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Water Detection Sensor for Generator Set's Fuel Tank

Hanif Dwi Nurcahya[1], KGS M Ismail[2], Benny Kurnianto[3], Suse Lamtiar[4]

[1,2,3,4]Airport Electrical Engineering

Politeknik Penerbangan Indonesia Curug

Indonesia

Abstract— This design of the water contamination sensor system for the diesel generator set's fuel tank combines an ultrasonic sensor, a TDS sensor, ESP 32 microcontrollers, and a monitoring application. An ultrasonic sensor measures the level of fuel in the tank. TDS sensor detects the Total Dissolved Solids (TDS) levels in the fuel which can be used to indicate submerged water. An ESP 32 microcontroller functions as a control center and processor that send the fuel level data and water existence data to the application database. The monitoring application would display the information of water existence by two colors indicator. If water is detected in the fuel tank, the indicator in the application would be yellow. If there is no water detected, the indicator would be blue. Then, the volume of the fuel would be displayed in liters and percentages. After testing, the system could read and display the volume of diesel fuel and the existence of water in the tank when the minimum level of the fluids was 5 mm.

Keywords— Contamination, ESP 32, Fuel Tank, Microcontroller, TDS sensor.

I. Introduction

Many building operators install generator sets as a backup power supply. Expectantly, the service of the building would never be interrupted. If the main power supply that comes from the electricity company were not available temporarily then the generator set would replace the function.

However, the generator should be active immediately when the main power supply from the electricity company has problems. This condition requires all the components of the generator to be in a normal state including the fuel supply. The fuel should not be contaminated with other substances especially water.

Water is one of the worst contaminations for a combustion engine. Even the engine is still running, the contamination of water wastes the fuel since the combustion would be ineffective. The generator could fail to start when the diesel engine could not tolerate the amount of water.

This contamination may occur from condensation since the generator is seldom to operate, and the fuel remains in the tank for a long period. Therefore, water that exists in the fuel tank should be checked by a technician regularly.

Nevertheless, the technician examines the water contamination in the fuel tank manually. The technician needed to open the drainage faucet and dump a large amount of fuel to detect the existence of water. The method was ineffective since the operator should waste an amount of fuel.

Therefore, it was feasible to install more precise tools to detect the contamination in generator sets' fuel tanks. This detector would monitor the presence of water and the remaining fuel in the tank. A previous research was completed to design of conductivity sensor for real time measurement of TDS (Total Dissolved Solid) in water. The experiment revealed that the measurement data TDS had an accuracy rate of 97.17 % [1].

Another problem faced by technicians was measuring the remaining fuel in the tank accurately so they could fill up the fuel precisely [2] [3]. Therefore, it was practicable to install a sensor that may detect the remaining fuel with digital display. Hence, this study would find out whether the two sensors could be working simultaneous in one processor and show the result digitally.

II. Material

A. Diesel Generator set

The generator set is a combination of a combustion engine and a power generator (alternator). The machine functions as a turning device. A power generator or alternator functions as a device that produces electricity [4].

The generator set used as a backup electric power supply generally consumes diesel fuel. To keep the fuel supply and prevent fire hazards around the generator set installation, diesel fuel is stored in daily tanks before it flows to the generator set's engine [5].

B. Ultrasonic Sensor

Ultrasound is a sound wave that has a frequency area above 20 kHz, above the human hearing ability. Like sound waves, ultrasound can transmit through solid, liquid, or gaseous mediums with different propagation speeds. Sound has a wavelength which is a function of the frequency and speed of propagation. The relationship between sound wavelength (λ), propagation speeds (c) and frequency (f) use the formula [6]:

$$\lambda = c / f \quad (1)$$

Ultrasonic sensor, a module, that functions to measure the distance of an object/obstacle by utilizing ultrasonic sound waves.

The ultrasonic sensor consists of an ultrasonic transmitter circuit called a transmitter and an ultrasonic receiver circuit called a receiver. The ultrasonic signal generated will be emitted from the ultrasonic transmitter. When the signal hits a barrier object, the signal will be reflected and received by the ultrasonic receiver. The signal received by the receiver circuit is sent to the microcontroller circuit and then processed to calculate the distance to the received reflection.

C. TDS Sensor

TDS (Total Dissolved Solids) sensor, a module that functions to measure an electrolyte in a solution, is often used to measure the existence of other substances in a solution.

The TDS sensor works by detecting the conductivity of a solution. The number of dissolved particles detected is measured in PPM (Part Per Million).

