OP-AMP

.

CMRR. it is ratio of **Differential Voltage gain to common mode voltage gain** Ideal Operational Amplifiers also have one output (although there are ones with an additional differential output) of low impedance that is referenced to a common ground terminal

and it should ignore any common mode signals that is, if an identical signal is applied to both the inverting and non-inverting inputs there should no change to the output. However, in real amplifiers there is always some variation therefore the ratio of the change to the output voltage with regards to the change in the common mode input voltage is called the **Common Mode Rejection Ratio**

Operational Amplifiers on their own have a very high open loop DC gain and by applying some form of **Negative Feedback** we can produce an operational amplifier circuit that has a very precise gain characteristic that is dependant only on the feedback used.

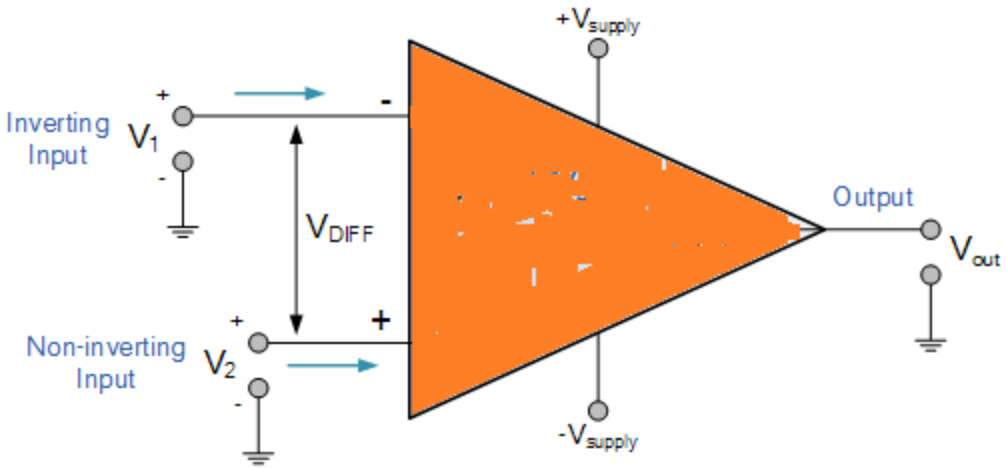
An operational amplifier only responds to the difference between the voltages on its two input terminals, known commonly as the "*Differential Input Voltage*" and not to their common potential. Then if the same voltage potential is applied to both terminals the resultant output will be zero. An Operational Amplifiers gain is commonly known as the **Open Loop Differential Gain**, and is given the symbol (A_o).

Operational Amplifier

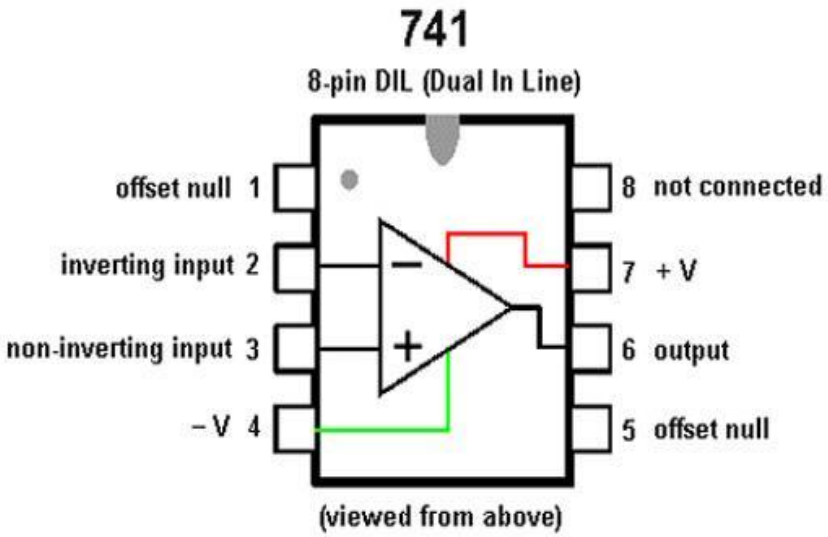
An ideal **Operational Amplifier** is basically a three-terminal device which consists of two high impedance inputs, and high gain coupled amplifiers one called the **Inverting Input**, marked with a negative or "minus" sign, (-) and the

other one called the **Non-inverting Input**, marked with a positive or "plus" sign (+).

The inverting input has a minus sign which indicates 180^0 phase shift between input and out signal non-inverting has plus sign which indicated no phase inversion between input and out put signal

