Proximity and Limit Switches

► A variety of sensors are available that give ON/OFF (or yes/no) binary outputs

► Mechanical limit switches
  ▪ often called “microswitches”
  ▪ activation causes electrical contacts to either “break” (“normally closed” or NC switch) or “make” (“normally open” or NO switch) - or both NC and NO

► More sophisticated binary sensors are collectively known as proximity switches
Standard Basic Switches

- Polished stainless steel plunger for long accurate performance
- Rugged brass cover pin (2)
- Fine silver contacts (standard)
- High grade phenolic cover and case
- Elongated hole for easier, more accurate mounting
- Long-life, one-piece beryllium copper spring
- Step construction for additional dielectric spacing (bottom facing screw terminals only)
- Bottom facing screw terminals shown. Also available are side facing screw and solder terminals
Standard Basic Switches

- **Roller leaf; Low-force, large movement actuation**
- **Lever; Very low force, slow cams and slides**
- **Leaf; Low-force, slow moving cams or slides**
- **Roller lever; Very low force, fast moving cams**
Standard Basic Switches

- **Pin plunger; in-line motion**
- **Overtravel plunger; in-line applications requiring additional overtravel**
- **Panel-mount roller plunger; Actuation by cams**
- **Panel-mount plunger; Heavy-duty in-line applications or slow cams. Cam rise should not exceed 30°**
Switch Contact Configurations

Single pole, single throw (SPST)
- Normally Open (NO)

Single pole, single throw (SPST)
- Normally Closed (NC)

Single pole, double throw (SPDT)
- NC to COM
- NO to COM

Double pole, double throw (DPDT)
- NC1 to COM1
- NO1 to COM1
- NC2 to COM2
- NO2 to COM2
Mercury Switch

Contacts

Mercury “puddle”

SHAFT

BIMETAL STRIP

TILT
Photoelectric Proximity Sensor

Current limiting resistor

$V_S$

Small current flows through transistor

$V_{OUT} \sim 0 \text{ V}$
Photoelectric Sensor - Blocked

\[ V_{S} \]

Sense resistor
No current

\[ V_{OUT} \sim V_{S} \]
Photoelectric Sensor - Design

Current limiting resistor usually "small"

\[ i \approx 10-30 \text{ mA} \]

\[ \approx 1.2-1.7 \text{ V} \]

Sense resistor usually large

\[ 10K\Omega \text{ to } 100K\Omega \]

V\text{S}

A (anode)

K (cathode)

V\text{S}

C (collector)

E (emitter)
"There are three basic types of photoelectric sensors. Transmitted beam, or through-beam, requires a sender and a receiver. Retroreflective senses light returning from a reflector. Both types switch an output when the beam is broken. Diffuse sensors sense light returning from the object to be detected and switch the output when it senses."

http://www.manufacturing.net/ctl/article/CA204923
Conveyor/Material Handling
A retroreflective sensor was chosen to look across the conveyor at the retroreflector. When the book blocks the beam, a signal is given to stop the conveyor.

Truck Height Control
A long range through-beam sensor was positioned at a height just below the overhanging roof and a couple of feet in front, so the breaking of the beam would activate an output wired to an alarm alerting the driver to stop.
Automatic Door Opener

from Warner

MCS-165

Retro-Mirror
Case Sorting - By Size

MCS-144

from Warner

Medium Cases Conveyor

Retro-Mirrors

Large Cases Conveyor
Production Counting

from Warner

Electronic Counter

Retro-Mirror

MCS-625
Reflective Photoelectric

“This type of sensor utilizes a special reflector to return the beam directed at it from the sensor. An object between the sensor and reflector is senses when it interrupts the beam. Medium sensing range. “

http://www.westemextralite.com/resources/basicsensor.htm
Inductive Proximity Sensor

Coil of wire forms inductor, L

Alternating field

Sensing face

Attenuating material

$LC$ oscillating circuit

Signal evaluator

Switching amplifier

Ultrasonic Proximity Sensing

High frequency (200 kHz) sound waves reflect from object

Correct

Wrong

Permissible
Ultrasonic Proximity Sensing

\[ \text{Distance} = \frac{(\text{Speed of sound in air}) \times \Delta T}{2} \]
# Proximity Switches

