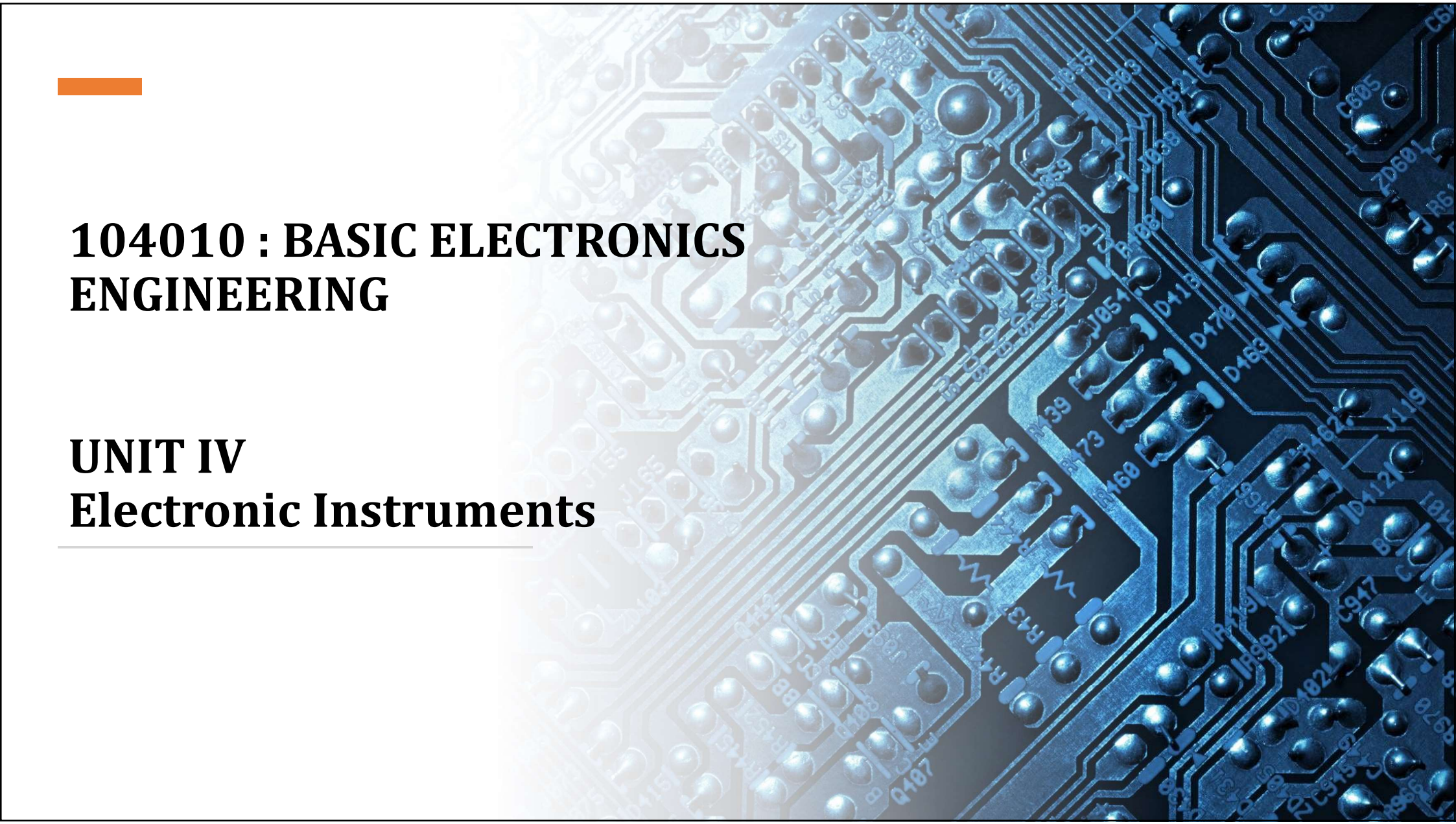
104010 : BASIC ELECTRONICS ENGINEERING

UNIT IV
Electronic Instruments



AC/DC Power Supply

Power Supply

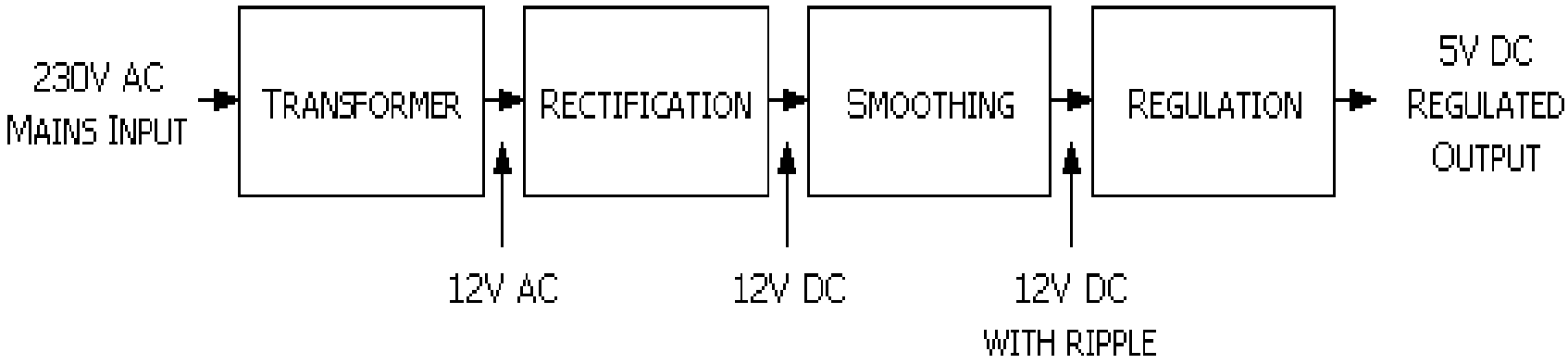
- A simple general purpose desktop power supply used in electronic labs, with power output connector seen at lower-left and power input connector located at the rear.
- A **power supply** is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct **voltage**, **current**, and **frequency** to power the load.

Books: Page No.: 424 David Bell

AC-to-DC Supply

- A DC power supply is one that supplies a constant DC voltage to its load. Depending on its design, a DC power supply may be powered from a DC source or from an AC source such as the power mains.
- DC power supplies use AC mains electricity as an energy source.
- Such power supplies will employ a transformer to convert the input voltage to a higher or lower AC voltage.
- A rectifier is used to convert the transformer output voltage to a varying DC voltage, which in turn is passed through an electronic filter to convert it to an unregulated DC voltage.
- The filter removes most, but not all of the AC voltage variations; the remaining AC voltage is known as *ripple*.
- The electric load's tolerance of ripple dictates the minimum amount of filtering that must be provided by a power supply.
- In some applications, high ripple is tolerated and therefore no filtering is required. For example, in some battery charging applications it is possible to implement a mains-powered DC power supply with nothing more than a transformer and a single rectifier diode, with a resistor in series with the output to limit charging current.

Block Diagram of DC Power Supply



DC Power Supply

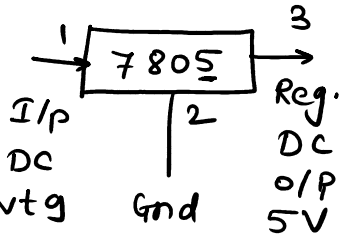
o/p of filter:

Circuit diagram :

i) Isolation
ii) overcurrent protection

Bridge Rectifier

Regulator Ic 7805:



