Proximity Sensors and Switches

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

- Single pole, single throw (SPST)
  - Normally Open (NO)
  - Normally Closed (NC)
- Single pole, double throw (SPDT)
- Double pole, double throw (DPDT)

Switch Contact Configurations

- **COM**
  - Single pole, single throw (SPST)
  - Normally Open (NO)
- **COM**
  - Single pole, single throw (SPST)
  - Normally Closed (NC)
- **COM**
  - Single pole, double throw (SPDT)
- **COM1**
  - Double pole, double throw (DPDT)

Mercury Switch

- Contacts
- Mercury "puddle"
Proximity Sensors and Switches

Photoelectric Proximity Sensor

- Current limiting resistor
- Small current flows through transistor
- \( V_{OUT} \approx 0 \) V

Photoelectric Sensor - Blocked

- Sense resistor
- No current
- \( V_{OUT} \approx V_S \)

Photoelectric Sensor - Design

- Current limiting resistor usually "small"
- \( \approx 1.2-1.7 \) V
- \( i \approx 10-30 \) mA
- Sense resistor usually large 10KΩ to 100KΩ

Thru-Beam Photoelectric

- from Warner
- from Eaton/Cutler-Hammer

Reflective Photoelectric

- from Warner
- from Eaton/Cutler-Hammer

Cross-Beam Photoelectric

- from Eaton/Cutler-Hammer
Automatic Door Opener

Case Sorting - By Size

Inductive Proximity Sensor

Inductive Sensor Considerations
Capacitive Proximity Sensors

► Capacitive proximity sensors are similar to inductive proximity sensors.
  - capacitive proximity sensors produce an ___________________ field
  - inductive sensors produce an electromagnetic field.

► Will sense metal as well as __________ materials such as paper, glass, liquids, and cloth

Capacitive Proximity Sensors

► The sensing surface is formed by two ___________ shaped metal electrodes of an unwound capacitor.

► When an object nears the sensing surface it enters the electrostatic field of the electrodes and changes the capacitance in an __________ circuit.

Capacitive Proximity Sensors

► Capacitive sensors depend on the ______________ of the target.

► The larger the dielectric number of a material the easier it is to detect.

Ultrasonic Proximity Sensing

High frequency (200 kHz) sound waves reflect from object

Ultrasonic Proximity Sensing

\[
\text{Distance} = \left( \frac{\text{Speed of sound in air}}{2} \right) \Delta T
\]
Proximity Sensors and Switches

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Proximity Switches

**Sensor** | **Targets** | **Sense Distance (typ. max)** | **Switch Rate (typ. max)**
--- | --- | --- | ---
Limit switch | Any | 0 (physical contact req'd) | 3 Hz
Mercury switch | Any | 0 (physical contact req'd) | 3 Hz
Reed switch | Magnet | 20 mm | 500 Hz
Photo-electric | Opaque | 0.1 to 50 m, depends on target shape | 100-1000 Hz
Ultrasonic | Nonporous, large | 30 mm to 10 m | 50 Hz

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Proximity Switches

**Sensor** | **Targets** | **Sense Distance (typ. max)** | **Switch Rate (typ. max)**
--- | --- | --- | ---
Inductive | Conductive material | Ferrous: 50 mm, Non-ferrous: less | 300-5000 Hz
Capacitive | Most solids, liquids | 30 mm | 500 Hz
Magnetic inductance | Ferromagnetic | 50 mm (depends on target mass) | 300 Hz
Hall effect | Magnet | 20 mm | 100 kHz
Wiegand effect | Magnet | | 100 kHz

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Proximity Switches

**Sensor** | **Environmental Sensitivities** | **Advantages** | **Disadvantages**
--- | --- | --- | ---
Limit switch | Temperature, moisture | Simple, inexpensive | Physical contact, arcing
Mercury switch | Vibration, mounting angle | Low contact resistance, sealed unit | Physical contact, SPST contacts only
Reed switch | Vibration | Small size, inexpensive | Contact arcing, magnet actuator
Photo-electric | Dust, dirt, ambient light | Good resolution | Poor resolution, large target
Ultrasonic | Noise, air motion | | Poor resolution, large target

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Proximity Switches

**Sensor** | **Environmental Sensitivities** | **Advantages** | **Disadvantages**
--- | --- | --- | ---
Inductive | Other nearby sensors | Usually fails ON, good resolution | Complex circuitry, false triggering
Capacitive | Humidity, temperature | Good resolution | Collects debris, no static sense
Magnetic inductance | Other nearby sensors | Good resolution | Poor resolution, needs magnet
Hall effect | Temperature | Simple, inexpensive | Poor resolution, needs magnet
Wiegand effect | | No static sense, magnet |

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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

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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

- NPN output
- Open-Collector output
- Current "sinking" output

Prox Sensor Output - PNP

- PNP output
- Current "sourcing" output

Both NPN and PNP outputs