MA40S4S/MA40S4R

Ultrasonic Sensor
Open Structure Type

Features

- **High S.P.L. and high sensitivity**
- **Compact size(10.0mm dia.)**
- **Open type structure (indoor applications)**

Applications

- **Object detection**
- **Measuring the distance**
- **Dynamic body detection**

Overview

MA40S4S / MA40S4R are ultrasonic transducer for various detections. MA40S4S is used to transmit ultrasonic waves. MA40S4R is used to receive them.

MA40S4S / MA40S4R consist of piezoelectric ceramics, metal plate, resonator and resin case.
Resonator has like a funnel shape to transmit ultrasonic waves which is generated by vibration of resonator to the air efficiently(or to concentrate ultrasonic waves from the air on the center of resonance).Sound pressure level(S.P.L.) is the most important characteristic for ultrasonic transducers. For example, in measuring distance application, high S.P.L. transducer enables to detect the further distance.

MA40S4S / MA40S4R cannot be used in outdoor applications because they are open type structure.
And they cannot be used for automotive applications. We can support only for consumer applications.

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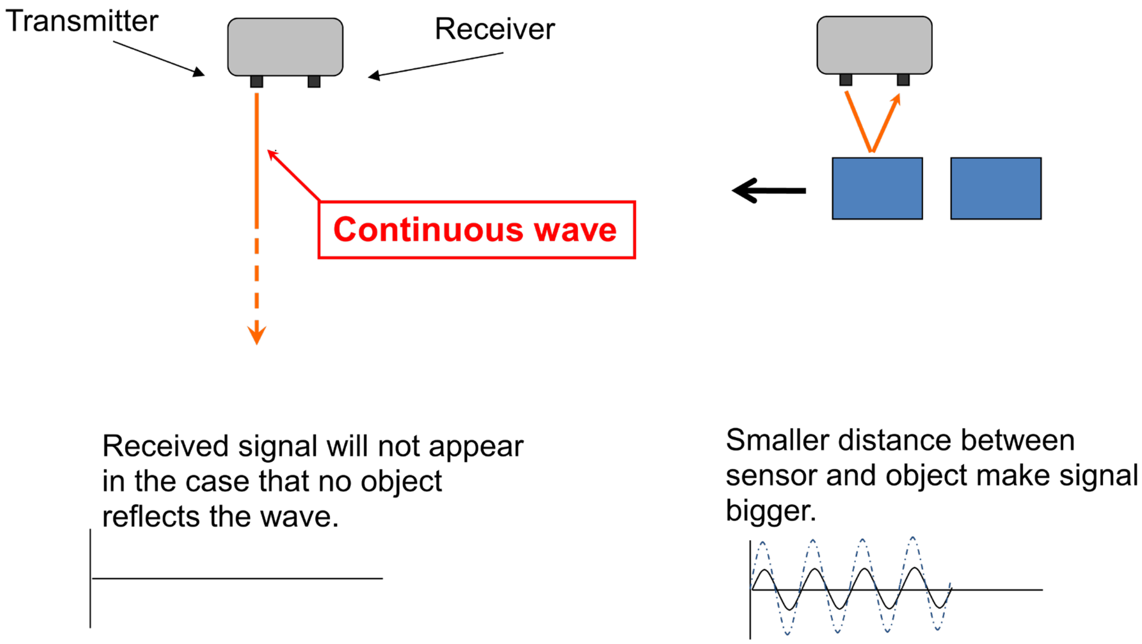
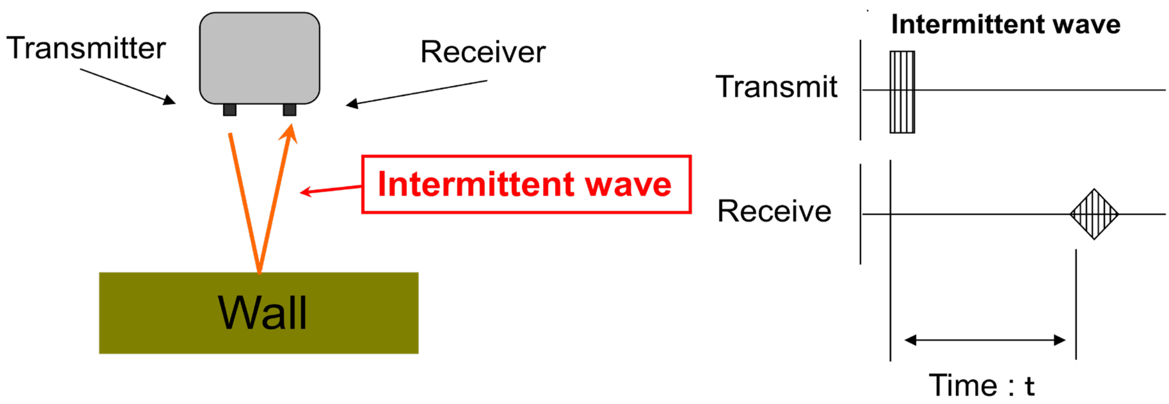
2. Usage of ultrasonic transducer

