

# Distance Measurement with the Help of Ultrasonic Sensor

Sandeep Kumar Gupta

Student, Dept. of Electrical & Electronics, Pranveer Singh Institute of Technology, Kanpur, Uttar Pradesh, India

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**Abstract** - Ultrasonic detection is most commonly used in industrial applications to detect hidden tracks, discontinuities in metals, composites, plastics, ceramics, and for water level detection. For this purpose the laws of physics which are indicating the propagation of sound waves through solid materials have been used since ultrasonic sensors using sound instead of light for detection.

taken between sending sound waves and receiving echo. The echo patterns will be compared with the patterns of sound.

**Key Words:** Ultrasonic sensor, Radiation, Transducer,

## 1. INTRODUCTION

An ultrasonic sensor transmit ultrasonic waves into the air and detects reflected waves from an object. There are many applications for ultrasonic sensors, such as in intrusion alarm systems, automatic door openers and backup sensors for automobiles. Accompanied by the rapid development of information processing technology, new fields of application, such as factory automation equipment and car electronics, are increasing and should continue to do so. Using its unique piezoelectric ceramics manufacturing technology developed over many years, Murata has developed various types of ultrasonic sensors which are compact and yet have very high performance. The information contained in this catalog will help you to make effective use of our ultrasonic sensors.

### 1.1 Principle of ultrasonic detection

Sound is a mechanical wave travelling through the mediums, which may be a solid, or liquid or gas. Sound waves can travel through the mediums with specific velocity depends on the medium of propagation. The sound waves which are having high frequency reflect from boundaries and produces distinctive echo patterns. Sound is a mechanical wave travelling through the mediums, which may be a solid, or liquid or gas. Sound waves can travel through the mediums with specific velocity depends on the medium of propagation. The sound waves which are having high frequency reflect from boundaries and produces distinctive echo patterns.

### 1.2 Operation of ultrasonic sensors:

#### Open Structure Type Ultrasonic Sensors

When an electrical pulse of high voltage is applied to the ultrasonic transducer it vibrates across a specific spectrum of frequencies and generates a burst of sound waves. Whenever any obstacle comes ahead of the ultrasonic sensor the sound waves will reflect back in the form of echo and generates an electric pulse. It calculates the time

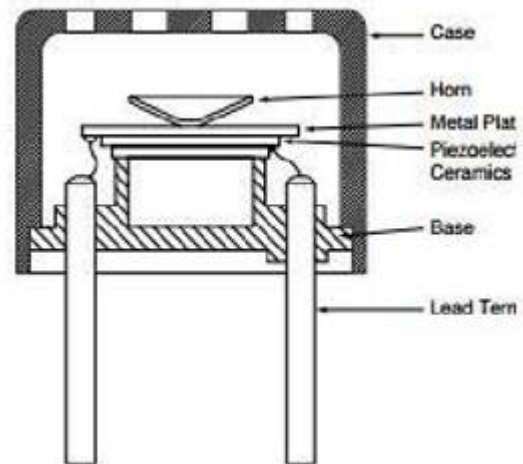


Figure 1 Open Structure Type

#### Enclosed type Ultrasonic Sensor

Ultrasonic sensors for outdoors use are sealed to protect them from dew, rain and dust. Piezoelectric ceramics are attached to the top inside of the metal case. The entrance of the case is covered with resin.

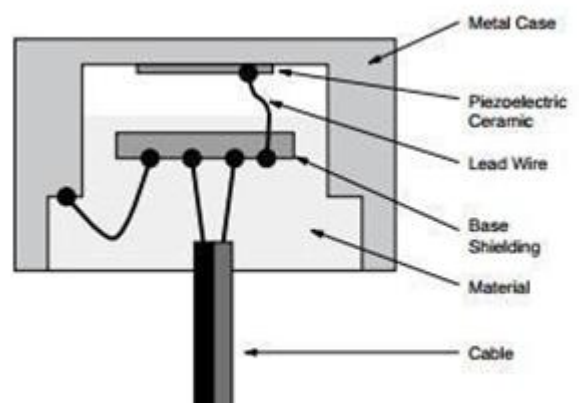


Figure 2. Enclosed type

#### High Frequency Ultrasonic Sensors

For use in industrial robots, accuracy as precise as 1mm and acute radiation are required. By flexure vibration of the conventional vibrator, no practical characteristics can be obtained in frequencies higher than 70kHz and, therefore, vertical thickness vibration mode of

piezoelectric ceramics is utilized for detection in high frequency. In this case, the matching of acoustic impedances of the piezoelectric ceramics and air becomes important. Acoustic impedance of piezoelectric ceramics is  $2.6 \times 10.7 \text{ kg/m}^2\text{s}$ , while that of air is  $4.3 \times 10.2 \text{ kg/m}^2\text{s}$ . This difference of 5 powers causes large loss on the vibration radiating surface of the piezoelectric ceramics. Matching the acoustic impedances with air is performed by bonding a special material to the piezoelectric ceramics as an acoustic matching layer. This construction enables the ultrasonic sensor to work in frequencies of up to several hundred kHz.

