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Solar Powered Automatic Hand Washing and Sanitizing System

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***Abstract**:: Coronavirus COVID-19 was declared a world pandemic by the World Health Organization (WHO) in March 2020. Countries were therefore put on high alert to seek remedies that would help to contain the spread of the virus as research on nding a vaccine and/or cure of the disease goes on. In the absence of a vaccine and/or cure, preventive measures such as physical distancing, sanitizing/washing of hands with running water and soap or wearing of masks have been highly recommended to curb the spread of this disease. In this study, we fabricated a cost-e ective automatic hand washing and sanitizing system employing locally available materials. The sanitizer system was engineered based on an infrared sensor that triggers a mechanical pump to eject the sanitizer from the container automatically by sensing the presence of the hand. The entire process eliminates touching any part of the system by the user manually. The system holds 20 litres of the sanitizer with the possibility of scaling up its size which can enable a huge population such as in slums, local dispensary workers, patients and other visitors to be served. The 20 litres of the container was evaluated and it could serve 500 people per day. The sensitivity of the system was adjusted accordingly and found to be in the range of 0 to 8.5 cm. The automatic hand washing and sanitizing system is powered by a solar battery making it self- sustainable for use in any area including remote locations where there is lack of the national grid.*

1 Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causes coronavirus disease (COVID-19). This is a communicable respiratory disease that is caused by a new strain of coronavirus that causes illness in humans. The outbreak was rst observed in Wuhan province in China in December 2019. Since then, it as spread globally a ecting many people [1, 2]. This disease is transmitted from person to person through inhaling the infected air droplets during sneezing or coughing, contacting infected surfaces with hands and in the process picking up the virus which is then passed to the eyes, nose or mouth through touch [3]. The World Health Organization (WHO) declared COVID-19 a world pandemic and an emergency of global attention and concern on 11th March 2020 [3, 4]. All countries of the world were supposed to set up the containment measures that were aimed to either slow down the rate of infection or eradicate the Corona virus disease altogether. Some of the containment measures that have disrupted people's way of living include lockdowns of entire/sections of the country, curfews that limit the time when people would be found outside their homes, mass closure of all learning institutions, eateries, entertainment places, market places and o ces. In addition to that, all forms of transport systems including air travel have been a ected therefore disrupting international travel .WHO has from time to time announced and guided nations on how to handle the disease as and when new discoveries about the disease emerge. The bottom line, however, has been prevention with special emphasis on personal responsibility that culminates to common ght for reducing and nally eliminating the spread of the disease. Some of the measures taken include social distancing such as avoiding crowded places through staying at home, improving hygienic practices such as hand washing using soap and clean running water regularly and use of alcohol-based sanitizers to kill the virus on our hands, as well as wearing of masks and personal protective equipment(PPEs) for frontline workers in clinical settings [1, 5]. Places where overcrowding is likely to occur such as learning institutions, worship centers and entertainment halls, malls and supermarkets have been instructed to put in place sanitation measures.

