Multiple Unit GSM Controlled Devices

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***Abstract*- The human mind always needs information of interest to control systems of his/her choice. In the age of electronic systems it is important to be able to control and acquire information from everywhere. Remote management of several home and office appliances is a subject of growing interest and in recent years we have seen many systems providing such controls. In this study, we have developed an interface which is a phone based home/office remote controller equipped with power to turn ON/OFF and receive STATUS of electrical appliances remotely located.**

Keywords: DTMF, mobile phone, Micro-controller, Keypad tone.

INTRODUCTION

This research is borne out of the need for man to control electrical devices that are remotely located to him. Anything from home devices such as alarms, heating, air conditioning and so on, to commercial security systems or IT equipment such as routers and servers and the like can be remotely controlled. The case of remote control capability and the possibility of achieving it at a reasonably low cost have motivated the need to research into it not only for industrial application but also for domestic use.

The desire of man to control an object that is remotely located to him has been for many ages. However, the technology that meets the perfect desire in this respect has not been obtained, though there is increasing improvement in technology that struggles to meet this need in terms of accuracy, speed, ease of operation and limitless operation point.

The introduction of the Global System for Mobile Communication (GSM) and particularly the use of hand-held mobile phones brought the innovation of distance communication at remote location. Based on this, research utilizes this facility for remote control of systems and appliances; take for instance, a man on a journey inside his car suddenly remembers that he left the Air Conditioner (AC), ON when it was supposed to be OFF. The normal condition is to drive back and switch OFF. But with the GSM mobile phone in the hand, one looks on how the same could be used to effect control at any point and time.

Method of controls rest on the input and output standard of mobile phones common to all phones. There are basic outputs and inputs of every mobile phone. Inputs like the keypads and microphones are the basic inputs [4]. The outputs are the speakers, backlights, vibrations and sounds. The basic inputs and outputs can be used with appropriate transducers. This research takes advantage of the keypad tone that is a standard in all phones.

AIM AND OBJECTIVE

The main aim and objective of the project is to develop an interface between the GSM and electrical appliances suitable for several models of mobile phones that enables a two way system of practical communication between the GSM and remote electrical appliances.

RELATED WORK

During the course of research some related works were found a few are briefly discussed:

Dial2open GSM Remote Control and GSM Alarm

The Dial2open GSM is a remote control switch that connects to the GSM mobile phone network. It enables one to open automated gates, barriers and garage doors using a mobile phone. Simply 'speed-dial' the dial2open which identifies you as an authorized user and the automatic gate, barrier or door opens [5]. There is no call costs incurred when calling the unit, it will recognize an authorized telephone number calling it and reject the call without answering. Easily programmed by SMS text message, authorized telephone numbers can be added and deleted as required.

GSM Based Device ON-OFF Control Especially Designed For Agricultural Needs

The device consists of GSM modem, microcontroller, Motor Starter, relays, memory and display. If the user wants to control some devices in his house he/she have to send the SMS indicating the operation of the device and then the system password, while the MODEM embedded with the system microcontroller receives SMS. The microcontroller will read SMS and check for the password the user had sent with the SMS [1]. If the password is correct then it will check whether the message is for switch ON or OFF the Motor, According to the received message the controller will switch on / off the relays. The device is password controlled, therefore only the people who know the device password are capable of controlling the device. The relay and buzzer are controlled by the microcontroller using single pins, i.e. giving high means device will switch on and vice versa. Sometimes it may be interchange according to the transistor used to drive the device.

GSM-Auto Remote Control Switch

The GSM-AUTO is a GSM remote control switch, it connects to the cell phone network and like a cell phone has its own cell phone number. The GSM-AUTO is activated by calling its cell phone

number, it will recognize an authorized telephone number calling it, reject the call without answering and switches ON or OFF the device connected to it, because it rejects the call without answering there are no call costs incurred. It has 2 independent relay switches with normally open and normally closed switch contacts, these can be programmed to switch on for a pre-determined length of time whenever the GSM-AUTO is called, alternatively the switches can be permanently switched ON or OFF by sending the GSM-AUTO a Short Message Service (SMS). Applications include the remote control of heating in holiday homes, lighting, engine pre-heaters, aviation engine heaters, irrigation systems, water well pumps, pumping stations, cabin heaters, resetting and reboot of remote servers and routers, arming and disarming security systems, access control of roller shutters, garage doors and gates.

In the above related work since the Short Message System (SMS) are used there is a disadvantage of late delivery of SMS because of traffic on the Networks. Users might not be able to track what appliance is ON at a particular time. In subsequent sections the method adopted for this "Multiple Unit GSM controlled devices" is discussed as it takes advantage of the keypad tone hence ensuring that user tracks each equipment just by the press of a button.

