Analysis of Automatic Hand Sanitizer Using PIC16F877A Microcontroller

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Abstract

The research was conducted to analyze an automatic non contactless hand sanitizer dispensing machine. Many researches focus on manual dispensers which makes the hand sanitizer dispenser to be contaminated. The system consists of monitoring and alert features. The liquid level of hand sanitizer was monitored by using LED-RED while alerting the system to remind the owner to refill the hand sanitizer if the level been low. Other than that, PIR sensor was used to detect the presents of human in nearby and thereafter dispenses the hand sanitizer. An automatic hand sanitizer dispensing machine was developed using microcontroller as the main brain behind of the system operation. Hand sanitizer dispenser can be used in many public places and else. The system employed usage of an ultrasonic sensor, which senses the hand placed near it, and connected to electrically operated pump that pumps out the hand sanitizer liquid for its users. The IR Sensor is the photodiode used for sensing the human hand detection and it is used to control the motor pump from the liquid.

Key Words: *Automatic hand sanitizer, Disease, Microcontroller and PIR sensor.*

Introduction: The outbreak of COVID-19 pandemic has made it crucial for everyone to wear a mask in public areas, maintain a social distance and wash hands with soap or hand sanitizer regularly. The essence of the project is to take measure in controlling the spread of the pandemic. In view of the problems emanated due to COVID-19, medical experts have proffered some preventive measures for curtailing the spread of the virus. Among those preventive measures are regular hand washing, wearing of face mask and sanitizing surfaces. Therefore, as a preventive measure, federal government of Nigeria submitted that hand sanitizer should be provided to the visitors at the front door or administrative counter, hospitals, schools, and public places. However, almost all the hand sanitizer dispensers used at public places are manual-type dispensers. The implications of using the manually operated hand sanitizers are the sanitizers might be used up without a control measure. Moreover, using a manually operated hand sanitizer dispenser will pose a way for direct contact between the dispenser and the user, and the dispenser

will be contaminated. Therefore, the main aim for this research is to design a smart hand sanitizer dispenser that dispenses optimum amount of sanitizer. An automatic hand sanitizer dispenser is a device that dispenses a controlled amount of sanitizer. According to [1] COVID-19 pandemic has negatively affected the world's economy. COVID-19 have affected many countries, and as a result brought about lockdown, made some businesses to shut down, decreasing the Gross Domestic Product of nations in [2].

Sanitizing hands is a simple activity that disinfects the hand from germs and impurities, which is done with the help of hand sanitizer. It is confirmed that hand sanitizer helps in preventing the spread of covid-19 and other related virus [3].

In order to avoid coming in contact at all with the containers of the hand sanitizers, there is a need to invent contactless or no-touch hand sanitizer dispensers [4]. This is because many sanitizer containers and pump devices are designed to be compatible only between products produced by the same manufacturers; hence consumers must also repurchase the container for the liquid if they replace the hand sanitizer [5]. The essence of the contactless hand sanitizing process has great impact in reducing the covid-19 transmission among people [6]. In [7] noted that achievements in technology have made it possible to automated hand sanitizer dispenser that is cost effective and functionally operational to be deployed in public places.

The automatic hand sanitizer is a smart device controlled by microcontroller that detects the presence of user and automatically dish out sanitizer. In line with Nigerian government protocols to keep everyone safe in public places, sanitizers are strategically positioned across almost every department of higher institutions in the country. But the sanitizers are manually operated which inefficient for public application. In addition to working automatically, the device was programmed to alert user when sanitizer is empty.

Related Review: Literature was reviewed in relation to automatic hand sanitizer, such as:

Applications of contactless sanitizer dispenser

Contactless sanitizer dispenser is the dispenser of sanitizer that does not require the contact of the users of the directly with the container of the sanitizer. In other words, contactless sanitizer is designed in such a way that the system senses the presence of its user and then alerts the electronic sanitizer pump aspect of the system to dispense the sanitizer liquid to such a user' hand.

I. It can be used in hospitals.
II. It can be used in public locations
III. It can used in school & colleges
IV. It can be used in Airports.
V. It can be used in hotel and restaurants.
VI. It can be used at shopping malls.
VII. It can be used in banks.

