Operational Amplifiers

The operational amplifier is a direct-coupled high gain amplifier usually consists of one or more differential amplifiers and usually followed by a level translator and an output stage.

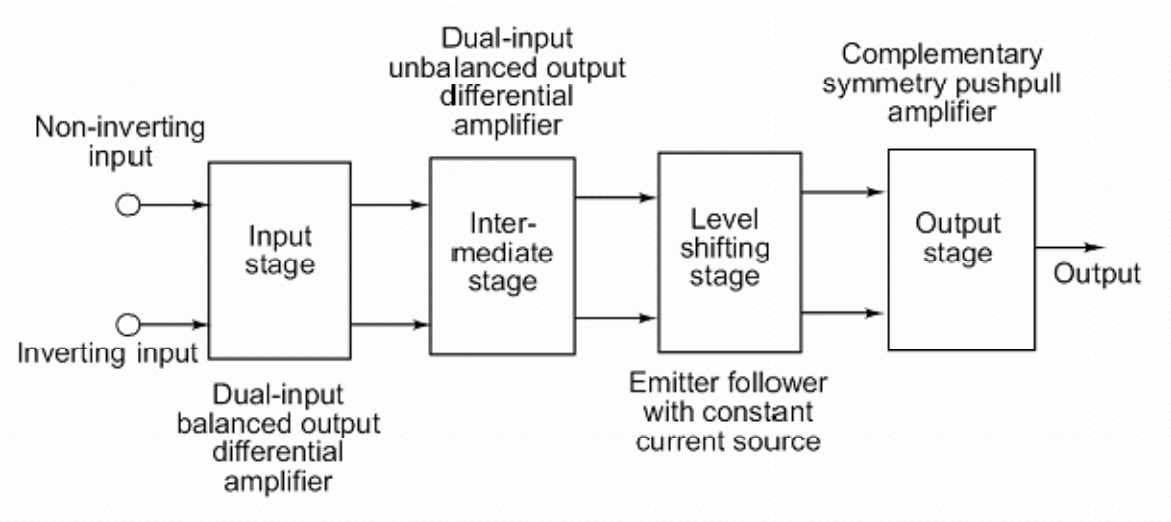

Figure 1.1

Such direct coupled (dc) amplifiers do not use blocking (coupling and by pass) capacitors since they would reduce the amplification to zero at zero frequency. Large by pass capacitors may be

used but it is not possible to fabricate large capacitors on a IC chip. The capacitors fabricated are usually less than 20 pf. Transistor, diodes and resistors are also fabricated on the same chip.

Differential Amplifiers:

Let us consider emitter biased circuit shown in the fig. two identical emitter biased circuits in that transistor Q1 has same characteristics as transistor Q2. 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? Let us consider two emitter-biased circuits as shown in figure.

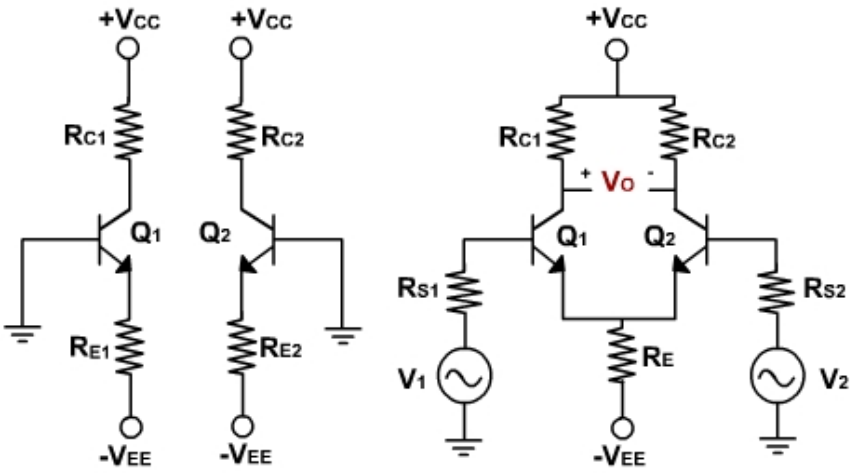

Figure 1.2

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 figure. 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 $R_C = R_{C1} = R_{C2}$. Label the voltages between collectors C1and C2 as V_0.

