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Design and Construction of a Smart Home Remote Control System

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ABSTRACT

This paper presents the design and implementation of a smart home remote control system which is a very important part of our everyday life. It is based on the Global System for Mobile communication (GSM) and designed to help control electronic equipments at home when far away. The system is made up of Dual Tone Multi-Frequency (DTMF) receiver, Darlington Transistor Arrays, a Microcontroller and Relays. The DTMF filters and decodes the frequency of the depressed key on the mobile phone in order to control the appropriate relay to either put off or on equipment. The system was designed using the ATMEGA 16 microcontroller to coordinate the overall functions of the various units. The circuit was switched on and a phone was used to call the phone embedded inside the system, the ON buttons (2,4,6,8,0) and the OFF buttons (1,3,5,7,9) were pressed respectively and each switched on or off the corresponding relay.

Keywords: GSM, Security, Home, Alarm, Sensors, Design, Remote Contol & Circuits.

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1. INTRODUCTION

Smart Home remote control is not a new concept in today's world, it is used to provide convenience for users to remotely control and monitor appliances as well as better power management. The efficient use of electricity makes the home control play an important role in our daily life. Mobile phones are getting more advanced which allow people to develop applications that run on them. Currently mobile phones are gradually replacing Personal Computers because of their ability to do almost all what computers can do. Remote management and control of devices is one of the areas where an application can be developed to make our life easier. Different approaches can be followed to develop remote management or control systems, some use DTMF (Dual Tone Multi Frequency) technology which involves using mobile phones tone to perform an action, while some use Short Message Service technology to send the command for a particular action, some also use GPRS (General Packet Radio Service) technology to directly interface mobile phone and the computer. Imagine how helpful it will be to be able to switch on your air conditioning system ten minutes before you get home on a hot afternoon in January.

This is what Smart Home remote control system is about and there is no end to its application. In fact, sophisticated home automation and control systems are now being developed that can maintain an inventory of household items, record their usage through an RFID (Radio Frequency Identification) tag, and prepare a shopping list or automatically order replacements. Home automation and control has made it possible to have what is often referred to as a smart home, a home where you can switch on the security lights at night and switch them off in the morning, heat water for bathe and tea, stream to you anywhere in the world via the internet a live video of what is happening in and around your house. It makes it possible to link lighting, entertainment, security, telecommunications, heating, and air conditioning into one centrally controlled system. This allows you to make your house an active partner in managing your busy life. Nowadays, you can hardly find a house without a home automation system which can range from the remote for the television, burglar alarm and hi-tech security gates, to an automated air conditioning system that maintains the temperature at a predefined value.

2. LITERATURE REVIEW

Delgado *et al*, (2006) and Ciubotaru *et al*, (2006) presented designs and implementations of SMS -text based control of home equipments, It is however not possible to confirm the SMS delivery and hence the equipment control.Cho and Jeon , (2008) worked on Remote Robot control System based on DTMF of Mobile Phone. This design apart from being expensive only uses Android phones. This implies that without an Android phone there will be no means of controlling the home appliances. Shahriyar *et al*, (2008) controlled home appliances using mobile telephony but the use of bluetooth makes it impossible to control the appliances when the range of coverage is exceeded. Mghawish *et al*, (2012) considers Multi Function Control System using GSM modem Based SM5100B Module. This requires internet connection to control any Home appliance. Mghawish, A. (2013) employed a Practical Approach for Mobile-Based Remote Control but without the possession of the remote control, no home appliance can be controlled. This paper presents the design and implementation of a smart home remote control system which uses DTMF, a microcontroller and mobile phone to control home appliances remotely. It is a simple, economical and efficient means of home automation as compared to some previous methods.

3. HARDWARE DESIGN

3.1 Power Supply

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to a load or group of loads is called a power supply unit (PSU). The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others. A 5volts DC power supply is needed for the different component parts. A transformer was used to step down the voltage from the mains supply, after which a bridge rectifier was used for full wave rectification. The rectified output was filtered using a filtering capacitor and finally a 5V voltage regulator was used to stabilize the output as shown in fig 1.

