Solar Panel and Battery Voltage Monitoring and Load Control Using Bluetooth



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Candidate's Declaration

It is declared hereby that this project paper or any part of it has not been submitted to anywhere else for the award of any degree.

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Abstract

Accurate monitoring and measurement of solar photovoltaic panel parameters are important for solar power plant analysis to evaluate the performance and predict the future energy generation. There are always challenges of getting such data readily available due to huge amount of money to be spent on state of the art equipment or the purchase of reliable satellite weather data. This study aimed at the development of a cost-effective parameter-measuring system for a solar photovoltaic panel using Arduino microprocessor board. The project aims is to design a Solar Panel & Battery Voltage monitoring and Load Control using Bluetooth. The system contains arduino microcontroller with voltage sensor, bluetooth module, solar panel and relay module. Voltage sensors are the input value for the Arduino and the LCD screen display output of the voltage and the load status. The purpose of Arduino to convert the analog input of parameter to the digital output and display via LCD screen. Other than that, this project also involve with a design to ensure that device case are easy to be carry around.

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CHAPTER I

INTRODUCTION

1.1 Introduction

The rising costs of fossil fuels, global warming, and severe weather conditions have compelled many nations to look into alternative sources of energy to reduce reliance on fossil-based fuels. The solar energy is one of the most promising renewable sources of energy currently being used globally for meeting rising demands of electric power. Solar energy is considered as fastest growing renewable energy source for electricity generation after the wind energy. It involves conversion of solar energy into electric and/or heat energies. The sunlight is collected either directly by using photovoltaics cells or indirectly using concentrated solar energy (Singh, 2013). The solar photovoltaic (PV) energy system directly converts the sun photons energy to electricity through the solar cells. Solar cells are made from light sensitive semiconductors that use photon energy to dislodge electrons to drive an electric current. The two broad classifications of photovoltaic modules are the monocrystalline and poly-crystalline. Polycrystalline solar cells are formed from multiple silicon crystals while mono-crystalline so cells are made from a single silicon crystal and they usually have higher efficiency. The output of power generated from a solar cell largely depends on weather conditions most especially the solar irradiance and air temperature. The recent development in energy sector have shown that solar-energy market is one of the most rapidly expanding renewable energy markets in the world. Presently there is significant increasing in demands for remote monitoring and control equipment for solar-energy applications. Solar manufacturing company now embeds electronics such as power optimizers, micro DC-to- DC converters, and condition monitoring devices in the solar PV modules. The monitoring and measurement of solar PV parameters and site condition has some importance in evaluating the performance of existing solar installations, advanced system monitoring and the prediction of future. They also aid in decision making, product development, system maintenance, and many other applications. A solar PV energy system requires reliable means of data acquisition of all the electrical and meteorological data for condition monitoring, and evaluation of the system performance. Acquiring such data has been capital intensive when state of the art equipment is to be installed at the site and there is a concern of reliability over the use of satellite data in place of site data.

In the present day, automation systems are playing an important role for comfort in life. This is achieved by the incorporation of various sub-systems into the automation system with a single control unit such as surveillance, intruder control, access control, fire detection, etc.
Automation is today's fact, where things are being controlled automatically, usually the basic tasks of turning ON/OFF certain devices and beyond, in close proximity. Automation lowers the human judgment to the lowest degree possible but does not completely eliminate it. The concept of remote management of household devices over the Smartphone from anywhere, any time today can be a reality. Assume a system where the user control the devices and decides to take control by tuning his TV set to his favourite channel, turns on the cooling system, say the air conditioner, and switches on or off some of the lights. This user could walk back home and only find a very comfortable, pleasant home. The recent developments in technology which permit the use of Bluetooth have enabled different devices to have capabilities of connecting with each other. This project involves the development of low-cost Arduino-based solar photovoltaic parameter- measuring system. The developed system successfully measures the solar photovoltaic voltage and battery voltage. The microcontroller is programmed by Arduino-IDE. For the project we used ATmega328 with Arduino platform which is an open source platform and more flexible to programming the chip.

1.2 Solar Panel Monitoring Methods

There are various methods of monitoring solar power generation, consumption, and performance. Some of these methods of solar power monitoring include:

Direct PC Connection

In this method, the inverter is connected to a PC either using a Bluetooth device or a CAT5 cable. Here, you can download a free monitoring software from the website of the inverter's manufacturer. This method gives you the data logging advantage, and it is one of the cheapest solar monitoring methods.

Use of Mobile Devices

With the advancement of new technology, you can now monitor your solar system from your smart phone. Since most inverters allow for Bluetooth integrations, you can, therefore, connect it to your mobile device and conveniently monitor it from there. This method enables you to remotely monitor your PV system, as well as allowing you to control core settings to make custom usage-profiles. The system allows for wireless solar energy monitoring. Also,

depending on your settings, you can remotely view data using internet connections or via SMS texts.

Monitoring Display Unit

Traditionally, this was the main and only way of monitoring your solar system. The method involves the gathering of data from one or multiple combined inverters and displaying it on the display unit. The data is collected either using Bluetooth units or through the CAT5 cable. And, although a dedicated display is an extra cost, it allows you to monitor your system through the display.

Internet-Based Monitoring

With this method, the energy production information is sent to a router, which makes it accessible on the internet. Then, since each user has a password-protected dedicated website, you can easily access the information. One good thing about this method is that you can get access to this data at any time remotely. However, the card that you will plug into the inverter, together with the router, will be an additional cost for the user. You can use a DAS type system to remote dial into your system's performance.

Use of Historic Data Viewing Features

The current solar monitoring units allow for easy integrations with various data storage systems. Therefore, the system gives you the ability to view your system's past performance data

1.3 Objective

- To measure battery voltage.
- To measure solar panel output voltage
- To monitor measured voltage using bluetooth
- To operate load using bluetooth

1.4 Methodology

The goal of the project is to develop a Solar Panel and Battery voltage monitoring and load control. The system is designed for homes, offices, industries etc. It is designed to detect solar and battery voltage. It will contain necessary sensors for detecting voltage. When the system detect the voltage then it will take following steps.

- Check solar voltage using voltage sensor.
- Measure battery voltage using voltage sensor.
- Shows data in microcontroller display solar and battery voltage using LCD display.
- Transfer measured voltage using bluetooth .
- Operate Load on basis of received data via bluetooth.

1.5 Goal of the Research Work

The main purpose of this project is to design and Voltage monitoring and control System that can be produced at a low cost with effective and competitive usage. This system is designed to be more users friendly and easy to operate at any level. The project is also been designed to be further working vision using minimum hardware at the lower level of processing. These systems are directed at specific applications.

CHAPTER II

THEORY OF THE PROJECT

2.1 Introduction

This chapter includes the total over view of the device. In this chapter we have followed-up the theory of Arduino UNO, LCD Display, Diode (IN 4007), Relay, briefly describe of Microcontroller (ATMEGA 328P), Crystal, LCD display (20x4), Vero board, and other components. Here we can know that the total system overview of the projects. And we will also know that how the equipment are working with each other.

2.2 Theory

The system architecture of the Solar and battery monitoring can be divided into 3 main Modules. They are:

1. Processing System
2. Detecting
3. Output system

Detecting system consists of voltage sensor and Bluetooth module. Voltage sensor measures the voltage of solar panel and battery, bluetooth module detects input command, both are connected to Arduino which is the processing system of the project. Microcontroller process the entire data and sent to display as visual output. Besides this microcontroller will operate load according to Bluetooth command.

2.3 Arduino UNO

Arduino Uno is one of the microcontroller boards manufactured by the Arduino and it is a microcontroller board based on Atmel's ATmega328P microcontroller. "Uno" means one in Italian and the Uno board is the latest in a series of USB (Universal Serial Bus) Arduino boards which is the reference model for the Arduino platform. The Arduino Uno board has a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, a reset button, 6 analog inputs and 14 digital input/output pins (of which 6 can be used as PWM outputs). It uses the Atmega16U2 programmed as a USB – to - serial converter instead of FTDI USB – to

– serial driver chip which was used in all the preceding boards. The board has 32 KB flash memory of which 0.5 KB is used by boot-loader, 2 KB of SRAM, 1 KB of EEPROM and 16 MHz clock speed.

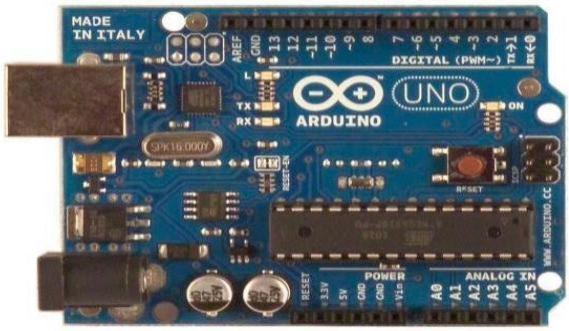


Fig 2.1: Arduino UNO

Re-printed from the Arduino Board Uno Figure 1 shows the Arduino Uno Board manufactured by the Arduino in Italy. It can be powered via a USB connection or with an external power supply. As it can be seen in figure 1, pins A0 to A5 are the analog input pins, pins 0 to 13 are 14 digital input/output pins and the pins with a "~" sign can be used as digital pins PWM o can be used as input or output pins by selecting the mode by using the function Pin-Mode() and then using the function digitalRead() or digitalWrite() according to the necessity. Pins 0(RX) and 1(TX) are used for serial communication while pins 10(SS), 11(MOSI), 12(MISO) and 13(SCK) are used for SPI (Serial Peripheral Interface) communication. In addition to pin 0 and 1, a Software Serial library allows serial communication on any of the Uno's digital pin.

