

SURVEYING

C.LAKSHUMANAN

DEPARTMENT OF REMOTE SENSING

BHARATHIDASAN UNIVERSITY

DEFINITION

- Surveying is the art, science and technology of determining the position of objects of interest.

(or)

- Surveying is the art of representing the relative positions of various objects within the field, correctly on a map.

- **MEASUREMENT CONCERNED**

1. Measurement of horizontal distances
2. Measurement of directions and
3. Measurement of heights

- **FIELD WORK CONCERNED**

1. Taking measurements including handling instruments
2. Recording the measurements
3. Plotting the data and preparation of the map.

TYPES OF SURVEYING

- Plane Surveying
 - Curvature of Earth IS NOT Considered
- Geodetic surveying
 - Curvature of Earth IS Considered

- When the area to be surveyed is large,
 - 1) The surveyor has to take into consideration the spheroidal shape of the earth
 - 2) He has to make elaborate computation to eliminate the influence of the curvature of the earth's surface in the GEODETIC survey.

- In a survey of smaller areas, this is negligible and hence does not affect the measurements.
- The curvature of the earth surface is not taken into account such survey is known as PLANE survey.

PLANE SURVEY further divided into several categories,

- Land surveying
- Topographical surveying
- Geographical surveying
- Route surveying

- For map preparation two procedures with respect to area available:

1) To survey and prepare the map of large area then divided into maps of smaller areas or sheets.

2) To survey and prepare maps of smaller areas and then to combine them (not in use)

MEASUREMENTS AND METHODS

- Estimation / Pacing
- Measurement of Levels (MSL)
- Measurement of Angles
- Measurement of Distances
- Traversing
- Triangulation
- Trilateration
- Computation of Co ordinates

INSTRUMENTS USED FOR SURVEYING

- Chain / Tape /Plane Tables
- Compass
- Leveling Instrument
- Theodolite
- EDM / MWDMS
- Total Stations
- GPS

USES OF SURVEYING

- To find the Co ordinates of Points of Interest
- To find the Levels of Points of Interest
- Distance between Points (Horizontal and Sloping)
- Height Difference between Points
- To find Geographic / Geodetic Co-ordinates.
- Mapping

TRIANGULATION

- TRIANGULATION consists of dividing large areas into a number of triangles
 - Theodolite used to find out the horizontal angle between various triangles or trigonometrical stations
 - With help of trigonometry the lengths of other sides can be calculated

- **Advantages of triangulation:**

- 1) Map of large areas can be prepared in lesser time
- 2) The accuracy of the map remains very high
- 3) Map of smaller areas can be easily obtained by splitting the larger map

TRAVERSING

- Traversing is a less finished or less delicate method of surveying. It constituted by measuring all distances that are traversed (walked over)
- This is a rapid and approximate method
- All distances measured along the ground
- Corrections for slope can be made if necessary
- Traversing generally preferred when surveying is done alone along the path, wherever turn or curve exist the angle should be measured.
- **(Two things are to be measured: Distances along connected lines and Angles between connected lines)**

- TRAVERSING divided into two
 - 1) Open traverse
 - 2) Closed traverse
- Traverse may be used with different types of instruments generally they are done with compass.
- When rapid and rough area works means with Theodolite.

CHAIN SURVEYING

- The simplest method of determining distances
 - Usually horizontal distance (some time through slope areas)
 - Direct measurement with chain and tape is known as chaining.

- When boundaries are to be carefully marked mostly in dividing estates and land properties
 - To avoid conflict with adjacent owners
 - so that chain survey is called boundary survey
- The area should be smaller
- The country should be open and too many obstacles do not bar the view
- Isolated details can be located (e.g Lake or well)
- Chaining is a slow and time consuming processes of surveying, it is only restored when accuracy is to be ensured at the cost of time

INSTRUMENTS USED FOR CHAIN SURVEY

- Chain
- Tape
- Arrows
- Ranging rods
- Offset rods
- Cross staff
- Plumb bob
- Pegs
- Survey field book, pencil, pen .,etc

TYPES OF CHAIN

- Metric chain
- Steel band
- Engineers chain
- Gunter's chain
- Revenue chain

TYPES OF TAPE

- Cloth (or) Linen tape
- Metallic tape
- Invar tape
- Steel tape

BASICS OF SURVEYING

Surveying is the art of determining the relative positions of points on, above or beneath the surface of the earth by means of direct or indirect measurements of distance, direction and elevation. It also includes the art of establishing points by predetermined angular and linear measurements.

Levelling is a branch of surveying the object of which is 1) to find the elevation of points with respect to a given or assumed datum. And 2) to establish points at a given elevation or at different elevations with respect to a given or assumed datum.

