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# Design of the Liquid Volume Meter Device Using Ultrasonic Waves Based on Microcontroller

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**Abstract**. The aim of this study was to design a digital volume meter device using ultrasonic waves based on microcontroller as well as to know the strengths and weaknesses of these device. The method used is an experimental method which consists of a field study and identification of the problem, the study of literature, consultations with specialists, design and manufacturing, testing and analysis of the test results. From the test results in a cylindrical container with radius of 7.5 cm and height of 15 cm, error percentage of water volume measuring is 0.537% and in a square container measured 17.1 x 14.3 x 17.5 cm, error percentage of water volume measuring is 0,486%. From the results, it can be concluded that the volume meter device using ultrasonic waves based on microcontroller is functioning properly to measure the volume of liquid in a cylindrical and square container.

## 1. Introduction

The volume measuring device in the industry has an important role. One of its functions is to measure the volume of solar used by industrial machinery in a production process. By knowing the exact amount of solar usage, we can know the cost of production appropriately, no less and no more. The use of digital device will provide more precise measurements than analogue device.

This liquid volume meter is a prototype to measure the volume of liquids in a container. The container used is cylindrical and square. When the device is used, the user selects the form and manually inserts the container size using the push button. The user enters the base radius and height of the container if selecting the cylinder menu or entering the length, width and height of the container if selecting the square menu. That is, this volume meter has one program that can be applicable for two types of containers that are cylindrical containers and square. The previous volume meter can only measure volume in one and only cylindrical container [1,2].

## 2. Method

The method used is an experimental method which consists of a field study and identification of the problem, the study of literature, consultations with specialists, design and manufacturing, testing and analysis of the test results.

## 3. System designing

### *3.1. Block diagram*

The diagram block of the liquid volume meter using the microcontroller based ultrasonic sensor is shown in Figure 1 as follows:

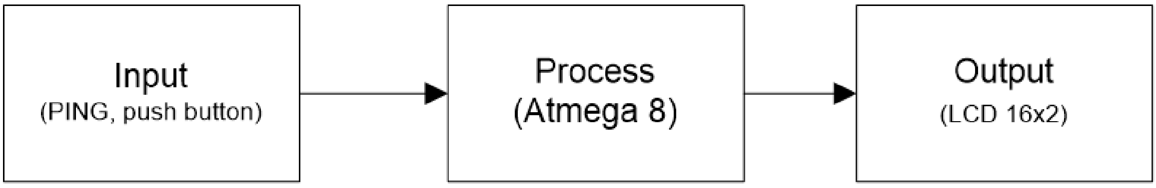


**Figure 1.** Block diagram system.

Input data from the user are through 4 pieces of push button to select the container form used whether the cylinder or square. The user then inputs the container size data in the form of length, width and height for the square container or the size of the radius and height for the cylindrical container. User inputted data will be stored in EEPROM of the Atmega8 microcontroller [3].

The sensor used is PING Ultrasonic Range Finder Sensor which has a maximum range of 3 meters [4]. Ultrasonic sensor serves to measure the distance from the water surface to the sensor. Sensors detect object distances by emitting ultrasonic waves (40kHz) during transmission time (Tburst = 200μs) and then detecting their reflections. The PING sensor emits ultrasonic waves according to the trigger pulse from the Atmega8 microcontroller as the controller. Then the microcontroller process it in such a way that it gets the height of water in the container to calculate the volume of water. For more details, see figure 2:

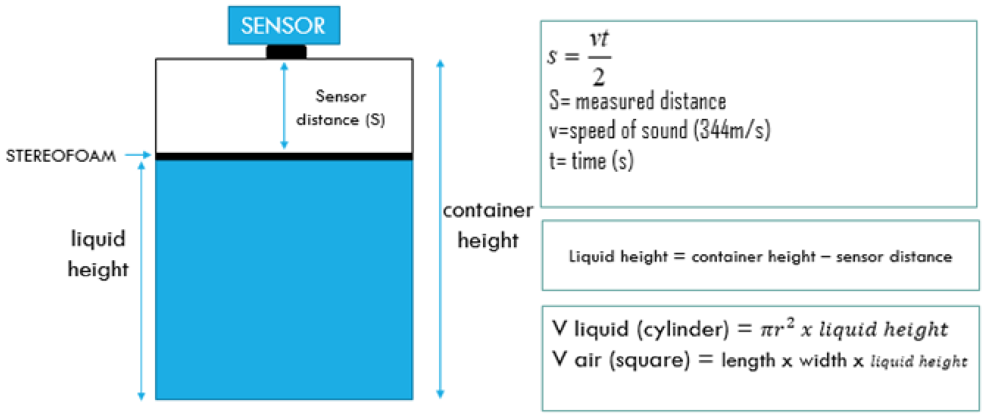


**Figure 2.** How ultrasonic sensors work.

Process block is the data processing part inputted by the user and data obtained from the ultrasonic sensor. Data received in this part of the process will be processed in such a way as to obtain the volume of the liquid in the container. The main part of this process block is an ATmega8 microcontroller. The output block consists of 16 x 2 LCD. In LCD will appear menu of container type selection, menu to enter container size and menu to display liquid volume in container.

### *3.2. Hardware designing*

Here are a schematic drawing and PCB layout of liquid volume meter using ultrasonic waves based on microcontroller using Cadsoft software EAGLE 7.2.0 (figure 3 and figure 4):

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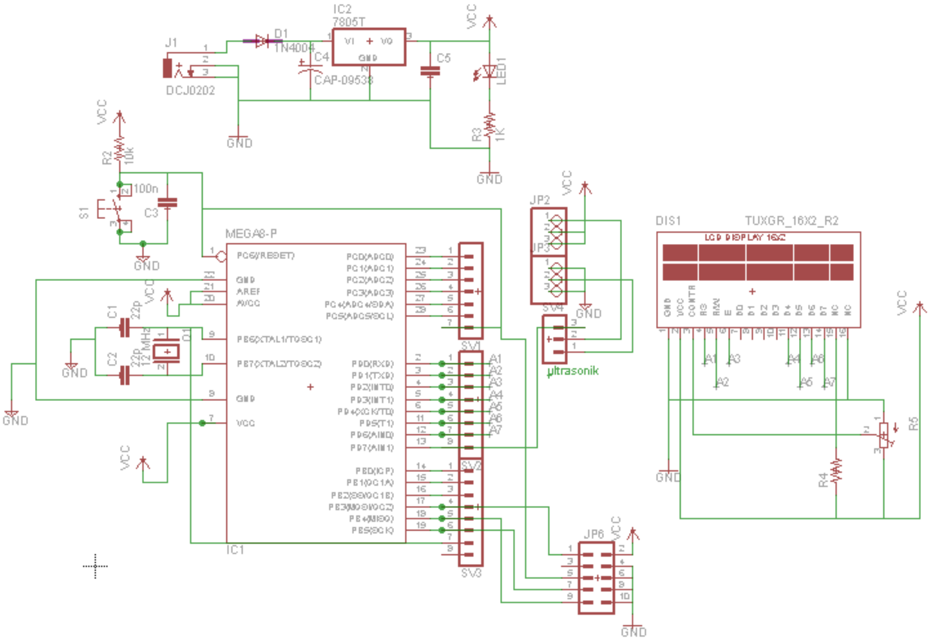


