Design & Developed of a Microcontroller Based Home Appliance Control System Using Wi-Fi

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DECLARATION

We hereby declare that we carried out the work reported in this project in the **Department of Electronics and Communication Engineering, East West University, under the supervision of Dr. Md. Habibur Rahman.** We solemnly declare that to the best of our knowledge, no part of this report has been submitted elsewhere for award of a degree. All sources of knowledge used have been duly acknowledged.

Signature:

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APPROVAL

This is to certify that the Project titled as "Design and Developing of a Microcontroller Based Home Appliance Control System Using Wi-Fi" submitted to the respected members of the Board of Examiners of the Faculty of Engineering for partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics & Telecommunications Engineering by the following students and has been accepted as satisfactory.

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ABSTRACT

In modern days, we must use various high-tech electronic devices and equipments to get our jobs done and make the life easier. The purpose of this project is to design a control system that is able to control a system device remotely from distant places and monitoring conditions of the system web page on the Arduino and advances step by step from there. This project shows how to set up an Arduino with Ethernet shield as a web server. The web servers in this project are used to serve up web pages that can be accessed from a web browser and allows our hardware to be controlled from web browser. Starting from basic, our example for this project is simple. We want to access our device by switching ON-OFF LED and monitor analog input data acquisition from web server, which are computer or mobile phone and Arduino connected to the same network. Also we can control (ON/OFF) every electronic and electrical load (operated by 220V) of our home like lights, fans, AC, refrigerators, TVs using relays with this system. The system has been designed and implemented practically. It is found that the system works perfectly.

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Chapter 1

INTRODUCTION

1.1 Physical Computing

Physical Computing uses electronics to prototype new materials for designers and artists. It involves the design of interactive objects that can communicate with humans using sensors and actuators controlled by a behavior implemented as software running inside a microcontroller (a small computer on a single chip). In the past, using electronics meant having to deal with engineers all the time, and building circuits one small component at the time; these issues kept creative people from playing around with the medium directly. Most of the tools were meant for engineers and required extensive knowledge. In recent years, microcontrollers have become cheaper and easier to use, allowing the creation of better tools. The progress that we have made with Arduino is to bring these tools one step closer to the novice, allowing people to start building stuff after only two or three days of a workshop. With Arduino, a designer or artist can get to know the basics of electronics and sensors very quickly and can start building prototypes with very little investment.

1.2 The Internet of Things

A thing, in the Internet of Things, can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network. So far, the Internet of Things has been most closely associated with machine-to-machine (M2M) communication in manufacturing and power, oil and gas utilities. Products built with M2M communication capabilities are often referred to as being smart.

1.3 Energy

In physics, energy is a property of objects which can be transferred to other objects or converted into deferent forms but cannot be created or destroyed. It is difficult to give a comprehensive definition of energy because of its many forms, but one common definition is that it is the ability of a system to perform work. Energy is also a very important issue in our world. Energy is two types (potential energy and kinetic energy). World energy consumption refers to the total energy used by all of human civilization. Typically measured per year, it involves from every energy source applied towards humanity's endeavors across every industrial and technological sector, across every country.

1.4 Electrical Energy

Electrical energy is the energy carried by moving electron sin an electric conductor. It cannot be seen, but it is one of our most useful forms of energy because it is relatively easy to transmit and use. All matter consists of atoms, and every atom contains one or more electrons, which are always moving. The movement of these electrons depends on how much energy it has. This means every object has potential energy, even though some have more than others. When electrons are forced along a path in a conducting substance such as a wire, the result is energy called electricity. Electrical generating plants do not create energy. They change other forms of energy into electricity. Lightning is one good example of electrical energy in nature, so powerful that it is not confined to a wire. Thunderclouds build up large amounts of electrical energy. This is called static electricity.

1.5 Purpose of this Project

This project shows how to set up an Arduino with Ethernet shield as a web server. The web servers in this project are used to serve up web pages that can be accessed from a web browser running on any computer and any Wi-Fi connected device connected to the same network as the Arduino. Arduino web server pages allow access to the Arduino hardware this allows hardware to be controlled (e.g. switching on and off an LED from the web page) and monitored (e.g. reading the state of a switch and displaying it on a web page). We can control every electronic device (Within 220V and more) of our home like Lights, Fan, AC, Refrigerator, TV etc. In this project, we describe how to control and designing a Wi-Fi based home appliance control system. In our project, we design a system which can turn on and off without using any switch. In home, a big office, a shop or in a university class room we can use it. For this project we use Arduino Ethernet shield, Arduino UNO, memory card, Wi-Fi router, pc and smart phone. It works after confirmation from smart phone or pc. It also used for secured our home or workplace. So this control system gives safe secured environment. In short the purpose of the project is

- To design a smart home appliance control system
- To construct a smart home controller circuit in the breadboard
- Test for its functionality
- Product commercialization
- To design the control system with low cost components

1.6 Outline of the report

Here we describe four chapters on the purpose of this project. First we describe the introduction part that contains physical computing, the internet of things, energy, electrical energy and purpose of this project.

Chapter 2

AN OVERVIEW OF MICROCONTROLLERS

2.1 Introduction

Arduino is an open source electronics platform based on easy-to-use hardware and software. In this project we use Arduino-UNO board. The Arduino hardware platform already has the power and reset circuitry setup as well as circuitry to program and communicate with the microcontroller over USB. In addition, the I/O pins of the microcontroller are typically already fed out to sockets/headers for easy access. On the software side, Arduino provides a number of libraries to make programming the microcontroller easier. The simplest of these are functions to control and read the I/O pins rather than having to fiddle with the bus/bit masks normally used to interface with the At mega I/O.

2.2 Microcontroller

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory and programmable input/output peripherals. It is highly integrated chip that contains all the components comprising a controller. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, implantable medical devices, appliance and other embedded systems. We used here for appliance cases.

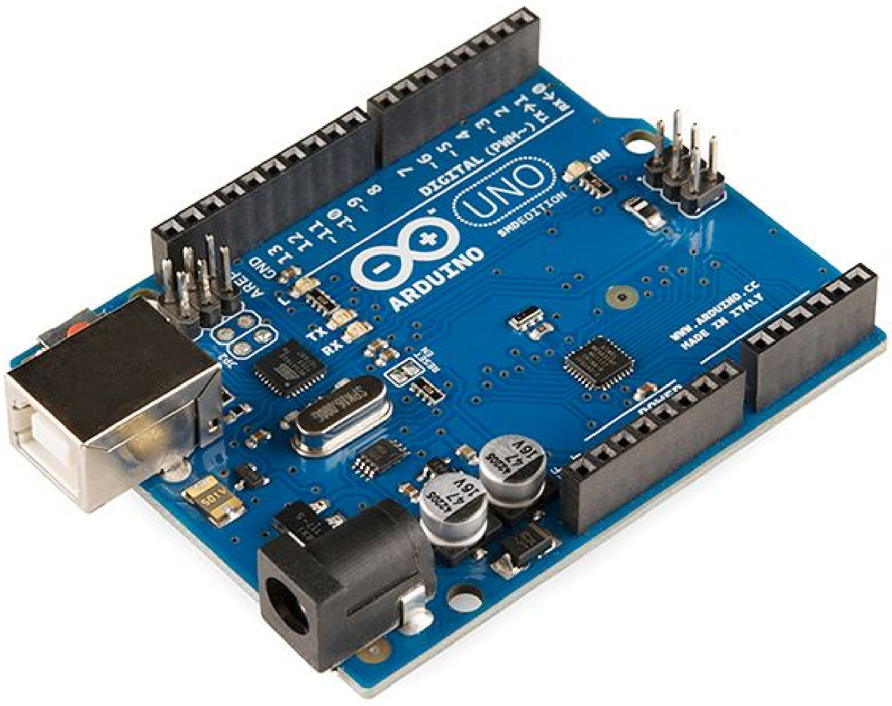
2.3 Advantages of Microcontroller

- The simplest computer processor is used as the "brain" of the future system.
- Single purposes and low power consumption.
- Depending on the taste of the manufacturer, a bit of memory, a few A/D converters,
- input/output lines etc. are added.
- Low cost and small packaging.
- Simple software able to control it all and which everyone can easily learn about has been developed.

2.4 Arduino-UNO

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use Hardware and software. Arduino consists of both a physical programmable circuit board and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware in order to load new code onto the board – simply use a USB cable. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package. The Arduino software is free, the hardware boards are pretty cheap, and both the software and hardware are easy to learn has led to a large community of users who have contributed code and released instructions for a huge variety of Arduino-based projects.

2.5 Figure of Arduino-UNO



2.1 Figure: Arduino-UNO

2.6 History of Arduino-UNO

The Arduino is developed in 2005. The Arduino microcontroller was initially created as an educational platform for a class project at the Interaction Design Institute Ivrea in Milan (Italy) in 2005. It derived from a previous work of the Wiring microcontroller designed by Hernando Barragan in 2004. From the beginning, the Arduino board was developed to attract artists and designers. The Wiring microcontroller was created by Hernando Barragan to be used for parsing data to electronic devices. His aim was that it could be used by non-technical people who only had basic experience with using computers. He first of all wanted it to be used as a prototyping tool. Since he needed help to create an easy software tool to programmed the board he engaged Casey Reas and Massimo Banzi as his assistants. Reas created the visual programming language for the prototyping tool.

2.7 Development

The computer, commonly defined as a tool for processing, storing, and displaying information, arose from a long line of analog devices used for effective counting and calculation, ranging from the simple abacus (first invented in Sumeria around 2300 BC), to Napier's Bones (conceived in 1617, and the precursor to the slide rule), to BlaisePascal's gear-based mechanical calculator (1645).The development of the computer accelerated during the 1940's, spurred on largely by the highly industrialized nature of military production in World War II.The 1960's marked a significant evolutionary leap for computing, due to the development of solid state computers (such as the IBM 1401), which used transistors for processing operations, and magnetic core memory for storage. The invention of integrated circuits in 1959 by Jack Kilby, which enabled transistors and circuits to be fused onto small chips of semiconducting materials (such as silicon), allowed further miniaturization of computer components. Another important development during this decade was the advent of high-level computer programming languages that were written in symbolic language, making computer code somewhat easier to read and learn than previous machine languages. COBOL and FORTRAN were the main languages introduced during this period. The microprocessor was introduced in 1970. The microprocessor essentially miniaturized all hardware components of a computers central processing unit to fit onto a single, tiny integrated circuit, now more popularly known as a microchip. The microchip also became the main driving component of microcontrollers (such as the Arduino), which generally consist of a microchip, memory storage hardware, and input/ output hardware for sensors. The 1970's and 1980's also saw the development of a new generation of more powerful programming languages (such as C, C++, and later Java) for applications in business and science.

2.8 Evoluation

The PIC microcontroller board, introduced in 1985 by General Instruments, became one of the most popular tools for electronics enthusiasts (before the Arduino) for several reasons. Other popular boards for hobbyists include the BASIC Stamp (Parallax Inc., 1990), and Wiring both of which share the benefits of simplicity of programming, and a resulting ease of rapid-prototyping. The Arduino project grew largely out of the “DIY” climate created by the burgeoning popularity of rapid- prototyping boards like PIC. In fact, the immediate precursor to the Arduino was a custom made Wiring microcontroller created by the artist/ designer Hernando Barragan in 2004 for his. In 2005, the Arduino team was formed in Ivrea, Italy, consisting of Barragan, Massimo Banzi, David Cuartielles, Dave Mellis, Gianluca Marino, and Nicholas Zambetti. As a result, the Arduino incorporated the following characteristic, a programming environment based on processing language (a programming language conceived by Ben Fry and Casey Reas, also conceived for artists/ designers), the ability to program the board via a standard USB connection, and a low price point. The Arduino achieved rapid success even within its first two years of existence, selling in a quantity of more than 50,000 boards. By 2009, it had spawned over 13 different incarnations, each specialized for different applications. Today, the Arduino microcontroller has become one of the most popular prototyping platforms in the world, and is a prime example of how hardware and software technologies originally created for military, business, and scientific applications can be repurposed to serve the needs of individuals creating projects in the realms of new media art and design[1].