The knowledge of surveying is advantageous in many phases of engineering. The earliest surveys were made in connection with land surveying. Practically, every engineering project such as water supply and irrigation schemes, railroads and transmission lines, mines, bridges and building etc., require surveys. Before plans and estimates are prepared boundaries should be determined and the site should be ascertained. After the plans are made the structure must be staked out on the ground. As the work progresses, lines and grades must be given.

In surveying, all measurement of lengths are horizontal, or else are subsequently reduced to horizontal distances. The object of a survey is to prepare plane or map so that it may represent plane. A plan or map is the horizontal projection of an area and shows only that horizontal distances of the points. Vertical distance between the points are, however shown by contour lines, hachures or some other methods. Vertical distance are usually represented by means of vertical sections drawn separately.

Primarily survey can be divided into two classes:

1. Plane Surveying
2. Geodetic surveying

Plane Surveying

Plane Surveying is that type of surveying in which the mean surface of the earth is considered as a plane and the spheroidal shape is neglected. All triangles formed by survey lines are considered as plane triangles. The level line is considered as straight and all plumb lines are considered parallel. In everyday life we are concerned with small portions of earth's surface and the above assumptions seem to be reasonable in light of the fact that the length of an arc 12 kilometers long lying in the earth's surface is only 1 cm greater than the subtended chord and further that the difference between the sum of the angles in a plane triangle and the sum of those in a spherical triangle is only one second for a triangle at the earth's surface having an area of 195 sq.km.

Geodetic surveying

Geodetic surveying is that type of surveying in which the shape of the earth is taken into account. All lines lying in the surface are curved lines and the triangles are spherical triangles. It therefore involves spherical trigonometry. All Geodetic survey include work of larger magnitude and high degree of precision. The object of geodetic survey is to determine the precise position on the surface of the earth of a system of widely distant points which form control stations which surveys of less precision may be referred.

CLASSIFICATION

Surveys may be classified under headings which define the user or purpose of the resulting maps.

CLASSIFICATION BASED UPON THE NATURE OF THE FIELD OF SURVEY:

1) Land Surveying

- I. **Topographical Surveying:** This consists of horizontal and vertical location of certain points by linear and angular measurements and is made to determine the natural features of a country such as river streams, lakes, woods, hills, etc., and such artificial features as roads, railways, canals, towns and villages.
- II. **Cadastral Surveys:** Cadastral surveys are made incident to the fixing of property lines the calculation of land area, or the transfer of land property from one owner to another. They are also made to fix the boundaries of municipalities and of State and Federal jurisdictions.
- III. **City Surveying:** They are made in connection with the construction of streets, water supply systems, sewers and other works.

2) Marine or Hydrographic Survey. Marine or hydrographic survey deals with bodies of water for purpose of navigation, water supply, harbour works or for the determination of mean sea level. The work consists in measurement of discharge of streams, making topographic survey of shores and banks taking and locating soundings to determine the depth of water and observing the fluctuations of the ocean tide.

3) Astronomical Survey. The astronomical survey offer the surveyor means of determining the absolute location of the point or the absolute location and direction of any line on the surface of the earth. This consists in observations to the heavenly bodies such as the sun or any fixed star.

B. CLASSIFICATION BASED ON THE OBJECT OF SURVEY

1. Engineering Survey. This is undertaken for the determination of quantities or to afford sufficient data for the designing of engineering works such as roads and reservoirs, or those connected with sewage disposal or water supply.
2. Military Survey. This is used for determining points of strategic importance.
3. Mine Survey: This is used for the exploring mineral wealth.
4. Geological Survey. This is used for determining different strata in the earth's crust.
5. Archaeological Survey: This is used for unearthing relics of antiquity.

C. CLASSIFICATION BASED ON INSTRUMENTS USED

An alternative classification may be based upon the instruments or methods employed, the chief types being:

1. Chain Survey
2. Theodolite survey
3. Traverse survey
4. Triangulation survey
5. Tacheometric survey
6. Plane table survey
7. Photographic survey
8. Aerial survey

EDM & TOTAL STATION

ELECTROMAGNETIC DISTANCE MEASUREMENT (EDM) & TOTAL STATION

- EDM is a general term embracing the measurement of distance using electronic methods. In Electromagnetic (or Electronic) method, distances are measured with instruments that rely on propagation, and subsequent reception of either light or microwaves
- using Theodolite. The range is limited to 150m only and also the accuracy obtained is 1 in 1,000 and 1 in 10,000
- Electromagnetic Distance Measurement (EDM) enables the accuracy up to 1 in 10, for range up to 5 km.
- The total spectrum of electromagnetic radiation used in Electro-optical and Microwave distance measurements encompasses wavelengths from the visible light of about 5×10^{-7} to about 3×10^4 m at the radio frequency region