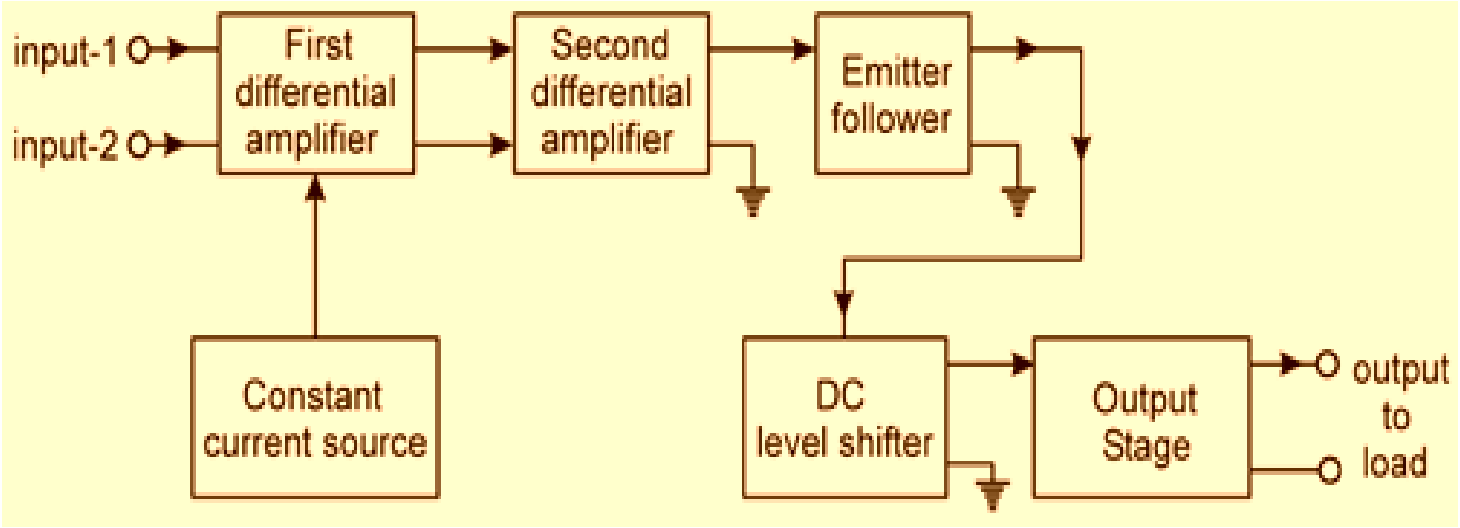


OP-AMP Pin-741



Block- Digram

Consider the following figure. Here a number of blocks are shown. The working of each block is given below.



OP-AMP

Op-amp Parameters

Input offset Voltage (V_{io})

Input offset voltage is the voltage that must be applied between the two input terminals of an op-amp to null the output. When input of opms are grounded must be zero Typical value of 741 IC is 6mV dc.

Input offset current (I_{0s})

The algebraic difference between the current in the inverting and non inverting terminal is known as the input offset current Ios. Ideally different is zero. this difference between and I become smaller. Typical value for 741 IC is 200mA(max).

Iso= I_1-I_2

Input Bias Current

I_B is the average current flows in the inverting and non-inverting terminal of an op-amp.

$I_B = (I_1 + I_2)/2$

Typical value for 741 is 500mA

Closed loo gain It is gain of the amplfier

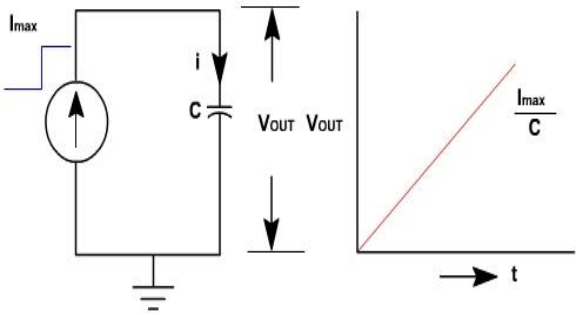
Op-amp Parameters

Slew rate is defined as the maximum rate of change of output voltage per unit of time under large signal conditions and is expressed in volts / m secs.

The Slew Rate of an op amp describes how fast the output voltage can change in response to an immediate change in voltage at the input. The higher the value (in V/μs) of slew rate, the faster the output can change and the more easily it can reproduce high frequency signals.

$$i = C\frac{dV}{dt}$$

$$\frac{dV}{dt} = \frac{i}{C}$$



$$SR = \left.\frac{dV_0}{dt}\right|_{max} \quad V/\mu s$$

If 'i' is more, capacitor charges quickly. If 'i' is limited to I_{max}, then rate of change is also limited.

Slew rate indicates how rapidly the output of an OPAMP can change in response to changes in the input frequency with input amplitude constant. The slew rate changes with change in voltage gain and is normally specified at unity gain.

If the slope requirement is greater than the slew rate, then distortion occurs. For the 741C the slew rate is low 0.5 V / m S. which limits its use in higher frequency applications

.

OP-AMP

Op-amp Parameters

- **Open Loop Gain, (Avo)Infinite** –i.e. $V_{0ut}/V_{in} = A_{vo}$The main function of an operational amplifier is to amplify the input signal and the more open loop gain is better.
- Open-loop gain is the gain of the op-amp without positive or negative feedback and for an ideal amplifier the gain will be infinite but typical real values range from about 20,000 to 200,000.
- **Input impedance, (Z_{in}) Infinite** - Input impedance is the ratio of input voltage to input current and is assumed to be infinite to prevent any current flowing from the source supply into the amplifiers input circuitry (Iin =0).

OP-AMP

- **Op-amp Parameters Output impedance**, (Z_{out}) **Zero** - The output impedance of the ideal operational amplifier is assumed to be zero acting as a perfect internal voltage source with no internal resistance so that it can supply as much current as necessary to the load.
- This internal resistance is effectively in series with the load thereby reducing the output voltage available to the load. Real op-amps have output-impedance in the 100-20Ω range
- **Bandwidth, (BW) Infinite -** An ideal operational amplifier has an infinite frequency response and can amplify any frequency signal from DC to the highest AC frequencies so it is therefore assumed to have an infinite bandwidth. With real op-amps, the bandwidth is limited by the Gain-Bandwidth product (GB), which is equal to the frequency where the amplifiers gain becomes unity.

OP-AMP

Op-amp Parameters

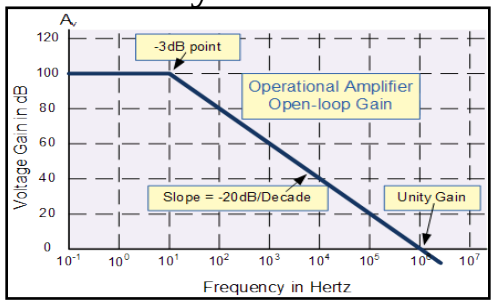
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frequency response and CMMR = Ad/Ac



