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# An Analysis of a Bluetooth Based Home Automation System

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***Abstract:*** *This paper aims to explain the design and implementation of low cost but yet flexible and secure cell phone based home automation scheme. The design is based on standalone Arduino UNO board and the home appliances are connected to the input/output ports of this board via relays. The communication between cell phone and Arduino UNO board is wireless. This system is designed to be low cost and scalable allowing variety of devices to be controlled with minimum changes to its core. The aspects discussed are oriented towards ease-of-use, design complexity and market acceptance.*

***Keywords****- Bluetooth, Home Automation System, Secured Communication*

## I. INTRODUCTION

Technology is a never ending process. To be able to design a product using the current technology that will be beneficial to the lives of others is a huge contribution to the community. The requirement of domestic automation is more inclined in the current scenario towards simple control and with the amount of ease with which the user can operate the system. Home automation is not just a means for making the lives of physically challenged people, but a luxury that every common man can afford. Many complex communication systems exist today that can provide with precise controls on different electronic media such as SMS, Bluetooth, Internet, Wi-Fi and the list is endless. The past decade has seen significant advancement in the field of consumer electronics. Various 'intelligent' appliances such as cellular phones, air conditioners, home security devices, home theatres, etc. are set to realize the concept of a smart home. They have given rise to a Personal Area Network in home environment, where all these appliances can be interconnected and monitored using a single controller. Busy families and individuals with physical limitation represent an attractive market for home automation and networking. A wireless home network that does not incur additional costs of wiring would be desirable. Bluetooth technology, which has emerged in late 1990s, is an ideal solution for this purpose. This paper describes an application of Bluetooth technology in home automation environment. It proposes a network, which contains a remote, mobile host controller and several client modules (home appliances). The client modules communicate with the host controller through Bluetooth devices.

## II. PREFERENCE TO THE HOME AUTOMATION SYSTEM

The "Home Automation" concept has existed for many years. The terms "Smart Home", "Intelligent Home" followed and has been used to introduce the concept of networking appliances and devices in the house. HASs becoming popular nowadays and enter quickly in this emerging market. However, end users, especially the disabled and elderly due to their complexity and cost, do not always accept these systems. Due to the advancement of wireless technology, there are several different of connections are introduced such as GSM, WIFI, ZIGBEE, and Bluetooth. Each of the connection has their own unique specifications and applications. Among the four popular wireless connections that often implemented in HAS, Bluetooth is being chosen with its suitable capability.

Bluetooth with globally available frequencies of 2.4GHz is able to provide connectivity up to 100 meters at speed of up to 3Mbps depending on the Bluetooth device class. In addition, a Bluetooth master device is able to connect up to 7 devices in a "Pico net". The capabilities of Bluetooth are more than enough to be implemented in the design. Also, most of the current laptop/notebook or cell phones are come with built-in Bluetooth adapter. It will indirectly reduce the cost of this system. In term of cost, this system implemented low cost microcontroller and Bluetooth module as the system main core. The total cost

 

of one unit of this system hardware is estimated less than 100 USD. With this low budget, this system is still performed with powerful remote functions to make our life in home become easier.

## III. CLASS (UML) DIAGRAMS

In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. The class diagram is the main building block of object oriented modeling. It is used both for general conceptual modeling of the systematic of the application, and for detailed modeling translating the models into programming code. Class diagrams can also be used for data modeling. The classes in a class diagram represent both the main objects, interactions in the application and the classes to be programmed. In the diagram, classes are represented with boxes which contain three parts:
The middle part contains the attributes of the class, the bottom part gives the methods or operations the class can take or undertake. In the design of a system, a number of classes are identified and grouped together in a class diagram which helps to determine the static relations between those objects. With detailed modeling, the classes of the conceptual design are often split into a number of subclasses. Here, Microprocessor is the main class which is associated with other component classes like Keyboard, LCD and Relay. Keyboard and LCD are aggregated with Microprocessor via one to one multiplicity.

