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Design and Construction of Bluetooth Based Home Automation System

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ABSTRACT: It is basically known that power supply to an electrical appliance is controlled with a switch. This method is becoming obsolete as automation and wireless control of devices is takin over due to advances in technology.

This project put forth the equipment which enable users (able and disable) to control power supply to their electrical appliances using the Bluetooth feature of their mobile phones. It shows the constructions and working of the device to wirelessly control the home appliances based on HC-06 Bluetooth module and PIC16F877A micro controller.

Initially an authenticated signal is sent from the user's cellular phone to the hc-06 module wirelessly. This signal or code contains information about the function or action to be taken place that is which appliance should be turned off or on. The message sent from the user's phone to the hc-06 module in turn sends the output digital signal to the microcontroller. Then the microcontroller, based on the received data and embedded program, controls the different relays connected through ULN 2003 (Darlington transistor) and trigger the required appliance.

I. INTRODUCTION

Different approaches are applied in home monitoring. Saito(2000), and . Alkar and Buhur(2005), implemented internet based wireless flexible solution where home appliances are connected through a gateway and network nodes.

Scanaile (2006), developed a tele-monitoring system base on short message service(SMS), to remotely monitor the long term mobility levels of elderly people in their natural environment. Mobility is measured by the accelerometer-based portable unit, worn by each monitored subject. The portable unit houses the analog devices ADUC8125 microcontroller board, Falcon A2D-1 GSM, and was constructed to use battery-based power supply. Mobility level summary were transmitted hourly as an SMS, directly from the portable unit to a remote server for long-term analysis. Also Jiang(2008), propose a system for early diagnosis of hypertension and other chronic diseases. The system is to transmits data to the medical practitioner through SMS.

Other work have been done using wireless sensor network. many wireless technologies like RF, wifi, bleutooth and zig bee have been developed. This technologies are popular due to flexibility, low operating charges, etc. today wireless sensor network are used in an increasing number of commercial solution, aimed at implementing distributed monitoring and control system in a great number of different application areas.

Wijetunge (2008), designed a general purpose controlling module designed with the capacity of controlling and sensing upto five devices simultaneously. The communication between the controlling module and the remote server was implemented using Bluetooth technology. The server can communicate with many such modules simultaneously.

INNOVATIONS

This work aims at developing a system that controls home appliances using mobile phone and Bluetooth module. This construction will provide flexibility to use any android phone model by people with less mobility to effectively control and monitor their home appliances remotely. The system will also aid to minimize power and time wastage.

MATERIALS

This work was developed using some electrical/electronic discrete components like diode, capacitors, resistor, light emitting diodes etc. Other components used are:

- **HC-06 MODULE**

HC-06 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial

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port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04 External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. it features an RX and TX pin which are used for the serial communication with the microcontroller. It also has an antenna to receive the bluetooth signal from the user's phone. The base AT commands are loaded into the program of microcontroller for it to interface with the bluetooth module.

Figure 1 HC-06 Bluetooth module

- **MICROCONTROLLER**

A microcontroller is a chip that contains processor, ROM, random access memory, clock generator and input/output ports. It is additionally called a ''work station on a chip'' (micro computer).

There are various types of microcontroller available in the market. There include but not limited to PIC16F84A, 8051 microcontroller, PIC18F4520 etc. PIC16f877a is chosen for this work. It receives data input from the HC-06 bluetooth module, interprets the received data based on pre-programmed instructions before outputting a signal which is utilized in turning the relays ON and OFF. The below figure portrays a schematic representation of PIC16f877a microcontroller.

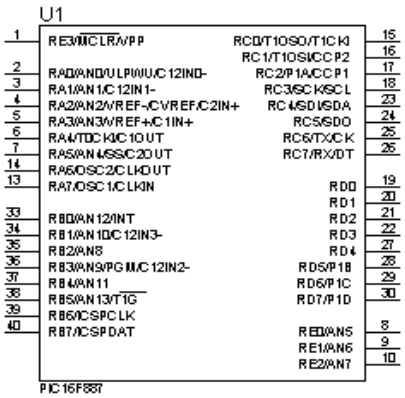

Figure 2: PIC16f877a MCU

- **LIQUID CRYSTAL DISPLAY (LCD)**

An LCD unit is coupled and initialized with this automation system, so as to view the message sent, and to also view the functions, which are being currently performed by the microcontroller.

The preferred LCD Display is a 2 X 16 line display, two lines of 16 characters each, for a total of 32 characters at a time. The LCD display must be properly interface with the microcontroller to ensure its proper working. In this project, an alphanumeric LCD module is used which is simple, cost effective and efficient LCD display screen.