2.1 Object detection



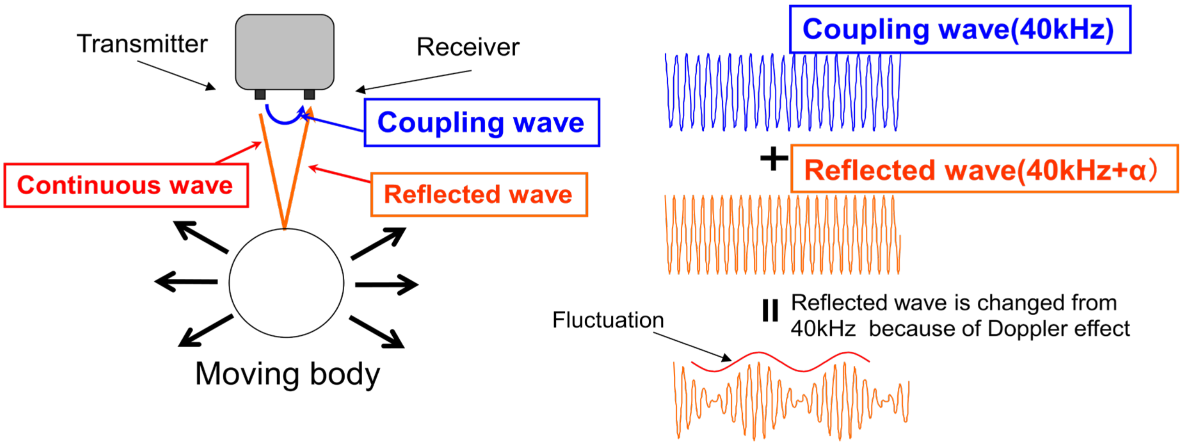
2.2 Measuring the distance



Measuring the time from transmitting to receiving (using clock)