**Figure 3.** Schematic drawing and PCB layout of liquid volume meter.

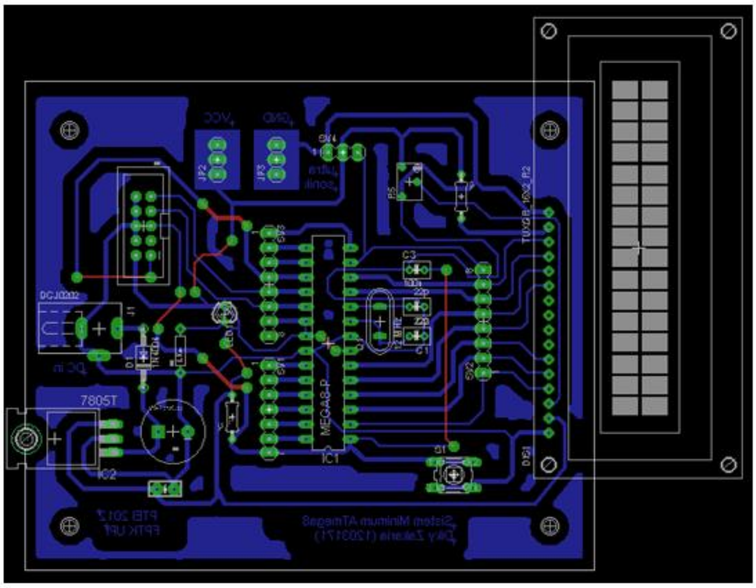


**Figure 4.** PCB layout.

### *3.3. Firmware designing*

Firmware is a program that serves to control hardware so that hardware can work as desired. Inside the firmware is set the way ultrasonic sensors work to transmit and receive ultrasonic waves, display the menu on the LCD, process the data received from the user input and from the sensor, to get the value of liquid volume then display it in LCD. The completed firmware is then downloaded to ATmega8 using USBasp connector and AVRDUDESS software [4]. Firmware programming uses CodeVisionAVR software which is a C language compiler to Assembly, a language understood by ATmega8 [6]. Here is a figure 5, the flowchart from a liquid volume meter program using ultrasonic waves based on microcontroller:

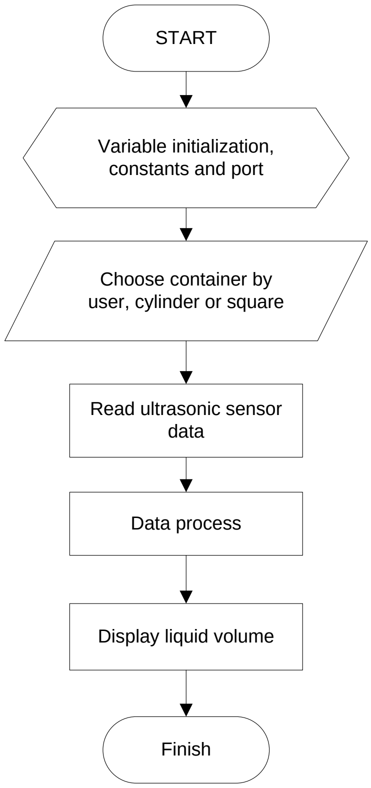


**Figure 5.** Liquid volume meter program flowchart.

## 4. Results and discussion

### *4.1. Device display*

Figure 6 is a display of volume meter using ultrasonic waves.


**Figure 6.** The front view of the device.

Figure 6 shows 4 push buttons to set the selection of container type and to enter the size of the container. Figure 7 is the LCD display to select the shape of the container.


**Figure 7.** LCD display to select the container shape used.

### 4.2. Device testing

This device is tested by measuring the volume of the liquid in a cylindrical container with the size of the radius of 7.5 cm and height of 15 cm and in a square container with the size of 17.1 x 14.3 x 17.5 cm. Liquid used is water.

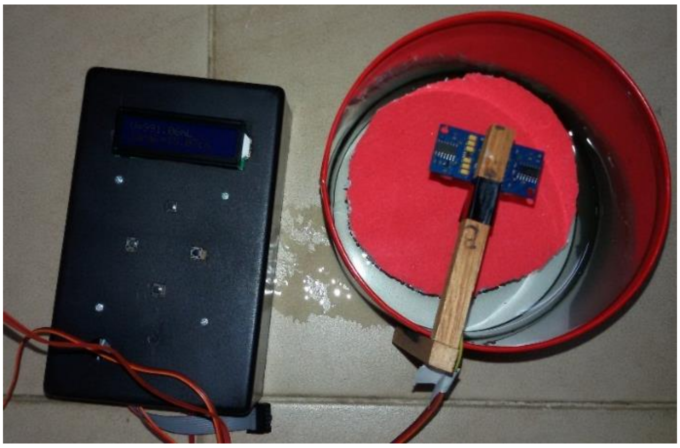

**Figure 8.** How to use the volume meter.

Figure 8 shows how to install the sensor on the surface of the container. The sensor will emit ultrasonic waves and will shoot into stereo foam with a thickness of 1cm. In the firmware program, the distance indicated by the sensor will be increased by 1cm to estimate the stereo foam thickness. Installation of stereo foam on the water surface due to ultrasonic sensors cannot bounce on water. The sample measurements shown on the LCD in figure 9.