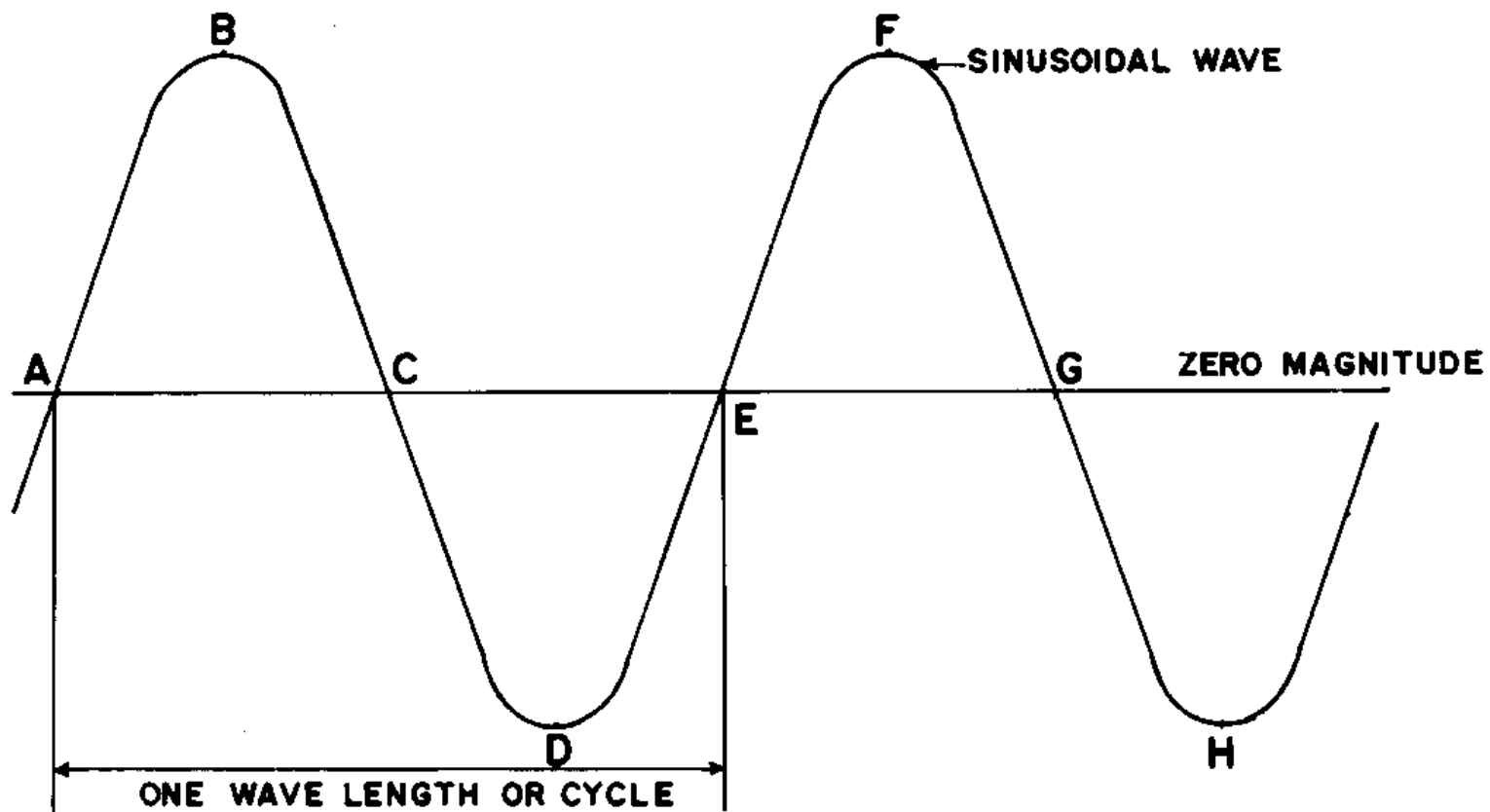


Fig 1. PERIODIC SINUSOIDAL WAVES

BASIC PRINCIPLE OF EDM

- Electromagnetic measurement of distance depends on electromagnetic waves (light or microwave) that travel through air with a velocity (V) of about 3×10^8 m/sec from point A to point B and return as shown in the figure