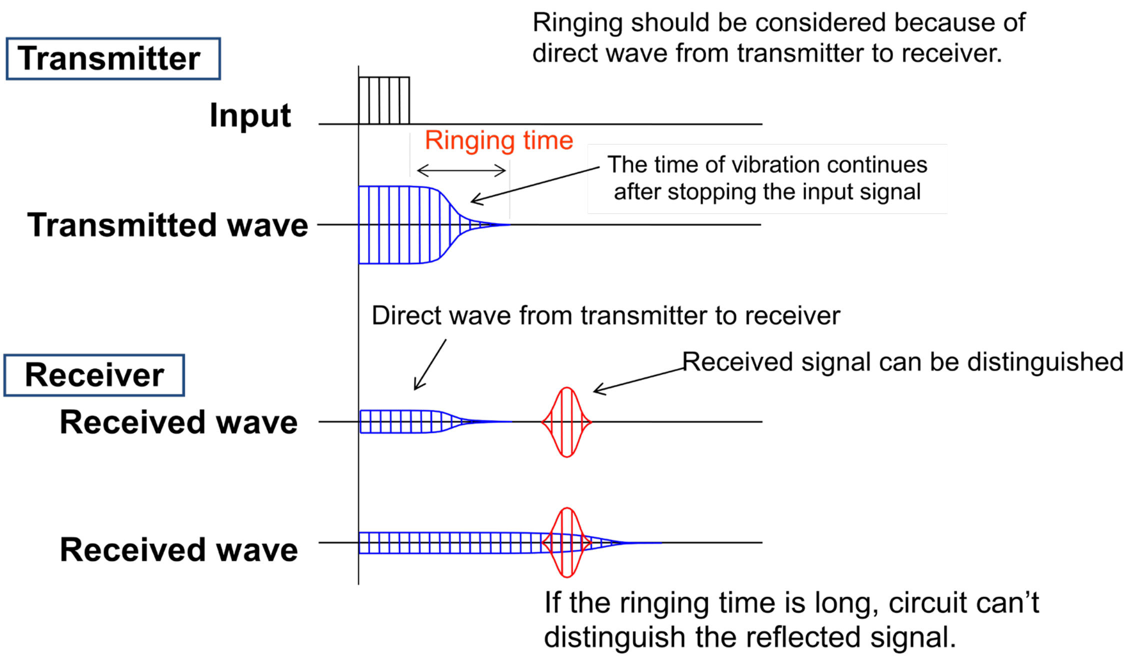
Time x Sonic speed(340m/s) ＝ Distance to the object

2.3 Dynamic body detection

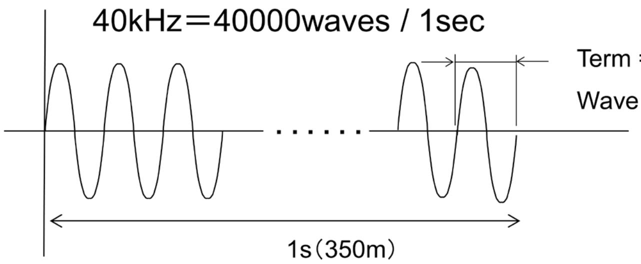


The movement is detected by fluctuations of mixed signal.

2.4 Ringing time

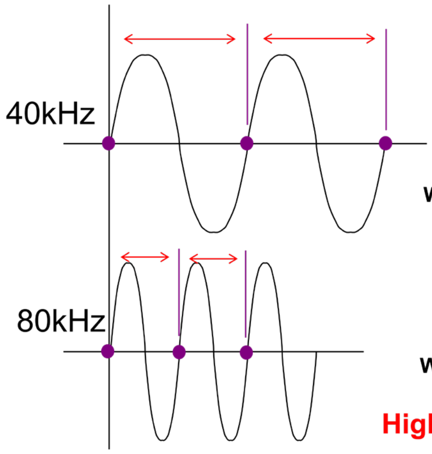


2.5 Resolution



Term = 0.025ms (=1/40000 cycle)

Wave length = 8.7mm (=340m/s / 40000 cycle)



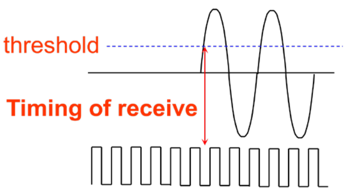
Usually zero cross point is easy to detect the signal timing.

Wave length is 8.7mm ＝**Resolution 8.7mm**

Wave length is 4.3mm ＝**Resolution 4.3mm**

Higher frequency sound can detect the shorter distance.

Actually in the signal processing, the sensor recognizes the received wave which exceeds threshold point.
And then the circuit calculates the distance with reference clock.



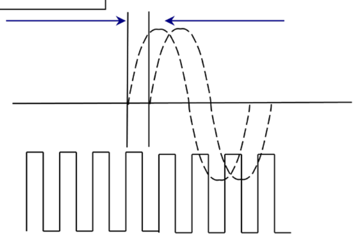
Count the clock pulse from the start of transmission to receive signal.

Distance is calculated as below example.

