

Use of Piezoelectric Materials As Ultrasonic Sensor Components

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ABSTRACT

Technical developments in the world of electronics are currently advancing rapidly, and technology continues to be developed to create more reliable technology. In an ultrasound transducer, a device called a piezoelectric produces ultrasound waves at a specific frequency. The use of ultrasonic sensors is characterized by the fact that the output voltage is directly proportional to the increase in the detection distance to the target. The farther the sensor detects an object, the longer it takes for the ultrasonic sensor to reflect the waves back to the sensor. Piezoelectric devices generate ultrasonic waves with a certain frequency. This piezoelectric generates ultrasonic waves (at a frequency of 40 kHz) when the oscillator aims at the target. Generally this tool shoots ultrasonic waves at an area or target.

Keywords: *Ultrasonic Sensor, piezoelectric*

1 Introduction

Technological developments in the world of electronics are now advancing rapidly, where the technology is being developed to create more reliable technology (Frima Yudha & Sani, 2019). Ultrasound technology can be classified as an NDE (non-destruction evaluation) method that utilizes ultrasonic waves to image objects in the body without surgery. This method is safer than other methods such as the use of MRI or CT X-rays. In terms of the quality of the resulting image, the use of ultrasonic from time to time has experienced significant developments. One important thing among efforts to improve image quality is through the selection of sensor materials that match the characteristics of the ultrasound system (Ridlo, 2020).

Sensors are components or devices whose purpose is to detect events or changes in the surrounding environment and produce a result according to its function. The way a sensor works is influenced by the purpose of the sensor, but they still have something in common, namely to detect changes or events in the environment. Sensors themselves have developed quite rapidly in the world of electronics (Ajar Rohmanu, 2018).

Ultrasound is a sound wave that is at a frequency higher than the upper limit of human hearing (ultrasonic frequencies are above 20 kHz to several GHz) and has no difference in terms of characteristics and physical properties when compared to audiosonic (sound waves with audible frequencies by humans, 20 Hz – 20 kHz), it's just that humans cannot hear sound with ultrasonic frequencies. Ultrasound can be used as a tool and test method using the help of ultrasonic sensors made of transducers that utilize the piezoelectric effect (forward and reverse) in its manufacture (Hidayat et al., 2020).

Piezoelectrics are sensor made of silicon or germanium that can generate electricity when bent (direct piezoelectricity), otherwise they will bend when a voltage is applied (reversed piezoelectricity)(Alfraila et al. 2022). Piezoelectric can deflect when pressed or vibrated directly through a medium such as a cantilever. Direct pressure creates a piezoelectric voltage that is proportional to the compressive force, but the piezoelectric can be damaged (Rahmawati et al. n.d).

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Piezoelectric is also a material that generates an electric current under pressure. Based on previous research, piezoelectric development has been applied in several places, such as in Yogyakarta as a piezoelectric earthquake early detection system and e.g. The electricity generator is generated by pressure to be piezoelectric (Musthafa et al., 2020). The development of piezoelectricity as a power generator is realized by several applications such as placing shoes, balls, carpets and quick mats on their mats. The number of piezoelectric generators in various applications encourages researchers to produce piezoelectric products using natural energy, with the aim of reducing government electricity use (Diniardi et al., 2018).

The wall tracker robot is an application of an ultrasonic piezoelectric sensor, namely the HC-SR04. The wall tracking robot detects objects in the vicinity that can be reached by the sensor, and the received data is processed to determine the speed of the DC motor. The sensor sends out ultrasonic waves and receives the reflected waves back. The microcontroller used is Arduino nano. The distance of the HC-SR04 sensor from the object is 2-400cm, so AC is needed to move the motor along the specified area to avoid the object. (Santoso, 2021).

Based on the description above, the researcher intends to examine and examine the application of ultrasonic sensors using piezoelectric materials in everyday life from previous literature and research.

2 Research Methodology

Piezoelectric converts electrical energy into mechanical energy. Piezoelectric materials are fabrics that generate an electric field under pressure or mechanical load. If the internal metering circuit works with the same piezoelectric element, it can be used as a transmitter and receiver. The resulting frequency depends on the oscillator which is adjusted to the working frequency of each sensor. These advantages make piezoelectric transducers more suitable for ultrasonic sensors (Rizki et al., 2018). From the reflection of ultrasonic waves can be used to measure the distance between the sensor and an object which can ideally be calculated by the following formula:

$$S = \frac{v.t}{2} \tag{Equation 1}$$

$$T = \frac{2.s}{v} \tag{Equation 2}$$

Information :

s = the distance between the object and the sensor (m)

t = travel time or pulse width (second)

v = the speed of sound in air is 340 m/s (1 cm every 29,034 μS)

The description of the use of piezoelectricity in ultrasonic sensor is carried out by designing it first. The following is a diagram of an instrument in several previous studies.

