Design of a Microcontroller based Covid19 Non-contact Hand Sanitizing Machine

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Abstract- The project uses various commonly used non-contact sensors to design COVID-19 hand sanitizing machines. The three designs methods were done using phototransistor, pedal and ultrasonic touch-less sensors. Arduino codes were written for Pedal and Ultrasonic sensors operated types being microcontroller controlled while phototransistor unit employed simple DC coupled transistorized designs to realise the machine. Codes were written and compiled on the Arduino IDE while simulation of pedal operated unit done on the Proteus platform. Phototransistor and pedal triggered designs were implemented on breadboards. It is believed that these designs will go long way to impede the spread of the Virus, flatten the epidemic curve and also help Power Electronic engineers and students alike to glean one or two ideas from their resources.

Keywords: *COVID19, Infrared, Pedal, Pulsed tone, Sensors, Simulation, Ultrasonic*

Introduction

From time immemorial, man has evolved means of self-survival. This was made possible by his aptitude to learn new things using agency of science. Scientists have continued to probe into their environments and matters; the resultant is discoveries that help in evolving methods of solving the numerous problems encountered. While developments are being experienced in all human endeavors, medical science propping out from infancy, have been tailored towards reducing mortality rates from diseases and epidemics. Each time a new disease is identified; medical scientists do put action plans towards having clear understandings among others, its causes, microbes, modes of transmissions, the incubation period. In case it is contagious and with potential of resulting to epidemics or becoming pandemic, according to WHO, a pandemic disease is that one that spread worldwide (WHO, 2020). The body provides guidelines on how to prevent its spread The nCOVID-19, coined from new Coronavirus disease 2019, which has its epicenter in Wuhan, China in December, 2019 (WHO, 2020) falls into categories of an epidemic. Its signs and symptoms are fever, cough, and shortness of breath (CDC, 2020). WHO, the global health body has continued to provide synergies among countries and their medical scientists on how to reduce the mortality rate by flattening their epidemic curves. The body has also continued to issue out technical guidelines on how to achieve the objectives. It has been established that nCOVID-19 can be spread through having contacts with surfaces with droplets of sneeze and cough bouts of a sufferer or a carrier who may be asymptomatic (CDC, 2020). It was on this premise that frequent cleaning of hands with sanitizer with at least 60% alcohol, washing of hands with soap and running water for at least 20seconds, covering of nose can bring about reduction in the viral spread (CDC, 2020). Thus sanitizer dispensers that dispenses automatically without a touch will be priceless in combating medical imbroglio.

The latter has provided reasons while engineers all over the world designs touch-less machines to reduce acts of surface contacts of their clients. Engineers use the knowledge of science to design machines to solve man problems (Akinwole, 2019). This design uses

simple power electronic devices to realise the sanitizer machine at affordable price, which can be mass-produced, for schools, churches and markets in Nigeria.

Methodology

The design uses an Ultrasonic sensor to sense human hands presence. The microcontroller is coded to trigger the sensor to send an ultrasonic signal, which is echoed back. The to and fro times are employed to calculate the distance between the sensor and human hands (Tutorial Point, 2020). Any hand within the predetermined distance allows the controller to energize a DC micro pump that dispense liquid sanitizer, A piezo-electric buzzer is activated to an audible sound while a LCD displays current machine cycle. Other sensors like Light dependent resistor (LDR), passive infra red (PIR), Infrared LED were explored, their usage were tainted by instability and bouts of self triggering due to environmental conditions. A momentary switch sensor, operated by foot pedal worked perfectly.

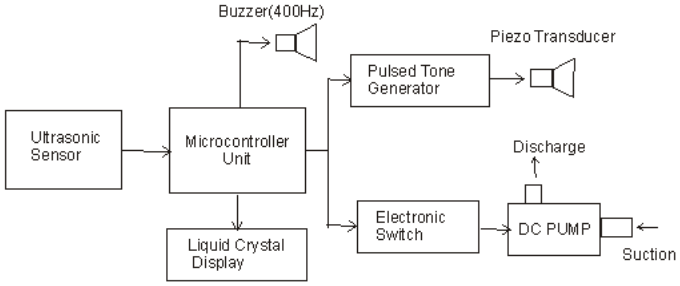


Figure 1: System Block Diagram

Infrared Phototransistor as Sensor.

