مجلة العلوم البحثة والتطبيقية
Journal of Pure & Applied Sciences
www.Suj.sebhau.edu.ly ISSN 2521-9200
Received 10/11/2017 Revised 26/01/2018 Published online 30/06/2018

PIC Microcontroller Based Water level Monitoring and Controlling System using Sharp Infra-red range sensor

*Ibrahim A. Nasir [a], Hasan Alkhadafe [b], Kadja Mohammed [c]
[a] Department of Electronic and Electrical Engineering , Faculty of engineering and technical science ,Sebah University, Libya
[b] Department Of Computer Science, Faculty of Information Technology, Sebah University, Libya
[c] Department Of Electronic and Electrical Engineering , Higher Institute of Comprehensive occupations ,Sebha, Libya
* Corresponding author: ibr.nasir@sebhau.edu.ly

Abstract The paper presents the design and implementation of the water level monitoring and controlling system, which aims to overcome of issues that may present as a result of using manual systems for filling up domestic water tanks, such as, flooding of water in residential areas, which leads to the decline in roads and disruption of traffic, waste of energy, an increase in the noise pollution caused by the sound of the pumps and lack of water available in the network. The implementation of the proposed system is based on PIC microcontroller and Sharp GP2D02 infra-red range sensor, which is used to measure the water level within a tank and based on this measurement, the water pump is turned ON or OFF automatically. The statuses of the water level and the pump are displayed using LEDs. The experimental results show that the proposed system is succeed in measuring the water level and turning the water pump ON or OFF according to the water level.

Keywords: water level, PIC microcontroller, Sharp GP2D02 infra-red, range sensor.

تصميم وتنفيذ لنظام مراقبة وتحكم بمستوى الماء باستخدام الحاكم الدقيق PIC ومتحسس الاشعة تحت الحمراء نوع شارب

*ابراهيم السنوسي نصر [1] و حسن صالح القذافي [2] و خديجة محمد [3]
[1] قسم الهندسة الكهربائية والالكترونية– كلية العلوم الهندسية والتقنية–جامعة سبها، ليبيا
[2] قسم علوم الحاسوب– كلية تقنية المعلومات –جامعة سبها، ليبيا
[3] قسم الهندسة الكهربائية والالكترونية–المعهد العالي للمهن الشاملة–سبها، ليبيا
* للمراسلة: ibr.nasir@sebhau.edu.ly

الملخص تقدم هذه الورقة تصميم وتنفيذ لنظام مراقبة وتحكم بمستوى المياه بالخزانات المنزلية، بهدف التغلب على المشاكل التي قد تنشأ نتيجة استخدام أنظمة يدوية لتعبئة خزانات المياه المنزلية وكمثال على ذلك: تسرب المياه في المناطق السكنية مما يؤدي إلى انخفاض الطرق وتعطيل حركة المرور، هدر الطاقة، زيادة في تلوث الضجيج نتيجة اصوات المضخات ونقص المياه المتاحة في الشبكة. تم تنفيذ النظام المقترح باستخدام المتحكم الدقيق نوع PIC ومتحسس الاشعة تحت الحمراء نوع شارب GP2D02 ، والذي تم استخدامه في قياس مستوى المياه داخل خزان وبناء على نتيجة القياس، يتم تشغيل مضخة المياه أو اطفاءها تلقائيا. يعمل النظام ايضا على عرض حالات مستوى الماء بالخزان وكذلك حالة التشغيل للمضخة باستخدام لوحة العرض المكونة من الثنائيات الضوئية. أظهرت النتائج التجريبية أن النظام المقترح قادر على قياس مستوى الماء وتشغيل أو اطفاء المضخة وفقا لمستوى الماء المقاس.

الكلمات المفتاحية: نظام مراقبة وتحكم، قياس مستوى الماء، المتحكم الدقيق، متحسس الاشعة تحت الحمراء.

Introduction

Sustainability of accessible water resource in many regions of the world is currently an issue of great importance. Indeed, it constitutes one of the most challenging to the future of life on the planet. Experts have confirmed in various reports that population growth and climate change are increasingly leading to changes in water availability, In addition to the fact that a large number of water resources are threatened by waste disposal and the disposal of industrial pollutants, contaminated water [1]. Moreover; authors in [2], suggested that the water crisis in the 21st century is much more related to lack of adequate and integrated water management.

