# Design and Development of a Control Circuitry for Secure Remote Device Access

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**Summary**
A novel secure remote device access procedure and control system is presented in this paper. The user can send DTMF tones to access the control panel of the robot, which is connected to a GSM module. The DTMF tones can be sent by any cellular phone with any existing operator. The advantage of this system is the use of GSM technology for communication and any GSM mobile phone can be employed. Furthermore it can be used in any remote device control system.

***Key words:***
*GSM module, DTMF tones, Decoder, 8051 MCU, Robot Control, Stepper Motor, Remote Devices and Motor Driver IC.*

## 1. Introduction

The application of remote control systems has gained immense popularity in recent times. This includes controlling machines in industries and home appliances from far away [1-2]. Existing systems are expensive to implement as different means of communication are used where immediate access is a challenge [3-5]. Existing systems also lack the security that would be required while implementing the system in a real world application [6]. So, a system is required to be designed such that can offer way out for both instant access and security issue.
The proposed system attempts to provide a cost effective solution to the problems found in controlling devices from off-site. The method of remote control is modified in this system focusing on faster access and diversity of applications. This is demonstrated in the system with precise control of robot and other devices. GSM technology is used in this system for communication between user and the remote devices to ensure the convenient access over appliances under GSM coverage [3-4,6]. This allows real time control and makes it more compatible compared to existing systems.
This system implements built in security feature in the form of separate password protection for each device [5,7]. The user inputs the password from the mobile keypad to assume control of any device. The password length can be modified according to the level of security and ease of use required by the user.

The suggested system is highly flexible and allows many devices to be controlled in different application areas [1,3,7-8]. In its current form the devices can only be controlled one at a time but parallel control can be achieved with some modifications. The following figure shows how GSM technology is used to implement the system.

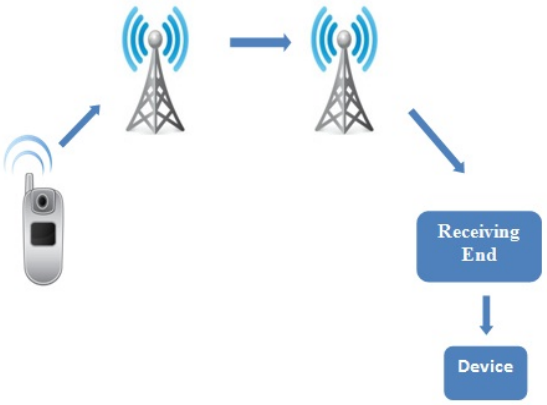


Fig. 1 System Diagram

## 2. Methodology

To operate the devices the user calls the Subscriber Identity Module (SIM) assigned to the GSM module. The GSM module automatically receives the call and receives the DTMF tone when a key is pressed by the user [3-5]. A DTMF decoder circuit decodes the DTMF tones [9]. Then the decoded binary value along with a status bit will be transferred to the Microcontroller Unit (MCU) from the decoder circuit [10]. The MCU always checks the status bit coming from decoder circuit. When MCU gets the status bit value is 1, it matches input with predefined password stored in its memory. If the input from the user matches the predefined password, the MCU grants the user access to the Device Control Subroutine. Otherwise the MCU moves to initial state and waits for next input command [Fig. 2].

### 2.1 Dual-tone Multi-Frequency (DTMF) Tone

DTMF tone is used to identify which key is pressed in the mobile keypad. The mobile keypad is used as password

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entry device. Pressing any key generates a unique tone which consists of two different frequencies one each of higher and lower frequency range. The resultant tone is the convolution of the two frequencies [11]. The frequencies and their corresponding digits are shown in Table 1.

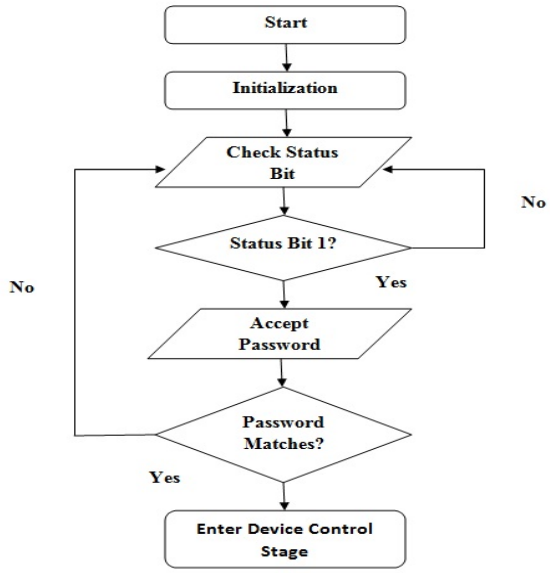


Fig. 2 System Flowchart

Table 1: The Frequencies and their corresponding numbers of DTMF

| **Frequency** | 1209Hz | 1336Hz | 1477Hz | 1633Hz |
|---|---|---|---|---|
| 697 Hz | 1 | 2 | 3 | A |
| 770 Hz | 4 | 5 | 6 | B |
| 852 Hz | 7 | 8 | 9 | C |
| 941 Hz | * | 0 | # | D |

There are three options for communication to implement in our system:

- Wireless Internet Platform (WIP)
- Short Message Service(SMS)
- DTMF Signal

WIP requires cost of network data usage for communication while DTMF does not [12]. As SMS requires external server to communicate, it causes delay [8]. But DTMF Signal System will allow real time control of the devices. Using of DTMF makes the system simpler to implement and independent of mobile operator. Among the three options DTMF signal is most convenient and the cheapest for the above mentioned reasons.