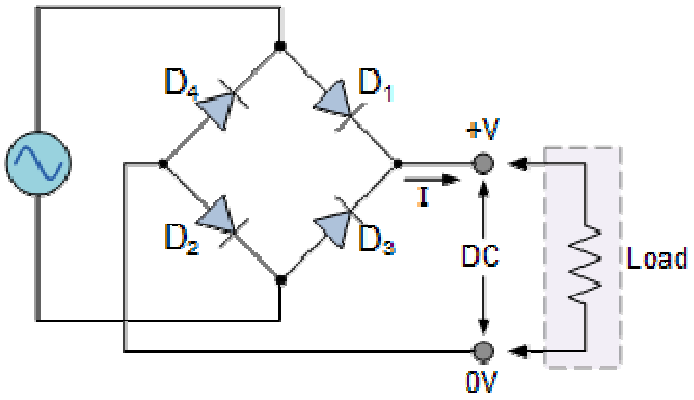

Fig 1: Power Supply Circuit

3.2 Dual Tone Multi Frequency

The MT8870D/MT8870D-1 is a complete DTMF receiver integrating both the bandsplit 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. External component count is minimized by on chip provision of a differential input amplifier, clock oscillator and latched three-state bus interface.

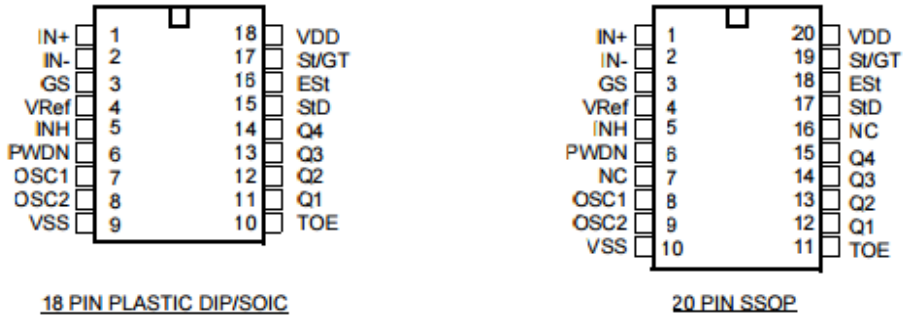

Fig 2: Pin arrangements

The MT8870D/MT8870D-1 monolithic DTMF receiver offers small size, low power consumption and high performance. Its architecture consists of a bandsplit filter section, which separates the high and low group tones, followed by a digital counting section which verifies the frequency and duration of the received tones before passing the corresponding code to the output bus. Filter Section Separation of the low-group and high group tones is achieved by applying the DTMF signal to the inputs of two sixth-order switched capacitor bandpass filters, the bandwidths of which correspond to the low and high group frequencies.

The filter section also incorporates notches at 350 and 440 Hz for exceptional dial tone rejection. Each filter output is followed by a single order switched capacitor filter section which smooth the signals prior to limiting. Limiting is performed by high-gain comparators which are provided with hysteresis to prevent detection of unwanted low-level signals. The outputs of the comparators provide full rail logic swings at the frequencies of the incoming DTMF signals.

Decoder Section Following the filter section is a decoder employing digital counting techniques to determine the frequencies of the incoming tones and to verify that they correspond to standard DTMF frequencies. A complex averaging algorithm protects against tone simulation by extraneous signals such as voice while providing tolerance to small frequency deviations and variations. This averaging algorithm has been developed to ensure an optimum combination of immunity to talk-off and tolerance to the presence of interfering frequencies (third tones) and noise. When the detector recognizes the presence of two valid tones (this is referred to as the "signal condition" in some industry specifications) the "Early Steering" (ESt) output will go to an active state. Any subsequent loss of signal condition will cause ESt to assume an inactive state