Where

Ad is Differential voltage gain

and

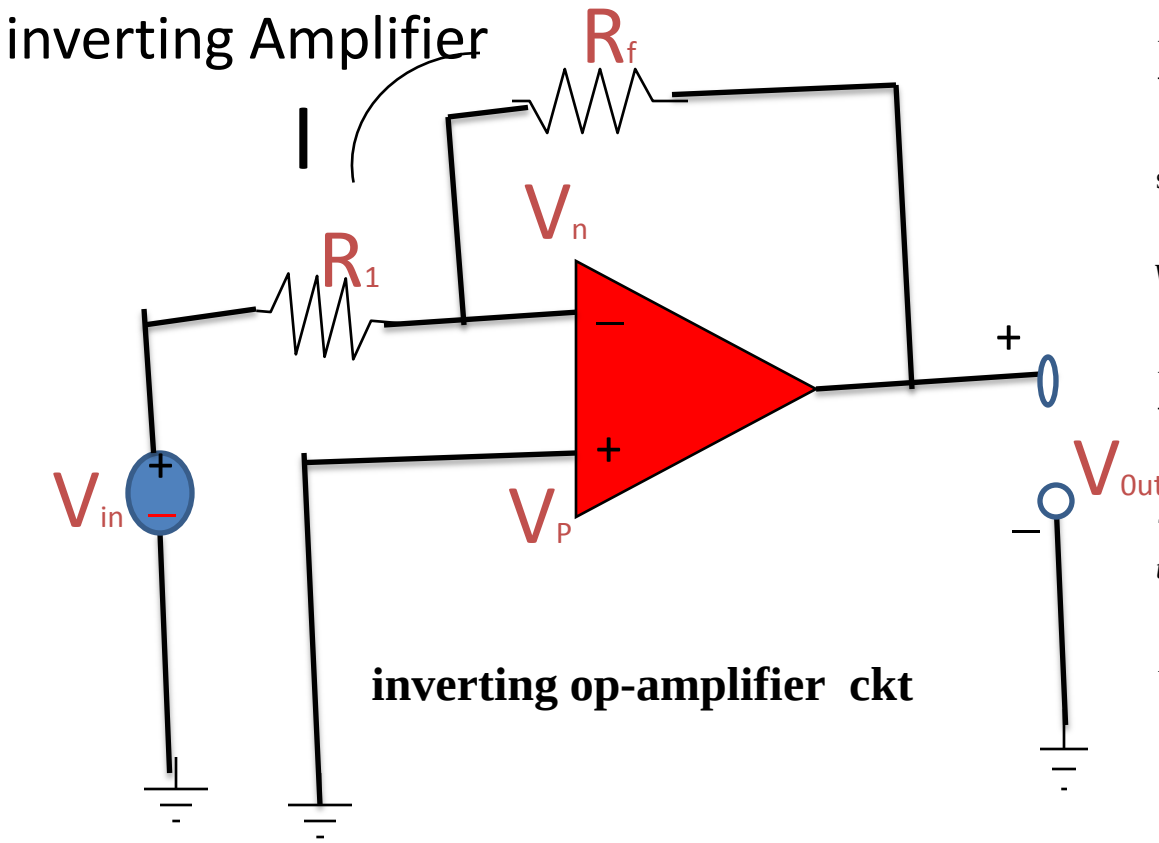
Ac is common mode voltage gain

it is defined as the ratio of differential voltage gain to common mode voltage gain

An important characteristic of any amplifier is its **frequency response**, in the ideal amplifier its frequency response should be infinite, it will amplify any and all frequencies equally. In practical amplifiers this is difficult/impossible to achieve, and not always desirable, but op amps have extremely wide, and easily variable bandwidths.

OP-AMP

- mathematical operations such as integration, differentiation, summing, and differencing. These operations are produced most simply with an op-amp connected in the inverting or virtual ground configuration, rather than in the non-inverting configuration The non-inverting configuration has the advantage of high input impedance,



$$\frac{V_{in} - V_n}{R_1} = \frac{V_n - V_{out}}{R_f}$$

$$since, V_n = 0$$

$$V_{out} = \left(-\frac{R_f}{R_1}\right) V_{in}$$

$$\frac{V_{out}}{V_{in}} = \left(-\frac{R_f}{R_1}\right)$$

gain – of – inverting – amp – is – always –

the – close – loop – amp – is

$$A_{CL} = -\frac{R_f}{R_1}$$

➢**In inverting amp non –inverting i/p is connected to the ground and i/p signal is given to inverting terminal**

R

➢o/p and i/p both are in 180 phase shift

➢**-ve feedback is applied to the invertind i/p through R_f**

➢**since for ideal op-amp V_p=Vn and v_p is grounded therefore Vn=0**

➢**Therefore current flowing R1 must be equal in magnitude and opposite in direction therefore apply Kirchhoff current law**

Non inverting Amplifier

➢**applied voltage divided formula to find Vn**

$$V_n = \left(\frac{R_1}{R_1 + R_f}\right) V_{out}$$

$$ideal - op - ampwe - know - that - V_{in} = V_p = V_n$$

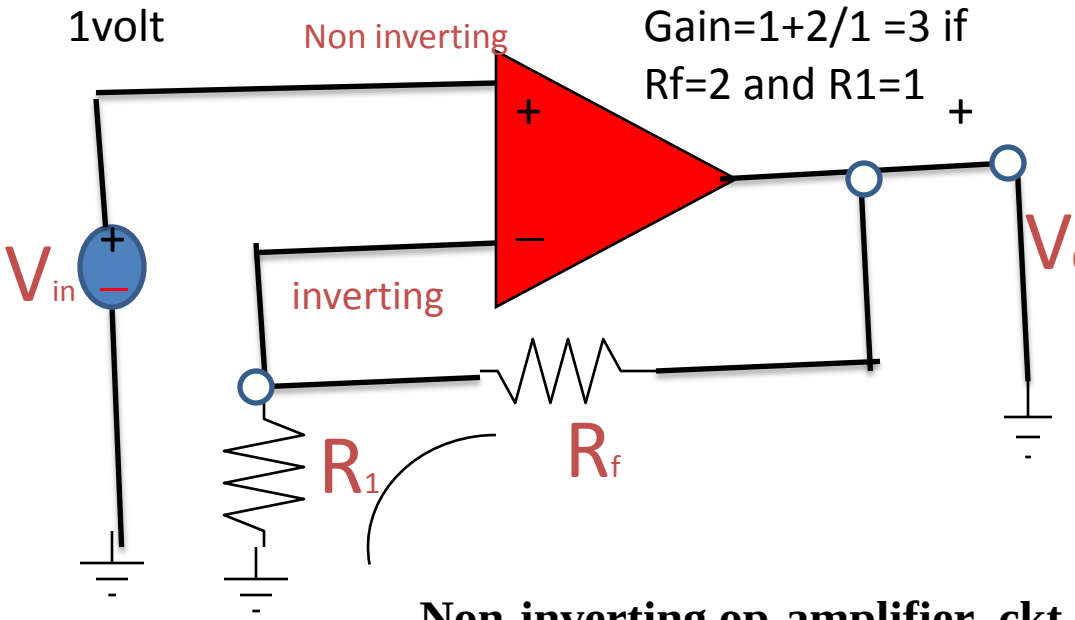
$$V_{out} = \left(1 + \frac{R_f}{R_1}\right) V_{in}$$

