

Reflectorless Laser Distance Measurement

A beam coming from the instrument. Aim it at a surface and push the button, and the distance is measured by laser. Reflectorless laser distance measurement, <i>I know what it is, I know what it does, but how does it work?</i>

EDM

Reflectorless Electronic Distance Measurement (EDM) enables the measurement of distances of up to hundreds of metres without needing to access the target. Inaccessible objects and objects located at dangerous sites can thus be mapped easily. In order to use the technology properly, the surveyor should be knowledgeable about the underlying physics and characteristics and peculiarities of reflectorless measurement.

Phase and Pulse

Laser stands for Light Amplification by Stimulated Emission of Radiation. The principle, already known to Einstein, was made operational in the early 1960s. In [land surveying](#), lasers are mainly used for:

- visualising a point or straight line as implemented in levelling instruments such as rotating and line lasers
- range measurement.

We focus here on range measurement. Basically, two laser principles are common in land surveying: phase shift and pulse – also called time of flight – measurements. The phase shift method is considered to be the most accurate one; it allows a very narrow beam, but its measuring range is limited. The pulse method has a much wider range but has the disadvantage of poor performance on short ranges. This is due to the limitations of the built-in clock and the width of the spot size. The most recent EDM systems use a hybrid method. More details on the principles of phase, pulse and hybrid technology are shown in the figure.

Distance Measurement

Until recently, EDM could only be applied in combination with a special retroprism. Today reflectorless EDM is increasingly becoming a standard surveying technique. Reflectorless EDM requires pulses with a high energy level typically in the range of 1 to 20 watt. In contrast, most phase-based EDMs using retroprisms emit signals at a level of a few milliwatt. The high energy level enables the detection of reflections on bare surfaces without the need of using prisms. Since the signal may reflect upon any surface present in the line between the in-instrument and the target, blunders may easily occur. For example, the signal may be reflected by a leaf present in the line of sight. Users should be aware of these types of side effects by un-derstanding the physics of the system well.

Beam Divergence

Another point of concern is beam divergence. Beam divergence causes the footprint of the laser beam to have a certain extent. This means that the laser spot hitting the surface is definitely not a point in the mathematical sense but will have a certain size. The size depends on the distance from the EDM system; the greater the distance, the larger the laser spot size. Beam divergence may generate two types of errors. The first one is a result of surface characteristics of the target and its vicinity. Depending on the characteristics of the vicinity surface, the waveform of the laser beam scattered back by the surface may be a rather distorted version of the emitted pulse. This makes matching difficult, resulting in uncertainties in the distance. A second type of error is caused by depth differences between the target and its vicinity. When the target is located on a plane that is not perpendicular to the line of sight, time differences will occur between the reflections. The part of the plane that is closest to the instrument will reflect the beam first, whilst the part that is farthest away will reflect last. Fortunately, the effect is negligible as long as the plane has homogeneous reflectance characteristics. The effects of beam divergence become more severe when discontinuities are present in the vicinity of the target. In particular, when the depth differences do not exceed one-half of the pulse length, the reflected pulse will be treated as stemming from one surface. Since the reflected pulse will be quite elongated, the time of flight cannot be detected accurately, resulting in an inaccurate measurement.