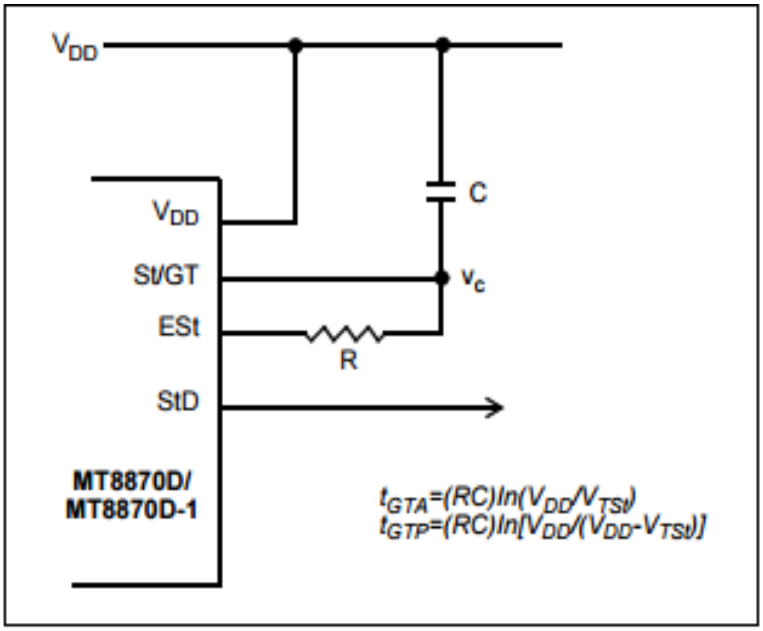

Fig 3: Basic Steering Circuit

Steering Circuit Before registration of a decoded tone pair, the receiver checks for a valid signal duration (referred to as character recognition condition). This check is performed by an external RC time constant driven by ESt.A logic high on ESt causes Vc to rise as the capacitor discharges. Provided signal condition is maintained (ESt remains high) for the validation period (tGTP), Vc reaches the threshold (VTSt) of the steering logic to register the tone pair, latching its corresponding 4-bit code into the output latch. At this point the GT output is activated and drives Vc to VDD. GT continues to drive high as long as ESt remains high. Finally, after a short delay to allow the output latch to settle, the delayed steering output flag (StD) goes high, signaling that a received tone pair has been registered. The contents of the output latch are made available on the 4-bit output bus by raising the three state control input (TOE) to a logic high. The steering circuit works in reverse to validate the interdigit pause between signals. Thus, as well as rejecting signals too short to be considered valid, the receiver will tolerate signal interruptions (dropout) too short to be considered a valid pause. This facility, together with the capability of selecting the steering time constants externally, allows the designer to tailor performance to meet a wide variety of system requirements.

3.3 ULN2803 Darlington Transistor Arrays

The ULN2803A device is a DIP IC having high-voltage, **high-current Darlington transistor array**. The device consists of (Single Output) eight NPN Darlington pairs that feature high-voltage output with common cathode clamp diodes for switching inductive loads.

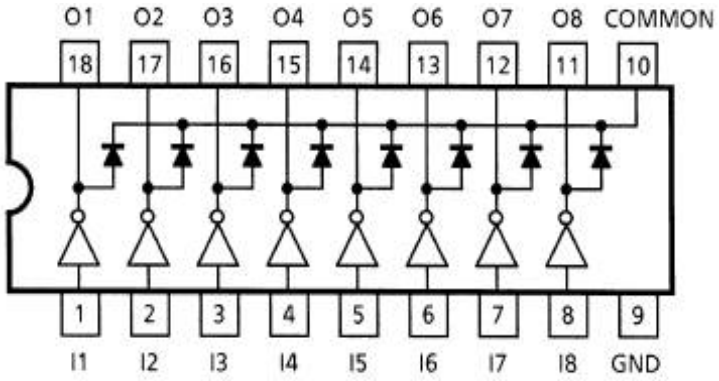

Fig 4: ULN2803 Darlington Transistor

3.4 Relays

Relays are electromechanical devices that use an electromagnet to operate a pair of movable contacts from an open position to a closed position. It is actuated by an electrical current. The current flowing in one circuit causes the opening or closing of another circuit.

