

# DTMF and GSM Based Home Automation System

Tathagata Biswas, Arghadeep Saha, Debraj Saha

Student member, IEEE, Department of Electrical Engineering, Meghnad Saha Institute of Technology, Kolkata 700150

*tathagatabiswas9@gmail.com, arghadeepsaha@gmail.com, debraj_saha@rocketmail.com*

**Abstract:** This research work investigates the potential of household appliance control which is the aim of the Home Automation Systems in near future. The analysis and implementation of the home automation technology using Global System for Mobile Communication (GSM) modem to control domestic appliances such as light, conditional system, garden system and security system via Dual Tone Multi Frequency (DTMF) signal detection and Short Message Service (SMS) text messages presented in this paper. The proposed research work is focused on functionality of the GSM protocol, which allows the user to control the target system away from residential using the frequency bandwidths. The concept of serial communication, decoding DTMF signals and AT-commands has been applied towards development of the smart GSM-based home automation system. Home owners will be able to receive feedback status of any home appliances under control whether switched on or off remotely from their mobile phones. Atmel ATMEGA microcontroller interfaced with a GSM modem provides the smart and low cost automated house system with the desired baud rate of 9600 bps. The proposed prototype of GSM based home automation system was implemented and tested with maximum of four loads and shows the accuracy of ≥98%.

**Keywords:** Global System for Mobile Communication (GSM); subscriber Identity Module (SIM); short messaging service (SMS); home automation; dual tone multi frequency (DTMF); solid state devices (SSD).

## 1 INTRODUCTION

In recent years, there has been a growing interest amongst consumer in the smart home concept [1]. Smart homes contain multiple, connected devices such as lightings, fans, security systems, pumps, garden water hose, home entertainment consoles, and surveillance. Intelligent home automation system is incorporated into smart homes to provide comfort, convenience, and security to home owners [2-4] while some solution also prevents misuse of electric energy and hence they can be considered as 'Smart Homes'. Home automation system reports the status of the connected devices in a user-friendly interface allowing the user to interact and control various devices with the touch of a few buttons. This system also responds to external parameters like temperature, soil moisture and occasionally reports to the user. Some of the explicitly used major communication technologies used by today's home automation system[5-7] for communication includes Bluetooth, WiMAX and

ISSN: 2222-7059 (print), ISSN: 2222-7067 (online), http://www.aspbs.com/aiem
DOI: 10.7508/aiem.2017.02.010

Wireless LAN (Wi-Fi), ZigBee, and Global System for Mobile Communication (GSM).

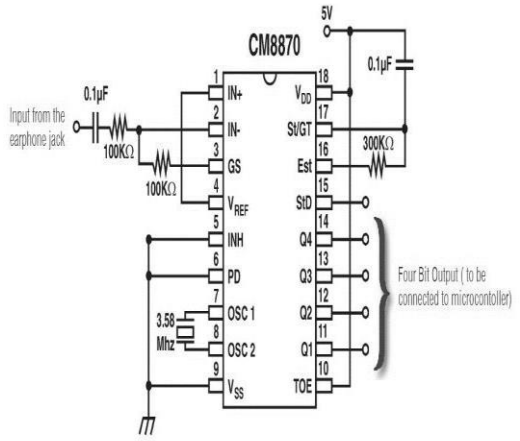


Fig. 1. Stage realization.

Among all these GSM is one of the most widely used cellular technologies in the world [8-9]. With the increase in the number of GSM subscribers, research and development [10-12] is heavily supported in further investigating the GSM implementation. However, one of the major limitations for the system is that it cannot control multiple appliances simultaneously but rather consecutively. ElKamchouchi and ElShafee [6] presented the design and prototype implementation of basic home automation system based on SMS technology using AT89C55 Atmel microcontroller. The microcontroller acts as the bridge between the GSM network and sensors of the home automation system. Further researches have been conducted to analyze the performance of other home automation control system [14-16]. Among the cellular technologies, GSM network is preferred for the communication between the home appliances and the user due to its wide spread coverage [8-9] which makes the whole system online for almost all the time. Also quite relatable with GSM is the DTMF signals which are low frequency unique audible tones that is emitted when a touch pad button is pressed allowing one to understand which button is pressed but they have to be decoded first and hence are practical and reliable. An advantage of using the GSM network in home automation is its high security infrastructure, which provides maximum reliability whereby other people cannot monitor the information sent or received. Hence, this work implements SMS and DTMF tone identification based control for home appliances using the GSM architecture without accessing the local network.