Water is commonly used for agriculture, industry, and domestic consumption. In Libya, the lack of adequate and integrated water management for domestic consumption cause the following issue: waste water on the roads from domestic water tanks as a result of using manual system for filling up the water tanks; lack of water available in the network; flooding of water in residential areas and thus lead to the decline in roads and disruption of traffic and also waste of energy as well as an increase in the noise pollution caused by the sound of the pumps, which leads to the inconvenience caused to the neighbours. Therefore, proper sensing, water level monitoring and control are potential constraint for domestic or office water management system.

Water levels can be measured using water level sensors, such as ultrasonic, infra-red, pressure, float and conductivity level sensors. Choosing these sensors is based on certain specifications factors include: accuracy, measurement range, resolution, long term stability, interchangeability, resistance to physical and chemical contaminants and cost effectiveness [3].

Recently, several notable efforts to develop water level monitoring and control systems, and a review of these methods are presented in [4]. Based on the advantage of the electrical conductivity property of water, authors in [5-12] use the conductivity level sensors to detect water level. The advantages of using this sensor that are very simple in operation, their working depends upon the electrical conductance or conductivity of the process liquid being measured, low cost and well suited for dual or multiple point control. In [5, 8] water level monitoring and management system based on microcontroller are presented, in which the conductivity water level sensors with three control points are used for measuring the level of the water that can be low, medium or high level. Authors in [10], present, the design and implementation of automated water level monitoring system based on microcontroller, they use the conductivity water level sensors with two control points which are low and high levels. Whereas, the authors in [6, 12] and use the conductivity water level sensors with eight and four control points, respectively. Authors in [7], discuss the design and implementation of wireless automatic water level control using radio frequency communication and for sensing the level of water, they use the conductivity water level sensor with two control points. Authors in [9], present, the design and implementation of multi-tank water monitoring system based on low-power ZigBee wireless communication technology. The authors use the conductivity water level sensor with two control points. The disadvantageous of using this type of sensors are that the sensor need periodic cleaning and limited suitability for products of varying conductivity.

Instead of using the conductivity water level sensor, authors in [13-15], use ultrasonic sensors to detect the level of water, which are advantageous as they are not in direct contact with the water, and the level measurement is done without involving any physical contact. Authors in [16] use the potentiometric level senor to detect the level of water. Authors in [17] present wireless automation to monitor the level of water. The infrared sensors have widely been used for object detection and avoidance collisions due to their low cost, ranging capability, perform accurate measurements of small level movements and they are not in contact with the process [18, 19]. In this paper, a new PIC microcontroller based water level monitoring and control system is presented. The proposed system measures the level of water in the domestic water tank using Sharp GP2D02 infra-red range sensors, which measuring the distance between surface of water and the sensor and depending on the distance, the motor pump is turned ON or OFF automatically.

The benefits of the proposed water level monitoring and control system can be surmised as follows:

(i) Saving power, this is because the amount of electricity used is limited due to the automatic controlling of water level.

(ii) Since the motor pump is turned off automatically when water is reach the high level of the tank, there is no need to check the water level manually and as result of that the time is saving.

(iii) Water usage can be maximized with a water level control system. This is because the proposed monitoring system automatically provides more water during the middle of the day and less water at night based on the water level. As a result, water remains at its appropriate level at all time.

(iv) Water regulation is optimized using the water level control system, which means that wasted electricity and water is kept at a minimum and as result of this a substantial amount of money over time is saved.

The rest of this paper is structured as follows. Section 2 covers the details of the proposed water level monitoring and controlling system. Section 3 presents the experimental results. Conclusions are drawn in Section 4.

The proposed water level monitoring and controlling system

The block diagram shown in Fig. 1 provides an overview of the proposed water level monitoring and controlling system, which consists of PIC microcontroller as a core of the system, the oscillator unit to generate the clock pulses required for the synchronization of all the internal operation of the PIC microcontroller, the power supply unit to provide the required voltages to the proposed system, the water level sensor to measure the level of water in a domestic tank, water pump control unit to turn the pump ON or OFF depending on the level of water and the display unit to display the current status of the water level in a domestic tank and the status of the pump. In the proposed system the Sharp GP2D02 infra-red range sensor is used to measure water level by measuring the distance between the surface of water and the sensor and based on this distance the amount of water within the tank can be determined.