Ex:) Receive the signal after clock counts 150 pulses.
Clock cycle = 0.01ms

0.01/1000(s) x 150（counts）x 340(m/s) ＝ 510mm = 51cm

However…



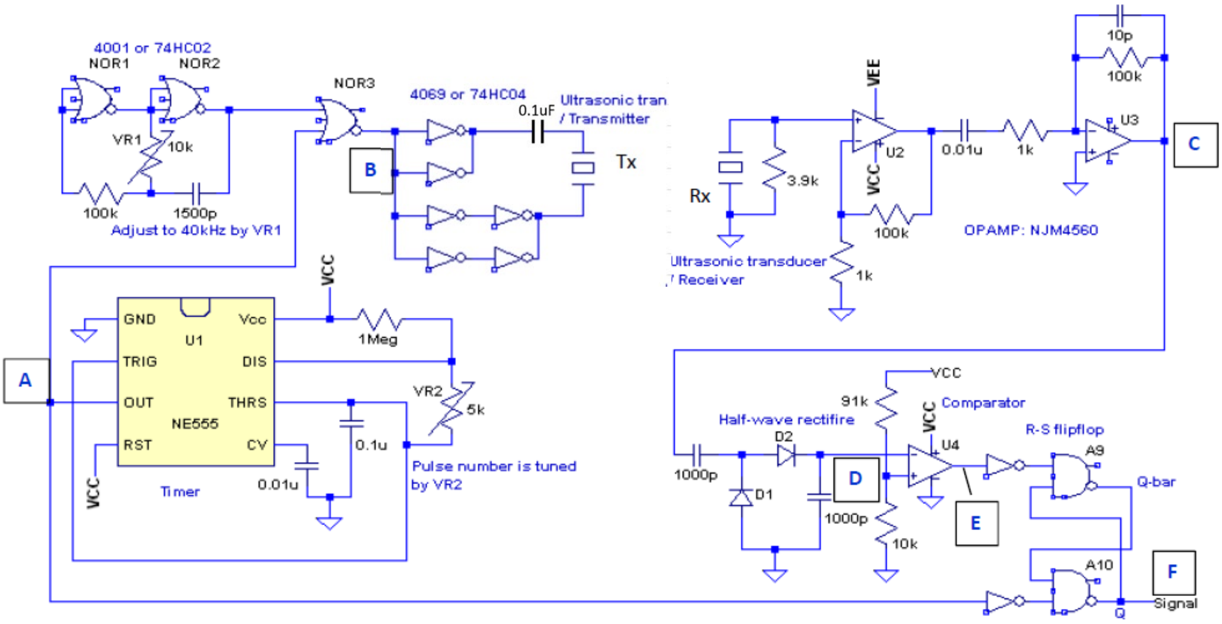
Even though the timing of received signal changes, if the number of clock pulse doesn’t change, the circuit will distinguish as the same distance.

Thus, the resolution of measuring distance also depends on the frequency of clock pulse.

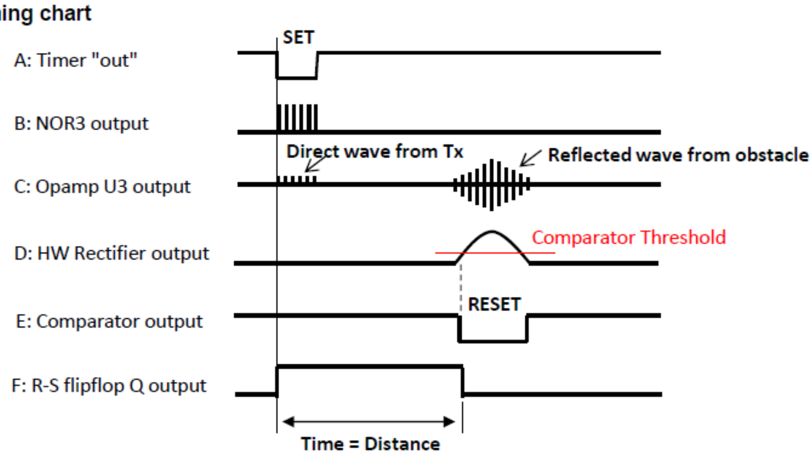
2.6 Circuit example

Distance measuring circuit example

Reference Only



Timing chart



<Measuring method>

1. SET the R-S flipflop at the rise of Timer output
2. Detect the received signal by comparator fall down and make RESET
3. The time between R-S flipflop is High equal to distance.
   Distance = time x 346 m/s at 25degC

