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Development of a Digital Gauge for Fuel Consumption in Vehicles

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ABSTRACT

Analogue vehicle fuel gaugeshaveshown obvious inaccuracies providing false impression as to actual fuel level.This research, based on embedded systems, developed a digital display of the exact amount of fuel contained in the fuel tank of the vehicle helps in cross checking the quantity of fuel filled at the petrol station. Whereas, analog fuel meters indicates three states of fuel level which are empty, half and full using needle or meter pointer, the digital fuel meter proposed indicate the amount of fuel in litres. The microcontroller is initia1ized and the fuel level in the tank is measured and LCD displays the fuel amount in the tank.

Keyword: Automobile, digital fuel gauge, Fuel consumption, microcontroller

Introduction

The requirement to measure liquid levels in containers typically arises in both big and small scale sectors, such as vegetable oil production plants, gas service stations, and so on, where significant volumes of liquids are held. Liquid measurement is also required in public water supplies and treatment plants, fuel depots, and even home water sources. Liquid level sensing is also crucial for breweries and bottling companies to maintain standards and reduce economic loss. These liquids might be nonconductive or conductive, inert or highly combustible. Due to a variety of circumstances such as human emotions, exhaustion, lack of attention, equipment inaccuracy, and so on, manual or mechanical measurements may be faulty. As a result, efforts have been focused on developing autonomous liquid level detecting technology (Ehiagwina, Afolabi, Kehinde,Olaoye & Jibola, 2017).

An important area today where liquid level need to be observed is in automobiles. Interest is shown here because of the economic and environmental consequences of vehicular fuel consumption. Economically, a vehicle owner wants to know the cost implications of fuel usage. The evidence points to a general increase in the cost of fuel in Nigeria. This was pointed out by Soile and Mu in (2015).In addition, with the increasing call for the development of environmentally sustainable products, the push have been toward vehicles with lesser fuel consumption (Cheah, Evans, Bandivadekar& Heywood,2008; Dioha& Kumar, 2020; Ojolo, Oke, Dinrifo& Eboda, 2007).

Owing to the fact that analogue meters is the commonestway of indicating fuel levels in automobiles in Nigeria, it is impossible to determine exactly how much fuel is currently in the vehicle or to cross-check the amount of fuel loaded at the filling station. However, analogue metersdemands manual reading of parameters from the scale which is cumbersome, the result is not accurate compared to a digital meter. The inaccurate results are caused due to three types of errors like improper counting on the scale, improper range setting, wrong setting on AC/DC. In addition, analogue meter, shown in Figure 1 are bulky in size and costly. The analoguepointer gets damaged if the meter gets dropped by mistake.

Figure 1: Picture of analogue fuel gauge for automobile. Source: www.autozone.com%2Fdiy%2Ffuel-systems%2Fwhats-wrong-with-your-fuel-gauge

The aforementioned drawbacks of analogue meters necessitate the development of digital meters capable of accurately indicating the levels of fuel in an automobile. But some newer automobiles implements their digital system by sending current directly to the fuel gauge, this could induce fire outbreak because of the high flammability of automobile fuel. Rather, smart fuel gauge system techniques have been implemented in some newer cars, in which an intermediate microprocessor is used to read the output of the resistor and then communicate with the dashboard to display the fuel on the gauge corresponding to the read output voltage from the sending unit, and this system helps to improve the system's accuracy. Newer cars have a microprocessor that reads the variable resistor in the tank and sends the data to another microprocessor in the dashboard, which displays the fuel label and a fuel light indicator signal based on the fuel level, such as a red light when the tank is low on fuel and a green light when the tank is full (Gijre, Mane, Gadade& Gandhi, 2017; Qadeer, Khan, Shylashree& Nath,2019).

By comparing the float position to a calibration curve that correlates the position of the float with the volume of fuel left in the tank, car manufacturers can play with the gauge movement a little while accounting for the shape of the tank. This allows the gauge to read more precisely, which is especially useful in vehicles with complex gas tank designs. In addition, the microprocessor can dampen the required movement. The fuel (liquid) level is automatically sensed by a pressure sensor weighing the mass of the liquid and presenting the output on a liquid crystal display (LCD). The system's input is the weight applied to the pressure sensor, which generates an electrical signal proportional to the weight, and the amplifier amplifies the output signal. The analogue to digital converter ADC converts the amplified signal into digital output for the microcontroller(Divakar, 2014).

