DESIGN AND IMPLEMENTATION OF A MICROCONTROLLER BASED FUEL DISPENSE ERROR DETECTOR FOR AUTOMOBILE

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Abstract

As the name implies fuel dispense error detector, is a system implemented to detect errors after dispense of fuel into the tank of a car. The errors can be in form of either shortage or excess. This is due to the problems encountered during the fuel scarcity period whereby oil marketers took the habit of altering their fuel dispensers while consumers were underserved the product. As a result of the problem at hand, the system was implemented using Arduino Mega Board, Ultrasonic sensor, LCD, keypad and buzzer. The sensor and the keypad were used for setting a set value which is used for comparing the set value with the final level of fuel in the tank. The Arduino served as the center of the system whereby all parts were interfaced to it. After coupling, a program was written and sent to the board. A test was conducted after successful implementing the system and some responses were gotten like, when the final level of fuel falls below the set value, it indicates shortage with continuous beep, when the final level falls above the set value, it indicates excess with 3 short beeps, while as the final value falls on the set value, it indicates ok with a single short beep.

I. INTRODUCTION

The fuel dispense error detector system as the name implies is a system used to detect error after dispensing fuel into the fuel tank of a car. The detection is achieved with reference to the height of liquid since the volume of the tank is fixed (i.e. constant). Some set of parameter are set using a number keypad to give a set point and comparing with the level of the fuel in the tank. Research and technological advancements in solid state electronics have contributed to the advancement of the human race and also in which way humans carryout their daily activities. Technology has advanced with many years and it has really changed the way we live, communicate, learn and mostly act in our day to day activities. As people make demand, lifestyle also changes as well. The demand for advancement in the type of technologies we use is also getting higher. The advancement has brought about comfort in the human lives with ease. Such advancement can also be used to also fight illegal practices in human race. With further advancement on technology, previous versions of electronic components/systems have now been revised and transformed from analog to digital which makes it much easier to realize and perform complex task. In July 2012, Aziz Ahmad, Varm Redhun and Umesh Gupta designed a liquid level control system using fuzzy control. They were able to monitor the level of liquid in the tank using the fuzzy control. When the water falls below a certain level, a 2 signal is sent to microcontroller to activate the pump switch. As it reaches a certain height, it sends a signal so as to deactivate the pump switch. In May 2015, N.T Makanjuola, O.O Shoewu, LA Akiyemi and A.A Ajasa designed a microcontroller based liquid level detector with graphical output using series of conductor placed at certain levels of the tank. They were able to monitor the water level and control. Also, they were able to provide constant water supply whereby when there water level should fall below a certain level, it turns on the pumping machine and as it reaches a certain level it turns off the machine to avoid water overflow. In January 2012, JaseemVp designed a water level detector using series of transistors, and gate with buzzer. He was able to show the level of water in a tank using leds and transistors. The transistors are activated by shorting the conductors that were placed at specific levels of the tank. In March 2014, Erua J Band, Anyasi F.I. designed an automatic water level detector using PIC Microcontroller and mercury float sensor. In this type of project, it employs both mechanical and electrical control. The mechanical control is achieved using counter weights, while the electrical control is achieved using PIC Microcontroller. The PIC also provides a platform for PC monitoring using network. A graphical view of the tank is seen on the screen. In September 2015, Ranjeed Singh, Indian based technologist working with NEVON Projects Company, designed an IOT water level indicator using ultrasonic sensor. IOT means internet of things. That means, status of the tank is sent through wireless network to a computer where a graphical representation of tank is viewed.

From all views and indications, they only concentrated on water level. They also concentrated on fixed levels, which is not conducive for the purpose of this project. Since fuels are highly combustible and flammable, it would not be conducive to run conductors and place them in the tank. Since fuels used in automobiles are liquid in nature, programming of microcontroller can be exploited, to explore more functions. The project also does not monitor the fuel content, it only gives the status at a particular time.