$$\frac{V_{out}}{V_{in}} = \left(\frac{R_1 + R_f}{R_1}\right)$$

$$the - closed - loop - gain - op - amp$$

$$A_{CL} = \frac{V_{out}}{V_{in}}$$

$$A_{CL} = \left(1 + \frac{R_f}{R_1}\right)$$



Non-inverting op-amplifier ckt

➢In this mode i/p signal is applied to the Non-inverting op-amplifier and o/p is feed back to inverting terminal of op-amplifier through the resister R_f .

o/p and i/p both are in phase

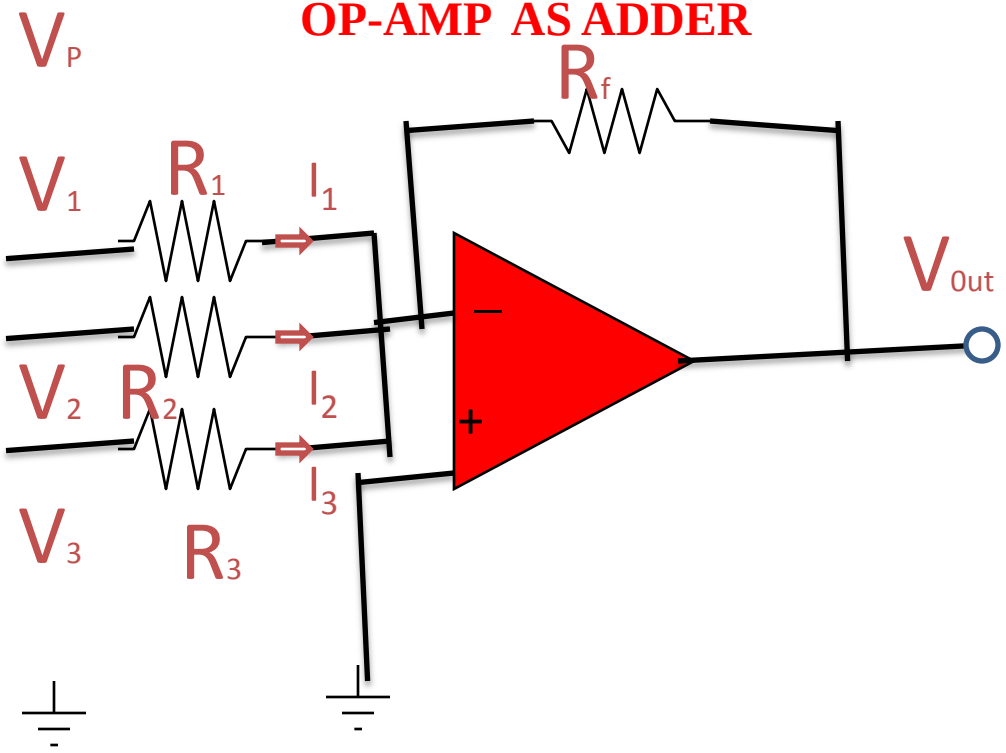
➢ the resister R_1 is connected between inverting terminal and ground

➢We know that no loading effect at the i/p at input ideal amplifier V_p= Vn

➢Since current flowing into the inverting i/p of ideal op-amp is zero . current flowing through R_1 is equal to current flowing through R_f

➢controlling the value of R1 and Rf control the gain of op-amp

OP-AMP AS ADDER



$$apply \quad -kcl$$

$$I_1 + I_2 + I_3 = I_f$$

$$\sin ce, V = 0$$

$$\frac{V_1 - 0}{R_1} + \frac{V_2 - 0}{R_2} + \frac{V_3 - 0}{R_3} = \frac{0 - V_{out}}{R_f}$$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = \frac{-V_{out}}{R_f}$$

$$V_{out} = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right] \quad for \quad -\sin \quad gle \quad -i/p$$