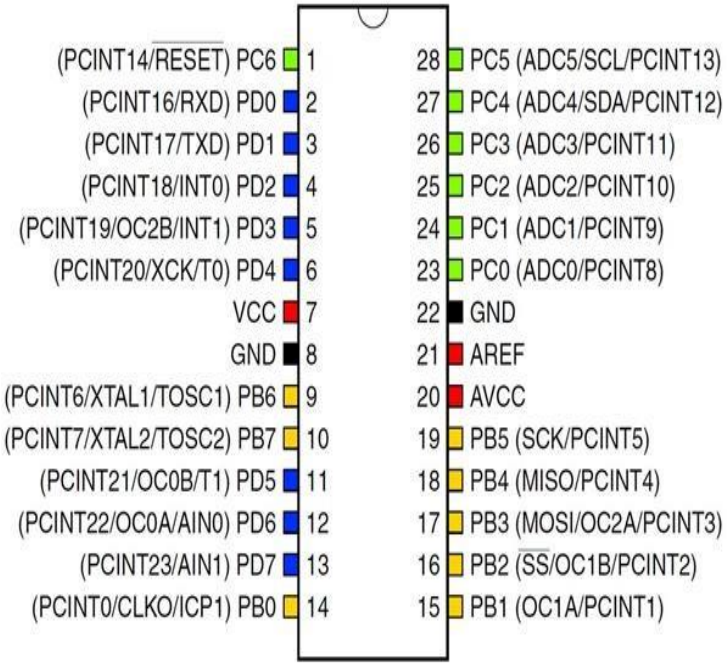


Fig 2.2: ATmega328P Microcontroller

The microcontroller is a low-power CMOS (Complementary Metal Oxide Semiconductor) 8bit microcontroller based on the AVR enhanced RISC (Reduced Instruction Set Computer) architecture. The powerful execution of instructions in a single clock cycle leads to the achievement of 1 MIPS per MHz throughputs allowing the designer to optimize power consumption versus processing speed.

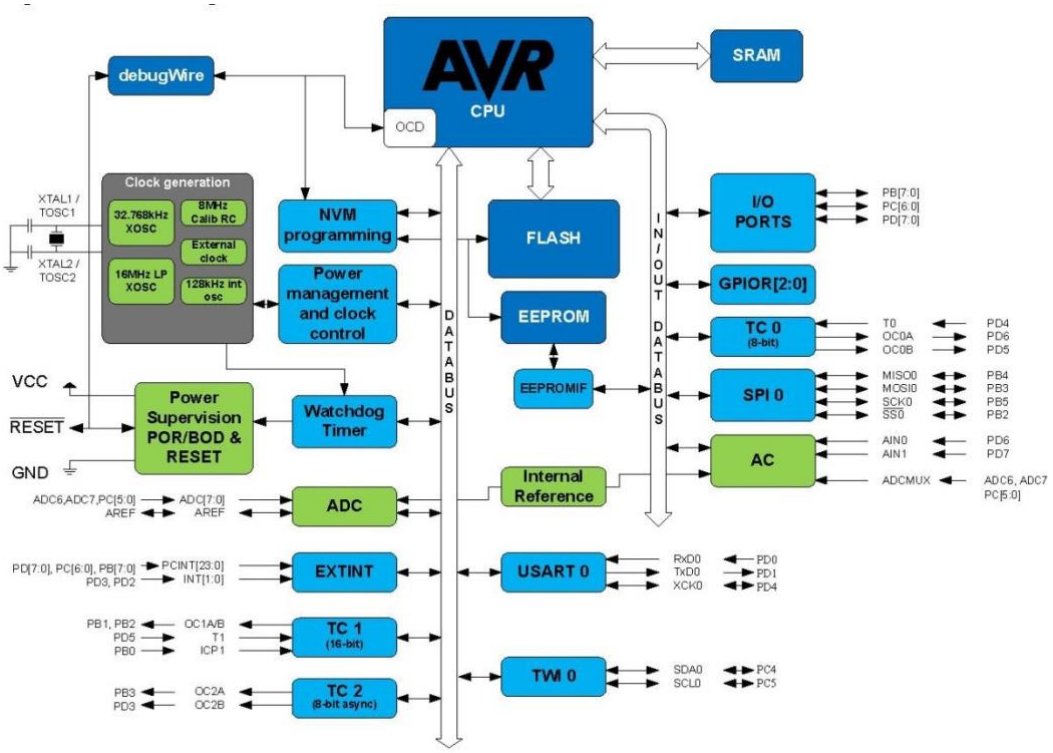


Fig 2.3: ATmega328 Microcontroller Architecture

Reprinted from Datasheet of ATMega328 the internal architecture of the microcontroller is shown in Fig 2.3. The central processing unit (CPU) is the brain of the microcontroller which controls the execution of the program. The MCU (Microcontroller unit) consists of 4K/8K bytes of in-system programmable flash with read-while-write capabilities, 256/412/1K bytes EEPROM along with the 512/1K/2K bytes of SRAM. Along with this, the MCU consists of many other features

- 23 general purpose I/O lines and 32general purpose working registers
- flexible timer/counters with compare modes, internal and external interrupts and a serial programmable USART
- A byte-oriented 2-wire serial interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), a programmable watch-dog timer with an internal oscillator and 5 software -selectable power saving modes.

The five software selectable power saving modes are idle mode, Power-down mode, Power save mode, ADC Noise Reduction mode and the Standby mode. As mentioned in section 2.1.2, the CPU is the brain of the microcontroller which controls the execution of the program. Therefore the CPU is able to access the memories, perform calculations, control peripherals and handle interrupts. The AVR uses the Harvard architecture with separate memories and buses for program and data to maximize the performance as well as the

parallelism. The principle of execution of instructions in the program memory is the single level pipelining. The concept of pre-fetching the next instruction while executing one instruction enables the instructions to be executed in every clock cycle and the program memory is in the System Reprogrammable Flash memory. Reprinted from Datasheet of ATMega328, The block diagram of AVR CPU Core architecture is shown in figure 2.5. The fast-access Register File contains 32 x 8 bit general-purpose working registers with a single cycle access time which results in a single -cycle ALU operation. The arithmetic and logical operations between the registers or between the constant and a register are supported by the ALU. The status register is updated to reflect information about the result of the operation after an arithmetic operation. The boot program section and the application program section are the two main sections of the program flash memory. Stack stores the return address of the program counter during the interrupts and subroutine calls which is allocated in the general data SRAM. The size of the stack is limited by the total size and usage of the SRAM. The data SRAM is accessible through five different addressing modes supported in the AVR architecture while the stack pointer is read/write accessible in the I/O space. The memory spaces in the AVR architecture are all linear and regular memory maps.

Specifications

Microcontroller: Atmel ATmega328

Operating Voltage (logic level):5 V

Input Voltage (recommended):7-12 V

Input Voltage (limits):6-20 V

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 8

DC Current per I/O Pin: 40 mA

Flash Memory: 32 KB (of which 2KB used by boot loader)

SRAM : 2 KB

EEPROM: 1 KB

Clock Speed: 16 MHz

Dimensions: 0.70” x 1.70”

Features

• Automatic reset during program download

• Power OK blue LED

• Green (TX), red (RX) and orange (L) LED

• Auto sensing/switching power input

• Small mini-B USB for programming and serial monitor

• ICSP header for direct program download

• Standard 0.1 spacing DIP (breadboard friendly)

• Manual reset switch

Microcontroller IC ATmega328p

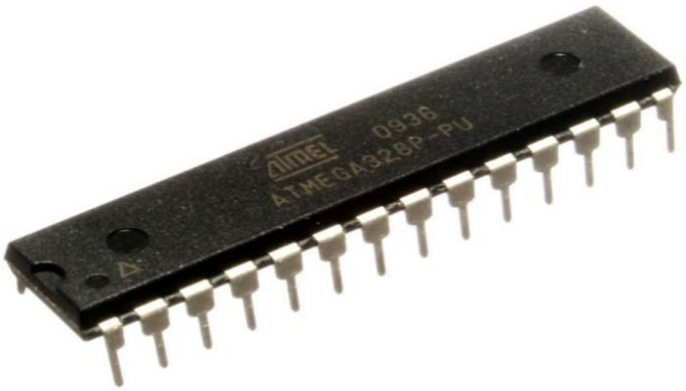


Fig 2.4: Microcontroller IC ATmega 328p.