In this proposed project, not all components used in past projects will be used. Some additional peripheral devices would be added.

Looking at the above works which are directly and indirectly related to this project, it can be seen that all works are interrelated in the sense that ideas were built on one another. Also, due to flexibility of the past projects, the functionality can also be extended wider such that they can perform other tasks besides what they were initially designed for.

II. METHODOLOGY

POWER SUPPLY UNIT

The power supply is simply just a battery source because all automobiles operate on battery. So the need to design a power supply unit is not necessary. The battery is 9v dry cell battery, for the purpose of this project so as to illustrate how it would perform the task it would be designed for. The 9v was chosen because the microcontroller board requires power within the range of 7v to 12v. If a battery of less than 7v is applied, the 5v port would give less than the 5v which is not proper and can lead to error during processing. Also when a battery more than 12v is applied to the board, the voltage regulator tends to heat up, making the board to go unstable and eventually the voltage regulator of the board would heat up and get damaged. For stable performance of the board as stated by the datasheet, 9v battery source should be used. This has brought ease to the construction. The board also provided 39 other means of sourcing power to it. Either using an AC-to-DC adapter or through the USB port or placing the terminals of the battery to the Vin and GND port on the board. Since automobiles use only battery source, the source of the board must come from the battery. Cars are powered by 12v batteries. The board requires 9v for stable operation. A voltage regulator has to be provided so as to regulate the 12v from battery to 9v.

CONTROL UNIT

The control unit is mainly the ATmega2560 microcontroller IC embedded on the board. And most of the peripherals are also embedded on the microcontroller board; such as the Crystal Oscillator, Master clear. The crystal oscillator is 16MHz clock; it is used to synchronize digital and logical circuits such as the keypad, Ultrasonic sensor, logic state of the buzzer, and flow of data between the LCD and Microcontroller.

MASTER CLEAR

The master clear is used for putting the microcontroller into a known condition. This practically means that microcontroller can behave rather inaccurately under certain undesirable condition. In order to continue its proper function, it has to be reset, meaning all registers would be placed in starting position. The reset is not only used when microcontroller doesn't behave the way it wants to, but can also be used when trying out device as an interrupt in the program execution, or to get microcontroller ready when loading a program. For this case, there is no need for that because the board is already embedded with the reset button, unlike other microcontrollers whereby the MCLR pin is connected to logic high, and a switch is used to initiate change in state, such that when the switch is pressed, a logic zero is seen by the pin and a reset is done. But an external reset button is provided by connecting a push button from the reset port to the ground terminal. This is to prevent accessing the board components which can result to damage.

FLOWCHART

The flowchart illustrates the working principle of the project. It is based on "INO file" that is Arduino which is an advanced language written in C. This form of programming is all about setting the ports to be either output or input, then specifying the operations to be performed in the process. The program starts with the initialization of ports to be used, since the ports to be used are all digital, we either set them to be (high or low) and (input or output). Also the type of device is to be used on the ports. The flowchart is represented as shown below:

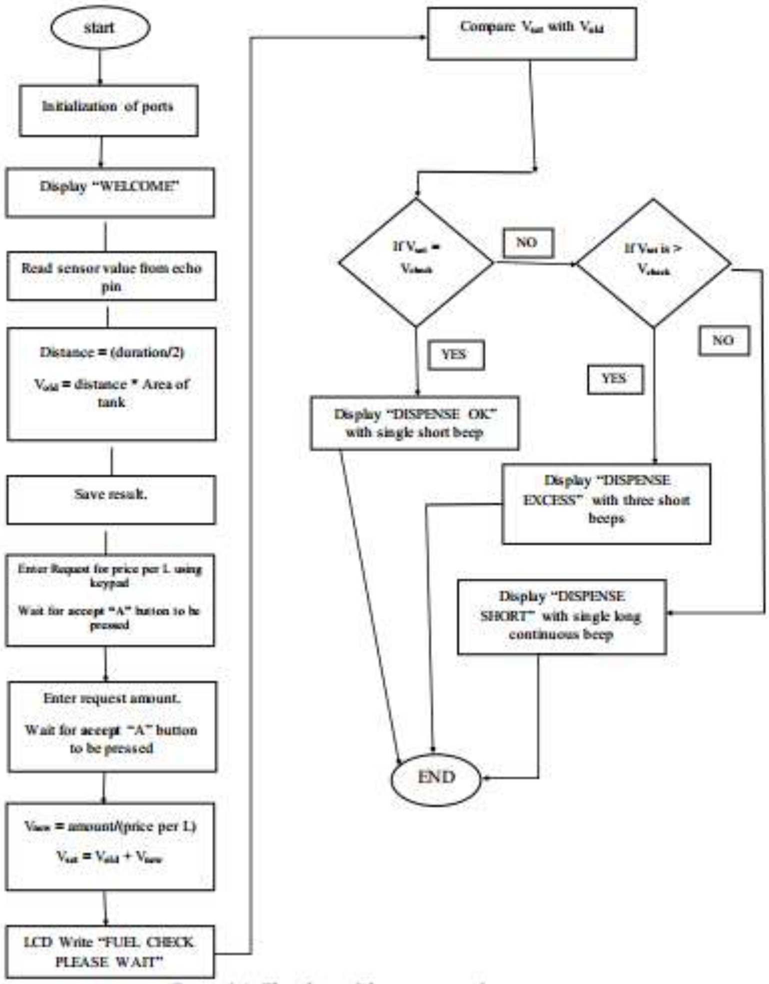

Figure 1: Flowchart of the program software.

TABLE1

Flowchart Parameters	As represented in the program
V_{old}	initialVolume
V_{new}	volumeToBuy
V_{set}	expectedVolume
V_{check}	currentVolume

ULTRASONIC SENSOR

The ultrasonic ranging sensor detects the level of liquid by sending ultrasonic sound waves by the transmitter in form of pulses. As the waves hit the surface of the liquid, they are reflected back and sensed by the receiver. The time at which the waves are sent and reflected back is known as the duration. To get the distance, the ultrasonic sensor would be programmed with some calibrations so as to give the distance in a specified format like cm, inches and feets. To get the distance in cm, it is calculated as:

targetDistance = (pingTime/2)/29.1

Also,

volume = heightOfLiquid*areaOfContainer;

The Area of the tank is constant, so a fixed value can be used to give a value at any level. The level in this case is the varying parameter. So converting cm3 to Litre, as it is known, 1000cm3 = 1L, we divided the result in cm3 by 1000. To make it easier, since the area and the converting factors are all constants, we can simply equate them to be 0.5. But height of liquid doesn't start from the sensor's reference. To get the height of liquid in tank, we subtract the distance from sensor to the surface of the liquid from the maximum height of the tank.

Flowchart Parameters As represented in the program
VoldinitialVolume
VnewvolumeToBuy
VsetexpectedVolume
VcheckcurrentVolume

heightOfLiquid = heightOfContainer-targetDistance;

Since all measurements are in cm, we continue to use all levels in cm. To achieve this, the trigger is set high for some time and then set low. Then the receiver is set to high to detect the reflected waves, the pingTime is what is used to calculate the level. Ultrasonic sensor must be placed 2cm above the maximum level of liquid because from the data sheet, it can only detect from 2cm to 400cm.

LIMITING CURRENT RESISTANCE

The source/sink current for the Arduino board is 40mA. The Ultrasonic sensor has its terminals for sourcing power, it requires no limiting resistance. But for LCD backlight, it requires a lesser voltage. Like the led, it requires 3.3V to operate and the operating current is 3mA as stated by the datasheet.

