Visvesvaraya Technological University

Belgaum, Karnataka-590 018

A Project Report on

"RES Based Smart Inverter"

Project Report submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Engineering
In
Electrical & Electronics Engineering

Submitted by

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2020-2021

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Certificate

Certified that the project work entitled **"RES based Smart Inverter"** carried out by Mr. HARISH R,1CR17EE022; Mr. KARTHIK SANTOSH,1CR17EE029; Ms. RADHIKA R, 1CR17EE053 are Bonafide students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2020-2021. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

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DECLARATION

We, [Mr. **HARISH R (1CR17EE022),** Mr. **KARTHIK SANTOSH (1CR17EE029),** Ms. **RADHIKA R (1CR17EE053)],** hereby declare that the report entitled **"RES BASED SMART INVERTER"** has been carried out by us under the guidance of Ms. **GEETHANJALI P,** Assistant Professor, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of **BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belgaum during the academic year 2020-21. The work done in this report is original and it has not been submitted for any other degree in any university.

Place: Bengaluru

Date:05/01/2021

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Abstract

The industrial revolution in power has become the foremost fundamental element required to fuel an economy. Every section like industries, homes, and the government itself is heavily hooked into power for its smooth functioning. Hence, it's time we use renewable energy sources so as to scale back pressure on power grids. Therefore, it's extremely important to specialize in the concept of energy generation using renewable sources and energy storage in an efficient manner to scale back the pressure on power grids. Energy storage comes in handy during emergencies like floods, storms, breakdowns, etc. which end in long power cuts. The population explosion has also resulted during a power shortage and consequential power cuts. But with the ever- rising technological advances, the inverter is predicted to be much smarter than it is now. A sensible inverter must use renewable energy to charge its battery, it should be adaptive and ready to send and receive messages quickly, also as share data with the owner. Hence there's scope for retrofitting the prevailing inverters to form them more user-friendly by displaying the battery voltage and also providing information on the run-time of his loads while using the battery, which can also promote the use of obtainable energy by the buyer.

Acknowledgement

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people, who are responsible for the completion of the project and who made it possible, because success is outcome of hard work and perseverance, but stead fast of all is encouraging guidance. So with gratitude we acknowledge all those whose guidance and encouragement served us to motivate towards the success of the project work.

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We are thankful to all the faculties and laboratory staffs of ***Electrical and Electronics Engineering Department, CMR Institute of Technology, Bengaluru*** *for helping us in all possible manners during the entire period.*

Finally, we acknowledge the people who mean a lot to us, our parents, for their inspiration, unconditional love, support, and faith for carrying out this work to the finishing line. We want to give special thanks to all our friends who went through hard times together, cheered us on, helped us a lot, and celebrated each accomplishment.

Lastly, to the ***Almighty****, for showering His Blessings and to many more, whom we didn't mention here.*

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CHAPTER 1

INTRODUCTION

The project “Smart Inverter”, is an inverter system with uninterrupted power supply which basically controls the load that is drawn from the backup battery that is used in the inverter system. There are different modes of operation which controls the current drawn from the battery.

We explain the different components required, the problems faced and the solutions given during the construction of this project. We also explain the day to day usage of power and its redundancy in today’s world. The explanation and solution to many different problems faced by mankind are given in elaborate. We try to analyze the forthcomings and misgivings of the power grid. The shortcomings of smart grids and its usage in India is also mentioned.

The smart inverter gives us an idea of the future and the solution to all the above problems. We try to make amends to the lack of usage of smart grids in many parts of the world and help the user to get a real time experience of how the inverter works and controls the household system.

1.1 HISTORY OF THE PROJECT

Fabrizio PILO from the late 19th century through the middle of the 20thcentury, DC-AC power conversion was accomplished using rotary converts or motor-generator sets. In the early 20th century, a vacuum tube and gas filled tube begin to be used as switches in the inverter circuits.

The most widely used type of tube was the thyratron. The origin of the electromechanically inverters explain the source of the term inverter. Early AC-DC converters used an induction, a synchronous AC motors direct-connected to a generator so that generators commutator reversed its connection at exactly the right movements to produce DC.

1.2 REASON FOR SELECTING THE PROJECT

Energy storage comes in handy during emergencies like floods, storms, equipment failure etc which result in long power cuts. The population explosion has also resulted in a power shortage and consequential power cuts. But with the ever-rising technological advances the inverter is expected to be much smarter than it is now.

