ELECTRICAL & ELECTRONICS ENGINEERING SOCIETY
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Project Report

On

GUI BASED HOME AUTOMATION

(USING MATLAB AND ARDUINO WITH ANDROID APP AND VOICE CONTROL)

BY:-

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BE/10244/2016

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CERTIFICATE

This is to certify that the contents of the project report entitled "**GUI BASED HOME AUTOMATION (USING MATLAB AND ARDUINO WITH ANDROID APP AND VOICE CONTROL)**" is a bonafide work carried out by Mr. **Abhinav Anand** (BE/10244/16) as a part of EEESOC SUMMER PROJECT PROGRAM 2017. The contents of the report have not been submitted earlier for the award of any other degree or certificates and we hereby commend the work done by him in this project.

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ABHINAV ANAND

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1. INTRODUCTION

From the beginning of civilization, the majority of inventions that have been done were for the simple reason of improving quality of life of humanity. Be it the wheel, telegram or an airplane, at their heart the inventors who have shaped our daily lives had the sole purpose of giving us a better life. This was the cornerstone of 'Automation'. Automation is the ability of machines to perform optimum work without the interference of man. It is the use of advanced electronics, IoT (internet of things), and artificially intelligent programs to ease the daily grind of humans be it in a factory, warehouse or homes.

Arthur C. Clarke once said that any technology advanced enough is indistinguishable from magic. This is what home automation means. Home automation is important because it is one way technology can directly improve lives of people. It is the connection of all the systems inside a home into one electronic network and to operate it using simplified command modules. The components which can be included into such a system are lights, fans, air-flow mechanisms (or A.C.), thermostat, doors, various household gadgets. The most important benefit of automation is increased security and safety. For both these concerns, a computer is much more reliable.

The following project is a scaled-down model of an automated house. It includes three small LED lights, a motor (as a fan) whose speed can be controlled using pulse width modulation and a 16x2 LCD display which takes temperature and humidity data and displays it. In the first part, a Matlab GUI is used to control the system which runs on an Arduino microcontroller. In the next part, Android application is used to control the system and in the final part voice control (built-in with smartphone) is used to operate the system.

2. LITERATURE REVIEW

Home automation gives us access to control devices in our home from a mobile device anywhere in the world. The term may be used for isolated programmable devices, like thermostats and sprinkler systems, but home automation more accurately describes homes in which nearly everything, lights, appliances, electrical outlets, heating and cooling systems, are hooked up to a remotely controllable network. From a home security perspective, this also includes our alarm system, and all of the doors, windows, locks, smoke detectors, surveillance cameras and any other sensors that are linked to it.[1]

Until fairly recently, automated central control of building-wide systems was found only in larger commercial buildings and expensive homes. Typically involving only lighting, heating and cooling systems, building automation rarely provided more than basic control, monitoring and scheduling functions.

The first and most obvious beneficiaries of this approach are "smart" devices and appliances that can be connected to a local area network, via Ethernet or Wi-Fi. However, electrical systems and even individual points, like light switches and electrical outlets, were also integrated into home automation networks, and businesses have even explored the potential of IP-based inventory tracking. Although the day is still far off when we'll be able to use our mobile browser to track down a lost sock, home networks are capable of including an increasing number of devices and systems.

Automation is, unsurprisingly, one of the two main characteristics of home automation. Automation refers to the ability to program and schedule events for the devices on the network. The programming may include time-related commands, such as having our lights turn on or off at specific times each day. It can also include non-scheduled events, such as turning on all the lights in our home when our security system alarm is triggered.[2]

The other main characteristic of cutting-edge home automation is remote monitoring and access. While a limited amount of one-way remote monitoring has been possible for some time, it's only

[1] www.safewise.com/home-security-faq/how-does-home-automation-work
[2] http://www.networx.com/article/intro-to-home-automation

since the rise in smartphones and tablets that we've had the ability to truly connect to our home networks while we're away. With the right home automation system, we can use any Internet-connected device to view and control the system itself and any attached devices.

One clear advantage of home automation is the unmatched potential for energy savings, and therefore cost savings. Our thermostat is already "smart" in the sense that it uses a temperature threshold to govern the home's heating and cooling system. In most cases, thermostats can also be programmed with different target temperatures in order to keep energy usage at a minimum during the hours when we're least likely to benefit from the heating and cooling.

In the near future, home automation may be standardized to let us truly take advantage of all of these additional possibilities. For the time being, the home security providers that specialize in home automation have focused on the most critical and useful parts of a connected home. At a basic level, this means the doors and windows and environmental devices (thermostat, smoke detectors, temperature, humidity, fire and carbon dioxide sensors) that keep we safe and comfortable. For additional real-time security, convenience and control, home automation systems from security providers should also include options for video cameras.[3]

[3] http://www.iotevolutionworld.com/m2m/articles/376816-history-smart-homes.htm

3. **PHASE – 1**

MATLAB GUI CONTROL

1. THEORY:-

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Cleve Moler, at the University of New Mexico, started developing MATLAB in the late 1970s. He designed it to give his students access to advanced algorithms without them having to learn FORTRAN. It soon spread to other universities and found a strong audience within the applied mathematics community.[4]

GUIs (also known as graphical user interfaces or UIs) provide point-and-click control of software applications, eliminating the need to learn a language or type commands in order to run the application.