Chapter 3

THEORY BEHIND THE PROJECT

3.1 Introduction

This project includes Arduino Uno broad, Arduino Ethernet Shield, Relay, Wi-Fi Router, Ethernet cable, RJ45 connector. We want to connect the Arduino Ethernet Shield to an Arduino. We developed the connection by using upper equipments. At first we developed a connection without load. Then we developed the circuit with 220V power load.

3.2 Architecture of Arduino-UNO

There are many varieties of Arduino boards that can be used for different purposes. The Arduino UNO components are:

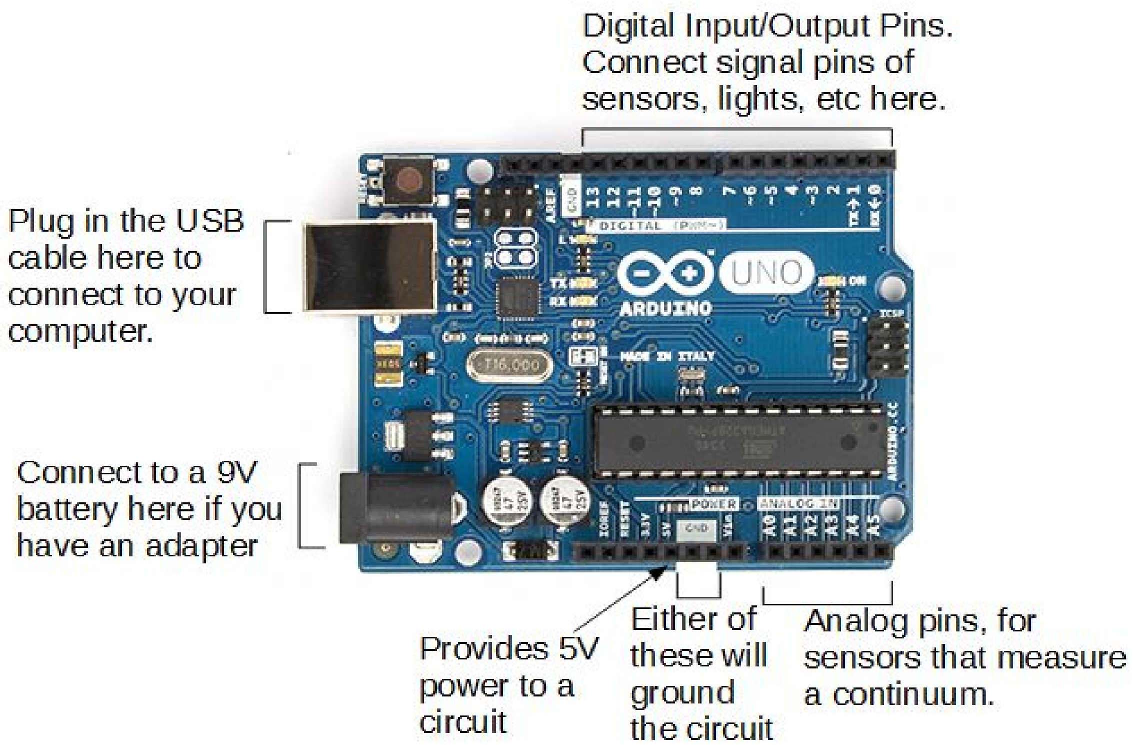

Digital Input/Output Pins. Connect signal pins of sensors, lights, etc here.
Plug in the USB cable here to connect to your computer.
Connect to a 9V battery here if you have an adapter
Provides 5V power to a circuit
Either of these will ground the circuit
Analog pins, for sensors that measure a continuum.

Figure 3.1: Arduino-UNO R3 Board

3.2.1 Power

The Arduino/Genuino Uno board 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 board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.
The power pins are as follows:

- V_{in}. The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V.This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.
- IOREF. This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.

3.2.2 Memory

The ATmega328 has 32 KB (with 0.5 KB occupied by 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).

3.2.3 Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function.

3.2.4 Power LED Indicator

Just beneath and to the right of the word “UNO” on circuit board, there’s a tiny LED next to the word ‘ON’. This LED should light up whenever plug Arduino into a power source. If this light doesn’t turn on, there’s a good chance something is wrong.

3.2.5 Reset Button

The Arduino has a reset button. Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very useful if code doesn't repeat, but we want to test it multiple times. Unlike the original Nintendo however, blowing on the Arduino doesn't usually fix any problems.

3.2.6 TX RX LEDs

TX is short for transmit, RX is short for receive. In our case, there are two places on the Arduino UNO where TX and RX appear once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs. These LEDs will give us some nice visual indications whenever Arduino is receiving or transmitting data.

3.2.7 Main IC

The black thing with all the metal legs is an IC, or Integrated Circuit. The main IC on the Arduino is slightly different from board type to board type, but is usually from the AT mega line of IC's from the ATMEL Company. This can be important, as may need to know the IC type before loading up a new program from the Arduino software. This information can usually be found in writing on the top side of the IC.

3.2.8 Voltage Regulator

The voltage regulator is not actually something interacting with on the Arduino. But it is potentially useful to know that it is there and what it's for. It controls the amount of voltage that is let into the Arduino board. It will turn away an extra voltage that might harm the circuit.

3.2.9 Technical specs

Microcontroller`	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 Ma
DC Current for 3.3V Pin	50 Ma
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

3.2.9 Schematic Diagram

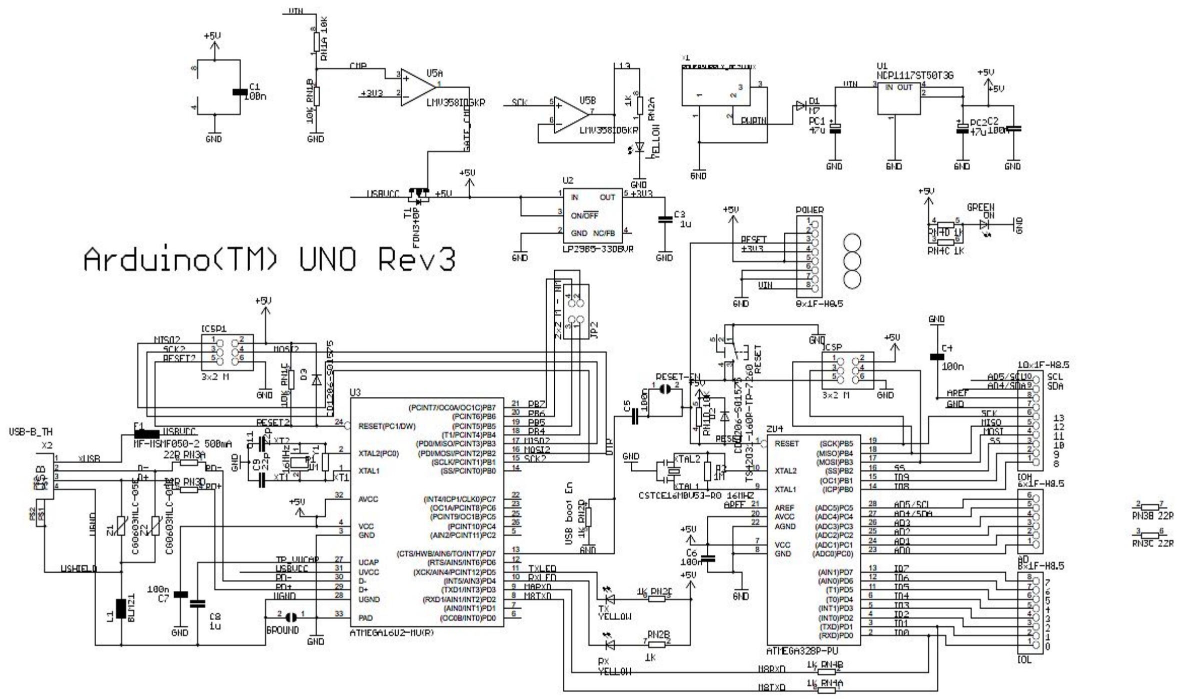


Figure 3.2: Schematic Diagram

3.3 Getting started with Arduino Software

First download and install the Arduino for Mac, Linux or Windows from arduino.cc. Windows users also need to install a driver. Connect your board via USB, launch the Arduino application and select Arduino-Uno from the tools to board menu. Open the sketch File.
Examples: 01. Basics: Blink. Click the toolbar button to upload it to your board.

3.3.1 The Integrated Development Environment (IDE)

Every microcontroller needs software to be programmed. The Arduino board is not a case apart. It has its own integrated development environment (IDE).It is free and everyone can download it from its official website using either the Windows, Mac OS X or Linux platform. That allows Arduino Board to gain more users and it also helps it to grow.

3.3.2 IDE Parts

- Compile: Before program “code” can be sent to the board, it needs to be converted into instructions that the board understands. This process is called Compiling.
- Stop: This stops the compilation process.
- Create new Sketch: This opens a new window to create news ketch.
- Open Existing Sketch: This loads a sketch from a file on our computer.
- Save Sketch: This saves the changes to the sketch.
- Upload to Board: This compiles and then transmits over the USB cable to our board.
- Serial Monitor: Until this point when our programs (sketches) didn’t work, we just pulled out our hair and tried harder.
- Tab Button: This lets you create multiple files in your sketch. This is for more advanced programming than we will do in this class.
- Sketch Editor: This is where write or edit sketches
- Text Console: This shows you what the IDE is currently doing and is also where error messages display if make a mistake in typing program.
- Line Number: This shows what line number your cursor is on.

3.4 Arduino Ethernet Shield

The Arduino Ethernet Shield connects your Arduino to the internet in mere minutes. Just plug this module onto your Arduino board, connect it to your network with an RJ45 cable (not included) and follow a few simple instructions to start controlling your world through the internet. As always with Arduino, every element of the platform – hardware, software and documentation – is freely available and open-source. This means you can learn exactly how it's made and use its design as the starting point for your own circuits. Hundreds of thousands of Arduino boards are already fueling people's creativity all over the world, everyday.