The high-performance Microchip picoPower 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byteoriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves

throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

2.3.1 Power supply, inputs and outputs

Either Arduino is supplied with USB connection or with an external power supply (recommended with 7-12V), outputs are going to have a continuous voltage due to voltage regulators and stabilization capacitors present on the board. These power supply pins are:

- **VIN:** it is the input power supply that will have the same voltage that we are supplying the Arduino with the external power supply
- **5V:** power supply of 5V, this voltage may come from VIN pin and a voltage regulator or from the USB connection.
- **3.3V:** power supply that will provide 3.3V generated by an internal regulator, with a maximum current of 50 mA. ➢ **GND:** grounding pins

2.3.2Digital inputs and outputs

Each of the 14 digital pins can be used as an input or output. Besides, each pincan supply or receive a maximum of 40 mA and has a pull-p resistance from 20 to50 kOhm. In addition, some pins have specialized functions such as:

- Pin 0 (RX) and 1 (TX). They are used to receive (RX) and transmit (TX)in TTL serial communication.
- Pin 2 and 3. External interruptions. Pins in charge of interrupting these quential program stablished by the user.
- Pin 3, 5, 6, 9, 10 and 11. PWM (pulse width modulation). They form 8output bits with PWM with the function analogWrite ().
- Pin 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI(Serial peripheral interface) communication.
- Pin 13. LED. There is a LED connected to the digital pin 13. When thepin value is HIGH, the LED is on, and when the value is LOW, the LED is off.

2.3.3 Analog inputs

Arduino UNO has 6 analogical inputs, from A0 to A5, and each one offers abresolution of 10 bits (1024 states). By default, there is a voltage of 5V, but that range can be modified using

the pin AREF and using the function *analog Reference(),* where the user introduces the DC external signal he wants to use as reference.

2.4 Detecting System

The goal of this project is to measure voltage. To fulfill this goal it needs voltage sensor. Our aim is to implement a low cost project so that we create a simple sensor which can fulfill the project demand and objective.

2.4.1 Voltage Sensor

The Voltage Sensor is a simple module that can used with Arduino (or any other microcontroller with input tolerance of 5V) to measure external voltages that are greater than its maximum acceptable value i.e. 5V in case of Arduino. Basically, a 25V Voltage Sensor, like the one used here, has 5 pins in total. Two of them are on the two-pin screw terminal and three are male header pins.

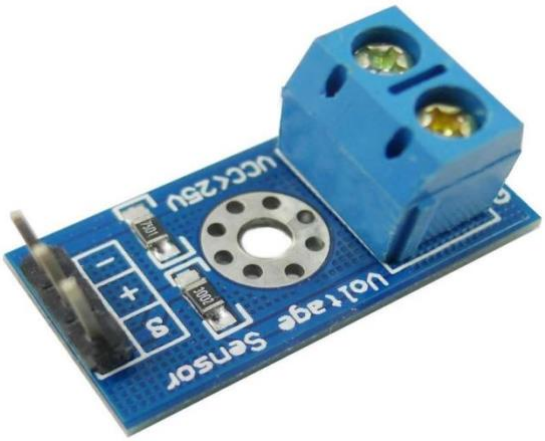


Figure 2.5: Voltage Sensor

The Screw Terminal pins are marked as VCC and GND and they must be connected to the external source of voltage i.e. the voltage that needs to be measured.

Coming to the three male headers, they are marked as S, + and –. The S pin is the "Sense" pin and it must be connected to the Analog Input of the Arduino. The "–" pin must be connected to the GND of the Arduino. The pin marked as "+" is not connected to anything (it is an N/C Pin). The following image shows the pins of a Voltage Sensor Module.

VCC: Positive terminal of the voltage to be measured (0-25V)

GND: Negative terminal of the voltage to be measured

S: Analog Input of Arduino

+: Not connected (N/C)

–: GND of Arduino

2.4.2 Schematic of Voltage Sensor

Now, let us talk about the important thing about the voltage sensor: it's schematic. The Voltage Sensor is basically a Voltage Divider consisting of two resistors with resistances of 30KΩ and 7.5KΩ i.e. a 5 to 1 voltage divider.

The following image shows the schematic of the Voltage Sensor Module with an input voltage limit of 25V.

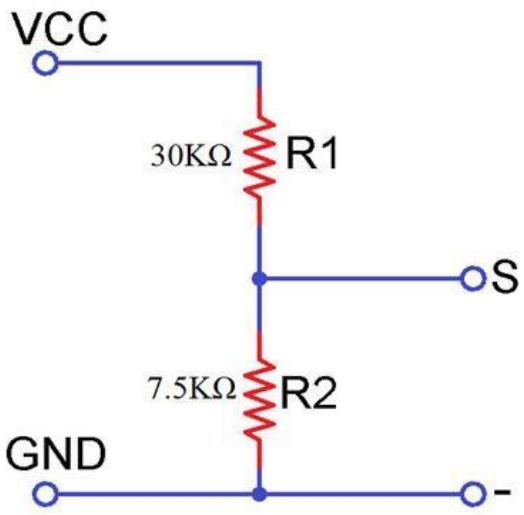


Figure 2.6: Voltage Sensor Schematic

2.5 Bluetooth Module

A number of signal detecting devices are available in the market. These devices include:

- Ethernet Module
- Wifi Module
- Bluetooth Module

All of the devices have their own advantages and disadvantages but we will be targeting that particular device which best suits our requirement. There are certain features that should be considered when choosing the Bluetooth module for use. The features are

- Wireless transceiver
- Function description
    - Can work at the low voltage (3.1V~4.2V).
    - The current in communication is 8mA.
    - This module can be used in the SMD.
    - It's made through RoHS process. The board PIN is half hole size.
    - Has a 2.4GHz digital wireless transceiver.
    - Small (27mm×13mm×2mm)
    - Peripherals circuit is simple.
    - It's at the Bluetooth class 2 power level.
- Low power consumption
- Has high-performance wireless transceiver system
- Low Cost

This Bluetooth module can easily achieve serial wireless data transmission. Its operating frequency is among the 2.4GHz frequency band. In Bluetooth 2.0, signal transmit time of different devices stands at a 0.5 seconds interval so that the workload of bluetooth chip can be reduced substantially and more sleeping time can be saved for bluetooth. This module is set with serial interface, which is easy to use and simplifies the overall design.

It need to download a bluetooth debugging assistant from play store for mobile phone to connect phone with the Bluetooth HC-06 module, after download and install the package on mobile it needs to enable Bluetooth and open app bye click connect it appear hc-06 and click. A window will pop up asking for a PIN, the password is: 1234, click ok to connect by thus the mobile is able to send data to controller.



Fig 2.7: Bluetooth Module

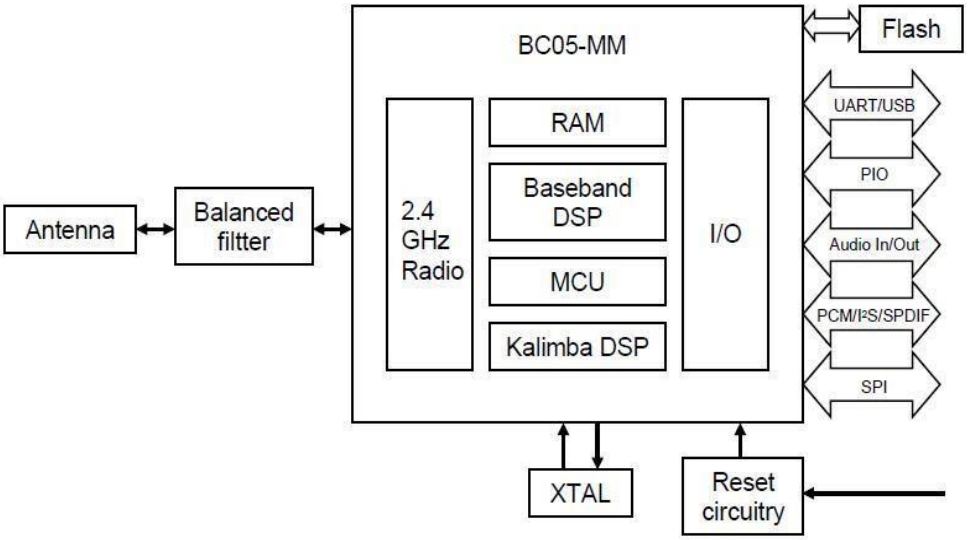


Fig 2.8: Schematic Diagram of Bluetooth Module

2.6 Solar Panel

The solar panels are polycrystalline with a max power of 0.5W each. The panels are connected in series with a resistance of 1.4 kohm to be able to measure the voltage and calculate the current.

Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones are

available, based on thin-film cells. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weather-proof connections to the rest of the system. Modules electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated.