- a. Ultrasonic sensor used as mobility aids for the blind using those applied to the waist belt

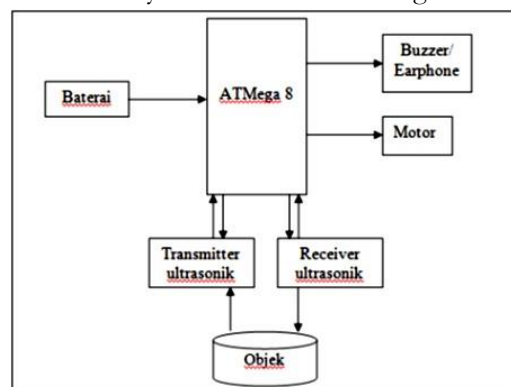


Figure 1: Circuit Program

- b. Designing an Ultrasonic sensor-based Underground clean water paperline Leak Detection Signal Receiver system

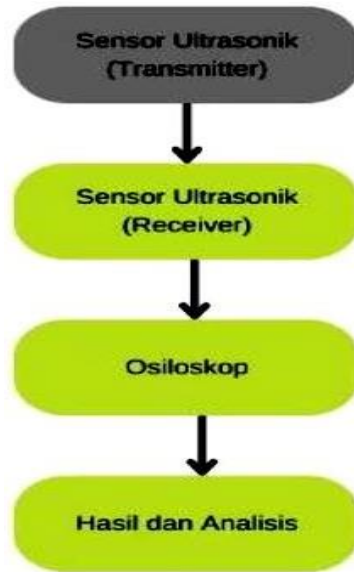


Figure 2 : System block diagram

From this diagram it can be seen that the ultrasonic sensor (transmitter) issues an ultrasonic signal which will be captured by the ultrasonic sensor (Receiver). Then the result of the ultrasonic signal from the ultrasonic sensor (receiver) will be displayed on the oscilloscope screen. Writer system block diagram process on green background.

3 Results and Discussion

Based on the method obtained by each researcher above, the following is the data from the results of research testing.

Research conducted by (Oktarina & Kalsum, 2017) on mobility aids for the blind uses an ultrasound sensor attached to a waist belt. Three sensors namely PING and SRF05 were used in this study to maximize the performance of the device against vibration and ringing from a distance of 3 cm to 3 meters. The measurement results show that the output voltage of the PING and SRF05 sensors is directly proportional to the increase in the detection distance to the target, and both sensors require reflection times of 74 ms and 91 ms at a distance of 10 cm.

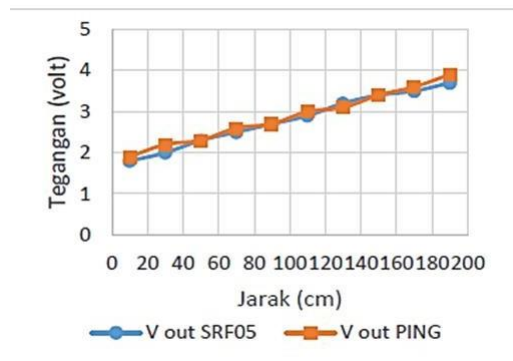


Figure 3: Measurement Graph when active sensor measures distance

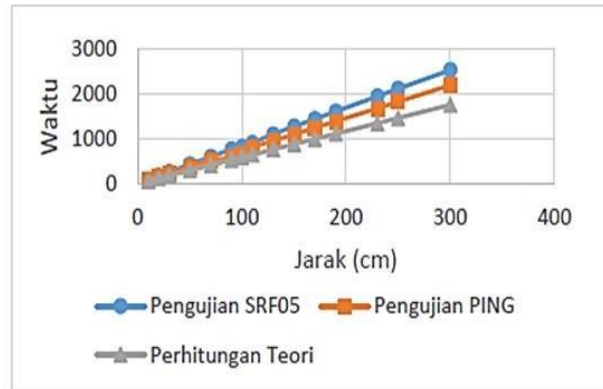


Figure 4: Active sensor measurement graph measures distance against time

Figures 3 and 4 show a comparison of the graphic results to analyze that the SRF05 and PING sensors have something in common, that is, the farther the distance of the ultrasonic radiation, the longer the travel time of the beam. The difference is that the SRF05 sensor has a longer exposure in seconds than the PING sensor, which has an exposure time in milliseconds. Research conducted by (Rahmandika, 2022) designed an Ultrasonic Sensor-based Underground Clean Water Pipe Leak Detection Signal Receiver system.