MATLAB apps are self-contained MATLAB programs with GUI front ends that automate a task or calculation. The GUI typically contains controls such as menus, toolbars, buttons, and sliders. GUIDE (GUI development environment) provides tools to design user interfaces for custom apps. Using the GUIDE Editor, we can graphically design our UI. GUIDE then automatically generates the MATLAB code for constructing the UI, which we can modify to program the behavior of our app.

ARDUINO

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone.

[4] https://in.mathworks.com/products/matlab.html?s_tid=hp_ff_p_matlab

In this project, the Arduino is loaded with a specific program named adios.pde which enables the control of the microcontroller to be done by MATLAB code. The template code used in Matlab is generated after the creation of graphic user interface. The GUI used here has various components for example – panels, push buttons, static text boxes and edit text boxes. When the push buttons are pressed a particular command, which is pre-programmed for that button, is executed and that function is performed by Arduino. By using Matlab to create a GUI for Arduino we have the added advantage of using the computational power of Matlab as well.

LED

Light emitting diodes are made from a very thin layer of fairly heavily doped semiconductor material and depending on the semiconductor material used and the amount of doping, when forward biased an LED will emit a coloured light at a particular spectral wavelength.

An LED junction does not actually emit that much light so the epoxy resin body is constructed in such a way that the photons of light emitted by the junction are reflected away from the surrounding substrate base to which the diode is attached and are focused upwards through the domed top of the LED, which itself acts like a lens concentrating the amount of light. This is why the emitted light appears to be brightest at the top of the LED.[5]

LCD SCREEN (16X2)

We get the definition of LCD from the name "Liquid Crystal" itself. It is actually a combination of two states of matter – the solid and the liquid. They have both the properties of solids and liquids and maintain their respective states with respect to another. Solids usually maintain their state unlike liquids who change their orientation and move everywhere in the particular liquid. Further studies have showed that liquid crystal materials show more of a liquid state than that of a solid. It must also be noted that liquid crystals are more heat sensitive than usual liquids. A little amount of heat can easily turn the liquid crystal into a liquid. This is the reason why they are also used to make thermometers.[6]

The liquid-crystal display has the distinct advantage of having a low power consumption than the LED. It is typically of the order of microwatts for the display in comparison to the some order of

[5] http://www.electronics-tutorials.ws/diode/diode_8.html
[6] http://www.circuitstoday.com/liquid-crystal-displays-lcd-working

milliwatts for LEDs. Low power consumption requirement has made it compatible with MOS integrated logic circuit. Its other advantages are its low cost, and good contrast. The main drawbacks of LCDs are additional requirement of light source, a limited temperature range of operation (between 0 and 60° C), low reliability, short operating life, poor visibility in low ambient lighting, slow speed and the need for an ac drive.

PULSE WIDTH MODULATION (PWM)

Pulse width modulation (PWM) is a powerful technique for controlling analog circuits with a microprocessor's digital outputs. PWM is employed in a wide variety of applications, ranging from measurement and communications to power control and conversion.

An analog signal has a continuously varying value, with infinite resolution in both time and magnitude. A nine-volt battery is an example of an analog device, in that its output voltage is not precisely 9V, changes over time, and can take any real-numbered value. Similarly, the amount of current drawn from a battery is not limited to a finite set of possible values. Analog signals are distinguishable from digital signals because the latter always take values only from a finite set of predetermined possibilities, such as the set {0V, 5V}.

Analog voltages and currents can be used to control things directly, like the volume of a car radio. In a simple analog radio, a knob is connected to a variable resistor. As we turn the knob, the resistance goes up or down. As that happens, the current flowing through the resistor increases or decreases. This changes the amount of current driving the speakers, thus increasing or decreasing the volume. In this project we cannot use resistors to control current to the motor and hence the speed because this would include a hardware knob and defeat the purpose of a GUI. An analog circuit is one, like the radio, whose output is linearly proportional to its input.[7]

The use of pulse width modulation to control a small motor has the advantage in that the power loss in the switching transistor is small because the transistor is either fully “ON” or fully “OFF”.

[7] http://www.embedded.com/electronics-blogs/beginner-s-corner/4023833/Introduction-to-Pulse-Width-Modulation

As a result the switching transistor has a much reduced power dissipation giving it a linear type of control which results in better speed stability.

