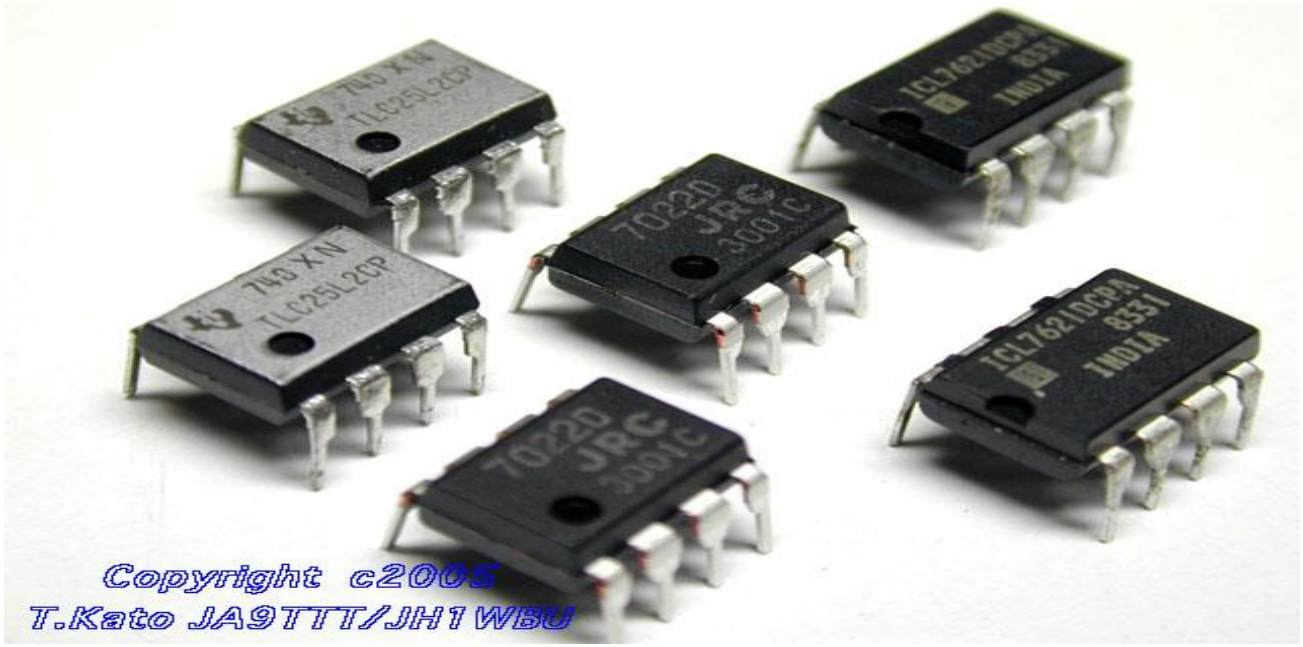
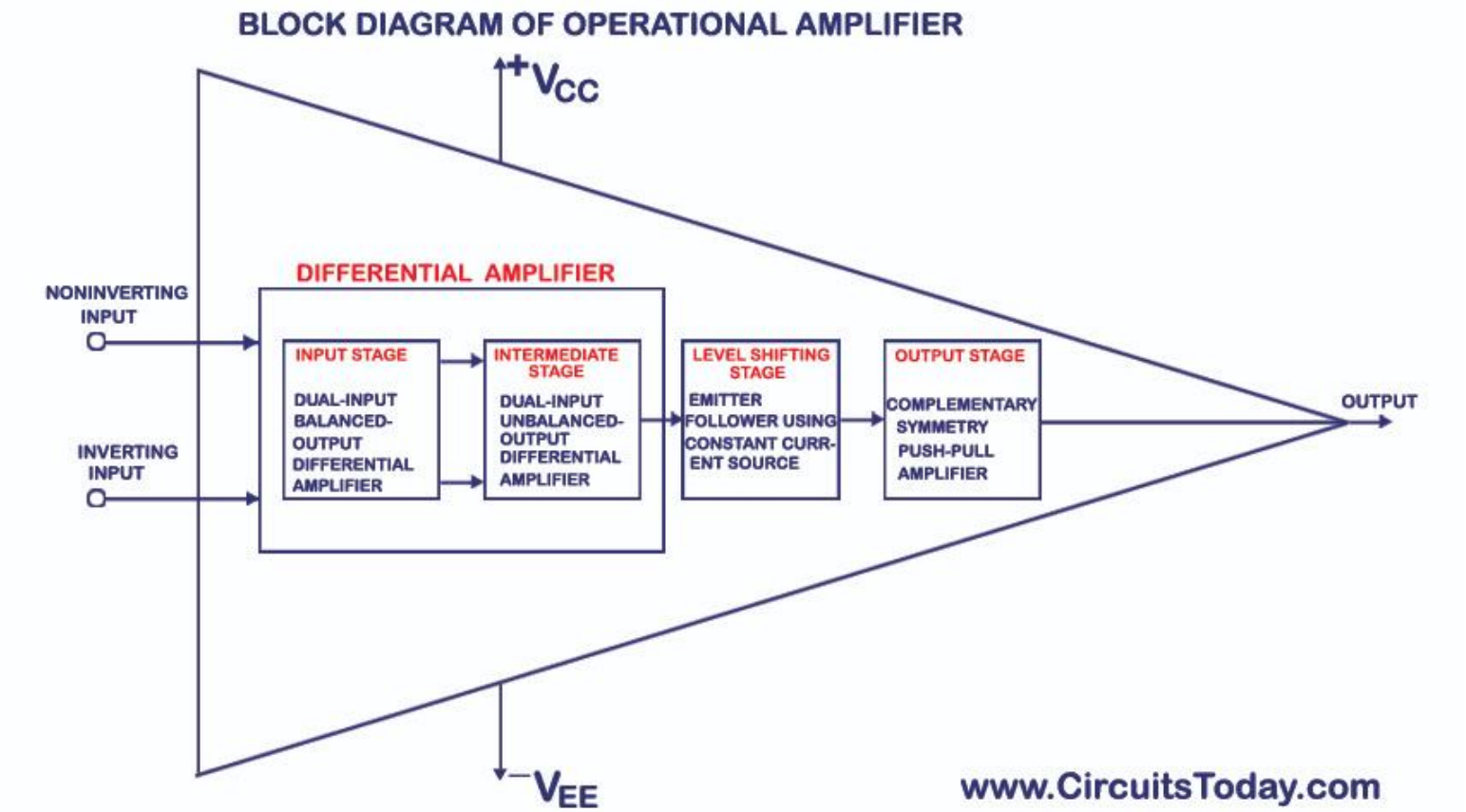