Related empirical studies on hand sanitizer were reviewed, as follows:

A low-cost automatic hand sanitizer dispenser was invented by [8]. In their design ATMEGA328P was used as central control. ATMEGA328P discharges sanitizer when it detects hand within the range of the dispenser using ultrasonic sensor. Its sensitivity is up to 10cm from the sanitizer outlet. The design of hand sanitizer by [8] incorporated a door control for inlet and

outlet of users. When someone gain entrance unless the person hand is sanitized the outlet door will remain closed. The study of [8] is related to the present study in that both studies employed usage of sensor for detecting the presence of user of sanitizer.

Another study was conducted by [9] on automatic hand sanitizer. The design employed Internet of things (IoT) in an infrared-ultrasonic based sensor automatic sanitizer. The infrared sensor was used as motion detector. The range of the sensor from the system was within 50mm and then sends the signal to the Arduino to activate the pump, while the ultrasonic sensor was used for hand detection. The system used Arduino to connect to the server. The entire operation was controlled by personal computer or smartphone. It was found out that the process was contactless, but the range of infrared was too small and may render the project less effective.

The study of [10] was targeted on a COVID-19 disinfection tunnel. The smart disinfection tunnel detects the height of persons through an ultrasonic sensor uses disinfectant fumes. The system was powered by solar cells in the day, while at night solar power-bank sustains its operation. The related study also employed IoT for intelligent sensing and storing important information on the cloud.

The study of [11], was centered on temperature monitor. A non-contact temperature monitor was introduced by [11], which has an automatic sanitizer dispenser. The system continuously monitors body temperature and raise alarm when temperature detected is beyond the normal. Microcontroller was the heart of the whole design. Microcontroller controlled temperature reader which checks body temperature of human. The temperature also alerts the microcontroller when the temperature exceeds 38 degrees and the microcontroller controls the sanitizer dispenser to dispense promptly.

Similarly, [12] suggested an advanced disinfection tunnel to take care of external surface disinfection against COVID-19. This automatic COVID-19 Virus Disinfection Tunnel consists of three disinfection processes and two chambers. There is also a provision of sensor for detecting entrance and exit of persons within a distance 2-450cm. There were various LED that indicated the entry and exit signals. Red shows entry and green light shows exit. The project was commended to be very effective.

In [13] introduced a chemical free disinfection process called the Ultraviolent Germicidal Irradiation (UVGI). This method employed solar energy in the war against Covid-19. Ultraviolet radiated light with wavelength ranging between 200nm to 280nm are capable of damaging the DNA of covid-19 to prevent their replication. UVGI also disinfect object surfaces as well as air, then as a result deactivating bacteria and viruses.
However, for this system to be functional 24 hours there must be a standalone source of solar energy, this makes the system implementation difficult and also difficult to be provided everywhere at all times.

In another development by [14] on design and application of an Ultrasonic Violent (UV) Based Facemask Disposal Bin. The study was concerned on the risk that waste collectors are exposed to during the course of discharging their duties. The Facemask Disposal Bin in this study has disinfectant gateway. The disinfectant gateway was made up of a chamber which

generates Hydrogen peroxide fumes and UV rays for decontamination. A fume of Hydrogen peroxide was considered effective for decontamination of the hands, body and clothes of a person and the UV system disinfects the chamber. The system was effective in protecting waste collectors from infection while discharging their duties.

A low voltage, low cost water level indicator that can be used to indicate water level in reservoir was developed by [15]. This system monitors and controls the wastage of water, as it is observed in time. The system enables user to take necessary actions in time to prevent wastage and shortage of water. The device made use of conducting wire for the water level indicator. However, since the device is not automated users have to be alerted at all times to monitor the system. The study is related to the present study in that the present study also has indicators in the container that shows the level of availability of the sanitizer liquid. Hence the liquid can be replaced before it finishes.

The study in [16] developed a system for observing the presence of object and human. The system employs the usage of raspberry pi and PIR sensor. The system is activated when someone's presence is detected. The system also employs Internet of Things (IoT) application for monitoring and receiving notifications when motion detected. The hardware for the system uses a lot of peripheral components such as Raspberry Pi, USB camera, PIR sensor and android devices. The short-coming of the system is that it notifies only its owner of the presence of an object and it is not cost effective. Unlike the automated hand sanitizer developed in this project that can serve every user at any time.