Also the amplitude of the motor voltage remains constant so the motor is always at full strength. The result is that the motor can be rotated much more slowly without it stalling. In this project, Pulse width modulation is used to give the ability of speed control for the fan.

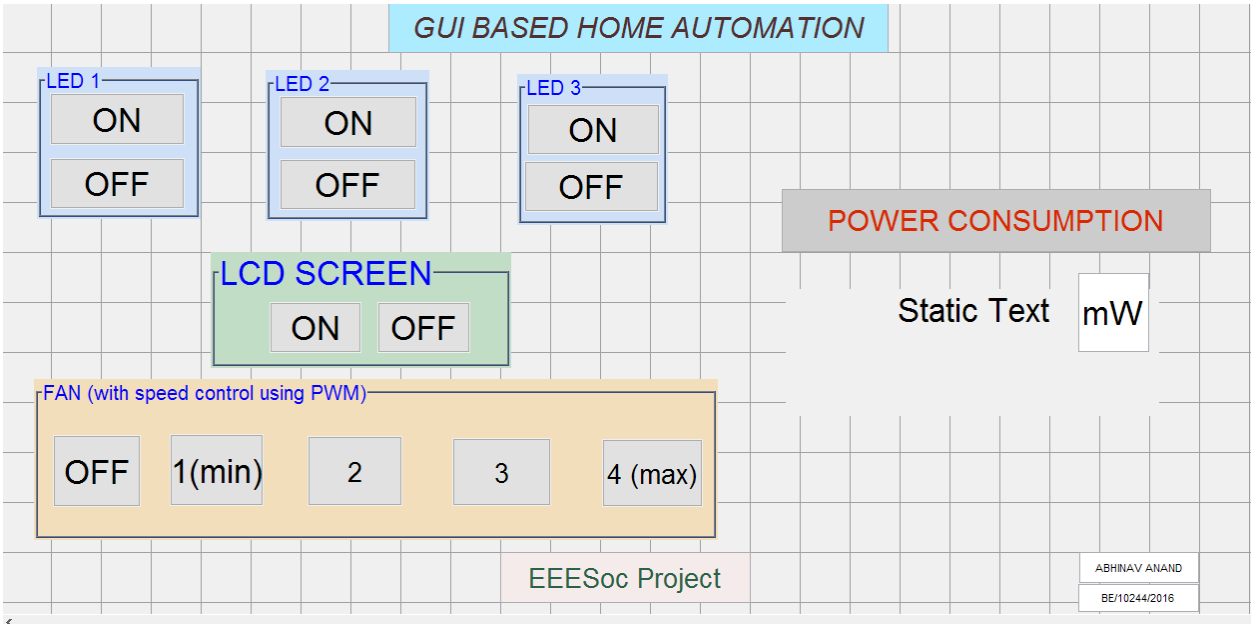
TEMPERATURE AND HUMIDITY SENSOR (DHT-11)

The DHT11 sensor comes in a single row 4-pin package and operates from 3.5 to 5.5V power supply. It can measure temperature from 0-50 °C with an accuracy of ±2°C and relative humidity ranging from 20-95% with an accuracy of ±5%. The sensor provides fully calibrated digital outputs for the two measurements. It has got its own proprietary 1-wire protocol, and therefore, the communication between the sensor and a microcontroller is not possible through a direct interface with any of its peripherals. The protocol must be implemented in the firmware of the MCU with precise timing required by the sensor.[8]

2. DIAGRAMS AND GRAPHIC REPRESENTATIONS:-

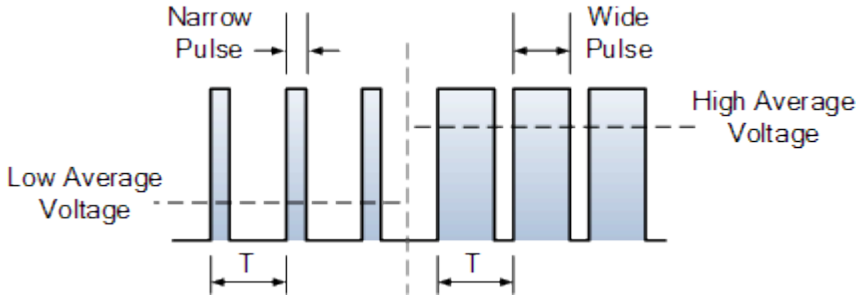
[8] http://embedded-lab.com/blog/measurement-of-temperature-and-relative-humidity-using-dht11-sensor-and-pic-microcontroller/

GUI created using MATLAB

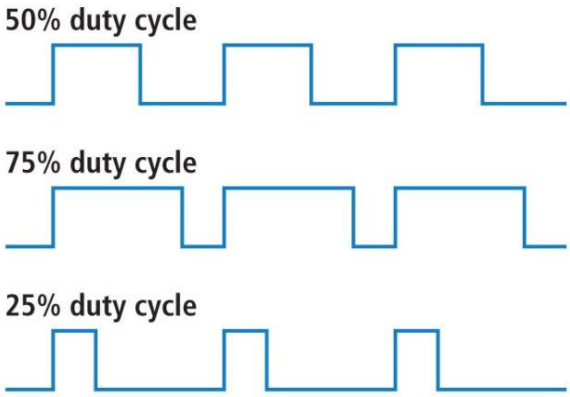


Here the buttons perform the task that has been mentioned on their panel headers, the buttons on the fan control use PWM technique to give the desired speed to the fan. Another feature of the GUI is the power consumption panel. It takes real time data from the Arduino and displays in milliwatts the power currently being consumed in the circuit.