The accuracy of the fuel level monitoring has not been a major concern until lately. Instead of precision, the goal of measuring the gasoline level with a fuel meter was to provide the data on the dashboard with a fuel meter. The two most important factors were to avoid quick fluctuations in the fuel level display (Mule, Patil,More and Kale(2016). When the gasoline level falls below a predetermined level, the meter displays that the tank is empty. This analogue car fuel gauge technology is not capable of displaying the exact amount of fuel in the tank. Also, such a system cannot protect us from being duped at 'petrol pumps,' which cost more for a smaller amount of fuel. As a result, it becomes vital to develop a system that provides the exact (numeric) value of fuel in the fuel tank.The digital gasoline indicator is suited for all fuel tank sizes and may be attached to the tank sending unit found on nearly all vehicles (Jade et al., 2014).

Sensing and indicating systems can be implemented using a variety of methods: The most common and traditional fuel indicator system currently in use uses resistive float type sensors to measure the level of fuel in the tank, and it consists of two units: a sender unit that measures the level of fuel in the tank, and a gauge unit that displays the measured fuel level to the driver. Another method is the smart fuel gauge system, which is similar to the classic method but incorporates embedded devices such as a microcontroller or microprocessor to improve accuracy.

A digital fuel gauge is a device that displays the exact amount of fuel in litres or millilitres in numeric digits and is used to indicate the level of fuel in a tank such as 1.2 lit, 1.3 lit, 1.4 lit, etc. Any tank, even underground storage tanks, can be used with it. The systems are made up of two key components: fuel level detection and signalling. The indication system detects the amount of electric current passing through the sensing unit and indicates fuel level, while the sensing unit employs a float type sensor to measure fuel level (Mule et al., 2016; Terzic et al., 2012).

Reviewof Related Works

In this section of the paper, we focuses on work similar to ours. For an overview of liquid level sensor technologies see Ehiagwina et al. (2017).

In Obikoya(2014), the study began with the design and building of a fuel-level sensor, which was followed by the setting of a remote Aplicom 12 global system for mobile communications (GSM) module to connect the sensor. After the module has been configured, remote fuel monitoring can be done by sending control messages from a compatible mobile phone to check the status of the remote fuel sensor (and hence the volume of fuel in the tank). The module's status message will be transmitted back to the mobile phone that issued the query (or control) message over the GSM network.

Mule et al.(2016) built a digital gasoline meter to digitally indicate the amount of fuel in the tank. That number has digits in it (ex: 1lit, 1.5 lit, 2lit etc). The system could also be used to monitor fuel theft by sounding an alarm in the event that the an owner parked his vehicle and the fuel reduces.

Jibia and Abdullahi (2016) proposed a microcontroller-based fuel level gauge for an underground cylindrical tank that is horizontally installed. A magnetostrictive level sensor, a microcontroller, and a liquid crystal display (LCD) unit are the main components. The sensor works by sensing the position of a permanent magnet and calculating the distance between it and the sensor head. The sensor produces an analog signal that is transmitted to the microcontroller. The microcontroller is programmed with an algorithm that uses a mathematical equation to compute data value based on petrol level sensor output and tank dimension to determine the contents of a tank fitted with a fuel level sensor. The height in meters and capacity in litres are displayed on an LCD display using the output of the programmed microcontroller.

Ma, Hu, Leslie, Zhou,Huang and Bared (2019)presented an eco-drive algorithm for optimizing vehicle fuel usage in rolling terrains, which frequently results in significant fuel waste due to inefficient kinetic and potential energy conversion. The relaxed Pontryagin's minimum principle (RPMP) technique is computationally efficient and may be used in real time. While similar algorithms have shown to be effective in simulations with several assumptions, field testing is required to better understand algorithm performance and, as a result, make improvements to properly operate vehicles for eco-drive. As a result, this study put the newly created algorithms to the test on an innovative CAV platform, calculating the fuel savings benefits of eco-drive. On a total of 7 road segments spanning 47 miles, the proposed eco-drive technology is pitted against traditional constant speed cruise control. Experiments have shown that over 20% of fuel use can be reduced. The primary geometrical contributions to the eco-drive fuel savings are also shown through detailed research using linear models. This study can help state transportation departments select highways where eco-drive should be installed by providing a rough estimate of their fuel-saving potential. The algorithm and experiment can also help original equipment manufacturers develop and market this technology in the future to minimize fuel consumption and pollutants.

