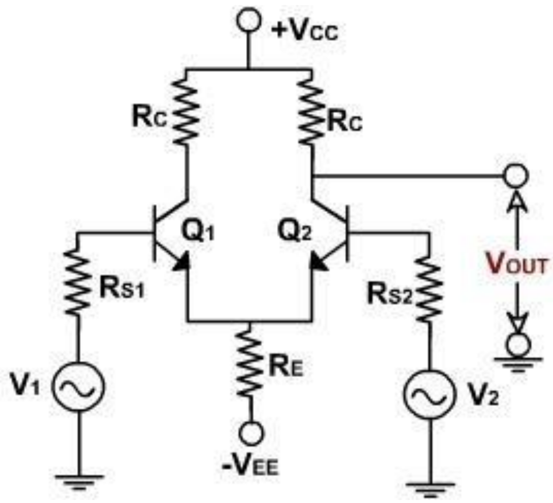
## ***DUAL INPUT, UNBALANCED OUTPUT DIFFERENTIAL AMPLIFIER:***

In this case, two input signals are given however the output is measured at only one of the two-collector w.r.t. ground as shown in fig. 1. The output is referred to as an unbalanced output because the collector at which the output voltage is measured is at some finite dc potential with respect to




ground. In other words, there is some dc voltage at the output terminal without any input signal applied. DC analysis is exactly same as that of first case.

**DC Analysis**:

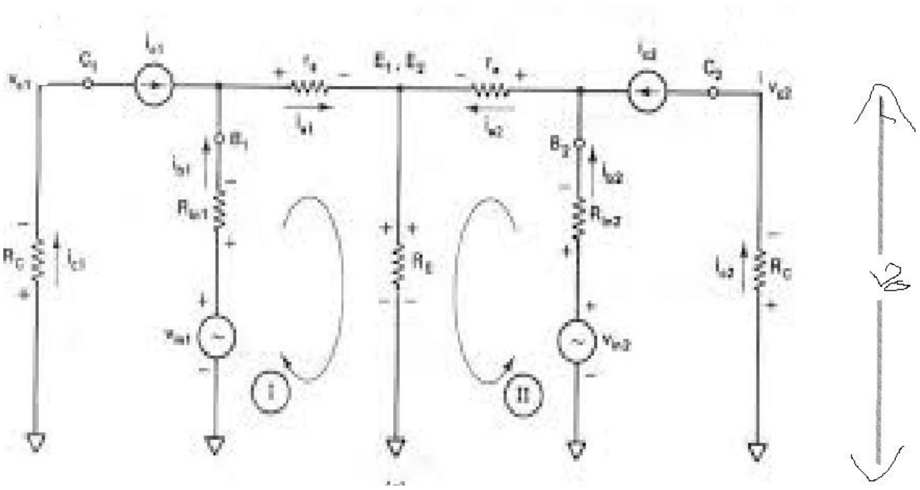
The dc analysis procedure for the dual input unbalanced output is identical to that dual input balanced output because both configuration use the same biasing arrangement. Therefore the emitter current and emitter to collector voltage for the dual input unbalanced output differential amplifier are determined from equations.

$I_E = I_{CQ} = (V_{EE}.V_{BE}) / (2R_E+\beta_{dc})$

$V_{CE}=V_{CEQ}=V_{CC}+V_{BE}-R_C I_{CQ}$

AC Analysis:

The output voltage gain in this case is given by



VOLTAGE GAIN:

Writing Kirchhoff's voltage equations of loops I and II is given as

$$V_{in1}-R_{in1}i_{b1}-r_e i_{e1}-R_E\ (i_{e1}+i_{e2}) =0$$

$$V_{in2}-R_{in2}i_{b2}-r_e i_{e2}-R_E\ (i_{e1}+i_{e2}) =0$$

Since these equations are the same as equations the expressions for $i_{e1}$ and $i_{e2}$ will be the same equations respectively.

$$i_{e1}= ((r_e+R_E)\ v_{in1}-R_E v_{in2})/\ ((r_e+R_E)^2-R_E^2)$$

$$i_{e2}= ((r_e+R_E)v_{in2}-R_E v_{in1})/\ ((r_e+R_E)\ ^2-R_E^2)$$

The output voltage is

$$Vo=v_{c2}=-R_C i_{c2}=-R_C i_{e2} \qquad \text{since } i_c=i_e$$

Substituting the value of $i_{e2}$

$$Vo=-Rc\ ((r_e+R_E)v_{in1}-R_E v_{in2})/((r_e+R_E)^2-R_E^2)$$

$$=Rc\ ((R_E v_{in2}-\ r_e+R_E)v_{in1}/((r_e+R_E)^2-R_E^2)$$

Generally $R_E>>r_e$ hence $(r_e+R_E) =R_E$ &$(re+R_E)=2R_E$ Therefore

$Vo=R_C(\ (R_E v_{in1}-\ R_E v_{in2})/2r_e R_E)$

$= R_C(\ (R_E(v_{in1}-v_{in2})/2r_e R_E)$

$$= R_C(v_{in1}-v_{in2})/2r_e)$$

$$A_d =v_o\ /v_{id}=R_C/2R_E$$

The voltage gain is half the gain of the dual input, balanced output differential amplifier. Since at the output there is a dc error voltage, therefore, to reduce the voltage to zero, this configuration is normally followed by a level translator circuit.