Conventionally, the use of mechanical running water taps involves one touching the tap to operate it. The user opens the tap for the water to run, rinses his/her hands and applies soap then thoroughly rubs his/her hands before nally rinsing with water. The hands which are now clean must again touch the tap to close it, in the process, one picks up the unseen pathogens including the coronaviruses. The sharing of hand sanitizer containers operated manually means that many people touch the container and if one is infected, the container surface becomes contaminated. Touching the container to squeeze the alcohol-based gel may leave the viruses on the container which may spread to the next user(s). Such a container becomes a tool for spreading pathogens rather than decimating them. There has to be a break between contact for dirty hands and clean hands. To navigate this problem that gives a user a psychological sense of safety yet physically unsafe, there is need to employ automatic water taps for hand washing as well as automatic sanitization. Contactless water taps and sanitizer dispensers have come in handy. They minimize contact between the machine and the person hence are an e ective way of containing the spread of the virus. Automatic hand sanitizing and washing machines have been designed by di erent research groups [6, 7]. They vary in the method of sensing and control such as;(a) Arduino based automatic hand washing and sanitizing machines is one of the methods which uses ultrasonic sensor [8] and Arduino. In this type, a hand placed at a distance from the washing machine is detected through sensing of the ultrasonic waves produced by the moving hand. The detected wave is then processed through conversion into electric signal. The signal is sent to Arduino micro-controller. The micro-controller actuates the pump via motor drive to pump out the sanitizer encased in a container within the system. (b) IR based hand washing and sanitizing machines is the design that employs IR sensor [9]. In this type, the presence of the hand ready to be sanitized is sensed by the IR sensor.Since, every living thing radiates within IR spectrum due to body temperature it can be sensed [10]. Once the radiations have been detected, the detector converts the signal into electric signal which is then used to actuate the pump by switching on the pump switch within the circuit. Alternatively, the signal is sent to the micro-controller for processing and control. (c) Hybrid hand washing and sanitizing machine is the one that has combined the two sensors to build a robust integrated system. Sarkar combined the two prior mentioned sensors together with PIR (passive infrared sensor) to build an automated system that could measure the temperature, automatically sanitize the hands and automatically detect motion then sanitize the surrounding area before use by the approaching individual. The method also integrates Arduino so that the output of each detector is sent to the micro-controller which in turn processes the signals and then sends them to their appropriate destinations. For instance; signal from IR sensor is processed and sent to the LCD to display the temperature, signal from PIR are sent to the motor drive in order to actuate long range sensitization while that from IR is sent to another motor (of low hp) to pump sanitizer to the hand [11]. Finally, all the above methods can be improved through introduction of algorithm into the system. This was demonstrated by [12] who introduced algorithm based sensing to the ultrasonic based system. The algorithm detects the hand a distance from the detector and only send signals to the Arduino when the hand has reached optimum distance. This allows for precise release of sanitizer based on the input so as to avoid wastage. However, most of these systems employ microcontroller or Arduino-based systems which makes such systems expensive. These systems sometimes also require the skills of a programmer which could be lacking in most disadvantaged areas.

The automatic handwashing system we developed uses locally available materials. A 20 litre plastic container was placed inside a box (casing) made from recycled boards, and an opto-coupler assembled locally which is suitable for automatic dispensing of the sanitizer, the system is then powered by a 12 V battery which is recharged using a solar panel mounted on top of the casing box. The system is portable, environmentally friendly, can be re-used and re- lled easily with the sanitizer. Simple, easy to build and cost-e ective systems are required in such a time of crisis to help in reducing the spread of the Corona virus and save lives. We developed a low-cost automatic hand sanitizer, which is appropriate for use by small- and large-scale organizations. The system is contactless when dispensing the sanitizer and ensure no contamination of the container through hand pressing, hence reduces chances of contamination and eliminate the transmission of the infections at the point of sanitization. The developed automatic handwashing and sanitizing system is appropriate for use by large populations such as learning institutions, churches,dispensaries, food kiosks (eateries), in front of shops and, market places and disadvantaged places(remote areas) which lack basic infrastructure like electricity.

2 Experimental description

2.1 The apparatus

1. Opto-coupler
   a). Infrared transmitter (IR LED) speci cation: Spectral bandwidth of 45nm, transmission angle 40^o, forward current, 300 mA (max.), 1.5 A surge forward current, 1.24v to 1.4v forward voltage, operating temperature, 40 to 100 ^{o}C, Soldering Temperature 260 ^{o}C (max), Power Dissipation of 150 mW at 25 ^{o}C.
   b). IR photodiode receiver speci cations: Operating Voltage, 3.0V - 5.0V, Detection range: 2 to 30 cm, forward current 23 to 43 mA, detection angle 40^o
2. Solar battery, 12 V
3. Circuit board
4. Connecting cables (0.7 mm sq)
5. 2m pressure Water pump
6. Water pipes with a constricted outlet nozzle

7. Sanitizer
8. Wooden biodegradable box, large enough to hold 20 litre container

2.2 Design and Fabrication

The circuit for the automatic hand washing and the sanitizing system is shown in Fig. ??. The system has three main parts; sensor circuit, ampli cation and actuation. The sensor is composed of the Infrared (IR) sensor which consist of a current limiter resistor R1 for IR diode LED1 which transmits IR frequencies that are detected by the photodiode after bouncing o an object. Resistor R2 works with the photodiode in voltage division. The potentiometer, R3 provides the reference voltage for the comparator LM358 at pin