PULSE WIDTH MODULATION



In this process, the waveform is manipulated in such a way that the maximum amplitude is reached only in pulses. In this manner the average value which is available to the circuit can be controlled.

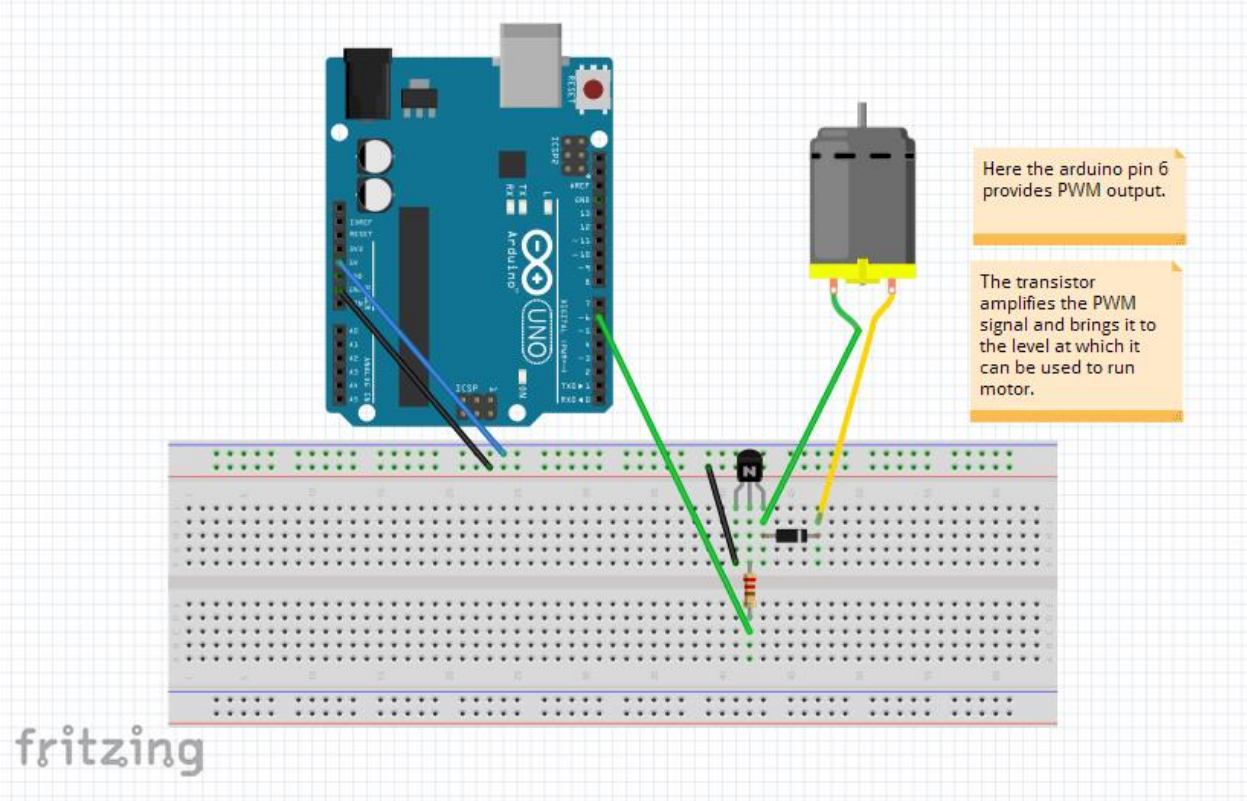


If maximum amplitude is 12V,

For 50% duty cycle, average value = 0.5x 12 = 6V

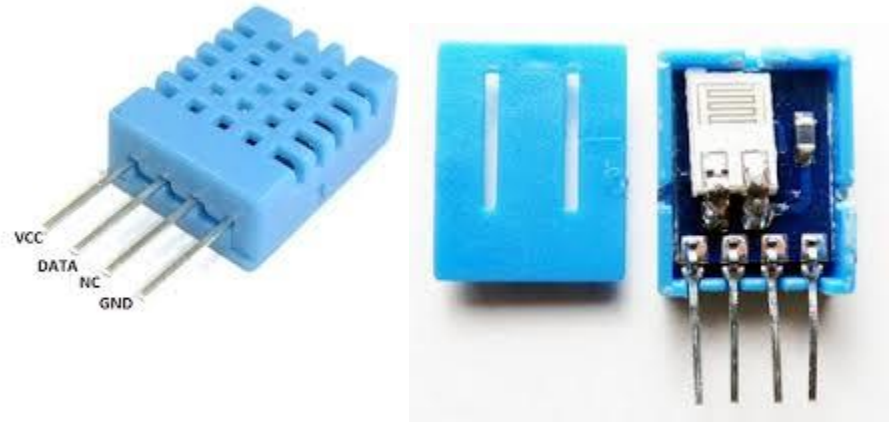
For 75% duty cycle, average value = 0.75x 12 = 9V

For 25% duty cycle, average value = 0.25x 12 = 3V



Circuit diagram which is used to implement PWM

TEMPERATURE AND HUMIDITY SENSOR (DHT11)



DHT11 uses a simplified single-bus communication. Single bus that only one data line, the system of data exchange, control by a single bus to complete. Device (master or slave) through an open-drain or tri-state port connected to the data line to allow the device does not send data to release the bus, while other devices use the bus; single bus usually require an external one about 5.1kΩ pull-up resistor, so that when the bus is idle, its status is high. Because they are the master-slave structure, and only when the host calls the slave, the slave can answer, the host access devices must strictly follow the single-bus sequence, if the chaotic sequence, the device will not respond to the host.[9]

[9] https://akizukidenshi.com/download/ds/aosong/DHT11.pdf

3. HARDWARE IMPLEMENTATION

This project uses two Arduino boards. The first one is used to switch on the components by taking commands from MATLAB and the components are connected to pins 8 to 12, where the pin 11 is used for the motor considering its PWM capabilities. The Arduino board is connected to the pc using USB cable type A/B Standard USB 2.0 cable.

The connections on this Arduino are as follows:-

Digital pin 8 – LED 1

Digital pin 9 – LED 2

Digital pin 10 – LED 3

Digital pin 11 – Motor

Digital pin 12 – Backlight Vcc of 16x2 LCD screen

The next Arduino has a pre-loaded code which is used to derive data from the DHT11 sensor using the single line communication protocol. This data is then displayed on the 16x2 display which is connected to this Arduino (except for the backlight Vcc pin).

