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INTRODUCTION

- *The term "**operational amplifier"** denotes a special type of amplifier that, by proper selection of its external components, could be configured for a variety of operations.*

HISTORY

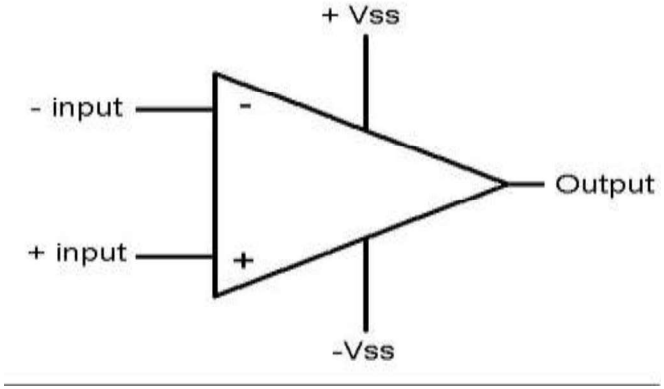
- *First developed by **John R. Ragazzine** in 1947 with vacuum tube.*
- *In 1960 at **FAIRCHILD SEMICONDUCTOR CORPORATION**, **Robert J. Widlar** fabricated op amp with the help of IC fabrication technology.*
- *In 1968 FAIRCHILD introduces the **op-amp** that was to become the industry standard.*

WHAT IS OP-AMP?

✓*An operational amplifier (op-amp) is a DC-coupled high-gain electronic voltage amplifier*

✓ *Direct- coupled high gain amplifier usually consisting of one or more differential amplifiers*

✓*Output stage is generally a push-pull or push-pull complementary-symmetry pair.*



✓*Op amps are differential amplifiers, and their output voltage is proportional to the difference of the two input voltages. The op amp's schematic symbol is shown in the above figure*

✓*The two input terminals, called the inverting and non-inverting, are labeled with - and +,*
respectively.

CIRCUIT SYMBOL

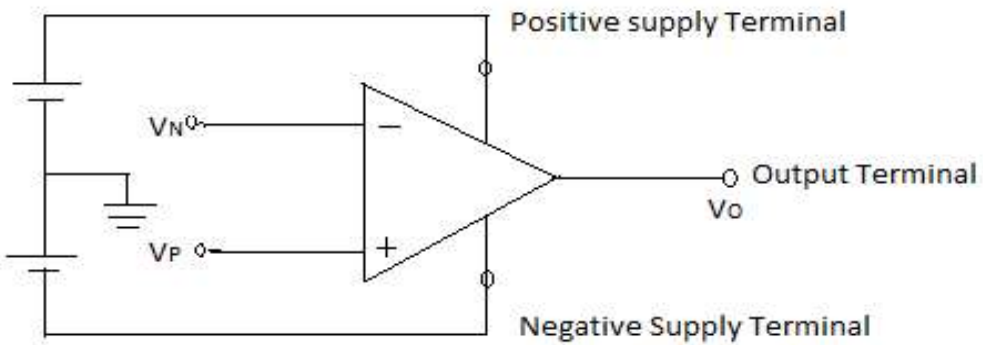


Fig.. Ckt symbol for general purpose op-amp

Figure shows the symbol of **op-amp** & the power supply connections to make it work. The input terminal identified by the '**-**' and "**+**" symbols are designated inverting & non-inverting. Their voltage w.r.t ground are denoted as $\mathbf{V_N}$ & $\mathbf{V_P}$ and output voltage as $\mathbf{V_o}$. Op-amp do not have a zero volt ground terminal Ground reference is established externally by the power supply common.

Operational Amplifiers picture

Figure: The Philbrick Operational Amplifier.

Figure : What an Op-Amp looks like in today's world

Op-amp pin diagram

There are 8 pins in a common Op-Amp, like the 741 which is used in many instructional courses.