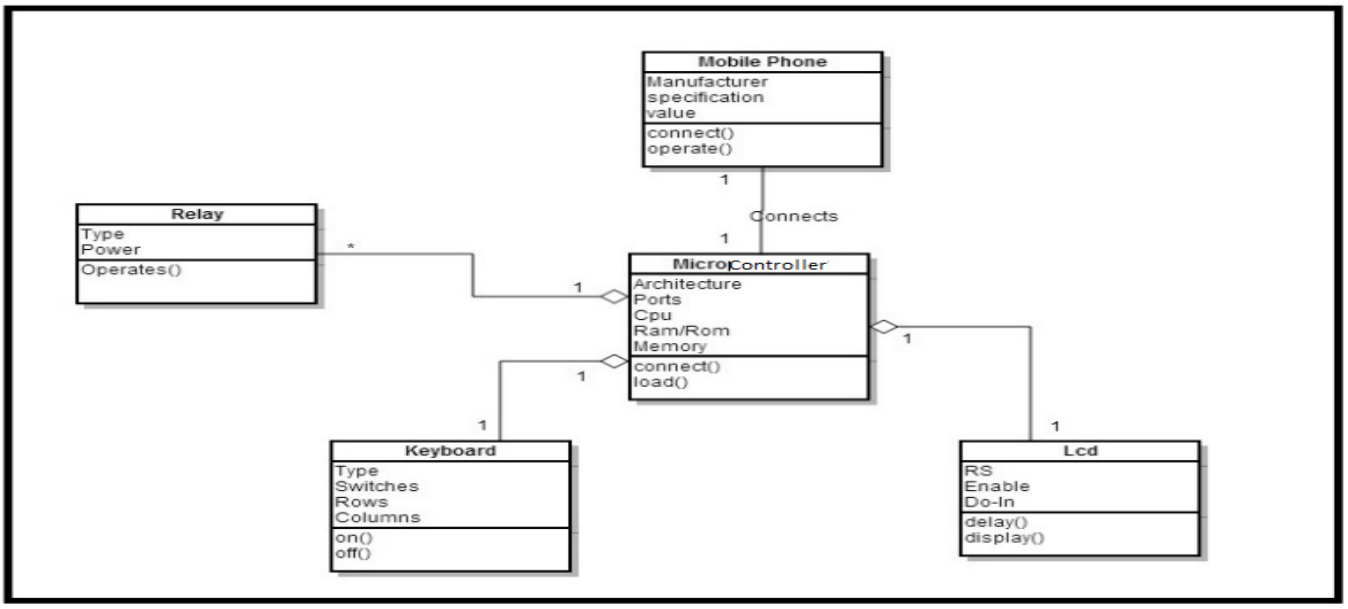


Fig 1 Class Diagram

A use case diagram at its simplest is a representation of a user's interaction with the system and depicting the specifications of a use case. A use case diagram can portray the different types of users of a system and the various ways that they interact with the system. This type of diagram is typically used in conjunction with the textual use case and will often be accompanied by other types of diagrams as well.

 

