Birzeit University
civil engineering department

EDM

Introduction

1- current EDMs use infrared, light, laser light or microwaves.

2- microwaves systems use a receiver/ transmitter at both ends of the measured line whereas infrared and laser systems utilize a transmitter at one end of the measured line and a reflecting prism at the other end.

Basic principle of electronic distance measurements (EDMs)

1- Light wave is travelling along x-axis with a velocity of 299792.5 ± 0.4 km/s

2- The frequency wave is the time taken for one complete length

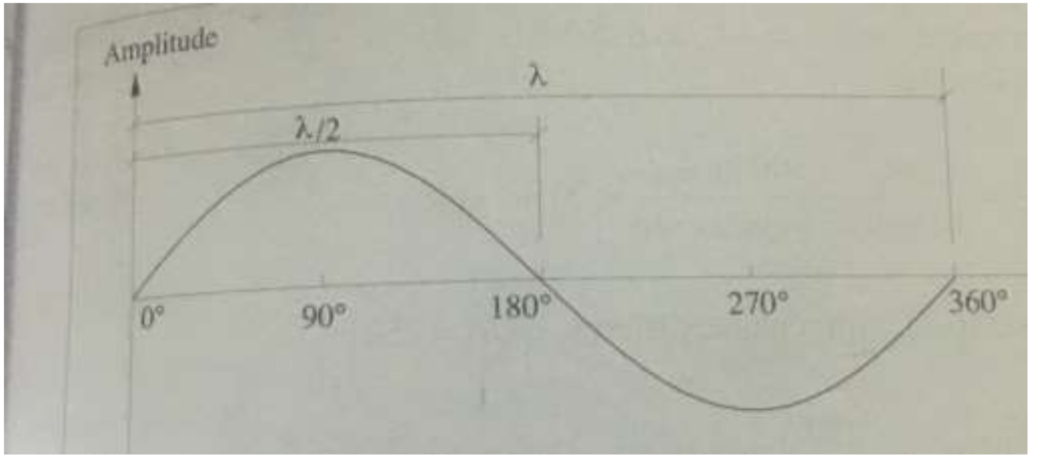
$$\lambda = \frac{c}{f}$$

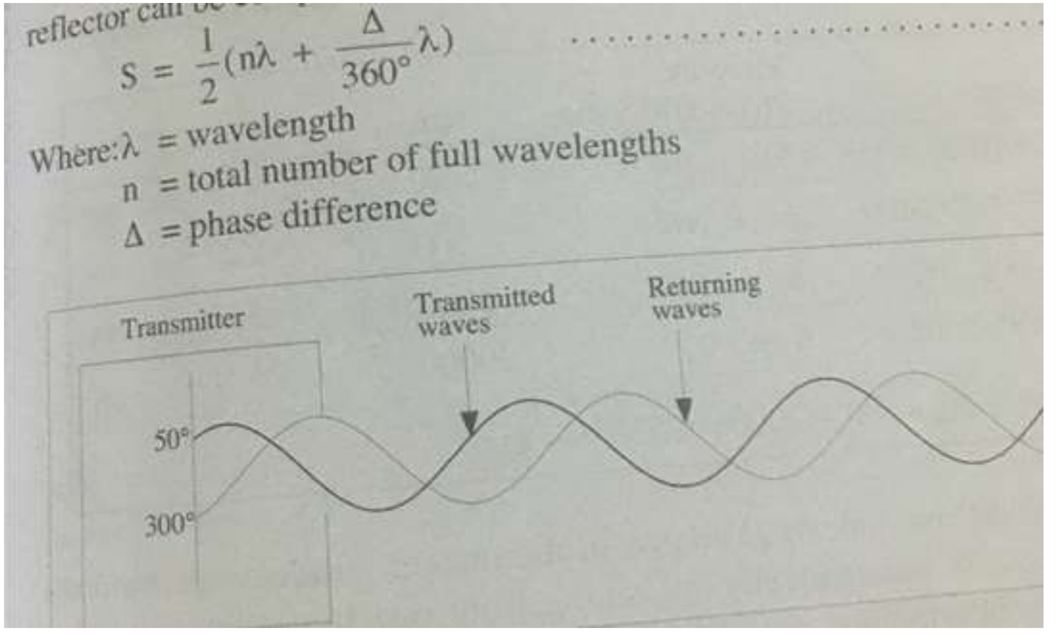
$$where \lambda = wave - length(meters)$$

$$c = velocity(km/\sec)$$

$$f = frequency(hertz = onecycle/\sec)$$

Sloping distance





3- The instrument can count number of full waves length or instead the instrument can send out a series (3 or 4) of modulated waves at different frequencies