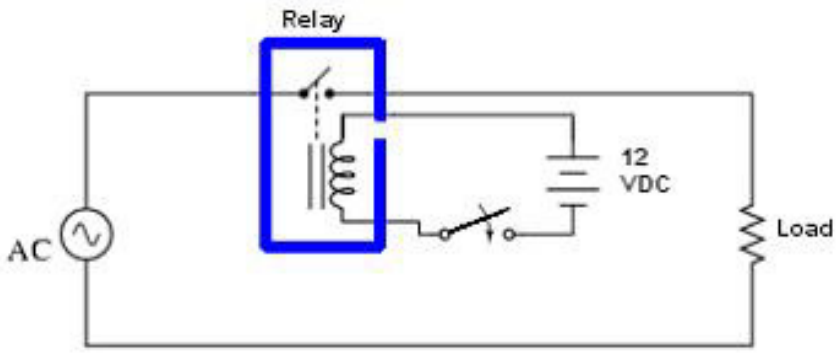

Fig 5: Relay Circuit

Relays are like remote control switches and are used in many applications because of their relative simplicity, long life, and proven high reliability. Relays are used in a wide variety of applications throughout industry, such as in telephone exchanges, digital computers and automation systems. Highly sophisticated relays are utilized to protect electric power systems against trouble and power blackouts as well as to regulate and control the generation and distribution of power. The advantage of relays is that it takes a relatively small amount of power to operate the relay coil, but the relay itself can be used to control motors, heaters, lamps or AC circuits which themselves can draw a lot more electrical power. Relays contain a sensing unit, the electric coil, which is powered by AC or DC current. When the applied current or voltage exceeds a threshold value, the coil activates the armature, which operates either to close the open contacts or to open the closed contacts. When a power is supplied to the coil, it generates a magnetic force that actuates the switch mechanism. The magnetic force is, in effect, relaying the action from one circuit to another. The first circuit is called the control circuit; the second is called the load circuit.

3.5 The Atmega16 Microcontroller

A microcontroller is a small computeron a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. The Microcontroller I used for this design is called ATmega16.

ATmega16 is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. Atmega16 is based on enhanced RISC (Reduced Instruction Set Computing) architecture with 131 powerful instructions. Most of the instructions execute in one machine cycle. Atmega16 can work on a maximum frequency of 16MHz.ATmega16 has 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 Bytes. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000, respectively.ATmega16 is a 40 pin microcontroller. There are 32 I/O (input/output) lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD.ATmega16 has various in-built peripherals like USART, ADC, Analog Comparator, SPI, JTAG etc. Each I/O pin has an alternative task related to in-built peripherals. The following table shows the pin description of ATmega16.