Hence the pin connection arrangement for second Arduino is:-

DTH11

Pin1 --> 5v and 10k ohm resistor

Pin2 --> Arduino Pin8 and 10k ohm resistor

Pin3 --> no connection

Pin4 --> Ground

16x2 LCD Screen

Pin1 --> Ground

Pin2 --> 5v

Pin3 --> 22k ohm potentiometer wiper pin (middle pin. the other two pins on the POT go to 5v and Ground)

Pin4 --> Arduino Pin12

Pin5 --> Ground

Pin6 --> Arduino Pin11

Pin7 --> no connection

Pin8 --> no connection

Pin9 --> no connection

Pin10 --> no connection

Pin11 --> Arduino Pin5

Pin12 --> Arduino Pin4

Pin13 --> Arduino Pin3

Pin14 --> Arduino Pin2

Pin15 --> 5v

Pin16 --> Ground

After this, we connect the Arduino 1 to the PC containing MATLAB and we run our GUI code from MATLAB and then operate the system.

4. PHASE-2

ANDROID APP CONTROL

1. THEORY:-

Internet of Things (IoT)

Internet of Things represents a general concept for the ability of network devices to sense and collect data from the world around us, and then share that data across the Internet where it can be processed and utilized for various interesting purposes.[10]

Some also use the term industrial Internet interchangeably with IoT. This refers primarily to commercial applications of IoT technology in the world of manufacturing. The Internet of Things is not limited to industrial applications, however.

All kinds of ordinary household gadgets can be modified to work in an IoT system. Wi-Fi network adapters, motion sensors, cameras, microphones and other instrumentation can be embedded in these devices to enable them for work in the Internet of Things Home already implement primitive versions of this concept for things like light bulbs, plus other devices like wireless scales and wireless blood pressure monitors that each represent early examples of IoT gadgets. Wearable computing devices like watches and glasses are also envisioned to be key components in future IoT systems.The same wireless communication protocols like Wi-Fi and Bluetooth naturally extend to the Internet of Things also.