INPUT RESISTENCE:

The only difference between the circuits is the way output voltage is measured. The input resistance seen from either input source does not depend on the way the output voltage is measured.

$$R_{i1}=R_{I2}=2\beta_{ac}r_e$$

OUTPUT RESISTENCE:

The output resistance $R_0$ measured at collector $C_2$ with respect to ground is equal to the collector resistor $R_C$.

$$R_0=R_C$$

## ***2)SINGLE INPUT, BALANCED OUTPUT DIFFERENTIAL AMPLIFIER:***

From the figure of single input balanced output differential amplifier, input is applied to the base of transistor Q1 and the output is measured between 2 collectors which are at the same dc potential. Therefore ,the output is said to be a balanced output

DC Analysis:

The dc analysis procedure and bias equations for the single input balanced output differential amplifier are identical to those of the 2 previous configurations is the same.Thus the bias equations are

$$I_E=I_{CQ}=(V_{EE}-V_{BE})/(2R_E + R_{in}\beta_{dc})$$

$$V_{CE}=V_{CEQ}=V_{CC}+V_{BE}-R_CI_{CQ}$$

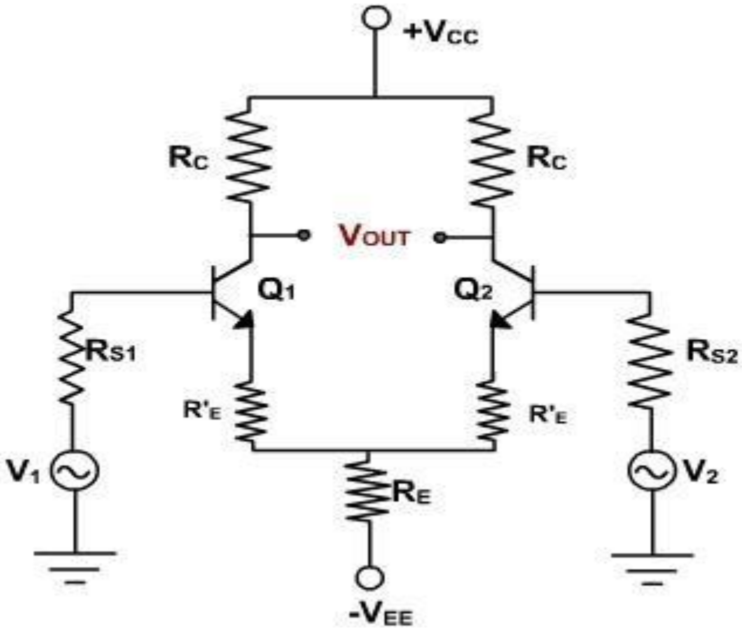
## **AC Analysis**:

The ac equivalent circuit of this differential amplifier with a small input T-equivalent model substituted for transistors

From input and output waveforms,

During the positive half cycle of the input signal, the base-emitter voltage of the transistor Q1 is positive and that of transistor Q2 is negative. This means that the collector current in Q1 increases and that in transistor Q2 decreases from the operating point value $I_{CQ}$. This change in collector currents during the positive half cycle of the input signal is indicated in figure in which the currents of both the sources $i_{c1}$ and $i_{c2}$ are shown to be in the same direction. In fact, during the negative half cycle of the input signal, the opposite action takes place that is; the collector current of transistor Q1 decreases and that in transistor Q2 increases.

## DIFFERENTIAL AMPLIFIER WITH SWAMPING RESISTORS




By using external resistors R'E in series with each emitter, the dependence of voltage gain on variations of r'e can be reduced. It also increases the linearity range of the differential amplifier shows the differential amplifier with swamping resistor R'E. The value of $R'_E$ is usually large enough to swamp the effect of $r'_{E.}$

$$R_1 \; I_B + V_{BE} + R'_E I_E + 2 R_E I_E = V_{EE}$$

$$R_1 I_E / \beta_{dc} + V_{BE} + R'_E I_E + 2 R_E I_E = V_{EE}$$

From the equation, $I_E$ can be obtained as

$$I_E = \frac{V_{EE} - V_{BE}}{R'_E + 2R_E + R_1 / \beta_{dc}}$$

$$V_{CEQ} = V_{CC} + V_{BE} - I_{CQ} R_C$$

The new voltage gain is given by $A_d = \dfrac{R_C}{r_e + R_E}$

The input resistance is given by $R_{i1} = R_{i2} = 2\beta \; (r'_e + R'_E)$

The output resistance with or without $R'_E$ is the same i.e.

$$R_{O1} = R_{O1} = R_C$$