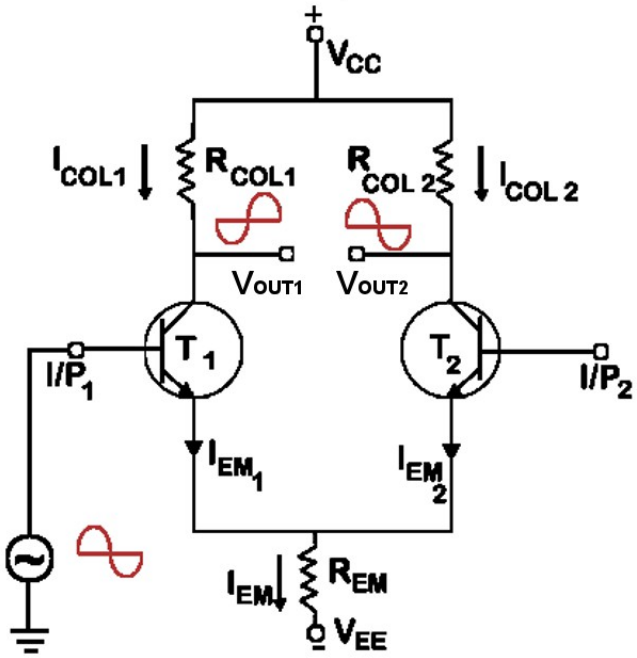
Differential Amplifier using Transistors

<*http://www.circuitstoday.com/differential-amplifier*>

A differential amplifier is designed to give the difference between two input signals. As shown in the circuit diagram, there are two inputs, I/P1 and I/P2 and two outputs V_{OUT1} and V_{OUT2}. I/P1 is applied to the base of the transistor T1 and IP2 is applied to the base of the transistor T2. The emitters of both T1 and T2 are connected to a common emitter resistor so that the two output terminals V_{OUT1} and V_{OUT2} gets affected by the two input signals I/P1 and I/P2. V_{CC} and V_{EE} are the two supply voltages for the circuit. The circuit will also work fine using just a single voltage supply. You may have also noted that there is no ground terminal indicated in the circuit. Hence it must be automatically understood that the opposite points of both the positive and negative voltage supplies are understood to be connected to the ground.

Differential Amplifier Circuit



When a differential amplifier is driven at one of the inputs, the output appears at both the collector outputs. When input signal I/P1 is applied to the transistor T1, there will be a higher voltage drop across the collector resistance R_{COL1}, and thus the collector of T1 will be less positive. When I/P1 is negative T1 is turned OFF, and the voltage drop across R_{COL1} becomes very low and thus the collector of T1 will be more positive, almost at V_{CC}. Thus we can conclude than an inverted output appears at T1's collector for applying signal at I/P1.

When T1 is turned ON by the positive value of I/P1 , the current through the emitter resistance R_{EM} increases as the emitter current is almost equal to the collector current ($I_E = I_C$). Thus the voltage drop across R_{EM} increases and makes the emitter of both transistors going in a positive direction. Making T2's emitter more positive is the same as making the base of T2 more negative. In such a condition the transistor T2 will conduct less current which in turn will cause less voltage drop in R_{COL2} and thus the collector of T2 will go in a positive direction for positive input signal. Thus we can conclude that the non-inverting output appears at the collector of transistor T2 for input at base of T1.

The amplification can be driven differentially by taking output between the collector of T1 and T2. If the transistor T1 and T2 are identical in all characteristics, and if the voltages are equal ($V_{BASE1} = V_{BASE2}$), then the emitter current can also be said to be equal

