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Automatic Water Tank Filling System Controlled using Arduino™ based Sensor for Home Application

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Abstract

Water supply is the most important thing in daily home activity especially for washing, cleaning, and taking a bath. The Indonesian villagers commonly supply the water by pumping the groundwater to fill a water tank. However, the utilization of non-automated switch used to turn on and turn off a pumping machine sometimes causes either the water spills or a wasteful electrical consumption. The previous works reported the utilizations of Arduino™ based sensors for plant watering system, water tank overflow control, and automated irrigation system. In this work, an automated water tank filling system will be proposed. The system is designed by applying an ultrasonic sensor, an automatic switch module, a water-flow sensor, an Arduino™ microcontroller, and a pumping machine in order to automatically switch the water filling. By applying an ultrasonic sensor, an ultrasonic transmitter is mounted on the top of the tank and transmits an ultrasonic pulse down into the tank. This pulse which travels at the speed of sound will be reflected back to the transmitter from the liquid surface. The time delay measurement between transmitted and received signals enables the device to calculate the distance to the surface. The transmitter is programmed to automatically determine the liquid level and switch the pumping machine. The dynamics of water flow and liquid level during filling and draining the water tank will be reported. We hope to this system, people will enjoy supplying water without their worries related to water spills and a wasteful electrical consumption.

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Keywords: Ultrasonic Sensor; Water Pump; Home Application; Microcontroller; Arduino Uno

1. Introduction

Water is the most important natural resources in human's life. Human needs the water in almost all daily activities such as washing, cleaning, taking a bath, the irrigation, and the industry needs. However, the amount of clean water is decreasing, whereas the number of people in the world are always increasing. Considering to the need of water for each island in Indonesia, especially Java island, Bali island, and Nusa Tenggara island, it can be analyzed that the clean water supply must be improved in order to fulfill the people need of the clean water regularly.

The technology contributes to the culture changes [1]. The technology is commonly made in order to help the people perform some activities easy. Consequently, the cultural change is usually triggered by the technological transformation. One of the present technologies is the automation technology. In some cases, the people sometimes want to carry out their work to be set automatically so that they can save the energy to perform another activity. Some sophisticated automation materials have been established in order to set some works automatically such as Arduino™ microprocessor, which enable to control the electrical circuits logically [2].

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Arduino is designed to control the circuit logically. Arduino possesses the main component of an integrated circuit chip that can be programmed using C++ language. This microcontroller is the AVR type produced by Atmel firm. The device is able to read the input, process the program, and produce many outputs based on our necessity. Therefore, microcontroller is like a human brain. At the previous works, considering to the watering purposes, it can be found that the Arduino™ based sensors have been utilized for the plant watering system [3], the automated irrigation system [4], the soil humidity monitoring [5], the automated bottle filling system [6], the distance measurement, the temperature control. In this research, we will propose a novel utilization of Arduino™ based sensor for the automatic water tank filling. A prototype of automatic water tank filling employing the Arduino™ microcontroller will be developed.

Water pump is a tool used for pumping the groundwater to fill a water tank. The various water pump models have currently been used. The first model, the water pump can be operated by turning on and turning off the machine manually. On the other model, the water pump is equipped by a floating ball acted as a physically tap when the water has fulfilled a tank. However, some weaknesses can be discovered due to both models. The manually-operating water pump is not efficient because the water pump cannot turn on and turn off automatically. Sometimes, the condition will cause the water spill when somebody forgot to turn off a pumping machine. It will affect to the wasteful electrical consumption, and it can also destruct the wall because the wall is moist, humid, and mossy. Likewise, we argue that the second model of floating ball tap-equipped water tank is more useful than manual switch, but the floater sometimes makes the tap and the pipe leakages because the ball has not firmly closed the tap frame then the water pressure cannot be retained by the pipe. To handle the problems caused by both model, we intend to propose the water pump equipped by ultrasonic sensor with Arduino™ microcontroller in order to make an automatic switch and control the level of the tank water filling. The sensor will automatically turn on the machine in the certain water tank level and it will be turned off automatically after the water tank is fully filled by the water.