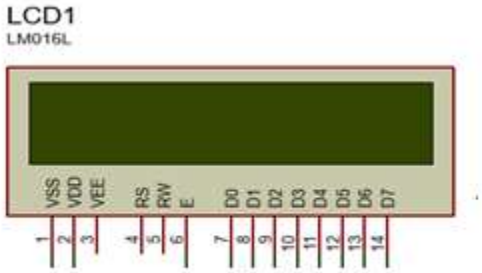

Figure 3: 2x16 LCD module

- **ULN2003 (INTEGRATED CIRCUIT)**

A ULN2003 IC is a high-voltage, high-current darlington transistor arrays. Each consist of seven NPN darlington pairs that feature high-voltage output with common-cathode clamps diode for switching inductive loads. In this project, the ULN2003 Ic is used as a buffer for switching ON and OFF the relays; due to the microcontroller's inability to provide such amount of current needed for the operation of the relay units. The ULN2003 IC internal schematic and block diagram is shown below.

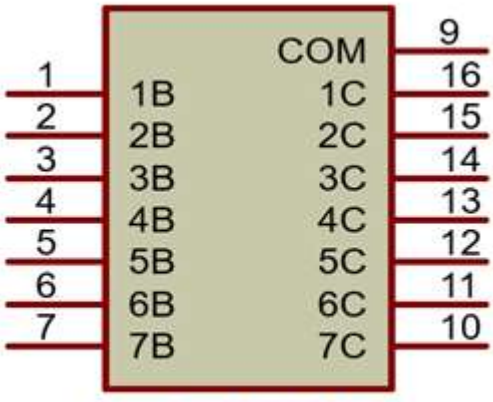

Figure 4: ULN2003 IC

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- **RELAY**

A relay is an electrical hardware device having an input and output gate. It acts as an electrical switch. The output gate consist of one or more electrical contacts that switches when the input gate or the coil is energize. Relays are usually single pole double throw (SPDT) or double pole double throw (DPDT), but they can have many more sets of switch contacts, base upon the requirements.

In this project, a single pole double throw (SPDT) relay is used since each of the appliances has its own fixed relay. This relay is chosen to minimize cost. The pictorial and internal schematic of a SPDT relay are shown below in figure;

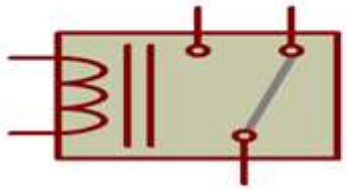

Figure 5: SPDT Relay

- **TRANSFORMER**

A transformer is a static (or stationary) piece of apparatus by means of which electric power in a circuit is transformed to electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit. Here we used 220VAC/12VDC to power the circuit. Since the units that make up the system requires a dc input of 5volt and since the regular input to the house is 220volts, the transformer was used to step-down the voltage. In it simplest form it consists of two inductive coils which are electrically separated but magnetically linked through a path of poses high mutual inductance.

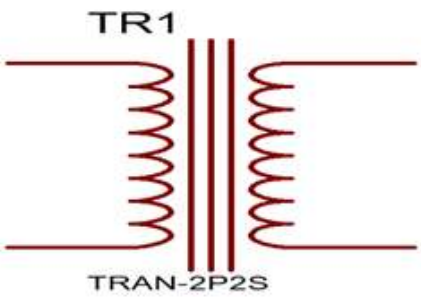

Figure 6: Transformer

- **CRYSTAL OSCILLATOR**

The quartz crystal or resonator operates due to the piezoelectric effect. The piezoelectric effect of quartz allows it to produce an electrical charge on its surface when the same surface(s) are distorted or subjected to pressure. This distortion allows the crystal to vibrate at a particular resonant frequency. Conversely, the application of an alternating voltage produces the same type of mechanical vibration. In this project the crystal oscillator is used to produce clock pulses for the operation of the microcontroller units.

Figure 7: Crystal Oscillator

II. METHODOLOGY

This project is implemented using a mobile phone which runs an android application that allows designated data to be transmitted over Bluetooth whenever certain buttons are being pressed. The HC-06 Bluetooth Module receives data sent from the user's phone and then decodes the sent message and sends the command to the microcontroller. Microcontroller now issue commands or energizes the relays by providing those signals through transistor (ULN2003), which then ON or OFF the device connected on it. The procedure followed to actualise this work is outlined using the block diagram.