Fig 2.9: Solar Panel

2.7 LCD

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 20x4 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 20x4 LCD means it can display 20 characters per line and there are 4 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

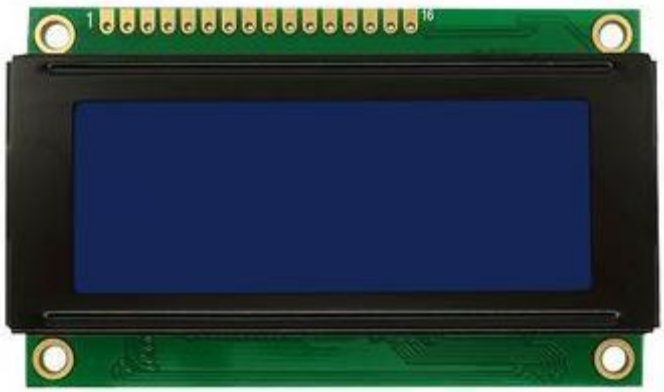


Fig 2.10: 20*4 LCD Display

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.

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/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.

2.8 Relay Module

A relay is defined as an electrically operated switch, their main use is controlling circuits by a low-power signal or when several circuits must be controlled by one signal. The first relay was used in long distance telegraph circuits as amplifiers, basically they repeated the signal they received from one circuit, and transmitted it into a different one, and they were also used in early computers to perform logical operations. The Arduino relay module is designed for a wide range for micro controllers such as the Arduino board, AVR, PIC, ARM, with digital outputs.

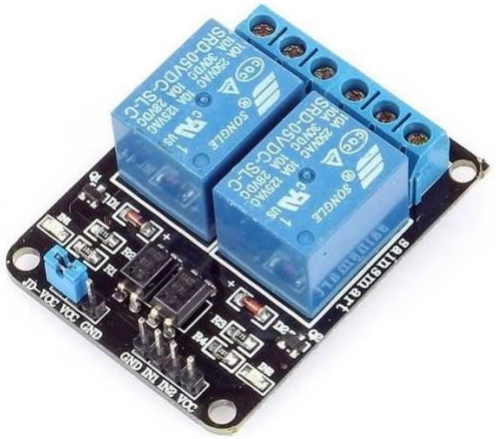


Figure 2.11: Relay Module

2.9 Diode

A diode is a specialized electronic component with two electrodes called the anode and the cathode. Most diodes are made with semiconductor materials such as silicon, germanium, or selenium. Some diodes are comprised of metal electrodes in a chamber evacuated or filled with a pure elemental gas at low pressure. Here we used converted AC into DC using a bridge-wave rectifier that consists of four diodes



Fig 2.12: Diode

2.10 Arduino IDE

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio. The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages *Processing* and *Wiring*. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple *one-click* mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. A program written with

the IDE for Arduino is called a *sketch*. Sketches are saved on the development computer as text files with the file extension *.ino*. Arduino Software (IDE) pre- 1.0 saved sketches with the extension *.pde*. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program *argued* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

To configure software we have to use ARDUINO IDE named arduino.exe To config this programmer with computer we need a USB cable then check serial port and select the programmer from IDE platform such as,

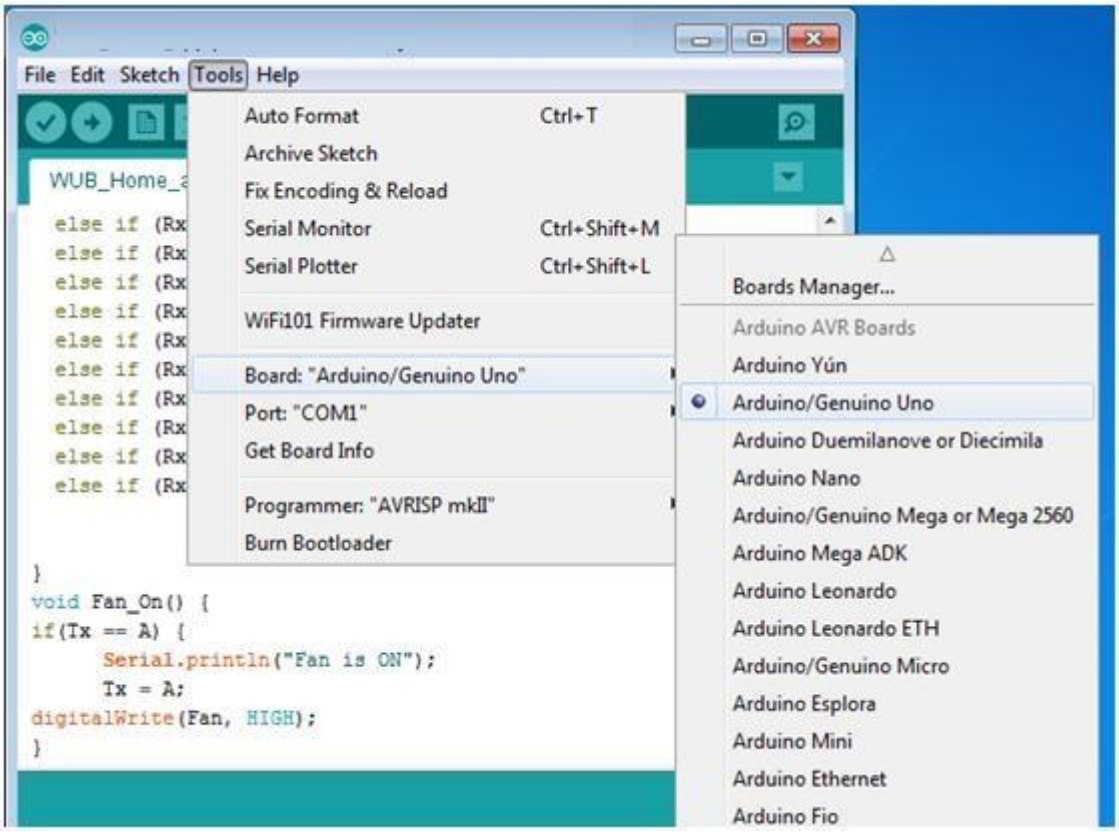


Fig 3.13: IDE configuration for ARDUINO UNO Programmer

After complete configuration IDE is ready for programming. At finally upload main program to new ATMEGA328P using IDE

CHAPTER III

DESIGN & FEBRICATION

3.1 Introduction

In this Chapter, we are going to explain about the system Design construction through Hardware and development of software. In addition, the chapter elaborates the hardware and the software stage by stage. All the operations of hardware and software are also included in this chapter. The system design of the total project is shown in below Figure3.1 with block diagram.

3.2 Block Diagram

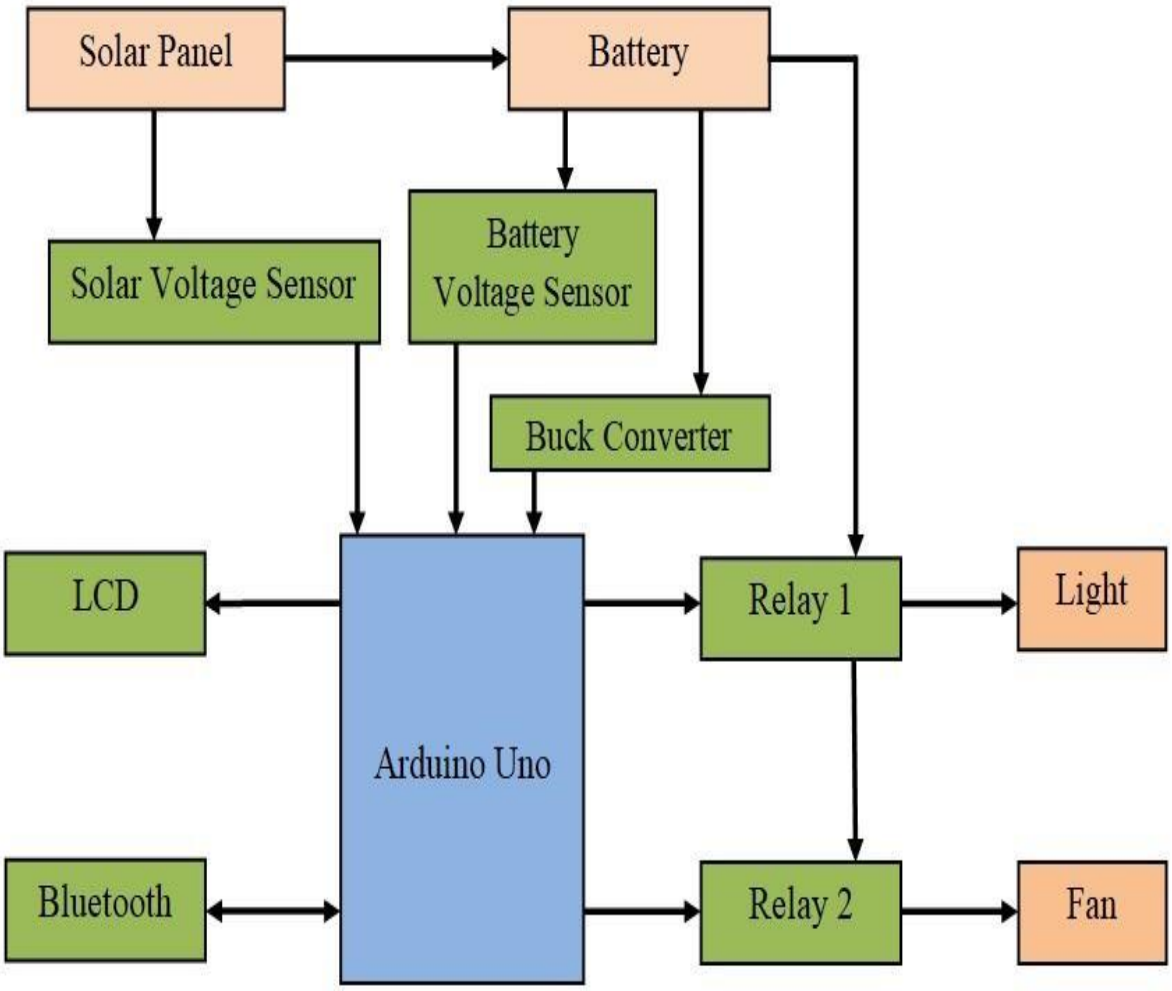


Fig 3.1: Block Diagram of the project.