Pin 1: Offset null

- Pin 2: Inverting input terminal
- Pin 3: Non-inverting input terminal

Pin 4: –VCC (negative voltage supply)

Pin 5: Offset null

- Pin 6: Output voltage

Pin 7: +VCC (positive voltage supply)

Pin 8: No Connection

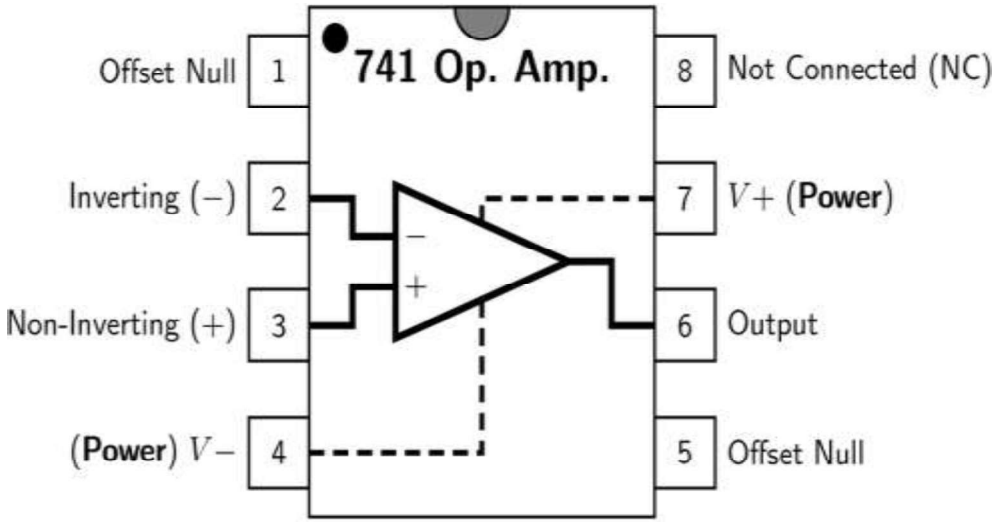
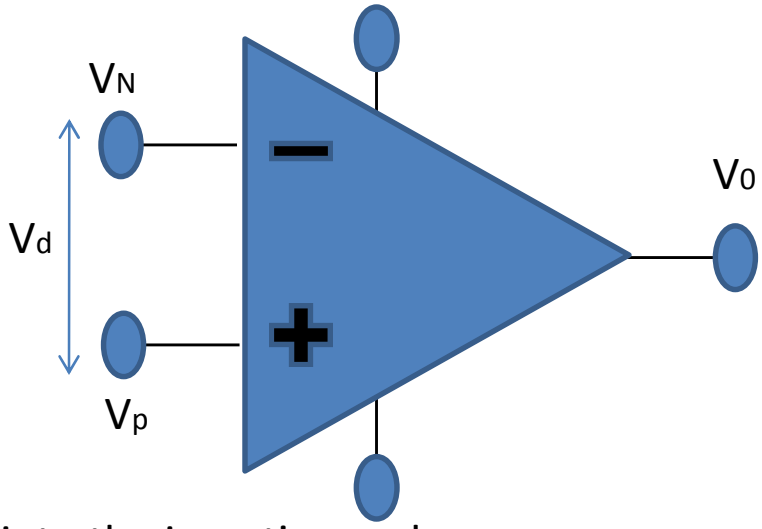


Figure : Pin connection, LM741.

Important terms and equation

a = gain of amplifiers.
V_d= difference between the voltage.
V_0= gain of voltage.
The equation :

$$V_0 = a\,(V_P - V_N)$$



Electrical parameter :

1.Input bias current(I_b): average of current that flows into the inverting and non-inverting input terminal of op-amp.

2. I/p and o/p impedance: It is the resistance offered by the inputs and the output terminals to varying voltages. The quantity is expressed in Ohms.

