EE 204 - Analog Circuits
Lecture 11

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Contents

1 Operational Amplifier (OpAmp)

In the previous lectures, we have seen the circuit diagram of an OpAmp constructed using BJT quite often. Now, we will further analyse the functioning and capabilites of an OpAmp and the range of circuits we can design using these.

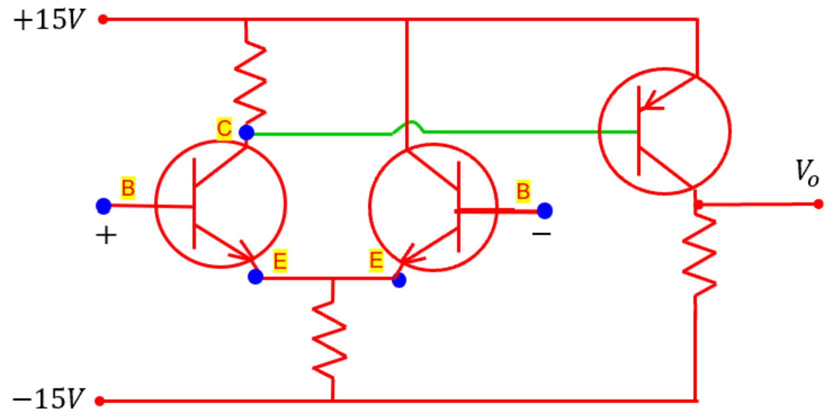

Figure 1: Operational Amplifier

Operational amplifiers are available in IC packages. The pin mapping for IC 741 is the following -

- 2: Inverting Input Terminal - This is the inverting input terminal, where the input signal to be amplified is applied.
- 3: Non-Inverting Input Terminal - The input signal is applied to this terminal, and it is usually at a higher voltage than the inverting input in most amplifier configurations. This is what leads to the differential amplification of input voltage in an OpAmp.
- 4: $-V_{CC}$ Supply - It is the lower voltage reference for the OpAmp
- 7: $+V_{CC}$ Supply - It is the higher voltage reference for the OpAmp
- 6: Output - This provides the amplified output voltage of the OpAmp. The output signal is proportional to the difference between the voltages at the inverting and non-inverting inputs.

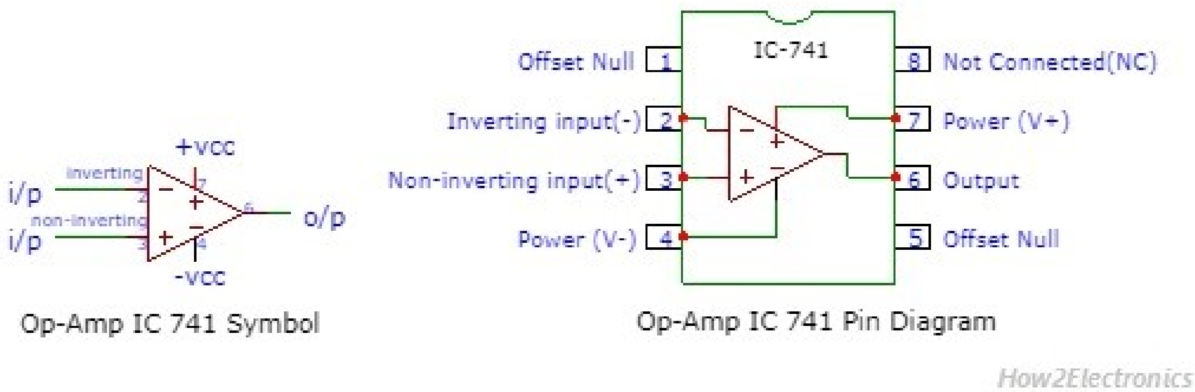

Figure 2: IC 741

The remaining ports, though of not much significance with respect to the operation of an Operational Amplifier, have some adjustment roles. Let's describe those briefly below -

- 1: Offset Null/Adjustment - It is used to adjust the input offset voltage of the op-amp, typically by connecting an external resistor or potentiometer to fine-tune the offset voltage.
- 5: Offset Null/Adjustment - It is used to adjust the input offset voltage of the op-amp, typically by connecting an external resistor or potentiometer to fine-tune the offset voltage.
- 8: NC (No Connection) - It is not internally connected to the op-amp circuitry and is typically left unconnected in most applications.