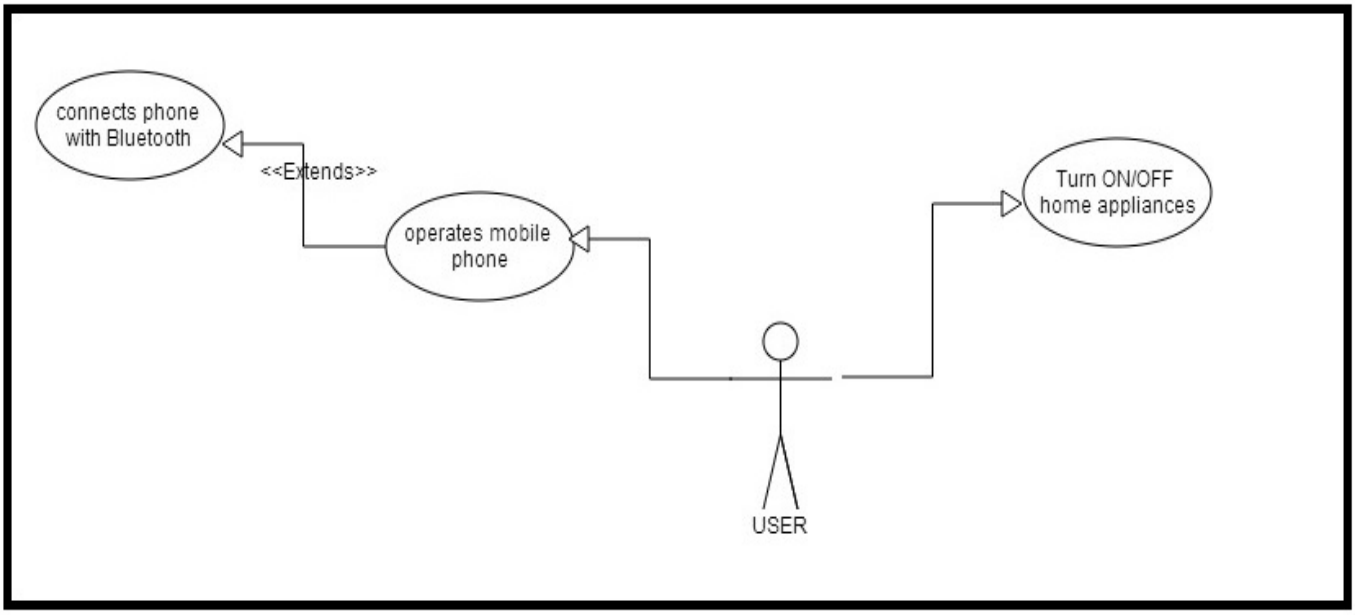


Fig 2 Use cases for User

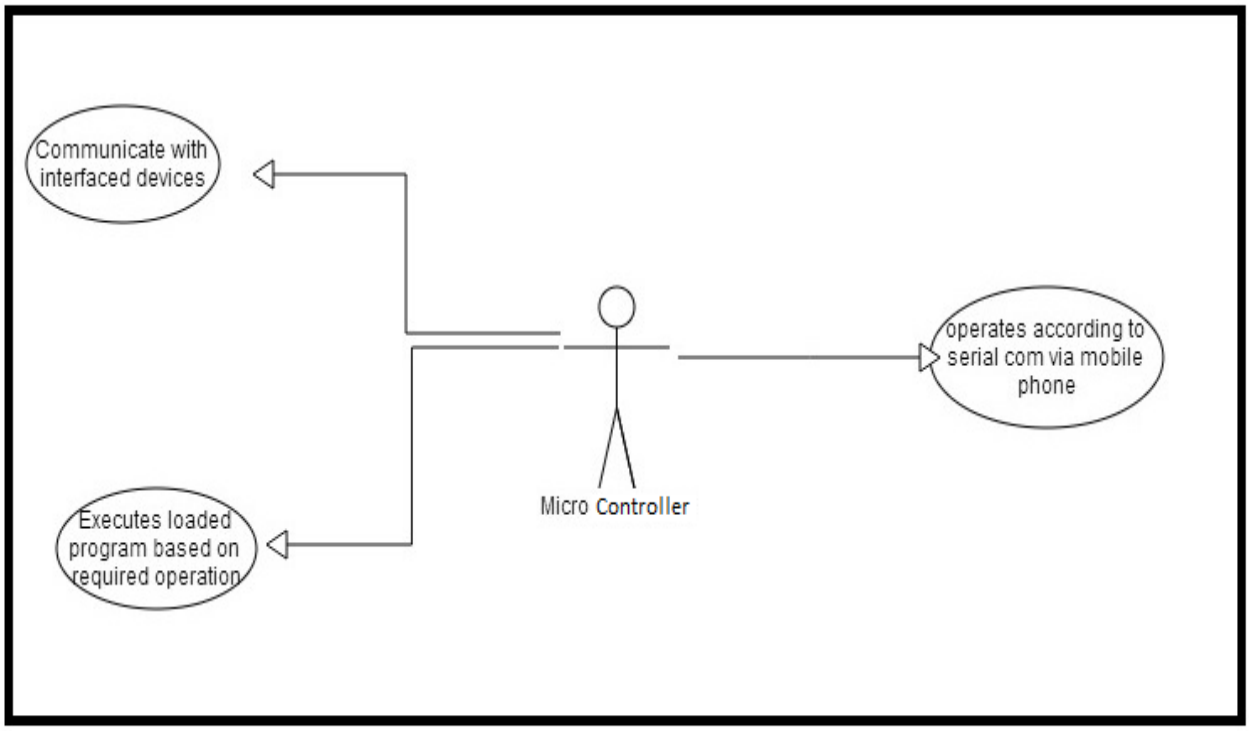


Fig 3 Use case for Microcontroller

 