This project is consists of Arduino uno, voltage sensor, solar panel, battery, Bluetooth, LCD display, relay and load. The battery will charged by solar panel. There are two voltage sensor, one is for solar panel and another is for battery. Those voltage sensor is the input of Arduino. We use an lcd display, relay which is output of Arduino. There are a buck converter which convert 12V to 5V for supply operating voltage.

3.3 Methodology

- After the detail literature survey through the books, periodical, journal, magazine, websites. The idea of the project is well defined.
- The logic is derived for the system. It is programmed and burn it to the Arduino by using the software Arduino IDE.
- The accuracy and viability of the program and electronic components is tested in the simulation software Proteus**.**
- After the successful simulation result it is implemented in the hardware.
- After the finishing the programming, electrical and electronics part, the stable, reliable and flexible mechanical design and fabrication is completed.
- Finally system is tested and encountered error is omitted.

3.4 Flow Chart

According to flow chart microcontroller measure solar sensor, if any voltage detected then measure voltage will transferred to user mobile via Bluetooth. Arduino do same work for the battery sensor. Microcontroller also check incoming signal of Bluetooth to operate load. If incoming data is 1 then microcontroller turn on the light, if data is 2 then microcontroller turn off the load, similarly if data is 3 then it will turn on the fan and it will off the fan when data incoming data is 4.

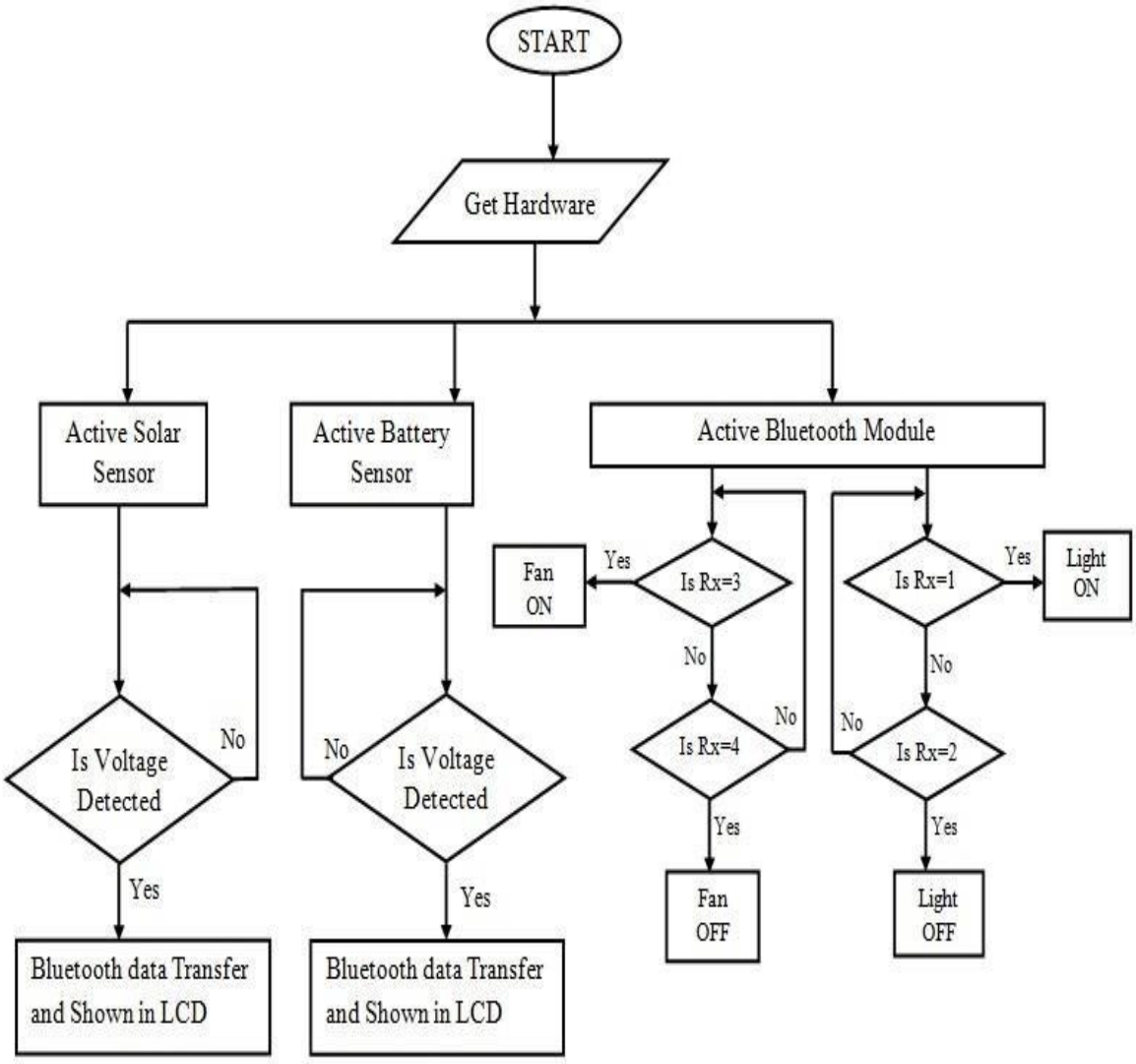


Fig 3.2: Flow Chart

3.5 Circuit Diagram

In this project we connected three solar panel in series connection which will generate voltage and charge the battery. There are a diode which protect solar panel from reverse voltage. Solar voltage sensor and battery voltage sensor both are powered by a buck converter and measure panel and solar voltage. Microcontroller measure both voltage by analog input pin A2 & A3. LCD display is connected to A4 & A5. In this project we use 5V DC relay to operate 12V DC light, both relay is connected to digital I/O pin 2 and 3. We connect bluetooth module to 0 & 1 pin of microcontroller.