Operational Amplifiers
Building Blocks
By Dr. Gargi Tiwari

- An op-amp is a multi-stage , direct coupled, high gain negative feedback amplifier that has one or more differential amplifiers and its concluded with a level translator and an output stage.
- A voltage-shunt feedback is provided in an op-amp to obtain a stabilized voltage gain. Op-amps are available as Integrated Circuits (IC's).
- The main use of an op-amp is to amplify ac and dc input signals and was initially used for basic mathematical operations such as addition, subtraction, multiplication, differentiation and integration.
- Nowadays , the application of op-amp varies from ac and dc signal amplification to use in active filters, oscillators, comparators, voltage regulators, instrumentation and control systems, pulse generators, square wave generators and many more electronic circuits.

Block Diagram Of Operational Amplifier (Op-amp)



The op-amp begins with a differential amplifier stage, which operates in the differential mode. Thus the inputs noted with ‘+’ & ‘- ‘ .

The positive sign is for the non-inverting input and negative is for the inverting input. The non-inverting input is the ac signal (or dc) applied to the differential amplifier which produces the same polarity of the signal at the output of op-amp.

The inverting signal input is the ac signal (or dc) applied to the differential amplifier. This produces a 180 degrees out of phase signal at the output.

The inverting and non-inverting inputs are provided to the input stage which is a dual input, balanced output differential amplifier. The voltage gain required for the amplifier is provided in this stage along with the input resistance for the op-amp.

The output of the initial stage is given to the intermediate stage, which is driven by the output of the input stage.