The working principle of the TDS sensor uses two separate electrodes to measure the electrical conductivity of the liquid (McCleskey, 2011). The character of the electrolyte or the content of ionic particles of a liquid will affect the electrical conductivity as a result of the TDS sensor measurement.

D. ESP 32 Microcontroller

A microcontroller is an electronic device that functions like a miniature computer system. Like a computer, a microcontroller can be programmed as desired. However, the microcontroller can only be used for a certain application or it can be said that the microcontroller can only store one program.

Microcontroller technology has several advantages such as [7]:

- small size,
- low power consumption,
- high processing speed
- and flexible to connect with other components

In this ESP 32 microcontroller, a WiFi module is already available in the chip [8]. Consequently, it is very encouraging to create an Internet of Things application system [9][10].

E. C+ Programming

C+ Programming is a unique programming application. It compiles programs as simple as high-level language programs, but it executes programs as fast as low-level language programs.

III. METHOD

A. Working Principle

The working principle of the liquid detector in the tank is organized as the following steps and illustrated in Fig. 1.

- After the tool gets a power supply, it waits for connection to WIFI which is already registered in the Arduino IDE application module.
- If the connection is successful, the device then runs the command to read the data.
- If there is water at the bottom of the tank, the ultrasonic sensor and the TDS sensor will simultaneously detect the distance and height of the water in the vessel. Then, the data obtained by the two sensors will be sent to the microcontroller.

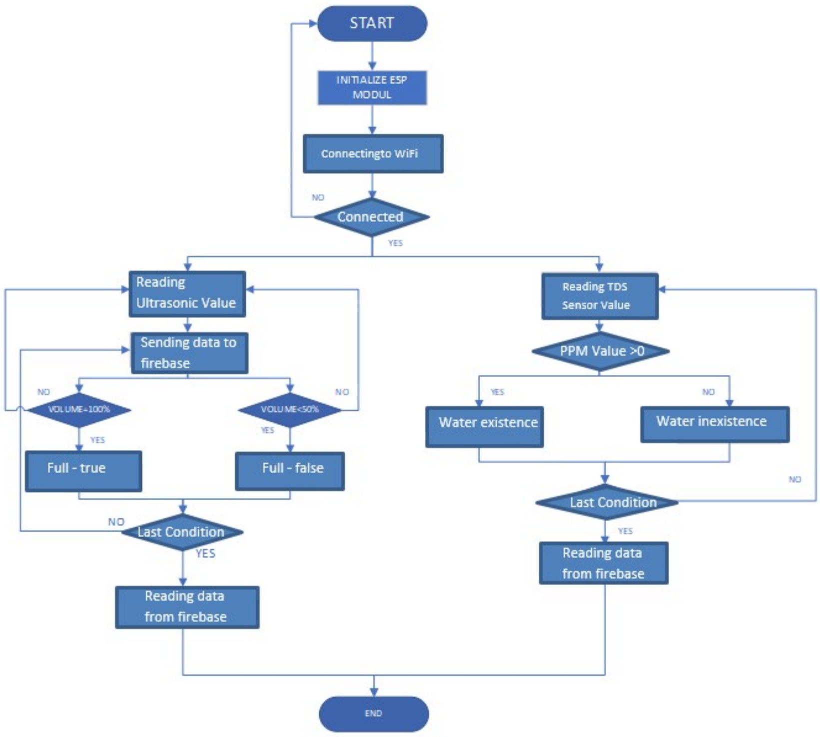

Fig. 1. Flow Chart Diagram of Working Principle

- When the fuel in the tank recedes, the ultrasonic sensor will maintain detecting the level of the liquid.
- Water and fuel are poured gradually into the tank to test the minimum level of the liquids that could be detected by the sensors.
- If there is diesel fuel volume changes or water occurs at the bottom of the tank, the system will continuously read the data and keep the data in the database. Then, it will be sent into the application.
- When water occurs in the tank, the application will send a notification. In addition, the level of the diesel fuel will also be monitored in real-time.

B. Design Criteria

The simulation uses a standard generator set diesel tank which has a length of 250 cm, a diameter of 125 cm, a radius of 62.5 cm, and a volume of 3068 l.

IV. FINDING AND DISCUSSION

The design of this fuel tank water detector combines two sensors connected into one module. The first sensor, TDS sensors, has code TDS SKU SEN0244. The second sensor, the ultrasonic sensor, has code SRF-04. The module code is UI ESP32_DEVKIT_V1. These components were then assembled following the circuit diagram as shown in Fig. 2.