3. Measurement details

3.1 Impedance curve

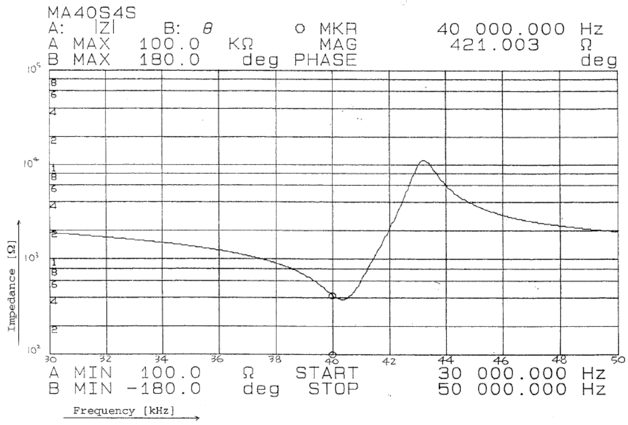


Fig.1 MA40S4S

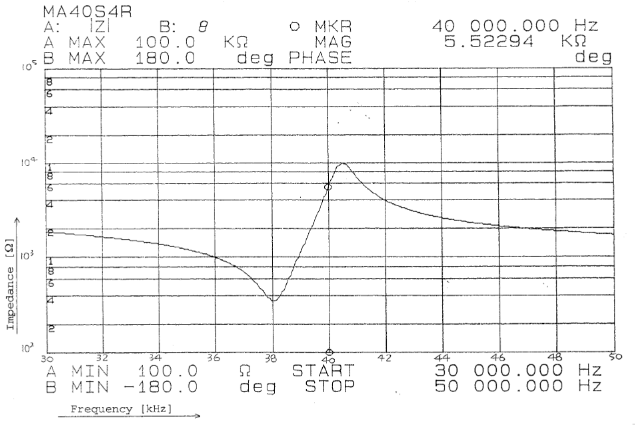
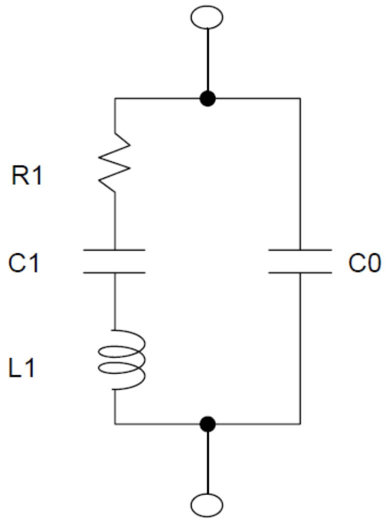


Fig.2 MA40S4R

3.2 Equivalent circuit



R1:Resonant Registance.(Serial Resistance)
C1:Serial Capacitance.
L1:Serial Inductance.
C0:pararel Capacitance.

Type	R1(ohm)	C1(pF)	L1(mH)	C0(pF)
MA40S4R	320	300	58	2200
MA40S4S	340	300	48	2150