$$V_{out} = \frac{R_f}{R_1}V_{in} \quad if \quad -ifR_1 = R_2 = R_3 = R_f = R$$

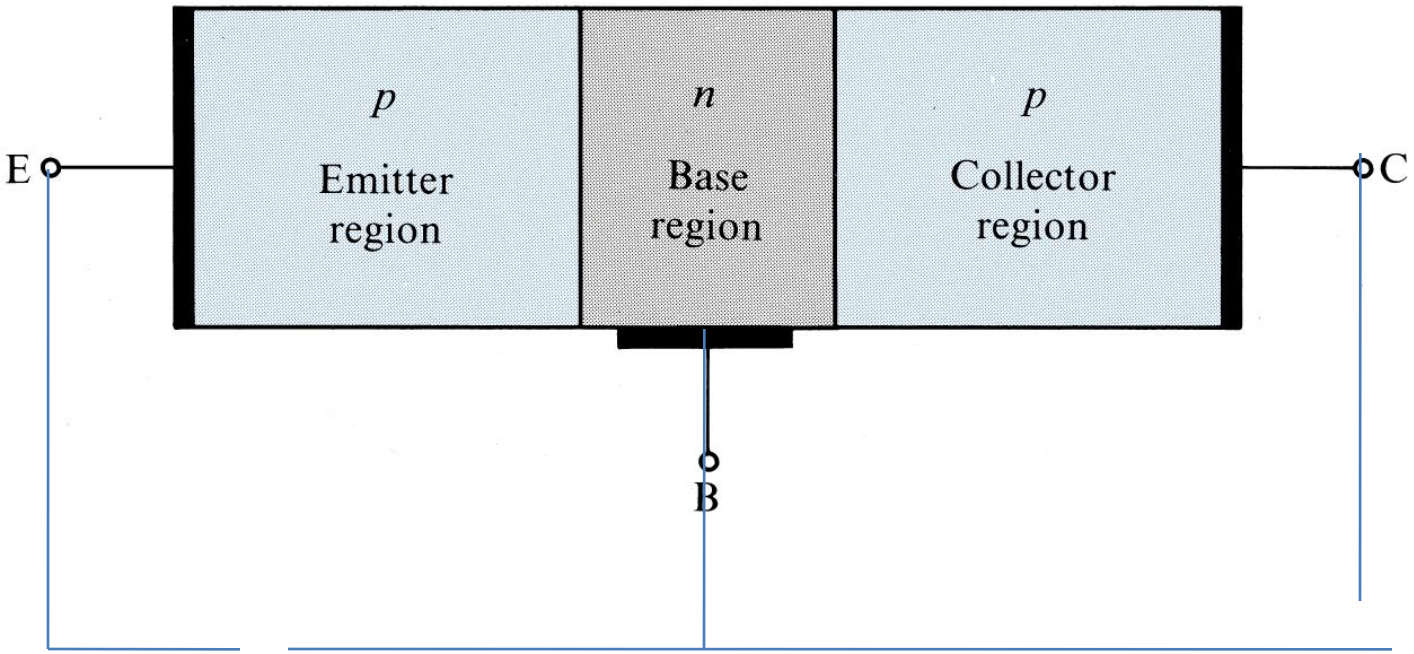
$$V_{out} = -[V_1 + V_2 + V_3]$$

- Early slide we will apply single i/p now by applying multiple inputs to either inverting or the non-inverting input terminal of the op-amp, it can be used as summing amplifier
- Find expression for out o/p voltage for different i/p voltage Apply i/p voltage V_1, V_2, V_3 by resistance R_1, R_2, R_3
- Let say current If following through R_f Assume that op-amp is ideal no current going inside op-amp
- Use the concept of virtual ground if whenever we apply –ve feedback apply any op-amp there is virtual shout exit between inverting and non inverting terminal
- One terminal is at ground potential another terminal will also at ground potential

Introduction:

- The transistors PNP and NPN are BJTs and it is a basic electrical component, used in various electrical and electronic circuits to build the projects. The operation of the PNP and NPN transistors mainly utilizes holes and electrons. These transistors can be used as amplifiers, switches and oscillators. In PNP transistor, the majority charge carriers are holes, where in NPN the majority charge carriers are electrons.

Now consider the operation of N-P-N t resistor when emitter junction is forward baised and collector junction is reversed biased As the E-B junction is forward baised and emitter is heavily doped n-region, number of electrons start to flow towards the base. This constituents the emitter current Ig. Now The base is very thin and lightly doped, therefore, the electrons emitted from the emitter flow through the p-type base. In this process, very few electrons(less than 5%) combine with holes creating valence electrons. This valence electrons flow down through the holes into the base terminal, which constitutes base current IB. The remaining number of electrons (nearly 95% or more) cross over into the


p
Emitter
region
n
Base
region
p
Collector
region
E
C
B

Now consider the operation of N-P-N t resistor when emitter junction is forward baised and collector junction is reversed biased

As the E-B junction is forward biased and emitter is heavily doped n-region, number of electrons start to flow towards the base.

This constituents the emitter current Ie. Now The base is very thin and lightly doped,

the electrons emitted from the emitter flow through the p-type base. In this process, very few electrons(less than 5%) combine with holes creating valence electrons.

This valence electrons flow down through the holes into the base terminal, which constitutes base current IB.

The remaining number of electrons (nearly 95% or more) cross over into the collector region to constitute collector current IC.

As the collector region is having physically large area, almost all electrons crossing base are collected by the collector.

Hence, we see that the emitter current flows through the collector except very few through base. Hence, we write emitter current as sum of the collector and base currents.

$$I_E = I_B + I_C$$

A brief history of superconductors

The first discovery of a superconductive material took place in 1911 when a Dutch scientist named Heike Kammerlingh Onnes, who was also the first person to liquefy helium, and reached temperatures as low as 1.7 kelvin (K).

In the 1960s, in a new era in which practical superconducting devices were developed and commercialized: one was the discovery of NbTi superconductor, which provided the first material for the practical manufacture of superconducting wire and shaped components; the second was the Josephson junction, which continues to provide the basis for a variety of unique electronic devices.

Despite the enormous success of NbTi and similar materials, even broader application of superconductors has been restricted by the requirement for cooling to very low temperatures (1.5 - 5K)using liquid helium.

at IBM's Zurich Lab, discovered announced an oxide material that superconducted at 30K. These two researchers were awarded the Nobel Prize in Physics 1987 for their work.

Then, in 1987, Paul Chu at the University of Houston discovered YBCO, which became a superconductor at just 90K. Because 90K can be reached using liquid nitrogen, a common industrial refrigerant, these discoveries opened up for the first time the potential for a much wider range of devices. Over the next several months, discoveries of BSCCO and TBCCO brought the transition temperature of superconductors up to 127K.

This discovery of these "High Temperature Superconductors" sparked vast interest, and an entire industry dedicated to the research and commercial development of these materials and their applications has emerged. Today, an enormous range of devices are under development for both low and high temperature superconductors.

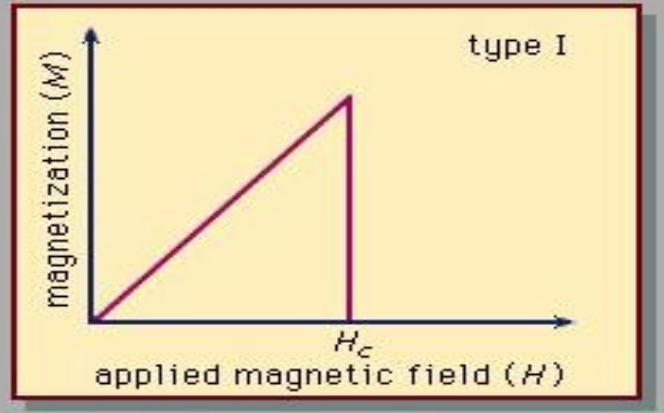
International competition is strong in these materials, and current efforts involve many facets of the electronics, communications, power, medical technology, transportation, military, and materials processing industries.