One way of doing it is to let the consumer monitor its status remotely. In this project we mainly focus on monitoring of inverter's battery, displaying the run-time utilization of the loads and controlling of loads wirelessly. Inverters found in most households and industries are powered by non-renewable energy resources and are primitive in their architecture and usage.

1.3 REQUIREMENTS

SOFTWARE REQUIREMENTS

- Arduino Sketch IDE 1.8.1 or higher version
- Blynk app from google play store
- Windows XP or higher version

HARDWARE REQUIREMENTS

- Arduino Mega 2560
- 20x4 Alpha Numeric LCD
- ESP8266 – Wi-Fi transceiver
- 10W Photo Voltaic panel
- DC to DC buck convertor
- 12V 7AH lead acid maintenance free rechargeable battery
- MOSFET's
- 12V – 220V @ 300W step-up transformer
- SPST Relay
- 5Amps Hall – effect current sensor etc.,

CHAPTER 2

LITERATURE SURVEY

A literature survey or a literature review in a project is a type of review articles. It is a scholarly paper, which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. Literatures reviews are secondary sources, and do not report new or original experimental work. It is a basis for research in nearly every academic field concentrate on the own field of expertise.

2.1 DETAILS OF LITERATURE SURVEY

Aishwarya Kumar, Anusha Ashok Bijapur, Chaitra B, Kirti R Kulkarni, Natarajan [1] proposed 'An IoT based smart inverter' the inverter and routers are commonly found in most households today. Implementation of a smart inverter that uses Wi-Fi technology to engage in a two-way communication with the user, informing the user of both, the battery voltage of the inverter as well as run time of the loads which the user chooses to run. Every section of society like industries, home and government itself is heavily dependent on power for its smooth functioning. However, the population expansion has resulted in an increased demand for power. In this concept the inverters battery is charged using solar panel making it an eco-friendly power generation. Since the definition of a smart inverter is that it is new generation of inverter uses renewable energy, the inverter is indeed a smart inverter a wireless system with which a user can control the house hold appliances wirelessly , monitor the battery health as well as inform the user the run time of the loads running on inverter battery alone .

Megha A Joshi, Kavya Shree S [2] proposed 'Smart Inverter integrating with Raspberry PI' which makes smart home. In this work a bi-level PV based micro grid configuration is proposed for low power residential applications. In the supervisory level along term control scheme is assigned to define the set of points for local controllers. The local level is mainly formed from a set controller which are basically responsible to control the power electronic interfaces and converters. Within the supervisory level a dynamic price scheduling frame work with load and solar energy forecasting is implemented using time series-based regression technic. In the local level, adaptive double mode controllers are developed to realize intelligent inverters with smart grid-tided (GT) capabilities and smooth transition between GT and stand-alone modes.

Santosh Kumar N, Shashi Kumar B, Suresh B and Vignesh S [3] Proposed, 'IoT based Smart Inverter'. This project deals about the improvement of the reliability of power supply for the high load demand and mainly for the critical load. Mostly power demand will be met with the power supply generation with EB supply and the combined battery inverter set. But in this project renewable energy from PV cell is majorly utilized to meet the power demand along with the EB supply and battery inverter combination. In a day, climate is changes continually so, that time power output in PV cells also changes. Here we have a controlling and monitoring of the power output is maintained for the stable output power in all atmospheric conditions to loads. Controlling of the input source connection with the load has been done with microcontroller with help of IoT.

Ninganagouda Biradar, Dr.Baswaraj Gadgay, Veeresh Pujari [4] Proposed 'IoT based smart inverter'. Inverters and routers are commonly found in most household's applications in today's life. However this work we discuss the implementation of a IoT enabled smart inverter i.e. a solar charged inverter that uses Wi-Fi technology to engage at two way communication with the user, and informing the user of both, the battery voltage of the inverter as well as utilization time of the loads which the user chooses to run. Moreover, the wireless control of loads is implemented to ease efficient utilization of energy also increase human comfort. This work uses the ARDUINO UNO microcontroller board based on the ATmega328P along with node MCU which runs on theESP8266 Wi-Fi module to implement the aforementioned objectives.

Rajagopal V. Koushik, D. Naveen Kumar, S. Vinay raj N, Dr. Rangaiah Leburu [5] proposed 'Smart Inverter'. In this current era of smart operation of electronic devices has indeed created a phenomenal improvement in our lives. The technology also helps us to improve manifold. The current smart UPS system has many places for improvement. In this time and age, there is a shortage of natural resources and hence a shortage in the power supplied through these power grids. In this paper, we explain about a smart inverter system that extends the basic life of a battery which is extremely useful during long and unprecedented power outages. The domestic life of the user goes unperturbed and helps him interact with inverter in a smart and easy way.

