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Experimental Design of Remotely Switched Devices using Tough Tone Signals for Physically Impaired Persons

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Abstract
In my country, the society faces challenges of embracing physically challenged persons. The vast majority being people with walking disabilities. This translates to segregation in job opportunities that require hands-on inclusion both at industrial and domestic scale. As a result, they are affected not only socially in emotions but also economically. Besides, they get inconvenienced in their daily activities and duties within their vicinity. This is much pronounced due to their inability to efficiently be mobile. This paper proposes an experimental design of a device for remote switching of actuated load circuits for physically impaired persons. It is to incorporate touch tone frequencies as a means of transmitting control commands. The touch tone frequencies are to be generated from the commanding end either through voice operated tones or key press tones. At the receiving end, a tone detector mostly a cellular phone is to be used to demodulate the tone which is the fed to the decoder circuit to generate the binary equivalent of received frequencies. This will then be fed to the control circuit which actuates the load circuitry. Unlike conventional wireless methods, touch tones can be transmitted over long distances as they rely on the service providers. This will prove effective for wider and complex applications if other interface systems are incorporated into the design. From the experimental set up, it was noticed that at least six actuator circuits could be controlled from an ordinary touch tone keypad. It was conclusive that touch tone controlled load circuitry would prove to be effective in terms of implementing such aid devices for physically impaired person. This is because cellular technology has a large coverage and relatively affordable to many households.

Index Terms— Key Words: Touch-tone; dual tone multi-frequency; actuators; electrical loads; switched devices.

1 Introduction

Persons with physical impairment face discrimination on daily functions including activities requiring hands on engagement (Oliver, 1999). This is despite their knowledge and capacity to serve equally in the society. When machine operation is mentioned, little is considered regarding this category of people. As seen in most industrial and domestic electrical applications, some machines need human engagement to operate fully. Unfortunately, these persons cannot be efficient in such operations with relevance to some technology applied. So as to effectively engage these persons, it is viable to involve wireless control applications which will allow them to remotely control devices that trigger actuation of both mechanical and electrical load circuits. There exists a number of wireless technologies in use but each come limitations. For instance, infrared communication is sensitive to line of path, Bluetooth protocol is limited to distance and Wi-Fi protocol requires complex infrastructure when this scenario is mentioned in third world states. In comparison, dual tone multi-frequency (DTMF) signaling uses existing infrastructure from service provides and hence more efficient to utilize.

According to Sharma (2006); Shatnawi (1997), touch tone better known as DTMF, is a system of signals used in telecom signaling over analog telephone lines in the voice frequency. The DTMF system uses a set of eight audio frequencies transmitted in pairs to represent 16 signals, represented by the ten digits, the letters A to D, and the symbols # and *. As the signals are audible tones in the voice frequency range, they can be transmitted through electrical repeaters and amplifiers, and over radio and microwave links, thus eliminating the need for intermediate operators on long-distance circuits.

Actuation on the other hand, implies the process of switching a load circuit. This can be achieved manually or using an automatic process. The automatic process can be done by interfacing relays or any other switching circuit as appropriate. The trigger signals can be from sensors or in this case the DTMF generator and receiver module.

This project provides an experimental design to this problem by utilizing DTMF signaling to come up with a remotely switched device for use in actuation of load circuits. This device can be interfaced together with normal mechanical switches/relays. This will enable this category of persons in the society to engage in any activity including mobility of parts through such simple automation circuitry.

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3 Materials and Methods

The project was implemented using Arduino microcontroller, relay bars, DTMF decoder module and 2 Nokia 105(TA-1203) phones. To demonstrate different loads, four AC bulbs were used in the experiment. The design was built on C programing language. The block diagram in Figure 1, was used to actualize the suggested system.

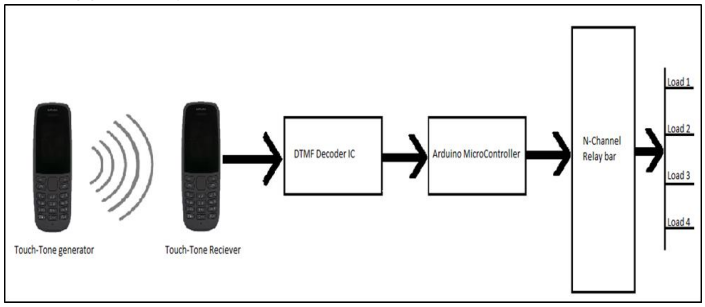

Figure 1: Experimental design block diagram

First, the receiver module was interfaced to the decoder IC. This is a typical GSM phone that is able to generate DTMF signals. In this case, a Nokia 1203 phone was used same as the touch tone generator. The receiver module works to receive/detect the DTMF signals. The generator module is one of the Nokia 1203 handsets which serves to produce respective touch-tone signals as shown in Table 1.