$I_{EM1} = I_{EM2}$

Total Emitter Current, $I_E = I_{EM1} + I_{EM2}$

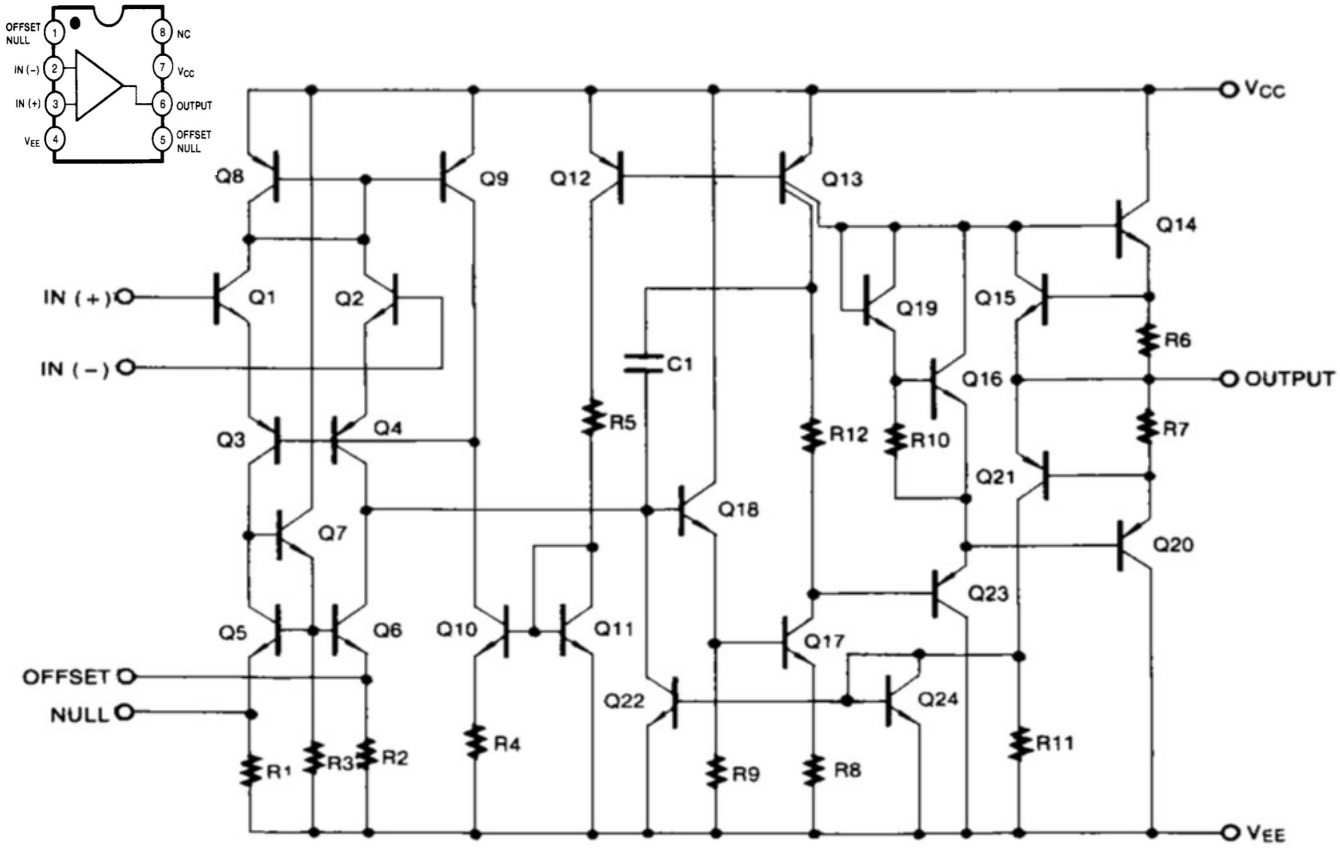
$V_{EM} = V_{BASE} – V_{BE}$

$I_{EM} = (V_{BASE} – V_{BE}) / R_{EM}$

The emitter current I_{EM} remains virtually constant regardless of the h_{FE} value of the transistors. Since $I_{COL1} = I_{EM1}$ and $I_{COL2} = I_{EM2}$, $I_{COL1} = I_{COL2}$. Also, $V_{COL1} = V_{COL2} = V_{CC} – I_{COL} R_{COL}$, assuming collector resistance $R_{COL1} = R_{COL2} = R_{COL}$. Differential amplifier is a closed loop amplifier circuit which amplifies the difference between two signals. Such a circuit is very useful in instrumentation systems. Differential amplifiers have high common mode rejection ratio (CMRR) and high input impedance. The front stage of an OP amp is typically a differential amplifier, which is followed by additional amplification stages.

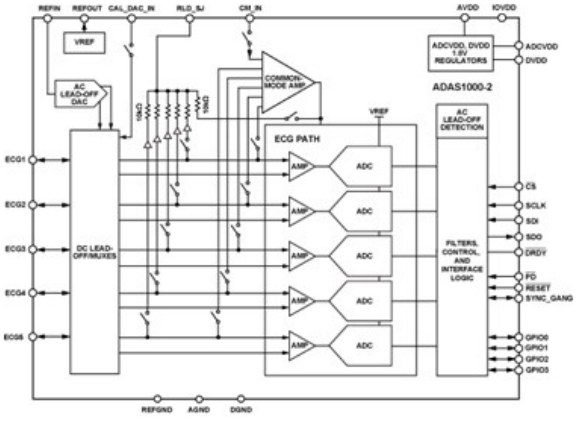
Operational Amplifier

LM741 (8-pin dual-in-line package): Pin assignment and schematic diagram

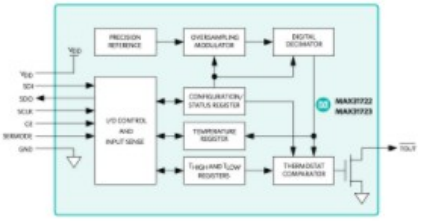


Examples of Special IC's for Medical Applications

Analog Devices ADAS1000-2 (right)
Low power 5-electrode ECG analog front end companion chip
(~$20)



Texas Instruments ADS1299 (above)
24-bit, 8-channel, analog-to-digital converter for electroencephalogram (EEG) and biopotential measurements
(~$60)



Maxim MAX31723 (right)
Digital thermometers and thermostats with SPI/3-wire interface
(~$2)