In the course of the design work, an infrared phototransistor was used as human sensor sensing human hands at reasonable distance of about 10cm. An infrared phototransistor is such a transistor type that has two legs, emitter and collector, and can be triggered from infrared light. (Learning, 2020) the base of which is normally made from infrared light sensitive materials. An infrared light is part of electromagnetic spectrum human it is not visible to human eye but man can detect it as heat (NASA, 2020). The device was sourced from an Arduino kit. It has black lens with forward voltage of 1.2-1.4V and forward current of 100mA. It is capable of receiving infrared signal at about 7-8m. A phototransistor exposed to sunlight has about 100Ω resistance between its collector and emitter and 10MΩ resistance at darkness. The circuit in Figure 2 below was designed with few components and works perfectly when bread-boarded except that it malfunctioned due to self triggering from the shadow cast by the environment.

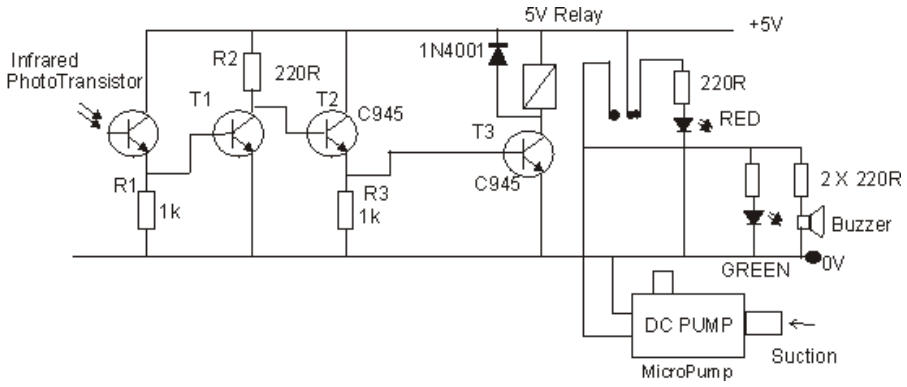


Figure 2: Phototransistor as a Sensor

Design using an Ultrasonic Sensor

An Ultrasound is sound wave with frequencies higher than 20 kHz, that is, beyond the upper audible limit for human ear, it is completely inaudible (Ballou, 2008). An Ultrasonic sensor uses Ultrasound to determine distance of an object. It is a non-contact sensor that finds its usage in this design work. The commonest types are HC-SR04.and HYSRF05; while the former offers precision of about 3mm, the latter has 2mm. Both have sensor angle of lesser than 15^{o}. The project used HC-SR04, being less expensive. HYSRF05 has an extra OUT pin thus making its pins equal to five (Arduino Learning, 2020). It is believed that the OUT pin goes high whenever it senses an obstacle.

Operations of HC-SR04

Its pins are Vcc, Trig, Echo and GND pins. The Trig. And Echo Pins are Input and Output pins respectively. Arduino codes produces a HIGH (+5V) across Trig pin to bias it to initialize a detect cycle, in order words, the pin has to be made HIGH for a duration of about 10μS to commence measurement. The sensor sends out Ultrasonic signal of eight square waves of 40kHz, (Components 101, 2020) it will now detect if there is any reflect signal. The Echo pin goes HIGH for the duration ultrasonic signal is sent out and returns.

