Distance Sensors

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It’s a What?

- **$ 3.70**
  - Ultrasonic
  - 2-400 cm
  - Analog (~3mm prec.)
  - HC-SR04
  
- **$ 15**
  - Infrared
  - 100-550 cm
  - Analog (~1cm prec.)
  - Sharp GP2Y0A02YK0F
  
- **$ 50**
  - Ultrasonic
  - 0-765 cm
  - Digital, 1cm LSB
  - MaxSonar-EZ3
  
- **$$$$$$**
  - IR Laser
  - 0.15-300 m
  - Digital, 3mm LSB
  - SICK Dx100

Image courtesy of sainsmart.com
Image courtesy of sparkfun.com
Image courtesy of sparkfun.com
Image courtesy of sick.com
General Applications

- Obstacle Detection
- Parking Assist
- Radar Gun
- Flight Safety
- General Navigation
- Robotics
- Sensing Distance

Images courtesy of insurancehunter.ca and google.com
Flavors by Function

- Proximity vs Distance/Range Finder
- Range (min/max)
- Precision (m/V) (mm, cm, in)
- Angle Measurement
- Outputs (Analog, I2C, SPI, etc)

Flavors by Form

- Ultrasonic
- Infrared Light (IR)
Infrared Distance Sensor

Image courtesy of edn.com
Meet the Sharp GP2Y0A710K0F

- Price: $16
- Interface: Analog
- Power Supply: 4.5-5.5 Volts
- Working Current: 30-50 mA
- Distance Range: 100 - 550 cm
- Precision: ~1 cm.
- Dimensions: 58 x 17.6 x 22.5 mm

[Datasheet]

Image courtesy of acroname.com
Characteristics of IR Sensor

- Narrow/focused area = high accuracy
- Don’t work in sunlight
- Can be affected by an object’s color
Ultrasonic Distance Sensor

Image courtesy of seminarsonly.com

Image courtesy of tehnomagazin.com
How it Works - Ultrasonic Sensor

- AC current passed through piezoelectric transducer
  - different currents cause the piezoelectric crystal to expand and contract
- Return ultrasonic wave measured expands and contracts piezoelectric transducer crystal, generating an AC current
- Converts to DC voltage
- ADC converter, depending on how expensive the device
Meet the HC - SR04

- Price: $3.70
- Power Supply: +5V DC
- Working Current: 15mA
- Effectual Angle: < ±15°
- Distance Range: 2cm – 400 cm
- Resolution: 0.3 cm
- Trigger Input Pulse width: 10uS
- Dimension: 45mm x 20mm x 15mm

Image courtesy of sainsmart.com
Interfacing - Ultrasonic Sensor (HC - SR04)

10μS Pulse to Trigger

Eight 40kHz pulses are transmitted

Time taken by the Ultrasonic Burst to Leave and Return to the Sensor

Image courtesy of electrosome.com
Interfacing - Ultrasonic Sensor (HC - SR04)

- Send 10us pulse trigger
- Listen for Echo to go high, start timer
- Capture when it goes low, and throw interrupt
- Calculate Distance:
  - distance(cm) = pulse_width(us)/58
Characteristics of Ultrasonic Sensors

- Some can measure angles
- Don’t work in noisy environment
- Can be affected by an object’s consistency (i.e. foam)
- Object must be perpendicular to sensor
- Accuracy can be affected by angle
Infrared vs. Ultrasonic

**Infrared**
- Narrow focus area
- Can be used in noisy environment
- Minimum sensing distance (100 cm for GP2Y0A710K0F)
- Color can affect reading

**Ultrasonic**
- Some can measure angles
- Can be used in sunlight
- Minimum sensing distance (2 cm for HC-SR04)
- Shape, angle, and texture can affect reading
- Often more accurate vs IR sensor of similar price ranges
MaxSonar-EZx Series

- $ 26-50
- Ultrasonic

Distance Ranges
- Min 0-15cm
- Max 500cm - 765cm
- 0.1cm - 3cm LSB Precision

Outputs
- Analog Voltage
- RS232
- UART
- TTL Serial
- Pulse Width

Image courtesy of sparkfun.com
MB1013
HRLV-MaxSonar®-EZ1™ Beam Pattern

Sample results for measured beam pattern are shown on a 30-cm grid. The detection pattern is shown for dowels of varying diameters that are placed in front of the sensor.