A superconductor is a material that can conduct electricity or transport electrons from one atom to another with no resistance.

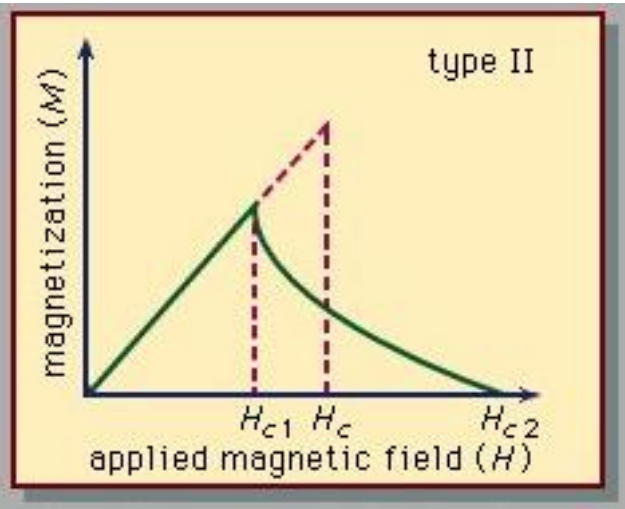
This means no heat, sound or any other form of energy would be released from the material when it has reached "critical temperature" (T_c), or the temperature at which the material becomes superconductive.

Unfortunately, most materials must be in an extremely low energy state (very cold) in order to become superconductive.

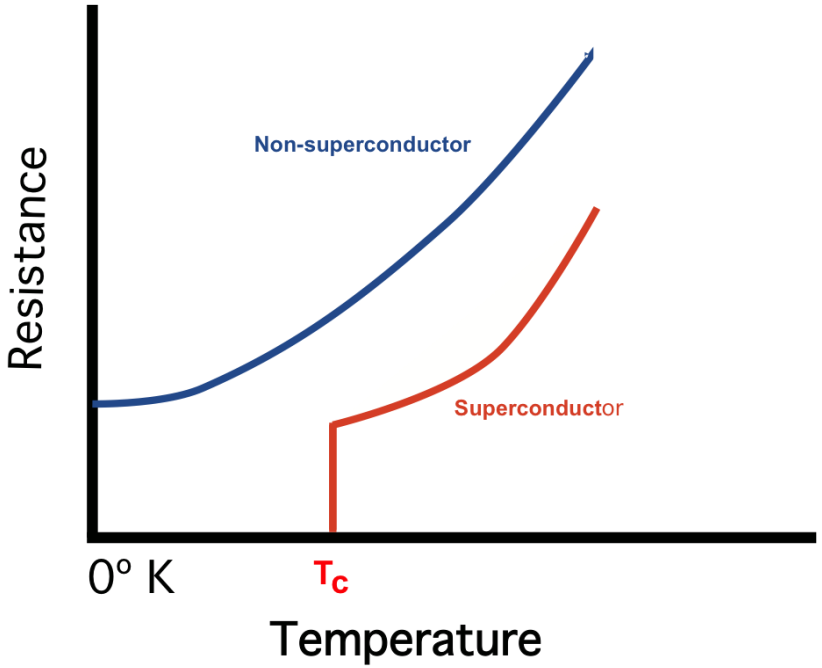
Research is underway to develop compounds that become superconductive at higher temperatures. Currently, an excessive amount of energy must be used in the cooling process making superconductors inefficient and uneconomical.



For a type I superconductor, magnetic flux is expelled, producing a magnetization (M) that increases with magnetic field (H) until a critical field (H_c) is reached, at which it falls to zero as with a normal conductor.



A type II superconductor has two critical magnetic fields (H_{c1} and H_{c2}); below H_{c1} type II behaves as type I, and above H_{c2} it becomes normal.



Type I and Type II superconductors

Depending upon their behavior in an external magnetic field, superconductors are divided into two types:

Type I superconductors:

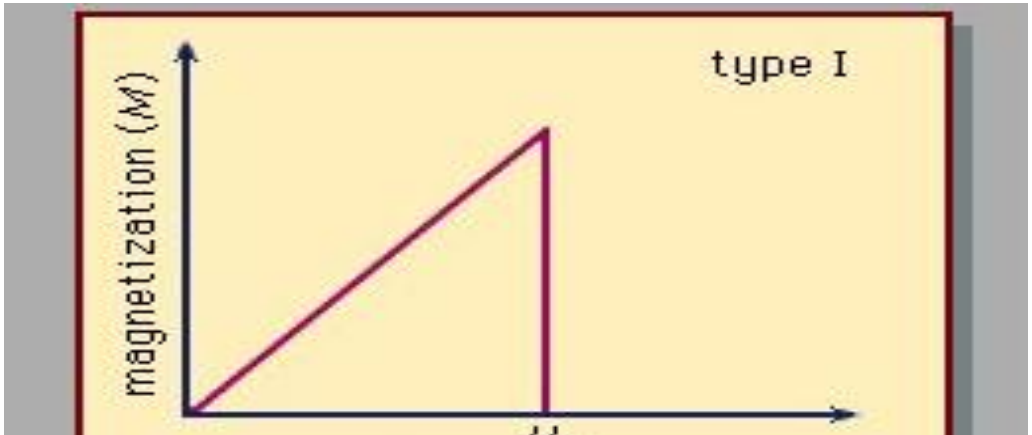
- Type I superconductors are those superconductors which loose their superconductivity very easily or abruptly when placed in the external magnetic field.
- As you can see from the graph of intensity of magnetization (M) versus applied magnetic field (H),
- when the Type I superconductor is placed in the magnetic field, it suddenly or easily looses its superconductivity at critical magnetic field (Hc).

After Hc, the Type I superconductor will become conductor.

Type I superconductors are also known as **soft superconductors** because of this reason that is they loose their superconductivity easily.