- Requires an Arduino board (not included)
- Operating voltage 5V (supplied from the Arduino Board)
- Ethernet Controller: W5100 with internal 16K buffer
- Connection speed: 10/100Mb
- Connection with Arduino on SPI port

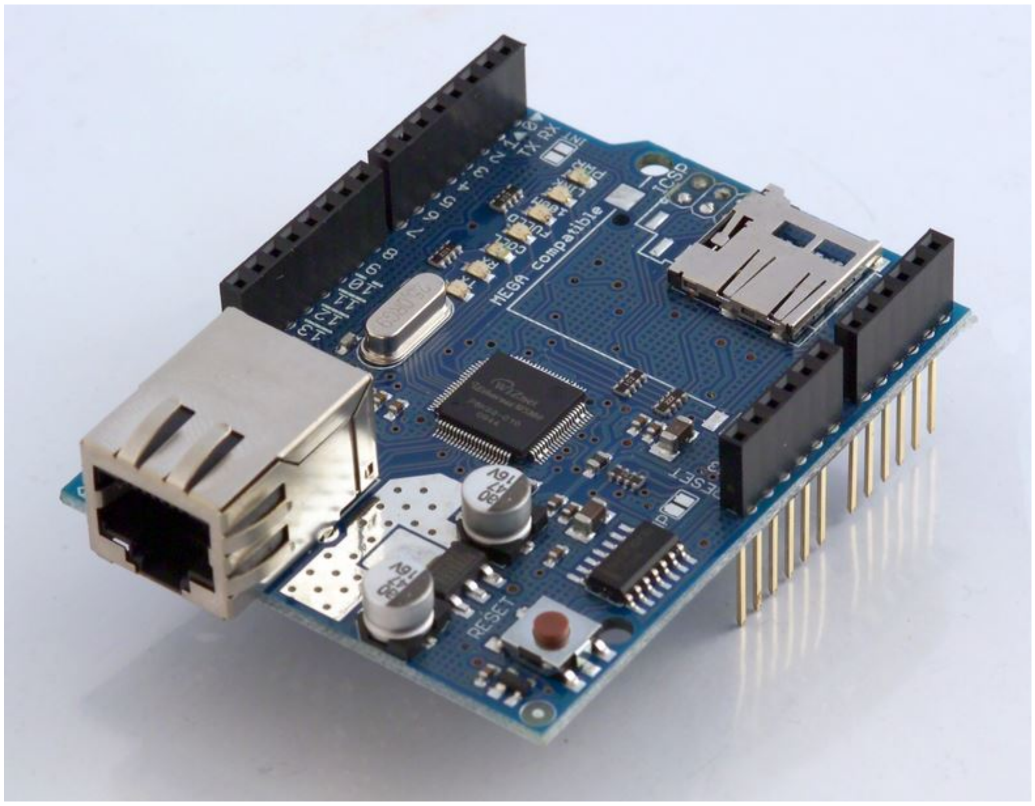


Figure 3.3: Arduino Ethernet Shield

3.4.1 Architecture of Arduino Ethernet Shield

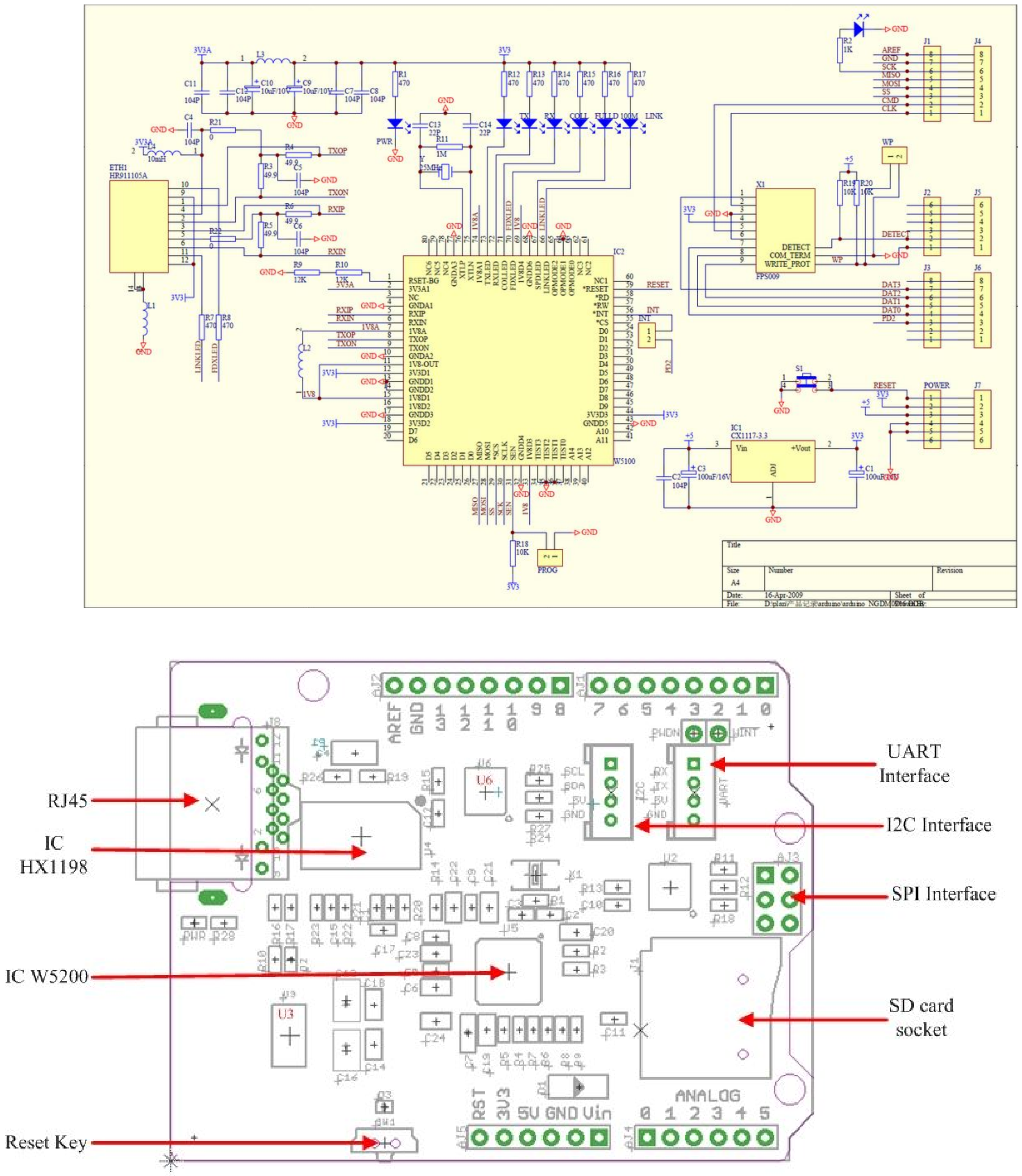


Figure 3.4: Architecture of Arduino Ethernet Shield

3.4.2 Description

The Arduino Ethernet Shield allows an Arduino board to connect to the internet. It is based on the Wiznet W5100ethernet chip (datasheet). The Wiznet W5100 provides a network (IP) stack capable of both TCP and UDP. It supports up to four simultaneous socket connections. Use the Ethernet library to write sketches which connect to the internet using the shield. The ethernet shield connects to an Arduino board using long wire-wrap headers which extend through the shield. This keeps the pin layout intact and allows another shield to be stacked on top. The most recent revision of the board exposes the 1.0 pinout on rev 3 of the Arduino UNO board. The Ethernet Shield has a standard RJ-45 connection, with an integrated line transformer and Power over Ethernet enabled. There is an onboard micro-SD card slot, which can be used to store files for serving over the network. It is compatible with the Arduino Uno and Mega (using the Ethernet library). The onboard microSD card reader is accessible through the SD Library. When working with this library, SS is on Pin 4. The original revision of the shield contained a full-size SD card slot; this is not supported. The shield also includes a reset controller, to ensure that the W5100 Ethernet module is properly reset on power-up. Previous revisions of the shield were not compatible with the Mega and need to be manually reset after power-up. The current shield has a Power over Ethernet (PoE) module designed to extract power from a conventional twisted pair Category 5 Ethernet cable:

- IEEE802.3af compliant
- Low output ripple and noise (100mVpp)
- Input voltage range 36V to 57V
- Overload and short-circuit protection
- 9V Output
    - High efficiency DC/DC converter: typ 75% @ 50% load
- 1500V isolation (input to output)

Arduino communicates with both the W5100 and SD card using the SPI bus (through the ICSP header). This is on digital pins 10, 11, 12, and 13 on the Uno and pins 50, 51, and 52 on the Mega. On both boards, pin 10 is used to select the W5100 and pin 4 for the SD card. These pins cannot be used for general I/O. On the Mega, the hardware SS pin, 53, is not used to select either the W5100 or the SD card, but it must be kept as an output or the SPI interface won't work. Note that because the W5100 and SD card share the SPI bus, only one can be active at a time. If you are using both peripherals in your program, this should be taken care of by the corresponding libraries. If you're not using one of the peripherals in your program, however, you'll need to explicitly deselect it. To do this with the SD card, set pin 4 as an output and write a high to it. For the W5100, set digital pin 10 as a high output. The shield provides a standard RJ45 ethernet jack. The reset button on the shield resets both the W5100 and the Arduino board. The shield contains a number of informational LEDs:

- PWR: indicates that the board and shield are powered
- LINK: indicates the presence of a network link and flashes when the shield transmits or receives data
- FULLD: indicates that the network connection is full duplex
- 100M: indicates the presence of a 100 Mb/s network connection (as opposed to 10 Mb/s)
- RX: flashes when the shield receives data
- TX: flashes when the shield sends data
- COLL: flashes when network collisions are detected

3.4.3 Connecting the Shield

To use the shield, mount it on top of an Arduino board (e.g. the Uno). To upload sketches to the board, connect it to your computer with a USB cable as you normally would. Once the sketch has been uploaded, you can disconnect the board from your computer and power it with an external power supply.Connect the shield to your computer or a network hub or router using a standard ethernet cable (CAT5 or CAT6 withRJ45 connectors). Connecting to a computer may require the use of a cross-over cable (although many computers, including all recent Macs can do the cross-over internally).

3.4.4 Network Settings

The shield must be assigned a MAC address and a fixed IP address using the Ethernet.begin() function. A MAC address is a globally unique identifier for a particular device. Current Ethernet shields come with a sticker indicating the MAC address you should use with them. For older shields without a dedicated MAC address, inventing a random one should work, but don't use the same one for multiple boards. Valid IP addresses depend on the configuration of your network. It is possible to use DHCP to dynamically assign an IP to the shield. Optionally, you can also specify a network gateway and subnet.

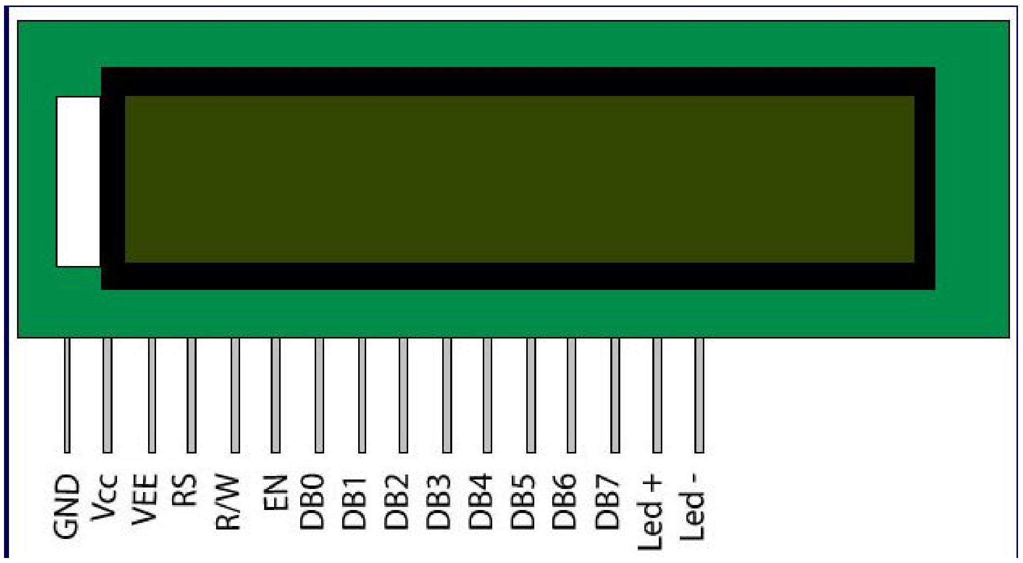
3.4.5 SD Card

The latest revision of the Ethernet Shield includes a micro-SD card slot, which can be interfaced with using the SD library.