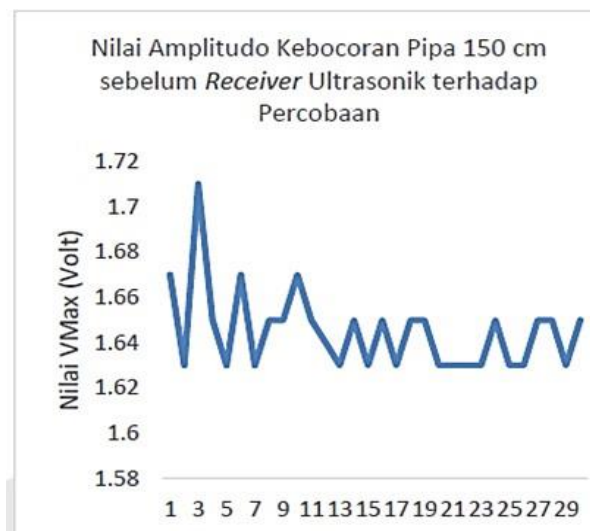


Figure 5: Data for the amplitude value of the leaking pipe condition 150 cm before the ultrasonic receiver

It can be seen that the amplitude value is stable with values between 1.63 Volts to 1.67 Volts, indicating that the pipe has a leak with the location of the leak close to the ultrasonic receiver. The amplitude value of the ultrasonic receiver that has been calibrated and the amplitude value of the condition where the pipe is leaking at a distance of 5 cm and 150 cm from the ultrasonic receiver have a significant difference in value from the pipe condition where there is no leak. This is because the ultrasonic receiver gets noise from leak holes in the pipe. However, if the amplitude value of the leaking pipe at a distance of 150 cm before the Ultrasonic Receiver is compared with the amplitude value of the leaking pipe at a distance of 5 cm before the Ultrasonic Receiver, the amplitude values are similar. This test shows that the ultrasonic receiver is able to detect leaks in underground water pipes up to a distance of 150 cm before the ultrasonic receiver.



Figure 6: data for the amplitude value of the leaking pipe condition 100 cm after the ultrasonic receiver.

The amplitude value ranges from 1.65 Volts to 1.71 Volts, 1 times the amplitude is 1.73 Volts. Indicates that the state of the pipe has a leak close to the ultrasonic receiver.

Based on the results of tests conducted by (Oktarina & Kalsum, 2017) regarding mobility aids for the blind using an ultrasonic sensor attached to a waist belt. The ultrasonic sensor detects the distance shown in Figures 4 and 5. The purpose of this test is to determine the ultrasonic SRF05. The two PING sensors show that the farther the distance, the longer it takes to transmit ultrasonic waves. The PING ultrasonic sensor and the SRF05 ultrasonic sensor have the same characteristics, namely the output voltage of the PING and SRF05 sensors is directly proportional to the increasing detection distance to the target.

While the results of research testing conducted by (Rahmandika, 2022) designed an ultrasonic sensor-based leak detection signal receiver system for underground clean water pipelines. It can be seen that there is a difference compared to the ultrasonic receiver test in the water pipe discharge condition. The amplitude value generated by the ultrasonic receiver has a different range compared to the amplitude value in the water pipe leak test before the ultrasonic receiver. The range belonging to the tube discharge mode after the ultrasound receiver is 1.65-1.71 volts, the range is 0.06 volts. Although the tube discharge condition at 5 cm and 150 cm in front of the ultrasound receiver is between 1.63 and 1.67 volts, the range is 0.04 volts. However, the ultrasonic receiver can detect leaking pipe conditions after the tool.

4 Conclusion

The use of ultrasonic sensors is characterized by the fact that the output voltage is directly proportional to the increase in the detection distance to the target. The farther the sensor detects an object, the longer it takes for the ultrasonic sensor to reflect the waves back to the sensor. Ultrasonic waves are generated by a piezoelectric device at a certain frequency. This piezoelectric generates ultrasonic waves (usually at a frequency of 40 kHz) when the oscillator aims at the target. Generally this tool shoots ultrasonic waves at an area or target. Ultrasonic sensors have several advantages that make them powerful enough to be used as a testing tool, including: they can be used in dark conditions, are not affected by the color and transparency of objects, and are an economical choice.

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