Type I superconductors perfectly obey Meissner effect.

Example of Type I superconductors: Aluminum (Hc = 0.0105 Tesla), Zinc (Hc = 0.0054)



Type II superconductors:

- Type II superconductors are those superconductors which loose their superconductivity gradually but not easily or abruptly when placed in the external magnetic field. As you can see from the graph of intensity of magnetization (M) versus applied magnetic field (H),
- when the Type II superconductor is placed in the magnetic field, it gradually looses its superconductivity. Type II superconductors start to loose their superconductivity at lower critical magnetic field (Hc1) and completely loose their superconductivity at upper critical magnetic field (Hc2).

- The state between the lower critical magnetic field (Hc1) and upper critical magnetic field (Hc2) is known as vortex state or intermediate state.
- After Hc2, the Type II superconductor will become conductor.
- Type II superconductors are also known as **hard superconductors** because of this reason that is they loose their superconductivity gradually but not easily.
- Type II superconductors obey Meissner effect but not completely.
- Example of Type II superconductors: NbN (Hc = 8 x 10^6 Tesla), $Babi_3$ (Hc = 59 x 10^3 Tesla)

Thermogravimetric analysis(TGA)

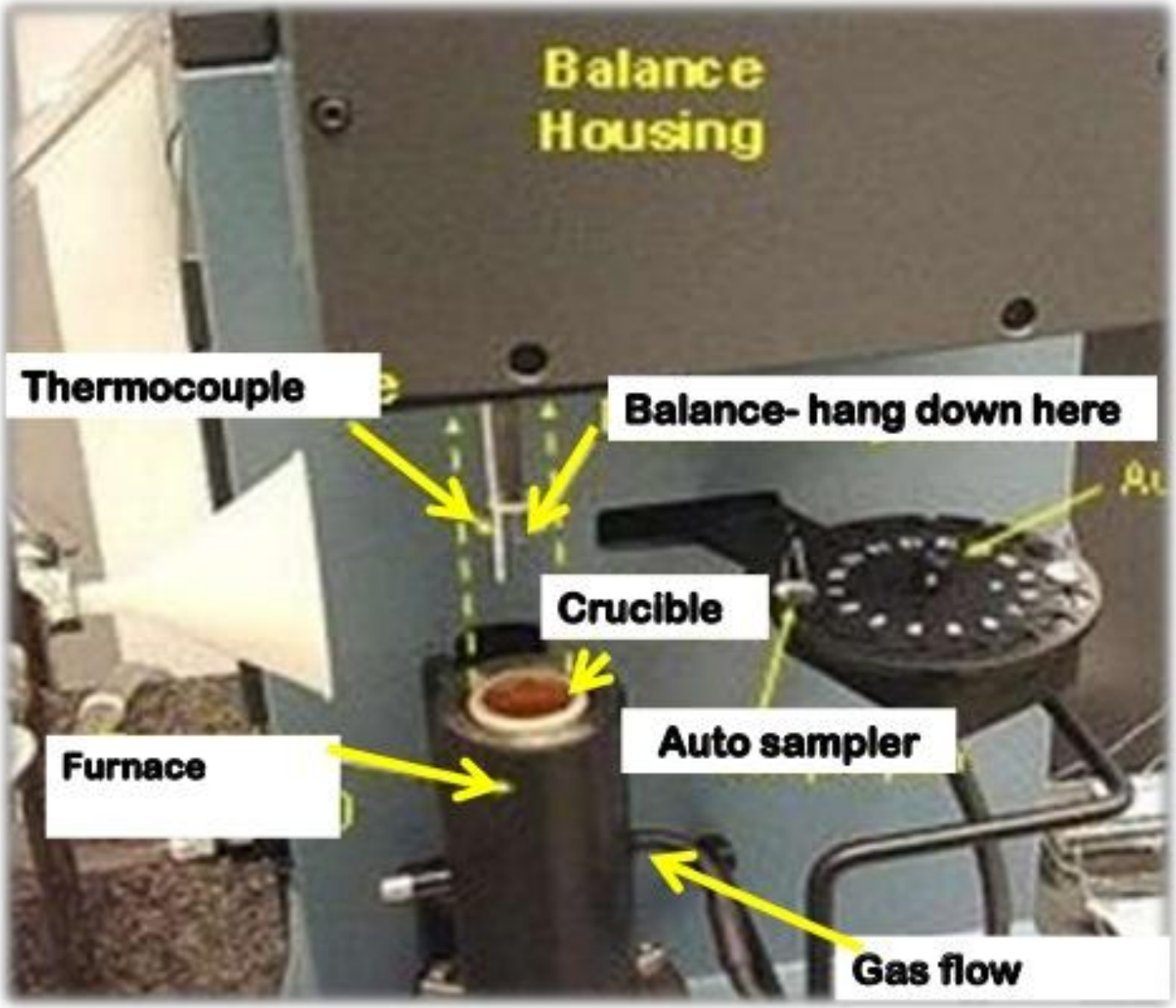
- **Principle:**

  In thermogravimetric analysis, the sample is heated in a given environment (air, N_2, CO_2, He, Ar, etc.) at controlled rate.

  The change in the weight of the substance is recorded as a function of temperature or time. The temperature is increased at a constant rate for a known initial weight of the substance and the changes in weights are recorded as a function of temperature at different time interval.

  This plot of weight change against temperature is called thermogravimetric curve or thermogram, this is the basic principle of TGA

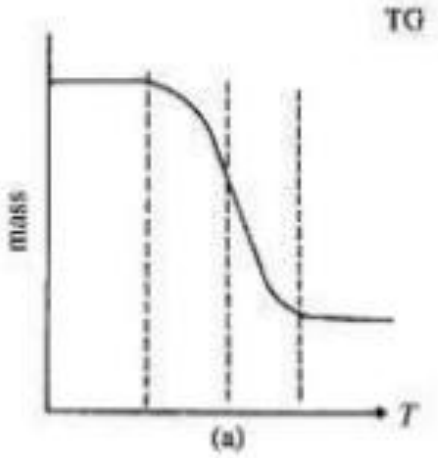
Thermal Gravimetric Instrument



Thermo gravimetric analysis (TGA)

- It is an analysis, the mass of sample is recorded continuously as its temperature is increased linearly from ambient to high temperature.