3.5 Liquid Crystal Display (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD

3.5.1 Features of LCD Display



- 5 x 8 dots with cursor
- Built-in controller (KS 0066 or Equivalent)
- + 5V power supply (Also available for + 3V)
- 1/16 duty cycle
- B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED)
- N.V. optional for + 3V power supply

Figure 3.5: LCD Display

3.6 What is a relay

A Relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate the switch and provide electrical isolation between two circuits. In this project there is no real need to isolate one circuit from the other, but we will use an Arduino UNO to control the relay. We will develop a simple circuit to demonstrate and distinguish between the NO (Normally open) and NC (Normally closed) terminals of the relay. We will then use the information gained in this tutorial to make a much more exciting circuit. But we have to start somewhere. So let's get on with it.

3.6.1 Parts Required

- Freetronics Eleven or (Arduino UNO compatible board)
- 4 Channel Relay Module
- 2x LEDs
- 2x 330 ohm resistors
- Jumper Wires (male to male)
- Jumper Wires (female to male)

3.6.3 Circuit Diagram of Relay

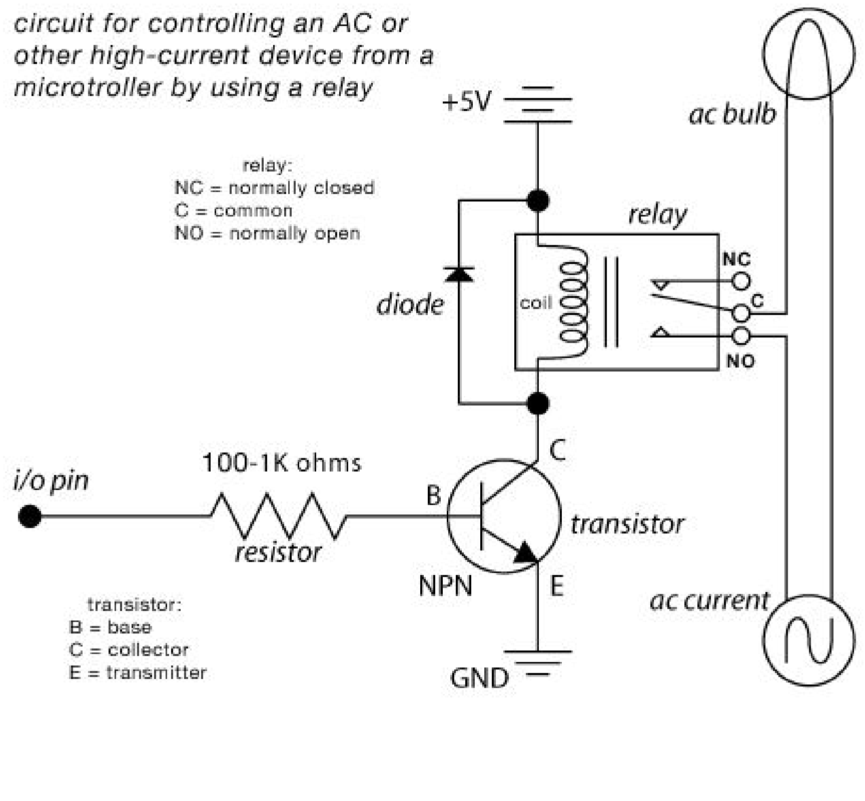


Figure 3.6: Circuit Diagram of Relay

3.6.2 Arduino Connected Reley Module

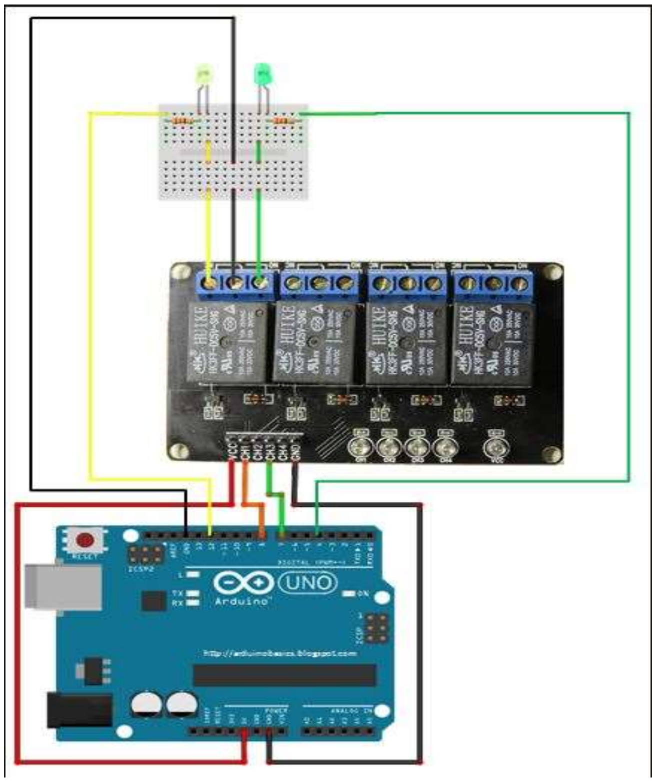
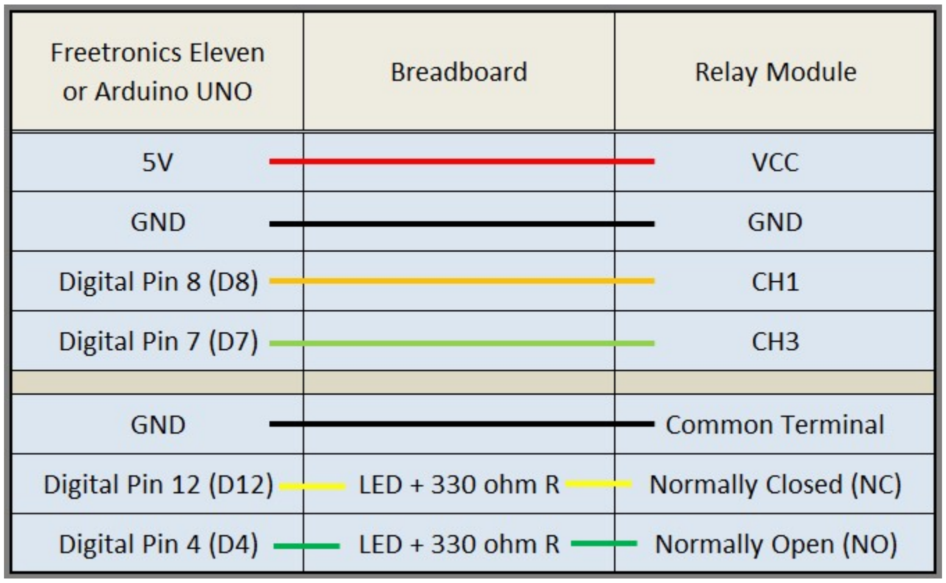


Figure 3.7: Arduino Connected Reley Module

3.6.4 Table of Connections



Freetronics Eleven or Arduino UNO	Breadboard	Relay Module
5V		VCC
GND		GND
Digital Pin 8 (D8)		CH1
Digital Pin 7 (D7)		CH3
GND		Common Terminal
Digital Pin 12 (D12)	LED + 330 ohm R	Normally Closed (NC)
Digital Pin 4 (D4)	LED + 330 ohm R	Normally Open (NO)

3.7 Wi-Fi

Wi-Fi is the name of a popular wireless networking technology that uses radio waves to provide wireless high-speed Internet and network connections. A common misconception is that the term Wi-Fi is short for "*wireless fidelity*," however this is not the case. Wi-Fi is simply a trademarked phrase that means *IEEE 802.11x*.

3.7.1 The Wi-Fi Alliance

The Wi-Fi Alliance, the organization that owns the Wi-Fi registered trademark term specifically defines Wi-Fi as any "*wireless local area network (*WLAN*) products that are based on the Institute of Electrical and Electronics Engineers' (*IEEE*) 802.11 standards.*" Initially, Wi-Fi was used in place of only the 2.4GHz 802.11b standard, however the Wi-Fi Alliance has expanded the generic use of the Wi-Fi term to include any type of network or WLAN product based on any of the 802.11 standards, including 802.11b, 802.11a, dual-band, and so on, in an attempt to stop confusion about wireless LAN interoperability.

3.7.2 Wi-Fi Support

Wi-Fi is supported by many applications and devices including video game consoles, home networks, PDAs, mobile phones, major operating systems, and other types of consumer electronics. Any products that are tested and approved as "Wi-Fi Certified" (a registered trademark) by the Wi-Fi Alliance are certified as interoperable with each other, even if they are from different manufacturers. For example, a user with a Wi-Fi Certified product can use any brand of access point with any other brand of client hardware that also is also "Wi-Fi Certified". Products that pass this certification are required to carry an identifying seal on their packaging that states "Wi-Fi Certified" and indicates the radio frequency band used (2.5GHz for 802.11b, 802.11g, or 802.11n, and 5GHz for802.11a).

3.7.3 How it works

A wireless network or Wireless Local Area Network (WLAN) serves the same purpose as a wired one — to link a group of computers. Because "wireless" doesn't require costly wiring, the main benefit is that it's generally easier, faster and cheaper to set up. By comparison, creating a network by pulling wires throughout the walls and ceilings of an office can be labor-intensive and thus expensive. But even when you have a wired network already in place, a wireless network can be a cost-effective way to expand or augment it. In fact, there's really no such thing as a purely wireless network, because most link back to a wired network at some point. The Basics Wireless networks operate using radio frequency (RF) technology, a frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space. The cornerstone of a wireless network is a device known as an access point (AP). The primary job of an access point is to broadcast a wireless signal that computers can detect and "tune" into. Since wireless networks are usually connected to wired ones, an access point also often serves as a link to the resources available on the a wired network, such as an Internet connection. In order to connect to an access point and join a wireless network, computers must be equipped with wireless network adapters. These are often built right into the computer, but if not, just about any computer or notebook can be made wireless-capable through the use of an add-on adapter plugged into an empty expansion slot, USB port, or in the case of notebooks, a PC Card slot.

3.7.4 Wireless Speed & Range

When you buy a piece of wireless network hardware, it will often quote performance figures (i.e., how fast it can transmit data) based on the type of wireless networking standard it uses, plus any added technological enhancements. In truth, these performance figures are almost always wildly optimistic. While the official speeds of 802.11b, 802.11g and 802.11n networks are 11, 54, and 270 megabits per second (Mbps) respectively, these figures represent a scenario that simply not attainable in the real world. As a general rule, you should assume that in a best-case scenario you will get roughly one-third of the advertised performance. It's also worth noting that a wireless network is by definition a shared network, so the more computers you have connected to a wireless access point the less data each will be able to send and receive. Just as a wireless network's speed can vary greatly, so too can the range. For example, 802.11b and g officially work over a distance of up to 328 feet indoors or 1,312 feet outdoors, but the key term there is "up to". Chances are you won't see anywhere close to those numbers. As you might expect, the closer you are to an access point, the stronger the signal and the faster the connection speed. The range and speed you get out of wireless network will also depend on the kind of environment in which it operates. And that brings us to the subject of interference.

3.8 Wireless Access Points or (WAPs)

Wireless access points (APs or WAPs) are special-purpose communication devices on wireless local area networks (WLANs). Access points act as a central transmitter and receiver of wireless radio signals. Mainstream wireless APs support Wi-Fi and are most commonly used to support public Internet hotspots and other business networks where larger buildings and spaces need wireless coverage. Access points are small hardware devices closely resembling home broadband routers. (Home routers actually integrate an access point into the rest of the device.) AP hardware consists of radio transceivers, antennas and device firmware. Access points enable so-called Wi-Fi infrastructure mode networking. Although Wi-Fi connections do not technically require the use of access points, APs enable Wi-Fi networks to scale to larger distances and numbers of clients. Modern access points support up to 255 clients (while very old ones supported only about 20). APs also provide *bridging* capability that enables a Wi-Fi network to connect to other wired networks.