4- The frequency is typically reduced each time by a factor of 10 so the wave length is increased each time by a factor of 10

5- substituting the resulting values of wave lengths and phase difference into S, the value of n can be found

6- the instruments are designed to carry out this procedure in a matter of seconds and then to display the value of L in digital form

The term $(\Delta/360°)\lambda$ represents the fractional wavelength ... preceding example, with f = 14.989625 MHz, and taking the speed ... be 299,792.5 km/sec:

$$\lambda = \frac{V}{f} = \frac{299{,}792{,}500 \text{ m/sec}}{14{,}989{,}625 \text{ cycles/sec}} = 20 \text{ m/cycle}$$

Using Equation (6.3) with a phase difference $(\Delta) = 250°$:

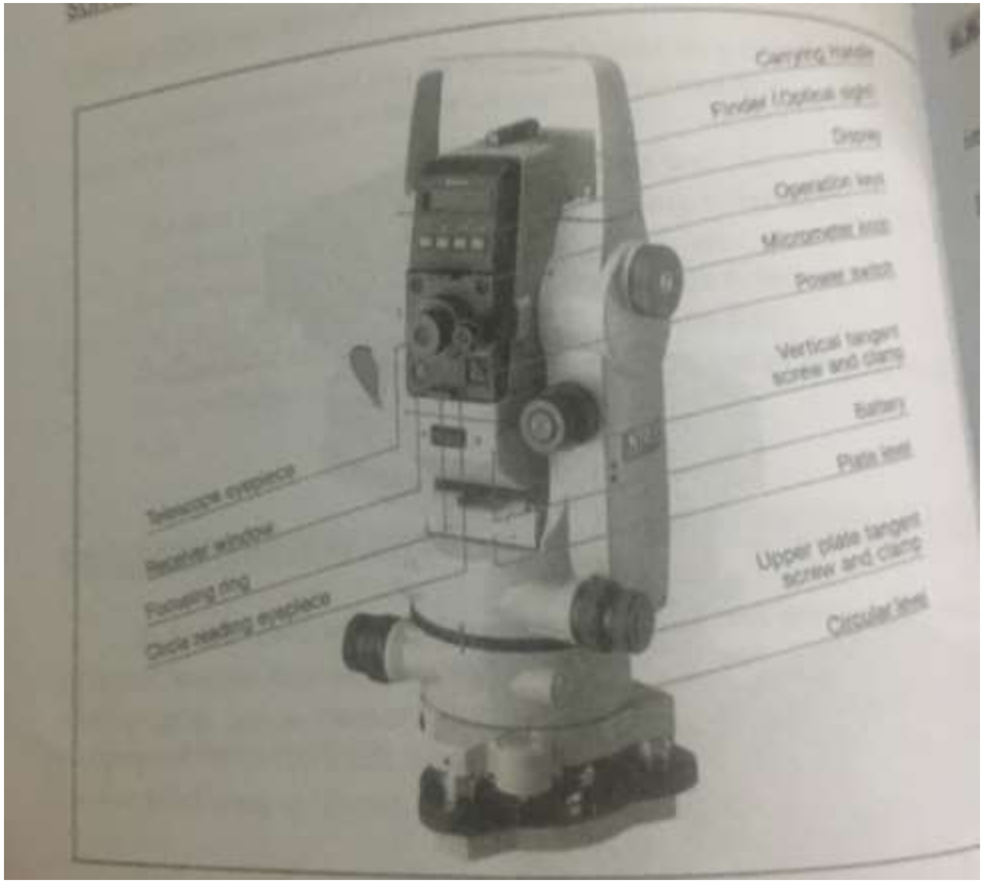
$$S = \frac{1}{2}\left[20n + \frac{250°}{360°}\cdot 20\right] \text{meters} = [10n + 6.944] \text{ meters}$$