## 2 SYSTEM MODELLING

The design of our proposed smart GSM-based home automation system is given in three stages as shown in Fig. 1.

The first stage consists of a mobile phone, a GSM module/modem and a DTMF decoder IC. GSM modem with SIMCOM make SIM900 works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. It is very compact in size and easy to use as plug in GSM modem. The modem is designed with RS232 Level converter circuitry, which allows one to directly interface PC Serial port. The baud rate can be configurable from 9600-115200 through AT command. This GSM/GPRS RS232 Modem has an internal TCP/IP stack to connect with internet via GPRS.

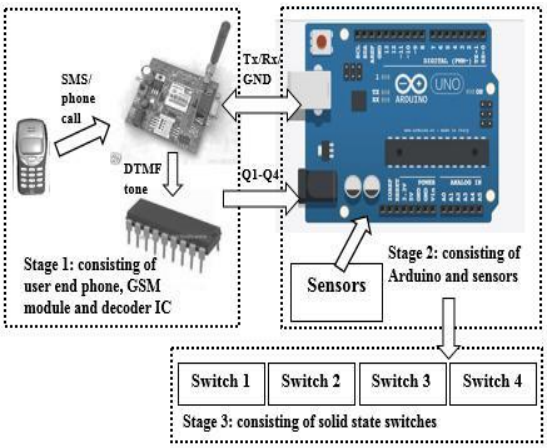


Fig. 2. DTMF Decoder IC pinout (CM8870).

It is suitable for SMS as well as DATA transfer application in M2M interface. The modem requires only 3 wires (Tx, Rx, GND) except an external power supply to interface with microcontroller. The built in Low Dropout Linear voltage regulator allows connection of wide range of unregulated power supply (4.2V -13V). The DTMF decoder is an 18pin IC capable of decoding the DTMF (refer to Fig 3) tones generated as numbers are pressed in keypad and outputs 4 bit binary equivalent via 4 pins (Q1-Q4 as in Fig 2). The GSM-MCU unit works on two modes. First of all, the user identifies his household appliances to be controlled and gives them a unique code of identification (in this case a single digit number) suitably and accordingly connect the devices to the switches. The user has to select a mode of operation comprising of 'MODE1' which is DTMF based control and 'MODE 2' a SMS based control. In case of 'MODE1' the modem is set to receive calls and at the same time the DTMF decoder is set to receive DTMF tones via SP+ and SP- pins of the modem. The user dials the SIM number in the GSM and presses appropriate numbers corresponding to the

appliances to be turned on or off. This number emits unique DTMF signals that are decoded the DTMF decoder IC by algorithms and digital signal processing to a 4 bit binary value and forwards them to the MCU. The DTMF decoded IC is shown in Fig 2 and the frequencies for each dial pad characters is shown in Fig 3. In case of MODE2, the user has to send an SMS to the modem where the message body consists of the operation to be carried out (for example, "SWON1" means switch device1 ON).The default mode is set to 'MODE2'. The GMS module runs on +12V DC and has an internal +5V regulator for TTL serial communication.

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

Fig. 3. DTMF keypad frequencies

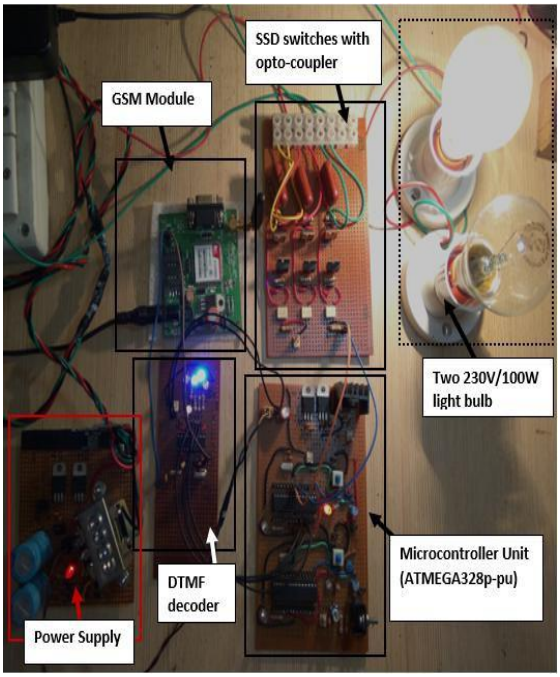


Fig. 4. Hardware Implementation.

