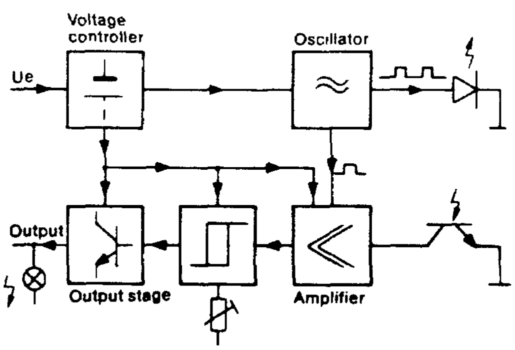
General points about opto-electronic sensors

To an increasing degree, components which operate without physical contact and without using electrical contacts are being used in place of mechanically operated control and sensing arrangements.
The advantage which all such sensors have is that they operate substantially without wear so long as they are not operated outside the limits (current, voltage, temperature) set by their specifications.
In what follows we will be looking at photoelectronic sensors in more detail together with their characteristics and the related problems.
RS photoelectric sensors consists of an emitter (E) and a receiver (R). Generally speaking the emitter puts out light of constant power and the light beam may be focussed to a greater or lesser degree. What is received at the receiver is light which has been modulated by something affecting the beam path between the emitter (E) and receiver (R). The ratio between the emitted and received power may be up to 10^9.

The principle of operation

In the next section we will look at the electronic operation of an opto-electronic switch with reference to a block diagram.



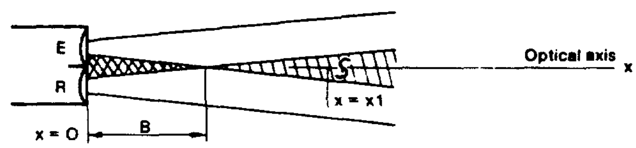
The working voltage supplied from outside, which may be from 10 to 40 V DC for example, is reduced internally to about 5 V. This means that the arrangement as a whole is not dependent on the supply voltage. The oscillator generates a train of square-wave pulses at a frequency of approx. 1 kHz with a pulse length of approx. 10 µs. In this way it is possible to draw a current pulse of approx. 1 A from the emitter diode.
Hence the average current is about 10 mA.
At the photo-receiver the incoming light is converted back into electrical current pulses.
An amplifier switched by the oscillator amplifies the photo-current signals precisely and only at the time when a signal is expected. This provides an effective means of suppressing interference signals. Due to the shortness of the pulses of photo-current which have to be handled it is also possible to give the amplifier a high bottom cut-off frequency (< 100 kHz), which means that steady light and, more particularly, fluctuating light of low frequencies (100 Hz) can be suppressed satisfactorily.
The Schmitt trigger which follows compares the signal with the switching threshold which has been set and controls the output stage.

Optical characteristics

Reading through the next section will help you to gain a better understanding of the photoelectric switch and the problems which occur and rules which apply in various fields of application.

Depending upon the type of equipment, the pulsed light generated by the emitter is focussed to a greater or lesser degree when transmitted. Broadly speaking the angle of divergence of the emitted beam is approx. 10 to 20°. The image of the receiver does not overlap with that of the transmitter until the beam has travelled a certain distance, thus creating a so-called **blind area** (B).
From drawing no. 1 it is very easy to see why the blind area arises.

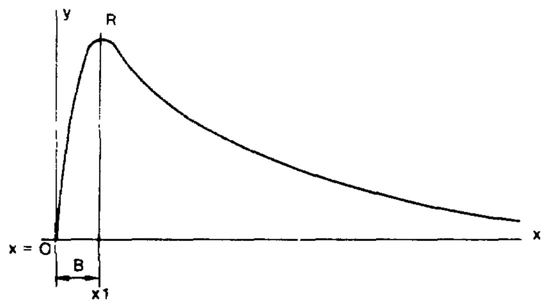
Drawing No. 1



Taking drawings nos. 1 and 2 together, it is also possible to gain an idea of the sensitivity curve which is generated when an object is moved along the optical axis in direction X.