Fig.3 Equivalent Circuit parameter

3.3 Frequency characteristics

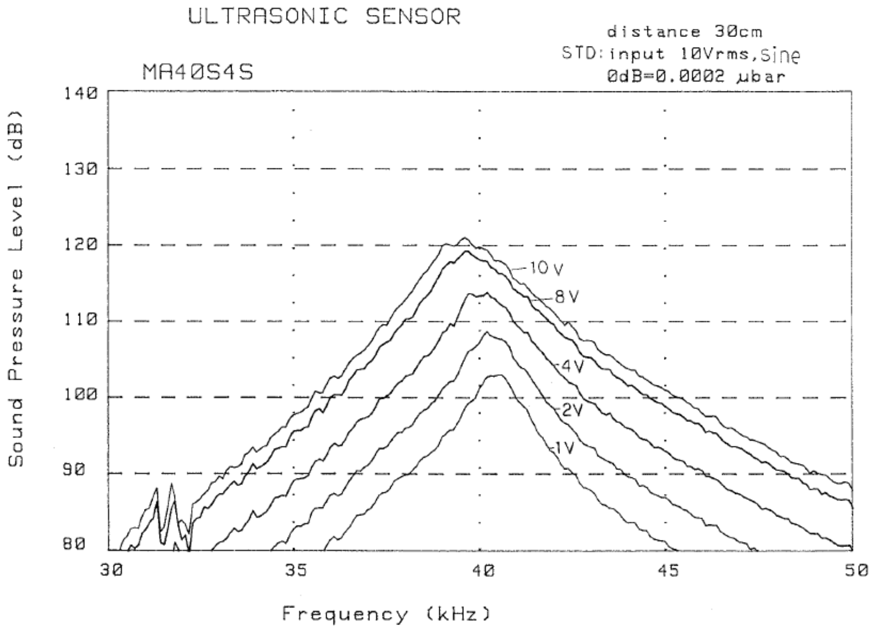


Fig.4 Frequency – Sound Pressure Level characteristic of MA40S4S (input voltage dependency)

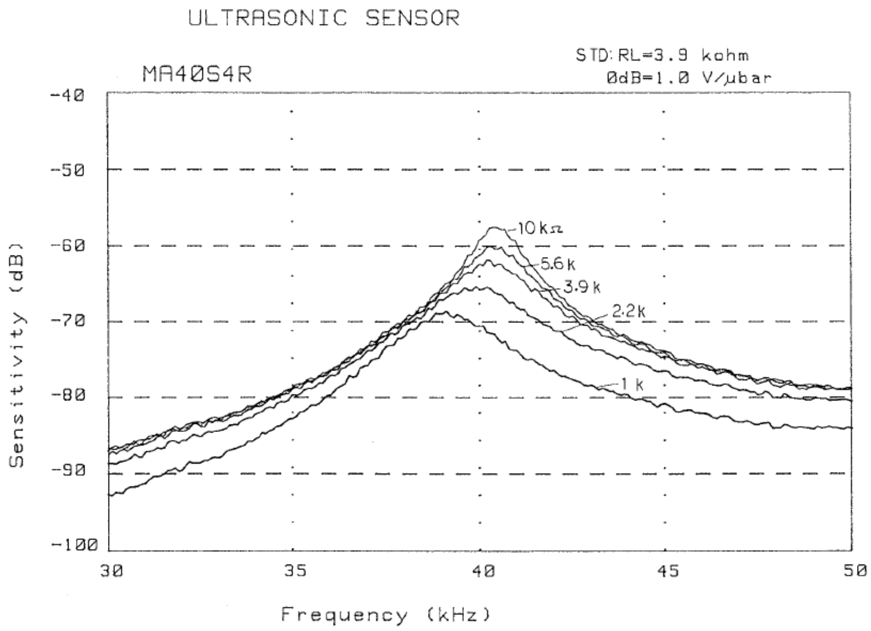


Fig.5 Frequency – Sensitivity characteristic of MA40S4R (load resistance dependency)

3.4 Temperature characteristics

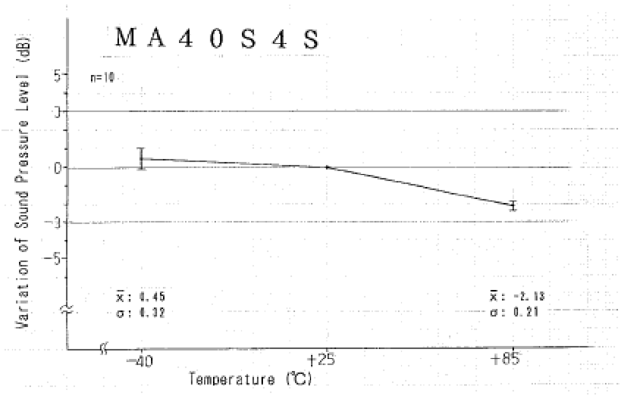


Fig.6 Sound Pressure Level (MA40S4S)