The second stage consists of an ATMEL ATMEGA328p-pu microcontroller [18] in an ARDUINO development board. The MCU consists of in built 10 bit ADC, The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX).The microcontroller is programmed via the Arduino IDE [19] with the instructions written in C language. Arduino IDE features syntax highlighting, brace matching, and automatic indentation, and it is also capable of compiling and uploading programs which are called 'sketches' to the Board with a single click. The baud rate is selected as 9600 bps and the modem automatically sets the baud rate of the first command sent by the microcontroller after it is powered up. The microcontroller continuously scans its ports for change in sensor values. It can be connected to various sensors including temperature sensor, Light Dependent Resistors (LDRs), mains power sensor, soil moisture and temperature sensors for gardening monitoring etc. For 'MODE1' it processes the information received at the digital pins from the decoder output (Q1-Q4) and decides whether to switch on or off a particular appliance based the decoded information and notifies the user communicating the GSM modem to send a SMS to the user for feedback. It is also programmed to notify the user in case of power failure or changes in sensor values. In MODE2, the MCU receives the SMS as a string of characters consisting of index, sending mobile number, date and time and the message body, through its serial port from which the actual command message is retrieved. The user can ask for 'STATUS 'to view present status of all appliances. The two modes provide flexibility to the user.

The third stage consists of some solid state devices (SSD) connected to the mains voltage and isolated from the MCU. The device used in this project work is a back to back combination of SCRs with an opto-coupler for each device. One advantage is that no separate source is necessary to operate the switches and the drivers. Isolation ensures that the MCU does not come into contact with mains voltage. The MCU is powered by an external supply of +12V.

## 3 IMPLEMENTATION

The entire set up has been implemented on hardware and on simulation as well. It is shown in Fig 4.The MCU with the SSD switches, opto-isolated TRIAC drivers and a virtual keypad with LEDs is simulated in Proteus 8 Professional to show the behavior of the decoder IC and to be assured of any transient problem during switching.

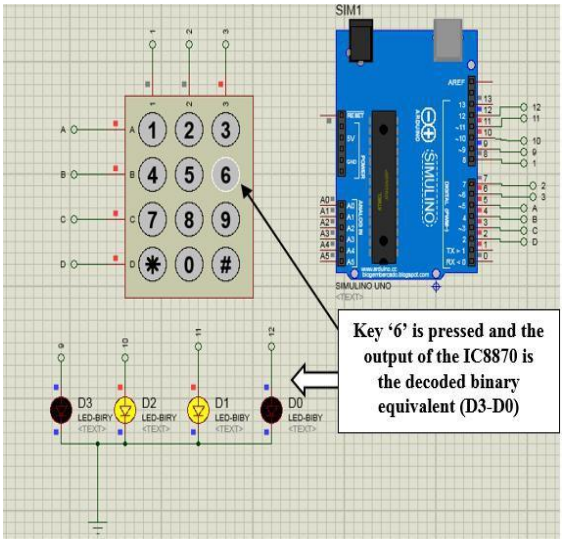


Fig. 5(a). Proteus simulation of working of DECODER IC XX8870 in the equivalent form of virtual Keypad with LEDs.

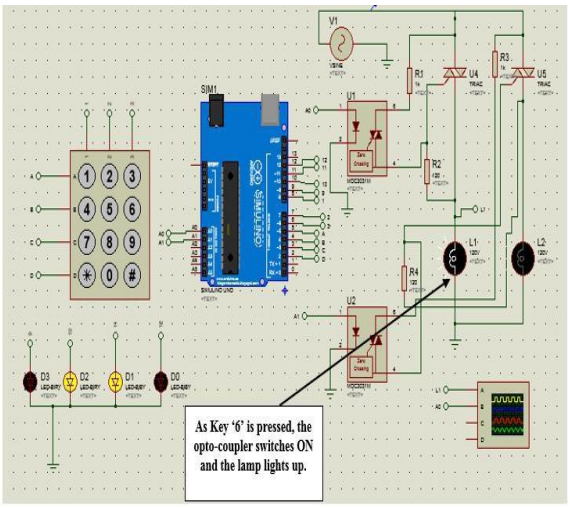


Fig. 5(b). Proteus simulation schematic of the DTMF control of load switching.

