Unit 4: Instrumentation

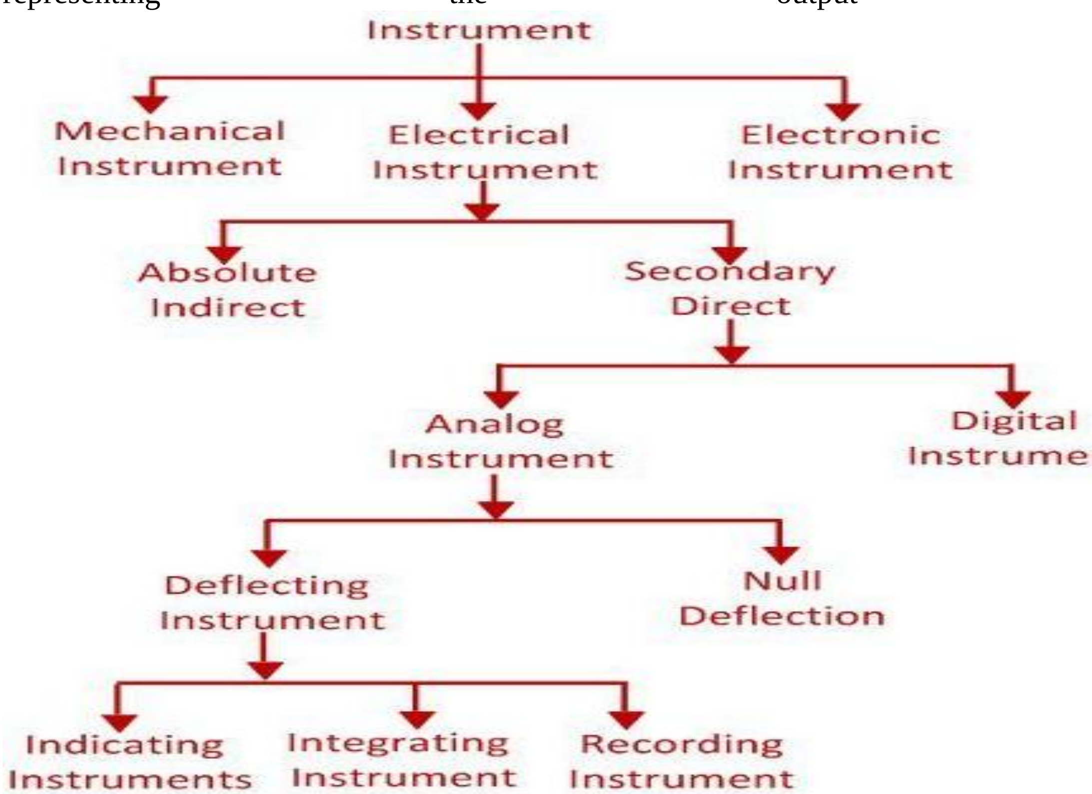
The instrument used for measuring the physical and electrical quantities is known as the measuring instrument. The term measurement means the comparison between the two quantities of the same unit. The magnitude of one of the quantity is unknown, and it is compared with the predefined value. The result of the comparison obtained regarding numerical value.

The measuring instrument categorised into three types;

- Electrical Instrument
- Electronic Instrument
- Mechanical Instrument

The mechanical instrument uses for measuring the physical quantities. This instrument is suitable for measuring the static and stable condition because the instrument is unable to give the response to the dynamic condition. **The electronic instrument has quick response time**. The instrument provides the quick response as compared to the electrical and mechanical instrument.

The electrical instrument is used for measuring electrical quantities likes current, voltage, power, etc. The ammeter, voltmeter, wattmeter are the examples of the electrical measuring instrument. The ammeter measures the current in amps; voltmeter measures voltage and Wattmeter are used for measuring the wer. The classification of the electric instruments depends on the methods of representing the output reading.



Absolute Instrument

The absolute instrument gives the value of measures quantities regarding the physical constant. The physical constant means the angle of deflection, degree and meter constant. The mathematical calculation requires for knowing the value of a physical constant.

The tangent galvanometer is the examples of the absolute instruments. In tangent galvanometer, the magnitude of current passes through the coil determines by the tangent of the angle of deflection of their coil, the horizontal component of the earth magnetic field, radius and the number of turns of wire used. The most common applications of this type of instrument are found in laboratories.

Secondary Instrument

In the secondary instrument, the deflection shows the magnitude of the measurable quantities**.** The calibration of the instruments with the standard instrument is essential for the measurement. The output of this type of device is directly obtained, and no mathematical calculation requires for knowing their value.