7805: +5V
7809: +9V
7812: +12V
7905: -5V
7909: -9V
7912: -12V

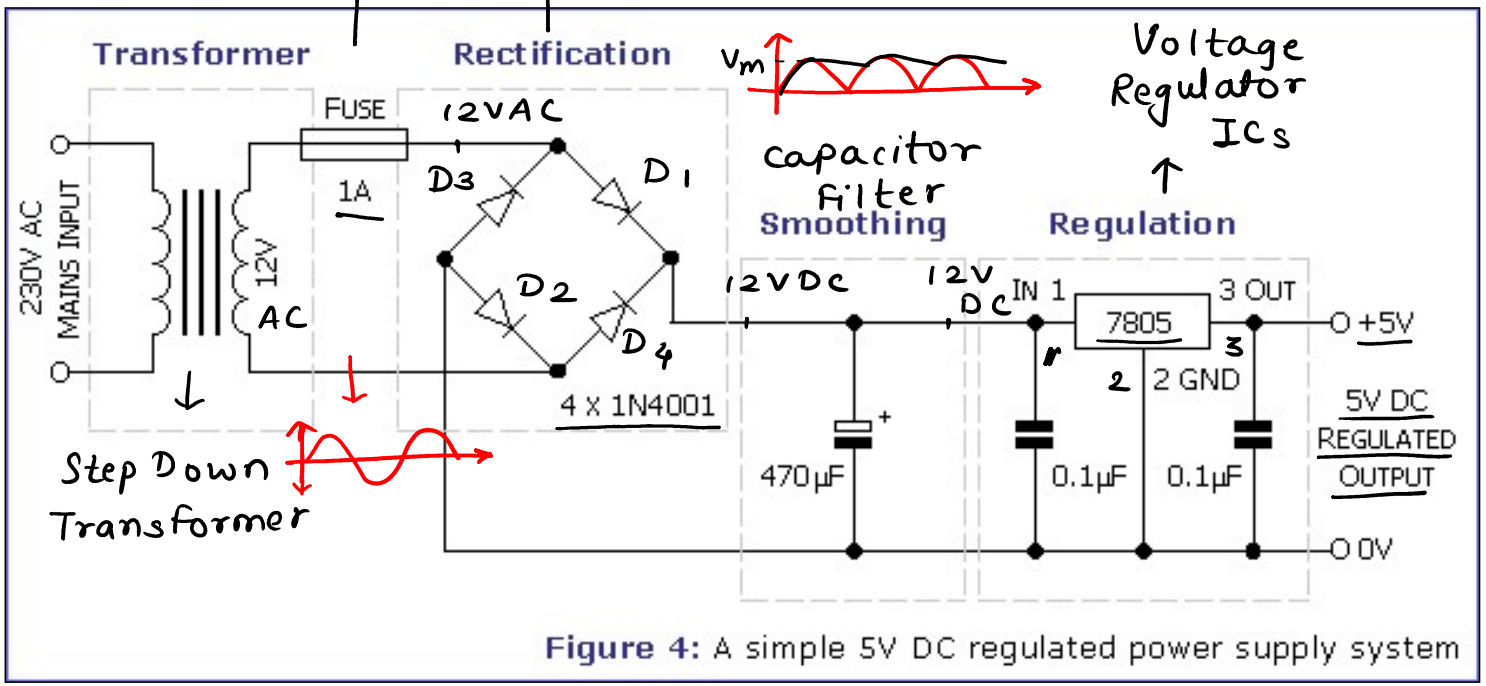


Figure 4: A simple 5V DC regulated power supply system

Voltage Regulator ICs

Variable voltage regulator ICs

Note: This configuration applies for 230V (Europe).

AC Power Supply

- An AC power supply typically takes the voltage from a wall outlet (mains supply) and uses a transformer to step up or step down the voltage to the desired voltage. Some filtering may take place as well.
- In some cases, the source voltage is the same as the output voltage; this is called an isolation transformer. Other AC power supply transformers do not provide mains isolation; these are called autotransformers; a variable output autotransformer is known as a variac. Other kinds of AC power supplies are designed to provide a nearly constant current, and output voltage may vary depending on impedance of the load. In cases when the power source is direct current, (like an automobile storage battery), an inverter and step-up transformer may be used to convert it to AC power.

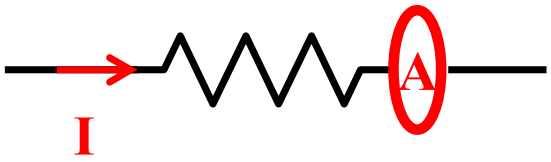
Power Supply

- The suitability : Determined by various attributes of the power supply, which are typically listed in the power supply's *specification*. Commonly specified attributes for a power supply include:
- Input voltage type (AC or DC) and range → AC /DC power source
- $\eta = \frac{P_{out}}{P_{in}}$ Efficiency of power conversion
- The amount of voltage and current it can supply to its load
- How stable its output voltage or current is under varying line and load conditions
  ↳ supply voltage
- How long it can supply energy without refueling or recharging (applies to power supplies that employ portable energy sources)
- Operating and storage temperature ranges