2. Methods

To perform this research, several materials will be provided such as an Arduino Uno microcontroller, an ultrasonic sensor HC-SR04 module, a relay SRD-05VDC-SL-C, an LCD 16 × 2 display, a 10 kΩ potentiometer, a printed circuit board (PCB), a water pump, some connector cables including male to male cables and male to female cables, and a home-made plastic box to cover the equipment as shown in figure 1. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It is intended for anyone who wants to make interactive projects. This microcontroller board uses the Atmega328P. It has 14 digital pins and 6 analog pins. Moreover, the board is the center processing controlling the installed devices. The script must firstly be uploaded to the board so that the device can be controlled based on our desire. Table 1 shows the Arduino™ code of the automatic water tank filling system. In this case, the Arduino™ board will receive the analog data converted from the ultrasonic signal recorded by the ultrasonic sensor. The analog data will be interpreted as certain distances by the processor and the distance will appear at the LCD display in real time. At the same time, the received data will trigger the relay to control the water pump on or off. The ultrasonic sensor works to measure the distance without contacting the surface. The signals are transmitted and reflected as the ultrasonic wave. Moreover, the relay serves as the 220V AC water pump switch controlled by the Arduino™ which works at 5V DC. This switch will turn on when the run out of water in the water tank and it will suddenly turn off when the water is full. To control the LCD display brightness, a 10 kΩ potentiometer is equipped in the circuit. Interestingly, the water level can be seen in the LCD. Finally, to fix the circuit, a PCB is served to assemble a complete circuit while the plastic box is used to cover the device.

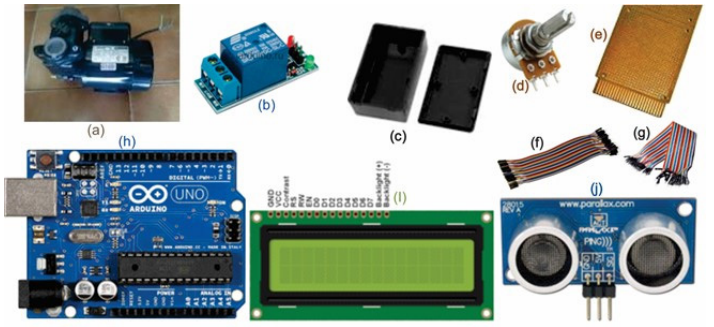


Fig. 1. Materials used to construct the automatic water tank filling system prototype. The materials are (a) a water pump, (b) a relay SRD-05VDC-SL-C, (c) a home-made plastic box, (d) a 10 kΩ potentiometer, (e) a printed circuit board (PCB), (f) male-to-female cable, (g) male-to-male cable, (h) an Arduino Uno microcontroller, (i) an LCD 16 × 2 display, and (j) an ultrasonic sensor HC-SR04 module

3. Results and Discussion

3.1. Automatic water tank filling system unit

Figure 2 shows the automatic water tank filling system unit. The height of water tank is measured firstly in order to determine the automatic water pump switch. In the water tank, the switch will turn on automatically if the height is more than 100 cm measured of the ultrasonic sensor while the sensor will turn off the pump if the height reaches 20 cm because the ultrasonic sensor is mounted on the top of water tank and the height always decreases during filling the water tank. Therefore, the computer is connected to the system in order to give this logic to Arduino™ microcontroller. The height data can be visualized either in the computer or in the LCD 16 × 2 display. The LCD displays the real-time data of the water height in the water tank.