Figure 3.8: 8 Wireless Access Points

Chapter 4

SYSTEM DESIGN AND ANALYSIS

4.1 Introduction

In this project helps those people who interested to build something with Arduino. To Design a project include into two parts, one is hardware design and another part is software design. We use Arduino Ethernet Shield, Relay module for the hardware design and we connected these components with microcontroller. Arduino software is downloaded from www.arduino.cc and C/C++ programmable language is used. Many examples are given in the ardiono.cc and this software is easy to usage.

4.2 Hardware Design

The whole system design is divided into two parts to design a smart home appliance control system. One is the design the smart system in the breadboard and controls the designed system. Another part is the display part design to count the value in smart system. Finally, the smart home appliance control system is formed a complete integrated system. In this project Arduino development board is more efficient.

4.2.1 Block Diagram of the control system

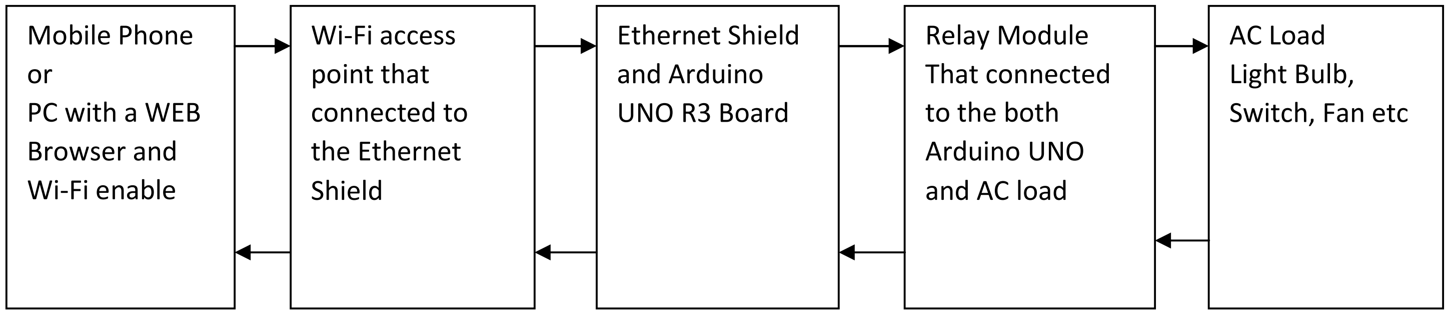

Mobile Phone or PC with a WEB Browser and Wi-Fi enable
Wi-Fi access point that connected to the Ethernet Shield
Ethernet Shield and Arduino UNO R3 Board
Relay Module That connected to the both Arduino UNO and AC load
AC Load Light Bulb, Switch, Fan etc

Figure 4.1: Block Diagram of the control system

4.2.2 Equipments Used in this System

- To design the project we use following component:
- One Arduino Uno Board.
- One bread board.
- One Arduino Ethernet Shield.
- One TP-link Wireless Access point.
- RJ-45 Connector.
- UTP Cable.
- FourLED.
- Four Relay & 12V power supply.
- 1k & 2k Resistance.
- One table fan.
- Three 100W bulb light.

4.2.3 Full Circuit Design

Here we have shown connection that we have done in this project.

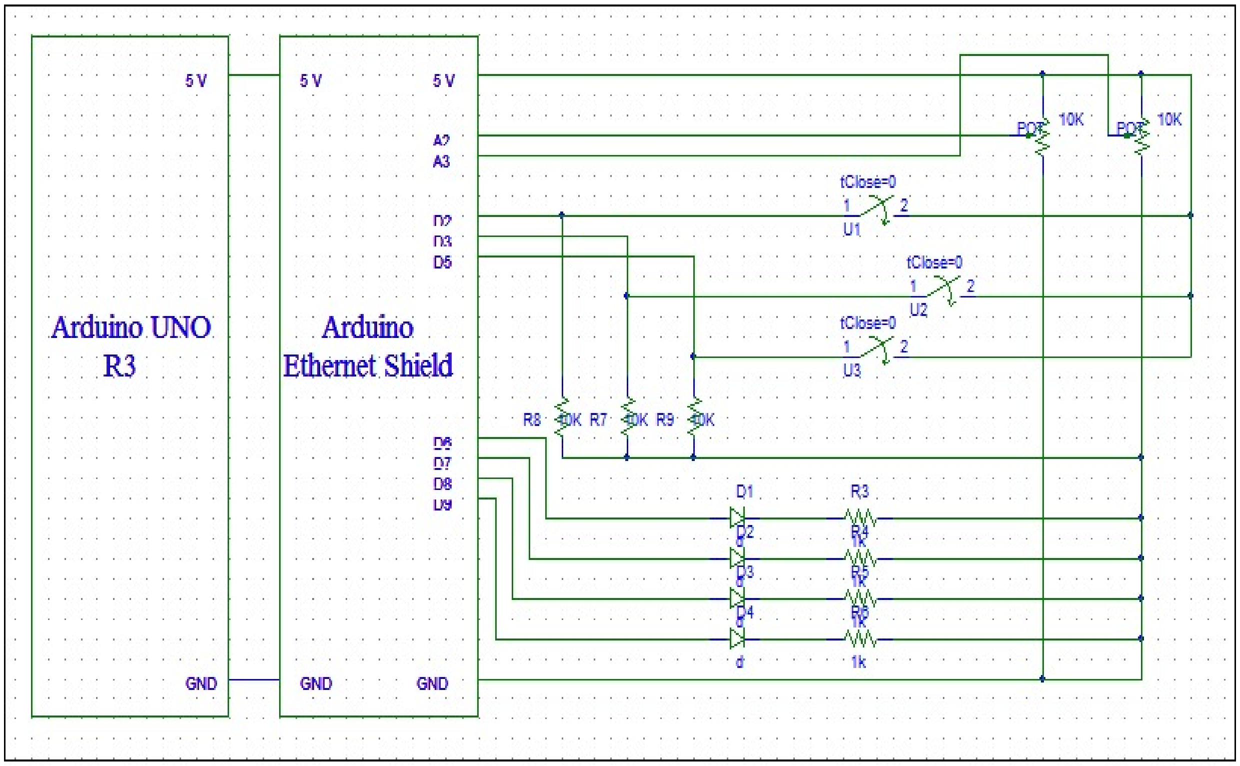


Figure 4.2: Full Circuit Design

4.2.4 Connecting the Arduino Ethernet Shield

Setting it up is as simple as plugging the header pins from the shield into your Arduino.

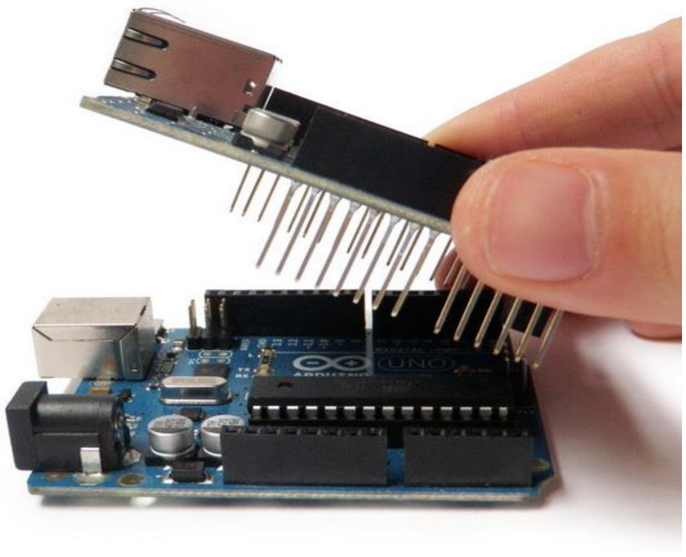


Figure 4.3: Connection of Arduino Ethernet Shield

4.2.5 Connection of Arduino Ethernet Shield with Wi-Fi access point

We also developed a connection of Arduino Ethernet Shield with Wi-Fi access point using RJ-45 connector and UTP cable. Plug the Arduino into computer's USB port and the Ethernet shield into Wi-Fi access point like the figure.

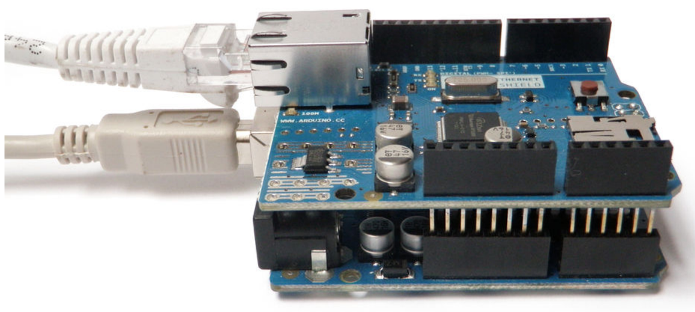


Figure 4.4: Connection of Arduino Ethernet Shield with Wi-Fi access point

4.2.6 Connection to Load with Power Source

We use 12V Relay for connect a light or electricity supply of a room. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. The high end applications of relays require high power to be driven by electric motors.