Sharma,Kumar,Dhyani, Ravisekharand Ravinder(2019) conducted idling fuel consumption studies on 341 test vehicles of various classifications, representing the traffic mix of Delhi, using a fuel flow meter set-up. Using fuel-based IPCC emission factors, direct greenhouse gas (CO_2, CH_4, and N_2O) and indirect greenhouse gas (CO, NO_x, etc.) emissions were calculated. According to the findings, motor vehicle idling at these crossings wastes 9036 liters of gasoline, diesel, LPG, and 5461 kg of CNG each day, amounting to roughly 4.5 million dollars per year. GHG emissions (CO_2, CH_4, and

N_2O) were calculated to be around 37 tonnes of CO_2 equivalent per day. The current study focuses on the methods for estimating idling fuel losses and associated emissions at signalized junctions. Finally, legislative interventions and mitigation methods to reduce idle emissions and associated emissions at these signalized junctions have been proposed.

However, this research proposed the development of an embedded system based digital gauge for fuel consumption in vehicles to improve meter accuracy. This research work will minimize the problem of fuel thefts at the petrol station. Further justifications the reduction of the stress and cost of fuel pump monitoring agencies, extermination ofthe problem of misinterpretation of the amount of fuel left by the drivers in the fuel tank of the vehicle, and solving the problem of the mileage of the vehicle and minimizing traffic regards the shortage of fuel in the tank.

Materials and Method

The arduino microcontroller is programmed for used, all other components are assembled on the bread board for circuitry test and later transferred on the veroboard for soldering using soldering iron and lead. This device is then cased and connected to analogue-digital converter (ADC) in the vehicle from the vehicle fuel tank. The main component of digital fuel indicator (gauge) in vehicles is the pressure sensor which generates the signal based on the amount of liquid available in the tank and displays it on LCD. The MPX 2010 series silicon piezo — resistive pressure sensors provide a very accurate and linear voltage output directly proportional to the applied pressure.

In this research a float type sensor is placed within the fuel tank, the variation of the fuel can change the position of variable resistance which is connected with the float. The varied resistance can change the voltage of the analogue fuel level indicator to show the approximate value but the variable resistance from the fuel tank is connected with the analog to digital converter unit to show the exact quantity of fuel in the tank. The set up can show the exact value of fuel in the connected LCD.

The fuel tank with float sensor is connected to an analogue fuel gauge like every vehicle. The float provides analogue value to the ADC which is further read by the microcontroller (which is flash programmable and erasable read only memory. At last, the microcontroller gives the result of the amount of fuel in the tank which is displayed on a LCD Screen. The system as a whole is connected to a battery.

Schematic Circuit Procedure

The Figure 2 shows the block diagram of a proposed circuit diagram to be implemented for digital fuel gauge in vehicles. This section outlines description of how the construction will be implemented.

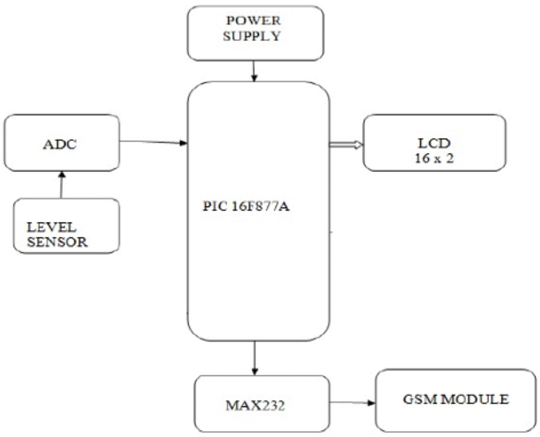

Figure2: Block Diagram of A Digital Fuel Meter

Liquid Crystal Display

The liquid crystal display is a flat, thin panel that electronically shows information such as images, text, and moving graphics. Computer monitors, televisions, and instrument panels all use it. Its portability, lightweight structure, and possibility to be created in even greater screen sizes are just a few of its highlights. It shows amount of fuel in the container in litres without much modification in the dashboard of the vehicle. The picture of the LCD along with the pins' description is shown in Figure 3.

Figure 3: Pin connection of the LCD. Source: (Falohun, Amoo, Rasheed& Omitoyinbo, 2016).

