I.J. Engineering and Manufacturing, **2020, 2, 41-51**
Published Online April 2020 in MECS (http://www.mecs-press.net)
DOI: 10.5815/ijem.2020.02.04

Available online at ***http://www.mecs-press.net/ijem***

Implementation of a Contactless Water Level Controller: Embracing Opportunities in Nigeria Computer Science NCE Curriculum

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Received: 15 February 2019; Accepted: 27 January 2020; Published: 08 April 2020

Abstract

The society is blessed with diverse natural resources such coal, oil and water. The significance of water to lives cannot be over-emphasized. The benefits of water include but not limited to an increases in provision of energy, promotes healthy living and regulate body temperature. In schools, the benefits of water are useful in the laboratories for chemical reactions, fish farming and irrigation system. However, the wastage of water by individuals has been evident in the society. For people that are used to electromechanical pumping machine to fetch water; they used to forget to switch off the machine after the water tank might have been filled. The consequences of over-flowing include flooding and weaken of the building foundation. In this technological era, many automatic systems have been developed to control the flow of water into the containers or water tanks. A contactless water level controller system was developed as a demonstration and application of educational sustainable development in Nigeria Certificate in Education (NCE) curriculum. The curriculum was aimed at encouraging the students to be up-to-date of relevant development in computer science and for the students to be able to impact the knowledge acquired to the young ones. Advanced programming is one of the course contents which involve learning C++, Java, C+ and Visual Basic at NCE level so as to be able to design and implement some application that will be of beneficial to the students and society at large. The controller work on the principle of signals transferred or received by the ultrasonic sensors. It consist of power supply, controller unit, ultrasound, display unit, water pump and water tank while C++ programming language was used and edited by using C++ Crimson editor. The system was installed outside the water tank. The sensor switched ON the motor pump when the water level is below 45cm and again switches OFF the motor pump when the water level is above 45cm. The system has low maintenance and installation cost which is more efficient. Also, electrical power wastage was successfully managed as the motor pump shut down when the water level reaches the desired level thereby reducing the cost of electricity bills for the user. The System was designed, implemented and tested to ascertain its working and viability practically to allow the students of computer science acquire relevant skills in programing language as outlined in the curriculum and to achieve and enhance capacity building. The finding of this research included acquisition of programming skills for implementation of automated system.

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Index Terms: Application, Controller, Contactless, Sensor, Ultrasonic.

1. Introduction

Education has been recognized globally as one of the universal ways of survival and improvement of the well-being of individuals and society. The advent of formal education is considered as the foundation for national development as well as the surest way of making all long life achievements [13]. For these reasons, families and citizens especially the youth and children now pay more attention to education. Consequently no nation, government, organization or family makes effective impact and lasting successes in their daily affairs without having educated citizens with relevant skills to solve problems [7]. Schools are institutions or places designed for teaching of students under the guidance of teachers.

The students of computer science can potentially develop capacities towards identifying and solving problems. One of the core benefits of computer science is availability of job opportunities. It is on this fundamental benefit that the Federal Government of Nigeria (FGN) introduced computer science into the Nigeria Certificate in Education (NCE) curriculum towards human capacity building across all levels of education [9]. In computer science, relevant skills are provided towards capacity building opportunities such as design, implementation, programming and problem-solving skills. This could be seen as a ways of achieving some capacity building.

[11] highlighted that the problem of control of water usage is all-encompassing whereby such controller are mostly used in chemical or power plants in order to prevent major accidents and loss of revenue. [10] on the other hand observed that due to existing method used for water level indicators which are costly and complexity of algorithm used, there is a need to look for lesser and cost effective method which will also broaden the scope of students by not limiting it to that level of educational system. According to [18] innovation is progressing at a fast rate such that it is required in every field of endeavor to achieve a good results which has led to using software in monitoring such as robots, hence, there is a need to solve the problem of NCE curriculum to cover the modern trend in technology, there is need to embark and adopt a friendly and simple approach in the teaching of the computer science at such level.

The wastage of water is major problem in our society cannot be ignored as the effects included flooding, erosion and damages to properties. This research focused on the implementation of a contactless water level controller to detect the level of water in a tank and automatically switch off the pumping machine to avoid water wastage and other environmental health challenges.

