# Differential Amplifier

A differential amplifier amplifies the voltage difference applied to two inputs.
An example of a configuration of the amplifier is a connecting the emitters of two transistors with equal characteristics as in Fig. 1.
The voltage difference applied to the base of these transistors is amplified.
Fig. 2 shows the waveform of each node in Fig. 1.
The output of differential amplifier circuitry shown in Fig. 1 is further amplified and applied utilizing negative feedback.
High performance and inexpensive differential amplifiers, so-called operational amplifiers (Integrated circuit), are available in the market.

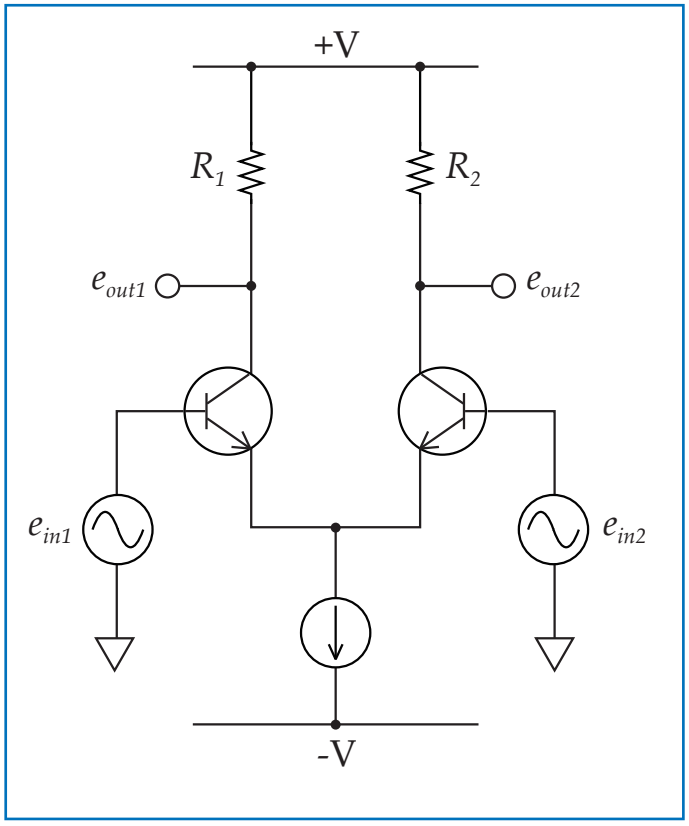


**Figure 1.** A differential amplifier circuitry

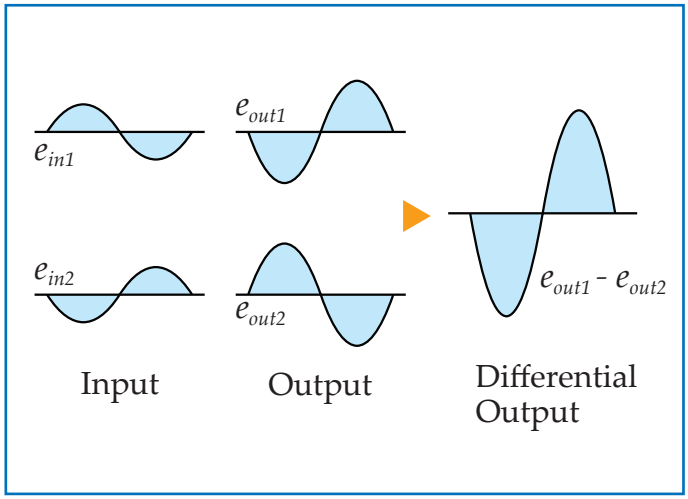


**Figure 2.** Waveforms

If two input signals of the differential amplifier are the same, the (differential) output will be nearly zero. That is, common-mode noise of the input is greatly attenuated, and only the signal is amplified.
A function of the amplifier to reduce the common-mode noise is CMRR (common-mode rejection ratio)

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The gain when negative feedback is delivered to the differential amplifier (op-amp) is the following equation.