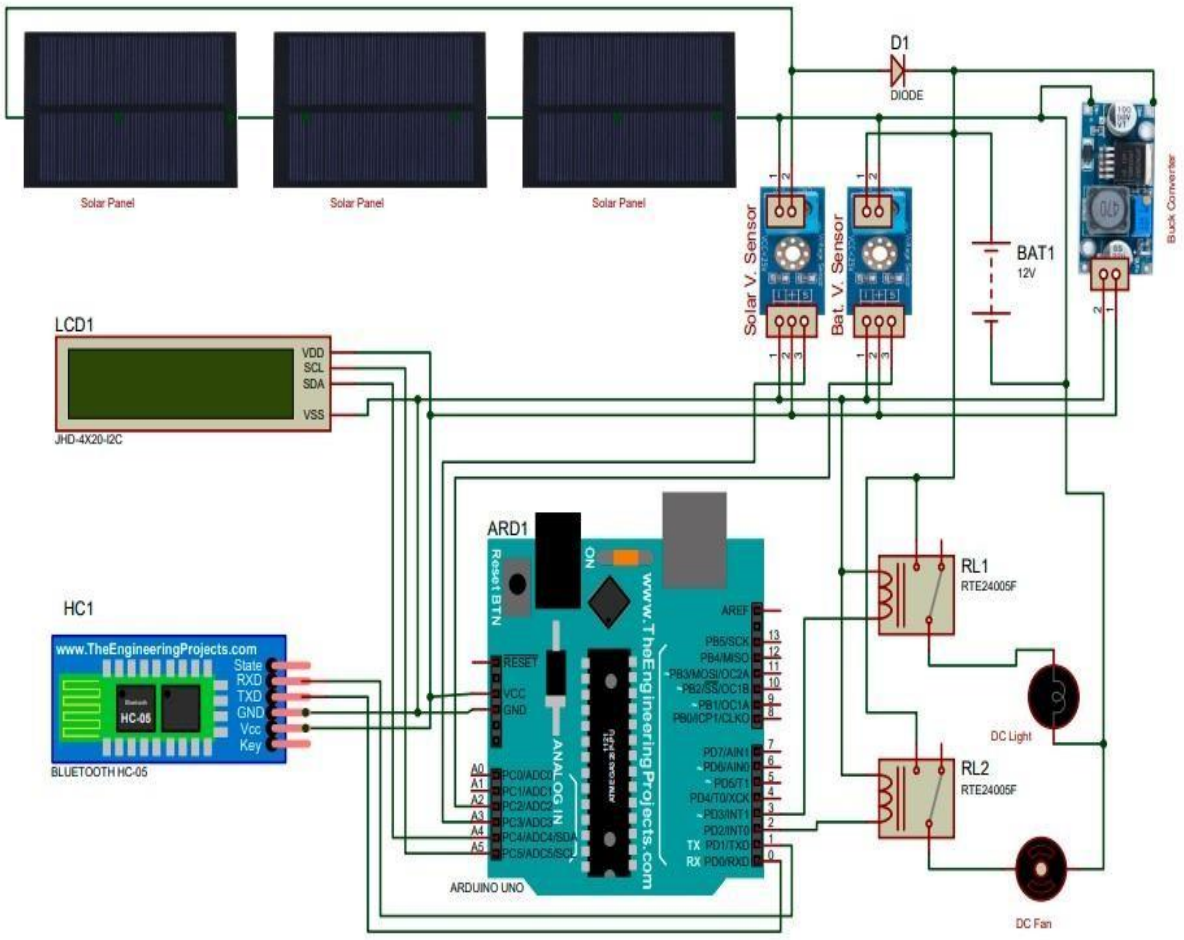


Fig 3.3: Circuit Diagram

3.6 Project Implementation

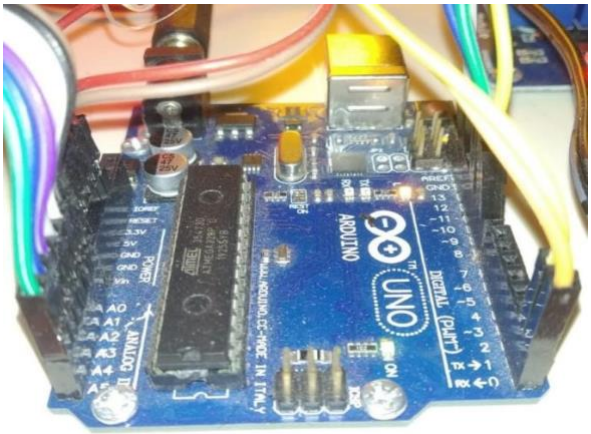


Fig 3.4: Arduino Uno



Fig 3.5: Relay Module



Fig 3.6: Buck Converter

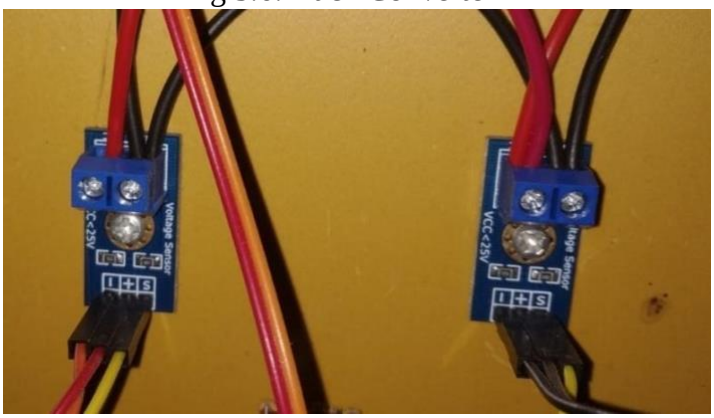


Fig 3.7: Voltage Sensor



Fig 3.8: Solar Panel



Fig 3.9: Battery

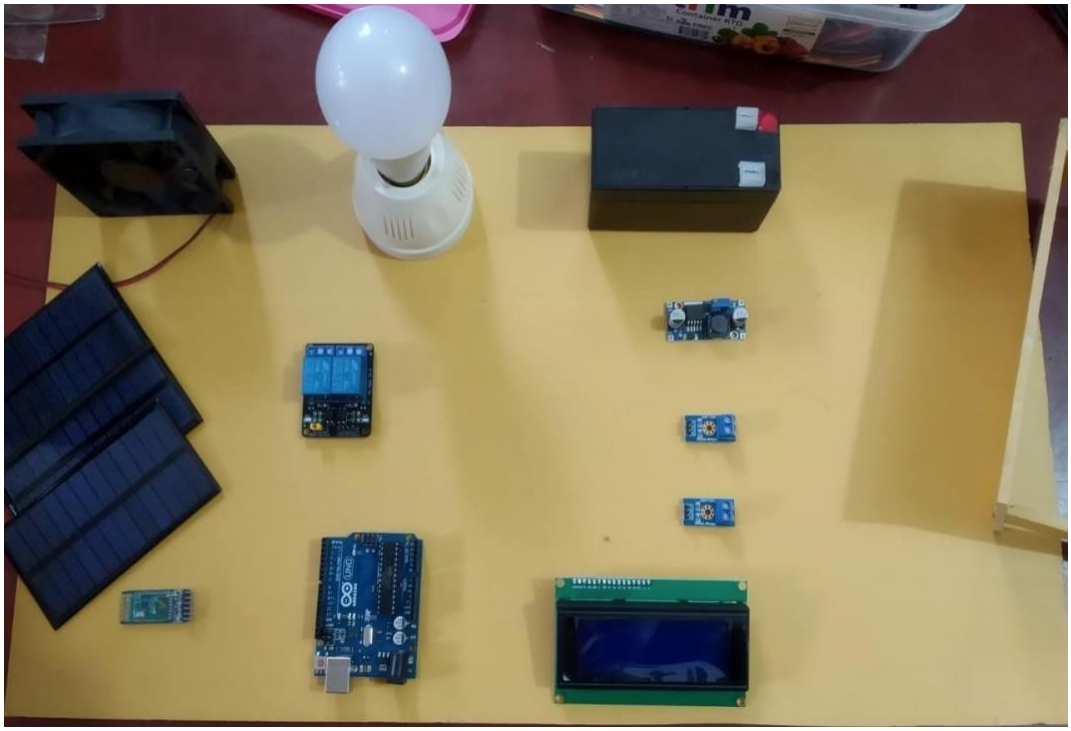


Fig 3.10: All components placing on project board

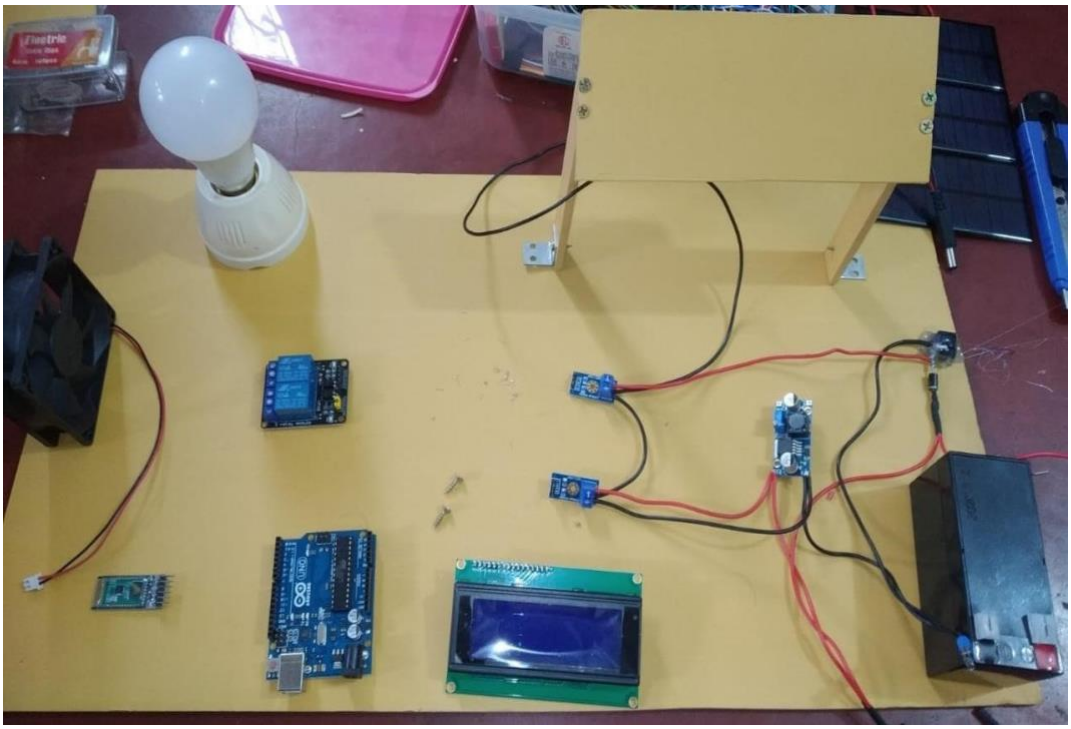


Fig 3.11: Component wiring

3.7 Project Picture

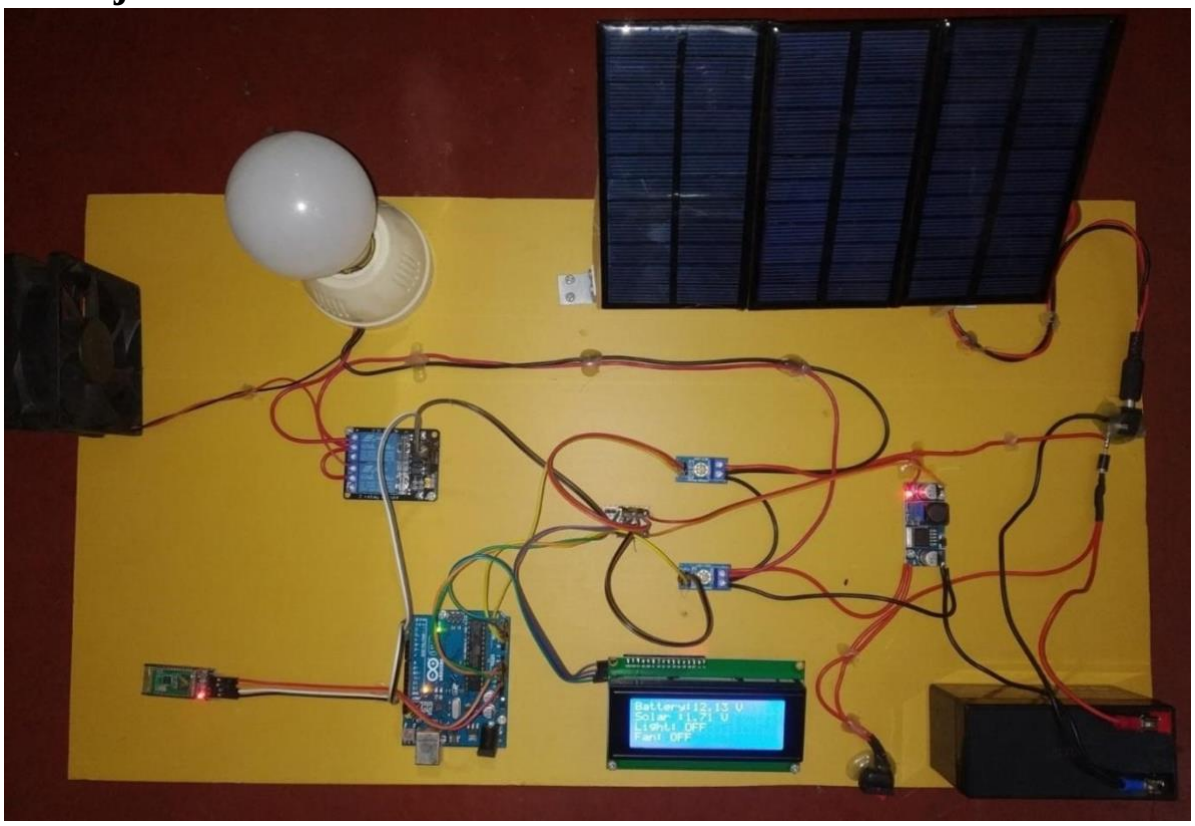


Fig 3.12: Project Picture

3.8 Software Configuration

The Arduino integrated development environment (IDE) could be a cross-platform application written in Java, and derives from the IDE for the process programing language and also the Wiring projects. It's designed to introduce programming to artists and different newcomers unfamiliar with code development. It includes a code editor with options like syntax highlighting, brace matching, and automatic indentation, and is additionally capable of compilation and uploading programs to the board with one click. A program or code written for Arduino is named a "sketch".

Arduino programs are written in C or C++. The Arduino IDE comes with a code library referred to as "Wiring" from the first Wiring project that makes several common input/output operations a lot of easier. The users would like solely to outline 2 functions to create a possible cyclic government program:

setup (): a function run once at the beginning of a program that may initialize settings loop (): a function referred to as repeatedly till the board powers off+ programming languages.

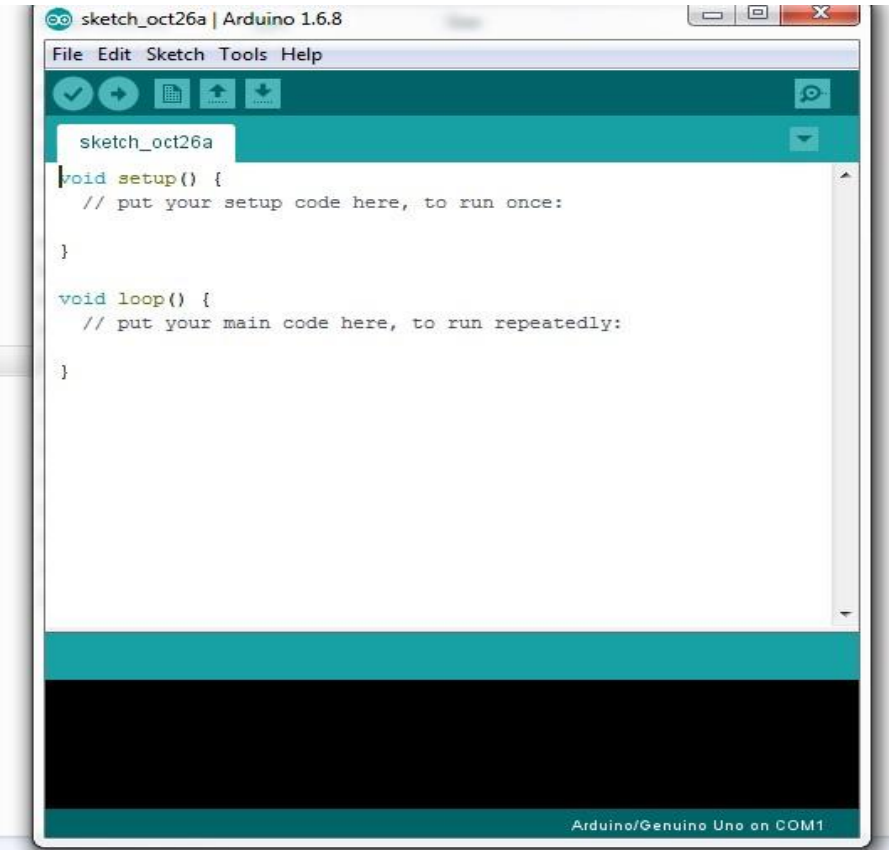


Fig 3.13: Programming platform for ARDUINO

microcontroller unit named as Arduino Uno can be programmed with the Arduino software. There is no requirement for installing other software rather than Arduino. Firstly, Select "Arduino Uno from the Tools , Board menu (according to the microcontroller on your board).The IC used named as ATmega328 on the Arduino Uno comes pre burned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer.

Programming software of this line follower is known as ARDUINO-1.6.8. This is open source programming platform**.** The open-source ARDUINO environment makes it easy to write code and upload it to the input/output board. Here we use ARDUINO-1.6.8 platform.

To configure software, we have to use ARDUINO -1.6.8 named arduino.exe

To configure this programmer with computer we need a USB cable then check serial port and select the programmer from Aruino-1.6.8 platform such as,

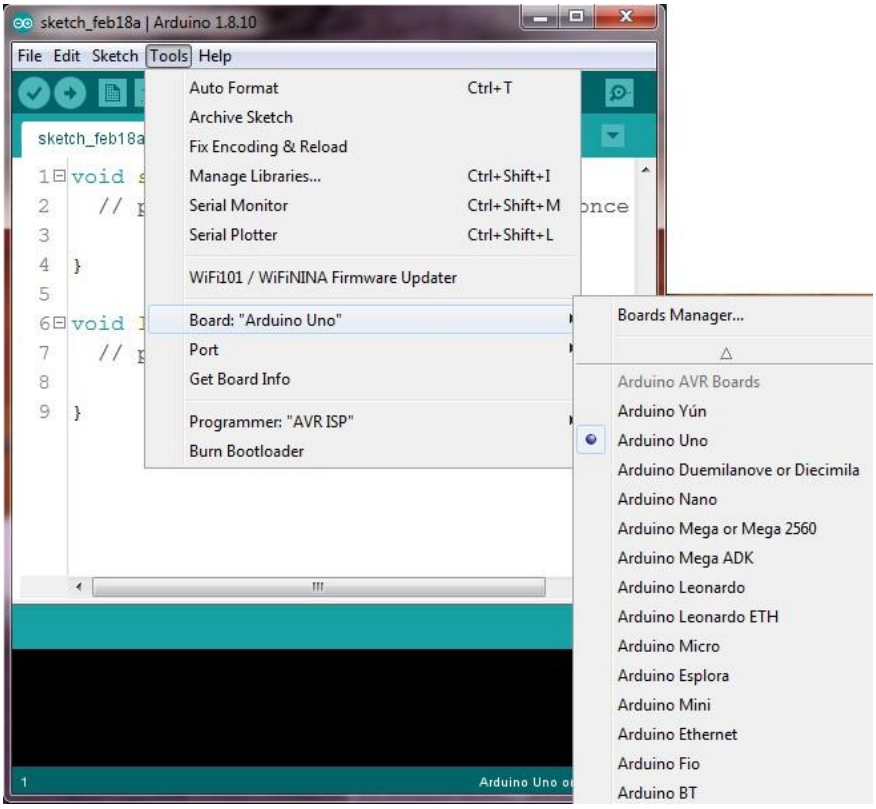


Fig 3.14: IDE configuration for ARDUINO UNO Programmer

Serial communication

It is used for the communication between Arduino and a computer or other devices. Every Arduino board has at least one serial port. This ports communicates

thanks to the digital pins 0 (RX) and 1 (TX), and with the computer thanks to the USB connection.

