

Solar Intelligent Integrated Hand Washing Machine (Washa Max)

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Abstract— As easy and simple as it may sound, hand washing with soap and water can be of very huge impact on personal and public health. It is a crucial, efficient and cost-effective way to limit the spread of transmissible diseases such as Cholera, Diarrhea, Ebola and Coronavirus (Covid-19); the most recent of all. Though washing of hands is important, this could also serve as a means through which someone may get infected especially when the hand washing station is in public areas for public usage. Therefore, having to washing our hands without having to touch the tap nor the soap vessel is extremely important especially in this era of Covid-19. It is in this light that the solar intelligent integrated hand washing machine was designed and implemented. The machine is actuated by a show of the hands under the tap which leads to the dispensation of soap and 20 seconds later, water is dispensed for 20 seconds. With the new Coronavirus, one of the signs and symptoms of infection is a rise in body temperature above the normal (37°C). Hence this is a first check to know if someone is a potential case of the virus. With this in mind, the solar intelligent integrated handwashing machine has been equipped with a temperature measurement unit which permits the contactless measurement of the body temperature of every person using the machine. The measured temperature is displayed for visualization. If the measured temperature is higher than normal (37°C), the machine sends an SMS alert to the security officer or to any other designated person in the facility where it is installed.

Keywords—Automatic, Hand washing, contactless, temperature

I. INTRODUCTION

Over the years, Africa has been hit by many transmissible diseases related to hygiene and sanitation. Of all, the most frequent and most re-occurrent being Cholera which was first reported in the year 1970 and from then till the year 2011, reported cases of the disease in Africa represented 46% of globally reported cases, with over 99% of worldwide deaths in 2011 [1]. Furthermore, Africa has had cases of the Ebola Hemorrhagic fever which emerged in several countries spanning the regions of the equatorial rain forest and this outbreak was first reported in 1976 in Sudan with a mortality rate of 53% [2]. Now, there is the Corona virus pandemic which made its appearance in December 2019 in Wuhan, China and is affecting the African continent and the world at large [3][4].

The similarity with all the above-mentioned outbreaks is that their rapid spread can be reduced through proper hygiene and

sanitation, the primordial being adequate and frequent hand washing. Frequent hand washing and the use of hand sanitizer has been the first and foremost recommendation by the World Health Organization (WHO). This is because the hands are the main pathway through which germs are being transmitted and therefore proper and frequent hand washing is most important to avoid their transmission [5]. Though frequent hand washing is extremely important, it could also be a means through which one can come in contact with germs, especially in public hand washing facilities. This could be by touching the tap or the liquid soap vessel. To solve this problem, quite a number of automatic and semi-automatic hand washing machines have been developed and implemented.

Automatic hand washing machines appeared for public usage way back in the 1980s at lavatories of airports [6]. This technology has undergone development since then and are now deployed in various places. Nowadays, hand washing machines are either mechanical or electronic based (automatic). Some mechanical hand washing machines have been designed to be actuated using foot pedals, where the user uses the foot to press a pedal to receive the liquid soap and then presses another pedal to receive the water.

In the past months, many hand washing machines of different sizes and shapes have been developed across Africa and the world at large to help reduce the rapid spread of the Corona virus (Covid-19). For example, in Ghana, a young entrepreneur invented a solar-powered hand washing sink, incorporating a motion sensor to detect the presence of hands [7]. The machine releases soap at the show of hands under the tap, followed by a noise for 25 seconds, after which water is released for rinsing [7]. This solution obliges users to wash their hands within the time frame of at least 20 seconds as recommended by the WHO [5]. In Nigeria, quite a number of Universities and higher institutes of learning have developed hand washing machines; some being solar-powered automatic, some depending on the grid for power and others being foot-operated [8][9]. In Kenya, foot-operated hand washing machines have been developed [10]. All these are solutions that permit users to wash their hands without having to touch any surface with the hands. Nevertheless, a number of these machines have drawbacks such as;

- The foot actuated machines cannot be used by people with

physical disabilities (the lame) and also by some aged people who are not able to press the foot pedals.

- Some of these machines do not have dispositions for waste water after hand washing.
- Some of the electronic-based hand washing machines depend on the utility company for power supply hence can not be used in areas with no access to grid electricity or in facilities with no nearby power socket.

Therefore, this research project aims at designing and realizing a solar intelligent integrated hand washing machine which is electronic based and convenient to use by all. In addition, the machine incorporates a temperature measurement unit that allows every user to take his/her body temperature since increase in body temperature is one of the signs and symptoms of corona virus infection [11]. Furthermore, a Global System for Mobile communication (GSM) module is added to the system for short message system (SMS) alert in case the measured temperature is high (above 37°C).