There were existing works logically reviewed to help in designing more sophisticated system. Among other limitations identified in the existing works included the limited duration of operation within which a system switches from ON to OFF mode that was not suitable for larger water tank capacity, the use of copper wires and mercury which could contaminate water and cause health hazard to human life. However, to meet up the modern phase of water saving technology which is characterized by high volume and complexities of information processing [4], this proposed system used ultrasonic sensor, HC-SR04/TE501 to detect the water level in the tank and send the appropriate signal to the microcontroller for necessary action of the pump.

2. Problem Statement

The jobless youths are in millions across the globe. If youths are future leader, then this group of human needed to be provided with skills to solve tomorrow problems. This research specifically focused on

providing design, programming and implementation skills to solve problem of water wastage in the society. This would greatly improve human capacity building towards solving problems.

In the real case, as noticed in most institutions and houses, water is pumped up to the overhead tank located on the roof. People generally switch on the pump when their taps go dry and switch off the pump when the overhead tank starts overflowing. This results in the unnecessary wastage and sometimes non-availability of water in the case of emergency. Also, many water level controller adopted insertion of copper wire for detection and control of the water level in the tank. This traditional method makes the water contaminated and causes a health hazard. These are the gaps this research will solve. The contactless water level controller will switch ON the pump when the water level in the overhead tank goes low and switches it OFF as soon as the water level reaches a pre-determined level. The problem of overflowing of the water tank would be tackled with this research and students would be equipped with skills towards human capacity building.

3. Justification of the Study

According to the stated objectives from Nigeria Certificate in Education (NCE) Minimum Standard for Sciences, 2012 Edition, page 63, on CSC 321 Course, titled Advanced Level Programming Language, it expected that the students should be able to write and develop computer applications to solve specific problems. Therefore, this research demonstrated the practical application of logic gates to design and develop a contactless water level controller towards human capacity building. This research would provide:

1. Job opportunities to graduated students that have interest in this modern microprocessor-based technology;
2. Investment made in this research secures life and properties;
3. Practical demonstration of writing computer programs and software development to the students;
4. This contactless liquid level controller system could be used in oil or chemical industries;
5. Saves water wastage;
6. Eliminates over-flowing and reducing artificial flooding;
7. Low maintenance and installation cost;
8. Saves electrical power wastage and
9. Job opportunities for human capacity building.

4. Objective of the Study

This research aims at designing and implementing a contactless water level detector to avoid the wastage of electrical power in pumping water as a practical demonstration of building human capacity. The specific objective is to implement a contactless water level controller to control the water level in a water tank.

5. Literature Review

According to [2], the rate at which the world grows, digital design has the role of ensuring efficiency and speed, whereby the design of asynchronous processor is to reduce the challenges that are faced in synchronous architecture, this was collaborated by [3] by proposing the concept of Internet of Things (IoT) technology, which was used to connect devise for collecting information whereby improvement was made in agriculture for rural and urban areas where embedded system for plant monitoring and watering system using IoT. A sensor was used to get possible outcome and then transmit such to the user.

An automatic regulator suitable for water level sensing and control was developed by [5] using the MC14066 integrated circuit. This enabled the entire circuit to function as a threshold detector; thus working

as an ON and OFF switch. The system water level sensor was tested in real time application by using it to control the level of water in a tank fed by a single phase 0.5 HP AC pump. Experimental performance results indicated that the device was quite suitable for the desired operation, since it maintained the set maximum and minimum levels of 50 litres and 10 litres respectively, by switching the pump ON or OFF as required. However, the IC, MC14066 has limited duration of operation within which it switches from ON to OFF mode. Its limitation was not suitable for larger water tank capacity. This paper tends to use Atmega168KA microcontroller that operates base on the signal receives from the ultrasonic sensor.

In many houses there is unnecessary wastage of water due to overflow in overhead tanks. Automatic Water Level Indicator and Controller can provide a solution to this problem. The operation of water level controller works upon the fact that water conducts electricity due to the presence of minerals in it. So water can be used to open or close a circuit. As the water level rises or falls, different circuits in the controller send different signals. These signals are used to switch ON or switch OFF the motor pump as per the requirements. [15] developed a simple and low cost water level indicator. This was not only for water tank but also used for oil level and chemical laboratory. In the design, water Sensors, 18 SWG copper wires were used as sensing probes that were inserted in the water tank. As the current required passing through the wire, a corresponding signal was sent to the pump to switch ON or OFF. However, the contact of copper wires with the water in the tank could cause health hazard to human while drinking the contaminated water. Also, as the copper wires aged, hence there is need for replacement. This system therefore, is a contactless that uses ultrasonic sensor, HC-SR04/TE501 to detect the water level in the tank and send the appropriate signal to the microcontroller for necessary action of the pump. This sensors used are devices whose function is to detect any inputs from physical environment which respond to any particular situation, such as input from heat, light, pressure, motion or any other from a number of environmental phenomena [1].