The System's Codes

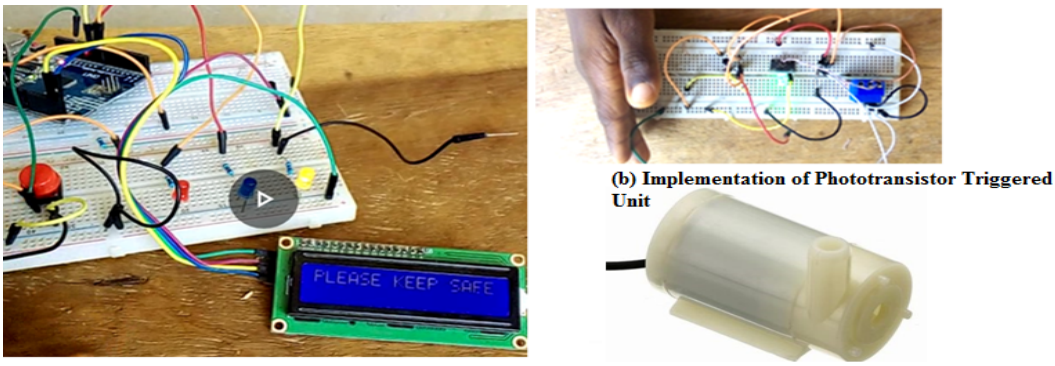
Codes were used to measure the period and calculate the distance of an object from the sensor, an IF and Else statements were used to determine when Sanitizer would be dispense, buzzer and pulsed tone coming on with LCD display session. System's codes are listed below.

```
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
LiquidCrystal_I2C lcd(0x3F,2,1,0,4,5,6,7);

#define trigPin  13
#define echoPin  12
#define sanitizerPump   8
#define  buzzerPin  9
#define  pulsedtonePin  10

void setup()
 {
 lcd.begin(16,2); // for 16 X 2 LCD module
 lcd.setBacklightPin(3,POSITIVE);
 lcd.setBacklight(HIGH);
 lcd.setCursor(0,0);
 lcd.print("HAND SANITIZER");
 lcd.setCursor(0,1);
 lcd.print(" MACHINE");
 delay(1000);
 pinMode(sanitizerPump,OUTPUT);
 pinMode(buzzerPin,OUTPUT);
 pinMode(trigPin,OUTPUT);
 pinMode(echoPin,INPUT);
  pinMode(pulsedtonePin,OUTPUT);
 }
void loop()
 {
```

```
 long  duration,distance;
 digitalWrite(trigPin,LOW);
 delayMicroseconds(2);
 digitalWrite(trigPin,HIGH);
 delayMicroseconds(10);
 digitalWrite(trigPin,LOW);
 duration=pulseIn(echoPin, HIGH);
 distance=(duration/2)/28.7;
 if(distance>=30||distance<=10)
 {
 digitalWrite(pulsedtonePin, HIGH);
 }
   else{
   delay(1000);
   digitalWrite(pulsedtonePin, LOW);
   lcd.clear();
   lcd.setCursor(0,0);
   lcd.print("HANDS DETECTED");
   delay(1000);
   lcd.setCursor(0,1);
   lcd.print("DISPENSE NOW");
   delay(1000);
   lcd.clear();
   lcd.setCursor(0,0);
   lcd.print("PLEASE KEEP SAFE");
     delay(1000);
   digitalWrite(sanitizerPump, HIGH);
   digitalWrite(buzzerPin, HIGH);
   delay(1000);
   digitalWrite(sanitizerPump, LOW);
   digitalWrite(buzzerPin, LOW);
     }
   delay(500);
}
```

Design using a Pedal Sensor.

Human presence can also be registered with the operation of Pedals. A pedal incorporates a switch that closes at depress and opens as the feet is removed (figure 3a). To realise the foregoing, a microcontroller pin was tied to a HIGH (+5V) through a pull-up 10kΩ resistor. The pedal switch contacts were connected between the pin and GROUND (0V). Since the system was active low, each time the pedal was depressed, HIGH (+5V) hitherto on the pin transit to LOW (0V) thus registering human presence. This triggering initialised a dispense cycle.