**Figure 9.** Example of measurement of water volume result.

Figure 9 is the measurement result for the water volume of 600ml and 700ml on a cylindrical container. Here are the results of testing devices that have been done:

**Table 1.** Device testing on cylindrical container.

| No. | Water volume (ml) | Water volume using device (ml) Xn | Error (ml) \|e\| =\|Yn-Xn\| | Distance Display (cm) |
|---|---|---|---|---|
| **1** | 600 | 597,49 | 2,51 | 11,62 |
| **2** | 700 | 699,42 | 0,58 | 11,04 |
| **3** | 800 | 801,35 | 1,35 | 10,46 |
| **4** | 900 | 903,29 | 3,29 | 9,89 |
| **5** | 1000 | 993,89 | 6,11 | 9,37 |
| **6** | 1100 | 1092,05 | 7,95 | 8,82 |
| **7** | 1200 | 1190,21 | 9,79 | 8,26 |
| **8** | 1300 | 1297,80 | 2,2 | 7,65 |
| **9** | 1400 | 1422,39 | 22,39 | 6,95 |
| **10** | 1500 | 1499,78 | 0,22 | 6,51 |
| **Total (Σ)** | **10500** | **10497,67** | **56,39** | |

**Table 2.** Device testing on square container.

| No. | Water volume (ml) | Water volume using device (ml) Xn | Error (ml) \|e\| =\|Yn-Xn\| | Distance Display (cm) |
|---|---|---|---|---|
| **1** | 600 | 602,23 | 2,23 | 15,04 |
| **2** | 700 | 701,54 | 1,54 | 14,63 |
| **3** | 800 | 798,23 | 1,77 | 14,24 |
| **4** | 900 | 905,38 | 5,38 | 13,80 |
| **5** | 1000 | 1025,59 | 25,59 | 13,31 |
| **6** | 1100 | 1101,38 | 1,38 | 13,00 |
| **7** | 1200 | 1200,69 | 0,69 | 12,59 |
| **8** | 1300 | 1300,00 | 0 | 12,18 |
| **9** | 1400 | 1396,69 | 3,31 | 11,79 |
| **10** | 1500 | 1490,77 | 9,23 | 11,40 |
| **Total (Σ)** | **10500** | **10522,5** | **51,12** | |

From Table 1 is obtained:

$$\text{Error percentage} = \frac{\sum |e|}{\sum Y_n} x\ 100\%$$
$$= \frac{56{,}39}{10500} x\ 100\%$$
$$= 0{,}537\ \%$$

The error percentage of water volume measuring in a cylindrical container is 0.537%. From table 2 is obtained:

$$\text{Error percentage} = \frac{\sum |e|}{\sum Y_n} x\ 100\%$$
$$= \frac{51{,}12}{10500} x\ 100\%$$
$$= 0{,}486\ \%$$

The error percentage of water volume measuring in a square container is 0,486%.

*4.3. Discussion*

The percentage error of the device in measuring the volume of water is small enough i.e. 0.537% for cylindrical containers and 0.486% for square containers. From the results of this percentage error can be said that this volume measuring device is good enough in measuring the volume of liquid.

The advantages of this volume meter devices using microcontroller based ultrasonic waves are able to measure the volume of liquids in cylindrical and square containers without change or modify the program. Users can select and enter the size of the container with the available push button. The volume measurements displayed by this device are 2 digits behind the comma so it is more thorough.

The lack of this volume meter using ultrasonic waves based on microcontroller is that there is still a measurement error. In addition, in entering the size of the container, it should push the button long enough to fit the size because it does not use the keypad.

## 5. Conclusion

This liquid volume meter device using ultrasonic waves based on microcontroller device is able to measure the volume of water well with small error value.

## References

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