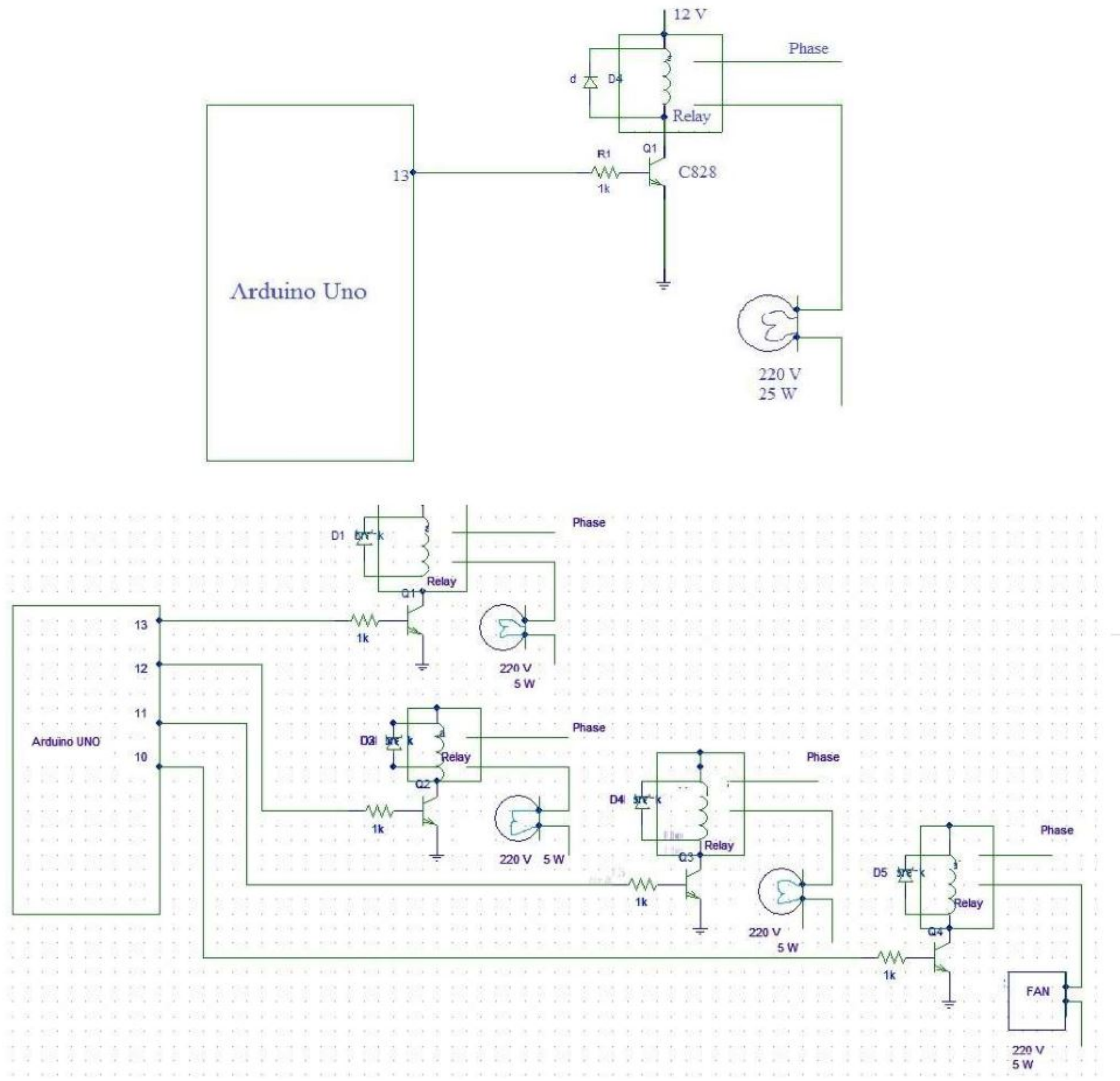


Figure 4.5: Connection to Load with Power Source

Relays are called contactors. We connect Arduino pin 13 with transistor’s base. The emitter is connected to ground and the collector is connected to relay and diode. The relay and diode are connected parallels. The two terminals of a relay operate as a switch. When the contacts are in contact then the current flows from Terminal to Terminal. There are two types of contacts, the NO and the NC. NO stands for Normal Open contact, while NC stands for Normal Closed contact. The Normal Open is a contact like the one showed in the previous illustration. When the contacts are still, then no current flows through it (because it is an OPEN circuit). On the other hand, a Normal Closed contact allows the current to flow when the contact is still. The NC contact is turned upside-down compared to the NO contact. This way, both contacts (NO and NC) will change state if a force is applied to the left metal heading from UP to DOWN. The device that forces the terminal to move is actually an electromagnet. A coil is placed right under the contact. When current is flown through this coil, magnetism is created. This magnetism can overcome the force of the spring and can pull the contact towards it, thus it changes its position. And due to the fact that the contact is usually a small piece of metal not capable to be pulled by the electromagnet, another piece of metal is attached to the common. The other side of relay is connected to bulb or electricity supply of a room. We need 12V power supply for relay.

4.3 Software Design

Software design is divided into two parts. First we write the Arduino program in Arduino software. Then we compile it to the Arduino hardware. This Arduino command is control the Arduino hardware and other circuit connection. For making connection between Arduino and Wi-Fi enable device we need to install Arduino SD card that host a web page that displays to the browser.

4.3.1 Installing Arduino

Arduino runs on Windows. Go to the Arduino software web site at http://arduino.cc/en/Main/Software and download the version of the software compatible with our system. We use Arduino 1.0.5 version.

4.3.2 Verifying the Hardware

Now that we have the Arduino IDE software installed, let's connect the computer to the Arduino board, load a small program, and verify that all components are working together. First, need to connect the USB cable to our mc board and then plug the other end of the USB cable into our computer.

4.3.3 Arduino Language

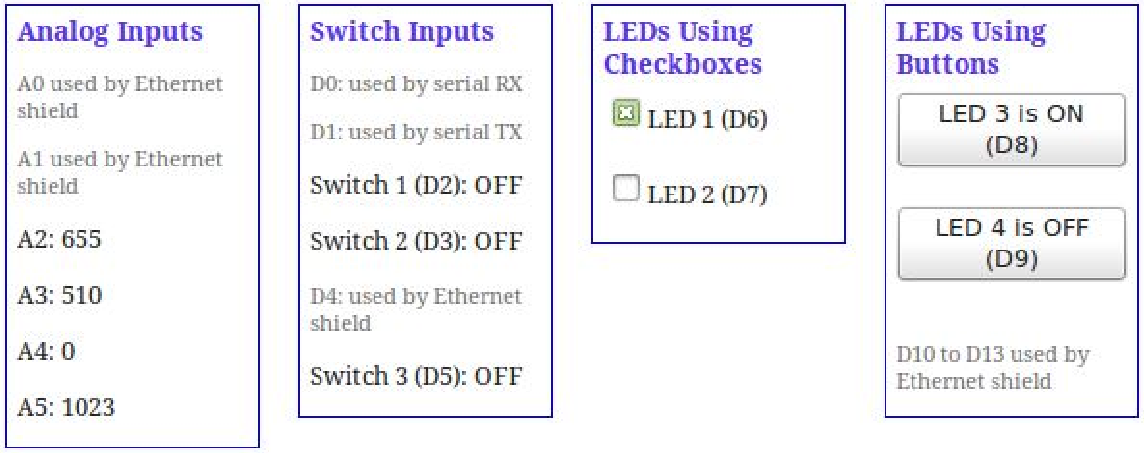
The Arduino language is implemented in C/C++ and based in Wiring. When we write an Arduino sketch, we are implicitly making use of the Wiring library, which is included with the Arduino IDE. This allows us to make run able programs by using only two functions: setup () and loop (). As mentioned, the Wiring language is inspired by Processing, and the Arduino language structure is inherited from the Processing language, where the equivalent functions are called setup (). We need to include both functions in every Arduino program, even if we don't need one of them. Let's analyze the structure of a simple Arduino sketch using again the Blink example.

4.3.4 SD Card Web Server I/O

In this project HTML, JavaScript, CSS, HTTP, Ajax and the SD card are used to make a web page that displays Arduino analog and digital inputs and allows digital outputs to be controlled. The Arduino web server hosts a web page that displays four analog input values and the state of three switches. The web page allows four LEDs to be controlled – two LEDs are controlled using checkboxes and two LEDs are controlled using buttons. When more than one computer (web browser) is connected to the Arduino web server, then outputs (LEDs) switched on using one computer will be updated on the other computer – i.e. when a checkbox is clicked to switch an LED on from one computer, the checkbox will also be checked on the other computer automatically.

4.3.5 Overview of How the Web Server Works

After a web browser has requested and loaded the web page from the Arduino web server, the JavaScript in the web page will send an Ajax request for data from the Arduino every second.
The web page that the Arduino web server hosts is shown here:



Analog Inputs

A0 used by Ethernet shield

A1 used by Ethernet shield

A2: 655

A3: 510

A4: 0

A5: 1023

Switch Inputs

D0: used by serial RX

D1: used by serial TX

Switch 1 (D2): OFF

Switch 2 (D3): OFF

D4: used by Ethernet shield

Switch 3 (D5): OFF

LEDs Using Checkboxes

☒ LED 1 (D6)

☐ LED 2 (D7)

LEDs Using Buttons

LED 3 is ON (D8)

LED 4 is OFF (D9)

D10 to D13 used by Ethernet shield

The Arduino will respond to every Ajax request by sending an XML file back to the web browser. The XML file contains the values from the four analog inputs of the Arduino (A2 to A5), the state of three pins (switches on pins 2, 3 and 5) and the state of the four LEDs.

```xml
<?xml version = "1.0" ?>
<inputs>
    <analog>655</analog>
    <analog>510</analog>
    <analog>0</analog>
    <analog>1023</analog>
    <switch>OFF</switch>
    <switch>OFF</switch>
    <switch>OFF</switch>
    <LED>checked</LED>
    <LED>unchecked</LED>
    <LED>on</LED>
    <LED>off</LED>
</inputs>
```

XML File Sent by Arduino

When an LED is switched on from the web page by checking a checkbox, the JavaScript will send the state of the checkbox (send an instruction to switch the LED on) with the next Ajax request. The same will occur if the LED is switched off or if one of the buttons is used to switch an LED on or off.

4.3.6 Source Code

The source code for both the Arduino sketch and web page are a bit big to include on this page. It will show in Appendix.

4.3.7 Flow Chart

We have a logical diagram for this project. Here android mobile phone works as a input signal which start from beginning part. We have got output from electronic devices.

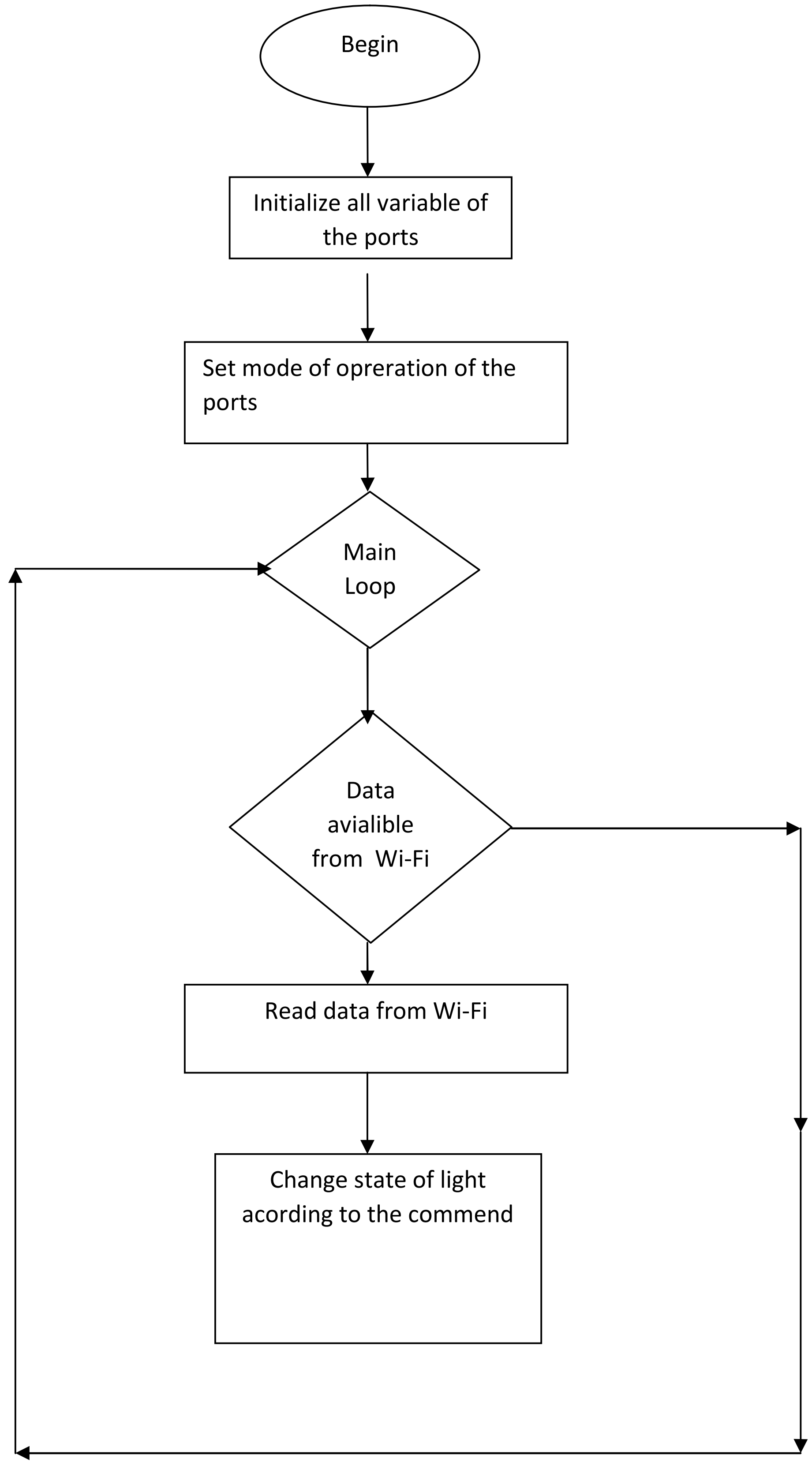

Begin
Initialize all variable of the ports
Set mode of opreration of the ports
Main Loop
Data avialible from Wi-Fi
Read data from Wi-Fi
Change state of light acording to the commend

Figure 4.6: Logical Diagram

Chapter 5

IMPLEMANTATION AND RESULT

5.1 Implementation

All the parts are connected as circuit design. Then we upload the programming code in the Arduino and we get positive result. It works properly according to our design

5.3 Connection without Load

After connecting the whole system we think about our main project. For testing of the circuit connection we used a LED with 1k resistance. We install a sufficient program for light ON/OFF. At first we tried to give connection without load for safety purposes. To build the circuit, connect one end of the resistor to Arduino pin 13. Connect the long leg of the LED (the positive leg, called the anode) to the other end of the resistor. Connect the short leg of the LED (the negative leg, called the cathode) to the Arduino GND. Here we represent the photo of this connection.