A 6.1-mm (0.25-inch) diameter dowel
B 2.54-cm (1-inch) diameter dowel
C 8.89-cm (3.5-inch) diameter dowel

Note: For people detection the pattern typically falls between charts A and B.

Beam Characteristics are Approximate
Beam Patterns drawn to a 1:95 scale for easy comparison to our other products.
Realtime Triggered Operation

Vcc

Pin 6 (Vcc)
Clean, Stable Power Provided to Vcc
(All signals are referenced to Vcc and 0V.)

Pin 4 (Ranging Start/Stop)
Initially set Low
Drive High for >20µS (<0.02mS) up to 97mS

Pin 3 (Analog Voltage Output)
Previous range voltage
Voltage set (as available)

Pin 2 (Pulse Width Output)

Pin 5 (RS232 Serial Output) default
Data sent in RS232
Low Idle State for RS232

Pin 5 (TTL Serial Output), jumper
Data sent in TTL
High Idle State for TTL

Time
0 ms
~85 ms
~90 ms
~98 ms

Power supply must be free of noise for best results.
To maintain real time range data, Pin 4 must be set Low before serial data send is complete.
The analog voltage output maintains the voltage corresponding to the latest range measurement.
Range information is output with a high pulse width between 300µS and 5000µS
Filtered Freerun Operation

Vcc
Pin 6 (Vcc) 0
Clean, Stable Power Provided to Vcc (All signals are referenced to Vcc and 0V.)

Power supply must be free of noise for best results.

Pin 4 (Ranging Start/Stop)
For continuous filtered range data, leave Pin 4 open or hold high.

Pin 3 (Analog Voltage Output)
The analog voltage output holds the voltage corresponding to the latest filtered range measurement.

Pin 2 (Pulse Width Output)
Range information is output with a high pulse width between 300uS and 5000uS

Pin 5 (RS232 Serial Output) default
Low Idle State For RS232

Pin 5 (TTL Serial Output), jumper
High Idle State For TTL
Reports first Range value Reports Filtered Range Data
For detailed reading to reading timing look at Realtime Triggered Operation timing diagram.
Summary

- Two main types of distance sensors
  - Ultrasonic
  - Infrared (IR)
- Many parameters & capabilities to consider
  - distance range
  - precision
  - indoor/outdoor
  - robustness, accuracy, noise resistance
  - interfaces
Questions?
References

mouser.com/ProductDetail/Parallax/28015/?qs=Re%252bcz0%2FMYCKqvqZW3g9mzg%3D%3D&gclid=CIyusID5kcsCFZCIaQod510A4A

tehnomagazin.com/Sensors/Ultrasonic-sensor.htm

phidgets.wordpress.com/2014/05/23/exploring-the-many-methods-of-object-detection/

edn.com/Home/PrintView?contentItemId=4397394

google.com/selfdrivingcar/

insurancehunter.ca/blog/4-exciting-car-tech-trends-2015

seminarsonly.com/Engineering-Projects/Electrical/Ultrasonic_Based_Distance_Measurement_System.php

sainsmart.com/ultrasonic-ranging-detector-mod-hc-sr04-distance-sensor.html

https://www.sparkfun.com/products/9495
References (continued)


http://www.npeducations.com/2013/10/low-cost-ir-based-distance-measurement.html


https://developer.mbed.org/forum/mbed/topic/1048/?page=1#comment-6420

https://graigroup.wordpress.com/category/sensors/

https://acroname.com/sites/default/files/assets/sharp_gp2y0a710yk0f_datasheet.pdf

https://docs.google.com/document/d/1Y-yZnNhMYy7rwhAgyL_pfa39RsB-x2qR4vP8saG73rE/edit