METHOD ADOPTED IN RESEARCH WORK

The keypad of the handset is a common but interesting feature on every phone . The keypad has tones, each with unique frequency (and hence sounds). Once a call is acknowledged by the receiving phone, the speakers of the two phones (the transmitter and the receiver) are automatically activated to receive keypad tones when the buttons of any of the phones is depressed. Every phone irrespective of manufacturer has twelve (12) keypads. The twelve keypads are Key 0 to 9, asterisk (*) and the hash (#). These tones are automatically transmitted and received as the keypad tones. With independent frequency and twelve in number, each button could be used to transmit command to the control equipment. Thus several independent commands could be generated using this approach. With the trend in technology where microcontroller has gained wide appreciation, the controls are not limited to twelve (12). The keypad tone is a frequency array in matrix form as indicated in the Table 1 below. The address of any number is given by two frequencies, the row and column frequencies. By so doing, every number of the keypad can be located on the matrix table. The keypad tone is used to generate the necessary command that will activate electromagnetic or solid state relays for switching ON and OFF and the accessing of the STATUS of several appliances.

TABLE 1
FREQUENCY MATRIX OF THE KEYPAD OF PHONES

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

PROPOSED SYSTEM

In the research, special attention is put on the critical condition that makes the component and the module operate efficiently. All components are discussed and the functions in this research. The major problem accosted in engineering design is to fully and correctly specify the requirements of the design. The 'multiple units GSM controlled devices' system design process involves the following;

1. Full analysis of the system specification.
2. Hardware design

The hardware tasks include the definition and analysis of suitable circuit components used in achieving the circuit design of the multiple units GSM controlled devices, and the circuits necessary for taking electrical signals as inputs, activating, deactivating and getting feedback from electrical appliances. The first task is getting DTMF IC to receive the signals from the keypad of the mobile phone. The second task here is the writing of a suitable program used by the Micro-controller, which will performs the right selection function that would switch ON/OFF and check STATUS of the electrical devices. The hardware or circuit would be clearly divided into some major divisions, which are:

1. The Dual Tone Multi Frequency (DTMF) Signaling (HT9170B)
2. The Micro-controller (PIC18F4550)
3. BCD Decade converter (4028B)
4. The Driver and Switching state
5. The Circuit Power Supply

The operator uses the transmitting mobile phone to call the phone number of the receiving mobile phone, immediately the receiving mobile phone receives the tones through the earpiece, which will be converted to binary number that each represents using a standard Integrated Circuit (IC) chip called Dual Tone Multi-Frequency Decoder (DTMF). The binary numbers are fed into BCD-to-Decimal decoder which converts the binary output of the DTMF into a form that the micro-controller can use. The output decimal is fed into a microcontroller that serves three purposes which are outlined as follows:

1. Decode each device address and send command signal to its corresponding driver.
2. Ensures dual operation action – device ON or OFF.
3. Provides a feedback STATUS of the device under control whether ON or OFF.

The final output of electrical devices is to the electromagnetic relays that are driven by electronic buffers. The figure 1 shows the operational block diagram of this proposed system.

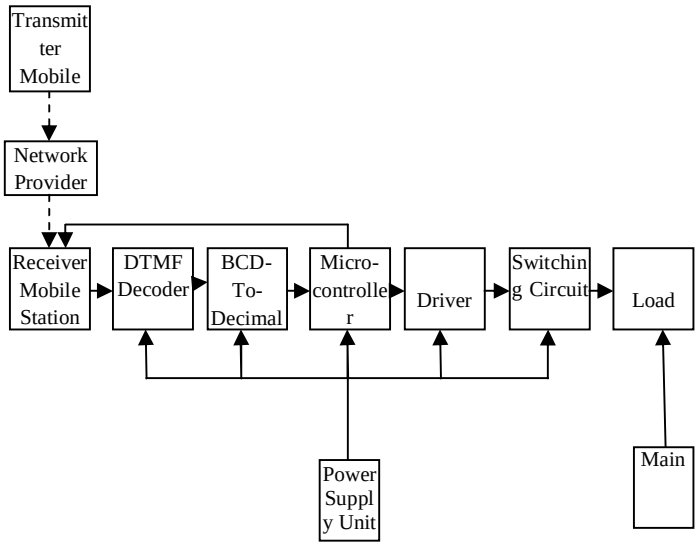


Fig 1 The operational block diagram of the project.

TRANSMITTING MOBILE STATION

The naming convention "Transmitting Mobile Station" has been chosen for the Mobile phone with the person that intends to control one or more devices at a remote location. The person who wants to switch ON/OFF and get STATUS of any device at the remote location dials the number of the Remote Station. The call to the Mobile Station can be via any Network Provider and their tariffs apply.