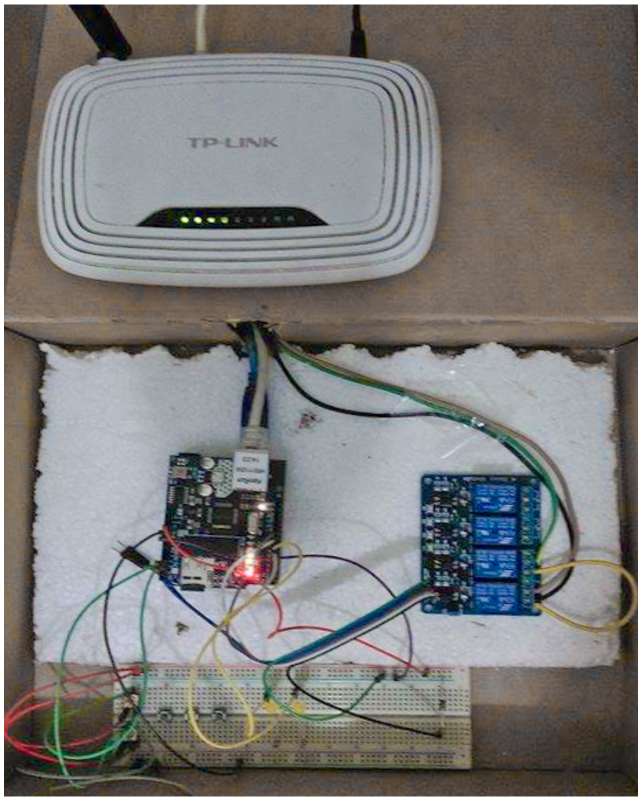


Figure 5.1: Connection without load when device in on mode.

5.4 Development of the Whole System with load

In this stage we developed the main connection of this project. We said as last part about without load connection of LED, now we discuss the load connection with fan, lights, AC, refrigerator etc. Here for AC load we use Arduino Relay Module. We also use some sensor for read the analog After all successful connection we will get output by controlling every device. We can control fan and lights by using Wi-Fi. Here we represent the photo of this connection.

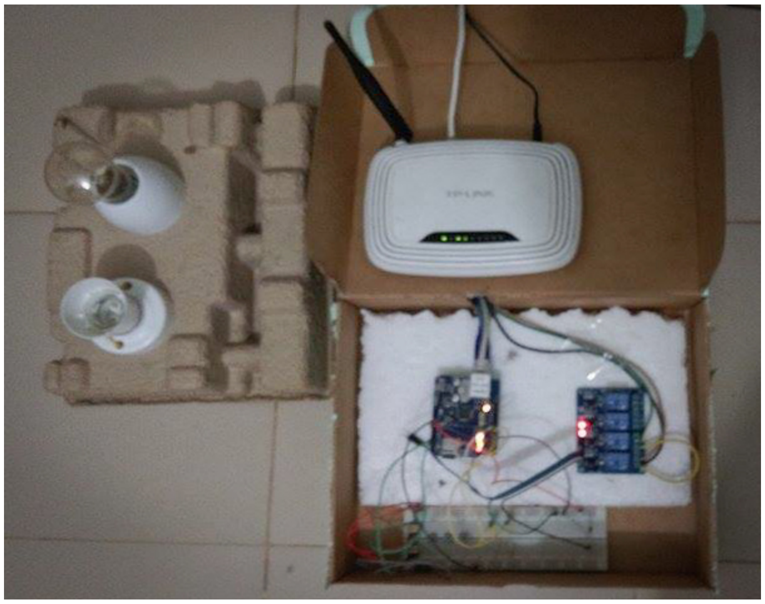


Figure 5.2: Connection with load when device in OFF mode

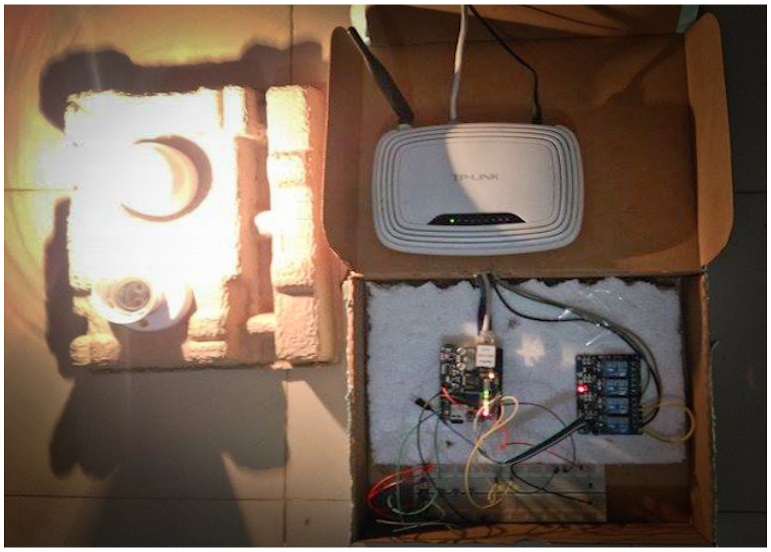


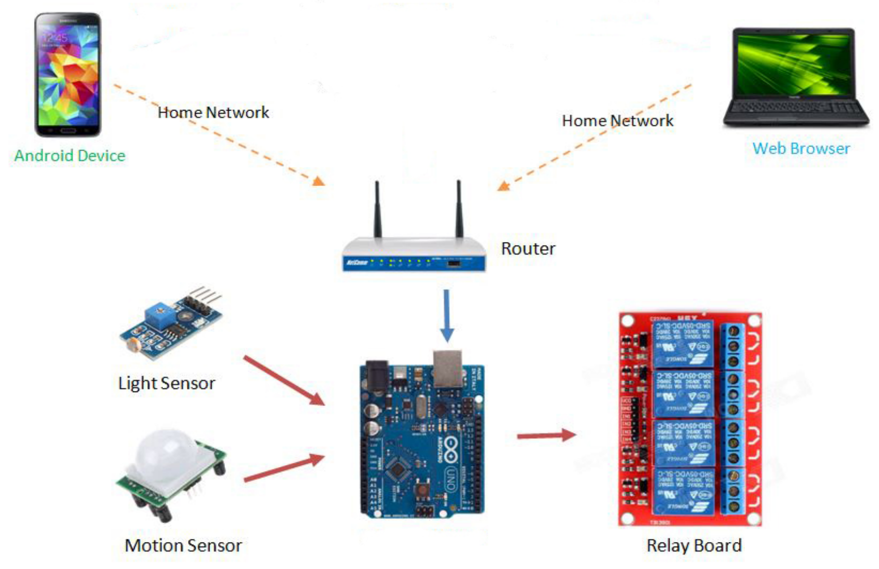
Figure 5.3: Connection with load when device in ON mode

Chapter 6

CONCLUSION

6.1 Conclusion

The Home Appliance Control System Using Wi-Fi has been designed and developed for making our life more easy and secured. We use 5V from Arduino board and use 12V DC power supply for relay connection. We use the Arduino Ethernet shield and Wi-Fi technology. Finally, we have designed and developed the whole control system and tested using Mobile Phone. We fix all the problems encountered during the design and testing of the system. Finally, we successfully achieved our goals. In this study, the application of microcontroller with improved algorithm of extended specifications has increased the use of android mobile phone and improves the controlling the home appliances. The developed home appliance control system is efficient and the production cost is low. So, our Home Appliance Control System Using Wi-Fi is suitable for commercial use.



6.2 Future Work Scope

We have used a small subset of each of these technologies. This project gives us an opportunity to do a big project in future. The applications stated above are some demo applications that are absolutely possible with its future development. Initially for the limitation of time and required fund we were able to develop just a Home Appliance Control System.