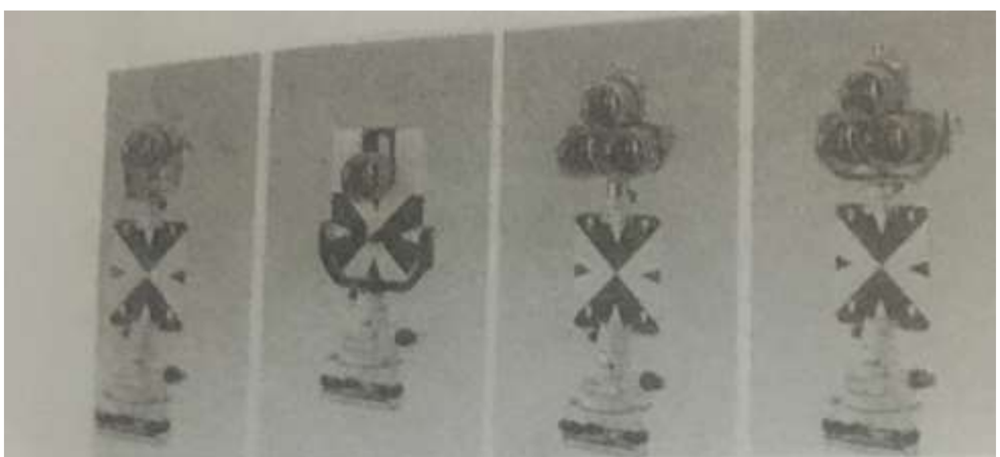
TABLE 6.1: Calculation ...

Frequency	Measured Phase Difference	λ (m)	$\frac{1}{2}\frac{\Delta}{360°}\lambda$
F_1 = 14.989625 MHz	$\Delta_1 = 250°$	20	6.944 m
F_2 = 1.4989625 MHz	$\Delta_2 = 98°$	200	27 m
F_3 = 149.89625 KHz	$\Delta_3 = 190°$	2000	527 m
F_4 = 14.989625 KHz	$\Delta_4 = 91°$	20000	2527 m

S = 6.944 + 20 + 500 + 2000 = 2526.944 m

Most EDM instruments available in the market nowadays perform th...


Carrying handle
Finder (Optical sight)
Display
Operation keys
Micrometer knob
Power switch
Vertical tangent screw and clamp
Battery
Plate level
Upper plate tangent screw and clamp
Circular level
Telescope eyepiece
Receiver window
Focusing ring
Circle reading eyepiece



Factors affecting the velocity of EDM

- The velocity of light through the atmosphere can be affected by 1- temperature 2- atmospheric pressure 3- water vapour content

- It can be corrected by consulting nomographs or by performing automatically on some EDMs by the on-board processor/ calculator after entering the values for temperature and pressure

- for short distances theses factors have relatively small significance but for large ones atmospheric corrections can become quite important

EDM characteristics

1- Distance range 800m-10 km (single prism with average atmospheric conditions)

2- short range EDMs can be extended to 1300 m using 3 prisms

3- long range

EDM accuracies

1- accuracies are stated in terms of a constant instrumental error plus a measuring error proportional to the distance being measured

2- Accuracy is claimed to be (±(5mm +5ppm)) where ± 5mm is the instrument error that is independent of length of measurements whereas 5ppm denotes the distance related error

6.9 SOURCES OF MEASUREMENT ERRORS

When using electro-optical instruments for distance measurement, the following sources of errors may occur:

(1) Eccentric error due to inexact centering of the instrument and reflector over the survey stations.

(2) Inexactness of the instrument in performing phase measurements.

(3) The zero point of the light ray used in phase measurement does not coincide exactly with the theoretical center of the instrument.

(4) The actual center of the reflector does not coincide with the theoretical center.

(5) The actual modulating frequencies differ from the theoretical values of these frequencies.

(6) The refraction index (N_a) is not constant through the line to be measured.

Index of refraction

The ratio between the velocity of propagation of electromagnetic wave in a vacuum (V_o) and the velocity in the atmosphere (V) is called the index of refraction (N_a); that is:

$$N_a = \frac{V_o}{V} \qquad \text{.......... (6.4)}$$

N_a depends on the wavelength, atmospheric pressure, temperature and relative humidity. For dry atmosphere at 0°C and at sea level (pressure = 760 mm Hg), the refractive index for light waves is given by:

$$N_g = 1 + \left(287.604 + 4.886\,\lambda^{-2} + 0.068\,\lambda^{-4}\right)10^{-6} \qquad \text{.......... (6.5)}$$

Where: λ = wavelength of light in μm
= 0.9 - 0.93 μm for near infrared light from Gallium Arsenide diode
= 0.6328 μm for light generated by helium-neon laser

At other atmospheric conditions:

$$N_a = 1 + \frac{0.359474\left(N_g - 1\right)P}{273.2 + t} \qquad \text{.......... (6.6)}$$

Where: P = atmospheric pressure in mm Hg
t = air temperature in °C

Thus for λ = 0.9 μm, N_a = 1.000294 at sea level (760 mm Hg) and air temperature of 20°C. In EDM applications, N_a is often expressed as follows:

$$N_a = 1 + 10^{-6}N \qquad \text{.......... (6.7)}$$

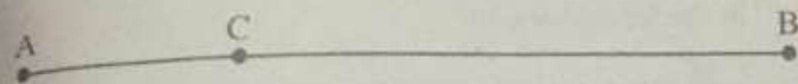


FIGURE 6.8: Layout for determination of correction for zero centering errors.