Some future consumer applications envisioned for IoT sound like science fiction, but some of the more practical and realistic sounding possibilities for the technology include:

- receiving warnings on our phone or wearable device when IoT networks detect some physical danger is detected nearby
- self-parking automobiles
- automatic ordering of groceries and other home supplies
- automatic tracking of exercise habits and other day-to-day personal activity including goal tracking and regular progress reports

[10] https://www.lifewire.com/introduction-to-the-internet-of-things-817766

Bluetooth module (HC-05)

HC- 05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial 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 Blue core 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

The Bluetooth module HC-05 is a MASTER/SLAVE module. By default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to our embedded project, etc.[11]

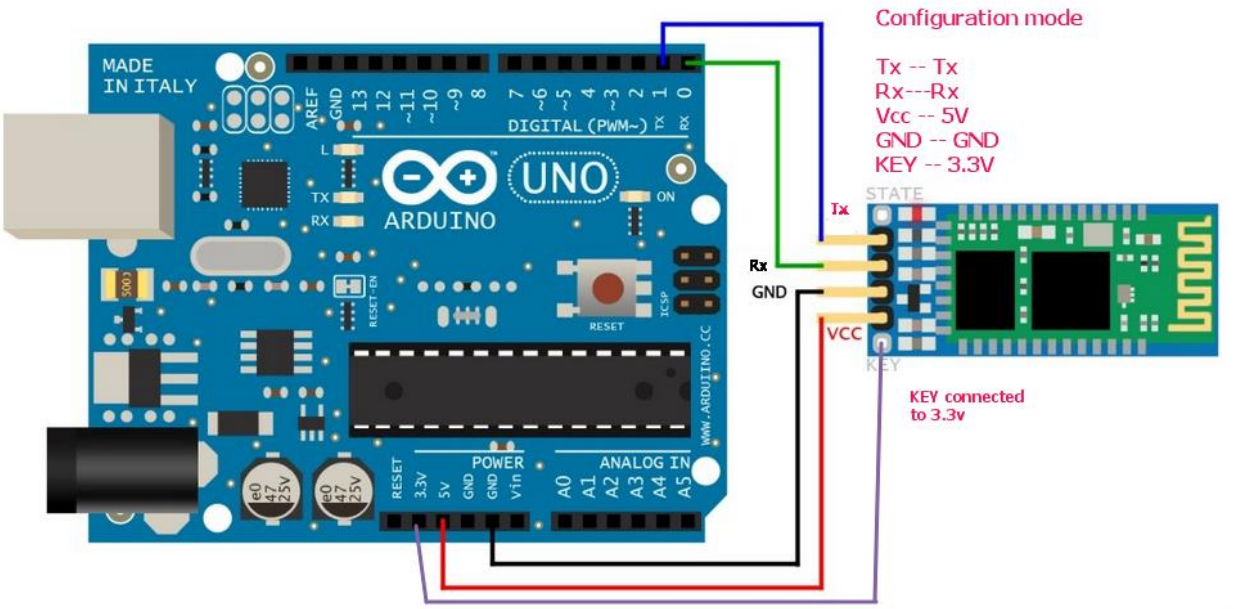
BLYNK APP

Blynk is a Platform with iOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. It's a digital dashboard where we can build a graphic interface for our project by simply dragging and dropping widgets. After selecting suitable hardware from the large selection available, we have to create various buttons and widgets according to our use. After this we have to program the purpose of each and every widget according to our needs. A code which is provided by Blynk website upon the creation of the project is uploaded to Arduino in order to enable control through Blynk project.[12]

[11] https://wiki.eprolabs.com/index.php?title=Bluetooth_Module_HC-05
[12] http://www.blynk.cc/