## IV. DESIGN ISSUE AND IMPLIMENATATION

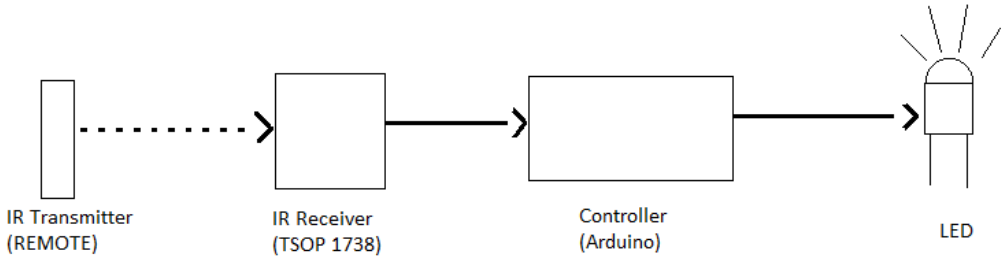


Fig 4 Implementation

The TSOP 1738 is a member of IR remote control receiver series. This IR sensor module consists of a PIN diode and a pre amplifier which are embedded into a single package. The output of TSOP is active low and it gives +5V in off state. When IR waves, from a source, with a centre frequency of 38 kHz incident on it, its output goes low. Lights coming from sunlight, fluorescent lamps etc. may cause disturbance to it and result in undesirable output even when the source is not transmitting IR signals. A band pass filter, an integrator stage and an automatic gain control are used to suppress such disturbances.

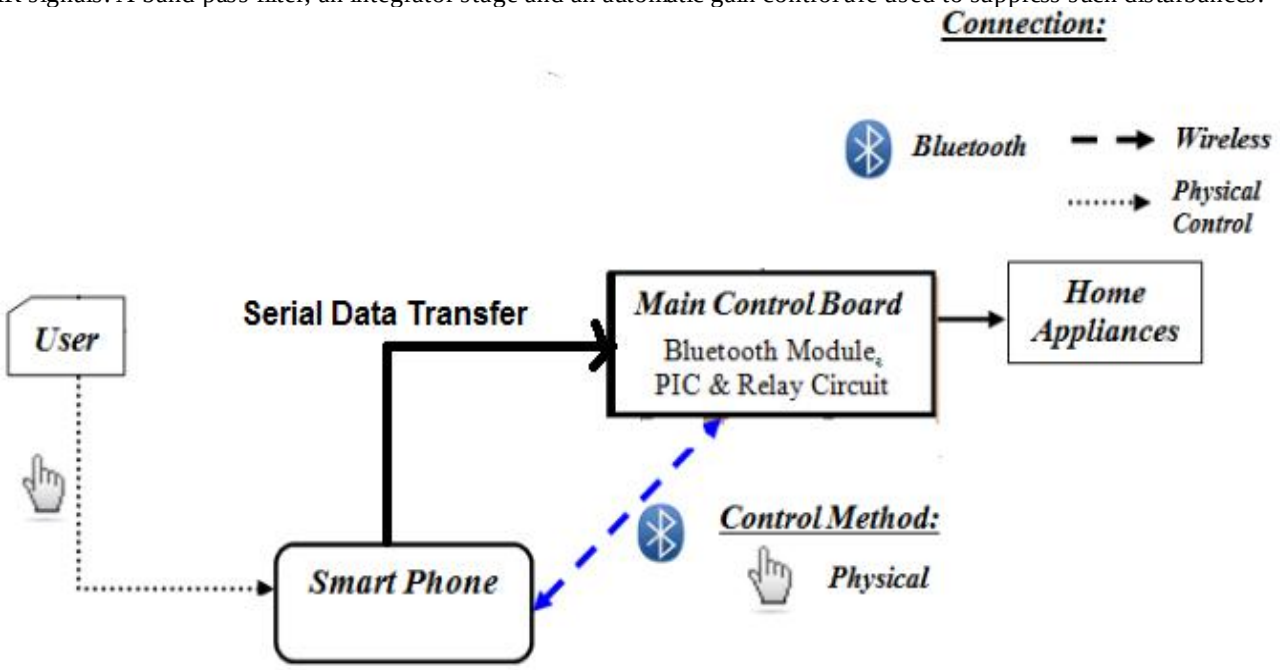


Fig 5 Structure

TSOP module has an inbuilt control circuit for amplifying the coded pulses from the IR transmitter. A signal is generated when PIN photodiode receives the signals. This input signal is received by an automatic gain control (AGC).