- Let the actual calibrated lengths be AB, AC & CB, and the measured lengths by the EDM instrument be $\overline{AB}$, $\overline{AC}$ & $\overline{CB}$.
- Let the unknown correction be (c).

Then: $AB = \overline{AB} + c$

$AC = \overline{AC} + c$

$CB = \overline{CB} + c$

But: $AB = AC + CB \Rightarrow \overline{AB} + c = \overline{AC} + \overline{CB} + 2c$

$$\Rightarrow c = \overline{AB} - \overline{AC} - \overline{CB} \qquad \text{(6.8)}$$

EXAMPLE 6.1:

To determine the zero centering correction for an EDM, the followin values for AB, AC and CB were measured by the EDM:

$\overline{AB} = 313.647$ m, $\overline{AC} = 112.556$ m, and $\overline{CB} = 201.088$ m.

(a) Find the correction for zero centering (c).

(b) A distance was recorded to be 718.128 m when using the sar instrument. Compute the correct distance.

SOLUTION:

(a) $c = \overline{AB} - \overline{AC} - \overline{CB} = 313.647 - 112.556 - 201.088 = +0.003$ m

(b) Corrected distance $= 718.128 + 0.003 = 718.131$ m

1- Measure f ' in the laboratory, or

2- If this is not possible, measure two known distances such as AB in Figure 6.8. Then:

$AB = g \cdot \overline{AB} + c$

$AC = g \cdot \overline{AC} + C$

Where: AB and AC are the known distances,
$\overline{AB}$ and $\overline{AC}$ are the measured distances,
$g = f'/f$ = scale factor,
c = correction for zero centering

EXAMPLE 6.2:

The following data belongs to Figure 6.8:

$AB = 1499.8635$ m, $AC = 149.9921$ m

$\overline{AB} = 1499.9000$ m, $\overline{AC} = 149.9935$ m.

Determine g and c.

SOLUTION:

$1499.8635 = 1499.9000\ g + c$

$149.9921 = 149.9935\ g + c$

Solving these two equations for g and c: ⇒

Distance and elevation

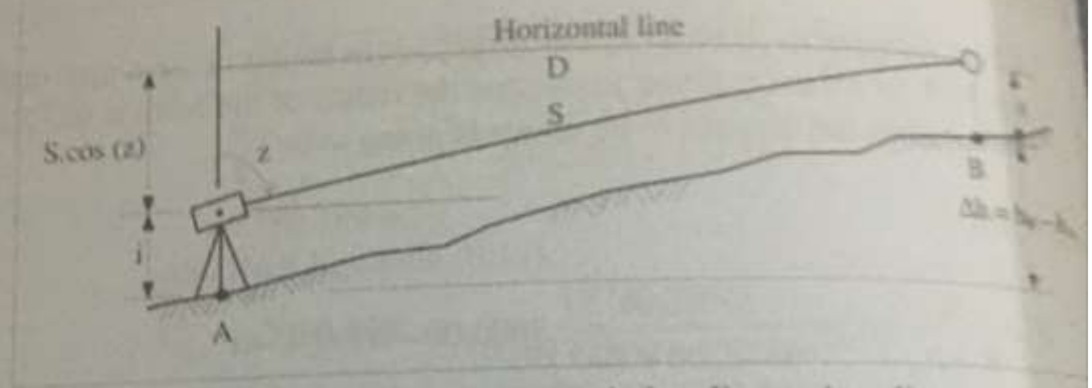


FIGURE 6.11: Trigonometric leveling – short line.

The following relation exists:

$\Delta h = h_B - h_A = s \cos z + i - t$ ....

Also, the horizontal distance (D):

$D = s \sin z$ ....

Where:

- h_A and h_B are the elevations of points A and B
- S = the slope distance along the line of sight
- z = zenith angle
- i = the height of the instrument (total station)
- t = the height of the sight target (reflector)