[8] presented a design of an automatic water level controller aimed at providing an appropriate control to pump water to an overhead thank when empty and automatically stop the pump when the tank is full. The system incorporated two mains contactor which are energized to provide a direct online start of the motor. An over load relay which sensed the presence of excess current and disconnect the supply and a mercury flood switch which uses the Archimedes principle of floatation to provide the electrical contact to switch ON or OFF supply to the motor when the tank is empty or full respectively. This is capable of providing a seamless utilization of water at domestic and industrial level without causing spillage. The system used mercury float switch to detect the level of liquid within a tank and the pump was stopped based on the level of water detected by the mercury. However, the contact of mercury float switch with the water in the tank could cause health hazard to human as a result of water contamination. Also, as the mercury float switch aged, the need to replace is inevitable which requires money. Therefore, this system is contactless that uses ultrasonic sensor, HC-SR04/TE501 to detect the water level in the tank and send the appropriate signal to the microcontroller for necessary action of the pump.

As a result of increase in the use of organic, chemical, gases, hazardous and non-hazardous, [16] developed a model that detect leakage of liquefied petroleum gas and carbon dioxide gas in the environment. The system has integrated modules, embedded-control, PC based VI was used. This clearly showed the need and importance attached to sensor based modules and the need to control leakages in water, gas and liquid waste so as not affect the environment.

[6] on the hand designed a model for cloud based waste water management system where by a cloud based decision support system for city was implemented based on temperature, and water pressure. The limitation of [6] was poor connectivity that could affect the switching on/off of the pumping machine. This proposed system did not utilize cloud computing to control the water levels. The proposed system used ultrasonic sensor to establish an effective communication between the pumping machine and the water tank towards the avoidance of water wastage. [14] believe that due to increase in exodus to urban areas, mostly in the third world, there was an increase in generation of solid waste which if not properly managed, it can pose

a great problem to local environment, hence the need to have a sustainably water management system to cater for the people and the environment

Several attempts have been made towards providing a reliable monitoring system for water and other waste materials in the society, [17] developed an approach for detecting a system using a multi sensor to detect an intruder before they got in contact with a pipeline. The system had a sounds and vibration sensor which pre-inform the personnel concerned. In view of this, it clearly shows that there is need to monitor natural resources either from human interventions or natural disasters. This was collaborated by [12] whereby, timely monitoring of degree of pollution of petroleum product is important and can be done in a fashion ways to prevent any disasters.

In the real case, as noticed in most institutions and houses, water is pumped up to the overhead tank located on the roof. People generally switch on the pump when their taps go dry and switch off the pump when the overhead tank starts overflowing. This results in the unnecessary wastage and sometimes non-availability of water in the case of emergency. Also, many water level controller adopted insertion of copper wire for detection and control of the water level in the tank. This traditional method makes the water contaminated and causes a health hazard. The contactless water level controller would switch ON the pump when the water level in the overhead tank goes low and switches it OFF as soon as the water level reaches a pre-determined level.

6. Methodology

The method used for the systems involves two parts: Hardware and software components

6.1 Hardware Components and Development

Figure 1 shows the block diagram of the system. It has six units. These units include: the power supply unit, the controller unit, the ultrasonic unit, the display unit, the pump unit and the water unit.