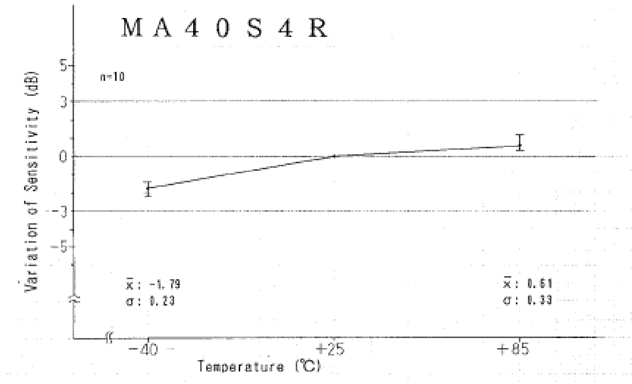


Fig.7 Sensitivity (MA40S4R)

4. FAQ

4. Characteristics

What are Decay time?

Generally, a “Decay time” refers to a sound generated by the oscillator during damped oscillation after the drive signal is switched off. For practical purposes, the decay time of an ultrasonic sensor is defined as the time it takes the oscillator to be damped to a certain reference voltage(refer to 1.4).

How much power does an ultrasonic sensor consume?I know it depends on the circuit in which it is used, but when used for xx-meter detection, what are the power supply voltage and consumption current?

The impedance during resonance is approximately 400Ω. When the oscillator is driven by a single pulse at a drive voltage of 5Vpp, a current of approximately 6.3mA flows through the sensor. However, no constant current flows during distance measurement since the sensor is driven intermittently for that purpose. For example, when the oscillator is driven by 8 pulses at an interval of 100ms, duty is 0.02% and therefore the mean current is 10μA. For a receiver circuit gain of 80dB, under the above driving conditions it is possible to detect distances of up to approximately 2m

Is it possible to make the sensor directive by an electrical means?

It is difficult to electrically control the beam pattern of Murata ultrasonic sensors. (With a sensor having broad resonance characteristics, it is possible to more or less control the beam pattern by changing the frequency of the drive signal. The drawback is that the broad resonance characteristics result in lower sound pressure.)

Is it possible to recognize the size and shape of the object detected?

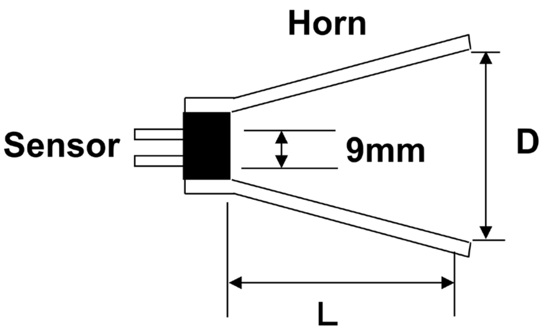
It is difficult for Murata ultrasonic sensors to determine the size of the object. If multiple sensors are used in an array, we assume it is possible to determine object size from differences in echo arrival time at individual sensors, however this is unrealistic in terms of both technical and cost efficiency. (For recognition of plane surface size, it is far more inexpensive to use a CCD camera.) To recognize object size, it is necessary to use an array of sensors and intelligent image processing, as in ultrasonic diagnosis equipment for medical use. It is also necessary to limit the range of sensing reflections. Therefore we believe it is not a realistic solution to recognize object size using ultrasonic sensors.)

Is it possible to detect short distances?

It is possible to detect approximately 15cm by adjusting the drive voltage and the number of drive waves, but we believe it is difficult to detect approximately 10cm or less because the impact of reverberations cannot be eliminated entirely.

Are there ways to narrow directivity?