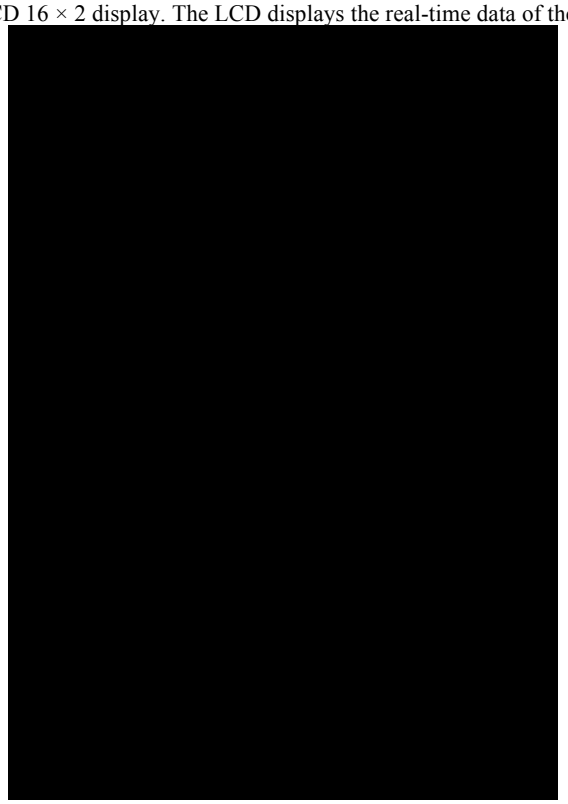


Fig. 2. Automatic water tank filling system unit

3.2. Arduino™ codes of the automatic water tank filling system

Table 1. Arduino™ code of the automatic water tank filling system

The Arduino™ code of the automatic water tank filling system without LCD display including the code of void setup and void loop	The void setup Arduino™ code of the automatic water tank filling system with LCD display	The void loop Arduino™ code of the automatic water tank filling system with LCD display
/*	/*	void loop ()
HC-SR04 Ping distance sensor:	HC-SR04 Ping distance sensor:	{
VCC to arduino 5v	VCC to arduino 5v	{
GND to arduino GND	GND to arduino GND	digitalWrite(trigpin,LOW);
Echo to Arduino pin 9	Echo to Arduino pin 9	delayMicroseconds(2);
Trig to Arduino pin 8*/	Trig to Arduino pin 8*/	
#define echopin 9 // echo pin	/* LCD RS pin to digital pin 12	digitalWrite(trigpin,HIGH);
#define trigpin 8 // Trigger pin	* LCD Enable pin to digital pin 11	delayMicroseconds(10);
	* LCD D4 pin to digital pin 5	
int maximumRange = 50;	* LCD D5 pin to digital pin 4	duration=pulseIn
long duration, distance;	* LCD D6 pin to digital pin 3	(echopin,HIGH);
	* LCD D7 pin to digital pin 2	

The Arduino™ code of the automatic water tank filling system without LCD display including the code of void setup and void loop

```
void setup() {
   Serial.begin (9600);
    pinMode (trigpin, OUTPUT);
   pinMode (echopin, INPUT );
    pinMode (4, OUTPUT);
  pinMode (13,OUTPUT);
}
 void loop ()
{
 {
     digitalWrite(trigpin,LOW);
     delayMicroseconds(2);

     digitalWrite(trigpin,HIGH);
     delayMicroseconds(10);

     duration=pulseIn (echopin,HIGH);

     distance= duration/58.2;
   delay (1000);
     Serial.println(distance);
  }

  if (distance >= 18 ){
   digitalWrite (4,HIGH);
  digitalWrite (13,HIGH);
}
else if (distance <= 5) {
    digitalWrite (4,LOW);
  digitalWrite (13,LOW);
}
}
```

The void setup Arduino™ code of the automatic water tank filling system with LCD display