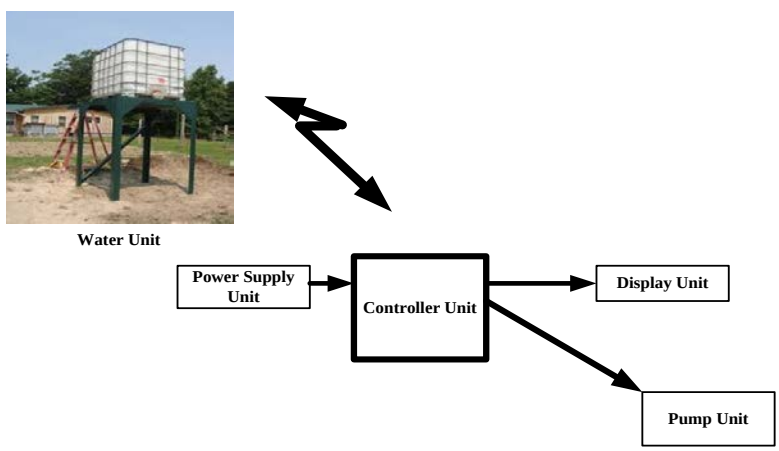

Fig. 1: Block Diagram

6.1.1. Power supply unit

This is the design of a basic AC to DC power supply system using transformer and bridge rectifier. A LM7809 voltage regulator producing a voltage of 9V output will be used. The voltage regulator requires 20V

input voltage and produces 12V output voltage. The next step involves selecting the transformer. Since primary voltage is 230V and required secondary voltage is about 20V, a 230V/20V basic transformer will be used. The third step is the selection of diodes for bridge rectifier. Since peak voltage across the transformer secondary is around 28V, the total PIV of the bridge would be around 112V. Hence, the diodes having PIV rating more than 112V will be required for effective operation. Therefore, a 1n4007 having PIV of about 1000V will be selected for the implementation. A 20uF electrolyte capacitor will be used to remove the ripples in the AC–DC voltage.

This unit fundamentally has the transformer, rectifier, filter, voltage regulator and battery to achieve an uninterruptible power supply to the electronic components.

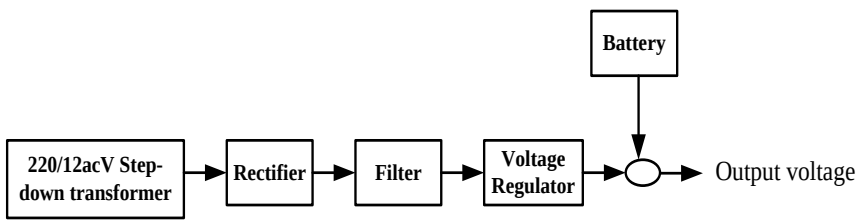

Fig. 2: Power supply block diagram

6.1.2. Controller unit

This controller unit of the system is the fundamental electronic circuitry that controls the entire functionality of the system based on the specified instructions. In this unit, a microcontroller, Atmega168KA was programmed to control the water level in an overhead tank or any other container. This system monitors the water level of the tank and automatically switches ON the motor whenever tank is empty.

6.1.3. Oscillator Circuit

A crystal oscillator was used to provide external clock signal to the Atmega168KA microcontroller. To get a sensible reset time lesser than 1second, a crystal of 10.24MHz.

$$T = \frac{1}{f} = \frac{1}{10.24} = 0.0997ms \quad (1)$$

6.1.4. Ultrasonic unit

This unit has ultrasonic sensor, HC-SR04/TE501 that is integrated with transmitter and ultrasonic receiver that sense the water level in the tank and according ON or OFF the pump when the water level within the threshold level. The ultrasonic transmitter sends the high frequency sound pulse while the ultrasonic receiver received the pulse for pump' operations (start or stop mode). This unit was interfaced with microcontroller for effective contactless water level detection and control.

6.1.5. Display unit

Display unit shows all the operational activities of the system for the user's understanding and response. S1602 Liquid Crystal Display (LCD) was used for the display.

Fig. 3: Ultrasonic sensor

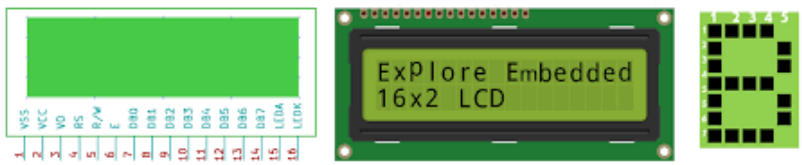

Fig. 4: Liquid Crystal Display (LCD)

6.1.6. Circuit Diagram

Figure 5 shows the circuit diagram of the system that technically has Atmega168KA microcontroller and HC-SR04/TE501 ultrasonic sensor to detect the water level in the tank and send the appropriate signal to the microcontroller for switching on/off of the pump. The volume of water in the water as indicated by the water level was displayed on the LCD and corresponding required action was initiated by the microcontroller and execution of stopping the flow of water into the water was terminated by the pumping machine as required by the microcontroller.