*Industrial Automation* by D.W. Pessen, Wiley Interscience

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Targets</th>
<th>Sense Distance (typ. max)</th>
<th>Switch Rate (typ. max)</th>
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<tbody>
<tr>
<td>Limit switch</td>
<td>Any</td>
<td>0 (physical contact req'd)</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Mercury switch</td>
<td>Any</td>
<td>0 (physical contact req'd)</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Reed switch</td>
<td>Magnet</td>
<td>20 mm</td>
<td>500 Hz</td>
</tr>
<tr>
<td>Photo-electric</td>
<td>Opaque</td>
<td>0.1 to 50 m, depends on target shape</td>
<td>100-1000 Hz</td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>Nonporous, large</td>
<td>30 mm to 10 m</td>
<td>50 Hz</td>
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<tr>
<td>Inductive</td>
<td>Conductive material</td>
<td>Ferrous: 50 mm, Non-ferrous: less</td>
<td>300-5000 Hz</td>
</tr>
<tr>
<td>Capacitive</td>
<td>Most solids, liquids</td>
<td>30 mm</td>
<td>500 Hz</td>
</tr>
<tr>
<td>Magnetic inductance</td>
<td>Ferromagnetic</td>
<td>50 mm (depends on target mass)</td>
<td>300 Hz</td>
</tr>
<tr>
<td>Hall effect</td>
<td>Magnet</td>
<td>20 mm</td>
<td>100 kHz</td>
</tr>
<tr>
<td>Wiegand effect</td>
<td>Magnet</td>
<td></td>
<td>100 kHz</td>
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## Proximity Switches

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<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Limit switch</td>
<td>Temperature, moisture</td>
<td>Simple, inexpensive</td>
<td>Physical contact, arcing</td>
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<tr>
<td>Mercury switch</td>
<td>Vibration, mounting angle</td>
<td>Low contact resistance, sealed</td>
<td>Physical contact, SPST contacts only</td>
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<tr>
<td>Reed switch</td>
<td>Vibration</td>
<td>Small size, inexpensive</td>
<td>Contact arcing, magnet actuator</td>
</tr>
<tr>
<td>Photo-electric</td>
<td>Dust, dirt, ambient light</td>
<td>Good resolution</td>
<td></td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>Noise, air motion</td>
<td></td>
<td>Poor resolution large target</td>
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# Proximity Switches

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<tr>
<td>Inductive</td>
<td>Other nearby sensors</td>
<td>Usually fails ON, good resolution</td>
<td></td>
</tr>
<tr>
<td>Capacitive</td>
<td>Humidity, temperature</td>
<td></td>
<td>Complex circuitry, false triggering</td>
</tr>
<tr>
<td>Magnetic inductance</td>
<td>Other nearby sensors</td>
<td>Good resolution</td>
<td>Collects debris, no static sense</td>
</tr>
<tr>
<td>Hall effect</td>
<td>Temperature</td>
<td>Simple, inexpensive</td>
<td>Poor resolution, needs magnet</td>
</tr>
<tr>
<td>Wiegand effect</td>
<td></td>
<td></td>
<td>No static sense, magnet</td>
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Limit & Proximity Switch Applications

- Don't use the limit switch as a mechanical stop (use another component)
- Use cam surfaces to allow gradual actuation
- Don't apply side forces to the switch roller or lever (will wear bearings quickly)
- Use appropriate switch actuator for type of force/motion applied
- Don't switch excessive currents through the switch contacts
Factors in Selecting Limit & Proximity Switches

► Type of output signal (high/low voltage?, high/low current?, DC or AC?, relay or triac?)

► Is mechanical contact with sensed object OK?

► Available space

► Environmental conditions

► Nature of target: size, shape, material, surface
Factors in Selecting Limit & Proximity Switches

- Sensor-to-target distance (max and min)
- Positional accuracy required
- Speed of target (will it remain in sensing area long enough?)
- Switching rate - how often will inputs be presented to the sensor? Can it recover quickly?
- Reliability and life expectancy - can you detect a failure?
Prox Sensor Output - NPN

Proximity Sensor

NPN output
or
Open-Collector output
or
Current "sinking" output
Prox Sensor Output - NPN

Typically +5V, +12V or +24V

Proximity Sensor

External sense (or load) resistor
Prox Sensor Output - PNP

Proximity Sensor

PNP output or Current "sourcing" output
Prox Sensor Output - PNP

Proximity Sensor

Typically +5V, +12V or +24V

External sense (or load) resistor
Both NPN and PNP outputs