2. The output at Pin 1 of LM358 is taken through a current limiting resistor R4 and observed at indicator LED2. The comparator is powered by 5V at Pin 8 and grounded at pin 4. When the two inputs are equal, the comparator LM358 provides high output at Pin 1. The output voltage is ampli ed by the n-p-n transistor (BC547A) in the ampli cation section. The ampli ed voltage then biases the base-emitter junction of the transistor BC547. The ampli ed signal at the collector of the BC547A transistor is used to switch the 5V dc relay, which acts as a switch for the pump circuit. The prototype for the sensor and ampli cation sections of the circuit are shown in Fig. 2.The prototype of the developed system is shown in Fig. 3.

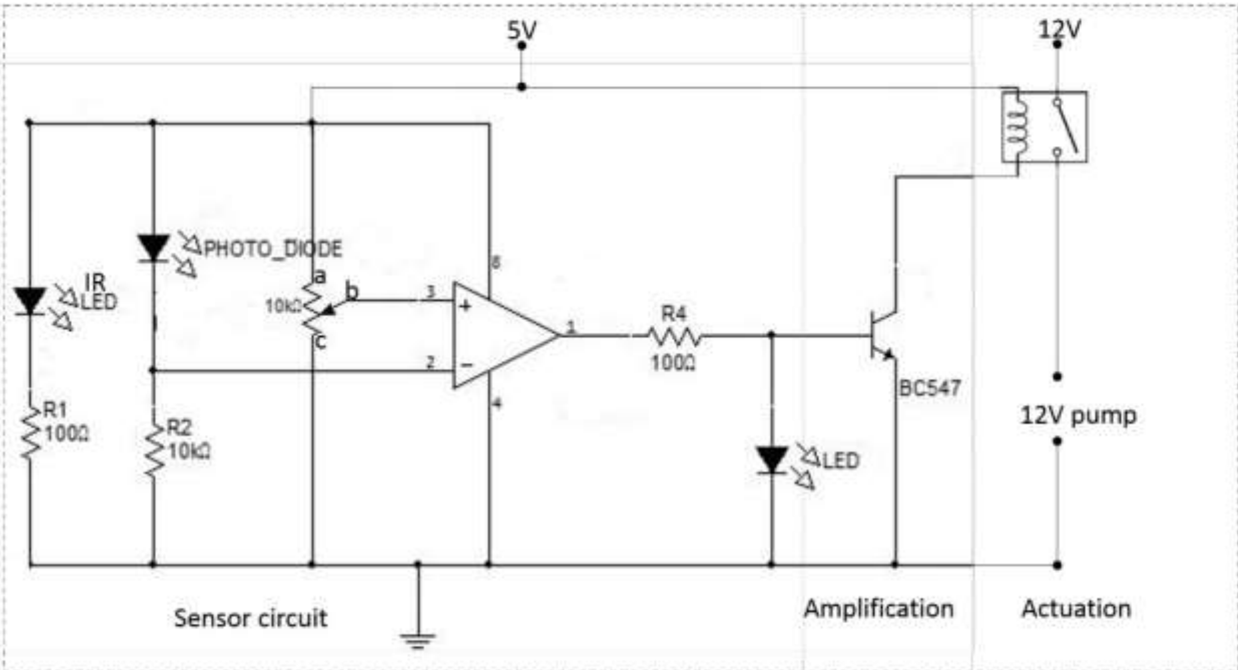

Figure 1: Circuit connection of the IR sensor with the power system and the pump.

3 System operational procedure

The pump circuit is powered by a 12V, 30 watts photovoltaic cell. The photovoltaic cell drives the 12 V dc, 2 meters pressure head water pump which pushes water, soap, or sanitizer automatically from the container. The sensing distance between the IR sensor and the re ecting object, in this case the palm of the user's hand is determined by adjusting the potentiometer R3. When hands to be washed or sanitized are moved to within the sensing distance, the IR sensor raises the input voltage at pin 3 of the comparator LM358N. When this voltage equalizes with the reference voltage, the comparator is triggered to give a commanding output. The pump is turned on and can eject water, soap, or sanitizer automatically. In this study, the sensing distance was set at 10 cm. Onces the hands are withdrawn from the sensing distance, the photodiode receives no re ected IR signal, therefore no current reaches the relay hence the pump circuit is open and the pump is switched o automatically.