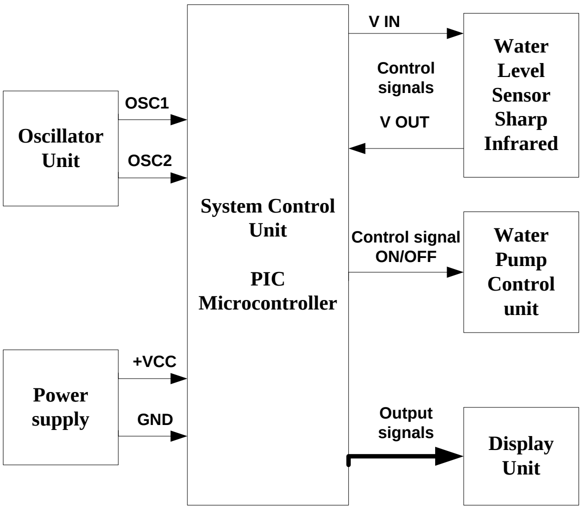

Fig. 1: The block diagram of the proposed system

1. Interfacing the Sharp GP2D02 Infra-red Range Sensor to the PIC microcontroller

Fig. 2 shows the Interface between PIC and the sharp GP2D02 infra-red range sensor, which requires two lines for interfacing with the PIC. Vin line to provides the signal to begin a measurement and also is used to provide clock pluses. Vout line to transmit the measurement back to the PIC microcontroller. The output of this sensor is 8 bit serial measured. due to the maximum characteristics of the open drain input a diode is used to only enable the current to flow when I/O pin is low [18]. The sharp GP2D02 infra-red range sensor is driven according to the timing diagram shown in Fig. 3, in which the measurement is initiated by forcing the Vin signal to logic low for at least 70 ms or until the Vout signal from GP2D02 sensor becomes logic high. Then, Vin signal is toggled at the rate of 0.2 ms or less to start clocking in the 8 serial bits from the sensor. To reset the sensor for another reading, Vin is floated high for at least 1.5ms.

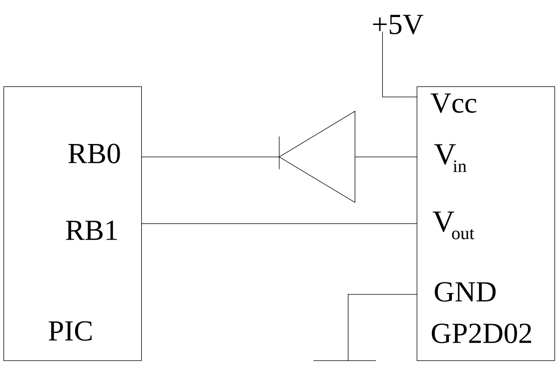

Fig. 2: Interfacing PIC with GP2D02 (water level sensor)

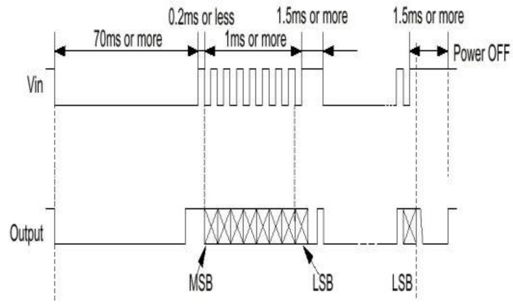

Fig. 3: the timing diagram for GP2D02 infra-red sensor

2. The implementation of the water level monitoring and controlling system

The implementation of the proposed water level monitoring and control system comprises of hardware and software implementation. In Former, the implementation covers power supply unit, oscillator unit, water pump unit and the display unit as shown in Fig. 4. The Sharp GP2D02 infra-red range sensor, which is used to measure water level within a tank is implemented as shown in Fig. 2. The sensor is connected to the microcontroller via RB0,RB1 pins on PORTB . The water level pump control unit is implemented using a relay device, which allows low power circuits to switch a relatively high current/voltage ON/OFF. AS illustrated in Fig.4, an NPN transistor 2N3904 is used to control the relay and in order to protect the transistor from damage due to the back electromotive force generated in the relay's inductive coil when the transistor is turned OFF, a fly back diode 1N4148 is used and connected in parallel to the coil of the relay. The water pump control unit is interfaced with PIC microcontroller via RB4 pin on the PORTB, and depending on the water level, the microcontroller producing logic low or high on RB4 pin to switch the pump OFF or ON, respectively. The display unit of the proposed system is consist of Four LEDS, these are connected via current-limiting resistors. The first LED is connected via RB4 and used to show the current status of the pump ON/OFF. The second, third and fourth LEDs are connected via RB5, RB6 and RB7, respectively and they are used to indicate the current status of the water level within a water tank. The status can be low, medium or high level.