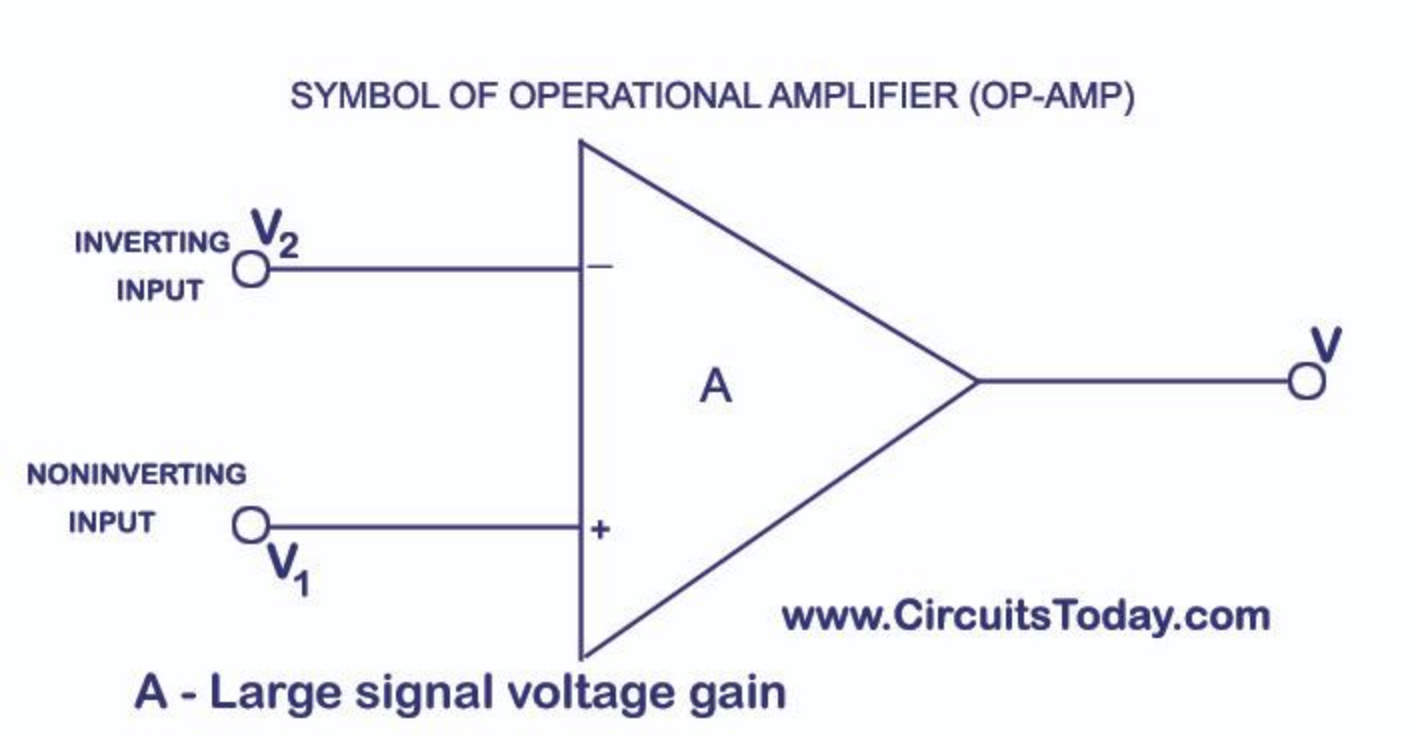
In this stage direct coupling is used, which makes the dc voltage at the output of the intermediate stage above ground potential.

Therefore, the dc level at its output must be shifted down to 0 Volts with respect to the ground.

For this, the level shifting stage is used where usually an emitter follower with the constant current source is applied.

The level shifted signal is then given to the output stage where a push-pull amplifier increases the output voltage swing of the signal and also increases the current supplying capability of the op-amp.

Symbol Of Operational Amplifier (Op-amp)