Methodology: Figure 1 depicts methodology that guides the operational principle of automatic hand sanitizer. Each stage of the project design is mounted on the bread boarded (for testing purposes), the working stage is then transferred to the general purpose PCB board by soldering. The system is functionless without the program running in the microcontroller. The source code is written, compiled and debugged using PIC C Compiler. After compiling the source code, the object code is transferred to the microcontroller using PIC Kit 2 Programmer. The system software consists of all the set of instructions that enables the microcontroller coordinate the operation of the entire system. The program is stored in the EEPROM of the microcontroller. In this project the source code was developed in 'C' programming language and compiled to machine language using PIC 'C' compiler Integrated Development Environment.

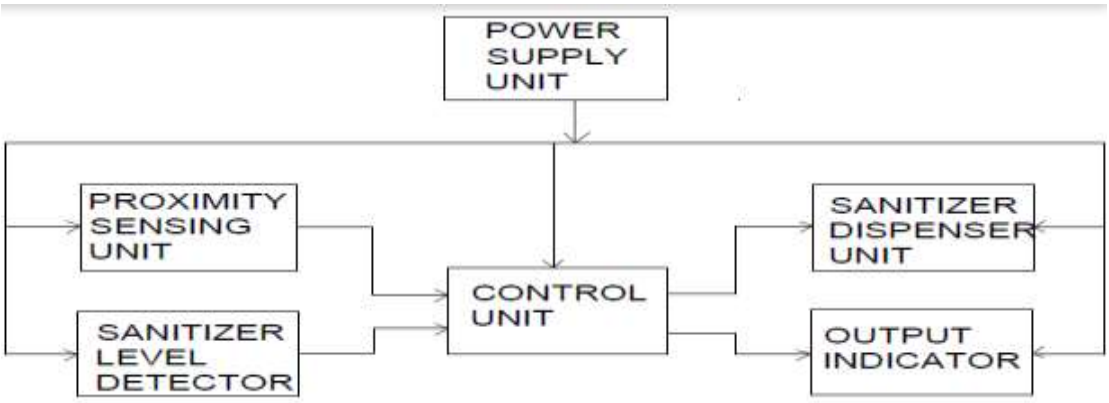

Figure 1: Block Diagram of Automatic Hand Sanitizer

Figure 1 consists of six blocks, which include power supply unit, proximity sensing unit, sanitizer level detector, control unit, sanitizer dispenser unit and output indicator.

Power supply unit: The system can operate smoothly with 5V DC power supply with a very low current consumption of about 250mA.

Proximity sensing unit: Passive Infrared Sensor (PIR sensor) or "IR motion" sensors is an electronic sensor that measures infrared light radiation from objects in its field of view. PIR sensors are used to sense motion; used to detect whether a human has moved in or out of the sensors range.

Sanitizer level detector: This section utilizes Hex Schmitt−Trigger Inverter – known as 74HC14 chip. Hex Schmitt−Trigger Inverter (74HC14). The 74HC14 is identical in pin out to the LS14, LS04 and the HC04. The device inputs are compatible with Standard CMOS outputs; with pull-ups resistors, they are compatible with LSTTL outputs.

Control unit: Microcontroller was used to control the whole operation of the system. The microcontroller selected was the Microchip Peripheral Interface Controller (PIC). This family of microcontroller offers the following advantages; ease of use, built in timers, and has many digital inputs and outputs.

The use of touch-less automated hand sanitizer dispenser has been proved to be more effective for the control of contact infectious diseases. However, most of the invented automated hand sanitizers have several challenges. Some of these challenges are no backup power incorporated to enable it operate for 24 hours daily. Likewise, sanitizer containers and pump devices are designed to be compatible only between products produced by the same manufacturer; consumers must also repurchase the container for the liquid if they replace the hand sanitizer. Therefore, this project suggests the design of an automatic hand sanitizer system, which will be compatible with various sanitizer containers. The present study has also taken care of continuity of power supply to ensure that the system is effective for 24 hours daily.

An additional intention was to implement a system that is continuously effective and user friendly, based on this the system requires minimum maintenance from the user and incorporate visual level indicator and an alarm for alerting users if the container is empty.

Microcontroller was used to control the whole operation of the system. The controller used is the Microchip Peripheral Interface Controller (PIC). The family of microcontroller offers the following advantages; ease of use, built in timers, and has many digital inputs and outputs. To avoid extra costs, this model is most basic that meets all the design criteria. Also, its programming kits are readily available. Thus**,** the PIC microcontroller is one of the best choices of microcontroller available. In particular, the microcontroller used in the design is PIC16F877A- a dual inline 40-Pin, Enhanced Flash-Based 8-Bit CMOS Microcontrollers with nanowatts technology. The Ultrasonic sensor has an echo and trig pins which are the receiver and transmitter respectively, by the algorithms the sensor is adjusted to get trigger within the distance, when the hand is placed in the required distance, the sensor sends the signals to the Arduino nano then the Arduino sends signal to the 5V relay board, which is triggered and activate the motor to pump sanitizer.