Let V1 = voltage at 5V port of the board be 5v

V1 = VL1 – V1

V1 = 5 – 3.3 = 1.7

Now,

R1 = (VR1/IL)

R1 = 1.7/3mA

R1 = 566.67Ω

Based on standard component rating, 566.67Ω cannot be gotten, but a standard value of 560Ω is available. It protects the LCD Backlight from over current. Also, the LCD requires 5V to operate under normal condition. But to adjust the contrast, a 10kΩ variable resistor is connected to the V0 line of the LCD. When theV0 I is grounded directly, the character would not be visible, they would be overshadowed by high contrast of pixels. Adjustment of contrast is achieved by varying the 10kΩ pot as stated by the datasheet.

KEYPAD

The keypad is used to enter some parameter so as to give a set point. The parameters are the Amount to be purchased and Price/Litre. The keypad was a 4 x4 matrix keypad. The row pins and column pins are connected directly to digital ports. The board is provided with internal pull-up resistors. When the program is written, it automatically configures the ports chosen. The row pins are connected to port 22, 23, 24 and 25. The column pins are connected to ports 26, 27, 28 and 29. The ports are configured in such a way that when a key is pressed, it scans for row and column, then sends a signal to the microcontroller. The keypad used is a 4 X 4 hex membrane keypad. From the datasheet, pins 8, 7, 6 and 5 represent the rows, while pins 4, 3, 2, and 1 represent the column pins. For the purpose of this project, pins 8, 7, 6, and 5 would be connected to ports 22, 23, 24, and 25. Pins 4, 3, 2 and 1 would be connected to ports 26, 27, 28 and 29. No need for external pull-up resistors.
The numbers are used to enter values; the “A” is used to accept values, while “C” is used to clear errors when inputting values or screen.

The push button switch is used to reset the system by connecting one of the terminals to the reset port, and the other terminal to the ground. This is used to bring back the system to initial state. Though, the board has been provided with a reset button. But due to casing of the project, accessing the reset button on the board is not advisable. The push button practically provides an external means of resetting the system without reaching board. Also, too much physical contact with components on the board can result to quick damage.

Liqiud Crystal Display (LCD)

The LCD is used to display characters. LCD can be connected in two modes 8-bit and 4-bit mode. In 8-bit mode, the pins D0 – D7 are connected to the data pins while in 4-bit mode, D4 – D7 are connected to the data pins. Most LCDs are connected in 4-bit mode. For the purpose of this project, the LCD would be configured in 4-bit mode.

Pins D4, D5, D6 and D7 to ports 5, 4, 3 and 2. Then the Register Select (RS) pin connected to the port 11 and the Enable (E) to port 12 on the board. The Vss, Vo**,** Read/Write(RW) pins are grounded. The backlight pins L+ connected in series with 48 a current limiting resistor, while the L- is grounded. In order to view characters on the LCD, a variable resistor is connected in series with V0 pin. The variable resistor is tuned so as to adjust the contrast of the LCD. A 10k pot variable resistor is used and then varied to the required value.

COMPLETE CIRCUIT DIAGRAM

The complete circuit diagram of the project consists of the LCD display, Ultrasonic sensor, keypad, limiting resistors, push button and buzzer.