Attach a horn.(per fig.8)



Horn Size

Line Color	L	D
Blue	none	none
Black	43	40
Red	33	33
Green	22	25
Yellow	11	17

(mm)

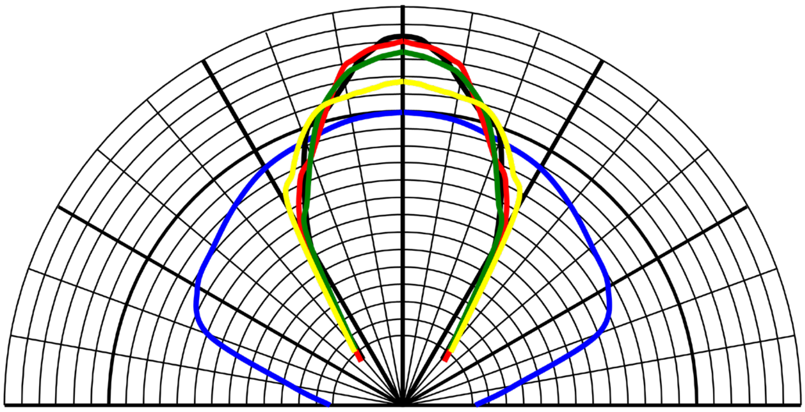


Fig.8 Directivity control with horn (ex.)

Do the ultrasonic waves interfere with remote control communication using 40kHz waves? Do they interfere only with sound waves?

Ultrasonic waves have no impact on electromagnetic waves. Note, however, that, if the 40kHz signal line runs in close vicinity of the ultrasonic sensor, noise from the signal line could be superimposed on the sensor signal, reducing the S/N ratio. Since the recipient sensor signal line has a high impedance, it is recommended that it be connected in the shortest possible length and shielded to minimize the impact of crosstalk and external noise.

Is it possible to detect human bodies?

It is possible to detect areas that easily reflect sound waves, such as the face and hands. Clothes are difficult to sense because they absorb sounds. The difference from infrared sensors is that ultrasonic sensors can detect stationary objects and measure the distances to them.

What is the distance that can be detected?

In general use of the open structure type, distances from 0.3 to 2.5m can be detected. This figure can be increased slightly depending on the drive voltage and receiver circuit gain (Murata products have been used to detect up to 4m.)

Is it possible to detect an object that is placed behind a film?

It depends on the thickness of the film and the distance to the object. It may be possible if the film is thin enough for the ultrasonic wave to penetrate and the object is placed at a short distance.

What are the differences among ultrasonic sensors for transmitters, receivers, and dual use?

Products for transmitters are tuned to deliver the maximum sound pressure at 40kHz, while those for receivers are set to be the most sensitive at 40kHz. Sensors for dual use are designed for intermediate applications.
(Using a pair of sensors, one for transmitters and the other for receivers, lengthens the sound transmission range.)

What about directivity?

Murata ultrasonic sensors have directivity of 80 deg. (isotropic). (Directivity is defined as the angles at which sound pressure is reduced to halve the sound pressure measured in front. With an 80 deg. directivity, sound pressure is reduced by half at 40 deg. on both sides.)

What is the resolution limit?
(What is the size in mm for the steps of distance detection?)

Approximately 9mm
(1 wavelength of the 40kHz sound) under ideal conditions.

4.2 Quality / Reliability

Can Murata ultrasonic sensors be used under water?

Murata ultrasonic sensors are designed for use in the air and not under water.
MA40S4S and MA40S4R should not be used outdoors, either.
They cannot be used in environments where they are exposed to rain and/or dust.

Is it possible to prevent false detection of dirt and dust?

Foreign matter, such as snow or dirt, attached to the sensor surface inevitably causes false detection because it reflects sound waves. Dirt and dust covering the surface reduces sound pressure and changes sound distribution due to scattering. These problems inevitably affect the detection area.
MA40S4S and MA40S4R cannot be used in environments where water drops adhere to the sensor.

Do Murata ultrasonic sensors cause health problems?
Do ultrasonic waves affect the health of the human body or animals (pets)?

There are no laws that regulate the “sound volume” of aerial ultrasonic waves. As a general guideline, it is reported that long exposure to ultrasounds of 105-115dB or more may cause buzzing in the ear and discomfort. It is recommended that the ultrasonic volume be kept below the above limit in the sensor range used.