Test and Result: Tests were carried out to ensure workability of the design. The test comprises of the following:

i. Design simulation test
ii. Component test
iii. Breadboard test
iv. Voltage test
v. Compiling and debugging
vi. Water level simulation test

Design simulation test: The system and the program was designed and simulated using Proteus and PIC C Compiler respectively. Proteus enables a propose system to be designed and modifying without making incurring cost during design stage of system implementation. The circuit diagram of the system hardware during simulation is shown in figure 2.

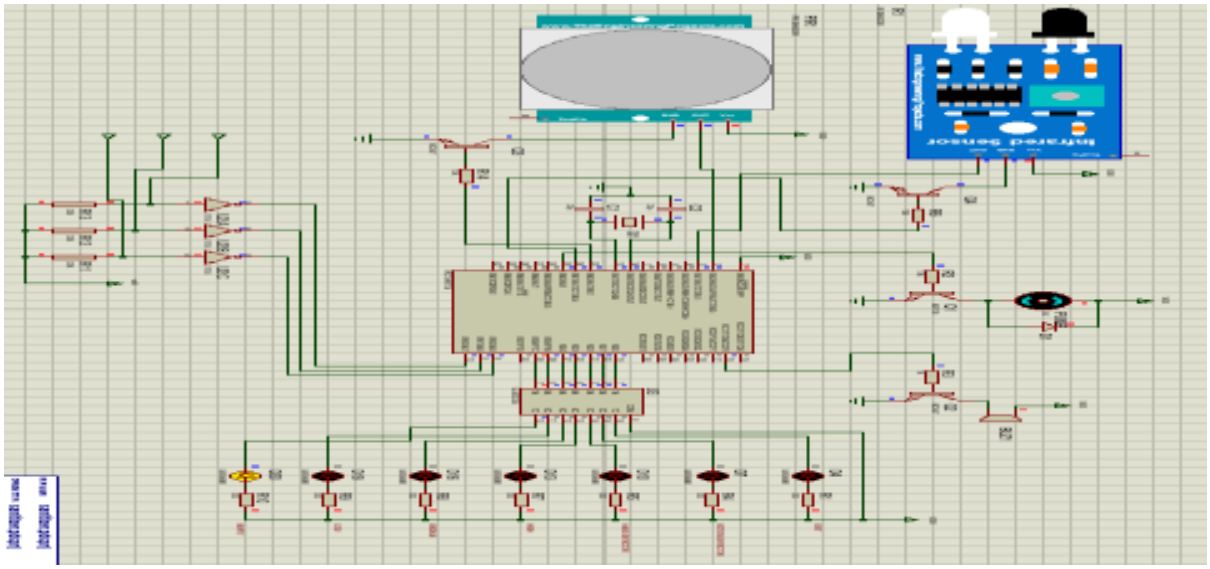

Figure 2: Circuit Diagram

Component Test: Each component used in the construction was tested using a multimeter. The multimeter was used to measure continuity; resistance, transistors, and the diode were all found approximately within specification.

Breadboard test: This test was carried out to verify and modify the construction before the prototype is built. The breadboard test result obtained was according to design expectation. This also provides an avenue for testing main program and the delay subroutine of the proper sequence of system conditions.

Voltage test: The voltage required in the construction project was measured using a multimeter. The values obtained from voltage test are indicated in Table one:

Table 1: Voltage Test Result

Test Point	Result
Input AC voltage	208V AC
Output AC voltage	8.1V-0-8.1V AC
Unregulated DC voltage	9.4V DC
DC Charging voltage	9.1V DC

Battery voltage	7.15V DC
Regulated DC voltage	4.98V DC

Compiling and debugging test: Compiling test was carried out in order to turn human readable code into code the machine can understand and execute. Whereas debugging was done in order to find out where in the code the application is going wrong. In other words, debugging is an act of getting rid of bugs.

Water level simulation test and Result

The system is built to test Sanitizer level. The system has three level of sanitizer detector. These are FULL, MEDIUM, and LOW. Using Schmitt inverter, the signal is converter to a digital level as shown in table 2, 3 and 4.