Digital Instrument

The digital instrument gives the output in the numeric form**.** The instrument is more accurate as compared to the analogue instrument because no human error occurs in the reading.

Analog instrument

The instrument whose output varies continuously is known as the analogue instrument. The analogue instrument has the pointer which shows the magnitude of the measurable quantities. The analogue device classifies into two types.

Null Type Instrument

In this instrument, the zero or null deflection indicates the magnitude of the measured quantity. The instrument has high accuracy and sensitivity. In null deflection instrument, the one known and one unknown quantity use. When the value of the known and the unknown measuring quantities are equal, the pointer shows the zero or null deflection. The null deflection instrument is used in the potentiometer and in galvanometer for obtaining the null point.

Deflection Type Instrument

The instrument in which the value of measuring quantity is determined through the deflection of the pointer is known as the deflection type instrument. The measuring quantity deflects the pointer of the moving system of the instrument which is fixed on the calibrated scale. Thus, the magnitude of the measured quantity is known.

The deflection type instrument is further sub-classified into three types.

1. **Indicating Instrument** – The instrument which indicates the magnitude of the measured quantity is known as the indicating instrument**.** The indicating instrument has the dial which moves on the graduated dial. The voltmeter, ammeter, power factor meter are the examples of the indicating instrument.
2. **Integrating Instrument** – The instrument which measures the total energy supplied at a particular interval of time is known as the integrating instrument. The total energy measured by the instrument is the product of the time and the measures electrical quantities. The energy meter, watt-hour meter and the energy meter are the examples of integrating instrument.
3. **Recording Instrument** – The instrument records the circuit condition at a particular interval of time is known as the recording instrument**.** The moving system of the recording instrument carries a pen which lightly touches on the paper sheet. The movement of the coil is traced on the paper sheet. The curve drawn on the paper shows the variation in the measurement of the electrical quantities.

The response time of the electronic instrument is very high as compared to the electrical and mechanical device.
Digital levels use electronic image processing to evaluate the special bar-coded staff reading, This bar-coded pattern is converted into elevation and distance values using a digital image matching procedure within the instrument.

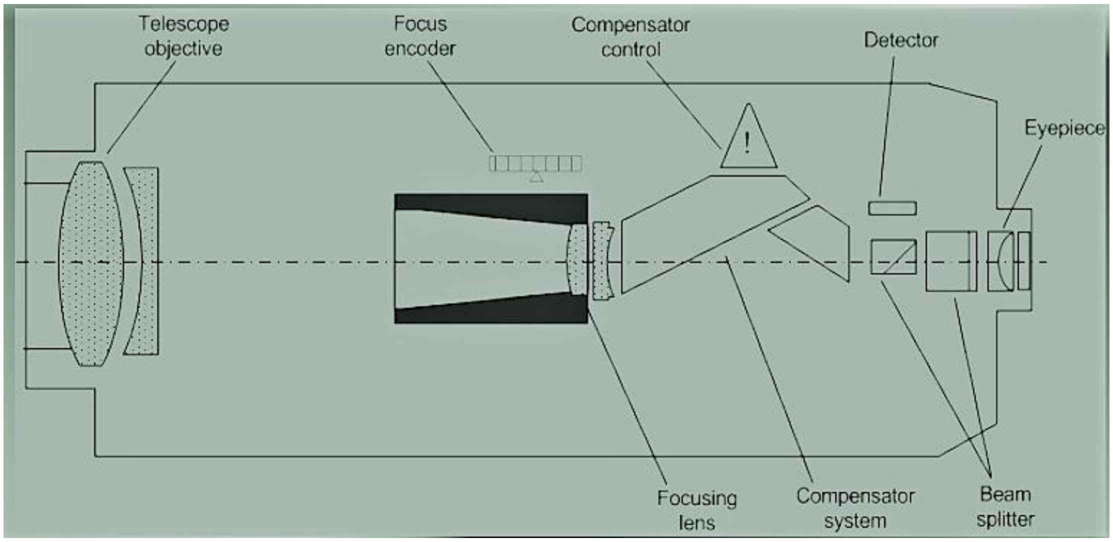
Advantages of digital level

- Correction of collimation error: Can be reliably determined and saved using the four integrated Check and Adjust procedures or it can be entered manually
- Minimize human error: Fatigue-free observation as visual staff reading by the observer is not required.
- User friendly menus with easy to read, digital display of results.
- Earth curvature correction: The measurements made are automatically free of the influence of the earth’s curvature.
- Measurement of consistent precision and reliability due to automation.
- Automatic data storage eliminates booking and its associated errors.
- We can operate in low light conditions.
- Fast, economic surveys resulting in saving in time (up to 50% less effort has been claimed by manufacturers).
- Data on the storage medium of the level can be downloaded to a computer enabling quick data reduction for various purposes.