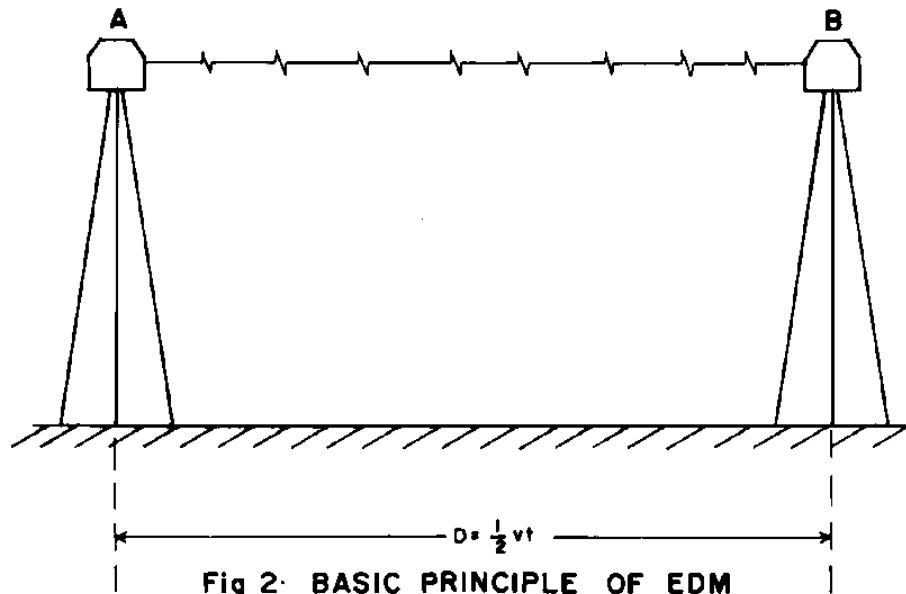


Fig 2. BASIC PRINCIPLE OF EDM

PHASE COMPARISON

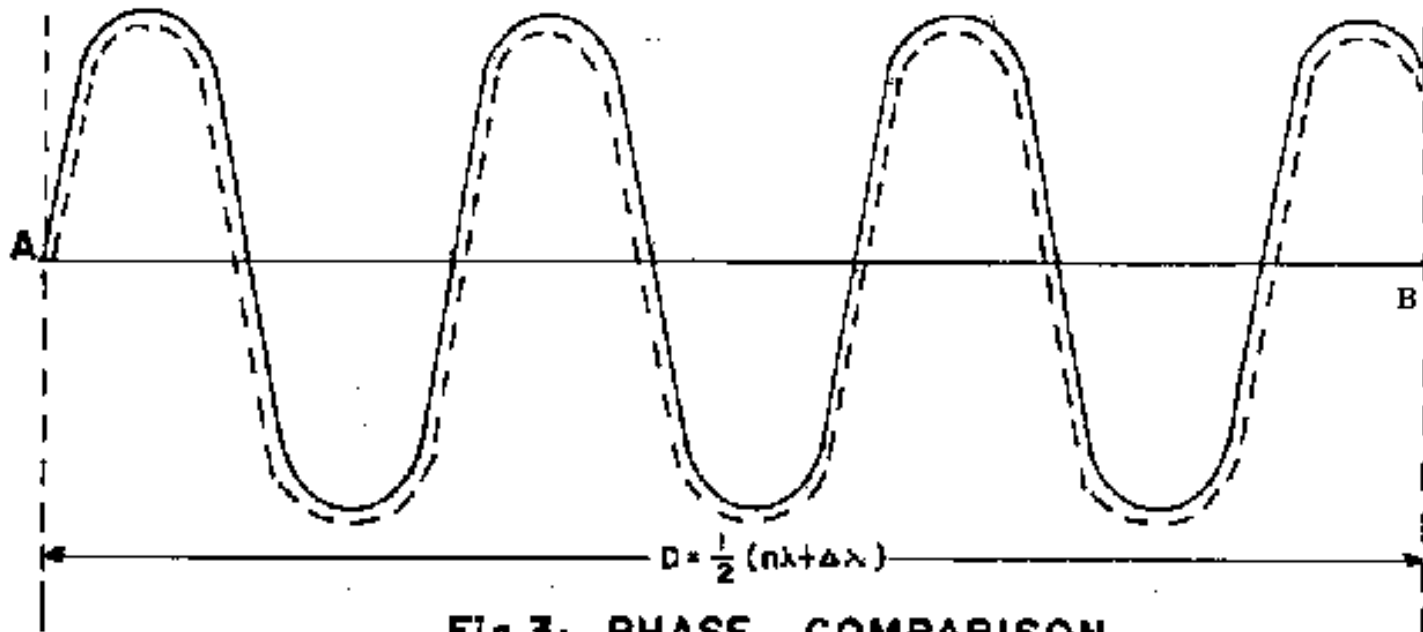


Fig 3. PHASE COMPARISON

MODULATION