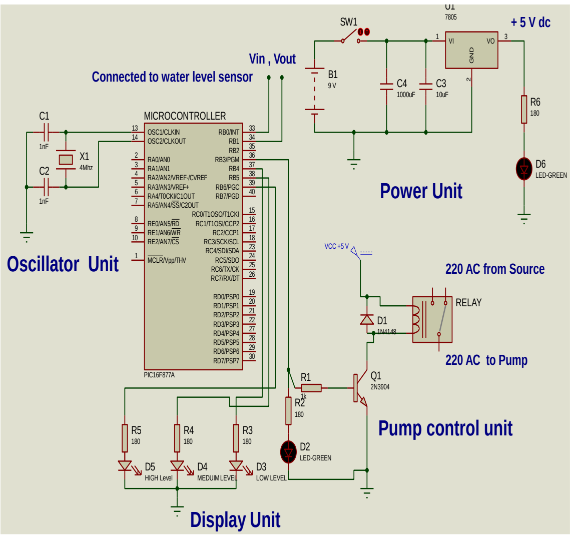

Fig. 4: the schematic circuit of the proposed system

The software design of the proposed system is shown in Fig. 5 and the implementation of the software is divided into four functions; the first is the Initialization function, which aims to initiate the PORTB in the PIC 16f877a microcontroller as, RB0 pin as output pin and RB1 as input pin in order to interface with the GP2D02 infra-red range sensor; RB3 as output pins to control the operation of water pump; RB4, RB5 and RB6 as output pins to connect with the display unit, which consist of three LEDs. PORTC as output for the purpose of calibration of the sensor. The second function is the measurement, which aims to initiate and drive the GP2D02 infra-red range sensor by generating the required waveform as illustrated in Fig. 3 and reading the sensor measurement. The third is the convert and display function, which aims to convert the 8bits serial distance information measured by sensor into a distance of centimetres and display the status of water level and the pump on LEDs. The output distance information of the sensor has an inverse relationship to the distance of an object. That is the further the object, the output values of the sensor will be small. The distance information can be converted into a distance of centimetres using the equation1.

$$D = Kg/(X\text{-}Ko) \qquad (1)$$

Where D denotes a distance and it is given in units of centimetres (cm), X is the sensor output, Kg is the gain and Ko is an offset. The values of Kg and Ko can be determined as follows:

Let D and X be the distance and output, respectively of the first measurement. Let D' and X' be the distance and output, respectively, of the second measurement.

$$Kg = (X'\text{-}X)\ D'D\ /\ (D\text{-}D') \qquad (2)$$

$$Ko = (D'X'\ \text{-}\ DX)\ /\ (D'\ \text{-}\ D) \qquad (3)$$

The fourth is the process function, which aims to turn the water pump ON or OFF depending on the water level. The water pump is turned ON once the water level is less than or equal to medium level and the pump is turned OFF once water reach the high level within a tank. The implementation of the proposed system is shown in Fig. 6.