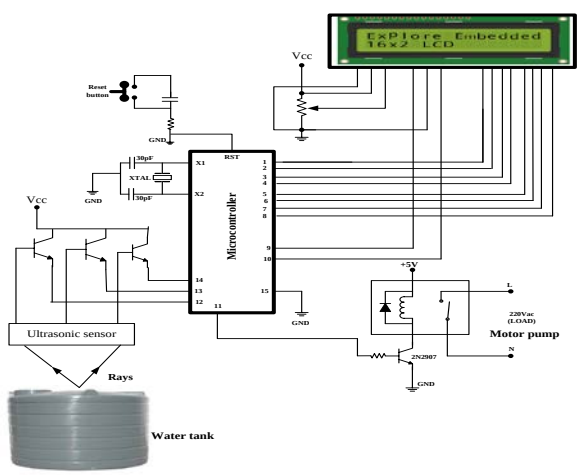

Fig. 5: Circuit Diagram

6.1.7. Pump unit

This unit of the system has a device that moves fluids (water) by mechanical action and powered by electrical energy. The operation of this unit is fundamentally controlled by the controller unit. The “start

mode" and the "stop mode" are activated by the controller unit. The "start mode" starts pumping water into the water tank and the "stop mode" stops pumping the water.

6.1.8. Water unit

The water unit is any container that stores water for domestic and industrial use.

6.2. Software Development

The water level contactless detector was programmed using C++ programming language. The C++ code was edited using C++ Crimson editor. The edited code was transferred into Small Device C Compiler (**SDCC**) to compile the source codes into **HEX CODES** needed by the chip (Atmega168KA) for proper execution. The HEX codes were then transferred into the chip' memory for contactless water level detection. Figures 6 showed the developed contactless water level controller.

Fig. 6: Developed Contactless Water Level Controller

7. Experimental Results

The system testing is indicated in Table 1.

8. Conclusion

Water is one of the natural resources from God to mankind. The fetching of water from beneath the earth requires traditional of digging wells which contaminate water easily and using a motor pump that uses electrical power. In our society, most commonly water level controller use insertion of copper wires into the water for detection. This insertion contaminates water and causes a health hazard. This paper enhanced the acquisition of programming skills, stimulated the students' interest in human capital development, capacity building opportunities in science, engineering and technology most especially computer science students and as well overall development of the society. The proposed system used ultrasonic sensor, HC-SR04/TE501 to detect the water level in the tank and send the appropriate signal to the microcontroller for necessary action of the pump as against the use of copper wires and mercury which could contaminate water and cause health hazard to human life. The developed system could be improved in the future work by allowing the user to manually adjust and set the water levels as desired for different purpose.

Table 1: System Testing Results

Test case	Test event	Description of test	Expected outcome/result
01	Testing ultrasonic sensor, microcontroller and LCD	The communication between the ultrasonic sensor and microcontroller tested to ensure free flow to signal	The LCD displayed the status of the water level.
02	Testing motor pump with an object (<45cm)	An electric bulb connected to the output of the motor pump to verify its ON and OFF modes as an object placed lesser than 45cm range	The electric bulb switched ON
03	Testing motor pump with an object (>45cm)	An electric bulb connected to the output of the motor pump to verify its ON and OFF modes as an object placed greater than 45cm range	The electric bulb switched OFF
04	Setting different heights for the system.	The system was set to ON the pumping machine when water level reached 15cm and OFF when water level reached 49cm	The values of the heights were successfully saved for required operation.
05	Testing contactless water level controller with height of 12cm.	The water tank was filled with water at height 12cm to test the pumping machine at 15cm	The contactless water level controller switched the motor pump ON when the water level reached 15cm
06	Testing contactless water level controller with height of 49cm.	The water tank was filled with water at height 49cm	The contactless water level controller switched the motor pump OFF when the water level reached the desire level of 49cm

Acknowledgement

The author wishes to appreciate and thank Tertiary Education Trust Fund of Nigeria (TetFund) for their support, funding and assistance for this research work.