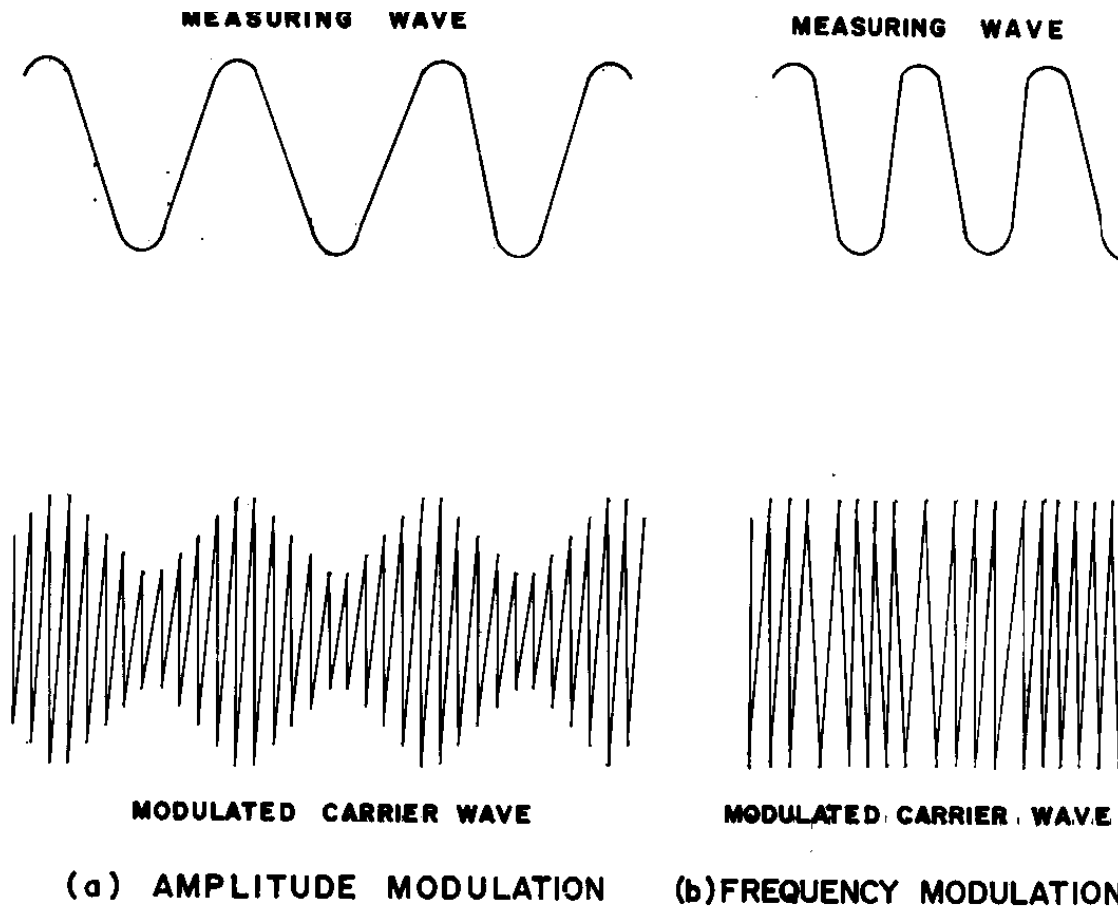


Fig4- MODULATION

DEMODULATION

- It is the process of separating the modulation signal from the modulated carrier wave in the receiver.