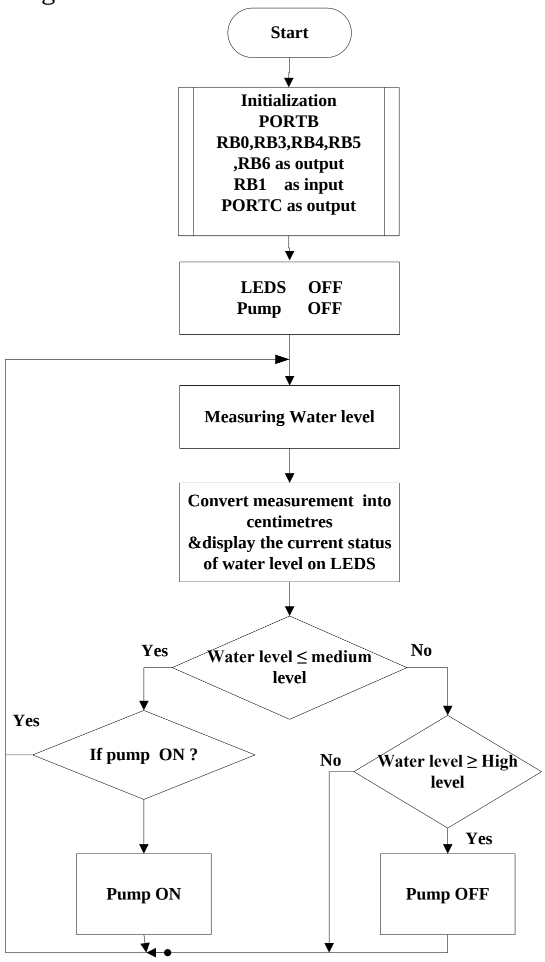

Fig. 5: the flowchart of the software design of the proposed system

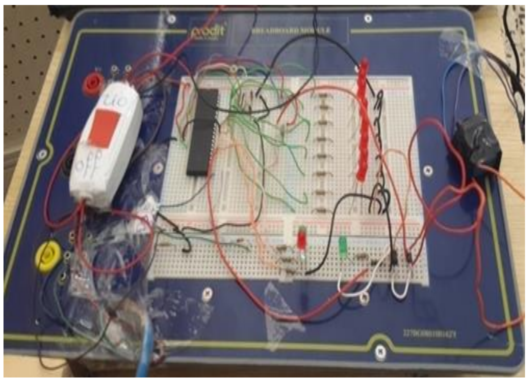

Fig. 6: the implementation of the proposed system

Experimental results

To test the performance of the proposed water level monitoring and controlling system, the experiments were organized in two phases. In the first phase, the values of Kg and Ko are determined based on equations (2) and (3) mentioned early. These values are used in order to calibrate and convert the 8bit information into a distance of centimetres using equation (1). The values of Kg and Ko are 1560 and 82, respectively. In the second phase, the performance of the proposed system in measuring the water level within a small tank and turning the pump

ON or OFF based on the measurement are tested using different water level. The sensor outputs are based on the measured distance from the sensor to surface of water in a small tank. The output has an inverse relationship to the distance of water surface. That is the further the water surface, the output values of the sensor will be small. The results of the experiments are shown in Fig. 7, in which shows, the output of the water level Sharp sensor within the range 10 cm - 80 cm. As illustrated, the sensor is able to produce different outputs in relation to different distance to water level. The values of water level parameters used in experiment are that low level = 70cm, medium level = 40 cm and high level =15 cm and based on these values, the proposed system was able to measure the water level and succeed in turning the pump ON or OFF according to the water level.

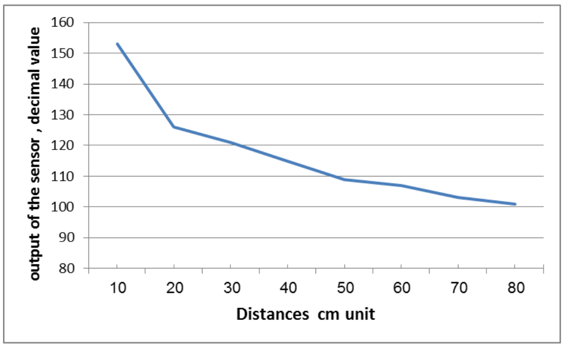

Fig. 7: the results of measuring the water level

Conclusion

The design and implementation of the water level monitoring and controlling system is presented. It is based on PIC microcontroller and Sharp infra-red range sensor. The advantages of the proposed system includes: saving energy, reduce noise, optimization of water regulation and improve the lifespan of the pumps duo to working automatically.

The idea of the proposed system can be extended for a large tanks by using different infra-red sensors that are able to measure more distances than 80 cm.

Further investigation for improving the performance of Sharp infr-red sensor can be done by using a float object on the top of a water surface that would reflect infrared instead of using water.

Moreover; more features can be added to the proposed system for the applications of monitoring and controlling smart houses, such as temperature, humidity, fire, gas leaking, lighting monitoring and controlling, etc.

Further investigation for increasing robustness by using adaptive embedding strength α depending on
blocks characteristics is on the way.

Further investigation for increasing robustness by using adaptive embedding strength α depending on blocks characteristics is on the way.

References

[1]- J. G. Tundisi, "Recursos hídricos no futuro: problemas e soluções," Estudos Avançados, vol. 22, pp. 7-16, 2008.