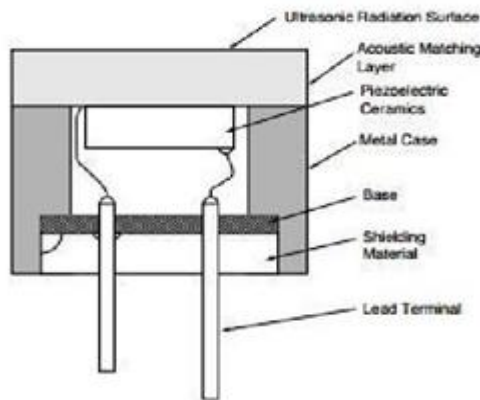


Figure 3 High Frequency

## 2. ELECTRICAL CHARACTERISTICS

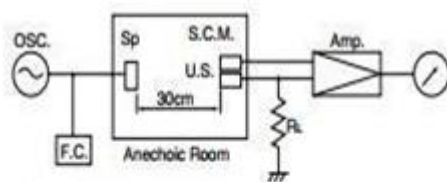
### Sound Pressure Characteristics

Sound pressure level (S.P.L.) is unit indicating the volume of sound and is expressed by the following formula.

$S.P.L. = 20 \log P \text{ (dB) } P_0$  where "P" is Sensor sound pressure (Pa) and "P<sub>0</sub>" is reference sound pressure (20μPa).

### Sensitivity Characteristics

Sensitivity is the unit indicating the sound receiving level and is expressed by the following formula.



RL	: 3.9kΩ	
U.S.	: Ultrasonic Sensor	
S.C.M.	: Standard Capacitor Microphone	(Brüel & Kjaer 4135)
Amp.	: Amplifier	(Brüel & Kjaer 2610)
OSC.	: Oscillator	
Sp.	: Tweeter	
F.C.	: Frequency Counter	0dB=10V/Pa

Figure 4 Sensitivity Measuring Circuit

Sensitivity =  $20 \log S \text{ (dB)}$  So where "S" is Sensor voltage (V) and "S<sub>0</sub>" is reference sound pressure (V/Pa). Fig.4 shows a sensitivity measuring circuit.

### Radiation

The 3.9kΩ resistor connected with the electrode terminal of the sensor is used to avoid the influence of outside noise.

The ultrasonic sensor is installed on a table. Then, the relationship between angle and sound pressure (sensitivity) is measured. In order to express radiation precisely, the angle in which the sound pressure (sensitivity) level attenuates by 6dB compared with the front is called the half attenuation angle with an expression of  $\theta 1/2$ .

## 4. APPLICATIONS INVOLVING ULTRASONIC DETECTION

### Ultrasonic Distance Measurement

Ultrasonic sensors are used for distance measuring applications. These gadgets regularly transmit a short burst of ultrasonic sound to a target, which reflects the sound back to the sensor. The system then measures the time for the echo to return to the sensor and computes the distance to the target using the speed of sound within the medium. Different sorts of transducers are utilized within industrially accessible ultrasonic cleaning devices. An ultrasonic transducer is affixed to a stainless steel pan which is filled with a solvent and a square wave is applied to it, conferring vibration energy on the liquid.

The ultrasonic distance sensors measures distance using sonar; an ultrasonic (well above human hearing) beat is transmitted from the unit and distance-to-target is determined by measuring the time required for the echo return. Output from the ultrasonic sensor is a variable-width beat that compares to the distance to the target.

### Features of Ultrasonic Distance Sensor:

1. Supply voltage: 5V (DC).
2. Supply current: 15mA.
3. Modulation frequency: 40Hz.
4. Output: 0 – 5V (Output high when obstacle detected in range).
5. Beam Angle: Max 15 degree.
6. Distance: 2cm – 400cm.
7. Accuracy: 0.3cm.
8. Communication: Positive TTL pulse.

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