MEASURING PRINCIPLES OF EODMS

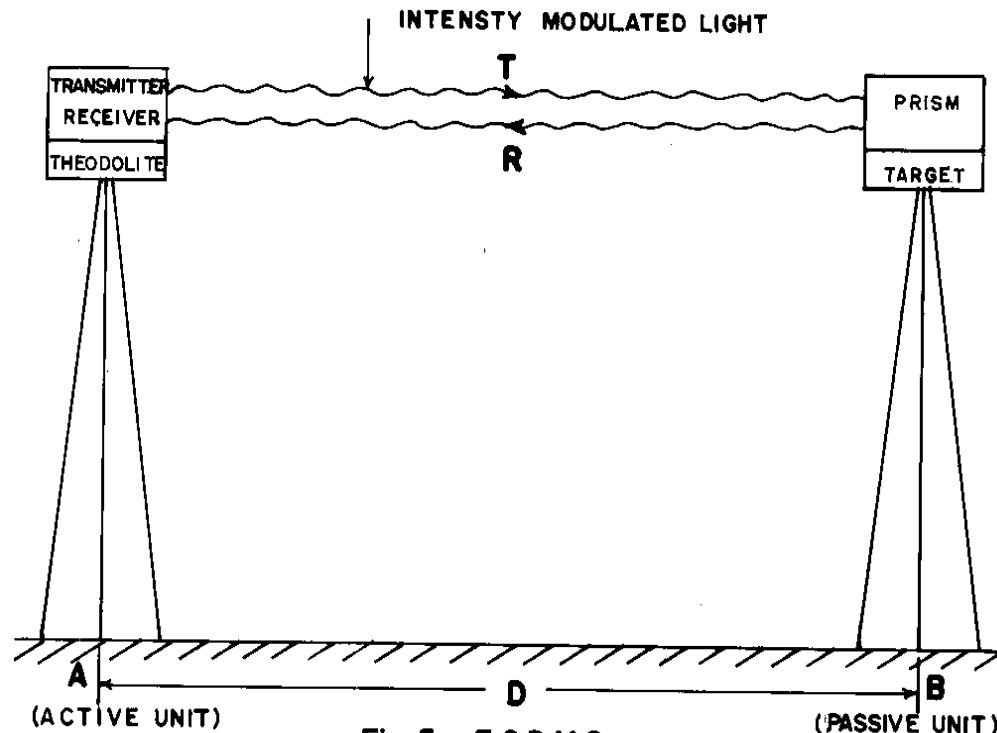


Fig 5. EODMS

The details of function of the EODMS are:

1. Generation of Carrier (Light Emitting Diode) and measuring wave (crystal controlled oscillator)
2. Modulation of waves (Kerr cell / pockels modulator) Here, Intensity/Amplitude Modulation technique is used.
3. Transmission of intensity modulated light through air (optics arrangement)
4. Reflection of transmitted ray by the reflector (Prism)
5. Reception of the reflected ray at the receiver of the active unit (optics arrangement)
6. Demodulation of measuring wave from intensity modulated carrier. (Photo diode)
7. Phase comparison between transmitted and received signals. Here, phase delay / Digital technique is used.
8. Display of the distance within a few millimeters in the Liquid Crystal Display (LCD) screen.