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:

1. Dual input, balanced output differential amplifier.
2. Dual input, unbalanced output differential amplifier.
3. Single input balanced output differential amplifier.
4. Single input unbalanced output differential amplifier.

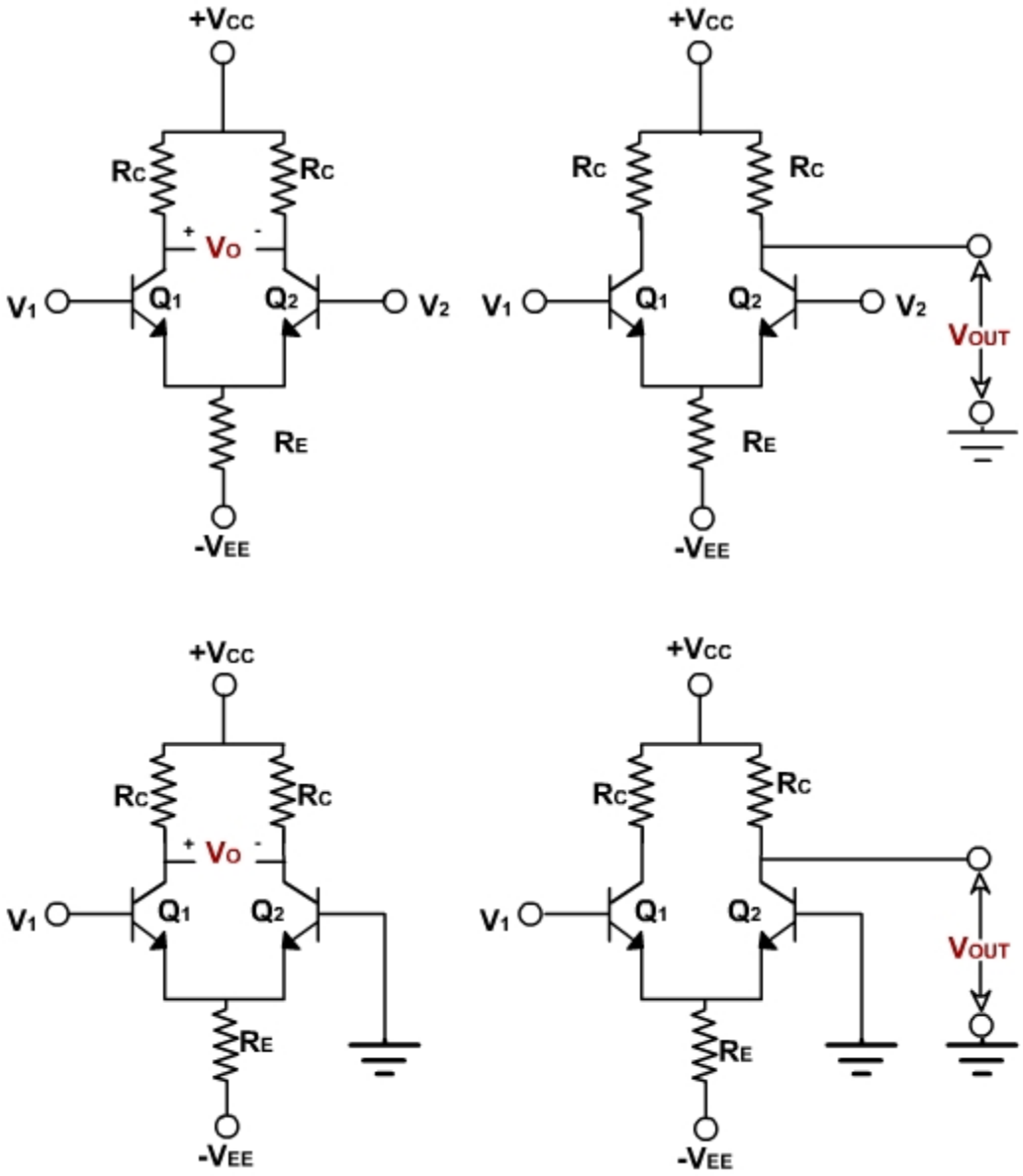

Figure 1.3

These configurations are shown in figure, and are defined by number of input signals used and the way an output voltage is measured. If two input signals used, 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 with respect to ground. If the output is measured at one of the collectors with respect to 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.