For a range of inputs, the output is fed back to AGC in order to adjust the gain to a suitable level. The signal from AGC is passed to a band pass filter to filter undesired frequencies. After this, the signal goes to a demodulator and this demodulated output drives an NPN transistor. The collector output of the transistor is obtained at pin 3 of TSOP module. Members of

 

TSOP17xx series are sensitive to different centre frequencies of the IR spectrum. For example TSOP1738 is sensitive to 38 kHz whereas TSOP1740 to 40 kHz centre frequency. For receiving signals send by the transmitter you need only TSOP1738. Connect 5V to Vs and Ground to GND pin of TSOP1738. The output will be active low. Output of TSOP1738 will be HIGH when no signals fall on it and the output will be LOW when 38 KHz infrared rays fall on it.IR Transmitter and Receiver pair can be easily made using 555 Timer, IR LED and TSOP1738 IR Receiver. This can be used for remote controls, burglar alarms etc. TSOP1738 is a very commonly used IR receiver for PCM remote control systems. It has only 3 pins, Vcc, GND and Output. It can be powered using a 5V power supply and its active low output can be directly connected to a microcontroller or microprocessor. It has high immunity against ambient light and other electrical disturbances. It is able to transfer data up to 2400 bits per second. The PCM carrier frequency of TSOP1738 is 38 KHz, so we want to design a stable multi vibrator of 38 KHz. This can be done by using 555 Timer. SOP 17… Series Photo modules are excellent Infrared sensors for remote control applications. These IR sensors are designed for improved shielding against electrical field disturbances. Its output is active low and gives +5 V when off. The demodulated output can be directly decoded by a microprocessor. The important features of the module includes internal filter for PCM frequency, TTL and CMOS compatibility, low power consumption (5 volt and 5 mA), immunity against ambient light, noise protection etc. The added features are continuous data transmission up to 2400 bps and suitable burst length of 10 cycles per burst. Transmitter transmits data to receiver, Receiver accordingly informs the controller. Arduino Microcontroller loads the program for IR components and LED will be switched on

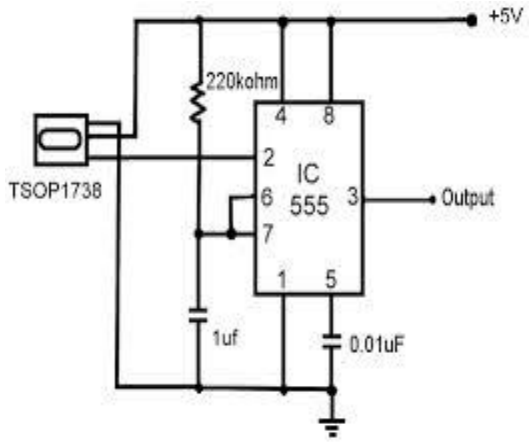


Fig 6 TSOP 1738 Internal Architecture

Fig 7 Bluetooth Shield

 