MEASURING PRINCIPLES OF MWDMS

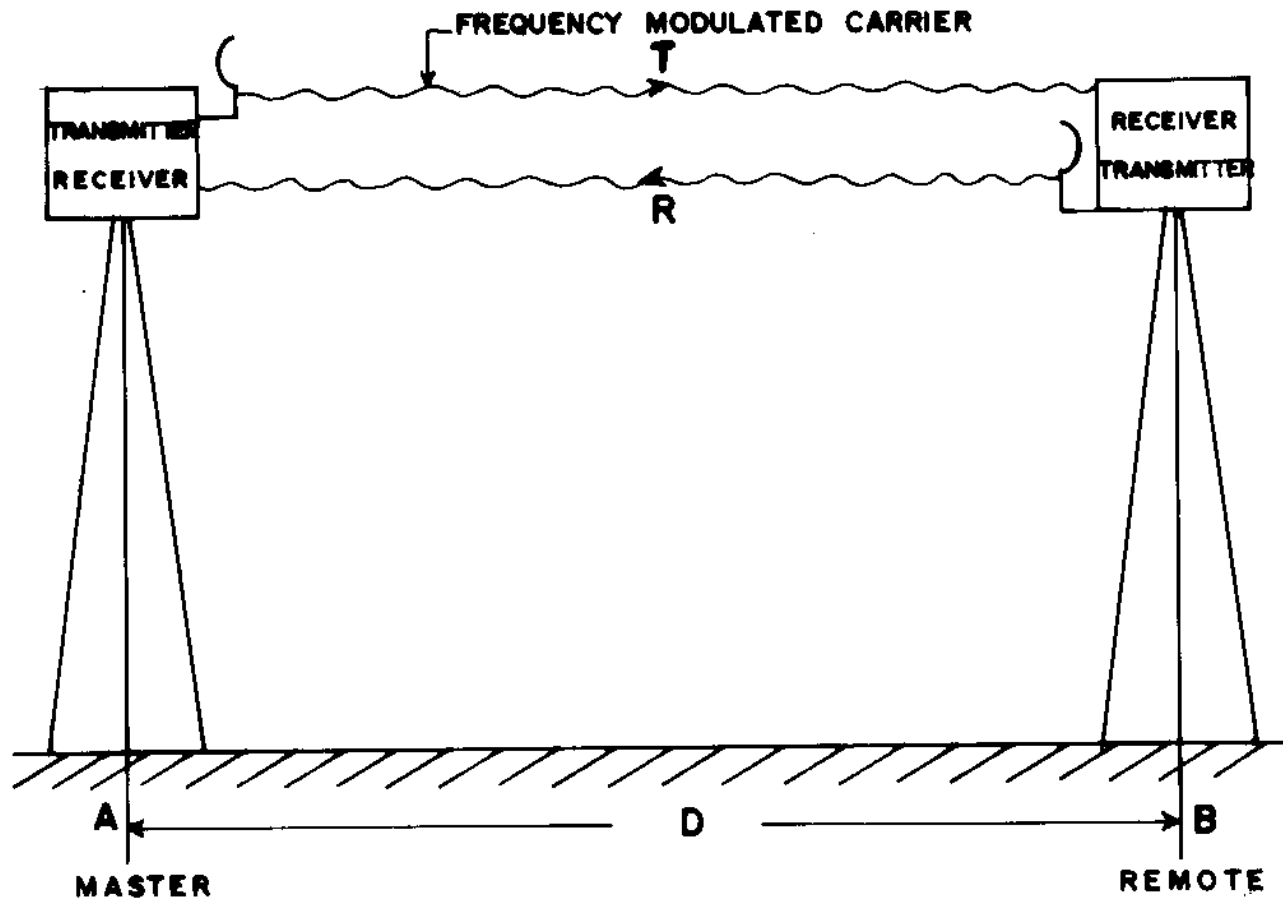


Fig 6. MWDMS

The details of function of the MWDMS are:

1. Generation of carrier (Gunn diode) and measuring wave (Crystal Controlled Oscillator)
2. Modulation of waves (Klystron tube) at the master unit. Here, frequency modulation technique is used.
3. Transmission of frequency modulated carrier through air (antenna arrangement)
4. Reception and demodulation of measuring wave at remote unit.
5. Modulation of measuring wave generated by remote and demodulated measuring wave with the carrier wave of the remote unit. Here also frequency modulation is used.
6. Retransmission of frequency modulated carrier through air. (antenna arrangement)
7. Reception and demodulation of measuring wave at master unit.
8. Phase comparison between transmitted and reflected retransmitted signals. Here, phase shift / Digital technique is used.
9. Display of the distance within a few millimeters in (LCD) Liquid Crystal Display

INSTRUMENTS AVAILABLE

- The available instruments in the market are many and a few of them are listed below:

A. EODMS

Sl. No.	Instruments/make	Carrier	Range (KM)	Accuracy mm $\pm$ ppm		
1.	Geodimeter – M8, AGA Geotronics, Sweden	He-Ne laser	65	5	1	
2.	Range Finder, Keuffel and Esser, USA	Infrared light by Ga-As diode	2	5	1	
3.	Distomat DI – 3S, Lieca, Switzerland	Infrared light from LED	2	5	5	
4.	EDM RED – 2 and RED – 3 Sokkia Company, Japan.	Infrared light from LED	5	5	5	
5.	Eldi – 10, Carl Zeiss, West Germany	Infrared light from LED	16	5	3	
6.	Citation CI - 450, Precision International, USA	Infrared light from LED	3	5	5	

B. MWDMS

Sl.No	Instruments/Make	Carrier	Range (Km)	Accuracy mm $\pm$ ppm	
1.	Tellurometer MRA 101 Tellurometer Pvt.Ltd., U.K	Microwave 10.05 to 10.45. GH _z	50	15	3
2.	Electro-tape DM 20 Cubic Corporation, California, USA	Microwave 10 to 10.50 GH _z	50	10	3
3.	Distomat DI 60, Lieca, Switzerland.	Microwave 10.20 to 10.50 GH _z	150	20	3
4.	EDM – 100 C Micro-fix, South Africa	Microwave 16.25 to 16.75 GH _z	60	15	3

USES OF EDM

Sl. No	Waves	Wave Length	Instruments	Uses
1.	Visible light: (non-Coherent) Mercury Vapor lamp Tungsten light	0.55 μ m 0.57 μ m	Geodimeter	Land to Land Surveying.
2.	Near infrared: (Coherent, laser light) He-Ne laser Ruby laser Semi conducting laser (Ga-As diode)	0.63 μ m 0.69 μ m 0.875 μ m	Range Master Ranger III Reg Elta	Land to land surveying Land to land surveying (Long distances). Land to land surveying (Tachometric type)
3.	Microwaves: EHF (x-band) SHF (S-band) UHF VHF (L-band) L ₁ L ₂ HF MF LF h) VLF	10mm 8cm 60cm 0.190m 0.244m 50m 500m 2,000m 20,000m	Tellurometer MRA-4 Electro-tape Radio Altimeter GPS GPS Toran, Gee-H Raydist Decca Omega	Land to land surveying Land, sea and air surveying Land and air surveying Satellite positioning system Land and air surveying Hydrographic surveying Hydrographic surveying (Navigation) Worldwide navigation system