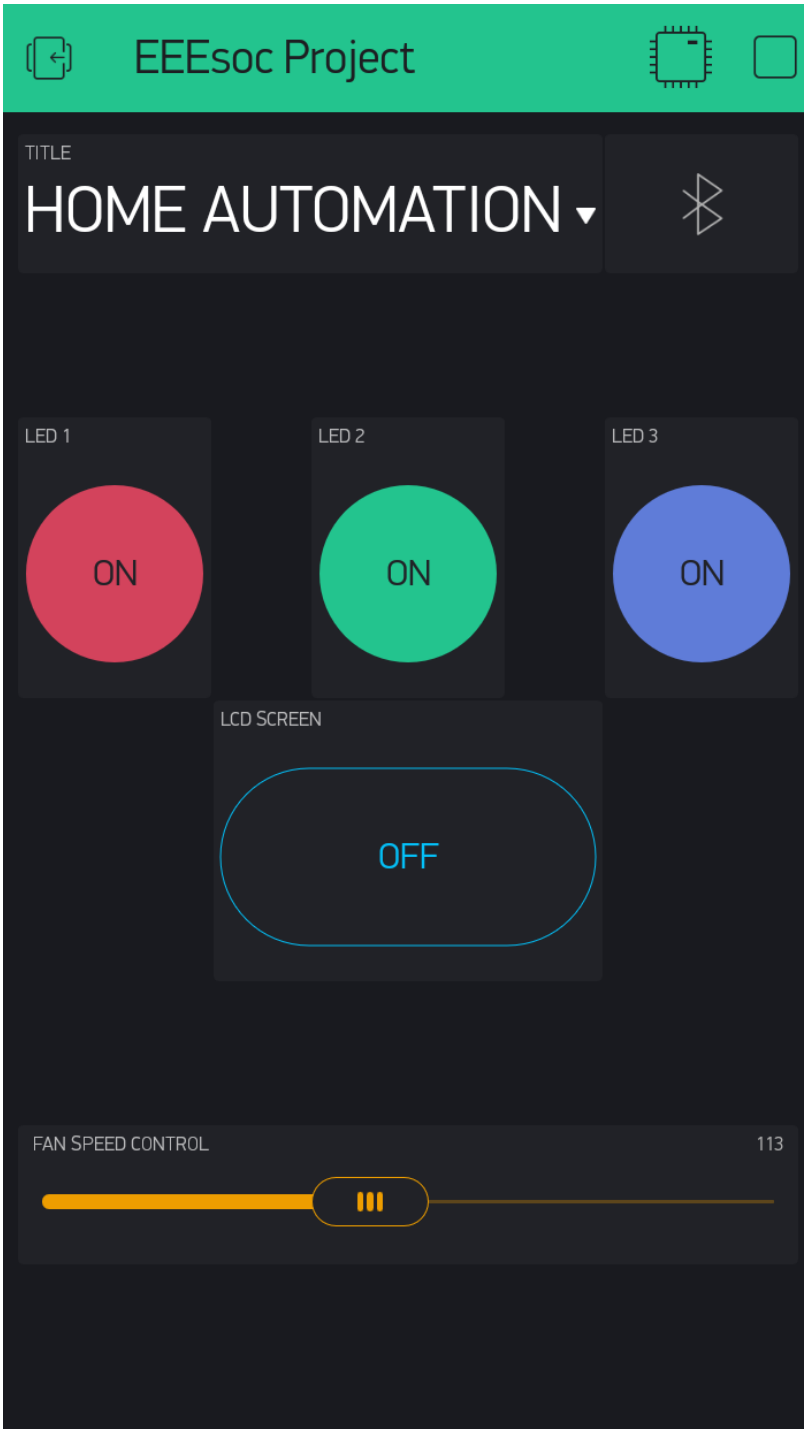
2. DIAGRAMS AND GRAPHIC REPRESENTATIONS:-

Bluetooth module:-



The Tx and Rx pins refer to the transmission and receiving pins respectively. This module can be powered by 5 volts or 3.3 volts. The default mode of HC-05 is SLAVE so it can only be connected to and not be used to start a connection. It is not necessary to connect the Key pin.

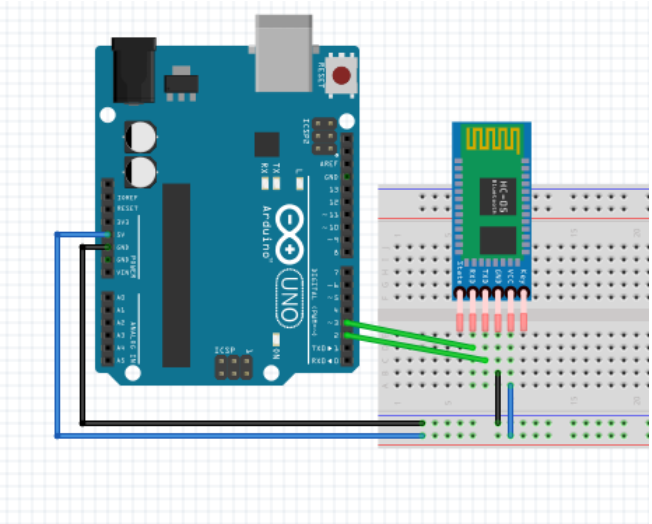
Mobile App:-

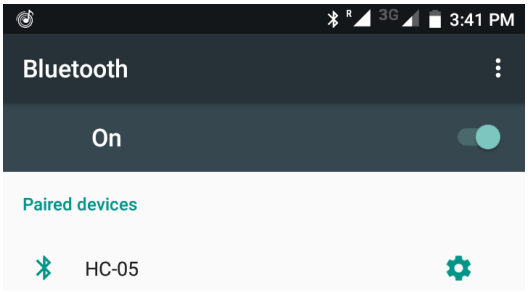


This is the screenshot of the mobile app created on blynk platform and the buttons are used to operate the components. The slider controls fan speed (max=255).

3. HARDWARE IMPLEMENTATION:-

The Bluetooth module is placed on the breadboard and the respective connections are made using jumper wires. The Tx and Rx pins are connected to the pins which are mentioned in the Blynk sketch. The module can be powered by 5 volts as well as 3.3 volts. As soon as the Bluetooth board is powered, we can connect to it using any android phone. It shows as HC-05 in the Bluetooth devices list. After pairing the device, we simply go to the app and connect to board from the GUI and then we can operate the system.