(a) Pedal Triggered Sanitizing Machine

(b) Implementation of Phototransistor Triggered Unit

(c) A Mini-micro Submersible Pump

Figure 3: Implementations on Breadboard

Pulsed Tone Generator

The design used Quad 2- input CMOS NOR gates CD4001 (Fairchild, 2020). The integrated circuit operates at voltage range of 3VDC to 15VDC. High level and Low level output voltages are 4.95V and 0.05V (Fairchild, 2020). At 25°C, quiescent device current I_{DD} at V_{DD} of 5V with Vin = V_{DD} or V_{SS} is 4µA. Low level and High-level output currents are 0.88mA and -0.88mA respectively. Low-level input voltage is 2V. The gates were connected in Astable modes. A 400Hz square wave was pulsed at every second. The Enable pin is active low: whenever the HIGH +5V becomes low, the unit becomes operative. For CMOS gates, time T which is the period is given by T =1.6RC (Nicholls, 2018) as different families of logic gate have different threshold voltage. A passive buzzer SFM -27 was connected across the output pin 12 and ground pin 7. The device has operating voltage of 3-24VDC and rated current of less than 12mA at 12VDC. Its resonant frequency is 3kHz (Open Circuit Shop, 2020). This buzzer requires a changing signal to make sound unlike an active type, which generates tone using an internal oscillator whenever a DC voltage is across its terminals. Passive buzzer is cheap and its sound frequency can be controlled to suit the designers' objectives. To enable the unit through pin1, a 180° phase shifter must be connected between microcontroller's pulsedtonePin 10 so that a HIGH +5V can be inverted since the tone generator is active low.

Simulation Using Proteus

Codes were written and compiled using Arduino IDE.

Results and Discussion

In the transistorized design (figure 2) having a phototransistor as sensor, with R1 of 1kΩ, at sunshine, voltage VR1 across R1 is 3.84V, as human hand was brought closer to the phototransistor, VR1 drops to 0.54V. Ti is direct coupled to the sensor stage; using a value of 220Ω for R2, at sunshine, the 3.84V drives T1 thus saturating it, hence making its collector to come down to 0.03V. In the same way, at a darkness occasioned by hands, 0.54V across R1 cut-off T1 thereby making its collector voltage VC rises to 5V. Transistor T2 was connected in common collector configuration, such configuration which is also termed emitter follower has 0^0 phase shift and gain of about unity. A high voltage across R3 switches ON T3 since it was connected in common emitter mode, a common emitter mode parades 180^0 phase shift, that is, it inverts signals at its input terminals, (Akinwole, 2020). Thus a high voltage at its base made its collector LOW voltage (0V), so a 5V is now effectively across the 5V operated relay. The energized relay closes its normally open contacts while opening the normally closed one. The normally open is connected to the 5V submersible micro pump and buzzer;

the relay common terminal was connected to VCC (+5V), thus as the normally open contact set is closed, 5V is connected to the pump and buzzer. While the pump delivers the sanitizer, the buzzer sounds an audible tone of 400Hz. A GREEN LED is lit whenever the pump dispenses while a RED LED connected to the normally closed set is always ON at standby, it will be off each time the pump operates. The other two designs, pedal and Ultrasonic sensors triggered, have same methods of operations going by their codes, the information on the LCD were also the same, only difference is the methods employed in detecting human presence. A pedal sensor is made up of a momentary switch which can be normally closed or opened, such switch is only closed or opened when depressed and remains closed or opened as long there is a depression. In this project, a normally opened momentary switch was used. A DC pump is basically of two parts, namely, electrical parts comprising a DC motor and a mechanical part, which incorporates carefully, formed impeller. The DC motor drives the mechanical unit thus imparting rotating motion on it. The speed of rotation is proportional to the DC voltage. The suitable pump selected was a 3-6VDC operated mini-micro submersible water pump with current ranging from 130-220mA, flow-rate of 80-120L/H and maximum head of 40-110mm. The Pulsed tone module is active low. According to the codes, signal generated to trigger the module was a HIGH (+5V). The triggering was achieved by connecting an inverter or NOT gate between microcontroller pin 6 and 1N4001 pin 1.