The virtual keypad is analogous to the keypad of the phone while the LEDS are analogous to the 4 bit digital output as binary equivalent from the decoder IC8870 via pins D3-D0. The mains voltage has been kept to an optimum 240V AC RMS. A virtual oscilloscope is used to observe the transient behavior during switching. The simulation model of the equivalent working of decoder IC is shown in Fig 5(a) and the overall simulation schematic with and results are shown in Fig 5(b) and 5(c) respectively with the lamp (L1) shown lit up when key '6' is pressed.

For simplicity only two switches are shown. Practically the number of loads is limited by the number of pins of the MCU. In this work, two loads of 230V, 100W, Incandescent bulbs are switched.

TRIAC opto-couplers are used as the driver stage of TRIAC switches and they switch at zero crossing of the voltage across the opto-coupler. No undesirable transient across the lamp during and after switching is detected as shown. The simulated load is a 230V, 240Ω lamp.

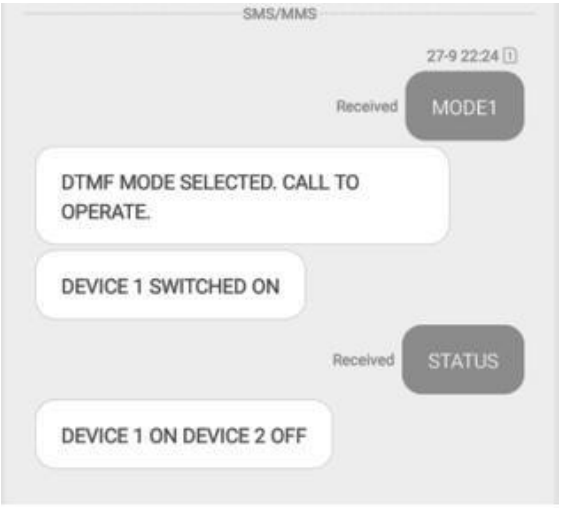


Fig. 5(c). Proteus simulation results.

✓ *Fig 5(c) needs to be interchanged with Fig (6) with labels unchanged.*

## 4 OBSERVATONS & DISCUSSIONS

The hardware was implemented and tested with both phone call (DTMF) and SMS on two domestic lamps of 100W, 230V and the outcome is promising. After detecting the message or DTMF tones, the MCU is supposed to read and decode the incoming message to execute the intended command, which is turning on the loads. The acknowledgement messages from the MCU during Mode selection and load switching via the GSM modem and also A 'STATUS' request message is shown is shown in Fig 6.

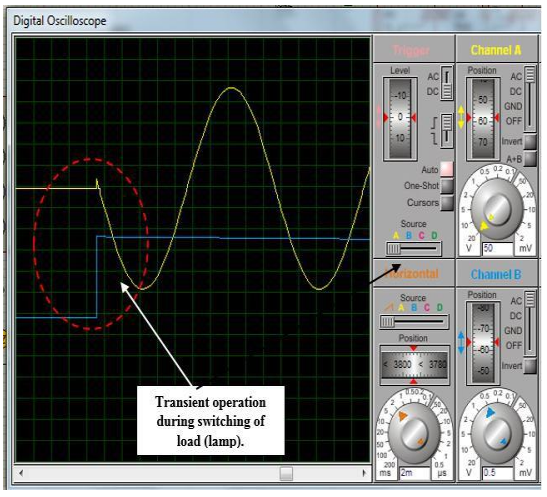


Fig. 6. SMS communication between User and GSM modem.

The whole process is being executed within a short period of time that does not exceed 2-3 seconds.

Also the delay in the operation of the MCU and GSM via SMS is totally dependent on the network availability of both at the user's end and the SIM plugged in the modem.

## 5 CONCLUSION

Recently, the home automation market is very promising field that is growing very fast and needs vast range of developments that can be carried out in the concept of smart home. Often it happens common people forget switching lights or fans before leaving their homes, in such cases smart controlling systems for domestic loads can also reduce energy wastage remotely. When integrated with proper sensors that will notify the user in case of any abnormality. In this project design and implementation of smart GSM based household loads monitoring control was considered. This type of ideas could be implemented in highly urbanized states where people due to their busy schedule often ignore their appliances resulting in energy wasted. Equipped with soils moisture and temperature sensors, this project could easily be implemented in rooftop or backyard garden watering without the physical presence of the owner. Here ATMEGA328p-pu microcontroller with the cooperation of GSM provides the smart automated house system. The proposed prototype was implemented and tested with maximum of four loads and shows the accuracy not less than 98%.

## REFERENCES


[1] B. I. Ahmad, F. Yakubu, M. A. Bagiwa, and U. I. Abdullahi. 2011. Remote Home Management: An alternative forworking at home while away. World of Computer Science andInformation Technology Journal (WCSIT), vol. 1, no. 4, pp. 144-147.