5. PHASE-3

VOICE CONTROL (Using Android App)

1. THEORY:-

Android comes with an inbuilt feature speech to text through which we can provide speech input to our app. With this we can add some of the features to our app like adding voice navigation (Helpful when we are targeting differently-abled people), filling a form with voice input etc. In the background how voice input works is, the speech input will be streamed to a server, on the server voice will be converted to text and finally text will be sent back to our app.

We will be using an app called Android meets robots to convert our voice command to our module via serial port protocol. The Arduino will then perform the task associated with a particular string.

Android Meets Robots: Voice Recognition Uses android mobiles internal voice recognition to pass voice commands to our robot. Pairs with Bluetooth Serial Modules and sends in the recognized voice as a string. For example if we say Hello the android phone will return a sting *Hello# to our Bluetooth module * and # indicate the start and stop bits. They can be used with any microcontroller which can handle strings. Examples Platforms: Arduino, ARM, PICAXE, MSP430, 8051 based and many other processors and controllers.[13]

[13] https://play.google.com/store/apps/details?id=robotspace.simplelabs.amr_voice&hl=en

2. DIAGRAM AND GRAPHIC REPRESENTATION

The app has the following interface:-

We have to press the microphone icon and then we have to give our command. The smartphone then converts it to text and sends it to Bluetooth module and also displays it on-screen.

3. HARDWARE IMPLEMENTATION

The only hardware change that has to be made is the removal of Tx and Rx connection of HC-05 from 2, 3 and put it in 0, 1. No other changes are required in the hardware.

6. CURRENT SCENARIO

The India automation and control systems market has seen significant changes in dynamics over the years. Initially concentrated in the areas of HVAC and security systems, the market has now evolved into newer areas like lighting systems, fire detection systems, entertainment systems and energy management systems as well. The automation not only integrates different automation systems as mentioned above but also enables substantial power savings.

If we take the recent market study on the home automation, it is expected to grow at a CAGR of 30% over the 5 years to 2016, with applications such as security, lighting and energy management likely to play an important role in achieving this significant growth rate.

Increasing data thefts, burglaries, demand for enhanced security, need for energy management / conversion are a few of the key factors that have spurred the India automation and control systems market.

Smart home products are becoming an affordable luxury to the average Indian, while the increasing awareness of energy efficiency and smart living has been growing over the last few years. However, India is still not the lucrative choice for home automation majors. Honeywell Security, which has been prominent in the global home automation business over the last 20 years, launched its home systems business in India only in 2006. Legrand India, a subsidiary of the Legrand group based at Limoges, France, a manufacturer of electrical installation and information network products, has been in the smart home products space in the country since 2003. Researchers, however, conclude that home automation has a long way to go in India, but surely the interest is catching on.[14]

[14] https://sahanraj.wordpress.com/2013/01/10/home-automation-market-in-indian-scenario

7. FUTURE PROSPECT

The next phase for the Home automation market will occur based on a few key improvements in the technology available in Automation, such as improvement in Wireless Automation solutions as well as lowering of price points as the market begins to accept Home automation usage in larger volumes. Some trends that we foresee for this phase of the industry are

• Big companies like Philips, Siemens & Schneider will eventually bring out fairly mass market automation products with appealing user interface but at a lower price point than today, and more people will be able to afford the products.

• Solution offerings will slowly move to a more user friendly design, where aside from a few key components, users will be able to buy and use the Automation products themselves without the aid of any technical expert.

• Some foreign companies will have niche in high end automation and focus on the premium market (>20 Lakh ticket size).[15]

According to research firm Red Seer Consulting, the home automation market in India is expected to reach 3.2 billion $ by 2017. The firm's report says that the key growth drivers for this demand are increasing consumer awareness and purchasing power, increased travel, desire for uniform experience product innovations (like smartphone apps), and builders' requirement for market.

As with any industry, as Automation for residences become common place, the market will eventually be crowded with several players, multiple product offerings and competitive pricing. If IoT were to become common place, then we're looking at a multi-billion dollar opportunity in the Indian market.

[15] http://thasmai.net/future-scope-for-home-automation-market-in-india

8. REFERENCES

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- www.electronicsforu.com
- www.sparkfun.com
- forum.arduino.cc

9. APPENDIX

ABBREVIATIONS:-

LED – Light Emitting Diode

LCD – Liquid Crystal Display

GUI – Graphic User Interface

GUIDE –Graphic User Interface Development Environment

IoT – Internet of Things

Wi-Fi – Wireless Fidelity

LGPL – Lesser General Public License

PWM – Pulse Width Modulation

MCU – Microcontroller Unit

USB – Universal Serial Bus

ARM – Advanced RISC Machine

RISC – Reduced Instruction Set Computing

HVAC – Heating, Ventilation and Air Conditioning

CAGR – Compound Annual Growth Rate