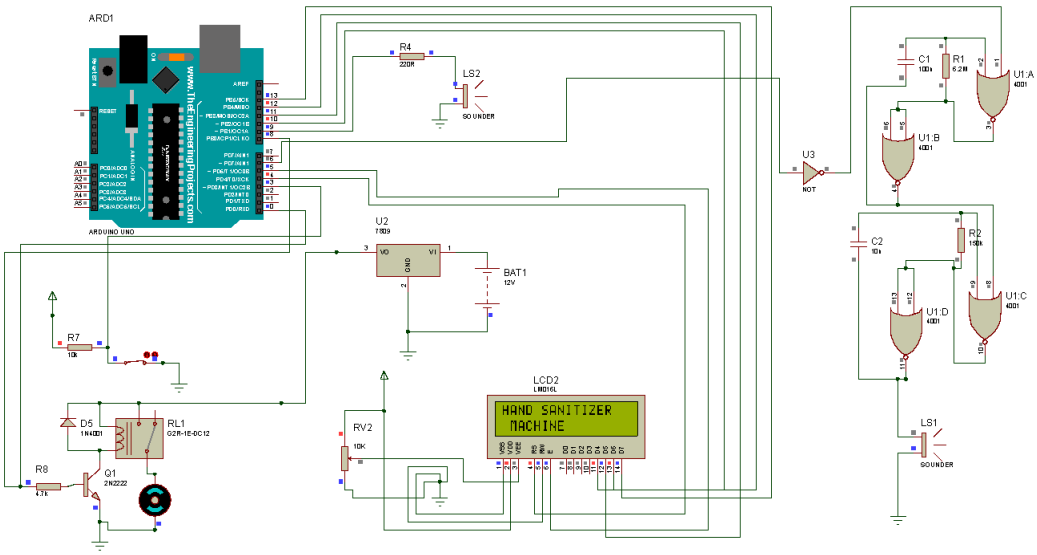


Figure 4: Complete Circuit in Proteus Environment

Conclusion

The paper has succeeded in summarizing simple design techniques used realizing touch-less sanitizing machines. Their codes, which were written with simplicity, will help any engineer or student to produce them in Nigeria thus helping in curbing the spread of COVID-19 virus. Also, the project will act as a springboard for acquiring knowledge on Arduino microcontroller based systems. In order to further enhance the availability of the machines going by the dearth of power supply in the rural areas. A solar powered solution comprising solar panel, deep cycle batteries and charge controller can be carefully selected to power the machines.

References

Arduino Learning. Arduino UNO and HYSRF05 Ultrasonic Sensor. Retrived online from www.arduinolearning.com August 2020.

Akinwole, O.O. (2018). Design and Simulation of a 1kVA Arduino Microcontroller Based Modified Sine Wave Inverter using Proteus. J. Electr. Electron Syst. 7:282

Akinwole, O.O. (2019). Design and Implementation of an Electric Cooker Control System as a Means of Preventing Domestic Fire Incidence. Journal of Engineering Research and Reports. 4(3):1-9

Akinwole, O.O. (2020). Design, Simulation and Implementation of an Arduino Based Automatic Water Level Controller with I2C LCD Display. International Journal of Advances in Applied Sciences. Vol 9. No 2. Pp 77-84

Ballou, G.M. (2008). Hand Book of Sound Engineers. Fourth edition, Focal Press. USA Pp40

CDC. What You Should Know About COVID-19 to Protect Yourself and Others. Publication of Centre for Disease Control. Retrieved online from www. cdc.gov. August, 2020

Components 101. HC-SR04 Ultrasonic Sensor. Retrieved online from www.components101.com, August, 2020

Fairchild Semiconductor. Quad 2 – Input NOR Gates Datasheets. Retrieved online from www.alldatasheet.com, August, 2020

Learning About Electronics. How to Build an Infrared Phototransistor Receiver Circuit. Retrieved online from www.aboutelectronics.com. August, 2020

NASA Science. What are Infrared Waves. Retrieved online from www.science.nasa.gov. September, 2020.

Nicholls, P. (2018). Electronics Resources, Accesses online from www.pfnicholls.com, August, 2020

Open Circuit Shop. Buzzer SFM-27. Accessed online from www.opencircuit.shop, August, 2020.

Tech Exploration. Arduino Sensor Tutorials. Retrieved online from www.techexplorations.com, August, 2020

Tutorial Point. Ultrasonic Sensor, HC-SR04. www.tutorialpoint.com. Accessed online August, 2020

World Health Organization. Bulletin of the World Health Organization, The Classical Definition of Pandemic. Retrieved online from www.who.int, August, 2020