II. METHODOLOGY

The solar intelligent integrated hand washing machine is an upgraded solar automatic hand washing machine, bearing the trade name **Washa Max**. The methodology undertaken in the design and fabrication of Washa Max is detailed as follows;

A. Electronic Control System

The electronic based control system was designed and simulated using Proteus Professional. An Arduino Mega is used as the brain of the systems and controls all the operations of the machine. The block diagram of the system can be visualized in fig. 1.

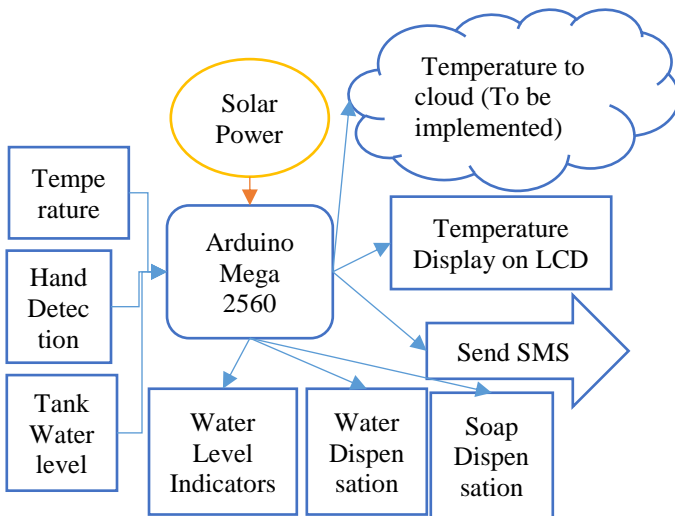


Fig. 1: Block Diagram of Washa Max

B. System Operation

The solar intelligent integrated hand washing machine (Washa Max) operates as shown in the flowchart in fig. 2.

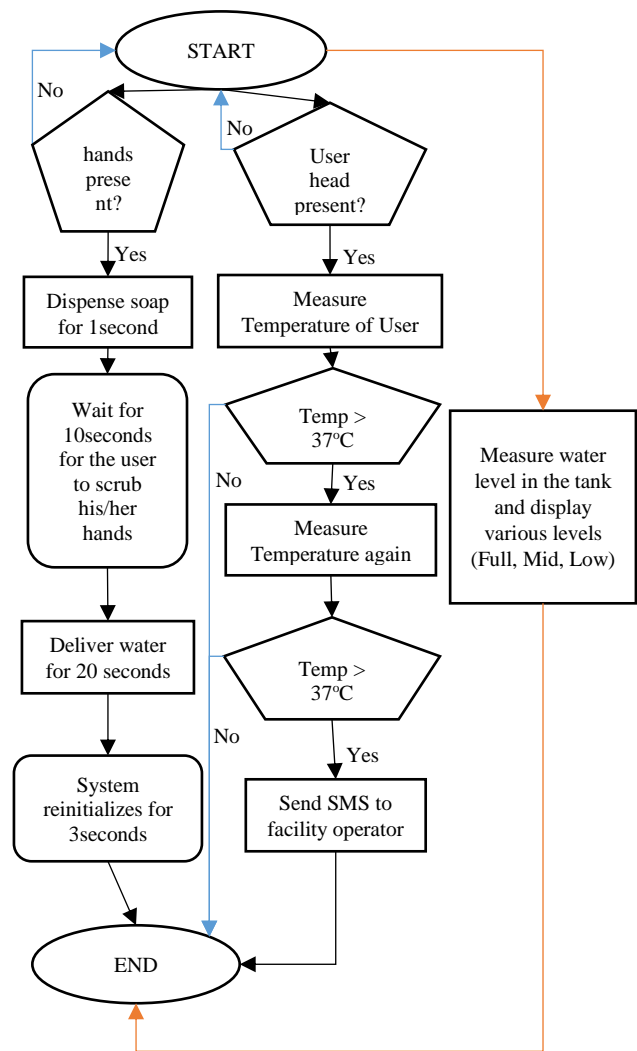


Fig. 2: Operation of Washa Max

C. Electronic and Power System Design and Fabrication

The major electronic components used in the operation of Washa Max are;

- An Arduino Mega which manages and controls the entire operation of the machine.
- An ultrasonic sensor, used to measure the water level in the water tank and display the levels on the display board in three states using light emitting diodes (LEDs) of different colours (Green for Full, Orange for Middle and Red for Empty)
- An ultrasonic sensor for hand detection to detect the presence of hands under the tap and actuate a solenoid valve which let the flow of the liquid soap for a second.
- A micropump, actuated by the Arduino Mega is used to pump water from the water tank.
- A Liquid Crystal Display (LCD), used to display the sequence of operation of the machine in both English and Kiswahili to facilitate the usage of the machine.
- A temperature measurement unit comprising of a temperature sensor and controlled by the Arduino, which measures and displays the body temperature of users.

