Investigation of ultrasonic sensor type JSN-SRT04 performance as flood elevation detection

by Asep Andang

IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

Investigation of ultrasonic sensor type JSN-SRT04 performance as flood elevation detection

To cite this article: A Andang *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **550** 012018

Investigation of ultrasonic sensor type JSN-SRT04 performance as flood elevation detection

A Andang, N Hiron, A Chobir and N Busaeri

Siliwangi University, Jln. Siliwangi No. 24 Kota Tasikmalaya 46155, Indonesia

Email: andhangs@unsil.ac.id

Abstract. To measure water surface elevation, the measurement technique with ultrasonic technology has been recently being applied to various sectors, such as automotive, robotic and industrial requirement. This research aims to create water surface elevation measurement with JSN-SR04T ultrasonic sensor, which has 0.5 cm measurement resolution. Arduino-Uno microcontroller with a microprocessor-Atmega238 type was used as a measurement data processing system. The system test was conducted in a river where the system was placed under the bridge, and then the elevation water surface levels were captured by the sensor. After that, the results were displayed on the LCD screen. The test was executed in 37 testing scenarios of the condition of the river water surface. Then, the measurement results from the system were compared to the manual measurement. The results showed that the value of measurement error was 0.75%. This finding is in line with the datasheet which indicates that WSN-SR04T sensor can provide a maximum resolution of 0.5 cm.

1. Introduction

Unpredictable weather condition results in unforeseeable and uneven distribution of rainfall. Flooding becomes a threat that can cause considerable losses. Hence, several human efforts to control flooding have been made. For instance, through the improvement of rainfall prediction techniques such as by using multilayer neural network with backpropagation algorithm [1], hydrological analysis, hydraulics analysis and flood prevention analysis [2], early detection system by monitoring the river water level using microcontroller and SMS technology [3], and using ultrasonic sensor PING [4].

Detection of river water level by using pressure ratio in the water principle technique based on Atmega328 microcontroller and pressure sensor BMP085 has been successfully done [5].

River level detection technique using ultrasonic sensor is currently widely used because of its high accuracy which reduces analysis errors. While ultrasonic sensor PING has an accuracy of 1 cm and an effective measurement range of 3 cm-3 m [4], the range of the JSN-SR04T type ultrasonic sensor is from 25 cm-4.5 m so that this type of sensor can be placed in a higher place and also safer from the submerged condition.

The JSN-SR04T type ultrasonic sensor is equipped with the IO port TRIG at the minimum signal level of 5μs. The JSN-SR04T sensor will send signals with a frequency of 40 KHz, and then it will process the return signals. Signals with high status will come out of IO port ECHO. The difference between the output and returned signals is determined by using an equation.

IOP Conf. Series: Materials Science and Engineering **550** (2019) 012018 doi:10.1088/1757-899X/550/1/012018

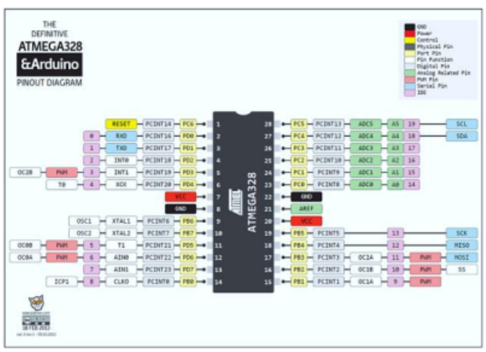
The process of determining the distance based on the difference of the output and returned signals is performed by using equation (1), where D is the distance between the water surface and the sensor (meter). HLT stands for High-Level Time, while SS means Speed of Sound that is equal to 340 m/s.

$$\mathrm{D} = \frac{(\mathrm{HLT})\ x\ (SS)}{2} \tag{1}$$

Arduino Uno is a circuit board with Atmega-328 type processor and 28 pins. On the circuit board, there are 14 digital inputs/outputs (six outputs for PWM), 6 analog inputs, 16 MHz ceramic crystal resonator, USB connector, adapter socket, and ICSP header pins. The difference between Arduino Uno and Arduino board one of which is the use of special chip as the USB-to-serial FTDI driver [6].

Figure 1. Arduino-Uno circuit board and JSN-SR04T sensor [6].