L.Pattathurani, Rajat Kumar Dwibedi, Dr.S.S.Dash[6] proposed 'Amultilevel inverter for solar application' in this paper, multilevel voltage source inverters offer several advantages compared to their conventional counterparts. Synthesizing the AC output terminal voltage from several levels of voltages, staircase waveforms can be produced, which approach the sinusoidal waveform with low harmonic distortion, thus reducing the filter requirements. By increasing

the level of the inverter, we can get several advantages: get a good voltage wave form, very low THD, reduced volume and cost. The need of several sources on the DC side of the converter makes multilevel technology attractive for photovoltaic applications. This paper provides an overview of a multilevel inverter topology and investigates their suitability for single-phase photovoltaic systems.

M.Sandhiya, S.Meena, DR G. Mahesh Manivanna Kumar [7] proposed 'A multilevel inverter topology with reduced number of switches' a novel multilevel inverter topology with reduced number of power switches is proposed. A multilevel inverter is a power electronic device that is used for high voltage and high-power applications of low switching stresses and lower total harmonic distortion, hence reduces the size and bulk of passive filters. This new topology is based on a combination of conventional diode clamped and H-bridge topologies. The proposed idea has not only achieved high power ratings but also enables the use of renewable energy source. It dramatically reduces the switching losses; cost and low order harmonics and thus effectively improves total harmonic distortion. A multilevel inverter with individual dc sources has been proposed for use in large electric drives. Simulation and experimental results have shown that with a control strategy operates the switches at the fundamental frequency, these converters have low output voltage THD and high efficiency.

Regine Mallwitz, Bernd Engel [8] proposed 'Solar Inverter' this paper reviews the history of solar power inverters and highlights aspects of power electronic packaging concerning functional and packaging integration in solar inverter technology. The most important indicators to characterize the advances in inverter technology are efficiency and losses respectively, mean time between failure and inverter costs. A high integration level is bounded up with high reliability and life time and less costs. Several generations of medium power inverter are analysed concerning integration level which will be described by different indicators.

2.2 OBJECTIVE OF THE PROJECT

1. To create an interactive IoT-enabled smart inverter which is charged by a solar PV panel and can display the existing battery voltage at any point in time

2. To allow the user to then decide which crucial loads to run in the event of a power failure and key in his preferences onto the provided GUI such as a Web page/Mobile Application

CHAPTER 3

PROPOSED MODEL WITH THEORETICAL BACKGROUND

METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Typically, it encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques.

3.1 INTERNET OF THINGS [IoT]

Internet of Things (**IoT**) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data. Each thing is uniquely identifiable through its embedded computing system but is able to inter-operate within the existing internet infrastructure. The definition of the internet of things has evolved due to convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. The IoT aims to unify everything in our world under a common infrastructure, giving us not only control of things around us, but also keeping us informed of the state of the things. The extensive set of applications for IoT devices is often divided into consumer application, building and home automation, industrial applications, manufacturing and agriculture. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.

"Things", in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, cameras streaming live feeds of wild animals in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring, or field operation devices that assist fire fighters in search and rescue operations. Legal scholars suggest regarding "things" as an "inextricable mixture of hardware, software, data and service". These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.

