

Topic: Differential Amplifier (DA)  
(For: M.Sem-III or P.G. Sem-III)  
From Un2-1 or Paper

In the conventional amplifiers, the signal is applied at the input terminals and terminals -fixed output is obtained at the output terminals. However, we can design an amplifier circuit that accepts two input signals and amplifier the difference between these two signals. Such an amplifier is called a differential amplifier. It has a circuit that can accept two input signals and amplify the difference between these two input signals is called "Differential Amplifier".

Fig (1) shows the block diagram of a differential amplifier. There are two input voltages  $V_1$  and  $V_2$ . This amplifier amplifies the difference between the two input voltages. Therefore, the output voltage is  $V_0 = A(V_1 - V_2)$ . Where  $A$  is the voltage gain of the amplifier.

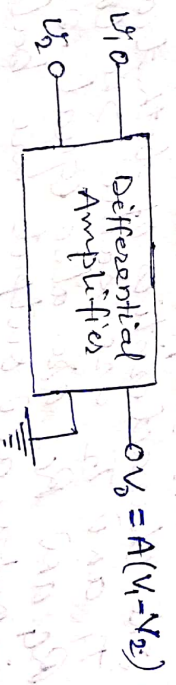


FIG (1)

Basic Circuit of Differential Amplifier

Fig (2) shows the basic circuit of a differential amplifier. It consists of two transistors  $T_1$  and  $T_2$  that have identical characteristics. For this circuit, we need two supply voltages  $+V_{cc}$  and  $-V_{cc}$  with common emitter resistor  $R_E$ . The negative terminal of  $V_{cc}$  is grounded and positive terminal of  $V_{EE}$  is grounded. Fig (2) shows the symbol of differential amplifier.

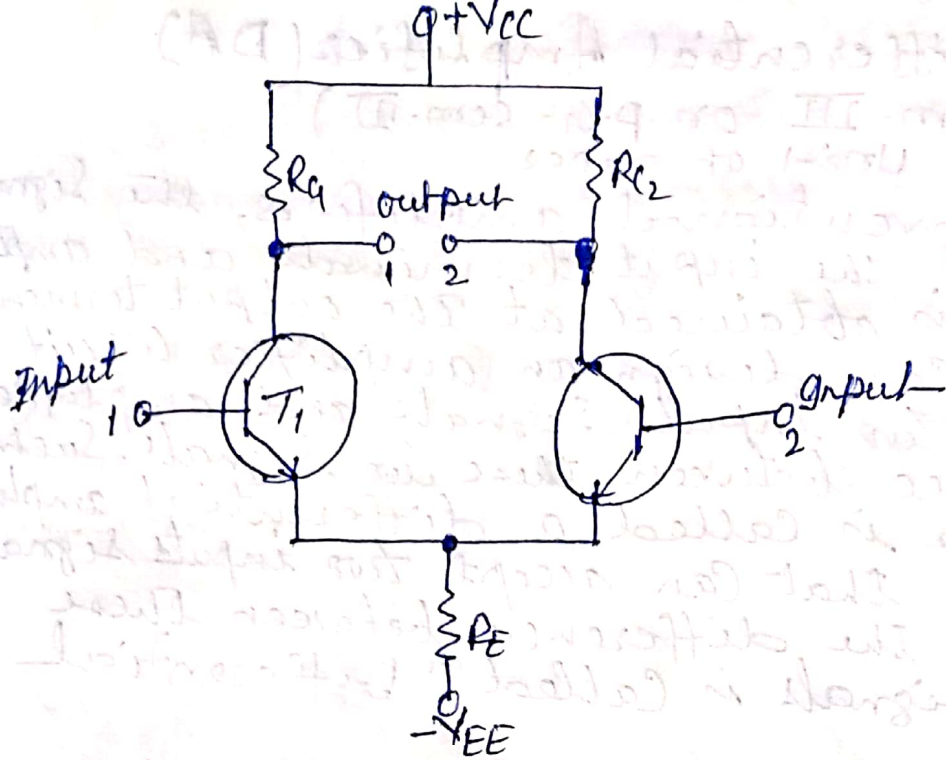


Fig (2)

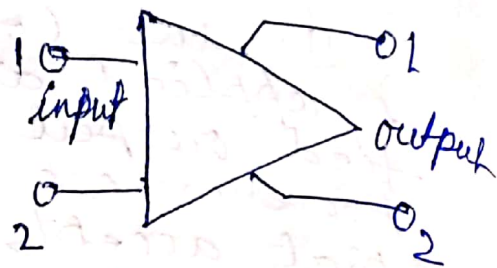


Fig (3)

The differential Amplifier possesses the following points

- (1) It is a two-input terminal device using at least two transistors. It has two output too marked 1 and 2.
- (2) The characteristics of both transistor  $T_1$  and  $T_2$  are same. The collector resistors  $R_{C1}$  and  $R_{C2}$  are also equal. Thus the two inputs, and outputs are balanced.