Figure 1 is Arduino-Uno circuit board and JSN-SR04T ultrasonic sensor, while IO pin configuration on Atmega-328 IC is as shown in figure 2. The Arduino-Uno block diagram is presented in figure 3.



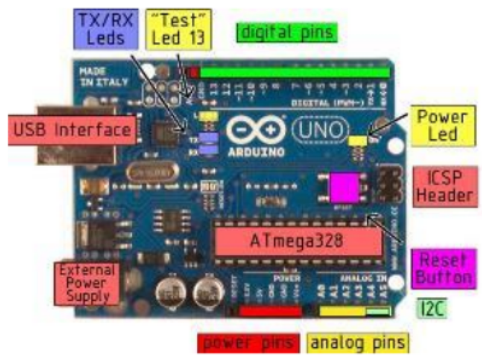


Figure 2 Atmega-328 IC pin configuration [7]. **Figure 3**. Diagram block of Arduino-Uno [6].

Ultrasonic is equal to sound waves with frequencies above 20 kHz [8]. In general, they have the same characteristics as sound waves. It has the properties of bouncing, propagating on solid medium and air with low energy. Thus, these waves are suitable for distance measurements both in air and water [9].

Figure 4 illustrates the working principle of the proximity sensor with the ultrasonic waves that is by transmitting a particular wave and then calculate the time when it is received back by the sensor [10].

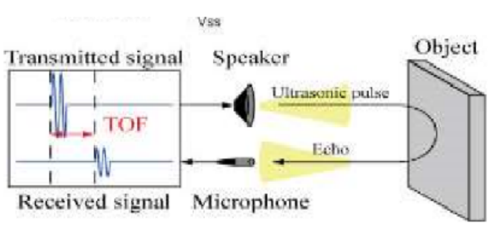


Figure 4. The principle of distance measurement with ultrasonic waves [7].

IOP Conf. Series: Materials Science and Engineering **550** (2019) 012018 doi:10.1088/1757-899X/550/1/012018

The sensor works by sending eight steps ultrasonic signal with a minimum frequency of 40 kHz when the positive pulse voltage is applied to the trigger pin for 10μs. Furthermore, the reflected signal that had been returned was received by the Echo pin (figure 5). The distance measurement of the object reflecting the signal can be performed using equation (1) that is by identifying the difference between the times of sending and receiving the reflected signal.

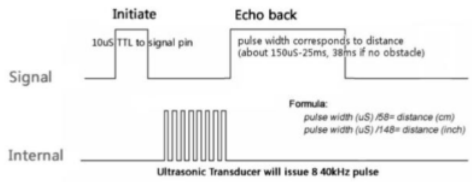


Figure 5. Timer system on the HC-SR04 sensor.

2. Methods

2.1. Hardware and system configuration

Figure 6. is a system architecture in which the sensor interacted by sending a comparison of the sent signal to a received signal in the processor. Then, the final result of the measurement was displayed on the LCD in meters unit.

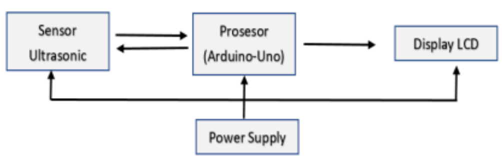


Figure 6. System architecture.

The sensor pole design process and the measurement were conducted as illustrated in figure 7. The sensor system was set at an altitude of about 4m from the surface of the river water.

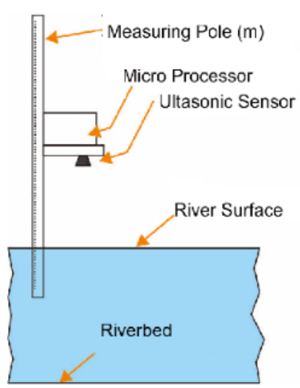


Figure 7. Model of the system and illustration of the system implementation.

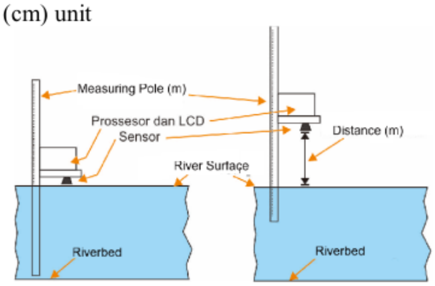
Figure 8. is the design of communication configuration between JSN-SRT04 ultrasonic sensors and Atmega-238. The system consisted of poles equipped with the manual measurement instrument,

IOP Conf. Series: Materials Science and Engineering **550** (2019) 012018 doi:10.1088/1757-899X/550/1/012018

processor units equipped with Arduino-Uno and LCD, and ultrasonic sensors that was directed to the water surface.