References

[1] Adegoke A. O , Oluseun D Oyeleke , Mahmud B, Ajoje J. O, Sadiq Thomase," Design and Construction of an Obstacle-Detecting Glasses for the Visually Impaired", International Journal of Engineering and Manufacturing(IJEM), Vol.9, No.4, pp.57-66, 2019.DOI: 10.5815/ijem.2019.04.05

[2] Archana Rani, Naresh Grover,"Design and Implementation of control Unit-ALU of 32 Bit Asynchronous Microprocessor based on FPGA", International Journal of Engineering and Manufacturing(IJEM), Vol.8, No.3, pp.12-22, 2018.DOI: 10.5815/ijem.2018.03.02

[3] Anusha k, U B Mahadevaswamy,"Automatic IoT BasedPlant Monitoring and Watering System using Raspberry Pi", International Journal of Engineering and Manufacturing(IJEM), Vol.8, No.6, pp.55-67, 2018.DOI: 10.5815/ijem.2018.06.05

[4] Anatolii I. Zhuchenko, Liudmyla V. Osipa, Evgeniy S. Cheropkin,"Design Database for an Automated Control System of Typical Wastewater Treatment Processes", International Journal of Engineering and Manufacturing(IJEM), Vol.7, No.4, pp.36-50, 2017.DOI: 10.5815/ijem.2017.04.04

[5] Anyanwu, C. N., Mbajiorgub, C. C., & Anoliefod, E. C. (2012). Design and implementation of a water level controller. Nigerian Journal of Technology, 31(1), 89–92.

[6] Archana, K. N., & Shah, J. S. (2017): Design Model of Cloud based waste water management System. International Journal of Advanced Research in Computer Science, 8(3), 52-54.

[7] Dittimiya, I. A (2010). Disciple in Schools in Peretomode, Introduction to Educational Administration, Planning and Supervision. Lagos: Joja Press Limited.

[8] Erua, J. B., & Anyasi, F. I. (2014). Design of an automatic water level controller using mercury float switch. Journal of Electronics and Communication Engineering, 9(2), 16-21.

[9] Maloney, M. (2005). Changing instructional practices through technology training: WebQuest. The Journal of Education, 19(5), 40-42.

[10] Minhwan, K., Jinhee, L., & Giltae, S. (2019). Implementation of Water Depth Indicator using Contactless Smart Sensors. Journal of the Korea Institute of Information and Communication Engineering, 23(6), 733~739

[11] Namrata, D., Ria, M., & Monica, M. S. (2013). Design and Implementation of a Water Level Controller using Fuzzy Logic. International Journal of Engineering and Technology , 5(3), 2277– 2285

[12] Nandini M.Naik, Girish S.Kulkarni, K.B.Prakash,"Analysis and Treatment of Water Contaminated by Petroleum Products", IJEM, vol.4, no.5, pp.1-11, 2014.DOI: 10.5815/ijem.2014.05.01

[13] Obe, E. O. (2008). Schools Indiscipline and Remedies. Lagos: Premier Press and Publishers.

[14] Odji Ebenezer, "Aesthetics Application in Solid Waste Management as a Means of Optimising Environmental Sustainability in Urbanizing Third-World Environments", International Journal of Engineering and Manufacturing(IJEM), Vol.9, No.4, pp.15-32, 2019. DOI:10.5815/ijem.2019.04.02

[15] Oyndrila, R. Aranyak R., & Debasis R. (2016). Automatic water level indicator. International Journal of Emerging Trends in Engineering and Development, 6(2), 145-148.

[16] Pallavi Singla, Prashant Jain, Roop Pahuja,"Implementation of Gas Scathe Admonisher and Control System Prototype", International Journal of Engineering and Manufacturing(IJEM), Vol.7, No.2, pp.23-38, 2017.DOI: 10.5815/ijem.2017.02.03

[17] Salihu O. Aliyu, Innocent O. Agbo, Saidu Muslim,Elizabeth N. Onwuka,"Multi-Sensor Approach for Monitoring Pipelines", International Journal of Engineering and Manufacturing(IJEM), Vol.7, No.6, pp.59-72, 2017.DOI: 10.5815/ijem.2017.06.06

[18] Sujata Bhavikatti, Sadanand P, Mukta Patil, Pradeep Vibhuti, Shailaja S.Mudengudi. "Automated Roof Top Plant Growth Monitoring System in Urban Areas", International Journal of Engineering and Manufacturing(IJEM), Vol.9, No.6, pp.14-23, 2019. DOI: 10.5815/ijem.2019.06.02

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How to cite this paper: Garba Suleiman. "Implementation of a Contactless Water Level Controller: Embracing Opportunities in Nigeria Computer Science NCE Curriculum", International Journal of Engineering and Manufacturing(IJEM), Vol.10, No.2, pp.41-51, 2020. DOI: 10.5815/ijem.2020.02.04