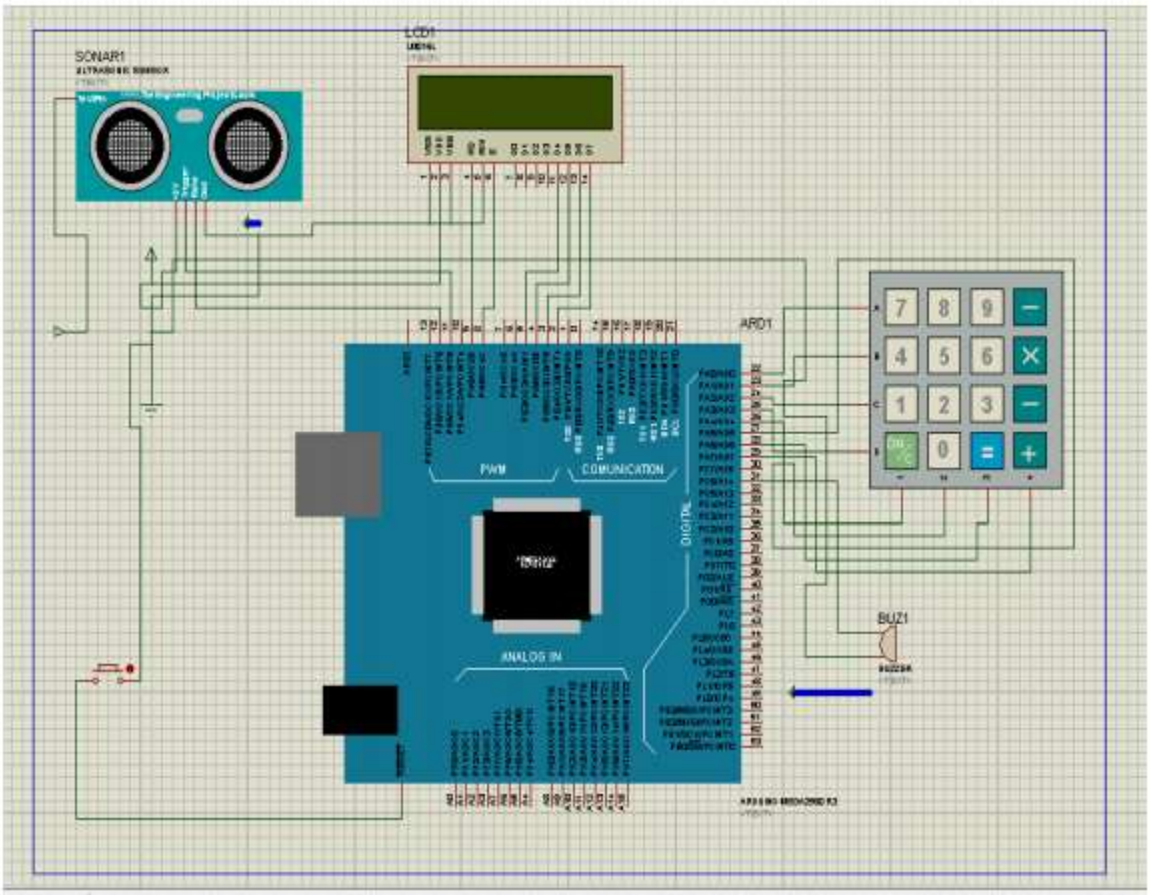

Figure 2: Circuit diagram of the system

III. RESULT AND DISCUSSION

Tests were conducted on the software program using Flow code simulator and the ultrasonic sensor using the Arduino Serial Monitor viewer. The following tests equipment were used: a standard meter rule calibrated in cm, the ultrasonic sensor, 52 test level board (flat smooth board). The following results were obtained and tabulated for quick and better comparism of values.

The program was tested to ensure continuous monitoring of levels such that for every change in level, it detects and sends the information to the PC via the USB using serial monitor window. The serial monitor is accessed on the sketchpad. It is used to monitor and display status of the operation of board.

TABLE2

NO	Sensor reading	Meter rule reading	Error
1	2.01cm	2.00cm	0.5%
2	2.54cm	2.50cm	1.6%
3	3.01cm	3.00cm	0.33%
4	3.47cm	3.50cm	-0.85%
5	3.99cm	4.00cm	-0.25%
6	4.53cm	4.50cm	0.67%
7	5.02cm	5.00cm	0.4%
8	5.55cm	5.50cm	0.91%
9	6.01cm	6.00cm	0.17%
10	6.56cm	6.50cm	0.92%
10	7.05cm	7.00cm	0.71%
11	7.53cm	7.50cm	0.4%
12	8.03cm	8.00cm	0.38%
13	8.55cm	8.50cm	0.59%
14	9.05cm	9.00cm	0.55%
15	9.55cm	9.50cm	0.53%

GRAPH

The graph below represents the values of the readings from the sensor versus the readings obtained from the standard meter rule. The graph is nearly a straight line graph. Why the graph is not fully straight is because of the errors in the sensor's reading which are negligible. The errors are as a result of using approximate values, also variation of speed of sound due to humidity and temperature.