2.2. Testing Procedure

The system testing, that was performed as shown in figure 8(a), was a scenario in which the river water was in rising or tidal conditions. Meanwhile, in figure 8(b), the river water was receding. After the measurement results had been displayed on the LCD, subsequently, they were compared to the measurement in centimeters (cm) unit



(a). High tide condition (b). Low tide condition

Figure 8. Test scenario at high tide and low tide level condition.

Then, to determine the level of error that occurred during the test,a validation of test results were performed by using the following equation:

$$Error\ (\%) = \frac{\text{System Measurement } - \text{Manual Measurement}}{\text{Manual Measurement}}\ x\ (100) \qquad (2)$$

Schematic sensor communication with Arduino is demonstrated in figure 9. The TX (Echo) pin on the sensor, which served as the signal sender, was connected to pin 13, while the RX (Trig) pin, as the signal receiver, was connected to pin 12 on the Arduino board. The Arduino board supplied a working voltage sensor of 5V.

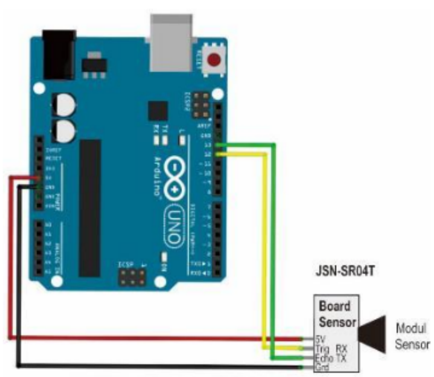


Figure 9. Wiring Diagram of communication between sensor and Arduino-Uno.

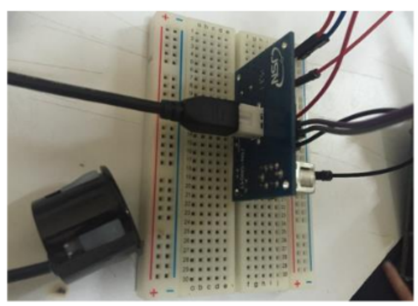


Figure 10. Sensor testing JSN-SRT04.

IOP Conf. Series: Materials Science and Engineering **550** (2019) 012018 doi:10.1088/1757-899X/550/1/012018

2.3. Software configuration

Figure 11. shows the software configuration where the initial stage was the variable and pin declaration. This stage was intended to state what variables would be used as well as the data type and the initial value. To connect with the ultrasonic sensor, the ports used on the Arduino Breakout pins were pin 1 and pin 13, while for ports connected to the LED pin was pin 8 (figure 11). Figure 12 is the result of sensor testing that had been connected with the Arduino-Uno board.

Figure 11. The syntax of communication program between sensor and Arduino-Uno.

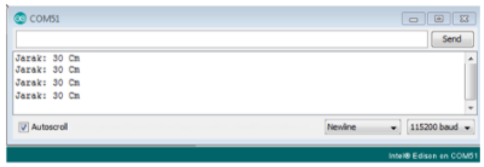


Figure 12. Distance testing validation in arduino programme.

3. Results and discussion

The system testing was undertaken in the river in Tasikmalaya city of Indonesia. The system which has been equipped with standalone power supply, in the middle of the river water through the bridge. The test scenario correspond to figure 8, with the assumption of the distance of 0 meters to 2 meters. At 0 meters, it represents the condition of the water level rising close to the sensor, while at a distance of 2 meters, it exemplifies the surface condition of the low tide. After the distance measurement results had been displayed on the LCD, they were compared with the manual distance measurement results. Not all of the photos of the test are presented in this paper.

After the data had been collected, then the validation of the error test was performed to calculate the error value of the test results. This validation aimed to determine to what extent the accuracy of the proximity sensor toward changes in surface elevation of the actual water level after being compared with the manual measurement.