3.2 BLOCK DIAGRAM

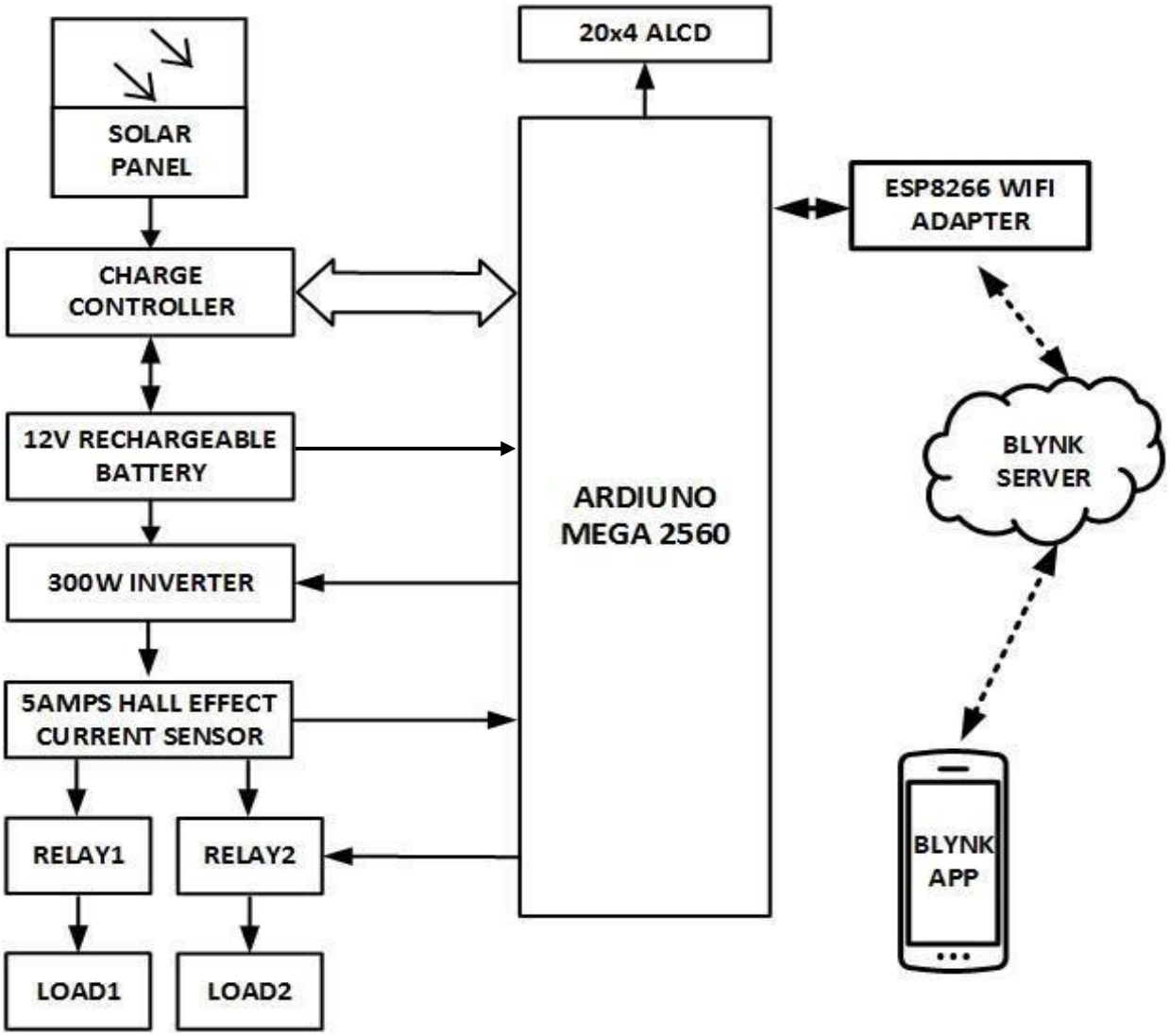


Fig 3.2: Block diagram of an IoT based smart inverter

3.2.1: Solar panel [17-21V,0.5-0.6A,10W]

Solar panels absorb the sunlight as a source of energy to generate electricity or heat. Photovoltaic solar panels use sunlight as a source of energy to generate direct current electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The cells are connected electrically in series, one to another to a desired voltage, and then in parallel to increase amperage. The wattage of the module is the mathematical product of the voltage and the amperage of the module. Cells must be protected from mechanical damage and moisture.

Fig 3.2.1: Solar panel

A single photovoltaic module can only produce a limited amount of power, many installations contain several modules or panels and this is known as a photovoltaic array. A photovoltaic installation typically includes an array of photovoltaic modules or panels, an inverter, batteries and interconnection wiring.

Solar panels use light energy (photons) from the sun to generate electricity through the photovoltaic effect (this is the photo-electric effect). The majority of modules use wafer-based crystalline silicon cells or a thin-film cell based on cadmium telluride or silicon. Crystalline silicon, which is commonly used in the wafer form in photovoltaic (PV) modules, is derived from silicon, a commonly used semi-conductor.

3.2.2 Charge controller

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries and also monitor battery temperature to prevent overheating. This controller is used to regulate the voltage and has DC-DC buck converter to provide constant voltage. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan of battery is increased. This controller stops charging a battery when they exceed a set high voltage level and re-enable charging when battery voltage drops back below that level.