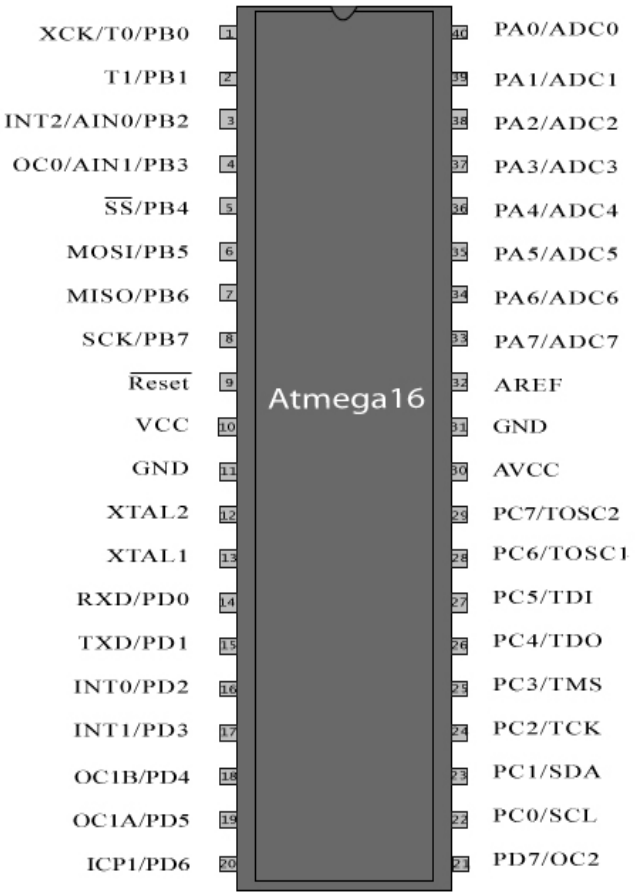

Fig 5: ATmega16 Pin Diagram

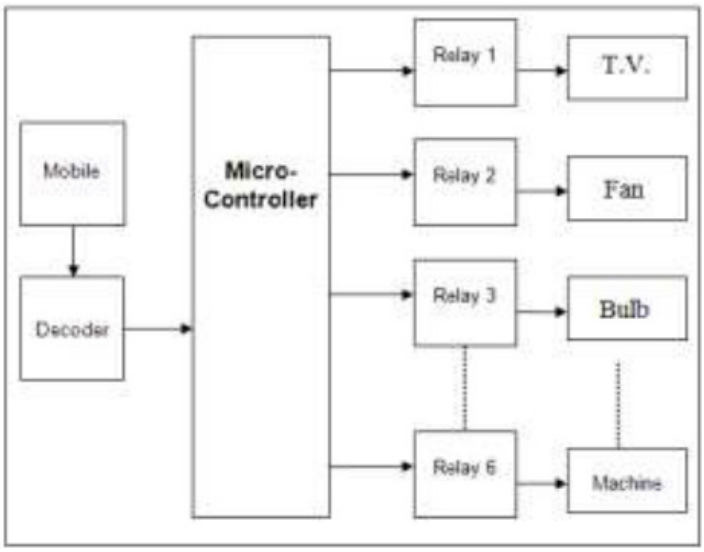

Fig 6: Block Diagram of Smart Home System

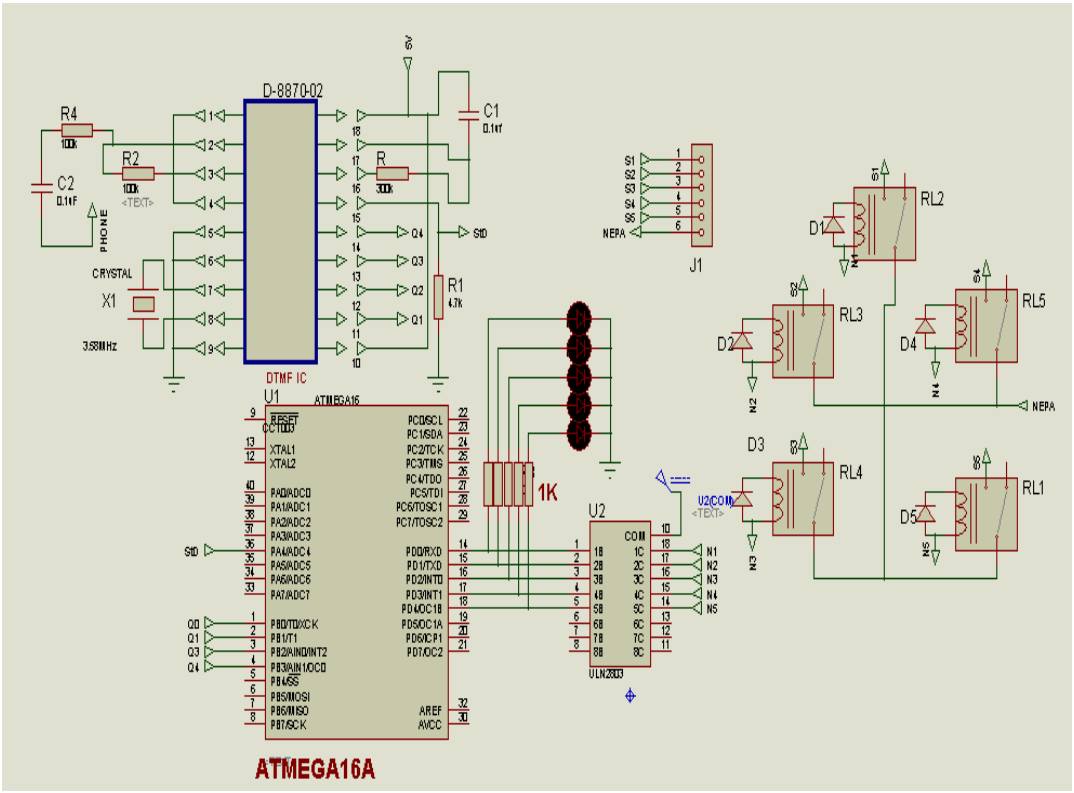

Fig 7: Complete Circuit diagram

4. IMPLEMENTATION

The Fig 7 above shows the complete diagram of the Smart Home remote control system. All intelligence is vested on the ATMEGA16A and other IC used, the connection is done by the use of connected instead of using wire that will make the circuit very complex and difficult to interpret. A fair amount of executable code run from the on-chip memory is able to take total control of the circuit, requiring just a 12-V supply voltage. The DTMF used is D-8870-02 which has 1 input pin connected to the phone inside the circuit. Four output pins were used in the DTMF which is connected to the Microcontroller. It uses the principle of Dual Tone Multi-Frequency, When you press any key from your phone,(the DTMF inside the Smart Home remote control system will decode the button ,because each button has its own specific frequency. Four (4) output pins was used from the DTMF and they are Q_1,Q_2,Q_3,Q_4,one of the pins in the DTMF is refer to as the STD pin),the initial state of the STD pin changes ,and when such happens, the initial state of the four output pins used also changes. The Microcontroller used is ATMEGA 16A. The pins have been grouped, we have group A,B, C andD, 12V power supply coming from the transformer will move from the DTMF to the MICROCONTROLLER, then to the ULN 2803(bank of transistor) and it will move to the Relay to energize it, it has a voltage suppress diode in it that will reduce the coming 12V to 5V to change the initial state of the relay.

5. MONITORING AND TESTING

The complete circuit was built and tested for a period of time and it worked according to specifications. When the circuit was switched on, another phone was used to call the phone inside the system, the ON (2,4,6,8,0) and OFF(1,3,5,7,9) button were pressed respectively and they functioned according to specification, and the circuit was repeatedly tested and found efficient and reliable.

6. RESULTS AND DISCUSSIONS