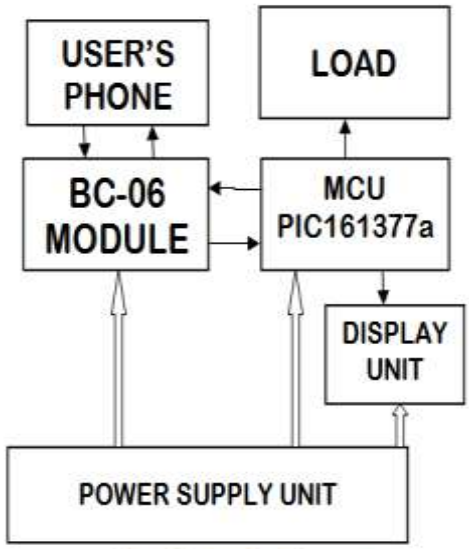

Figure 8: System block diagram

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Power Supply Unit

Basically an electronic circuit runs with power supply. Here we are giving a 5volts supply to the various IC's used in this design. We arrange a 220volts supply, so in order to provide our circuit appropriate supply voltage a different power circuit is made base on requirement. The different stages of the design of the circuit is given below.

A. Bridge rectifier:

The equipment needs a 5vdc supply. The output from the transformer is connected to the bridge rectifier to make it DC. A bridge rectifier basically has four diode connected as shown in figure below to provide rectification. this diode has a forward bias voltage of 0.7volts and must exceed for them to conduct.

Figure 9: Bridge Rectifier

B. **Filter Circuit**

The filter circuit is simply a capacitor of 1000farad associated in parallel to the power circuit. It goes about as a filter that seems to be, it filters outs the ripples present in the circuit brought on throughout the rectification from the diodes in the bridge circuit. Regardless of the amount consideration is taken there are still ripples in the output voltage of the circuit, which may be destructive to the IC's utilized. So filter capacitor evokes them, along this lines helping keeping up security in the outlined circuit.

C. Voltage regulator

At last voltage controllers are associated over the circuit to secure the supply from any kind of voltage variances. All the gadget we utilize are delicate and sensitive, so protection from any kind of variance in supply voltage is very important. A voltage regulator (LM7805 IC) is intended to naturally keep up a consistent voltage level of 5volt dc.

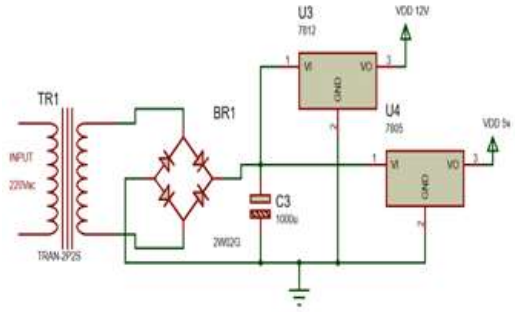

Figure 10: Power Supply Unit

TRANSMISSION UNIT/ RECEIVING UNIT

As seen in the block diagram of figure 1, data is to be send from a mobile phone device using an android application, through the established Bluetooth network. The mobile station serve as the transmitter from which user's sends a code that contains command and instruction. The signal sent is transmitted to the Bluetooth module present in the automation system. The Bluetooth module receives the strings and immediately transfers it to the microcontroller through the Universal Synchronous Asynchronous Transmitter and Receiver module pins.

The microcontroller then extracts the information and performs the intended action through the code embedded in its memory.

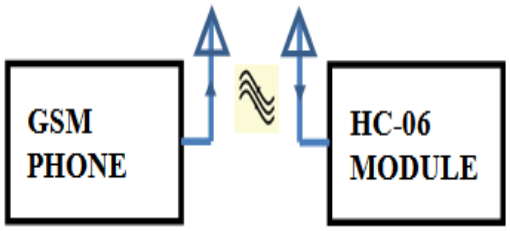

Figure 11: Transmitting and receiving unit

SWITCHING AND DISPLAY UNIT

The switching system consist of a microcontroller, a darlington pair transistor and a single pole double throw(SPDT) relay. A darlington pair has a characteristics higher-current gain as a single transistor and it is used in this project to provide the current required to actuate the relay. By programming the microcontroller appropriately, the message is received, compared, and if found matching, the suitable required action is performed. The relays, which act as switches for the appliances, are connected to the digital pin21, 22 and 27 of the microcontroller circuit board. Base on the inputs message, the microcontroller send an activating high or low signal to the required pin to

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turn ON or turn OFF the required appliance. The general circuit diagram is shown in the figure below.