The sanitizer container, solar battery and circuit components were enclosed within a single box. The top lid can be opened and sanitizer lled to the desired user level. With all circuit components in place, the operational switch which is on the side can be turned on. Then,the user can bring his/her hands towards the outlet nozzle. When the user's hands are within a 10 cm distance directly in front of the IR sensor, they are detected by the IR sensor which is directly beneath the outlet nozzle. The IR sensor triggers the ow of current which closes the relay switch of the water pump circuit. The water pump turns on and dispenses the sanitizer into the hands of the user. The system may also be used to dispense water, liquid soap or the sanitizer automatically. The user then can withdraw his/her hands, The IR induced current ceases the opening of the relay in the pump circuit. The pump turns o and stops further release of the sanitizer. The entire process is contactless. The solar battery can store energy for several days with a large population using the system continuously before being depleted. The battery may also be continuously charged by a solar panel mounted on the top cover or charged at the times of no human tra c.

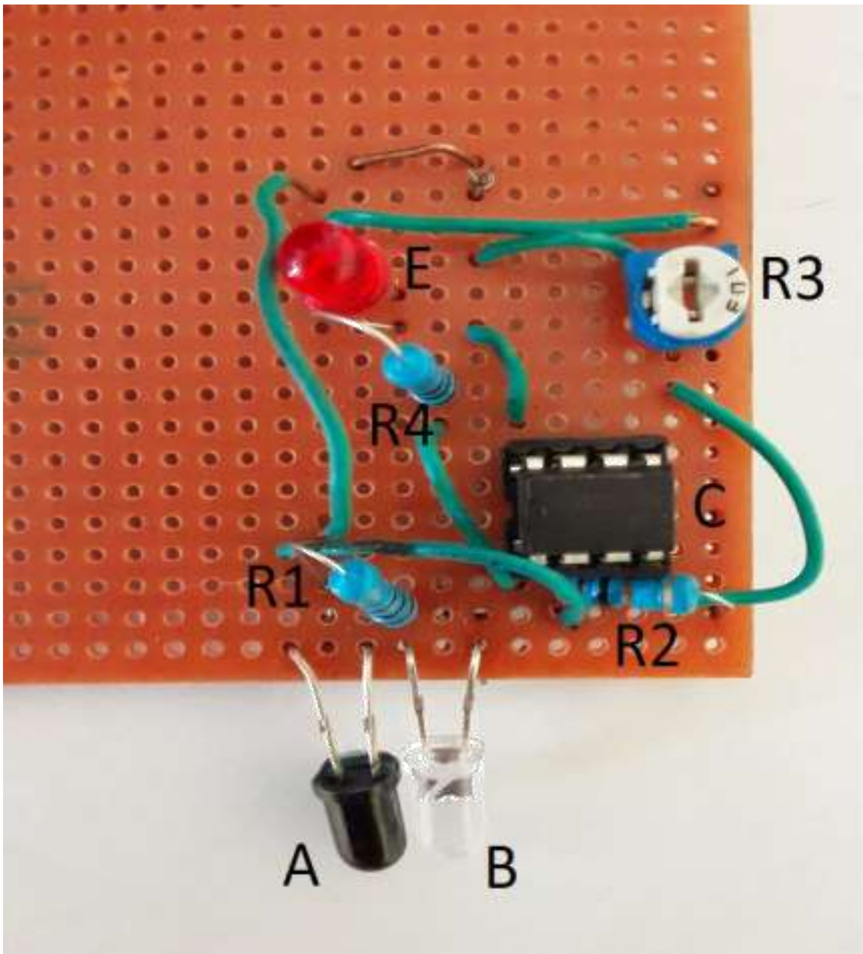

Figure 2: The implemented IR sensor circuit: A: IR receiver, B: IR transmitter, C: Comparator LM358, E: LED2 and the biasing resistors R1, R2, R3 and R4 (R1 is the limiting resistor, R2 is standard resistor which works as potential divider with a photodiode, R3 is potentiometer and R4 is an output current limiting resistor).