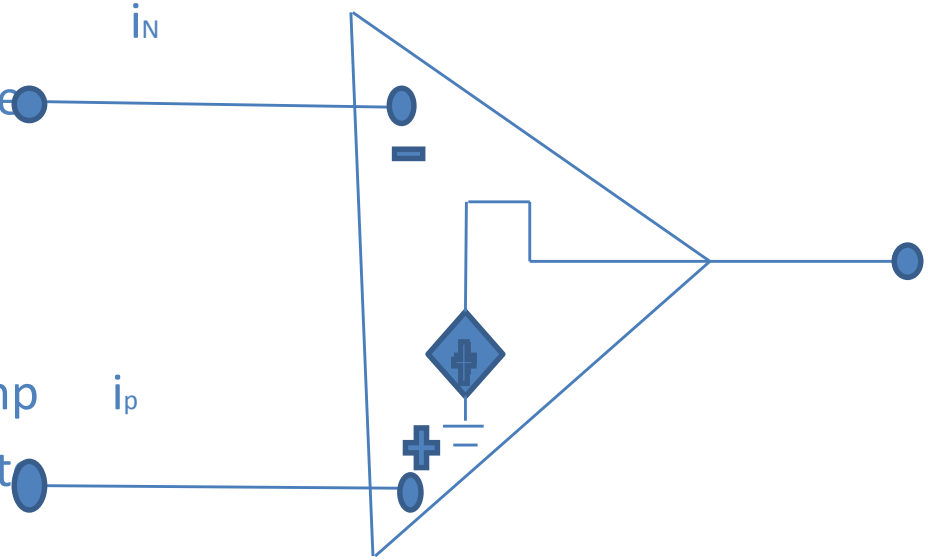
3. Open Loop Gain: It is the overall voltage gain or the amplification.

4. Input offset voltage : It is a voltage that must be applied between the two terminal of an op-amp to null the o/p.

5. Input offset current (I_i): The algebraic different between the current in to the inverting and Non-inverting terminal.

IDEAL OP-AMP

We know to minimize loading , a well designed voltage amplifier must draw negligible current from the input source and must present negligible resistance To the output load . Op-amp are no exception so we define the ideal op-amp as an ideal voltage amplifier with infinit open loop gain.



$a \Longrightarrow \text{infinity}$

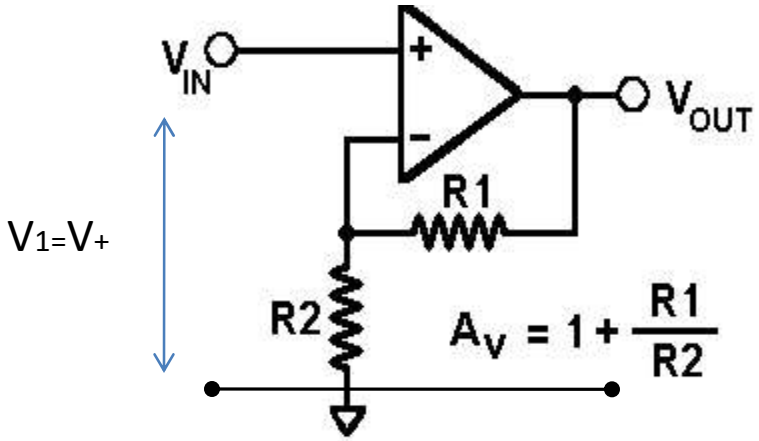
Its ideal terminal condition are

$r_d = \text{infinity}, r_o = 0, i_p = i_n = 0$

IDEAL OP-AMP FOLLOWS THE GIVEN PROPERTY

1. Infinite voltage gain a
2. Infinite input resistance r_d so that almost any signal source can drive it and there is no loading of the preceding stage.
3. Zero output resistance r_o so that the output can drive an infinite number of other device.
4. Zero output voltage when input is zero.
5. Infinite common mode rejection ratio so that the output common mode noise voltage is zero.
6. Infinite slew rate so that output voltage changes occurs simultaneously with input voltage changes.

Non -ideal op-amp



1. This is opposite to the ideal op-amp only the positive and Negative terminal are change there position.

2. There is a single external input signal V_1=V+ that is applied to the +Ve pin of op-amp.

3. A signal is also made to appear at the -Ve input terminal, But this is derived from resistors R_1 and R_2.

CHARACTERISTICS OF IDEAL OP-AMP

- Infinite input impedance(about 2Mohm)
- Low output impedance(about 200 ohm)
- Very large voltage gain at low frequency
- Thus,small changes in voltages can be amplified byusing an op-amp
- Infinte bandwidth(all frequencies are amplified by same factor

❑Infinite Common-mode rejection ratio

❑Infinite Power supply rejection ratio.