TABLE 1
DTMF Keypad frequencies

	1209Hz	1336Hz	1477Hz
697Hz	1	2	3
770Hz	4	5	6
852Hz	7	8	9
941Hz	*	0	#

After which the touch tone decoder was configured to the Arduino microcontroller digital input pins as shown in the Figure 2. The decoder module accepts incoming DTMF signals and converts them to binary equivalent as shown in Table 2. An algorithm was implemented as described below to implement the C program that was used to control the relays for the different load circuits

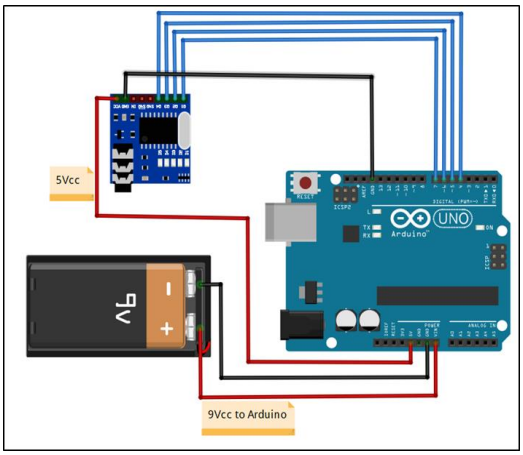

Fig. 2. Interfacing MT8870 IC to Arduino µP

TABLE 2
DTMF Signals binary equivalents

	(As indicated on MT8870 IC)			
Key	**Q4**	**Q3**	**Q2**	**Q1**
1	LOW	LOW	LOW	HIGH
2	LOW	LOW	HIGH	LOW
3	LOW	LOW	HIGH	HIGH
4	LOW	HIGH	LOW	LOW
5	LOW	HIGH	LOW	HIGH
6	LOW	HIGH	HIGH	LOW
7	LOW	HIGH	HIGH	HIGH
8	HIGH	LOW	LOW	LOW
9	HIGH	LOW	LOW	HIGH
#	HIGH	LOW	HIGH	HIGH
*****	HIGH	HIGH	LOW	LOW

Declare the constants and variables in the program and set up the outputs and inputs pins;

Let A, B, C and D be input terminals;

Let M, N, O and P be output terminals;

1. Start;
2. Digital read terminals A, B, C and D was commanded using a nested IF statement to detect the binary equivalent for each tone detected by the decoder IC;
3. Digital write command was initiated for the output terminals depending the read decoder IC outputs to initiate relay actuation for the four loads. Referring to the Table 2 above;
4. End.

To protect the high and low side switching, the relay bar module comes with opto-isolator. This protects the microcontroller from reverse leakages from high voltage interface. This process of operation is also called low-side switching. The final experimental design is represented in Figure 3.