Measuring current, voltage, and resistance

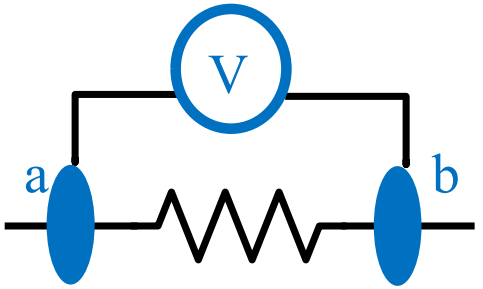
Ammeter:

- measures current (A) (Amperes)
- connected **in series**
  (current must go through instrument)



Voltmeter:

- measures potential difference (V)
- connected **in parallel**



Voltmeter

Books : Page No.740-783 A.K Shawaney, Page No. 57 Cooper, Page No. 68 Bowens

- A voltmeter is an instrument that measures the difference in electrical potential between two points in an electric circuit.
- An analog voltmeter moves a pointer across a scale in proportion to the circuit's voltage; a digital voltmeter provides a numerical display.
- Any measurement that can be converted to voltage can be displayed on a meter that is properly calibrated; such measurements include pressure, temperature, and flow.

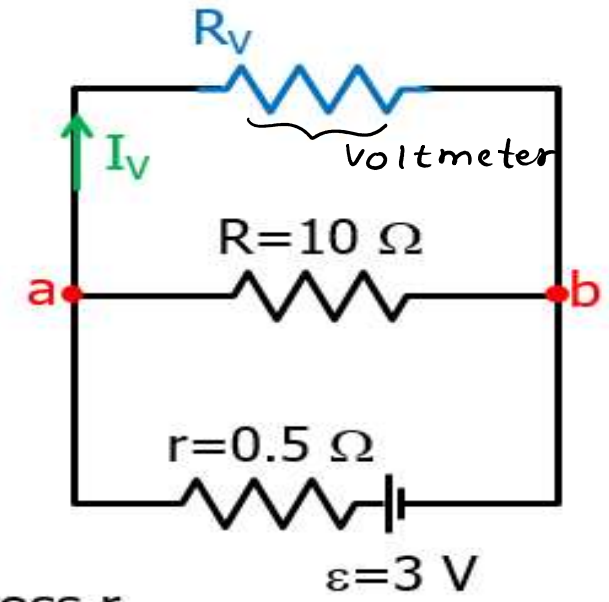
Effect of voltmeter on circuit

Measuring voltage (potential difference) V_{ab} in a simple circuit:

- connect voltmeter in parallel

Are we measuring the correct voltage?
(the voltage in the circuit without voltmeter)

- voltmeter has **some resistance R_V**
- **current** I_V flows through voltmeter
- extra current changes voltage drop across r and thus V_{ab}



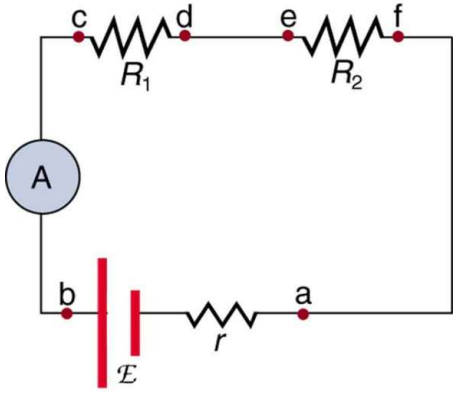
To minimize error, voltmeter resistance r must be very large.
(ideal voltmeter would have infinite resistance)

Voltmeter

- For a voltmeter to measure a device's voltage, it must be connected in parallel to that device.
- This is necessary because objects in parallel experience the same potential difference.