This is roughly what the curve will look like:

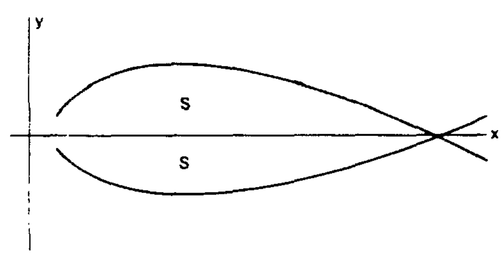
Drawing No. 2
Sensitivity curve:



Starting from x = 0, the reflected signal R rises steeply because the area of the field S (drawing 1) in which the emitter and receiver overlap increases roughly as the square of x. A maximum is reached at a distance of x1. After this the curve follows the law of increasing distance which states that the reflected signal R decreases roughly as $1/x^2$. The shape of the curve is independent of the gain which has been set. From this description it will now be appreciated that there are two switching points at which the equipment switches on or off. With all types of equipment the maximum is at approx. 5 to 10% of the rated switching distance S_n.
From what has been said above, it will be seen that there is also a switching lobe which arises.

The explanation for this is as follows:

Drawing No. 3
Switching lobe:



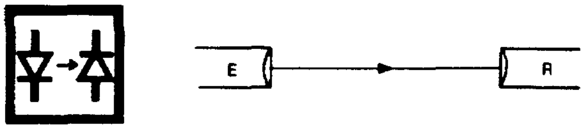
When the reception field S is entered from the side in direction y it is necessary to draw very close to the optical axis to cause the equipment to switch.
The curve reaches a maximum, that is to say the switching lobe is of maximum diameter, roughly at the centre of the rated switching interval (S_n). Further movement in direction S means that a larger proportion of the object has to be in the reception field to provide an adequate received signal. From this it will also be clear that the sensing distance necessarily depends on the size of the object providing the object is in the beam.

Arrangement and use of different types

Basic alternatives:

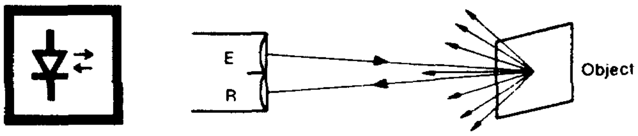
1. Thru-scan technique (E + R)

The emitter (E) and receiver (R) are separate and mounted directly opposite each other.



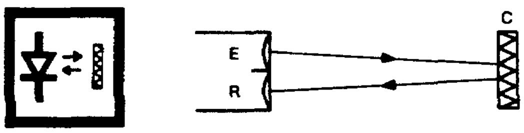
2. Diffuse reflective scan technique (ER)

When the object to be detected is itself a reflector, the emitter (E) and receiver (R) are housed in the same case, and the arrangement "sees" the object by diffuse or direct reflection.



3. Retroreflective scan technique (ER + C)

The emitter (E) and receiver (R) are housed in the same case; the light beam is reflected by a retroreflector (C), so that an object is detected when it interrupts the beam.



Advantages and disadvantages of each arrangement

1. Thru-scan technique (E + R)

Suitable for:
- Opaque objects
- Shiny or glossy objects
- Suspension of tiny particles in gas or fluid (particle size must be larger than the light wavelength)

Advantages:
- High resolution
- Good reproducibility
- No problems regarding mirror surface area, background etc.

Disadvantages:
- Needs delicate adjustment
- Needs separate emitter and receiver

2. Diffuse technique (ER)

Suitable for objects having glossy or light-diffusing surfaces.

Advantages:
- Fully uses the reflectiveness of the object to be detected.
- Distinguishes between light, dark and coloured objects, under suitable conditions.
- Relatively good reproducibility.

Disadvantages:
- Risk of interference by reflecting or shiny backgrounds.
- Risk of overloading by too close reflexion.
- Sensing capability depends on the colour and nature of the object's surface area.

3. Retroreflective technique (ER + C)

Suitable for:
- Opaque or transparent objects
- Objects the same size or larger than the reflector
- Objects with low reflectiveness

Advantages:
- High resolution capability
- Compact size
- Reflector can be a perfect mirror

Disadvantages:
- Needs delicate adjustment
- Under certain circumstances, some light-diffusing or glossy objects may not be correctly detected.