- A sim9001 GSM module used to send SMS alerts in cases where the measured temperature is above 37°C.
- A 10W, 12V monocrystalline solar panel with a 7Ah backup battery, which is used to supply power to the control system.

The electronic system was designed, simulated and the printed circuit board (PCB) done using Proteus Professional which is a robust software for electronic system designs and fabrications. Arduino Uno was used in the simulation as shown in fig. 3. The bottom layer of the PCB designed is shown in fig. 4.

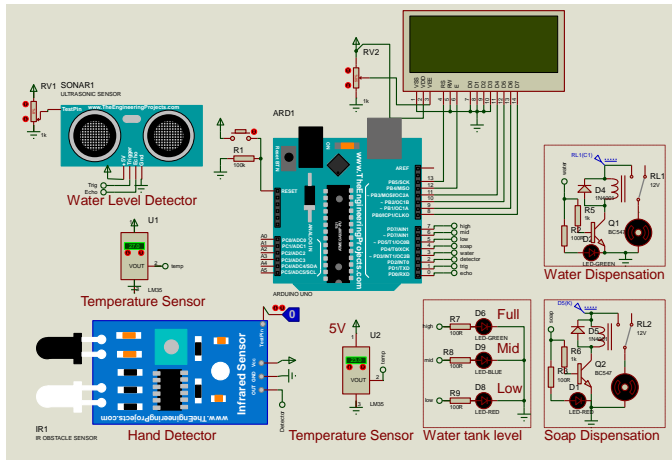


Fig. 3: Electronic Control System of the hand washing machine

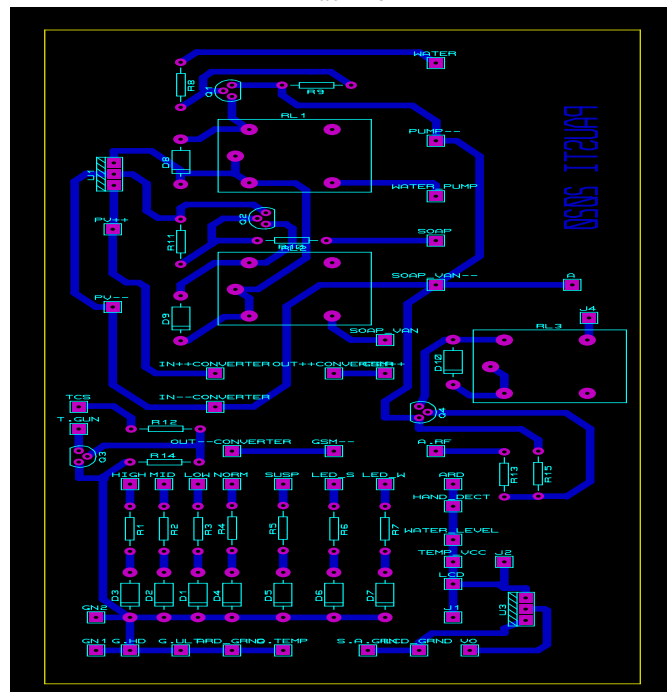


Fig. 4: Control System PCB Using Proteus Professional

The designed PCB was printed using a PCB printing machines and the electronic components soldered on the board as can be seen in fig. 5.

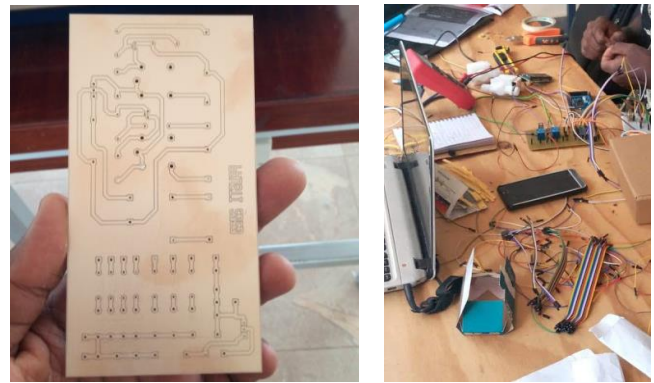


Fig. 5:(a) PCB after printing (b) Soldering of Electronic Components on the PCB

D. Mechanical Material and Structure Mounting

The mechanical structure of Washa Max was drawn and dimensioned using SolidWorks software. Fig. 6 shows the 3D drawing of the machine realized with SolidWorks.