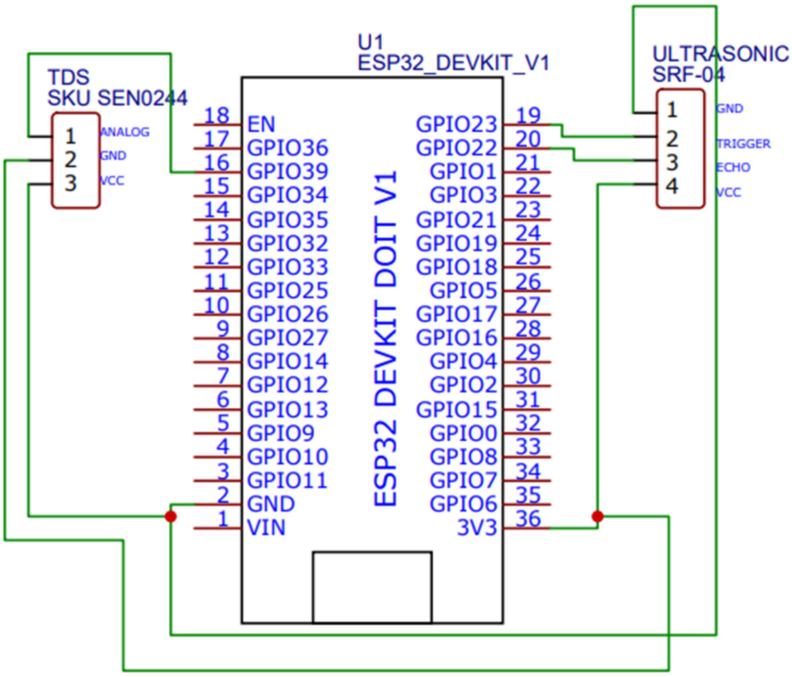

Fig. 2. Electronic Circuit of TDS Sensor, Ultrasonic Sensor, and ESP Modul

A. Integrating Components

The four pins of the ultrasonic sensor were connected into four pins of the ESP module. Each connection has a different function which is explained in TABLE I.

TABLE I. ULTRASONIC SENSOR – ESP MODULE CONNECTION FUNCTION

No	*Microcontroller ESP 32*	*Ultrasonic Sensor*	*Function*
1	5 Volt power supply	VCC	to provide power source from ESP32 microcontroller module to ultrasonic sensor
2	GND	GND	the ground of ESP32 microcontroller module

No	*Microcontroller ESP 32*	*Ultrasonic Sensor*	*Function*
			and Ultrasonic sensor
3	Pin 19	Trigger	to input data from the ESP32 microcontroller module to the Ultrasonic sensor
4	Pin 20	Echo	to output data from the ESP32 microcontroller module to the Ultrasonic sensor

The volume of the fuel in the vessel is detected and measured in real-time. Hence, the technician could monitor the remain fuel in the tank while the generator is operating and or refueling.

The maximum capacity of the tank became the base data to calculate the remaining fuel in the tank. It was calculated as the formula (2) below.

V = π x r2 x t

V= 3.14 x 62.5x62.5 x 250

V=12.265,626 x 250

V= 3.066.406 cm^3

V=3.066,406 liters (2)

Then, the ultrasonic sensor will measure the height of the fuel in the tank while it is decreasing or increasing. This height fluctuation data will be sent to the microcontroller to calculate the remaining fuel as the formula 3 below and illustrated in Fig. 3.

The formula for the area of a segment:

L = Area of Square AOB – Area of Triangle AOB

Area AOB = a/360 r2

Area of Triangle AOB = 1/2 r2 sin (a)

L Segment = a/360 r2 – 1/2 r2 sin (a)

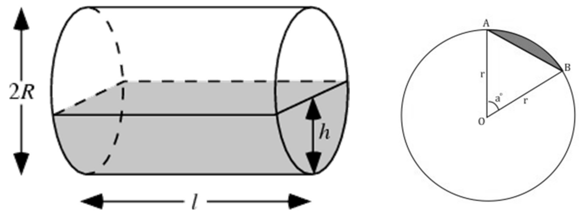

Fig. 3. Remaining Fuel

The data used to analyze the remaining volume of the tank is the height of the fuel.