TOTAL STATION or ELECTRONIC TACHEOMETER

- The **Electronic total station** includes a distancer, electronic Theodolite with an electronic field book.
- The total station is in one unit and measures the slope distance, zenith-angle electronically and computes, displays the horizontal and vertical distances, Angles also X, Y, or N, E co-ordinates
- The measured data can be recorded automatically in a cassette or Electronic field book. Manual recording is also possible.
- Then the recorded data can be transferred to any data processing system for further computations.

TOTAL STATION or ELECTRONIC TACHEOMETER

Sl. No.	Manufacturer	Model	Range (KM)	Accuracy mm ±ppm	
1.	AGA Geotronics, Sweden.	Geodimeter M140	5.5	5	5
2.	Hewlett Packard, USA	HP 3810B	8.0	5	1
3.	Kern and Co. Ltd., Switzerland	CH-5001	2.0	3	5
4.	Topcon, Japan	GTS-10D	2.0	5	5
5.	Lieca, Switzerland	TC-2000	2.8	3	2
6.	Carl Zeiss, Germany	Elta – 3	5.0	5	2
7.	Sokkia, Japan	SET – 2	3.1	3	2

GLOBAL POSITIONING SYSTEM (GPS)

- Advanced Surveying Techniques
- Provides Position anywhere on the globe at any time
- Accurate Time, Velocity to help Navigation

WHY GPS?

- All weather capability
- Inter visibility is not required
- Rapid surveying is possible
- High accuracy achievable
- Day and night survey possible
- Ease of operation

GPS is a system comprising three segments

- Space Segment
- Control Segments
- User Segments

SPACE SEGMENT

- 24 satellites with a minimum of 21 operating 98 % of the time
- 6 Orbital planes
- 55 degrees orbital inclination
- 20,200 km above the earths surface
- 11 hours 58 minute orbital period
- Visible for approximately 5 hrs

CONTROL SEGMENTS

Consists of

- Master Control Station,
- Monitor station and
- Ground Antennas
- To monitor and Control satellite Configuration continuously
- To Update Satellite clock and ephemeris through Ground Antennas

USER SEGMENTS

- The user segments comprises the receiver with
- Antenna with pre-amplifier
- Radio frequency sections (channels)
- Micro-processor
- Power supply
- User Interface
- Memory for Data storage

There are two type of service available to GPS users

- PPS and
- SPS.
- **PRECISE POSITIONING SERVICE (PPS)**
- Authorized users with cryptographic equipment and keys specially equipped
- (U. S. and Allied military, certain U. S. Govt agencies)
- ***PPS Predictable Accuracy***
 - 22 meter horizontal accuracy
 - 27.7 meter vertical accuracy
 - 200 nanosecond time (UTC) accuracy

STANDARD POSITIONING SERVICE (SPS)

- All Civil users worldwide
- Degraded by the DOD by using of selective availability and anti spoofing.
- SPS predictable accuracy
 - 100 meter horizontal accuracy
 - 156 meter vertical accuracy
 - 340 nanoseconds time accuracy

HOW GPS WORKs

- Similar to three point problem in plane tabling and Trilateration with EDM
- Based on signal travel time, distance is calculated (pseudo-range)
- Three co-ordinate (X, Y and Z) and clock synchronization error are four unknowns
- With known distance and locations of four satellites, the co-ordinates of GPS station can be calculated

- **DIFFERENTIAL GPS**
- GPS observations are recorded at a known station
- Corrections are calculated and transmitted through data link
- These corrections are used by GPS at unknown station
- Accuracy achieved in position improves to 5 m
- Number of DGPS stations is available throughout the world
- DGPS stations are at Bangalore and Hyderabad

APPLICATION OF GPS

- Mainly meant for Military Use
- Geodetic control surveys
- Oil exploration-onshore / offshore
- Photogrammetric control works
- Detailed engineering surveys
- Mining operations
- Hydrographic applications
- Utility mapping
- Map Updation
- Highway inventories
- Cadastral surveys
- Vehicle tracking / navigation
- Plus many more...!

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