Ammeters

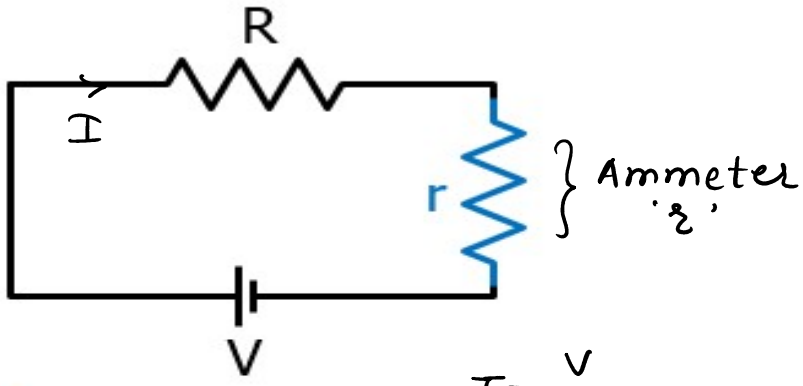
- An ammeter measures the electric current in a circuit. The name is derived from the name for the SI unit for electric current, amperes (A).
- For an ammeter to measure a device's current, it must be connected in series to that device. This is necessary because objects in series experience the same current. They must not be connected to a voltage source — ammeters are designed to work under a minimal burden, (which refers to the voltage drop across the ammeter, typically a small fraction of a volt).



Effect of ammeter on circuit

Measuring current in a simple circuit:

- connect ammeter in series



Are we measuring the correct current?
(the current in the circuit without ammeter)

- any ammeter has **some resistance r.**
- current in presence of ammeter is $I = \frac{V}{R+r}$.
- current without the ammeter would be $I = \frac{V}{R}$.

$I = \frac{V}{R+r}$

↳ Negligible

If $r = 0$,

$I = V/R$

To minimize error, ammeter resistance r must be very small.
(ideal ammeter would have zero resistance)

Difference between Ammeter & Voltmeter

- The major difference between the ammeter and the voltmeter is that the ammeter measures the flow of current, whereas the voltmeter measures the emf or voltage across any two points of the electrical circuit. The other differences between the ammeter and voltmeter are presented below in the comparison chart.
- Electricity is measured in two ways. i.e., either through current or voltage. The current and voltage of the circuit are measured through ammeter and voltmeter. The working principle of the ammeter and voltmeter are same as that of the galvanometer.
- The galvanometer uses a coil which is placed between the magnet. When the current flows through the coils, it becomes deflected. The deflection of the coils depends on the charge passing through it. This deflection is used for measuring the current or voltage. The galvanometer works as a voltmeter when the resistor is placed in series with the galvanometer.

Comparison between Ammeter and Voltmeter

Basis For Comparison	Ammeter	Voltmeter
Definition	The instruments used for measuring the current.	It measures the voltage between any two points of the circuit.
Symbolic Representation		
Resistance	Low	High
Connection	It is connected in series with the circuit.	It is connected in parallel with the circuit.
Accuracy	More	Less
Changing of Range	Not possible	Possible

Measurement Error

A measurable quantity is a property of phenomena, bodies, or substances that can be defined qualitatively and expressed quantitatively. Measurable quantities are also called physical quantities

True value of a *measurand* is the value of the measured physical quantity, which, would ideally reflect, both qualitatively and quantitatively, the corresponding property of the object

Measurement Error is the deviation of the result of measurement from the true value of the measurable quantity, expressed in absolute or relative form

Error = Measured or Observed – True Value

Types of Static Error

Gross Error (Human error): Due to human mistakes in reading or in using instruments or in recording observations.

- Errors may also occur due to incorrect adjustment of an instrument & computational mistakes.
- These errors can not be treated mathematically.

Types of Static Error

Systematic Errors:

- Due to shortcomings of the instrument, defective or worn parts, or ageing or effects of the environment on the instrument.

Random Errors:

- Remain after gross & systematic errors are reduced.
- Accumulation of a large no. of small effects.
- Concerned in measurements of high degree of accuracy.
- Can be analysed statistically.

Sources of Errors

Other than Inability of An Instrument

- Insufficient knowledge of process parameters & design conditions.
- Poor design.
- Change in process parameters, irregularities, upsets.
- Poor maintenance.
- Errors caused by person operating the instrument.
- Certain design limitations.

Absolute Error and Relative Error

If A_m is Observed or measured value of a physical quantity with A_t is its true value, then

Error or Absolute Error $\Delta A = A_m - A_t$

Relative Errors are Error expressed as fraction of true value.

Relative Error = $\Delta A / A_t$

and can be expressed in % by multiplying with hundred.

References:

- “Electronic Instrumentation” by H.S. Kalsi, 3rd Edition, Tata McGraw Hill.
- “Electronic Instrumentation and Measurement” by William D. Cooper, Albert D. Helfrick , Prentice Hall PTR.
- Web Resources

Thank you!