### 2.2 Decoding

For the decoding of DTMF tone MT8870 IC is used in the system. The MT8870 is a complete DTMF receiver containing both a band split filter and digital decoder functions. The filter section uses switched capacitor techniques for high and low group filters; the decoder uses digital counting techniques to detect and decode all 16 DTMF tone-pairs into a 4-bit code. Considering some special features such as complete DTMF receiver, low power consumption, internal gain setting amplifier, adjustable guard time, power-down mode [9]; the MT8870 IC is suitable for the system. The Pins 12, 13, 14 and 15 holds the corresponding decoded binary value. Pin 16 is a status bit which gives a pulse every time a key is pressed [Fig. 3].

### 2.3 Interfacing with MCU

8051 MCU was used for data processing in this system. Binary output from the decoder circuit is interfaced with a port of the MCU out of four [10]. Status bit of the MT8870 was connected to a pin of the MCU. The MCU takes decision depending on the decoded value which it receives from decoder circuit [Fig. 3].

## 3. Device Control

The Remote Device Access System implemented above can be used to control any electrical of electronic devices [2-3,5,7-8]. This will allow us to implement a Robot Control System as well as a system to control a Direct Current (DC) and an Alternate Current (AC) device. A Central Control unit will receive DTMF decoded binary values and decide whether the operator is allowed access to the control of the device by matching the input password with predefined password [Fig. 6].

### 3.1 Robot Control

The robot is isolated from the Central Unit. The Central Unit communicates with the robot through Radio Frequency Module which provides the separation from the Central Unit [Fig. 5]. During robot control stage whenever a key is pressed for any operation system first checks for status bit, then collects input command [1,6,12]. If the input matches to the predefined command input stored in the MCU of robot, it goes to the selected operation directly.

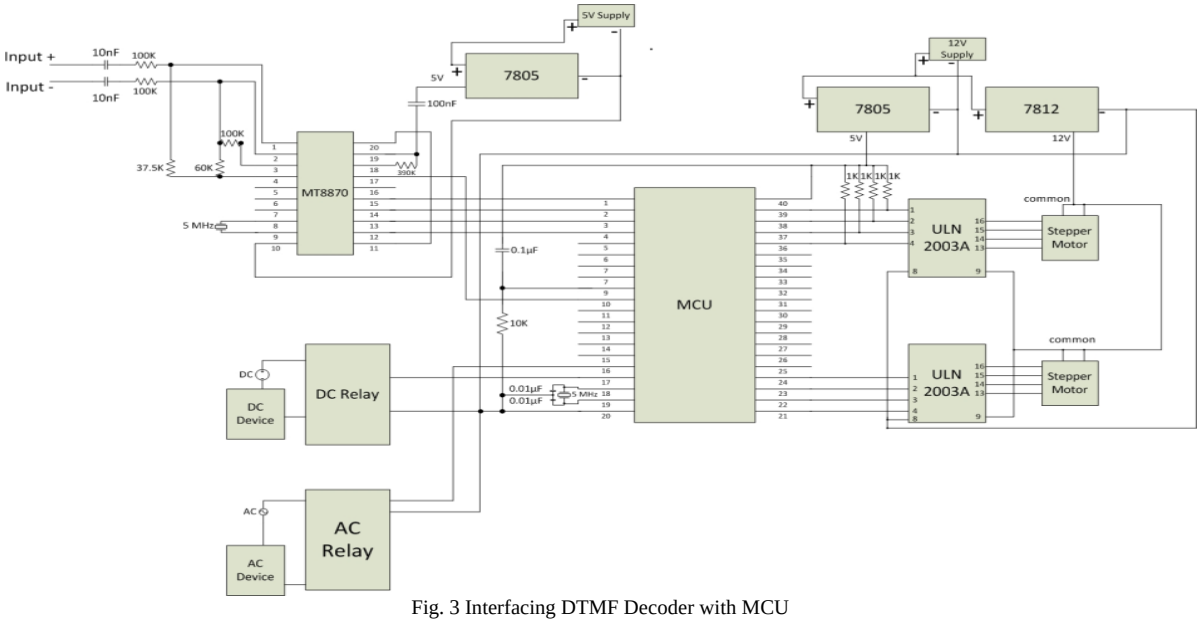


Fig. 3 Interfacing DTMF Decoder with MCU

When the robot is in a particular operation the MCU connected to the robot looks for new command continuously. As soon as it identifies a new command, it moves to that new operation. Otherwise, the robot remains in its previous operation. Thus the system provides a real time control on robot operation without interrupting present condition of movement [Fig. 4].