It is an alphanumeric display, which means it can show numbers, alphabets, and special symbols. Unlike a seven-segment display, which can only show numbers and some alphabets, LCD is a user-friendly display device that can show a variety of messages. It can be utilized in battery-powered electronic gadgets due to its low electrical power consumption. It's a color or monochrome image-producing electronic modulated optical device made up of any number of pixels filled with liquid crystals and placed in front of a light source, backlight or reflector (Anakath et al., 2016).

Microcontroller

A microcontroller will be used which is a small computer on a single integrated circuit containing a processor core memory and programmable input/output peripherals. The microcontroller used is a flash programmable and erasable read only memory.The PIC 16F877A has all of the components found in current microcontrollers. 8K bytes of Flash, 368 bytes of RAM, 256 bytes of EPROM, 5 I/O ports, 3 timers, and 35 simple word instructions are all included in it. Other standard features include: I) Software-controlled self-programming 2) A/D converter with 10 bit resolution and up to 8 channels 3) A wide range of working voltages (2.0-5.56) is available. 4) EEPROM/CMOS flash with high speed and low power 5) RISC CPU with high performance (Anakath et al., 2016). The pin diagram is shown in Figure 4.

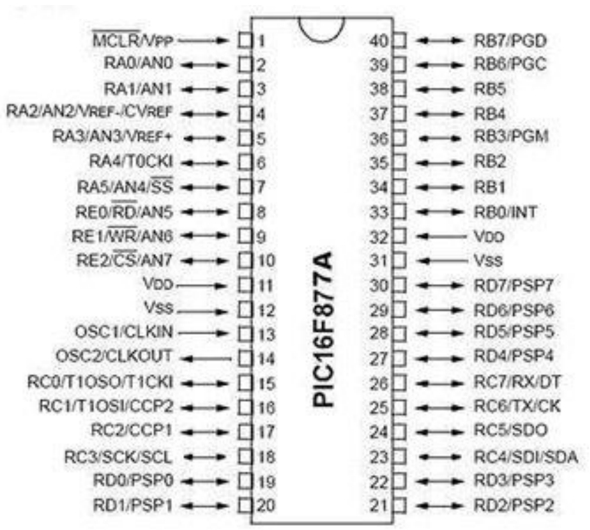

Figure 4: Pin diagram PIC16F877A. Source: Anakath et al. (2016)

Max232 Interface

The MAX232 is a dual driver/receiver with a capacitive voltage generator that can generate TIA/EIA-232-F voltage levels from a single 5-V source. TIA/EIA-232-F inputs are converted to 5-V TTL/CMOS levels by each receiver. These receivers feature a 1.3 V typical threshold, 0.5 V atypical hysteresis, and can tolerate 30-V inputs. TTL/CMOS input levels are converted to TIA/EIA-232-F values by each driver. MAX 232 is used in this project for serial connection between the GSM modem and the microcontroller. The Max232 interface is shown in Figure 5.

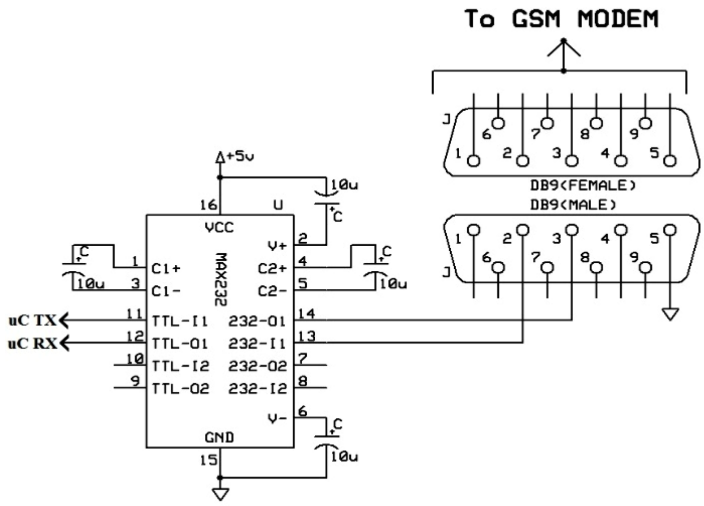

Figure 5: Connection diagram of GSM modem with MAX232 unit. Source: (Khan, Banerjee, Bhat& Banerjee, 2014)

Analogue-Digital Converter

It is a converter which converts analogue value to digital value. Figure 6 shows a 2-bit-ADC used in this system.