In Fig. 3

$e = e_i - \beta \cdot e_o$

$e \cdot A_o = e_o$

From both equations, the output voltage $e_o$ is

$$e_o = \frac{A_o}{1 + A_o \cdot \beta} \times e_i$$

if $A_o \cdot \beta$ is much larger than 1,

$e_o = e_i \div \beta$

The gain $A$ when negative feedback is applied is

$$A = \frac{e_o}{e_i} = \frac{1}{\beta} = \frac{R_1 + R_2}{R_2}$$

The gain is determined by the value of $\beta$.

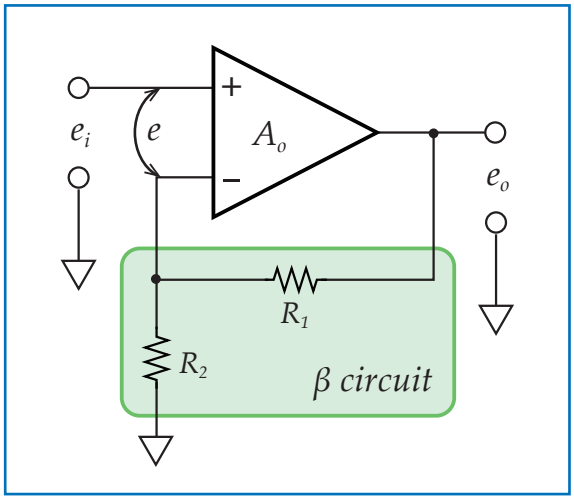



**Figure 3.**
Differential Amplifier configuration using a negative feedback circuit

The matching of two transistors is essential to achieve optimum differential characteristics in the circuit, Fig 1. Therefore, we would integrate them into one chip, utilize dual transistor, or sort individual parts strictly.
NF could even balance unequal characteristics transistors with our negative feedback technology to achieve optimum differential characteristics (Fig 4).
Our amplifiers, SA-420F5, SA-421F5, and SA-430F5 meet the world's highest standards of low-noise characteristics using our technologies above.

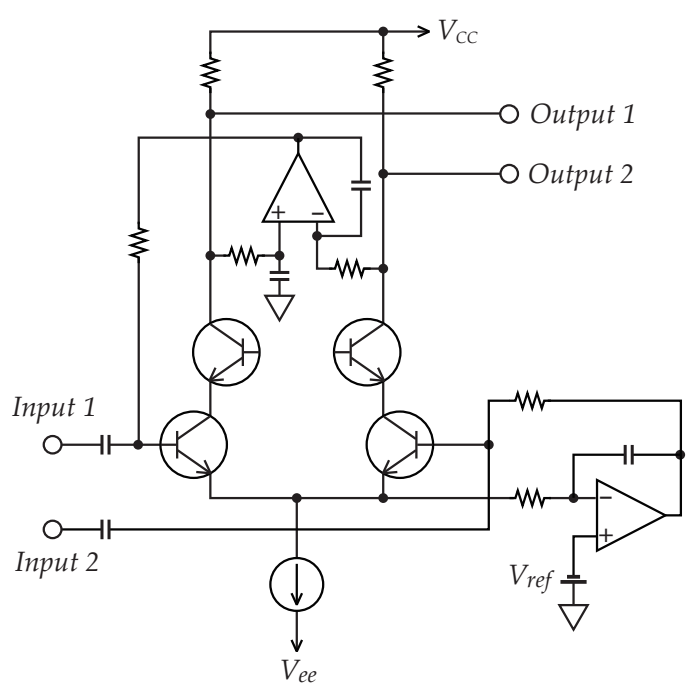
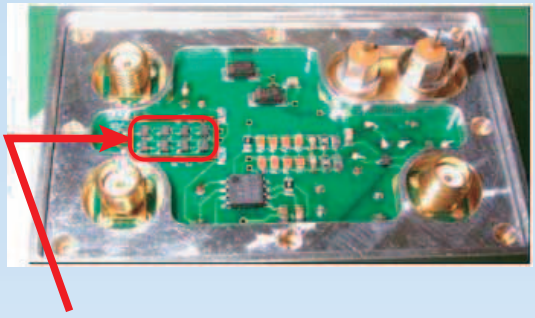



**Figure 4.**
A differential amplifier circuitry which performs optimum differential characteristics even with discrete parts



8 FETs mounted on both sides of a substrate

**Figure 5.**
"SA-421F5" Differential FET Amplifier achieves 0.5 nV/√Hz equivalent input noise density