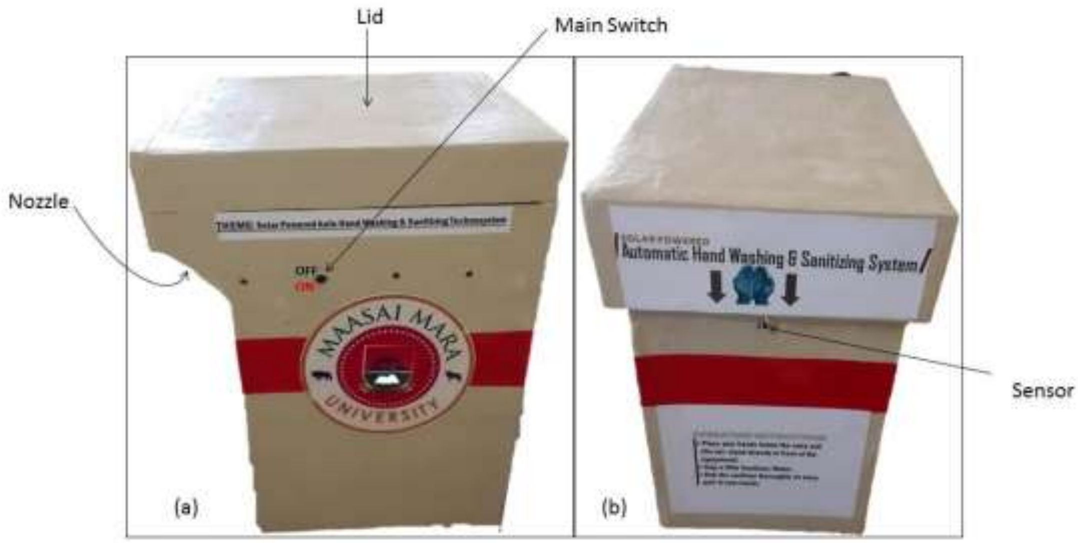

Figure 3: (a) and (b) are the external views of the side and front of the assembled system, respectively.

3.1 Results and evaluation of the system

We evaluated the IR sensor sensitivity range for possible switching distances, the obtained results is illustrated in Fig. 4.The maximum sensitivity was observed at 8.5 cm at R_{ab} = 1:8k . Sensitivity diminished at higher resistances R_{ab}. The appropriate potentiometer setting for our design was obtained at 1:8k < R_{ab} < 2:5k . We optimized the sensor to sense the presence of the hand up to the maximum sensitivity of range of 8.5 cm. In the range of 0 to 8.5 cm varied distances of the users are catered and the system is able to detect the presence of hand and eject the sanitizer automatically. Further we evaluated the time span of the battery powering the system before requiring to be re-charged and we found out that it could take 36 hrs continous usage with a population of about 500 people per day.The ow rate of the 20 liters of sanitizer was adjusted to serve the 500 people daily. The container is re lled with the sanitizer manually. For next generation of this system we suggest to incooperate a oat sensor to detect the sanitizer level and help re ll it automatically incase the population to be served at a any given day increases beyond the 500 people.