## V. Bluetooth Module, Communication and Programming

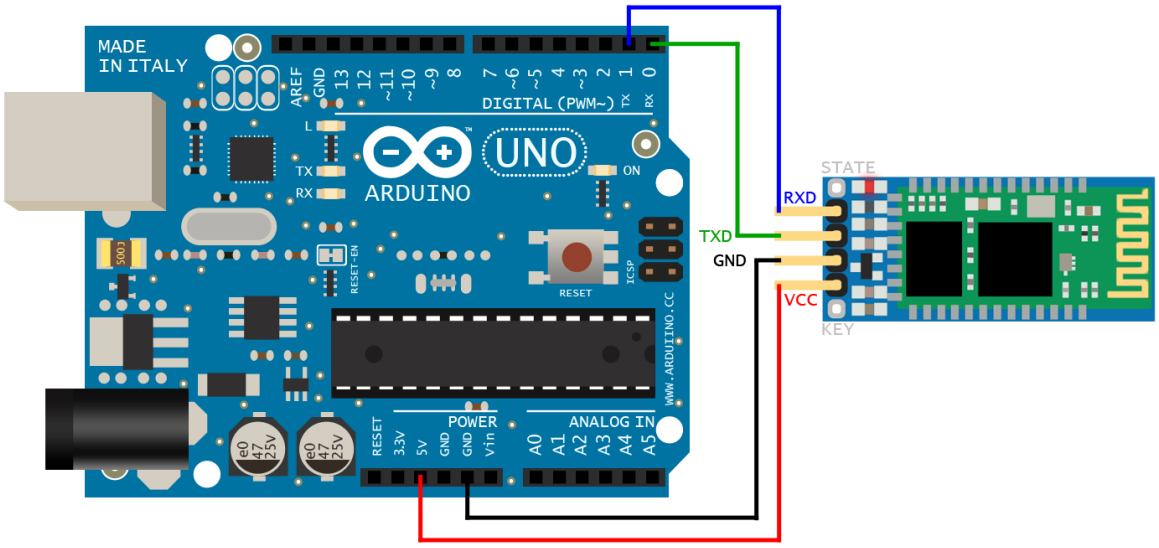


Fig 8 Bluetooth Shield Interfacing

We'll go through the Bluetooth specifications and interfacing part of Bluetooth shield with Arduino Uno R

Specification

| Item | Min | Typical | Max | Unit |
|---|---|---|---|---|
| Voltage | 2.8 | 3.3 | 3.5 | VDC |
| Current | 3 | / | 100 | mA |
| Communication Distance(in house) | / | / | 10 | m |
| Protocol | Bluetooth V2.0 with SPP firmware | | | / |
| Interface | Uart Serial Port(TTL) | | | / |
| Supported Baudrate | 9600, 19200, 38400, 57600, 115200, 230400, 460800 | | | bps |
| Dimension | 57.4x45.3x19.4 | | | mm |
| Net Weight | 10±2 | | | g |

Fig 9 Bluetooth Shield Specifications

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

 

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).
A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega328 on the Arduino Uno comes pre burned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).You can also bypass the boot loader and programs the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.
The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:
->On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
->On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.
You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader). See this user-contributed tutorial for more information.

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data. The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

## VI. MERITS AND DEMERITS

### A) MERITS

The Home Automation System described here has the following advantages:

1. Low power requirements: therefore ideal for laptops, telephones, personal digital assistants
2. Simple circuitry: no special or proprietary hardware is required, can be incorporated into the integrated circuit of a product
3. Higher security: directionality of the beam helps ensure that data isn't leaked or spilled to nearby devices as it's transmitted
4. Portable
5. Few international regulatory constraints: IrDA (Infrared Data Association) functional devices will ideally be usable by international travelers, no matter where they may be
6. High noise immunity: not as likely to have interference from signals from other devices

 

7. Low circuitry costs: $2-$5 for the entire coding/decoding circuitry
8. The system is immune to noise as it does not use a complex wireless transmission protocol.
9. Can support raw infrared codes for custom remotes that do not follow an international infrared data format.
10. The user can operate the system easily without having a prior knowledge of the functioning.

### B) DEMRITS

The Home Automation System described here has the following disadvantages:

1. Line of sight: transmitters and receivers must be almost directly aligned (i.e. able to see each other) to communicate
2. Blocked by common materials: people, walls, plants, etc. can block transmission
3. Short range: performance drops off with longer distances
4. Light, weather sensitive: direct sunlight, rain, fog, dust, pollution can affect transmission
5. Speed: data rate transmission is lower than typical wired transmission.

## VII. APPLICATIONS

The Home Automation System described here find Various Practical Applications, Some of them are listed below:

- In homes for physically challenged or old people
- In smart homes or offices
- For modern hotel rooms
- In industries for switching of lights according to presence of an operator
- Use in public halls so as to maintain correct lighting and temperature

## VIII. REENGINEERING THE ABOVE SYSTEM

There is a scope for re-engineering the above system in following aspects:

- Implementation of more complex wireless protocols for control.
- Use of a "learning algorithm" – which will be used by the system to learn which remote codes are used frequently and in what format, so as to prevent the calling of an experienced personnel in case the codes have to be changed.
- A better appearance may be provided, inbuilt with graphics LCD and touch screen for use without a remote or buttons.

## IX. CONCLUSION

In a nutshell, this is a basic lighting and fan control system which can be used alone or as a part of a larger home automation system at a lower investment but with robust features and better compatibility with the present room surroundings.one thing shoud be remebred that the format and design may be slightly modified as per the need of specific branch.

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