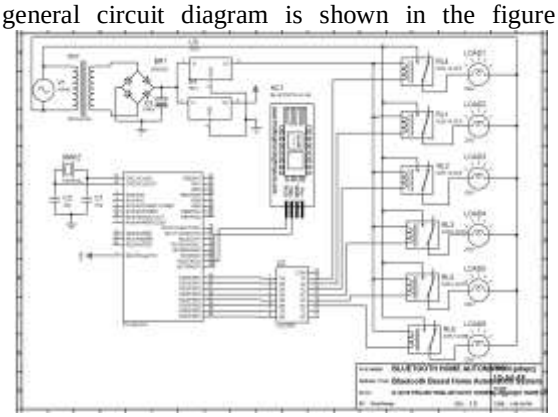

Figure 12: Complete circuit diagram

III. DESIGN ANALYSIS

Power supply Unit

TR2 is a 220V/12-0-12 V,1A transformer, it receives 220Vac from the wall socket and outputs 12-0-12 V ac for the operation of the entire system. BR2 is a bridge rectifier, consisting of 4 silicon diodes arranged in a full wave manner. These diodes help rectify the 12-0-12 AC voltage to 12V DC voltage, suitable for the operation of the voltage regulators. C9 is a 1000Uf capacitor used for filtering out the ac ripples at the output of the bridge rectifier, BR1. U10 and U7 are both 12 V regulators. We chosed to use two of these voltage regulators, as using one of it, could not provide enough current for the operation of the 7 relays in the circuit. U9 is a 5V regulator used to regulate 5V DC for the operation of the microcontroller and Bluetooth module. C10 is a filter capacitor placed at the output of the voltage regulators to eliminate voltage transients that can induced into the circuit as noise of EMI.

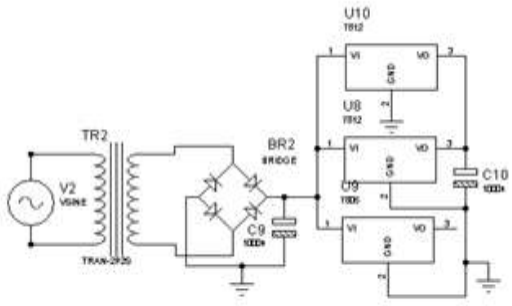

Figure 13: Power supply circuit

Wireless receiver unit

The wireless receiver unit consists mainly of the HC-06 bluetooth module and its voltage filtering elements C12 and C11. HC1 in the diagram is the HC-06 bluetooth module which operates on 5V dc.

The control unit

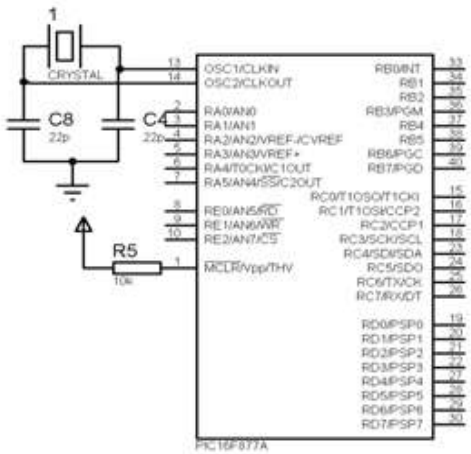

Figure 15: Control Unit

At the core of the control unit is the PIC16F877A microcontroller which has been embedded with software program to enable it intercept received signals from the Bluetooth wireless receiver and send outputs to the switching units. It is backed up by a crystal oscillator element and a pull up resistor which is attached to its Pin 1, to prevent undesired resetting of the microcontroller during operation. The microcontroller was placed on a 40-pin DIP IC socket, as directly soldering it to the printed circuit board was considered harmful for the device due to the high soldering temperatures.

The Display Unit

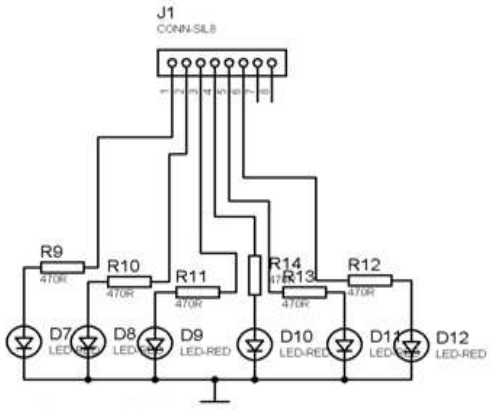

Figure 16: Display unit

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The control unit was achieved using seven RED LEDs. To limit the amount of current flowing through the LEDs, seven 220 ohms current limiting resistors were attached in series with each of the LEDs. Red LEDs drop a forward voltage of 2.0V. Therefore by using 220ohms resistors, the current through the LEDs was reduced to 13mA, obtainable using the formula:

$I = \frac{V_s - V_f}{R}$, where I is the Current through the LED, Vs is the supply voltage (5V), Vf is the LEDs forward voltage drop (2.0V) and R is the resistance value of the current limiting resistor.