(3) We can apply signal to a differential amplifier in the following two ways

(a) The signal is applied to one input of DA and the other input is grounded. In that case, it is called ~~single-input~~ single-ended input arrangement.

(b) The signal are applied to both inputs of DA. In that case, it is called dual-ended or double-input ended arrangement.

(4) We can take output from DA in the following two ways:

(a) The output can be taken from one of the output terminals and the other grounded. In that case, it is called "single-ended output arrangement."

(b) The output can be taken between the two output terminals, it is called "double-ended input."

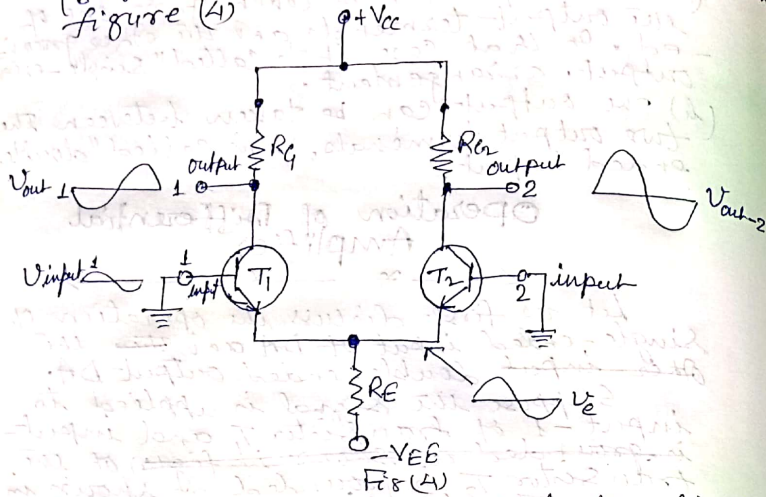
## Operation of Differential Amplifier



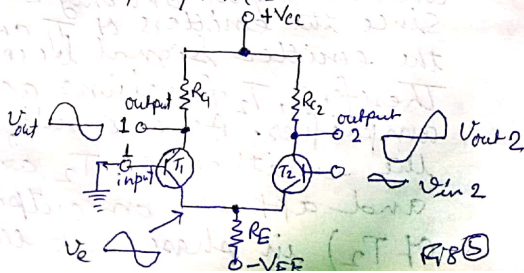
Let us first discuss the operation of single-ended input of DA and then the ~~other input~~ double-ended output DA.

Suppose the signal is applied to input-1 of transistor  $T_1$  and input-2 is ~~grounded as shown in fig(4)~~ of the transistor  $T_2$  is grounded as shown in fig (4). The transistor  $Q_1$  will act in two ways: as a common emitter amplifier and as a common collector amplifier. In case of common emitter amplifier, the input signal to  $T_1$  (input-1) will appear at output 1 (i.e. collector of  $T_1$ ) ~~whereas in case of~~ as amplified inverted signal as shown in fig(4) whereas in case of common collector amplifier, the signal appears on the emitter of  $T_1$  in phase with the input and only slightly smaller. Since the emitters of  $T_1$  and  $T_2$  are common, the emitter signal becomes input to  $T_2$ . Therefore,  $T_2$  functions as a "common base amplifier." As a result, the signal on the emitter of  $T_2$  will be amplified and appears on output-2 (i.e. collector of  $T_2$ ) in phase with the emitter signal

and hence in phase with the input signal (Signal at input 1). This is illustrated in figure (4)



Now suppose the signal is applied to input-2 i.e. base of transistor  $T_2$  and input-1 (base of transistor  $T_1$ ) is grounded. As explained above, now  $T_2$  acts as a common emitter amplifier and  $T_1$  functions as common base amplifier. Therefore an inverted and amplified signal appears at output-2 i.e. at collector of  $T_2$  and non-inverted, amplified signal appears at output-1 i.e. at collector of  $T_1$ . This is illustrated in fig(5)



Thus the phase of output of single-ended input DA depends upon which input receives the input signal. When signal applied to the input of DA produces no phase shift in the output, it is called "non-inverting input" and represented by (+) sign. Next when the signal applied to the input of DA produces  $180^\circ$  phase shift, it is called "inverting input" and denoted by (-) sign.

### Objective Question

1. A differential amplifier. . . . .  
Ans:- is a part of an op-amp having two outputs.
2. When a differential amplifier is operated single-ended. . . . .  
Ans:- one input is grounded and signal is applied to the other.