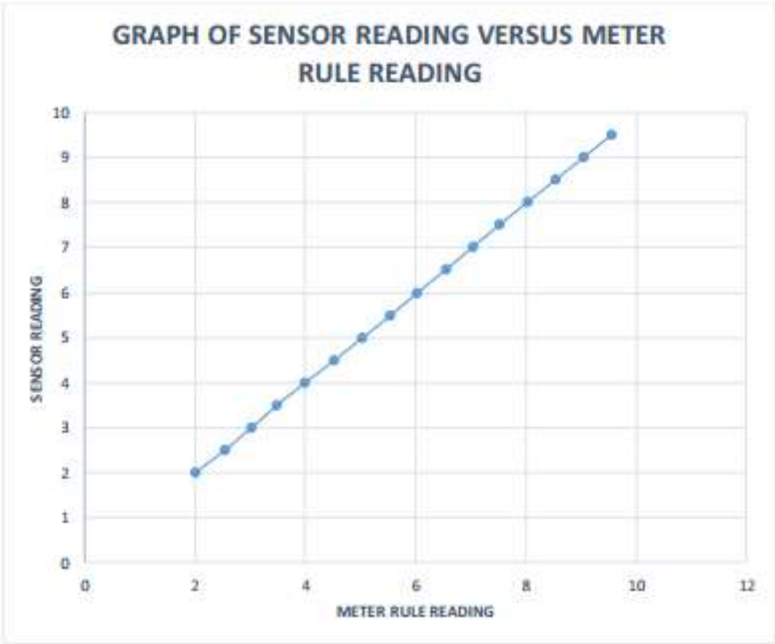

Figure 3: Graph of Senor's reading versus Meter rule reading using Excel

IV. CONCLUSION

This paper deals with design and construction of a microcontroller based fuel dispense error detector for automobiles which is capable of detecting errors after dispensing of fuel into the tanks of cars. At the end of the project, an error detector was produced which is essential in most automobile projects to ensure standard dispense of fuel. The dispense error detector can be used in any part of the world irrespective of currency.

However, the project represents the techniques of using ultrasonic ranging sensors that is HC-SR04, a sensor that measures the distance with reference from the sensor to the surface of target; the target can be liquid or solid. Because sound waves can pass through liquid or solid materials

RECOMMENDATION

The realized project was accurate with very little which is negligible percentage error as 0.756%. Concerning the sensor, immersion type of sensor should be used because they are more protected and can withstand more harsh conditions unlike the HC-SR04 when the control circuits are open. Even though some form of protection can be provided, but can result in distortion of accuracy. In case of 65 errors or malfunctioning of process, the microcontroller board can be accessed using the USB port and reprogrammed. The project work can be applicable mainly in liquid level detection such as water tanks, fuel tanks and oil tanks.

REFERENCES

[1] Abang O.J. (2013). Construction of Water Level Controller for both Overhead and Underground Tanks. Enugu, Nigeria: Electrical Engineering Department, Faculty of Engineering, Caristas University.

[2] ADMIN. (2014, June 16). *Arduino Forum (setting variables using keypad)*. (Ardiuino) Retrieved August 31, 2016, from www.arduino.cc/forums.

[3] ADMIN. (2015, January 25). *Electronics Hub, Projects/Tutorial/Courses*. (AVR Microcontroller) Retrieved July 25, 2016, from www.electronicshub.org/AVR/waterlevel-indicator.