The measurement data will be sent to the microcontroller for conversion processing which is encoded as shown in Fig. 4.

```
void loop() {
  jarak=distance_value();
  //konversi cm to ltr
  int d = 125-jarak ;
  int r = d/2;
  float vol = (3.14*r*r)*250/1000;
  String xx = "{\"TinggiSolar\":\"" ;
  Level = xx +  String(vol) + "\"}";
  pushData("Tinggi_Solar",Level);
  Serial.println(Level);
  distance_value();
  tds();
  kondisi();
  kondisiTDS();
  Serial.println(jarak);
  Serial.println(tdsValue);
```

Fig. 4. Remaining Fuel Sketch

TABLE II. TDS SENSOR – ESP MODULE CONNECTION FUNCTION

No	***Microcontroller ESP 32***	***TDS Sensor***	***Function***
1	5 Volt power supply	VCC	to provide power source from ESP32 microcontroller module to TDS sensor
2	GND	GND	the ground of ESP32 microcontroller module and TDS sensor
3	Pin 39	Analog	to gain data from the TDS sensor to the ESP32 microcontroller module

The three pins of the TDS sensor were connected into four pins of the ESP module. Each connection has a different function which is explained in TABLE II.

Fig. 5. Fuel Contamination Sketch

Fig. 5 illustrates the sketch of TDS sensor which detect water that sink in the bottom of the diesel fuel tank by measuring the conductivity level of the water.

B. Testing

The first step of the testing is checking the connection between each sensor and the application. The results were shown in fig. as 6. inferred that they were connected perfectly.

```
09:51:56.195 -> configsip: 0, SPIWP:0xee
09:51:56.195 -> clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
09:51:56.195 -> mode:DIO, clock div:1
09:51:56.195 -> load:0x3fff0018,len:4
09:51:56.195 -> load:0x3fff001c,len:1216
09:51:56.195 -> ho 0 tail 12 room 4
09:51:56.195 -> load:0x40078000,len:10944
09:51:56.195 -> load:0x40080400,len:6388
09:51:56.195 -> entry 0x400806b4
09:51:57.605 -> Connecting to Amb.....
09:52:00.095 -> Connected to Amb
09:52:00.095 -> IP Address is : 192.168.43.192
09:52:01.363 -> [system start]
```

Fig. 7. Sensor, Wi-Fi, and Database Connection Testing

The next step was checking the connection between sensor, Wi-Fi and database. It can be concluded as shown in Fig. 7 that the system was connected thoroughly.

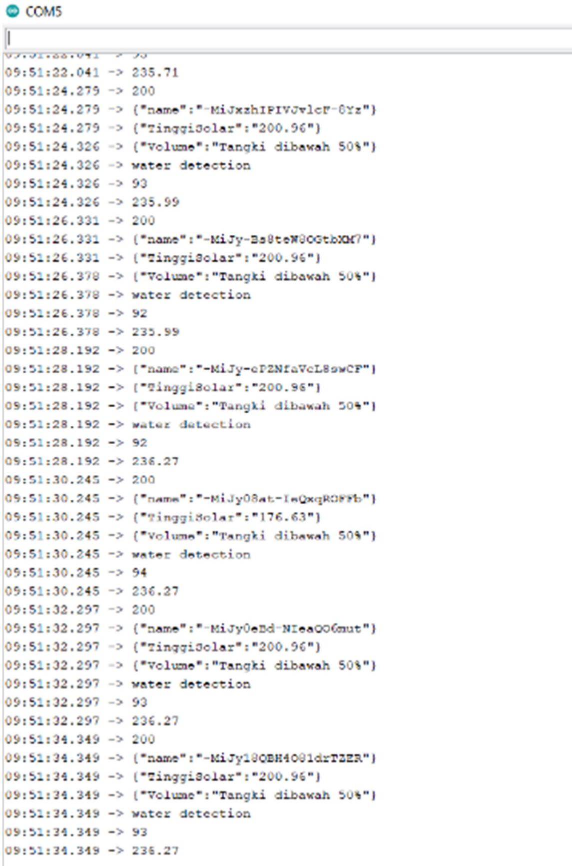

Fig. 7. Application and Database Connection Testing

Next, Fig. 7 demonstrated the database and application connection testing. It can be inferred that the connection was established.