Components of digital level

Main components of digital level consist of two parts:

- **Hardware (Digital level and levelling staff)and**
- **Software**.



Components of digital level

1. Both digital level and associated staff are manufactured so that they can be used for both conventional and digital operations.
2. Typically digital level has the same optical and mechanical components as a normal automatic level.
3. However, for the purpose of electronic staff reading a beam splitter is incorporated which transfers the bar code image to a detector diode array.
4. The light, reflected from the white elements only of the bar code, is divided into infrared and visible light components by the beam splitter.
5. The visible light passes on to the observer, the infrared to diode array.
6. The acquired bar code image is converted into an analogous video signal, which is then compared with a stored reference code within the instrument.

Types of digital levels

1. Spinter 50
2. Spinter 150
3. Spinter 150m


Leica DNA Digital Level Spinter

4. Spinter 250m
5. Leica DNA10 Digital Level
6. Leica DNA03 Digital Level

Total station

- The Total station is designed for measuring of slant distances, horizontal and vertical angles and elevations in topographic and geodetic works, tachometric surveys, as well as for solution of application geodetic tasks. The measurement results can be recorded into the internal memory and transferred to a personal computer interface.
- The basic properties are unsurpassed range, speed and accuracy of measurements. Total stations are developed in view of the maximal convenience of work of the user. High-efficiency electronic tachometers are intended for the decision. it has the broad audience for sole of industrial problems.
- Angles and distances are measured from the total station to points under survey, and the coordinates (X, Y, and Z or northing, easting and elevation) of surveyed points relative to the total station position are calculated using trigonometry and triangulation.
- Data can be downloaded from the total station to a computer and application software used to compute results and generate a map of the surveyed area.
- A **total station** is an electronic/optical instrument used in modern surveying. It is also used by archaeologists to record excavations as well as by police, crime scene investigators, private accident Reconstructionists and insurance companies to take measurements of scenes. The total station is an electronic theodolite (transit) integrated with an electronic distance meter (EDM), plus internal data storage and/or external data collector.
    - The purpose of any survey is to prepare maps, control points formed a basic requirement for the preparation of these maps.
    - There are several numbers of methods like traverse, triangulation etc., to provide these control points.
    - Whatever the method the provision of control points, includes the measurement of two entities(Distance and Angle).
    - Again, distance can be measured by using various instruments like **chain, tape.**
    - Linear Tap.
    - Gunter’s chain (20m and 30m).
    - Steel band(20m and 30m).
    - Inver tap.
    - Hunter Short Base (80m).
    - Electronic Distance Measurement Instruments, Total station and GPS.
    - Electronic Distance Measurement Instruments, Total station and GPS.
    - Angle can be measured by using a THEODOLITE.
    - Once distance and angular measurement is over computation is performed to provide the control points. A combination of all the three results in a powerful instrument called total station. hence, the total station is an instrument which consists of the following:

i) Distance measuring instrument (EDM).

ii) An angle measuring instrument (Theodolite).

iii) A simple microprocessor.. Instrumentation:

It consists of an EDM, Theodolite, Microprocessor combined into one. It also has a memory card to store the data. It also consists of battery socket which houses the battery. A fully charged battery works for about 3 to 5 hrs continuously.

Accuracy of a Total Station:

Accuracy depending upon the instrument and varies from instrument to instrument
1.The angular accuracy varies from1″ to 20 ″.
2.Distance accuracy depends upon two factors.
Instrumental error which ranges from
+ / – 10mm to + / – 2mm.
b) Error due to the length of measurement.
It can be from + / – 10mm to + / – 2mm per kilometre.

Accuracy & Precision
• Precision is the reproducibility of the measurement.
• Accuracy is how close the measured position is to the actual location
Measurement of distance is accomplished with a modulated microwave or infrared carrier signal, generated by a small solid-state emitter within the instrument's optical path, and reflected by a prism reflector or the object under survey. The modulation pattern in the returning signal is read and interpreted by the onboard computer in the total station. The distance is determined by emitting and receiving multiple frequencies, and determining the integer number of wavelengths to the target for each frequency. Most total stations use purpose-built glass Porro prism reflectors for the EDM signal, and can measure distances to a few kilometers. Reflectorless total stations can measure distances to any object that is reasonably light in color, to a few hundred meters.