An Ideal OpAmp can function as an Adder, Subtractor, Differentiator, Amplifier or Integrator. For an Ideal OpAmp, the differential inputs give a single ended output (this property will be used for differential amplifier)

The ideal OpAmp has an infinite input resistance and zero output resistance. The open loop gain for the OpAmp (represented as A_v) is infinite and has zero common mode gain.

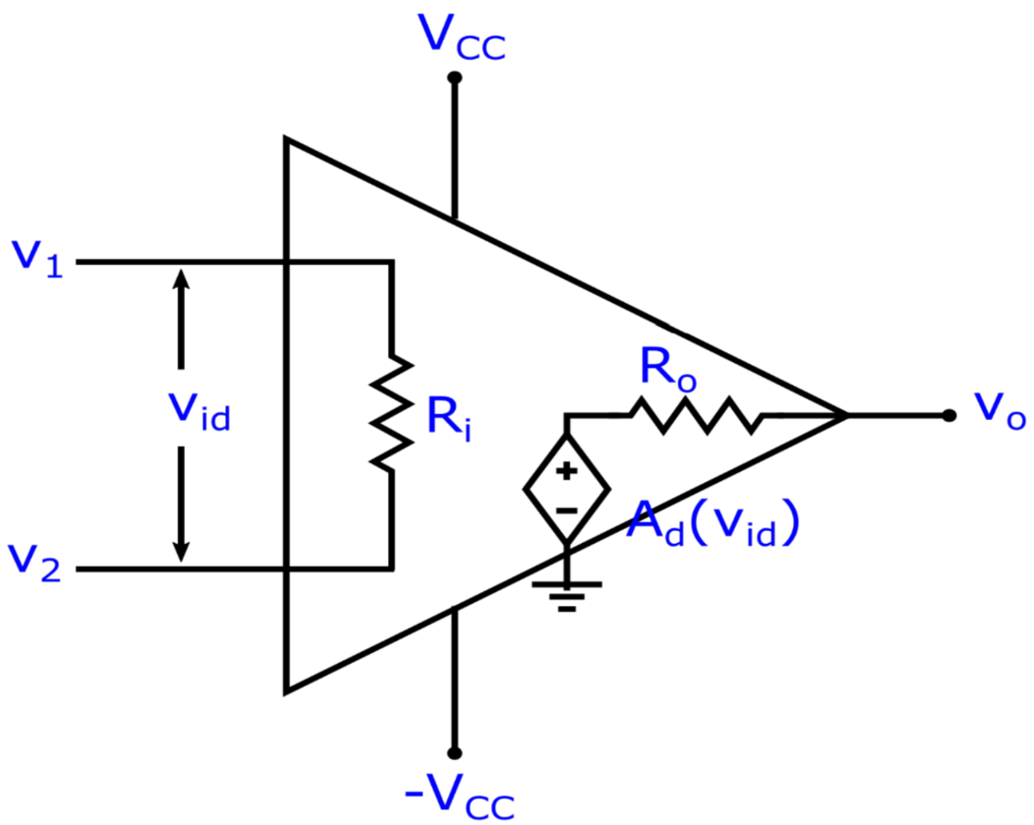

Figure 3: Operational Amplifier

To summarise, these are the characteristics of an Ideal Operational Amplifier:

- Differential inputs and single ended output
- Infinite Input Resistance
- Zero Output Resistance

- Infinite Open Loop Gain
- Zero Common Mode Gain

2 Differential Amplifier

The Differential Amplifier is one of the most basic operations of an OpAmp. The circuit amplifies the differential voltage of the inputs and gives the resulting voltage as the output. This amplification factor is known as the Open Loop Gain or also known as A_v.