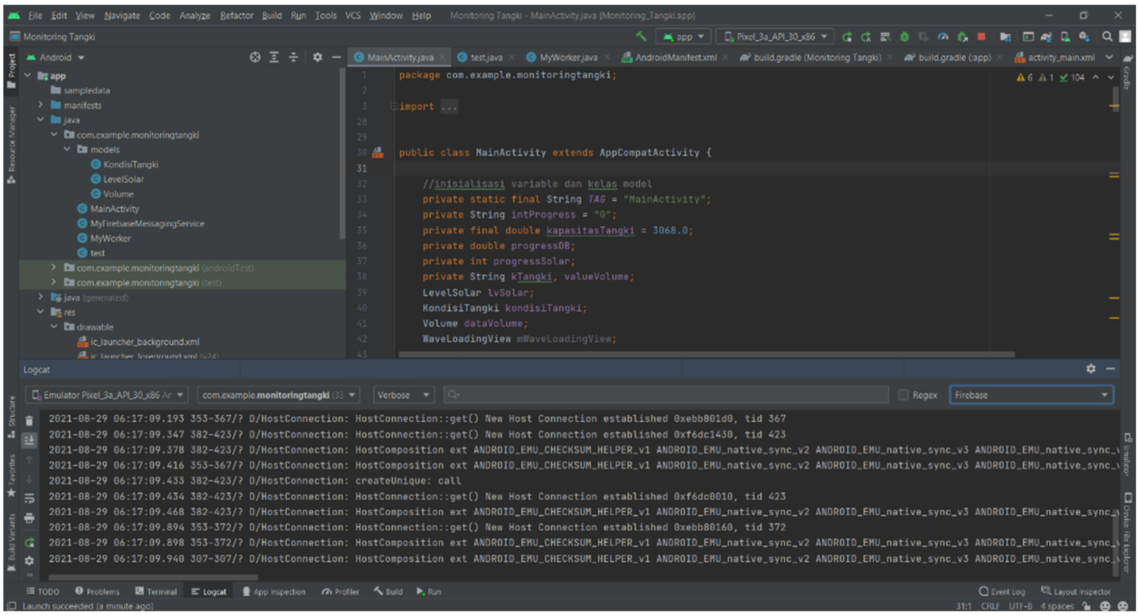

Fig. 7. Database and Application Connection Testing

After checking the hardware connection, the next step is checking the programs that developed using Arduino IDE. From the test results, it could be concluded that the program was running well. There was no error message during compilation. The notification "done compiling" appear that indicate the compilation was completed.

The sensor were then installed onto a diesel tank that has dimension of 250 centimeters length, 62.5 centimeters radius. Thus, the maximum volume of the tube is 3,066.406 liters.

3,066.406 liters of diesel fuel are then poured into the tube. After checking the application, it can be concluded that the maximum volume of the tank was read accurately.

Then, the fuel was drained gradually. Compared with the volume of the fuel drained, the system displayed the volume of the fuel in the tank accurately. Fig 8 showed the application interface when tank was drained until 69 % of the fuel remained in the tank. The sensor needed 30 seconds to show fixed number since the surface of the fuel in the tank was fluctuating during draining or filling up process.

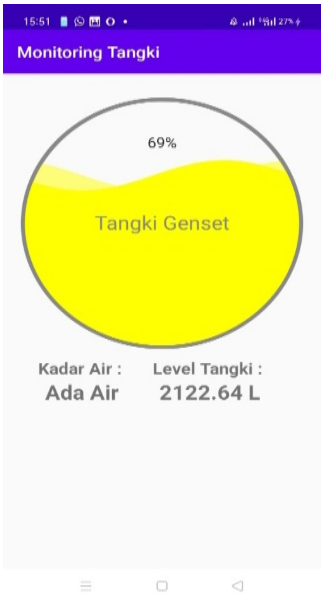

Fig. 8. Android Interface

The last test was checking the water contamination in the tank. The interface showed "Ada air" which means the sensor detected water during the test. The TDS sensor would detect water which reached 5 mm height since the sensor was installed 5 mm from the bottom of the tank as the minimum distance to avoid short circuit.

V. Conclusion

Based on the testing, the combination of an ultrasonic sensor, a TDS sensor, and an ESP 32 microcontrollers could be working simultaneous. The ultrasonic sensor could take the volume data of remaining fuel in the tank. The TDS sensor could detect the water residue which reached 5 mm height from the bottom of the tank. The ESP 32 microcontrollers then processed both data sent the result to the application. The application could read the data and displayed into more readable interface.

By monitoring the display, the technician can make decision to fill up the fuel when the tank was in shortage or to drain the tank when the water contamination was detected.

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