Table 2: Sanitizer Detector Result Truth Table

Combination	**Sanitizer level**	**Result**
0 0 0	Empty	Blinking Empty indicator and Beeping Sound
0 0 1	Low	No Beeping, LOW indicator ON
0 1 1	Medium	LOW and MEDIUM Indicator ON
1 1 1	Full	both LOW, MEDIUM and HIGH indicators are ON

Also, the bottom, middle and high electrode are connected to channel A (yellow colour), B (blue colour), C (red colour) and D (green colour) of oscilloscope in the simulation environment, figure 3, 4, 5 and 6 show the result.

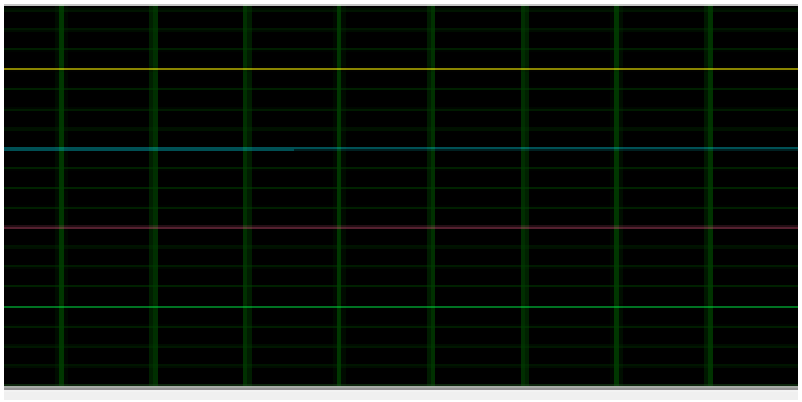

Figure 3: Sanitizer Empty Level Waveform

Figure 3 shows the waveform for empty sanitizer level. As shown in the figure when sanitizer is empty all the signals in channel A, B, C and D remain Low. This is because there is no electrode that is grounded when sanitizer is empty.

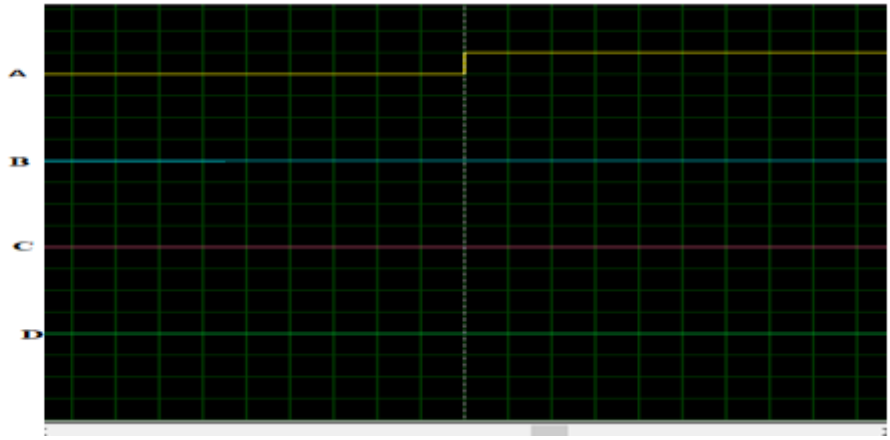

Figure 4: Sanitizer Level low waveform

Figure 4 shows the waveform for low sanitizer level. As shown in the figure when sanitizer is low only the signal in channel A goes high and channel B and C remain Low. This is because it is only the bottom electrode that is grounded when sanitizer is low.