Serial.begin(speed)

It establishes the speed of data in bits per second (bauds) for the transmission of data in serial communication.

Serial.read()

It reads the data from the serial port.

Serial.print(val,[format])

It prints the data to the serial port as ASCII text

Serial.println(val,[format])

It prints the data to the serial port as ASCII text but it jumps to a new line.

Serial.available()

It gives back the number of available bytes to be read by the serial port. It refersto data that has already been received and is available in the buffer of the port.

3.9 Summarization

In this chapter all hardware and software configuration and implementation and simulation are explained properly. ARDUINO is an open source platform so clear concept is necessary to work with ARDUINO. Burn boot loader or change Pin configuration of microcontroller is a new technique and to work and implementation of any project is much easier than before. After study this chapter concept will be clear about ARDUINO.

CHAPTER IV
RESULT & DISCUSSION

4.1 Introduction

The recent development in energy sector have shown that solar-energy market is one of the most rapidly expanding renewable energy markets in the world. Presently there is significant increasing in demands for remote monitoring and control equipment for solar-energy applications. The advancement in the solar cell technology has led to the development of a more efficient, flexible and lighter PV cells named smart solar cells. Solar manufacturing company now embeds electronics such as power optimizers, micro DC-to-DC converters, and condition monitoring devices in the solar PV modules. The monitoring and measurement of solar PV parameters and site condition has some importance in evaluating the performance of existing solar installations, advanced system monitoring and the prediction of future generation. They also aid in decision making, product development, system maintenance, and many other applications.

4.2 Result

The experimental model was made according to the circuit diagram and the results were as expected. Testing was carried out under sun light. The results of test carried out on the device at different times and days.

- Microcontroller reads solar and battery voltage and display it on LCD
- Solar and Battery voltage information transfer to mobile phone via bluetooth module.
- Load can be ON and OFF by Mobile Phone.

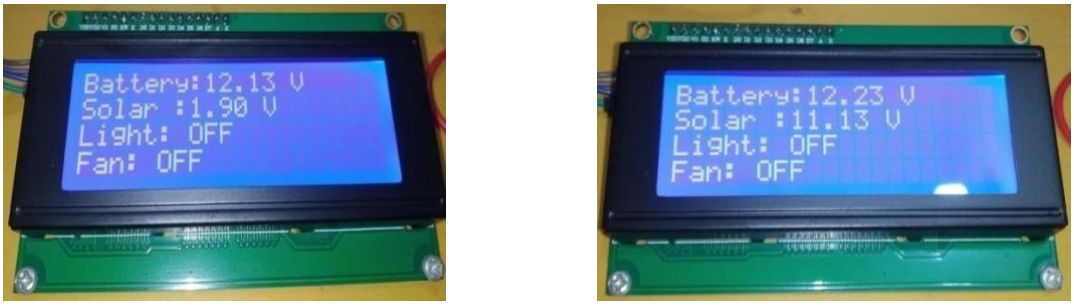


Fig 4.1: Panel and battery voltage monitoring



Fig 4.2: Load status show on LCD



Fig 4.3: Light and Fan On using Bluetooth

4.3 Application

- Can be used for small & medium scale power generations.
- Can be used for power generation at remote places where power lines are not accessible.
- Can be used for domestic backup power systems.
- Can also be utilized for automatic switching ON/OFF the street lights
- Can also used for some home appliance like solar water heater or something like that.

4.4 Advantages

- One time investment, which provides higher efficiency & flexibility on dependency over other sources.
- Bulk implementations of tracking systems help reduced consumption of power by other sources.

- It enhances the clean and emission free power production. ➢ Smart Monitoring and load control System

4.5 Costing

Average price of parts used in this project is given bellow,

Sl. No	Parts Name	Qty	Unit Price	Total Price
1	Arduino Uno	1 Unit	700	700
2	LCD display	1 Unit	550	550
3	Bluetooth Module	1 Unit	300	300
4	Voltage Sensor	2 Unit	90	180
5	Solar Panel	3 Unit	250	750
6	Relay Module	1 Unit	140	140
7	Battery	1 Unit	800	800
8	DC Jack	1 Unit	10	10
9	DC Socket	1 Unit	10	10
10	Switch	1 Unit	15	15
11	Diode	1 Unit	15	15
12	DC Fan	1 Unit	90	90
13	Buck Converter	1 Unit	100	100
14	DC Light	1 Unit	100	100
15	Jumper wire	20 Unit	2	42
16	Wire	1 Unit	30	30
17	Screw, Glue, etc	1 Unit	100	100
18	Project Board	1 Unit	250	250
Total				**4,182/-**

Table 4.1: Price list of hardware used at solar monitoring System

4.6 Discussion

An Arduino based solar power parameter-measuring system has been designed and constructed using the optimized simulated parameter from Proteus ISIS. This device was then used to acquire solar PV current, voltage, power, temperature, pressure and light intensity. The system can measure data from solar panel that can be used to evaluate the performance of solar energy generated for future energy generation prediction. Based on the measurement data, it was observed that the solar PV energy generation directly depends on the solar irradiance.

CHAPTER V

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

In the conclusion, the project is achieved by all the objective. A solar panel and battery voltage monitoring system was designed and implemented for the voltage parameter by using the voltage divider method in order to reduce the maximum value of the solar panel to the voltage value suitable for the Arduino of power supply. The aim of the monitoring system is to measure the voltage for find better efficiency of the solar panel has shown in the experimental results. This work can be executed on a large scale which be beneficial to developing countries like Bangladesh. Lastly, to develop a portable device for measuring the solar energy can be achieved by developing the light in weight of the casing of the device and the neat arrangement of the electrical component inside the casing.

5.2 Future Scopes of the Work

- Solar panel movement structure can be implement.
- Improving the load carrying capacity.
- Adding Current sensor to measure consumed voltage.
- For large scale internet based monitoring system can be implement

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Appendix

Programming Code:

```
////////// LCD Configuration ////////
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,20,4);

//////// Light & Fan relay Connection ///////
int light=3;
int fan=2;

////////// Initial Bluetooth Command ////////
int rx=0;

//////// input or output configuration (setup)////////
void setup() {

Serial.begin(9600);    ////Bluetooth communication speed
lcd.init();                  ///LCD initialization
lcd.backlight();          ///LCD light on
lcd.setCursor(0,0);  //Line & Colum number
 lcd.print("Solar Monitor");   ///Text on LCD

 pinMode(light, OUTPUT);         ///Output
pinMode(fan, OUTPUT);            ///Output
digitalWrite(light, HIGH);          ///relay Off when
start  digitalWrite(fan, HIGH);   /// relay Off when
start delay(1000);
}


////// Continuous Program (loop) ////////////
void loop() {
battery_voltage = analogRead(A2);   /// Battery Sensor Reading
solar_voltage = analogRead(A3);      /// Solar Sensor Reading


////// if bluetooth receive 1 then light on //////////////
if (rx== '1')
{digitalWrite(light, LOW);
```

```
lcd.setCursor(0, 2);
lcd.print("Light: ON ");}

////// if Bluetooth receive 2 then light off //////////////
if (rx== '2')
{digitalWrite(light, HIGH);
lcd.setCursor(0, 2);
lcd.print("Light: OFF");
}

////// if Bluetooth receive 3 then fan on //////////
if (rx== '3')
{digitalWrite(fan, LOW);
lcd.setCursor(0, 3);
lcd.print("Fan: ON ");
}

////// if Bluetooth receive 4 then fan off //////////
if (rx== '4')
{digitalWrite(fan, HIGH);
lcd.setCursor(0, 3);
lcd.print("Fan: OFF");}


/////// Print Battery Sensor Reading on LCD /////////
lcd.setCursor(0,0);
lcd.print("Battery:");
lcd.print(battery_voltage);
lcd.print(" V");


/////// Print Solar Sensor Reading on LCD /////////
lcd.setCursor(0,1);
lcd.print("Solar :");
lcd.print(solar_voltage);
lcd.print(" V");

delay(1500);  //// wait 1 min & 30 second for continue the loop again
}
```