Characteristics of non ideal op-amp

- Finite open-loop gain that causes gain error
- Finite input impedance
- Non zero output impedance
- Finite CMRR
- Common-mode input resistance
- Finite bandwidth
- Finite power supply rejection ratio.

APPLICATIONS

- A to D Converters
- Power source
- Zero Crossing Detector (ZCD)

1. A to D Converters

Digital-to-Analog converters (DACs) and Analog-to-Digital converters (ADC) are important building blocks with interface sensors. An ADC takes an analog signal and converts it into a binary one, while a DAC converts a binary signal into an analog value. Figure 1 gives a block diagram of such a system. An example of such a system is a PC sound card.

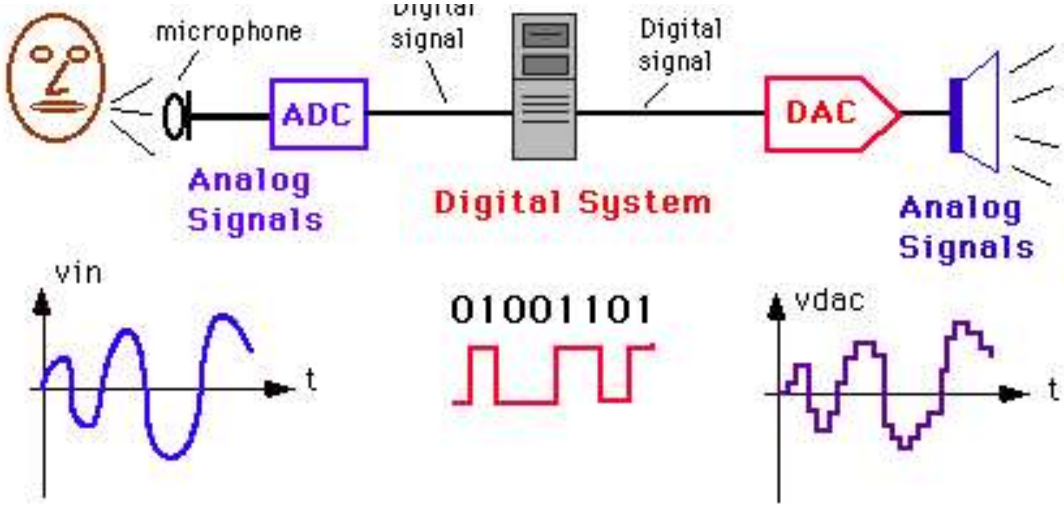
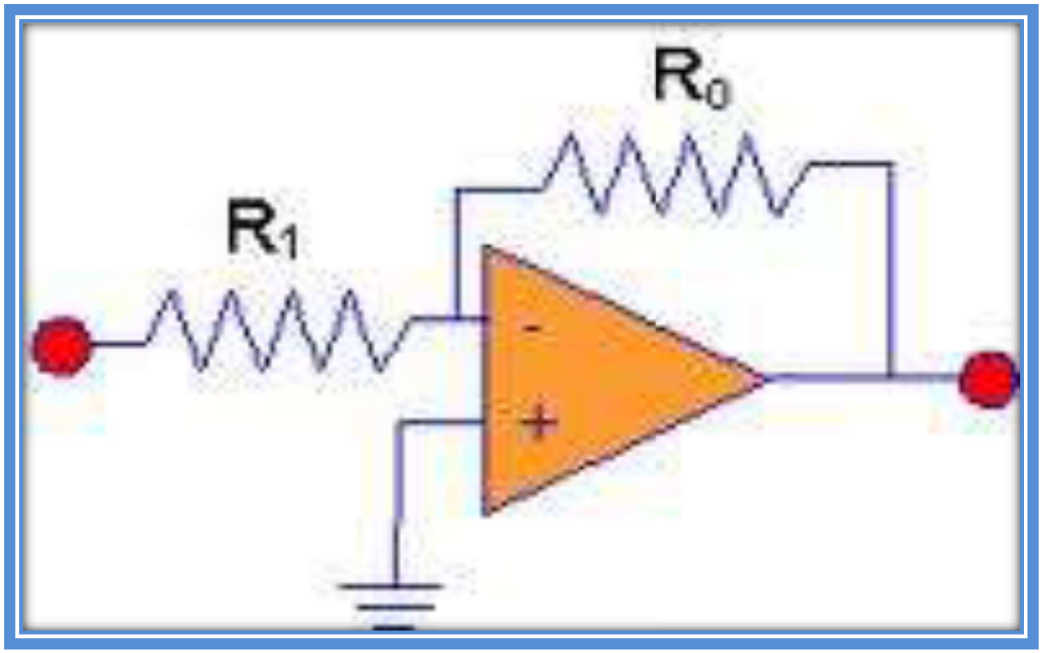