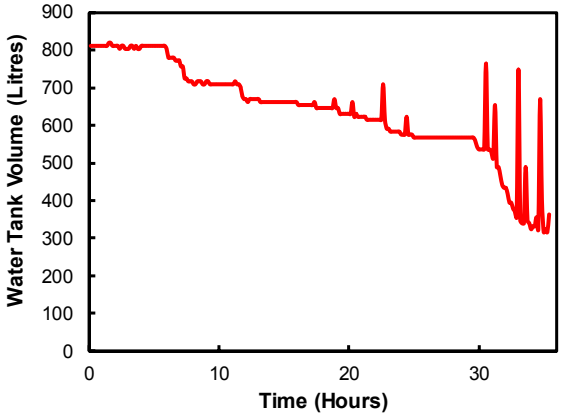
```
 * LCD R/W pin to ground
 * 10K resistor:
 * ends to +5V and ground
 * wiper to LCD VO pin (pin 3)*/

#include<LiquidCrystal.h> // include the
library code for lcd
LiquidCrystal lcd(12, 11, 5, 4, 3, 2); //
#define echopin  9 // echo pin
#define trigpin 8 // Trigger pin

int maximumRange = 50;
long duration, distance;

void setup() {
 lcd.begin(16,2);
 Serial.begin (9600);
  pinMode (trigpin, OUTPUT);


  pinMode (echopin, INPUT );
   pinMode (4, OUTPUT);
 pinMode (13,OUTPUT);
}
```

The void loop Arduino™ code of the automatic water tank filling system with LCD display

```
    distance= duration/58.2;
  delay (50);
   Serial.println(distance);
    lcd.clear();
    lcd.setCursor(0,0);
  lcd.print("level air:");
  lcd.print(distance);
  lcd.print(" cm");
  delay(100);


 }

 if (distance >= 100 ){
    digitalWrite (7,HIGH);//
connect to relay(motor)
    digitalWrite (13,HIGH);
    lcd.setCursor(0,1);
  lcd.print("Pompa Hidup");
  delay(100);
 }

  else if (distance <= 20) {
    digitalWrite (7,LOW); //
connect to relay(motor)
    digitalWrite (13,LOW);
    lcd.setCursor(0,1);
  lcd.print("Tanki Penuh");
  delay(100);
 }

}
```

3.3. Water consumption analysis of home activity

Figure 3 shows the results of the test and the calculation of water consumption used in home activity. A family consisting of 4 people consumed 259.2 liters of water in a day. It means that they spent 64.8 liters/person/day. According to the survey taken by the Indonesian Directorate of Water Development and General Directorate of Human Settlements in 2006, they stated that a daily average water consumption per person in Indonesia was 144 liters. Therefore, it can be concluded that this family has consumed the water sparingly. Besides the sensor system function as an automatically-controlled switch, it can be proposed that this system can be used to analyze the home water consumption successfully.



Linear Regression for Data1_Volume:
Y = A + B * X

Parameter	Value	Error
A	835.03034	6.07296
B	-0.003	0.00008

R	SD	N	P
-0.91556	47.9632	251	<0.0001

Fig. 3. The dynamic of water consumption recorded by the automatic water tank filling system

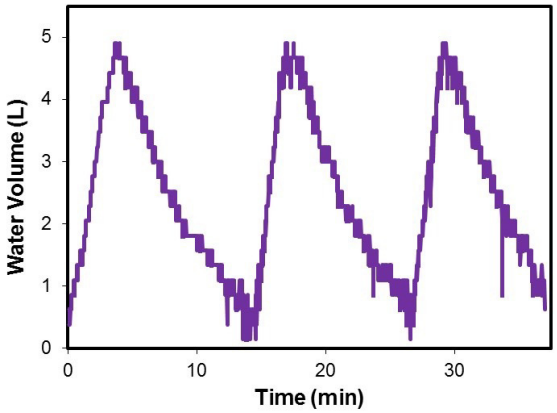


Fig. 4. The dynamic test of automatic water tank filling system

Figure 4 shows the dynamic test of automatic water tank filling system. The water pump will automatically turn on when the volume of water becomes 0.6118 L, and it will automatically turn off when the water volume reaches 4.6648 L. It is found that the system has performed well following as good as our desire.

4. Conclusion

The automatic water tank filling system has been constructed successfully. The novel system is suitable to be used in home activity contributing to the decrease of the energy consumption due to the water spills. Moreover, it can help the people analyze the water consumption. The prototype can be proposed to handle the water pump problems due to the utilizations of the manual switch as well as the floating ball tap to stop the water tank filling.

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