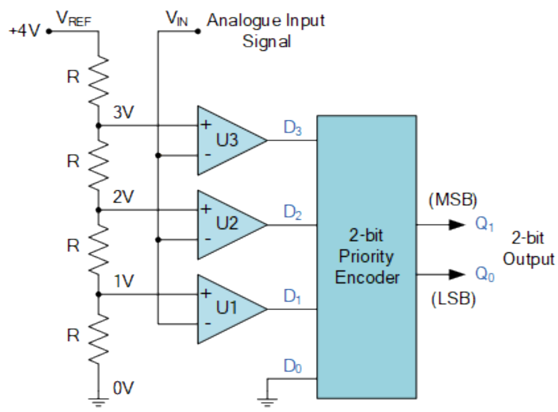

Figure 6: 2-bit Analogue to Digital Converter Circuit. Source: https://www.electronics-tutorials.ws/combination/analogue-to-digital-converter.html

Petrol tank with float sensor

A petrol tank is a container where fuel is stored. It is provided with an instrument namely float sensor which measures the amount of the fuel in the tank. The image of a commercially available float sensor is depicted in Figure 7. The float sensor pick up the fuel level for conversion to electrical signal.

Figure 7: A commercially available float sensor. Source: https://www.electronicscomp.com/water-level-sensor-float-switch-p43-india

Circuit Components

Transformer 220v-12v, switch, diode bridge (IN4001), (4) capacitor l000µf, 5volt power regulator, capacitor 10µf, LED, resistor, ultrasonic sensor, crystal oscillator 20mA, resistor l0kΩ, switch/reset button, resistor 220Ω, LED indicator, variable resistor 5KΩ, LCD (16x2). Figures 8 and 9 show the regulated power supply circuit and the overall system circuit connection.

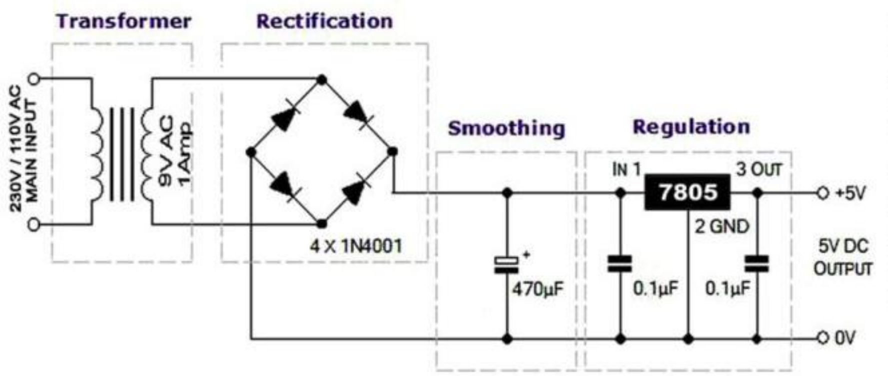

Figure 8: Circuit diagram of the regulated power supply. Source: https://easyelectronicsproject.com/mini-projects/5v-power-supply-circuit-7805/