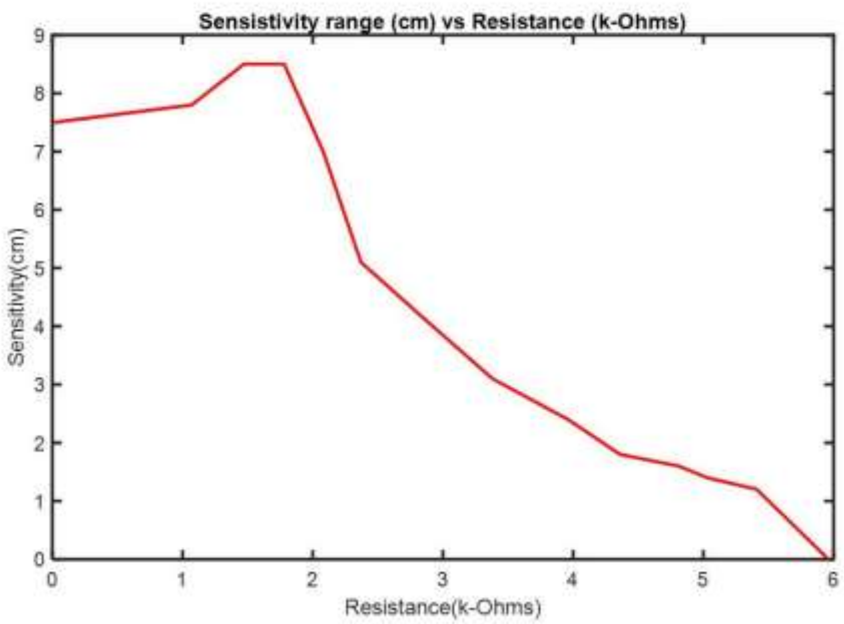

Figure 4: The sensor sensitivity range against the switching resistances

4 Conclusion

We successfuly demonstrated an automatic hand washing and sanitizing system using locally available ma-terials. The sensitivity of the system was adjusted accordingly and found to be in the range of 0 to 8.5 cm. The automatic hand washing and sanitizing system is powered by a solar battery making it self- sustainable for use in any area including remote locations where there is lack of the national grid. It can be used in small and large sized organizations such as Universities,Secondary schools etc as an important tool that can help the ght against the spread of COVID-19.

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References

[1] F. DiGennaro, D. Pizzol, C. Marotta, M. Antunes, V. Racalbuto, N. Veronese and L. Smith, 2020 Coro-navirus diseases (Covid-19) current status and Future perspectives : A narrative review, International Journal of Environmental Research and Public health, 17,1-11

[2] Q. Cai, M. Yang, D, Liu, J. Chen et al, 2020 Experimental treatment with Favipiravir for COVID-19: An open-label control study, Engineering, xxx,xxx

[3] G. Yan-Rong,C. Qing-Dong, H. Zhong-Si, T. Yuan-Yang, C. Shou-Deng, J. Hong-Jun, T. Kai-Sen, W. De-Yun and Y. Yan 2020, The origin, transmission and clinical therapies on coronavirus disease 2019 (Covid-19) outbreak-an update on the status, Military medical Research, 7:11, 1-10

[4] H. Li Yang, C. Po Ying,L. Jeremy FY, 2020 The Novel coronavirus (SARS-COV-2) epidemic, Ann. Acad. Med. Singap, 49, 1-3

[5] World Health Organization, 2020, Coronavirus disease (Covid-19) advice for the public, Available online at https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.

[6] H. Wanga, J. Thobius, C. B. Mauna, 2020 War against coronavirus (Covid-19) in Tanzania: Designing a low cost automatic water tap, International Journal of Computer Applications Technology and Research, 9 no.04, 150-154

[7] A. Chouldhary, 2020 Automatic hand sanitizer dispenser with Covid-19 live updates, Available online https://circuitdigest.com/microcontroller-projects/

[8] M.S Sumbawati, H.A Chandra, T Wrahatnolo,Ibrohim,L.E Cahya Ningrum ,K Khotimah,and A Nur Fathoni,2020 Design Automatic Hand Sanitizer Microcontroller Based using Arduino Nano and Ultra-sonic Sensors as an E ort to Prevent the Spread of Covid-19, Advances in Engineering Research, 190, 136-139

[9] J Lee, Jin-Young Lee, Sung-Min Cho, Ki-Cheol Yoon, Young Jae Kim, K. Gi Kim,2020 Design of Au-tomatic Hand Sanitizer System Compatible with Various Containers," Healthcare information research, 26, no. 3,243-247

[10] P.W Rusimamto, N Nurhayati, E Yundra, R Rahmadian,2020 "Automatic Hand Sanitizer Container to Prevent the Spread of Corona Virus Disease," Advances in Engineering Research, 196,60-64

[11] A. Sarkar,2020 "Design of Automatic Hand Sanitizer with Temperature Sensing," International Journal of Innovative Science and Research Technology, 5,no. 5,1269-1275

[12] Mahesh T. Dubey, Vaibhav P. Kale, Prajwal P.Jagtap, Ankita P. Mende, Vrushabh P. Kalbande, Kirti B. Nagne,2020 IoT based Automatic Hand Sanitizer Dispenser," International Research Journal of En-gineering and Technology (IRJET), vol. 7, no. 12, 7,no. 12,1731-1734