[2]- P. P. ROGERS, "Water governance, water security and water sustainability," ROGERS,P. P. et al. (Ed.) Water crisis: myth or reality? London: Fundación Marcelino Botín,Taylor & Francis, pp. 3-36, 2006.

[3]- A. j. Alzubaidi and O. I. Alaga, "Automated Liquid Fuel Level Sensing and Controlling using Microcontroller," Int. Journal of Computer Technology and Applications, vol. 6, pp. 649-653, 2015.

[4]- M. Rajput, R. Patil, R. Shende, and Prof.P.R.Jawale, "Review of Water Level Monitoring System," Int. Journal of Research in Advent Technology, pp. 139-143, 2016.

[5]- SMK Reza, SAM Tariq, and S. Reza, "Microcontroller based automated water level sensing and controlling: design and implementation issue," presented at the Proceedings of the World Congress on Engineering and Computer Science, 2010.

[6]- E. V. Ebere and O. O. Francisca, "Microcontroller based Automatic Water level Control System," Int. Journal of Innovative Research in Computer and Communcation Engineering vol. 1, p. 13901396, 2013.

[7]- M. S. K, J. K, M. E. O, N. I. P, and H. Herle, "Wireless Automatic Water Level Control using Radio Frequency Communication," Int. Journal of Advanced Research in Eletrical, Electronic and Instrumentation Engineering, vol. 2, pp. 1320-1324, 2013.

[8]- Y. Patil and R. Singh, "Smart Water Tank Management System for Residential Colonies Using Atmega128A Microcontroller," Int. Journal of Scientific & Engineering Research, vol. 5, pp. 355-357, 2016.

[9]- S. M. Gulhane, N. R. Patel, and W. M. Khan, "Design and Implemntation of Multi Tank Momitoring Based On Low-Power ZIGBEE and AVR for Automatic Wter System Control," Special Issue of Journal of Electronic, Communcation & Computing Science and Enigneering pp. 223-226, 2015.

[10]- D. Mounika, D. Srujana, P. Hareesh, K. Ranadheera, and P. Venkateshwarlu, "Design and Implementation of Microcontroller Based Automated Water Level Indicator," Int. Jornal of Innovative Technology and Research, Special Issue, pp. 95-98, 2016.

[11]- O. O. Kehinde, O. O. Bamigboye, and a. F. O. Ehiagwina, "Design and Implementation of an AT89C52 Microcontroller Based Water Pump Controller," Int. Journal of Innovative Science, Engineering & Technology, vol. 3, pp. 355-360, 2015.

[12]- A. Kumar, C. Naikodi, and L. Suresh, "Water Level Indicator using Smart Bluetooth," Int. Journal of Engineering Research, vol. 5, pp. 790-991, 2016.

[13]- V. Mittal, "Automatic Water Level Controller," Int. Journal of Science and Research, vol. 6, pp. 136-138, 2015.
[14]- J. E. Okhaifoh, C. K. Igbinoba, and K. O. Eriaganoma, "Microcontroller Based Automatic Control for Water Pumping M achine with Water Level Indicators using Ultrasoinc Sensor," Nigerion Journal of Technology, vol. 35, pp. 579-583, 2016.
[15]- H. I. Azeez, N. Pimkumwong, and S.-C. Chen, "Automatic Water Level Control using LabVIEW," Kurdish Journal for Applied Research vol. 2, 2017.
[16]- B. Roy, P. Banerjee, S. Debnath, S. Chakraborty, and A. Chakraborty, "Microcontroller Based Automated Water Level Sensing," Advances in Industrial Engineering and Management, vol. 5, pp. 193-196, 2016.
[17]- K. N, K. S. S, K. G, K. D. V, and D. M. S, "Wireless Automation for Multi Water Tank," Int. Journal of Research in Advent Technology, vol. 5, pp. 32-34, 2017.
[18]- I. A. Nasir, "Low cost obstacle detection system for wheeled mobile robot," in International Conference on Control UKACC, 2012, pp. 529-533.
[19]- S. A. Daud;, S. S. M. Sobani;, M. H. R. N. H. Mahmood;, P. L. Leow;, and F. K. C. Harun, "Application of Infrared sensor for shape detection," in IEEE 4th International Conference on Photonics (ICP) 2013, pp. 145-147.