <https://components101.com/ics/lm311-differential-comparator-ic>
- ❖ <https://www.onsemi.com/pub/Collateral/LM358-D.PDF>



Thanks !



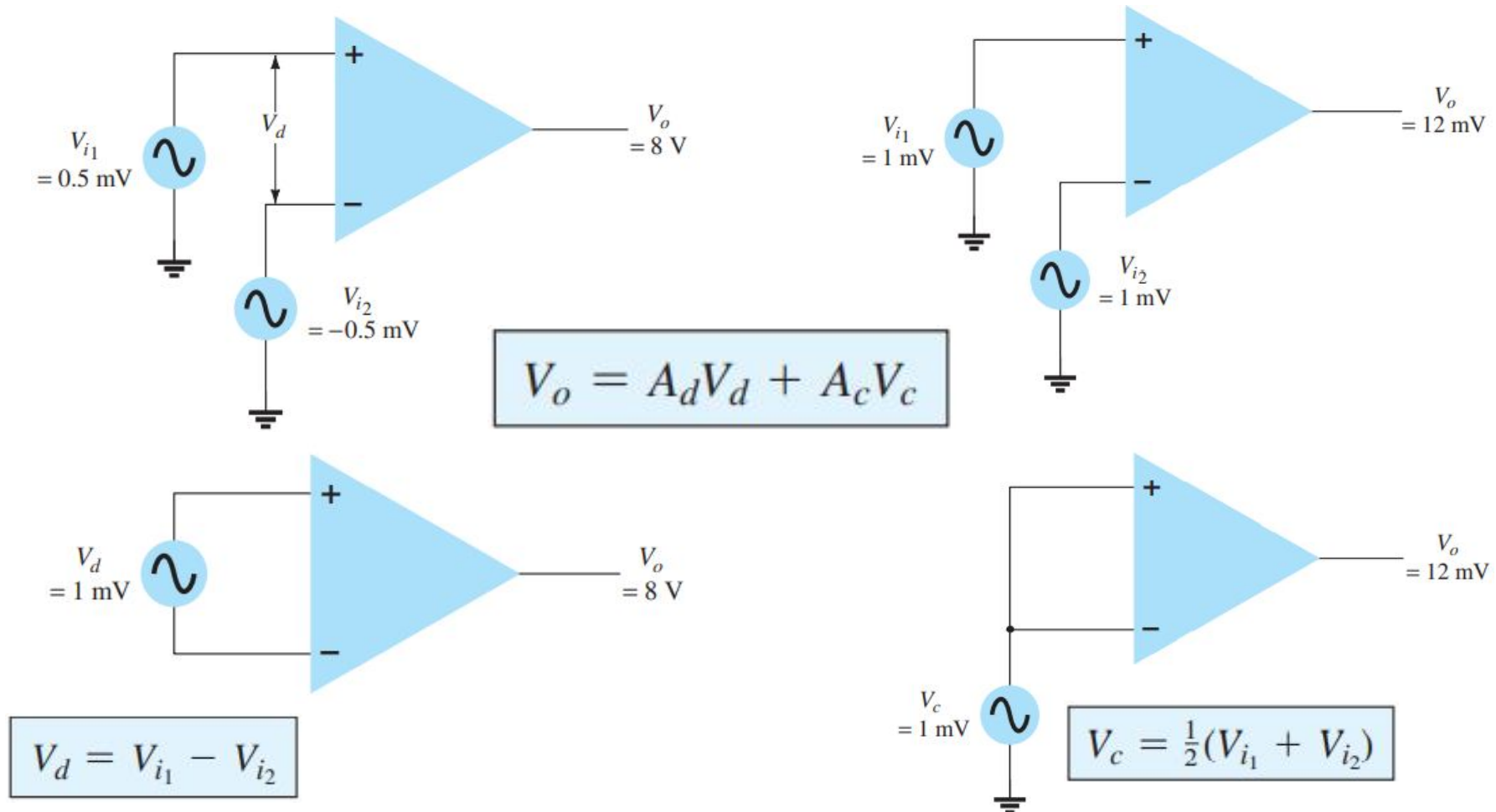


Common mode rejection ratio (CMRR)

$$\text{CMRR} = \frac{A_d}{A_c}$$

A high CMRR is **required** when a differential signal must be **amplified** in the **presence** of a possibly large **common-mode input**, such as strong electromagnetic interference (**EMI**). An example is audio transmission over balanced line in sound reinforcement or recording.

Example: Calculate CMRR



Courtesy: Electronics devices and circuit theory by R. L. Boylestad



Continued...

$$V_o = A_d V_d + A_c V_c$$

$$A_d = \frac{V_o}{V_d} = \frac{8 \text{ V}}{1 \text{ mV}} = 8000$$

$$A_c = \frac{V_o}{V_c} = \frac{12 \text{ mV}}{1 \text{ mV}} = 12$$

$$\text{CMRR} = \frac{A_d}{A_c} = \frac{8000}{12} = \mathbf{666.7}$$

$$\text{CMRR} = 20 \log_{10} \frac{A_d}{A_c} = 20 \log_{10} 666.7 = \mathbf{56.48 \text{ dB}}$$



Power Supply rejection ratio (PSRR)

PSRR describe the capability of an electronic circuit to suppress any power supply variations to its output signal.

$$\text{PSRR}[\text{dB}] = 10 \log_{10} \left(\frac{\Delta V_{\text{supply}}^2 A_v^2}{\Delta V_{\text{out}}^2} \right) \text{dB}$$

where A_v is the voltage gain.

Example: An amplifier with a PSRR of 100 dB in a circuit to give 40 dB closed-loop gain would allow about 1 millivolt of power supply ripple to be superimposed on the output for every 1 volt of ripple in the supply. This is because

$$100 \text{ dB} - 40 \text{ dB} = 60 \text{ dB}.$$

And since that's 60 dB of rejection, the sign is negative so:

$$1 \text{ V} \cdot 10^{\frac{-60}{20}} = 0.001 \text{ V} = 1 \text{ mV}$$



Supply Voltage rejection ratio (SVRR)

9. Supply Voltage Rejection Ratio (SVRR)

The change in the op-amp's offset voltage caused by variations in supply voltage is called SVRR. The change in supply voltage can be denoted by dV and the corresponding change in input offset voltage can be denoted by dV_{io} .

$$SVRR = \text{Change in input offset voltage (dV}_{io}\text{)} / \text{Change in supply voltage (dV)}$$

For 741 IC, $SVRR = 150\mu\text{V/V}$.

The lower the value of SVRR, the better will be the op-amp performance.

Internal circuit diagram of operational amplifier