It was observed when the circuit was switched on and a phone was used to call the phone embedded inside the system, the ON buttons (2,4,6,8,0) were depressed to activate five different relays which controlled different household appliances. These worked perfectly to control the switching on of the respective appliances. It was observed as well when the OFF buttons (1,3,5,7,9) were pressed to deactivate the five different relays earlier activated, these also worked efficiently in switching off the respectively appliances by deactivating the corresponding relays.

7.0 CONCLUSION

In Nigerian Homes, appliances are known to be controlled via the switch button and only when close to the appliance you are controlling. This design can avoid the problems caused when you are far away from home and you need to turn ON/OFF any of your home appliances, with this system you would only need to remember the number of the sim card in it and have little credit on your phone, thus making it much safer and easier. This system can find its applications in various areas like, offices, and personal houses and virtually anywhere where appliances are used. The design is flexible because the code can be changed easily without much stress and the likelihood of failure or malfunction is controlled.

REFERENCES

1. Delgado, A. R., Picking, R. and Grout, V. (2006) "***Remote-Controlled Home Automation Systems with Different Network Technologies"*** 6th International Network Conference (INC 2006)] 11-14 July 2006.
2. Ciubotaru-Petrescu, B., Chiciudean, D., Cioarga, R., & Stanescu, D. (2006). "Wireless Solutions for Telemetry in Civil Equipment and Infrastructure Monitoring" 3rd Romanian-Hungarian Joint Symposium on Applied Computational Intelligence (SACI) May 25-26, 2006.
3. Cho, Y. C. and Jeon, J. W. (2008) "Remote Robot control System based on DTMF of Mobile Phone", IEEE International Conference INDIN 2008, July 2008.
4. Shahriyar, R., Hoque, E., Sohan, S. M., Naim, I., Akbar, M. and Khan, M. K (2008) "Remote Controlling of Home Appliances using Mobile Telephony" International Journal of Smart Home Vol. 2, No. 3, July, 2008.
5. Mghawish, A., AbdelQader, A. A., Al-Jezawi, M. A. and AbuMahfouz, M. (2012) "Multi Function Control System using GSM modem Based SM5100B Module" International Conference for Internet Technology and Secured Transactions (ICITST-2012).
6. Mghawish, A. (2013) "A Practical Approach for Mobile-Based Remote Control" European Scientific Journal June 2013 edition vol.9, No.18, pages 194-201.
7. Kuo, S. M., Lee, B. H. and Tian, W. (2006) "Real-Time Digital Signal Processing Implementations and Applications", Second Edition, John Wiley & Sons, Ltd, 2006.