Various things to note

Correcting factors (S_n x factor = new S_n)

Material	Factor (approx.)
Paper, matt white 200 g/m²	1
Polished metal	1,2…1,6
Aluminium, black anodized	1,1…1,8
Expanded polystyrene, white	1
Cotton material, white	0,6
PVC, grey	0,5
Wood, raw	0,4
Carton, matt black	0,1

Cable-colors

3-wire-model:
1 = plus (BN = brown)
2 = load (BK = black)
3 = minus (BU = blue)

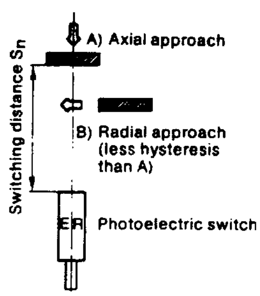
2-wire-model:
1 = plus (BN = brown)
3 = minus (BU = blue)

Connection numbers

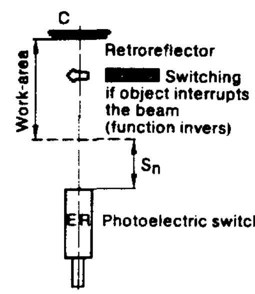
DC-1/2/3 = NC
1/4/3 = NO
AC-1/3 = NO/NC

Application examples

Diffuse reflection scan technique



Retroreflective scan technique



Hints for setting (with potentiometer)

Diffuse scan application

Place the object into the detection zone. Turn potentiometer until LED lights. If LED does not go out when object is removed, look for strongly reflecting parts in sensing zone and cover with matt black.

Retroreflection scan application

The distance within S_n **must not be used** owing to possible reflection from the objects to be detected.

Hints for setting (without potentiometer)

Diffuse scan application

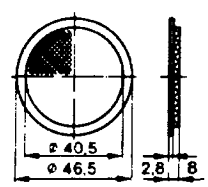
Place the object into the detection zone. If the LED is not extinguished after the removal of the object, cover any strongly reflecting parts or surfaces in the background with matt black.

Retroreflection scan application

The distance within S_n **must not be used** owing to possible reflection from the objects to be detected.

Retroreflector

Prismatic type C 104 as retroreflector for retroreflective scan application.
Material: Plastic.
(A larger distance possible on larger reflector)



General Information

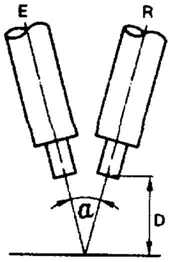
The R.S. light guide consists of a bundle of extremely fine (50 micron) glass fibres protected by a plastic or metal sheath. The sensing head is of blackened brass, and the coupling is of plastic. To protect the guide where it enters the sensing head and coupling, an anti-kink device is fitted to prevent fracture of the glass fibres.
The light guides combined with photo-electric proximity switches are used wherever accuracy, long live and safety must be guaranteed in measuring and switching applications. The marriage of optical sensing with electronic precision gives solutions for a wide variety of problems in modern control and production processes.

Applications

a) Diffuse reflective scan technique
Operates by direct reflection from the object.
Emitter/receiver (ER) are optically coupled to the same fibre bundle.

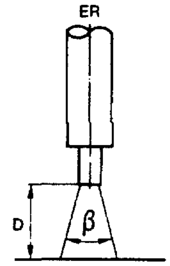
b) Thru-scan technique
Operates by the object breaking the beam between separate emitter and receiver.
Emitter and receiver use separate light guides and are separately mounted.

c) Retroreflective scan technique
The object breaking the beam between emitter/receiver (ER) and the reflector (R).

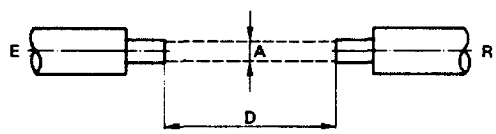


Application information

a) Diffuse reflective scan technique
D = Sensing distance, dependant on light guide cross-section, colour and reflectivity of the object and angle α.
Angle β (about 60°) is the receiving angle of the light guide. This is a fixed value, independent of the cross-section of the guide, sensing head etc.



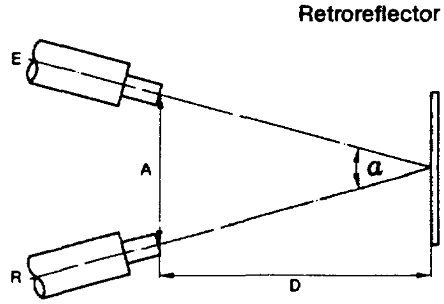
b) Thru-scan technique



D = Distance between emitter and receiver (E + R).
A = Zone in which an object can break the beam.This corresponds with the diameter of the fibre glass bundle.

c) Retroreflection scan techhique

D = Distance between emitter/receiver and reflector. This will depend on the separation A of the sensing heads, the angle α and the quality of the reflector. The active zone in which interruption of the beam is possible lies between the dotted lines.