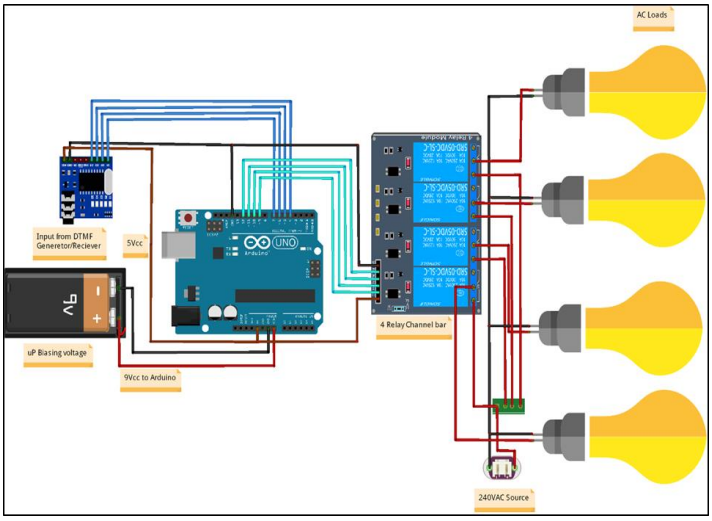

Fig. 3. Experimental design of DTMF based remotely switched devices

4 Results and Discussions

As shown in Figure 1, the user has to establish a connection with the control module. This is made possible by service provider networks. Control module has the Receiver node, Decoder IC, Microcontroller and Relays channel. When the user dials a key on any DTMF supported phone in this case Nokia 1203, a signal is generated and detected by the receiver circuit. The decoder (MT8870) which converts the signals to binary equivalent as given in Table 2. Using the embedded program based on the algorithm developed, respective activities are initiated. This is seen as the actuation of load 1 to load 4 to either turned ON or OFF accordingly. Therefore, the user achieves the intended goals by a simple dial of a keypad number on a GSM connected phone. For example, pressing the key 1: it has respective frequencies as 697Hz and 1209Hz. These frequencies through modulation are form a signal represented by binary sequence that is decoded by the MT8870 IC. The 0s represent digital LOW while 1s represent digital HIGH. Using the program as written in the sketch, load 1 is switched ON. When key 2 is pressed the respective binary code is used to switch OFF load 1. This sketch was implemented accordingly for the other keys and functions. The final embedded program sketch is illustrated below.

```
// constants won't change. They're used here to set pin
numbers:
const int buttonPin1 = 2;     // the number of the input pin
const int buttonPin2 = 3;
const int buttonPin3 = 4;
const int buttonPin4 = 5;

int ledPin1 =  13;      // the number of the LED pin defining
load relays 1 - 4
int ledPin2 =  12;
int ledPin3 =  11;
int ledPin4 =  10;

// variables will change:
int buttonState1 = 0;         // variable for reading the
MT8870 status
int buttonState2 = 0;
int buttonState3 = 0;
int buttonState4 = 0;

void setup() {
  // initialize the LED pin as an output:
  pinMode(ledPin1, OUTPUT);
  pinMode(ledPin2, OUTPUT);
  pinMode(ledPin3, OUTPUT);
  pinMode(ledPin4, OUTPUT);
  // initialize the pushbutton pin as an input:
  pinMode(buttonPin1, INPUT);
  pinMode(buttonPin2, INPUT);
  pinMode(buttonPin3, INPUT);
  pinMode(buttonPin4, INPUT);
}

void loop() {
  // read the state of the pushbutton value:
  buttonState1 = digitalRead(buttonPin1);
  buttonState2 = digitalRead(buttonPin2);
  buttonState3 = digitalRead(buttonPin3);
  buttonState4 = digitalRead(buttonPin4);

  // check if the Keypad is pressed. If it is, the
buttonStates toggle accordingly:
  if (buttonState1 == LOW && buttonState2 == LOW &&
buttonState3 == LOW &&buttonState4 == HIGH) {
    // turn LOAD 1 on:
    digitalWrite(ledPin1, HIGH);
  } else if (buttonState1 == LOW && buttonState2 == LOW &&
buttonState3 == HIGH &&buttonState4 == LOW){
    // turn LOAD 1 off:
    digitalWrite(ledPin1, LOW);
  } else if (buttonState1 == LOW && buttonState2 == LOW &&
buttonState3 == HIGH &&buttonState4 == HIGH){
    // turn LOAD 2 on:
    digitalWrite(ledPin2, HIGH);
  } else if (buttonState1 == LOW && buttonState2 == HIGH &&
buttonState3 == LOW &&buttonState4 == LOW){
    // turn LOAD 2 off:
    digitalWrite(ledPin2, LOW);
  } else if (buttonState1 == LOW && buttonState2 == HIGH &&
buttonState3 == LOW &&buttonState4 == HIGH){
    // turn LOAD 3 on:
    digitalWrite(ledPin3, HIGH);
  } else if (buttonState1 == LOW && buttonState2 == HIGH &&
buttonState3 == HIGH &&buttonState4 == LOW){
    // turn LOAD 3 off:

  } else if (buttonState1 == LOW && buttonState2 == HIGH &&
buttonState3 == HIGH &&buttonState4 == HIGH){
    // turn LOAD 4 on:
    digitalWrite(ledPin4, HIGH);
  }else if (buttonState1 == HIGH && buttonState2 == LOW &&
buttonState3 == LOW &&buttonState4 == HIGH){
    // turn LOAD 4 off:
    digitalWrite(ledPin4, LOW);
  }
  }
```

5 Conclusion

It was clear from the project findings that different loads were able to be controlled using dialed keys on a GSM connected phone. Provided the phone was able to support DTMF signaling. This can be utilized as an experimental design of a system for use by persons with physical impairment. This will see improvement in their efficiency when performing daily functions involving interaction with electrical devices that are isolated to their physical reach.

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