[4] ADMIN. (n.d.). *Engineers Garage*. Retrieved from Engineers Garage Devices: www.engineersgarage.com

[5] *Aduino Tutorial Chapter 42 Numeric Keypads*. (2013, December 16). (Arduino) Retrieved July 30, 2016, from toxinstuff.com/2013/12/16/arduino-tutorials-chapter-42-numeric-keypads.

[6] Andy A. (2014, January). *Electronics Stack Exchange.* Retrieved October 17, 2016, from electronics.stakeexchange.com/questions/96412/time-convertion-to-distance.

[7] Aziz Ahmad et al. (July 2012). Liquid Level Control using Fuzzy Logic Controller. *International Journal of Advances in Engineering and Technology.*

[8] Brian W. Evans. (August 2007). *Arduino Programming Notebook.* San Fransisco, USA: Creative Commons.

[9] Corporation, A. (2014). Atmel. In *Atmel 2549-8-biy-AVR-Microcontroller-ATmega640-1280-1281-2560-2561-datasheet.* San Jose, USA: Atmel Corporation.

[10] Datasheet, L. (2002, October 01). *VISHAY.* Retrieved July 30, 2016, from www.datasheetcatalog.com

[11] Erua J. Band, Anyasi F.I. (2014). Design of an Autmatic Water Level cotroller using mercury float switch. *IOSR Journal of Electronics and Communication Engineering, 9*(2).

[12] Hani T.M and O.M Maing. (2011). Design and Construction of Microcontroller based Water Flow control System. *Proceedings of International Conference on Circuits, System and Simulation.* Bangkok, Thailand.

[13] JaseemVp. (2013, November 13). *Circuits Gallery*. (i - St@r Group) Retrieved July 27, 2016, from www.circuitgallery.com/author/admin/water- level-sensor-circuit.

[14] Jason CH. (2007, June 29). *Arduino Tutorials*. (Arduino Playground) Retrieved June 30, 2016, from arduino.cc/parallax-ping.

[15] John. (2015). *Elec Freaks.* Retrieved March 11, 2016, from www.elecfreaks.com/hc-sr04-datasheet.

[16] Karim Nice. (2009). *HOW STUFF WORKS AUTO*. (HOWSTUFFWORS LLC) Retrieved June 30, 2016, from auto.howstuffworks.com.

[17] Marlin P. Jones. (2013, March 18). *Marlin P. Jones and Associates Inc.* Retrieved March 11, 2016, from www.Mpjt.com.

[18] N.T Makanjuola et al. (2015). Design and Development of Microcontroller based Liquid level detector with Graphical Output. *The Pacific Journal of Science and Technology, 16*(1), 173 - 181.

[19] Olabimpe A.I. (2010). Design and Construction o Water Pump control with level indicator. Lagos, Nigeria: University of Lagos.

[20] Omomlola R.A. (2010). Design and Construction of a water Detector with Pump Control. Minna, Nigeria: University of Technology.

[21] *Parallax Inc.* (2011, December 16). Retrieved October 17, 2016, from www.parallax.com/4x4- Matrix-Membrae-KeyPad.

[22] Paul P.P. (2015, August 29). *HABEROCEAN*. (Haber Ocean) Retrieved 11 15, 2016, from www.haberocean.com.

[23] Ranjeed Singh. (2015, January 13). *Nevon Projects*. (Nevon Projects) Retrieved May 22, 2016, from www.nevonprojects.com.

[24] Reza et al. (2010). Microcontroller Based Automated Water Level sesnsing and Controlling: Design and Implementation. In *Proceedings ofthe Worlds Congress on Engineering and Comuter Science* (Vol. 1, pp. 20 - 22). San Francisco, CA: WCECS.

[25] *Robot Shop.* (n.d.). Retrieved March 11, 2016, from www.robotshop.com/ArduinoMega2560- datasheet.

[26] Rui Santos. (n.d.). *18+ RANDOM NERD TUTORIALS PROJECTS.* Retrieved from Random Nerd Tutorials: http://RandomNerdTutorials.com.