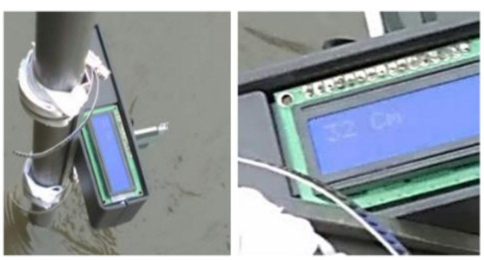


Figure 13. Water level testing at 32cm.

Figure 14. Water level testing at 50cm.

IOP Conf. Series: Materials Science and Engineering **550** (2019) 012018 doi:10.1088/1757-899X/550/1/012018

Figure 15. Water level testing at 70cm.

Figure 16. Water level testing at 100 cm.

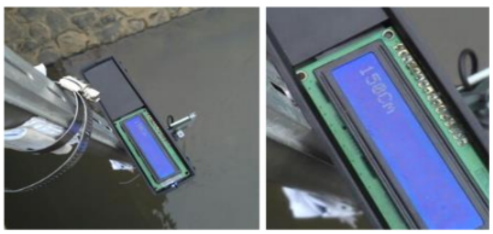


Figure 17. Water level testing at 150 cm.

Figure 18. Water level testing at 200 cm.

The result of system testing in river depicted in figures 13-18. Measurements are made sequentially from the height of the river water level at 32 cm to 200 cm. After a comparison between the measurements of the system and the measurement results manually, it was obtained that the accuracy of the measurement system is quite good, although the measurement value change due to the water surface is not fixed.

Figure 19. Validation of measurement result by measuring pole.

The test results suggested that the difference in value between the measurement by using the system and the manual measurement was less than 0.5 cm. This is in accordance with the resolution of the sensor JSN-SRT04 contained in the sensor datasheet that is 0.5 cm.

Table 1 shows the results of comparison between the measurement by using the system and the manual measurement of 37 experiments. The measurement error value was obtained by using equation (2) that is 0.75 present (less than 1). This result illustrates that the measurement results of the system are acceptable

Figure 20 is a graph of comparison between the measurement by using the system and by the manual technique. In the test, it was also found that at the time of measurement by the manual technique, the water surface was uneven or wavy as a result of water flow. In addition, the manual measuring medium (a metric tape measurer) also swayed. Therefore, it can be concluded that natural interference and human error are possible to contribute to the measurement by using the manual technique.

IOP Conf. Series: Materials Science and Engineering **550** (2019) 012018 doi:10.1088/1757-899X/550/1/012018

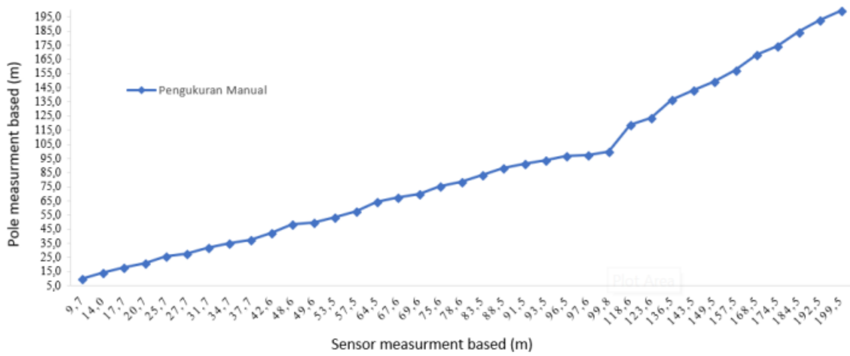


Figure 20. The comparison result of the measurement system to manual measurement.

4. Conclusions

Flood elevation detection system based on Arduino-Uno with sensor JSN-SRT04 has been successfully made and tested. For all water surface condition has been investigated and the error measurement was found 0.74%. compared with manual measurement. It was also found that at the time of measurement by the manual technique, the water surface was uneven or wavy as a result of water flow. In addition, the manual measuring medium (a metric tape measurement) also swayed. Therefore, it can be concluded that natural interference and human error were possible to contribute to the measurement by using the manual technique

The communications between Arduino-Uno and sensors with 37 experiments went successfully with no lag (lag) on the process of data processing by Atmega328. In the tests with the manual technique, natural interference and human error, which happened due to the wavy water surface and the water flow, caused the manual measuring media also swayed.