[2] A. W. Ahmad, N. Jan, S. Iqbal, and C. Lee, 2011. Implementation of ZigBee-GSM based Home Security Monitoring and Remote Control system, in Proc. 2011 IEEE 54th International Midwest Symposium on Circuits and Systems (MWSCAS), Seoul, pp.1-4.

[3] T. Begum, M. S. Hossain, M. B. Uddin, and M. S. H.Chowdhury, 2009. Design and development of activation andmonitoring of home automation system via SMS throughmicrocontroller, in Proc. 2009 4th International Conferenceon Computers and Devices for Communication (CODEC2009), Kolkata, pp. 1-3.

[4] Y. Zhai and X. Cheng, 2011. Design of smart home remote monitoring system based on embedded system, in Proc. 2011 2nd International Conference on Computing, Control and Industrial Engineering (CCIE), Wuhan, pp. 41-44.

[5] S. I. Azid and S. Kumar, 2011. Analysis and Performance of a Low Cost SMS Based Home Security System. International Journal of Smart Home, vol. 5, no. 3, pp. 15-24.

[6] H. ElKamchouchi and A. ElShafee, "Design and prototype implementation of SMS based home automation system", in Proc. 2012 IEEE International Conference on Electronics Design, Systems and Applications (ICEDSA), Kuala Lumpur, pp. 162-167.

[7] M. S. Khandare and A. Mahajan, 2010. Mobile Monitoring System for Smart Home, in Proc. 2010 3rd International Conference on Emerging Trends in Engineering and Technology (ICETET), Goa, pp. 848-852.

[8] G. Gu and G. Peng, 2010. The survey of GSM wireless communication system," in Proc. 2010 International Conference on Computer and Information Application (ICCIA), Tianjin, pp. 121-124.

[9] G. Mingming, Shaoliangshan, Huixiaowei, and Sunqingwei, 2010. The System of Wireless Smart House Based on GSM and ZigBee," in Proc. 2010 International Conference on Intelligent Computation Technology and Automation (ICICTA), Changsha, pp.1017-1020.

[10] C. Felix and I. J. Raglend, 2011. Home automation using GSM," in Proc. 2011 International Conference on Signal Processing, Communication, Computing and Networking Technologies (ICSCCN), Thuckafay, pp. 15-19.

[11] C. Peijiang and J. Xuehua, 2008. Design and Implementation of Remote Monitoring System Based on GSM, in Proc. 2008 Pacific-Asia Workshop on Computational Intelligence and Industrial Application (PACIIA '08), Wuhan, pp. 678-681.

[12] B. S. Rao, S. D. V. Prasad, and R.M. Mohan, 2010. A prototype for Home Automation using GSM technology, in Proc. 2010 International Conference on Power, Control and Embedded Systems (ICPCES), Allahabad, pp. 1-4.

[13] C. K. Das, M. Sanaullah, H. M. G. Sarower, and M. M. Hassan, 2009. Development of a Cell Phone based Remote Control System: an Effective Switching System for Controlling Home and Office Appliances. International Journal of

Electrical & Computer Sciences, vol. 9, no. 10, pp. 23-29.

[14] K. Gill, S. -H. Yang, F. Yao, and X. Lu. 2009. A zigbeebased home automation system. IEEE Transactions on Consumer Electronics, vol. 55, no. 2, pp. 422-430.

[15] L. Pu, "An Improved Short Message Security Protocol for Home Network," in Proc. 2009 International Conference on Future Computer and Communication (FCC '09), Wuhan, pp. 62-65.

[16] T. Perumal, M. N. Sulaiman, Khaironi Yatim Sharif, A. R. Ramli, and C. Y. Leong. 2013. Development of an Embedded Smart Home Management Scheme. International Journal of Smart Home, vol. 7, no. 2, pp. 15-26.

[17] L. Wei, Y. Min, C. LiangLiang, and C. Ping, 2011. The Design of Intelligent Household Control System Based on Internet and GSM," in Proc. 2011 Second International Conference on Networking and Distributed Computing (ICNDC), Beijing, pp. 254-256.

[18] Atmega328p-pu Mouser, http: // www. Mouser. com/ds/2/36/atmel-8271-8-bit-avr-microcontroller-atmega48a-48p-365589.pdf

[19] Arduino IDE, http://arduino.cc/en/main /software.