Figure 1 – Digital processing system with an ADC at the input and a DAC at the output

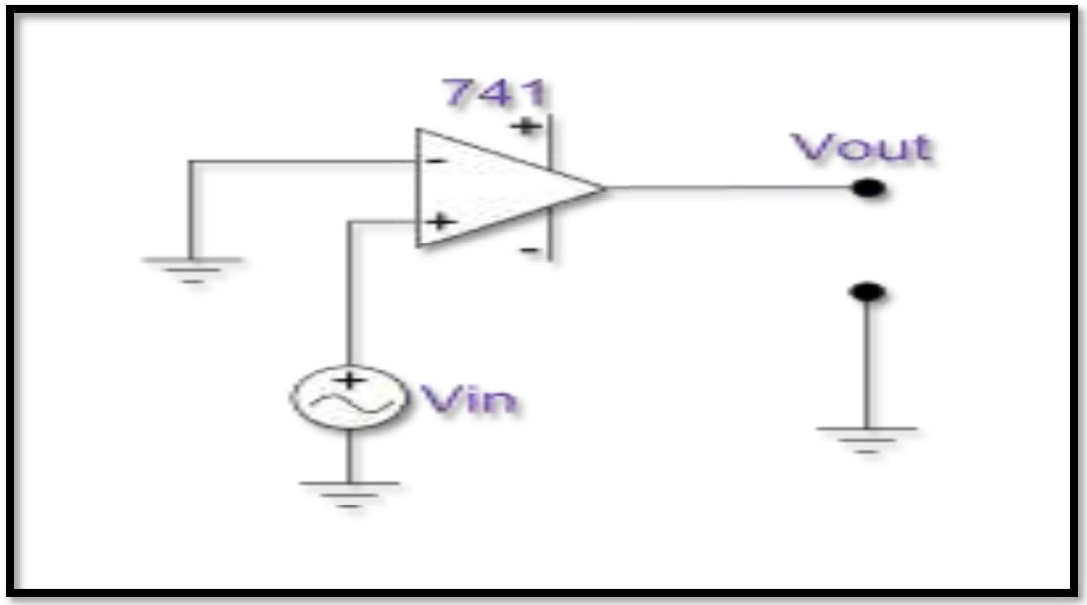
2. Op-Amp as a Current Source

A current source can be made from an inverting amplifier as shown in figure. The current in the load resistor, R_0 must be equal to the current in R_1. The current is then obtained by dividing the input voltage by R_1.



3. Zero crossing detector applications

ZCD circuit can be used to check whether the op-amp is in good condition. Zero crossing detectors can be used as frequency counters and for switching purposes in power electronics circuits. ZCD is a basic op amp circuit.



ADVANTAGES OF AN OPAM:-

1.OPAM IS AN UNIVERSAL AMPLIFIER.

2.VOLTAGE COMPARATORS.

3.PRECISION RECTIFIERS.

4.ANOLOGUE TO DIGITAL CONVERTERS.

5. DIGITAL TO ANALOGUE CONVERTERS.
6. FILTERS.
7. DIFFRENTIATORS AND INTEGRATORS.
8. VOLTAGE AND CURRENT REGULATOR.
9. ANALOGUE TO COMPUTERS.

DISADVANTAGES OF AN OPAM:-

- 1. MOST OPAM ARE DESIGNED TO FOR LOWER POWER OPERATION.
- 2. FOR HIGH OUTPUT IS DESIRED THEN THE OPAM SPECIFICALLY DESIGNED FOR THAT PURPOSE MUST BE SEEN.
- 3.MOST COMMERCIAL OPAM SHUTS OFF WHEN THE LOAD RESISTANCE IS BELOW A SPECIFIC LEVEL.