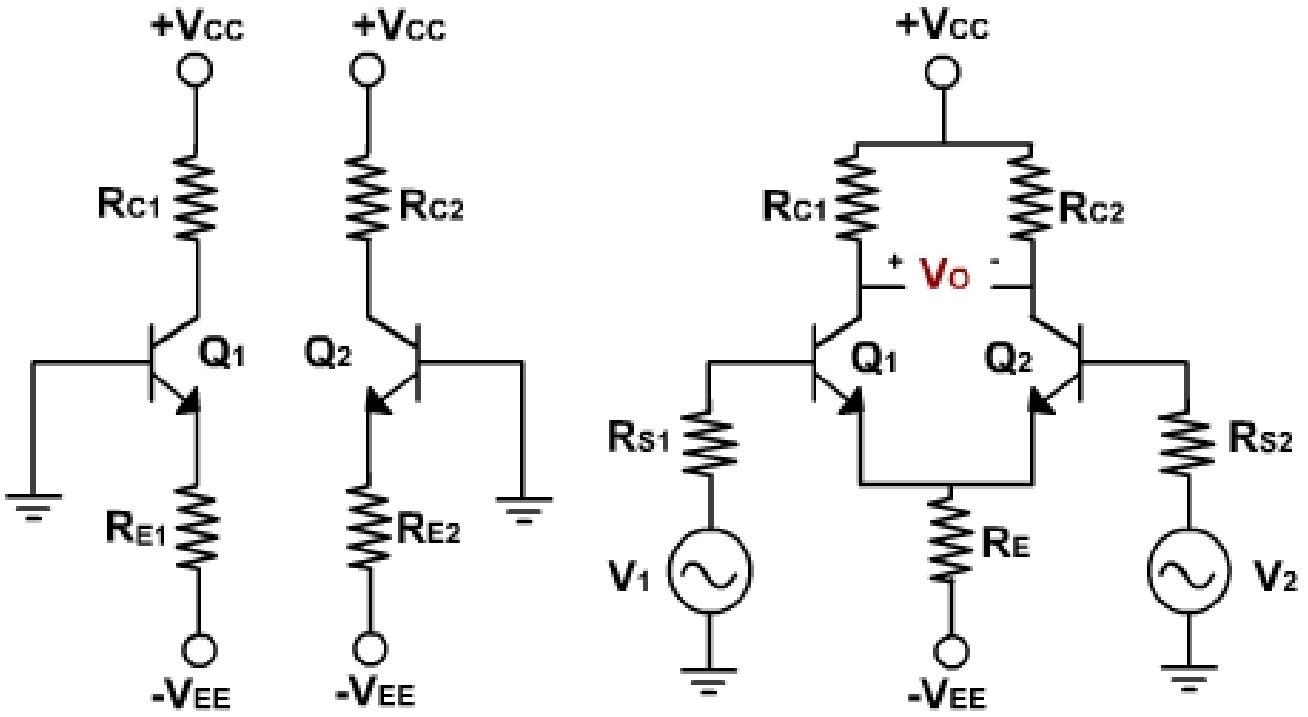


The above shown symbol is the most widely used op-amp symbol for all electronic circuits.

V1 (Volts) – Non-inverting input voltage.

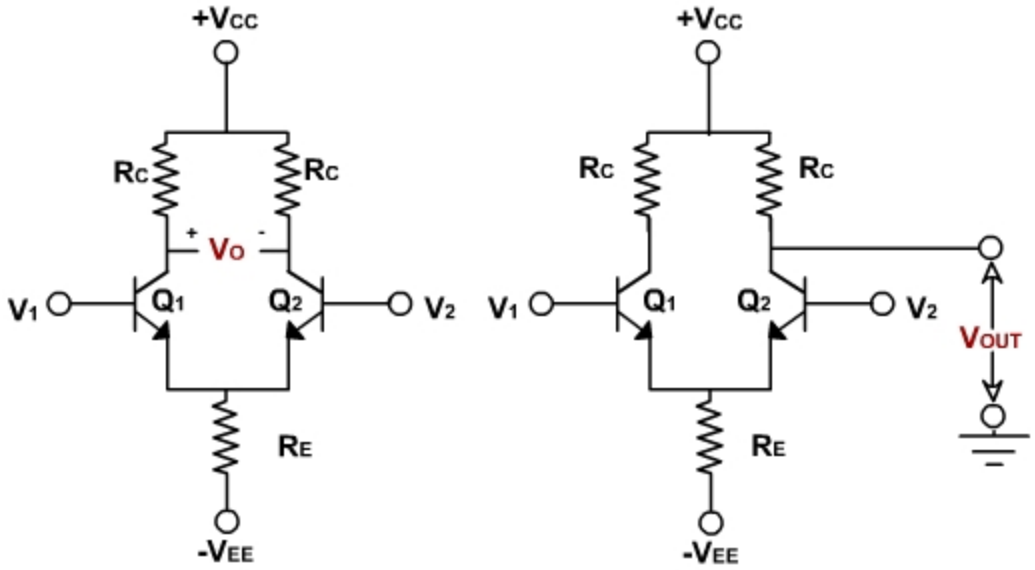
V2 (Volts) – Inverting input voltage.