RECEIVING MOBILE STATION (BASE STATION)

The naming convention used for the phone that is in the remote location, attached to the circuitry is "Receiving Mobile Station". In this design we take advantage of the Automatic Answer that is activated with the insertion of an Earphone. The mobile phone on the receiver side picks up the phone automatically after 5 seconds (timing can be specified), and then makes the tones available to the DTMF tone decoder IC through the headphone jack of the phone. This research can be used with any model of mobile phone the only major challenge is that the pin connections of the earphones may differ and so the right earphone must be used.

DTMF DECODER (HT9170D)

The DTMF decoder decodes DTMF signals and it is audible sound that can be heard when the keys are depressed on the telephone keypad. The DTMF decoder converts the received tones to their respective binary values and then outputs them [8]. Its internal architecture consists of a band split filter section which separates the low and the high tone of the received tone pair, followed by a digital decode(counting) section which verifies both the frequency and duration of the received tones before passing resultant 4-bit code to the output bus.

BCD-TO- DECADE DECODER (HEF4028B IC)

The BCD Decade Converter (HEF4028B IC) is a 4-bit BCD to decimal decoder. The outputs are fully buffered for best performance. When used as a BCD to decimal decoder a 1-2-4-8 BCD code applied to inputs A0 to A3 causes the selected output to be HIGH while the other nine outputs will be LOW [10]. The 4028 converter decodes a 4-bit BCD code from the DTMF to a decimal which only allows for one output to be high at a time while the others low. As a BCD to decade converter, it will only respond to input value from 0 to 9.

MICRO-CONTROLLER (PIC18F4550)

The micro-controller is a microprocessor with provisions for input and output embedded in it. It consists of timers, Analog to Digital Converters (ADCs), Universal Synchronous Asynchronous Receiver Transmitter (USART), etc. It is an 8-bit microcontroller with flash program memory and Electrically Erasable Programmable Read Only Memory (EEPROM); it contains 83-instructions which includes byte-operations, bits-operations and branching. It has five 8-bits ports which can be bit-wise or byte-wise addressed [9].

The three major features of the design are:

1. Receives instructions on pin 2,3,4,5 and 33, decodes them to give device address and command, then sends corresponding signals to the driver of the power circuit.
2. Ensures dual independent operation action – device ON or OFF.
3. Provides a feedback STATUS of any device under control whether ON or OFF.

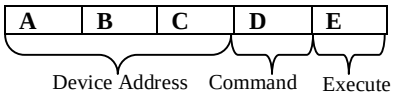
The design parameters and steps are outlined as follows:

1. Read and store received key values in a First-In-First-Out (FIFO) buffer
2. All commands ends with key "5" to execute the last four digits stored in the FIFO buffer.
3. Decode the first three digits to device address and the fourth digit to a command to be executed.

Design for switch ON, OFF and STATUS

For individual control of the devices, three digits address are allocated to them. A forth digit is added to determine which command is to be executed on the device. Then, the system uses a 5-digit instruction code as shown below in the Table 2:

TABLE 2
INSTRUCTION CODE FORMAT FOR A DEVICE



The instruction code determines if the device should be ON, OFF or the STATUS should be returned to the user. The following are the codes for the commands:

- "**2**" on the instruction code indicates that the device should be switched **ON.**
- "**7**" on the instruction code indicates that the device should be switched **OFF.**
- "**9**" on the instruction code indicates that the **STATUS** of the device should be returned.
- The fifth digit of the instruction is always "**5**" for execution.

The Table 3 shows the instruction codes for each device.

TABLE 3
INSTRUCTION CODE FOR ALL THE DEVICES

Device	ON instruction code	OFF instruction code	Get STATUS instruction code
1	2 7 6 **2** 5	2 7 6 **7** 5	2 7 6 **9** 5
2	2 9 6 **2** 5	2 9 6 **7** 5	2 9 6 **9** 5

Device	ON instruction code	OFF instruction code	Get STATUS instruction code
3	6 2 6 **2** 5	6 2 6 **7** 5	6 2 6 **9** 5
4	6 7 6 **2** 5	6 7 6 **7** 5	6 7 6 **9** 5
5	6 9 6 **2** 5	6 9 6 **7** 5	6 9 6 **9** 5
6	7 2 6 **2** 5	7 2 6 **7** 5	7 2 6 **9** 5
7	7 9 6 **2** 5	7 9 6 **7** 5	7 9 6 **9** 5
ALL	9 2 6 **2** 5	9 2 6 **7** 5	Not available

Design of the feedback (Device STATUS)

The system is programmed to give one beep when the device is OFF and five beeps when it is ON. At any point in time, this STATUS can be obtained.