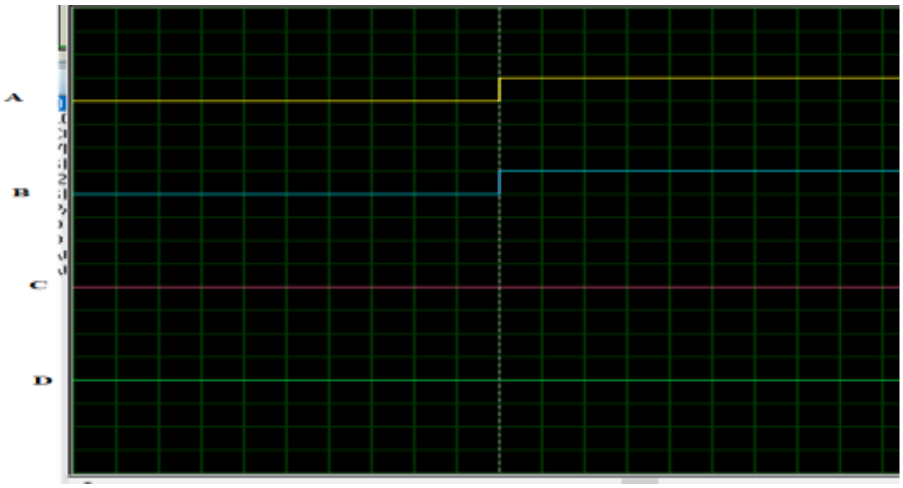

Figure 5: Sanitizer Level medium waveform

Similarly, Figure 5 shows the waveform for medium sanitizer level. As shown in the figure when sanitizer is medium the signals in channel A and B goes high while C remains Low. This is because both bottom and the middle electrodes are grounded when the sanitizer's container is half way full by the sanitizer liquid.

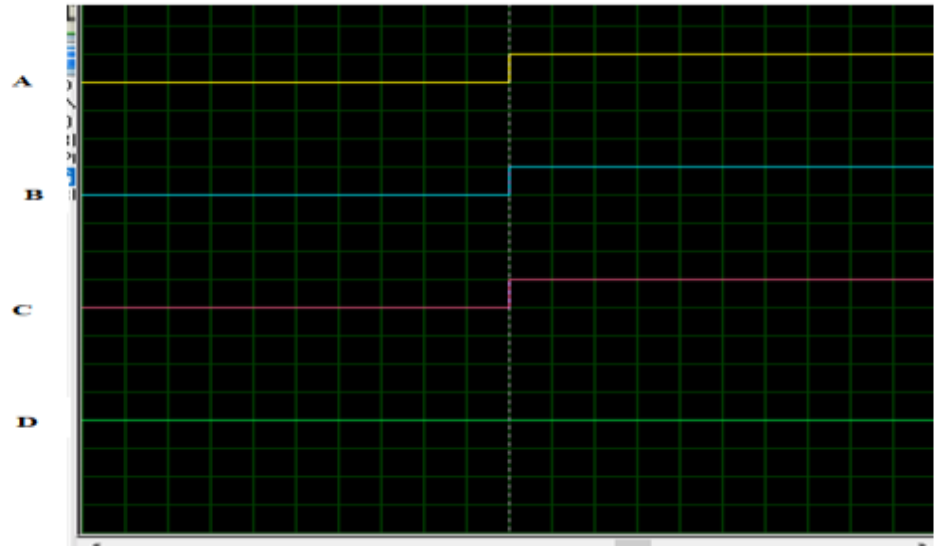

Figure 6: Sanitizer Level Full waveform

Figure 6 shows the waveform for high sanitizer level. As shown in the figure, when sanitizer is full all the three signals in channel A, B and C go high. This is because all three electrodes are grounded when sanitizer is full.

Discussion of findings

Table 3 presents parameters measurement and brief discussion on the results obtained on the robot arm mechanism.

Table 3: System Parameter

Parameter	**Result**	**Discussion**
Maximum current consumption	0.76A	A very Low current consuming device.
Sanitizer capacity	2litres.	Reasonable capacity that can expanded
Cross-sectional Area (cm)	Length = 21.5cm	for this cross-sectional area
	Width = 24.5cm	it is table top and wall mount
	Height = 39cm	kept on table

All the materials and components used for the implementation of this system were within specifications. The result of voltage test recorded in Table 2 indicated that power unit supply and the voltage level were according to the system requirement.

From table 3 the following can be deduced:

i. The sanitizer capacity of this device is reasonable enough for public use.
ii. The system consumes minimum amount of power.
iii. The cross-sectional area is suitable for both table and wall mount applications.

Fig.7: Automatic Hand Sanitizer Dispenser

Therefore, the entire various units making up the system are functioning as expected. The system operation is as follows: When the device is switched ON, two beeping sounds will be hard and all the LED indicators will blink three times system this is indication that the system has initializes. The system now checks the level of the hand sanitizer and displays it. If the sanitizer is detected to be empty, a continuous beeping sound will be heard (alerting the concern party to refill it. And at this point no operation as regarded to discharging sanitizer can be performed. Since the sanitizer is empty. However, if there is sanitizer, the system continues to monitor the motion within its perimeter. When motion is detected, it activates hand detection. If hand is detected it discharge a constant volume of hand sanitizer. The indicator for motion is a blue LED, which continuously blinks when no motion is detected.

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