Therefore the output voltage, V_o can be represented by the following equation -

$$V_o = A_v(V_p - V_n)$$

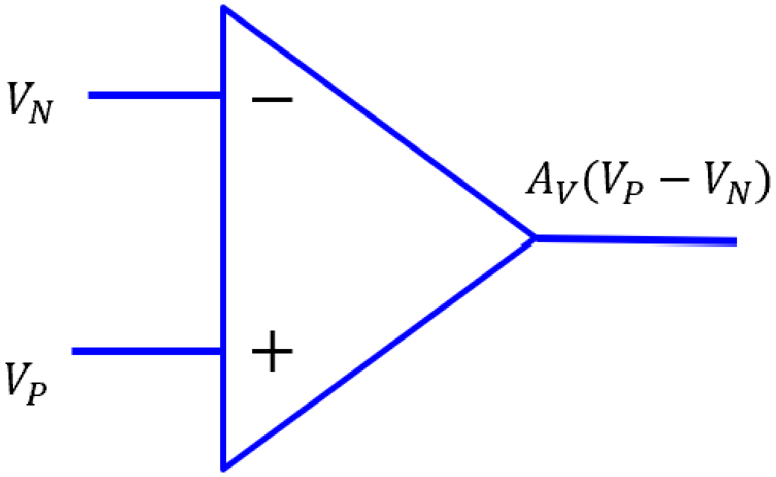

Figure 4: Differential Amplifier

So, we can define two signals, the common mode signal(V_{cm}) and the differential signal(V_{id}). Using these two signals also, we can get the voltages at the inverting and non-inverting terminals.

$$V_p = V_{cm} + \frac{V_{id}}{2}$$

and

$$V_n = V_{cm} - \frac{V_{id}}{2}$$

This changes our circuit to the following,

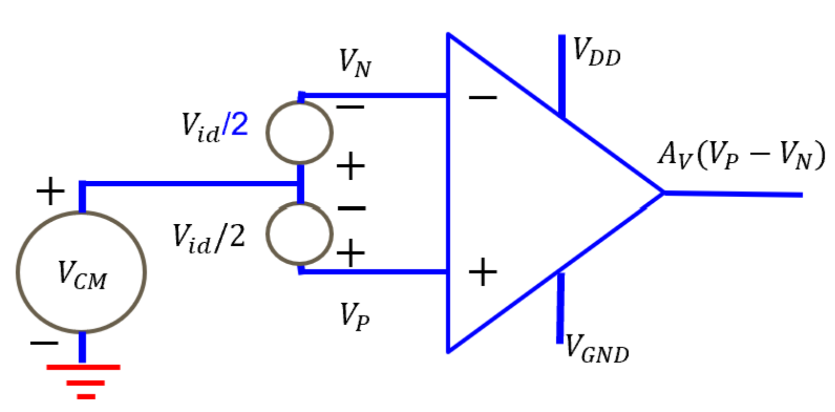

Figure 5: Differential Amplifier (using Common Mode)

3 Functional Block Diagram

We also looked at the datasheet of LM741 OpAmp by Texas Instruments and the following is the functional block diagram for the OpAmp circuit.

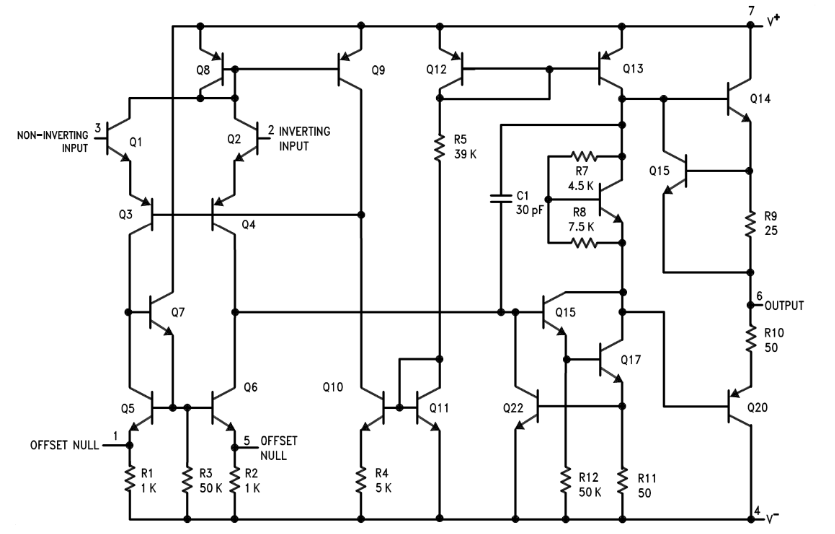

Figure 6: Functional Block Diagram