Assignment cover page

of

Institute of science trade and techonoloy (ISTT)

Department of CSE

Assignment Title :.....

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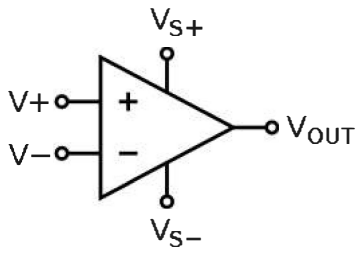
Differential amplifier

A **differential amplifier** is a type of electronic amplifier that amplifies the difference between two input voltages but suppresses any voltage common to the two inputs. It is an analog circuit with two inputs V_{in}^- and V_{in}^+ and one output V_{out}, in which the output is ideally proportional to the difference between the two voltages:

$$V_{\text{out}} = A(V_{\text{in}}^+ - V_{\text{in}}^-),$$

where A is the gain of the amplifier.

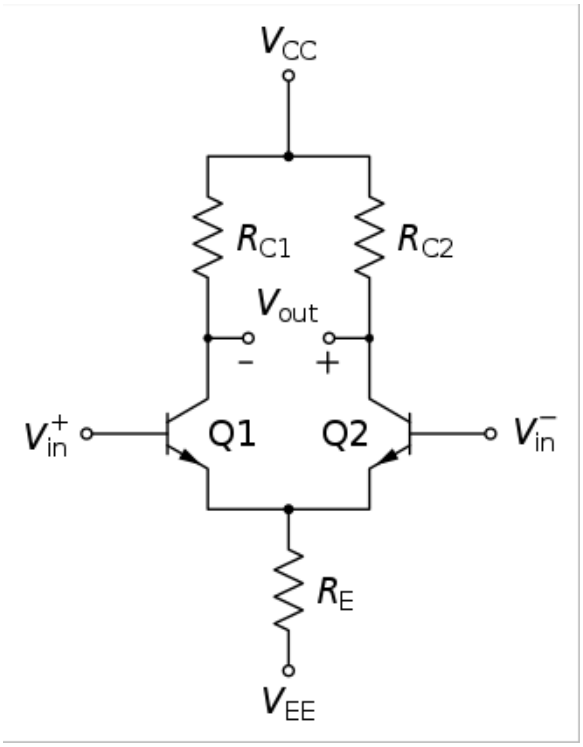


Operational amplifier symbol. The inverting and non-inverting inputs are distinguished by "−" and "+" placed in the amplifier triangle. V_{S+} and V_{S-} are the power-supply voltages; they are often omitted from the diagram for simplicity but must be present in the actual circuit.

Single amplifiers are usually implemented by either adding the appropriate feedback resistors to a standard op-amp, or with a dedicated integrated circuit containing internal feedback resistors. It is also a common sub-component of larger integrated circuits handling analog signals.

Operation

To explain the circuit operation, four particular modes are isolated below although, in practice, some of them act simultaneously and their effects are superimposed.



Biasing

In contrast with classic amplifying stages that are biased from the side of the base (and so they are highly β-dependent), the differential pair is directly biased from the side of the emitters by sinking/injecting the total quiescent current. The series negative feedback (the emitter degeneration) makes the transistors act as voltage stabilizers; it forces them to adjust their V_{BE} voltages (base currents) to pass the quiescent current through their collector-emitter junctions.[nb 4] So, due to the negative feedback, the quiescent current depends only slightly on the transistor's β.

The biasing base currents needed to evoke the quiescent collector currents usually come from the ground, pass through the input sources and enter the bases. So, the sources have to be galvanic (DC) to ensure paths for the biasing current and low resistive enough to not create significant voltage drops across them. Otherwise, additional DC elements should be connected between the bases and the ground (or the positive power supply).

Common mode

In common mode (the two input voltages change in the same directions), the two voltage (emitter) followers cooperate with each other working together on the common high-resistive emitter load (the "long tail"). They all together increase or decrease the voltage of the common emitter point (figuratively speaking, they together "pull up" or "pull down" it so that it moves). In addition, the dynamic load "helps" them by changing its instant ohmic resistance in the same direction as the input voltages (it increases when the voltage increases and vice versa.) thus keeping up constant total resistance between the two supply rails. There is a full (100%) negative feedback; the two input base voltages and the emitter voltage change simultaneously while the collector currents and the total current do not change. As a result, the output collector voltages do not change as well.

Differential mode

Normal. In differential mode (the two input voltages change in opposite directions), the two voltage (emitter) followers oppose each other—while one of them tries to increase the voltage of the common emitter point, the other tries to decrease it (figuratively speaking, one of them "pulls up" the common point while the other "pulls down" it so that it stays immovable) and vice versa. So, the common point does not change its voltage; it behaves like a virtual ground with a magnitude determined by the common-mode input voltages. The high-resistance emitter element does not play any role—it is shunted by the other low-resistance emitter follower. There is no negative feedback, since the emitter voltage does not change at all when the input base voltages change. The common quiescent current vigorously steers between the two transistors and the output collector voltages vigorously change. The two transistors mutually ground their emitters; so, although they are common-collector stages, they actually act as common-emitter stages with maximum gain. Bias stability and independence from variations in device parameters can be improved by negative feedback introduced via cathode/emitter resistors with relatively small resistances.

Overdriven. If the input differential voltage changes significantly (more than about a hundred millivolts), the transistor driven by the lower input voltage turns off and its collector voltage reaches the positive supply rail. At high overdrive the base-emitter junction gets reversed. The other transistor (driven by the higher input voltage) drives all the current. If the resistor at the collector is relatively large, the transistor will saturate. With relatively small collector resistor and moderate overdrive, the emitter can still follow the input signal without saturation. This mode is used in differential switches and ECL gates.

Breakdown. If the input voltage continues increasing and exceeds the base-emitter breakdown voltage, the base-emitter junction of the transistor driven by the lower input voltage breaks down. If the input sources are low resistive, an unlimited current will flow directly through the "diode bridge" between the two input sources and will damage them.

In common mode, the emitter voltage follows the input voltage variations; there is a full negative feedback and the gain is minimum. In differential mode, the emitter voltage is fixed (equal to the instant common input voltage); there is no negative feedback and the gain is maximum.