- Mass of material a functions of temperature.

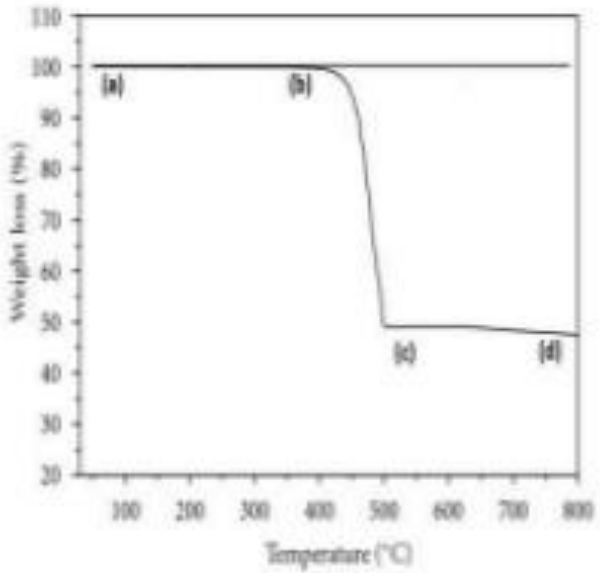


Reactant(s) → Product(s) + Gas (a mass loss)
Gas + Reactant(s) → Product(s) (a mass gain

Processes occurring without change in mass (e.g.- Physical transitions) cannot be studied by TG.

Example: TGA Curve for $AgNO_3$

- The horizontal portion of the curve indicates that, there is no change in weight (AB &CD) and the portion BC indicates that there is weight change.
- The weight of the substance ($AgNO_3$) remains constant upto a temperature of 473°C indicating that $AgNO_3$ is thermally stable upto a temperature of 473°C.
- At this temperature it starts losing its weight and this indicates that the decomposition starts at this temperature. It decomposes to NO_2, O_2 and Ag.



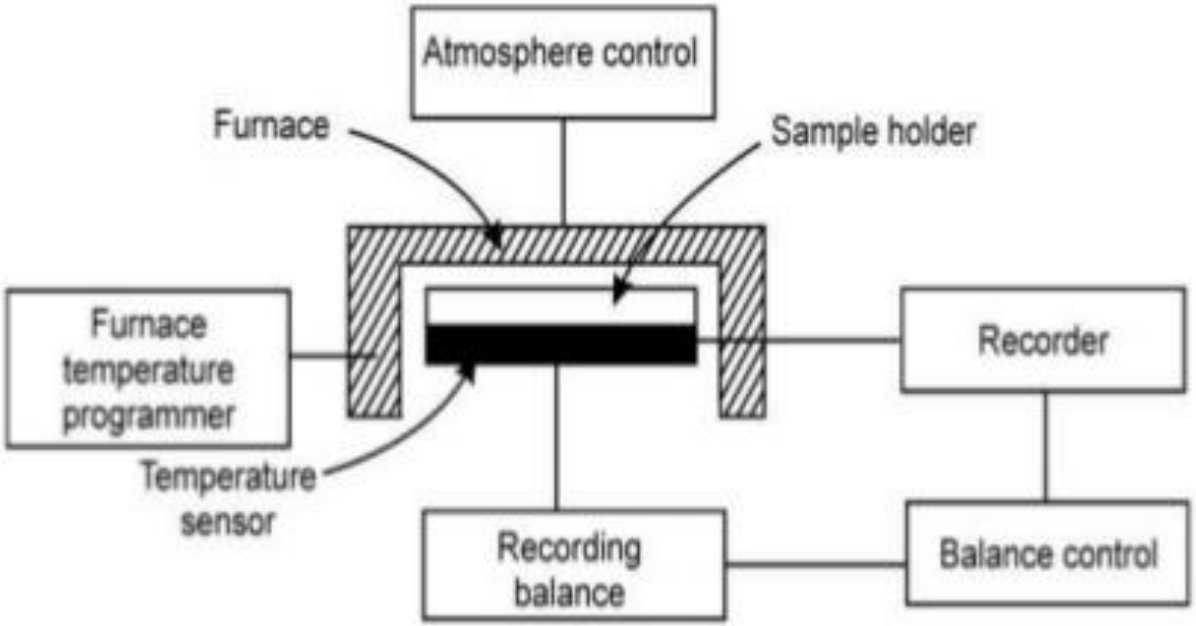
The diagram indicates the TGA curve for $AgNO_3$.

$$AgNO_3 \rightarrow Ag + NO_2 + O_2$$

TGA Curve for $AgNO_3$

- The loss in weight continues upto 608°C and beyond this temperature the weight of the sample remains constant, this is shown by the portion of the curve CD.
- The portion between BC, represents the decomposition of silver nitrate, the decomposition is complete at 608°C leaving metallic silver as the stable residue

Instrumentation / Block diagram of TGA



Instrumentation / Block diagram of TGA

The apparatus required for TGA analysis are

(a) A furnace which can be heated so that the temperature gives linearity with time.

(b) A furnace controlled thermobalance

- A known weight of the sample is taken in a crucible(c), which is enclosed by a furnace(F). The furnace(F) temperature is raised slowly, the temperature of the sample and the corresponding weight are taken.
- A platinum/platinum rhodium thermocouple is used to measure the sample temperature, and the change in weights are found out by finding the beam deflection on adding a known weight to the pan.(i.e) the change in the weight are recorded from the beam deflection.

Applications of TGA

- From TGA, we can determine the purity and thermal stability of both primary and secondary standard.
- Determination of the composition of complex mixture and decomposition of complex.
- For studying the sublimation behaviour of various substances.
- TGA is used to study the kinetics of the reaction rate constant.
- Used in the study of catalyst: The change in the chemical states of the catalyst may be studied by TGA techniques. (Zn-$ZnCrO_4$) Zinc-Zinc chromate is used as the catalyst in the synthesis of methanol.