APPENDIX

1. Programming Code Arduino Scatch

```
#include <SPI.h>
#include <Ethernet.h>
#include <SD.h>
// size of buffer used to capture HTTP requests
#define REQ_BUF_SZ   60

// MAC address from Ethernet shield sticker under board
byte mac[] = { 0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED };
IPAddress ip(192, 168, 0, 115); // IP address, may need to change depending
on network
EthernetServer server(80);  // create a server at port 80
File webFile;               // the web page file on the SD card
char HTTP_req[REQ_BUF_SZ] = {0}; // buffered HTTP request stored as
null terminated string
char req_index = 0;              // index into HTTP_req buffer
boolean LED_state[4] = {0}; // stores the states of the LEDs

void setup()
{
   // disable Ethernet chip
   pinMode(10, OUTPUT);
   digitalWrite(10, HIGH);
```

```
Serial.begin(9600);       // for debugging

// initialize SD card
Serial.println("Initializing SD card...");
if (!SD.begin(4)) {
   Serial.println("ERROR - SD card initialization failed!");
   return;    // init failed
}
Serial.println("SUCCESS - SD card initialized.");
// check for index.htm file
if (!SD.exists("index.htm")) {
   Serial.println("ERROR - Can't find index.htm file!");
   return;  // can't find index file
}
Serial.println("SUCCESS - Found index.htm file.");
// switches on pins 2, 3 and 5
pinMode(2, INPUT);
pinMode(3, INPUT);
pinMode(5, INPUT);
// LEDs
pinMode(6, OUTPUT);
pinMode(7, OUTPUT);
pinMode(8, OUTPUT);
pinMode(9, OUTPUT);
```

```
    Ethernet.begin(mac, ip);  // initialize Ethernet device
    server.begin();           // start to listen for clients
}

void loop()
{
    EthernetClient client = server.available();  // try to get client

    if (client) {  // got client?
        boolean currentLineIsBlank = true;
        while (client.connected()) {
            if (client.available()) {   // client data available to read
                char c = client.read(); // read 1 byte (character) from client
                // limit the size of the stored received HTTP request
                // buffer first part of HTTP request in HTTP_req array (string)
                // leave last element in array as 0 to null terminate string
(REQ_BUF_SZ - 1)
                if (req_index < (REQ_BUF_SZ - 1)) {
                    HTTP_req[req_index] = c;        // save HTTP request character
                    req_index++;
                }
                // last line of client request is blank and ends with \n
                // respond to client only after last line received
                if (c == '\n' && currentLineIsBlank) {
                    // send a standard http response header
```

```
client.println("HTTP/1.1 200 OK");
// remainder of header follows below, depending on if
// web page or XML page is requested
// Ajax request - send XML file
if (StrContains(HTTP_req, "ajax_inputs")) {
   // send rest of HTTP header
   client.println("Content-Type: text/xml");
   client.println("Connection: keep-alive");
   client.println();
   SetLEDs();
   // send XML file containing input states
   XML_response(client);
}
else {  // web page request
   // send rest of HTTP header
   client.println("Content-Type: text/html");
   client.println("Connection: keep-alive");
   client.println();
   // send web page
   webFile = SD.open("index.htm");        // open web page file
   if (webFile) {
      while(webFile.available()) {
         client.write(webFile.read()); // send web page to client
      }
      webFile.close();
```

```
                    }
                }
                // display received HTTP request on serial port
                Serial.print(HTTP_req);
                // reset buffer index and all buffer elements to 0
                req_index = 0;
                StrClear(HTTP_req, REQ_BUF_SZ);
                break;
            }
            // every line of text received from the client ends with \r\n
            if (c == '\n') {
                // last character on line of received text
                // starting new line with next character read
                currentLineIsBlank = true;
            }
            else if (c != '\r') {
                // a text character was received from client
                currentLineIsBlank = false;
            }
        } // end if (client.available())
    } // end while (client.connected())
    delay(1);      // give the web browser time to receive the data
    client.stop(); // close the connection
  } // end if (client)
}
```

```
// checks if received HTTP request is switching on/off LEDs
// also saves the state of the LEDs
void SetLEDs(void)
{
  // LED 1 (pin 6)
  if (StrContains(HTTP_req, "LED1=1")) {
    LED_state[0] = 1;  // save LED state
    digitalWrite(6, HIGH);
  }
  else if (StrContains(HTTP_req, "LED1=0")) {
    LED_state[0] = 0;  // save LED state
    digitalWrite(6, LOW);
  }
  // LED 2 (pin 7)
  if (StrContains(HTTP_req, "LED2=1")) {
    LED_state[1] = 1;  // save LED state
    digitalWrite(7, HIGH);
  }
  else if (StrContains(HTTP_req, "LED2=0")) {
    LED_state[1] = 0;  // save LED state
    digitalWrite(7, LOW);
  }
  // LED 3 (pin 8)
  if (StrContains(HTTP_req, "LED3=1")) {
        LED_state[2] = 1;  // save LED state
        digitalWrite(8, HIGH);
    }
    else if (StrContains(HTTP_req, "LED3=0")) {
        LED_state[2] = 0;  // save LED state
        digitalWrite(8, LOW);
    }
    // LED 4 (pin 9)
    if (StrContains(HTTP_req, "LED4=1")) {
        LED_state[3] = 1;  // save LED state
        digitalWrite(9, HIGH);
    }
    else if (StrContains(HTTP_req, "LED4=0")) {
        LED_state[3] = 0;  // save LED state
        digitalWrite(9, LOW);
    }
}

// send the XML file with analog values, switch status
//  and LED status
void XML_response(EthernetClient cl)
{
    int analog_val;            // stores value read from analog inputs
    int count;                 // used by 'for' loops
    int sw_arr[] = {2, 3, 5};  // pins interfaced to switches
```

```
cl.print("<?xml version = \"1.0\" ?>");
cl.print("<inputs>");
// read analog inputs
for (count = 2; count <= 5; count++) { // A2 to A5
    analog_val = analogRead(count);
    cl.print("<analog>");
    cl.print(analog_val);
    cl.println("</analog>");
}
// read switches
for (count = 0; count < 3; count++) {
    cl.print("<switch>");
    if (digitalRead(sw_arr[count])) {
        cl.print("ON");
    }
    else {
        cl.print("OFF");
    }
    cl.println("</switch>");
}
// checkbox LED states
// LED1
cl.print("<LED>");
if (LED_state[0]) {
    cl.print("checked");
}
else {
    cl.print("unchecked");
}
cl.println("</LED>");
// LED2
cl.print("<LED>");
if (LED_state[1]) {
    cl.print("checked");
}
else {
    cl.print("unchecked");
}
 cl.println("</LED>");
// button LED states
// LED3
cl.print("<LED>");
if (LED_state[2]) {
    cl.print("on");
}
else {
    cl.print("off");
}
cl.println("</LED>");
```

```
    // LED4
    cl.print("<LED>");
    if (LED_state[3]) {
        cl.print("on");
    }
    else {
        cl.print("off");
    }
    cl.println("</LED>");

    cl.print("</inputs>");
}

// sets every element of str to 0 (clears array)
void StrClear(char *str, char length)
{
    for (int i = 0; i < length; i++) {
        str[i] = 0;
    }
}

// searches for the string sfind in the string str
// returns 1 if string found
// returns 0 if string not found
char StrContains(char *str, char *sfind)
```

```
{
   char found = 0;
   char index = 0;
   char len;

   len = strlen(str);

   if (strlen(sfind) > len) {
      return 0;
   }
   while (index < len) {
      if (str[index] == sfind[found]) {
         found++;
         if (strlen(sfind) == found) {
            return 1;
         }
      }
      else {
         found = 0;
      }
      index++;
   }
return 0;
}
```

2. SD Card WEB page Code

```
<!DOCTYPE html>
<html>
  <head>
    <title>Arduino Ajax I/O</title>
    <script>
            strLED1 = "";
            strLED2 = "";
            strLED3 = "";
            strLED4 = "";
            var LED3_state = 0;
            var LED4_state = 0;
            function GetArduinoIO()
            {
                  nocache = "&nocache=" + Math.random() * 1000000;
                  var request = new XMLHttpRequest();
                  request.onreadystatechange = function()
                  {
                        if (this.readyState == 4) {
                              if (this.status == 200) {
                                    if (this.responseXML != null) {
                                          // XML file received - contains
analog values, switch values and LED states
                                          var count;
                                          // get analog inputs
                                          var num_an =
this.responseXML.getElementsByTagName('analog').length;
```

```
                                        for (count = 0; count < num_an;
count++) {

    document.getElementsByClassName("analog")[count].innerHTML =

    this.responseXML.getElementsByTagName('analog')[count].childNodes[0].node
Value;
                                        }
                                        // get switch inputs
                                        var         num_an         =
this.responseXML.getElementsByTagName('switch').length;
                                        for (count = 0; count < num_an;
count++) {

    document.getElementsByClassName("switches")[count].innerHTML =

    this.responseXML.getElementsByTagName('switch')[count].childNodes[0].node
Value;
                                        }
                                        // LED 1
                                        if
(this.responseXML.getElementsByTagName('LED')[0].childNodes[0].nodeValue    ===
"checked") {

    document.LED_form.LED1.checked = true;
                                        }
                                        else {

    document.LED_form.LED1.checked = false;
                                        }
                                        // LED 2
```

```
                                                    if
(this.responseXML.getElementsByTagName('LED')[1].childNodes[0].nodeValue      ===
"checked") {

        document.LED_form.LED2.checked = true;
                                                    }
                                                    else {

        document.LED_form.LED2.checked = false;
                                                    }
                                                    // LED 3
                                                    if
(this.responseXML.getElementsByTagName('LED')[2].childNodes[0].nodeValue      ===
"on") {

        document.getElementById("LED3").innerHTML = "LED 3 is ON (D8)";
                                                            LED3_state = 1;
                                                    }
                                                    else {

        document.getElementById("LED3").innerHTML = "LED 3 is OFF (D8)";
                                                            LED3_state = 0;
                                                    }
                                                    // LED 4
                                                    if
(this.responseXML.getElementsByTagName('LED')[3].childNodes[0].nodeValue      ===
"on") {

        document.getElementById("LED4").innerHTML = "LED 4 is ON (D9)";
                                                            LED4_state = 1;
                                                    }
                                                    else {
```

```
        document.getElementById("LED4").innerHTML = "LED 4 is OFF (D9)";
                                                        LED4_state = 0;
                                                  }
                                             }
                                        }
                                   }
                              }
                              // send HTTP GET request with LEDs to switch on/off if any
                              request.open("GET", "ajax_inputs" + strLED1 + strLED2 +
strLED3 + strLED4 + nocache, true);
                              request.send(null);
                              setTimeout('GetArduinoIO()', 1000);
                              strLED1 = "";
                              strLED2 = "";
                              strLED3 = "";
                              strLED4 = "";
                         }
                         // service LEDs when checkbox checked/unchecked
                         function GetCheck()
                         {
                              if (LED_form.LED1.checked) {
                                   strLED1 = "&LED1=1";
                              }
                              else {
                                   strLED1 = "&LED1=0";
                              }
                              if (LED_form.LED2.checked) {
                                   strLED2 = "&LED2=1";
```

```
                }
                else {
                        strLED2 = "&LED2=0";
                }
        }
        function GetButton1()
        {
                if (LED3_state === 1) {
                        LED3_state = 0;
                        strLED3 = "&LED3=0";
                }
                else {
                        LED3_state = 1;
                        strLED3 = "&LED3=1";
                }
        }
        function GetButton2()
        {
                if (LED4_state === 1) {
                        LED4_state = 0;
                        strLED4 = "&LED4=0";
                }
                else {
                        LED4_state = 1;
                        strLED4 = "&LED4=1";
                }
        }
</script>
```

```
    <style>
        .IO_box {
            float: left;
            margin: 0 20px 20px 0;
            border: 1px solid blue;
            padding: 0 5px 0 5px;
            width: 120px;
        }
        h1 {
            font-size: 120%;
            color: blue;
            margin: 0 0 10px 0;
        }
        h2 {
            font-size: 85%;
            color: #5734E6;
            margin: 5px 0 5px 0;
        }
        p, form, button {
            font-size: 80%;
            color: #252525;
        }
        .small_text {
            font-size: 70%;
            color: #737373;
        }
    </style>
</head>
```

```
<body onload="GetArduinoIO()">
    <h1>Arduino Ajax I/O</h1>
    <div class="IO_box">
                    <h2>Analog Inputs</h2>
                    <p class="small_text">A0 used by Ethernet shield</p>
                    <p class="small_text">A1 used by Ethernet shield</p>
                    <p>A2: <span class="analog">...</span></p>
                    <p>A3: <span class="analog">...</span></p>
                    <p>A4: <span class="analog">...</span></p>
                    <p>A5: <span class="analog">...</span></p>
            </div>
            <div class="IO_box">
                    <h2>Switch Inputs</h2>
                    <p class="small_text">D0: used by serial RX</p>
                    <p class="small_text">D1: used by serial TX</p>
                    <p>Switch 1 (D2): <span class="switches">...</span></p>
                    <p>Switch 2 (D3): <span class="switches">...</span></p>
                    <p class="small_text">D4: used by Ethernet shield</p>
                    <p>Switch 3 (D5): <span class="switches">...</span></p>
            </div>
            <div class="IO_box">
                    <h2>LEDs Using Checkboxes</h2>
                    <form id="check_LEDs" name="LED_form">
                            <input type="checkbox" name="LED1" value="0"
onclick="GetCheck()" />LED 1 (D6)<br /><br />
                            <input type="checkbox" name="LED2" value="0"
onclick="GetCheck()" />LED 2 (D7)<br /><br />
                    </form>
            </div>
            <div class="IO_box">
                  <h2>LEDs Using Buttons</h2>
                  <button type="button" id="LED3" onclick="GetButton1()">LED 3 is OFF (D8)</button><br /><br />
                  <button type="button" id="LED4" onclick="GetButton2()">LED 4 is OFF (D9)</button><br /><br />
                  <p class="small_text">D10 to D13 used by Ethernet shield</p>
            </div>
  </body>
</html>
```

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