References

[1] Yuniar R J, Rahadi D and Setyawati O 2013 *Jurnal EECCIS* **7** 65–70
[2] Dewandaru G G T and Lasminto U 2014 *Jurnal Teknik Pomits* **3** C35–40
[3] Sulistyowati R, Sujono H A and Musthofa A K 2015 *Prosiding Seminar Nasional Sains dan Teknologi Terapan* **III** 49–57
[4] Saleh K, Fauziyah, Hadi and Freddy 2013 *Prosiding Semirata FMIPA Universitas Lampung* 511–15
[5] Indarto B, Sunarno H, Fahrudin M and Rahmat D B 2015 *Jurnal Fisika Dan Aplikasinya* **11** 120–26
[6] Sudhan R H, kumar M G, Prakash A U, Devi S R and Sathiya P 2015 *IJIREEICE*. **3** 27–9
[7] Atmel Coorporation 2015 *ATmega328P: 8-bit AVR Microcontroller with 32K Bytes In-System Programmable Flash [DATASHEET]* (CA 95110 USA: www.microchip.com)
[8] Kaur M and Pal J 2015 *IJSRD*. **3** 503–05
[9] David J and Cheeke N 2002 *Fundamentals of ultrasonic waves* (Florida, USA: CRC Press)
[10] Prawiroredjo K and Asteria N 2008 *JETri*. **7** 41–52

Acknowledgment
This research is a research funded by Siliwangi University through Internal research Program of Higher Education 2017. We are grateful to KEMENRISTEK DIKTI, LPPM-PMP of Siliwangi University for its support.

Investigation of ultrasonic sensor type JSN-SRT04 performance as flood elevation detection

ORIGINALITY REPORT

19%	14%	17%	11%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Aston University Student Paper	4%
2	ro.ecu.edu.au Internet Source	3%
3	link.springer.com Internet Source	1%
4	Anang Suryana, Heppi Familiana. "Automatic Braking System on Motorbikes Using the Concept of Kinematics Non-Uniform Slowing Down Motion For Safety of Motorcycle Riders on the Highway", 2019 International Conference on ICT for Smart Society (ICISS), 2019 Publication	1%
5	Sixtinah Dswilan, Harmadi, Marzuki. "Flood monitoring system using ultrasonic sensor SN-SR04T and SIM 900A", Journal of Physics: Conference Series, 2021 Publication	1%

6	d3tk.del.ac.id Internet Source	1 %
7	jurnal.unipasby.ac.id Internet Source	1 %
8	sintadev.ristekdikti.go.id Internet Source	1 %
9	Submitted to Universitas Islam Indonesia Student Paper	1 %
10	F Andika, J Kustija. "Nominal of Money and Colour Detector for the Blind People", IOP Conference Series: Materials Science and Engineering, 2018 Publication	1 %
11	Submitted to Southampton Solent University Student Paper	1 %
12	repositori.unsil.ac.id Internet Source	1 %
13	A Rahmatulloh, R Gunawan, F M S Nursuwars. " Performance comparison of signed algorithms on ", IOP Conference Series: Materials Science and Engineering, 2019 Publication	1 %
14	E G Wahyuni, L M F Fauzan, F Abriyani, N F Muchlis, M Ulfa. "Rainfall prediction with backpropagation method", Journal of Physics: Conference Series, 2018	<1 %

Publication

15	F. Cherqui, R. James, P. Poelsma, M. J. Burns, C. Szota, T. Fletcher, J.-L. Bertrand-Krajewski. "A platform and protocol to standardise the test and selection low-cost sensors for water level monitoring", H2Open Journal, 2020 Publication	<1%
16	ejournal-balitbang.kkp.go.id Internet Source	<1%
17	Himawan Putranta, Abdul Aziz Nur Rohman, Ernasari, Rida Siti Nur'aini Mahmudah, Wipsar Sunu Brams Dwandaru. "A simple distance measurement instrument based on the law of light reflection", Physics Education, 2019 Publication	<1%
18	ejurnal.itenas.ac.id Internet Source	<1%
19	Adam Faroqi, Mufid Ridlo Efendi, D T Ismail, Wahyudin Darmalaksana. "Design of Arduino Uno Based Duck Egg Hatching Machine With Sensor DHT22 and PIR Sensor", 2020 6th International Conference on Wireless and Telematics (ICWT), 2020 Publication	<1%

Exclude quotes Off

Exclude matches Off

Exclude bibliography Off