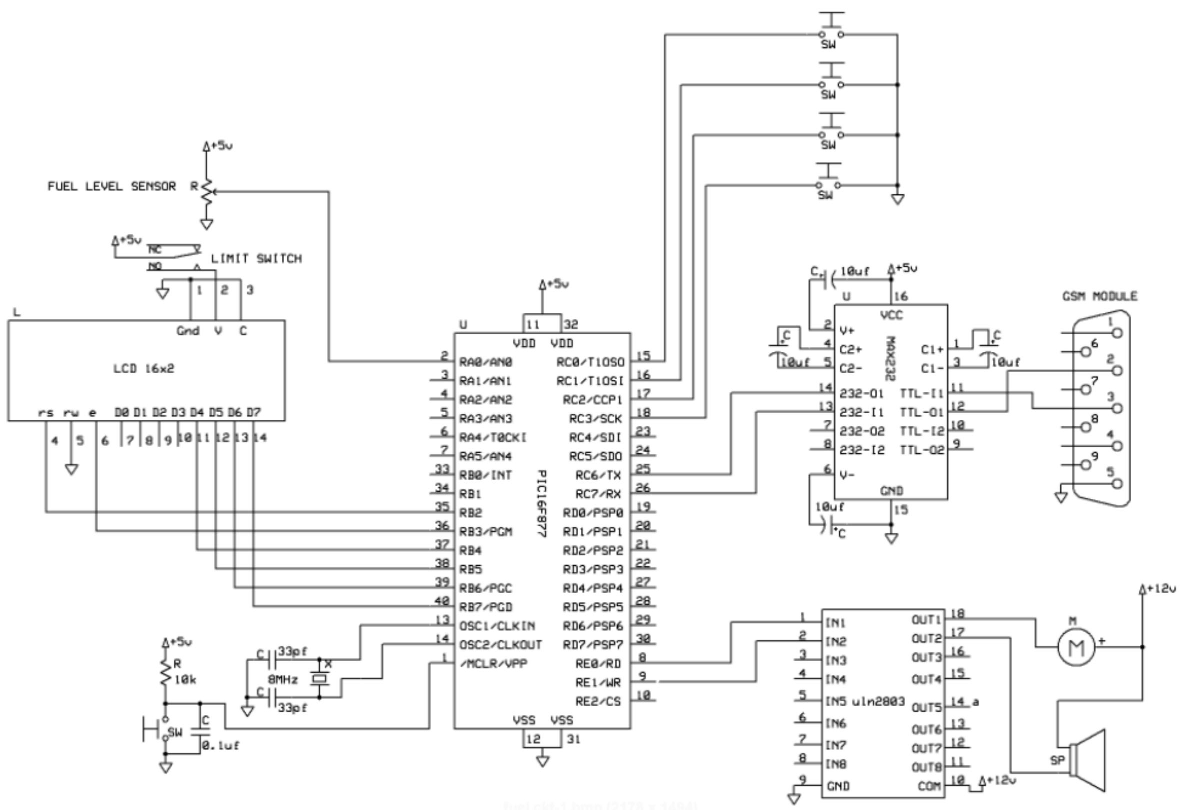

Figure 9: Circuit Diagram ofthe system. Source: Mule et al. (2016)

Principle of Operation of the system

The traditional fuel indicator consists of two units; sending unit and the gauge. The sending unit is located in the fuel tank of the car and it consist of a float, usually made of foam, connected to a thin metal rod. The end of the metal rod is mounted on a variable resistor or potentiometer. The variable resistor consists of a strip of resistive material over it which moves across the variable resistor changing resistance and flow of the current depending on movement of the float with respect to the level of fuel present in the fuel tank. The Arduino microcontroller (ATmega 328/8A) initialized and the fuel lc'iel in the tank is measured, if the fuel level is low, then it is indicated on the display and fuel is filled into the tank and if the fuel is full then the pressure is sense and the analog value is converted into digital form by the microcontroller and displayed in numeric digital form on the LCD display.

Implementation and Result

The physical construction of the project was done properly following the prototype layout during the process of the research. And it was packaged in a casing that fits the size of the circuit. This project was implemented, constructed and tested and found that it met the purpose of the research. This project work was first arranged and tested on a breadboard before transferring it to the Vero board for final soldering and implementation as depicted in Figures 10a and b. The constructed system was tested stage by stage to ascertain that the circuit operation conforms to the model design for this project and all worked as expected. The digital meter follows these procedure: 1. Start 2. Initializing the switch of vehicle 3. Start the engine of the vehicle 4. Display the level of the fuel on LCD 5. Keep the engine ON, and display current value of fuel level. 6. Stop the engine of the vehicle 7. Store the petrol level value 8. Then fuel status in form of SMS to owner's number 9. Stop.

(a)

(b)

Figure 10: The proposed digital fuel level indicator (a) Internal connection (b) external features

The problems encountered during the development of the system are highlighted below:

1. Periodical errors displayed while programming the integrated circuit of the Arduino microcontroller.
2. The device damaged instantly when the polarities of the system were interchanged accidentally.
3. Diffulties in cooperation between the resistance sensors of the float and the embedded digital gages
4. Some components failed to work within their species ranges,so much times were spent before the components used were selected.

To overcome these challenges, the programming were run several times on the Arduino microcontroller. The polarities were properly identified. The resistance of the float was made frictionless to ensure better sensitive of the information of the liquid. The components were put under intense testing and the suspected faulty ones were not used.

Conclusion

The research's stated goal was accomplished. Following the procedure, the hardware and software installations and operations worked as intended. The circuit's simplicity, while still being economical and reliable, was given top importance. To make the designed program more user-friendly, responsive buttons were used to make the program design dynamic. In addition, the project circuit was constructed using the fewest available electronics components to get the intended outcome at the lowest possible cost while retaining the project's quality, performance, and functionality.

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