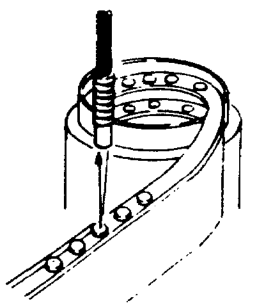


Details concerning use!

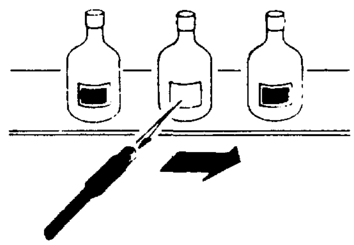
- The bending radius under moving conditions must not be less than 6 times the tube diameter.
(When used without movement in operation, radius can be up to 50% less provided light cable is not crimped. Varies with cable type!)
- No tension should be exerted on the light cable!
- The glass-fibers must be protected from damage at light-exit end (scratching)!
- For high mechanical loads and for use in high temperatures the metal cased type should be used!

APPLICATIONS

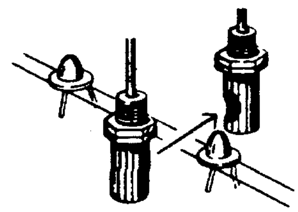
Detection of parts feeding



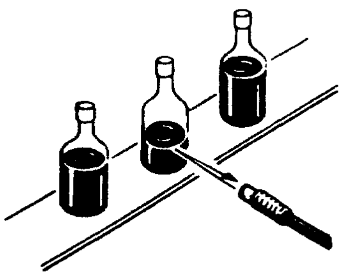
Detection of label presence



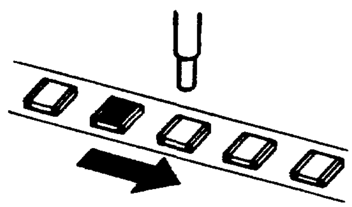
Application of side view attachment



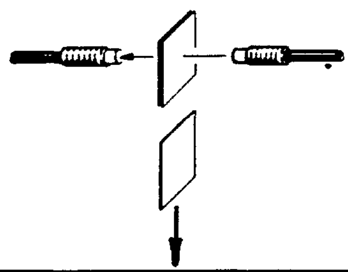
Detection of liquid level



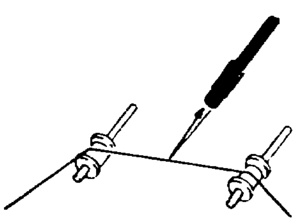
Discrimination of chip part's face with stainless sleeve head



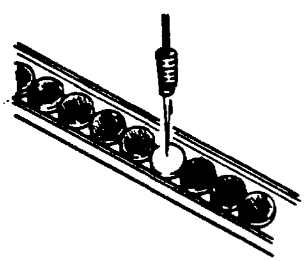
Detection of double sheets of paper



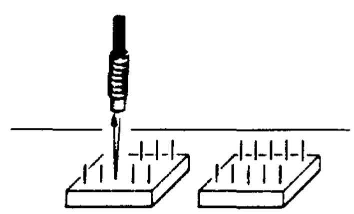
Detection of broken wire



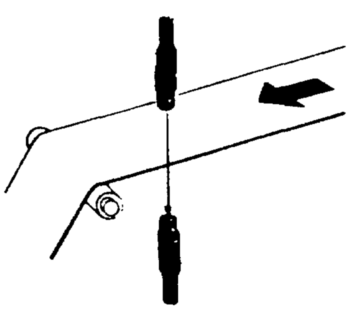
Discrimination of chip part's face with stainless sleeve head



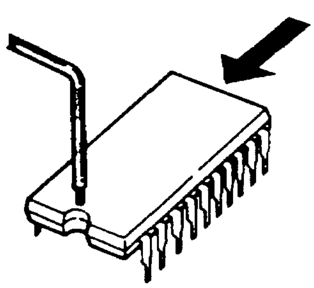
Detection of connector pin



Edge Control



Detection of IC orientation with stainless sleeve head



Detection of groove