### 3.1.1 Stepper Motor

Unipolar stepper motors were used in the robot which has six inputs [13]. Four of the inputs were connected to four phases of the motor that were then connected to motor driver ULN2003A [14]. The remaining two inputs are common and were connected to 12V DC supply.

Four sequences are used to drive the Stepper Motor:

- 1 0 0 0 b (1a)
- 0 1 0 0 b (2a)
- 0 0 1 0 b (1b)
- 0 0 0 1 b (2b)

For each Motor per step rotation angle is 7.5° and 48 steps are required for one revolution. This allows for precise control of the movement of the robot.

### 3.1.2 Motor Driver IC

ULN2003A IC is used for stepper motor control in the system because the MCU cannot supply sufficient current to drive the stepper motors. ULNA2003A supports TTL, DTL, MOS or CMOS Compatible Inputs. It can provide output current up to 600mA and output voltage up to 50V with transient-protected outputs [14]. The Common pin of the ULN2003A is connected to 12V supply. The input pins of ULN2003A are connected to output of the MCU. The outputs of ULN2003A are connected to different coils of the Stepper Motors [Fig. 3]. If logic one is input to a pin of ULN2003A the output pin is shorted to ground. This completes the circuit by shorting that output to ground. Thus the corresponding coil connected to that output is energized.

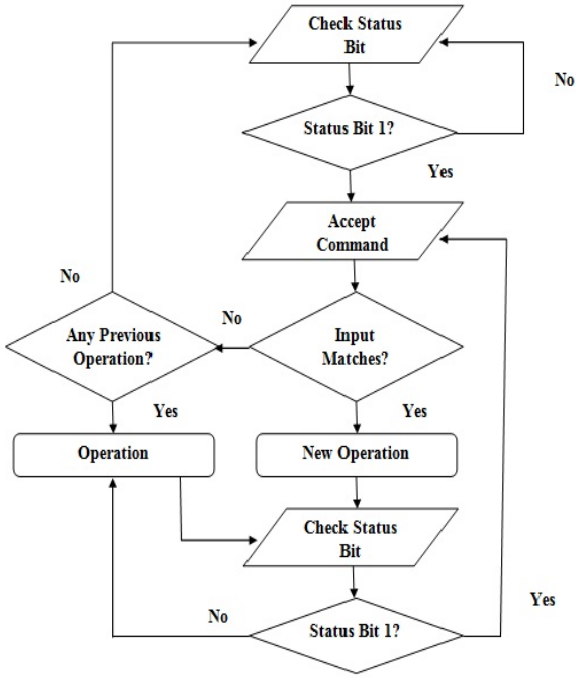


Fig. 4 Robot Control Flowchart

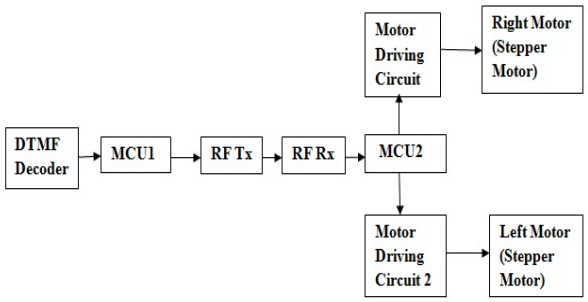


Fig. 5 Robot Control Block Diagram

### 3.2 AC or DC Device Control

If the operator inputs the correct password for any device the central command unit grants the operator access to the device control connected to the Central Unit. Then the operator can turn the device on or off according to his wish where the AC and DC devices are connected through AC and DC relay respectively [Fig. 6]. The AC and DC relay provide isolation between the Central Unit and the devices as they operate with different voltage levels [15].

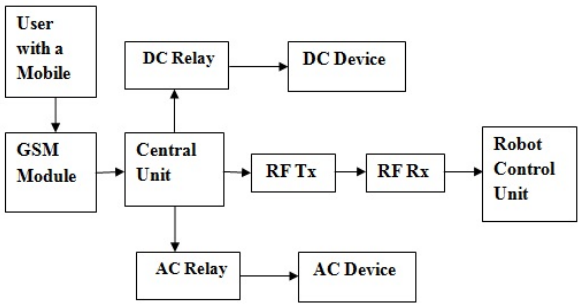


Fig. 6 Complete Block Diagram of System

## 4. Conclusions

As mentioned above the implemented system uses password protection for device control. It also uses GSM technology to communicate which reduces cost and simplifies the system. Thus a secure, low cost and user friendly system of remote device control has been proposed in this paper. The system has achieved its target of accessing remote devices and includes improvements compared to similar systems implemented previously. The improvements include secured access to any electrical and electronic devices which can themselves be separated from central control unit and communicates with RF modules. The potential for practical applications of this system is infinite, it can be used to implement intelligent homes; control of devices in industry from a central location and so on.

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