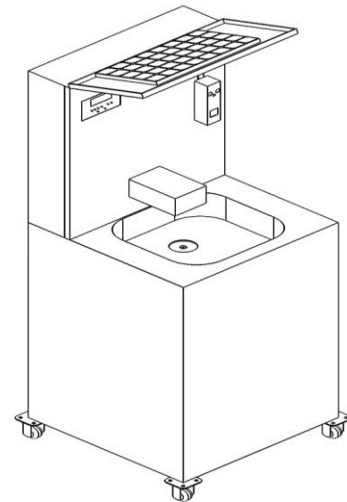


Fig. 6: 3D View of Washa Max

The fabrication of the structure was done using 25x25mm iron tubes and was later painted and dried as shown in fig. 7.



Fig. 7: Structure of Washa Max; unpainted (left), painted (right)

The covering of the skeleton was done using aluminum sheets. A stainless-steel sink is used as the hand washing area. A 70ltr water tank is placed inside the structure of the machine to store the water used for the hand washing. A polyvinyl chloride (PVC) pipe is used to channel the waste water after hand washing into a bucket for later disposal or to the drainage system of the facility in which the machine is installed.

III. RESULTS AND DISCUSSIONS

The finished solar intelligent integrated hand washing machine (Washa Max) is shown in fig. 8.



Fig. 8: Washa Max Upon Implementation

All the functionalities of the Washa Max were tested and the results coincided with the simulation results. That is; the liquid soap is dispensed for a second at the show of the hands under the tap and 20 seconds later, the water is dispenses for 20 seconds. The temperature measurement unit accurately measures and displays the temperature of the user washing his/her hands. Fig. 9 depicts the utilization of the machine during testing.



Fig. 9: Hand washing and temperature measurement

To test the SMS alert module, it was required to device a

means for the temperature sensor to measure a temperature above 37°C. Since there was no one at our disposal with such temperatures, the temperature sensor was made to measure the temperature of a burning piece of paper. Upon measuring the high temperature, the system requested for a second measurement, after which is sent the SMS alert to the designated number written in the Arduino program. The demonstration of the SMS alert is shown in fig. 10.

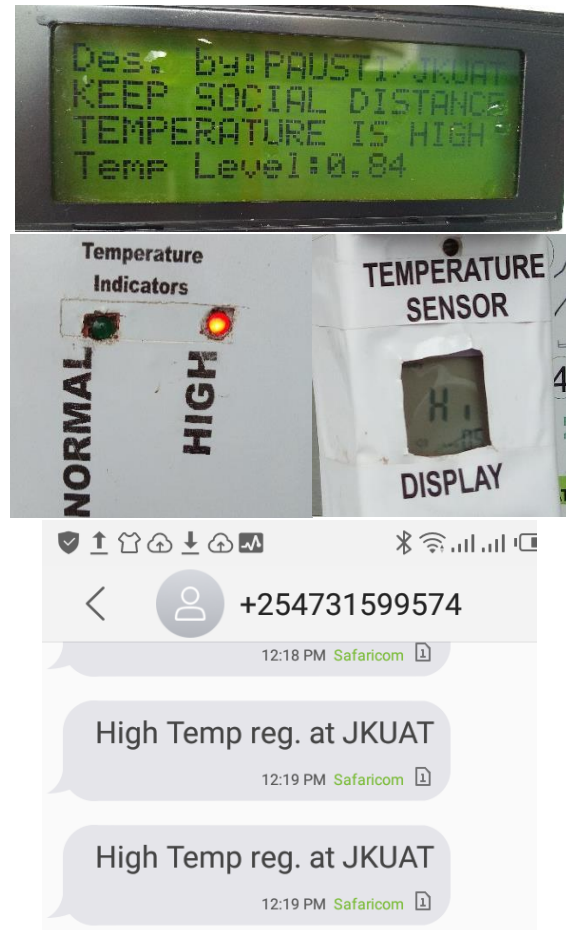


Fig. 10: Testing SMS alert module

IV. CONCLUSION

In this research work, a solar intelligent integrated hand washing machine was designed and fabricated. The machine was tested and results showed that the machine functioned fully as expected; Users are able to wash their hands and take their body temperature without having to touch any surface. Hand washing is a top priority in daily life and it is recognized as part of sustainable development goal 6 (*water and sanitation for all*). Hence, the solar intelligent integrated hand washing machine in a substantial solution to minimize the spread of Covid-19 and other existing and yet to exist diseases related to hygiene and sanitation.

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