Principle:

Total station can be used

- When two points are given.
- When only one co-ordinate is given. In this case the coordinate of the back station is determined by any suitable method.
- When no co-ordinates were given in which case arbitrary system of coordinates can be used.

These devices, also called electronic Tachometers, can automatically measure horizontal and vertical angles as well as slope distances from a single set up. From these data they can instantaneously compute horizontal and vertical distance components, elevations, and coordinates, and display the results on LCD. They can also store the data, either on board or in external data collectors. If the coordinates of the occupied station and a reference azimuth are input to the system, the coordinates of the sighted point are immediately obtained. This information can be directly stored in an automatic data collector, there by eliminating manual recording. These instruments are of tremendous value in all types of surveying. Total Stations offer many advantages for almost all types of surveying. They are used for topographic, Hydrographic, cadastral, project and construction surveys.

Operation of Total Station

Because the Total Station contains delicate electronic components they are not as rugged as ordinary Theodolite. They must be packed and transported carefully, handled gently and carefully removed form their cases.

The setting of Total Station over the station mark is similar to an ordinary Theodolite. This includes

- Centring
- Levelling
- Removal of parallax

Total Stations are controlled with entries made either through their built-in keyboards or through the keyboards of hand-held data collectors.Details for operating each individual total station vary somewhat and therefore are not described here.

The accuracy achieved with total station is mainly depends on operator procedure of Careful centering and levelling of the instrument

- Accurate pointing at targets.
- Taking averages of multiple angle measurements made in both direct and reverse positions

Peripheral equipment that can affect accuracy includes

- Tribrachs
- Optical plummets
- Prism and
- Prism poles

Tribrachs must provide a snug fit without slippage. Optical plummets that are out of adjustment cause instruments to be set up erroneously over the measurement point. The prism poles should be perfectly vertical and prism should be well fitted on that. Prisms should be checked frequently to determine their constants.

Applications of Total Station

There are many other facilities available, the total station can be used for the following purposes.

- Detail survey i.e., data collection.
- Control Survey (Traverse).
- Height measurement (Remove elevation measurement- REM).
- Fixing of missing pillars (or) Setting out (or) Stake out.
- Resection.
- Area calculations, etc.
- Remote distance measurement (RDM) or Missing line measurement (MLM).

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Data Collection Option

Measurements can be stored "on board" with all the total stations. The two options that are available are

- Data can be stored directly in the memory of the microcomputer, and later downloaded to an external storage device via a RS – 232 connections.
- The second option is the removable memory card. When one card is full, it can be removed and another card can be quickly installed.

Detail Survey

Given two points whose coordinates are known, a total station can be used to get the coordinates of various other points based upon those two co-ordinates. Care should be taken that the new points survey are carefully coded. The Map of the area can be obtained after downloading and processing.

Control Survey / Traverse:

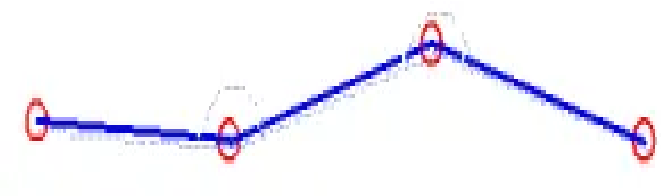
It is similar to any type of EDM Traverse.

Definition of Traverse: –

Traverse is the method of control survey in providing horizontal and vertical controls along a pre-defined route by means of establishing a series of connected lines joining the traverse stations.

Traverse:

- In traverse a number of connected survey lines form a framework of survey.
- The direction and length of survey lines are measured with the help of an angular measuring device (Theodolite) and distance measuring device (Tape, chain, EDM, GPS etc.).

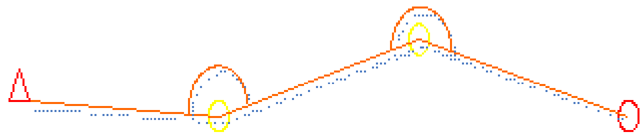


Classification of Traverse (Based on accuracy & Based on Instrument used):

- Based on accuracy
- Primary traverse: accuracy 1:50,000 (Instrument: T3 and invar wire)
- Secondary traverse: accuracy 1:20,000 (Instrument: T3 and EDM)
- Tertiary traverse: accuracy 1:1000 (Instrument: T2 and Chain) 1:2000 (Instrument: T2 and Steel Band)
- Based on Instrument used
- Chain traverse

- EDM traverse
- Plane-table traverse

  - **Open traverse:** Starts from a known control point and ends at unknown point.



  - **Closed traverse:** Starts from and ends at known control points.

  - **Closed Circuit traverse:** Starts from and ends at known control points.