DRIVER/ BUFFER (ULN2003A)

The output of the micro-controller is of low power and cannot directly drive the switching circuit hence the need for a driver or buffer circuit. Each unit is a Darlington pair transistor with very high gain. It is equipped with freewheeling diode protection system. The input current can be as low as 100uA for an output of 100mA current at a voltage between 3V to 5V. This is suitable for the electromagnetic rely of load current 80mA

SWITCHING CIRCUIT

The switching circuit comprises of the relays and socket. The switching circuit uses low power to switch high power and depends on the power requirement of the load. Typical values are 76mA current at 12V used to switch 20A load at 240V. With the advent of semi-conductors, solid state relays can conveniently replace the conventional relays. The size of the switching circuit is dependent on the type and capacity of load to be driven. For demonstration of this project, moderate loads shall be driven hence relays of 20A, 250V are used which would require a driving current of 76mA at 12V.

POWER SUPPLY

The power requirement of the work is the sum of all individual power requirements of the DTMF decoder, BCD decoder, micro-controller, driver and switching circuits.

CIRCUIT DIAGRAM

This research adhered to all specifications for all Integrated Circuit (IC) as stated in the manufacturers' data sheet. The proposed systems' circuit diagram showing the interconnection between devices is shown in Figure 2.

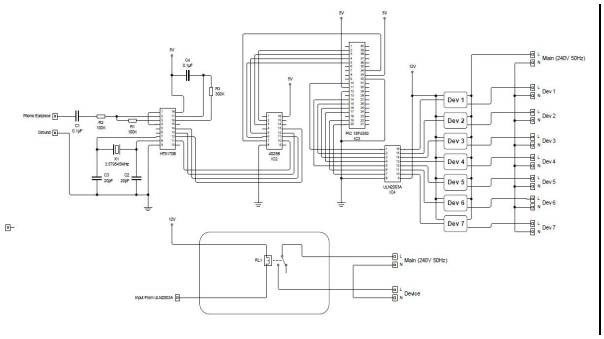


Fig 2: The circuit diagram of the multiple units GSM controlled device.

SYSTEM OPERATION

The following is a step by step outlined process of how the proposed system is used:

1. Ensure the battery of the receiving mobile phone is fully charged and the ear piece is connected.
2. Connect the load appliances to the output terminals of the relay block.
3. Connect the circuitry to 240Volts power supply.
4. Dial the receiving mobile phone number using any phone. Wait for 3 to 5 sec for the acknowledgement from the receiving mobile phone.

5a) ***To Switch ON a Device***

i. To switch ON device 1 press **27625**
ii. To switch ON device 2 press **29625**
iii. To switch ON device 3 press **62625**
iv. To switch ON device 4 press **67625**
v. To switch ON device 5 press **69625**
vi. To switch ON device 6 press **72625**
vii. To switch ON device 7 press **79625**
viii. To switch ON all the devices press **92625**

5b) ***To Switch OFF Device***

i. To switch OFF device 1 press **27675**
ii. To switch OFF device 2 press **29675**
iii. To switch OFF device 3 press **62675**
iv. To switch OFF device 4 press **67675**
v. To switch OFF device 5 press **69675**
vi. To switch OFF device 6 press **72675**
vii. To switch OFF device 7 press **79675**
viii. To switch OFF all device press **96275**

5c) ***To Obtain the STATUS of a device***

The following steps below are followed each time to listen to the feedback beeps. If the device is in the ON, five feedback beeps will be received. If the device is OFF, a single beep will be received. You can repeat the status command as many times as required for any of the device**.**

i. To check STATUS of device 1 press **27695**
ii. To check STATUS of device 2 press **29695**
iii. To check STATUS of device 3 press **62695**
iv. To check STATUS of device 4 press **67695**
v. To check STATUS of device 5 press **69695**
vi. To check STATUS of device 6 press **72695**
vii. To check STATUS of device 7 press **79695**

Note that: on the transmitter side the user controlling the appliance has to allow some time interval while pressing the buttons. A typical time of 1sec is required.

FUTHER WORK

This research work can still be further improved to make it more efficient and user friendly. The following are features that during research were discovered:

i. To enable user friendliness a Voice chip (ISD2500series) could be included to allow voice feedback while checking for STATUS or switching ON/OFF the system. The voice chip would store and play the address of the device to control, the command key, instruction code and the STATUS of the device.

ii. The systems security can also be improved by writing a program in addition to the micro-controller to be able to request for a Personal Identifier Number (PIN), this would ensure that only authorized users of the system would be able to control devices.

CONCLUSION

The project is a clear indication of a multipurpose control done via the keypad tone reducing the manual efforts and time required while paying individual attention for controlling each device. For people who want to switch ON/OFF and check STATUS of device when they are not present this research work saves time and energy of the individual. The system requires less design and implementation cost. For handicapped people it may be really not entertaining to involve much in work and this system helps them to locate themselves in a place and operate the lights of their room, switch on the fan etc. In every sect of our daily lives people ranging from scientists to handymen and farmers can make use of this system for controlling motor, sprinklers, tanks, scientific equipment and also several other devices.

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