Load switching Unit

The Load switching Unit was constructed using 7 30Amps, 12V relays and a ULN2003 darlington pair IC. The ULN darlington pair IC is being used as the Relays driver due to their high current sinking capabilities (up to 500mA on each output). Also the ULN2003 also has free whelling diodes at each of its output, which eliminated the use of 7 extra rectifying diodes at each of the relays coils, thereby reducing component count in the circuit. Due to the heavy current expected to be driven by the system, crimped terminals were used for extending the relay contacts to a connector, rather than soldering, which may melt over time, due to excessive current draw. An IC socket was also used for the placement of the ULN2003 Integrated circuit chip.

IV. RESULT AND DISCUSSION

Each of the units that make up the system were separately tested. The test procedures and results obtained are as discussed below.

POWER SUPPLY UNIT

The output of the Transformer was tested using a multimeter, set to the AC voltage measuring range. An AC voltage of 13V was recorded, when an input Voltage of 225Vac was applied to its input.

The Output DC voltage after rectification and filtering was recorded as 12.1VDC. Finally, the output of the voltage regulators was recorded as 12.01 and 5.05V respectively, for the 12volts and 5Volts regulators.

THE CONTROL UNIT

The supply voltage to the microcontroller was measured to be 5.00 volts DC. Total current draw by the microcontroller when all the relays were turned on was recorded as 230mA. Outputs voltage for all the output pins used was 5.0 volts. The crystal oscillator frequency was maintained at a level of 2.3V DC. Pullup voltage at Pin 1 was maintained at 3.8V Dc.

WIRELESS RECEIVER UNIT

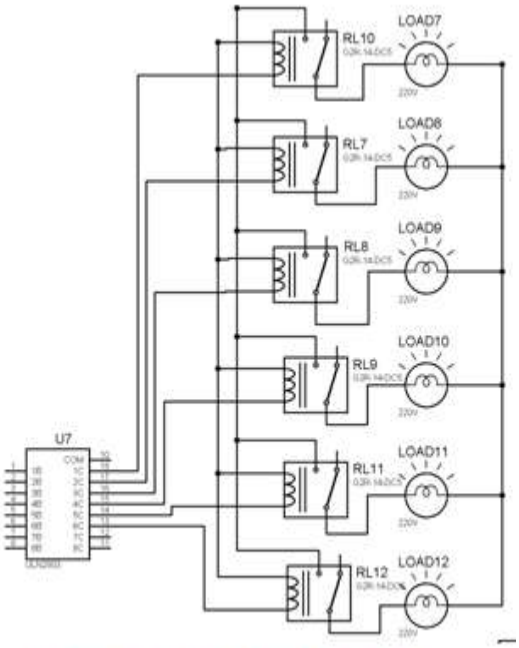

Figure 17: Receiving and display unit

A control distance of 20Meters was achieved using the Bluetooth module and a Tecno Spark4 android phone. Voltage supplied to the Bluetooth module was measured to be 5.0V DC. Total current drawn by the HC-06 module was 50.6mA.

THE DISPLAY UNIT

Each of the LEDs used had a forward voltage drop of 2.0 V when supplied with 5VDC. Operating current of the LEDs was also measured as 13.6mA as a result of the 220ohms current limiting resistors used.

LOAD SWITCHING UNIT

Input voltage to the ULN2003 was recorded as 5.0V, while its output voltage was 0.6V when active. The relay coils resistance was measured to be 170 ohms, and drew a maximum of 120mA when active. Voltage across the relay coils was 12.01 Volts DC.

V. CONCLUSION AND RECOMMENDATION

A Bluetooth controlled home Appliances switching system was designed and constructed. This was realized after the successful implementation of the objectives of the project. The entire work was enclosed in an acrylic plastic casing. Also a connector was provided for easy termination of the appliance wires.

VI. RECOMMENDATION

Having completed this project work, and being witnesses to its strength and drawbacks, we therefore recommend that future developments on this project, should aim at incorporating overvoltage and under-voltage protection/warning, and possibly an over-current monitoring and protection system.

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