- **Differential amplifier is a basic building block of an op-amp. The function of a differential amplifier is to amplify the difference between two input signals.**
- **How the differential amplifier is developed?**



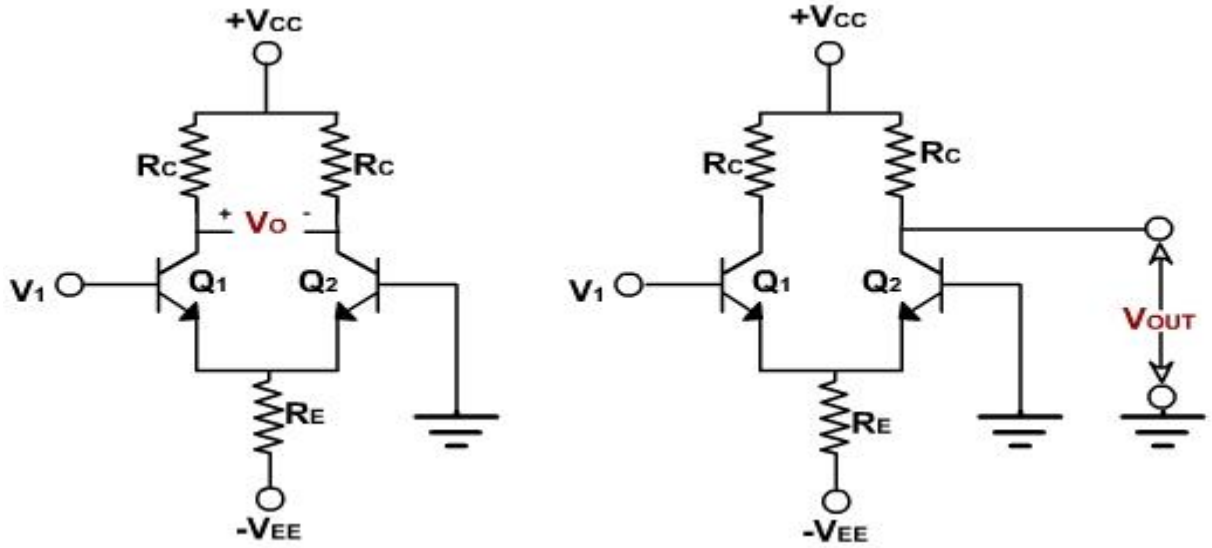
- The two transistors Q_1 and Q_2 have identical characteristics.
- The resistances of the circuits are equal, i.e. $R_{E1} = R_{E2}$, $R_{C1} = R_{C2}$ and the magnitude of $+V_{CC}$ is equal to the magnitude of $-V_{EE}$. These voltages are measured with respect to ground.
- To make a differential amplifier, the two circuits are connected as shown in fig.
- The two $+V_{CC}$ and $-V_{EE}$ supply terminals are made common because they are same.
- The two emitters are also connected and the parallel combination of R_{E1} and R_{E2} is replaced by a resistance R_E.
- The two input signals v_1 & v_2 are applied at the base of Q_1 and at the base of Q_2.
- The output voltage is taken between two collectors. The collector resistances are equal and therefore denoted by $R_C = R_{C1} = R_{C2}$.

- Ideally, the output voltage is zero when the two inputs are equal. When v_1 is greater then v_2 the output voltage with the polarity shown appears. When v_1 is less than v_2, the output voltage has the opposite polarity.
- The four differential amplifier configurations are following:
- Dual input, balanced output differential amplifier.
- Dual input, unbalanced output differential amplifier.
- Single input balanced output differential amplifier.
- Single input unbalanced output differential amplifier.



These configurations are shown in **fig.**, and are defined by number of input signals used and the way an output voltage is measured. If we use two input signals, the configuration is said to be dual input, otherwise it is a single input configuration. On the other hand, if the output voltage is measured between two collectors, it is referred to as a balanced output because both the collectors are at the same dc potential w.r.t. ground.

If the output is measured at one of the collectors w.r.t. ground, the configuration is called an unbalanced output.



A multistage amplifier with a desired gain can be obtained using direct connection between successive stages of differential amplifiers. The advantage of direct coupling is that it removes the lower cut off frequency imposed by the coupling capacitors, and they are therefore, capable of amplifying dc as well as ac input signals.