3.2.3 Inverter

A power inverter, or inverter, is a power electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry.

The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

3.2.3.1 Power supply

Power inverters are primarily used in electrical power applications where high currents and voltages are present; circuits that perform the same function for electronic signals, which usually have very low currents and voltages, are called oscillators. Circuits that perform the opposite function, converting AC to DC, are called rectifiers. A power inverter will often have an overall power rating expressed in watts or kilowatts.

The runtime of an inverter powered by batteries is dependent on the battery power and the amount of power being drawn from the inverter at a given time. As the amount of equipment using the inverter increases, the runtime will decrease.

In order to prolong the runtime of an inverter, additional batteries can be added to the inverter. Inverters convert low frequency main AC power to higher frequency for use in induction heating. To do this, AC power is first rectified to provide DC power. The inverter then changes the DC power to high frequency AC power.

Due to the reduction in the number of DC sources employed, the structure becomes more reliable and the output voltage has higher resolution due to an increase in the number of steps so that the reference sinusoidal voltage can be better achieved. This configuration has recently become very popular in AC power supply and adjustable speed drive applications.

3.2.4 Batteries [12V, 7Ah]

The runtime of an inverter powered by batteries is dependent on the battery power and the amount of power being drawn from the inverter at a given time. As the amount of equipment using the inverter increases, the runtime will decrease. In order to prolong the runtime of an

inverter, additional batteries can be added to the inverter. Here lead acid maintenance free battery is used.

Fig 3.2.4: Lead acid battery

Lead-acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. Large-format lead-acid designs are widely used for storage in backup power supplies in cell phone towers, high-availability settings like hospitals, and stand-alone power systems.

3.2.5 Current sensor

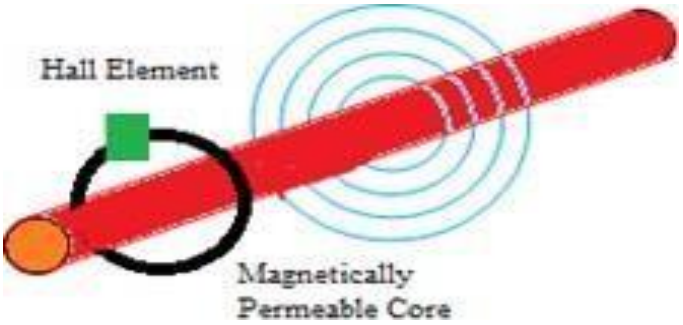


Fig 3.2.5: Hall effect current sensor

It is a device that detects electrical current in a wire, and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for the purpose of control. The hall effect current sensor is a type of current sensor which is based on the hall effect phenomenon.

Hall effect current sensors can measure all types of current signals (i.e. AC, DC, or pulsating current). These sensors are currently being used widely in many industries because

of their vast applications and the type of output they provide, which can be manipulated and can be used for various application.

3.2.6 Relay

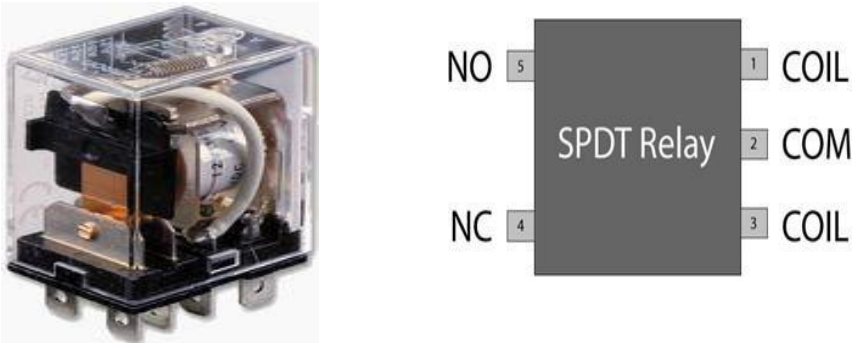


Fig 3.2.6: Electromechanical relay

The term relay generally refers to a device that provides an electrical connection between two or more points in response to the application of a control signal. A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals.

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. The most fundamental control of any equipment is the ability to turn it "ON" and "OFF". The easiest way to do this is using switches to interrupt the electrical supply. Electromechanical relays are electromagnetic devices that convert a magnetic flux generated by the application of a low voltage electrical control signal either AC or DC across the relay terminals, into a pulling mechanical force which operates the electrical contacts within the relay.

3.2.7 Load

Usually load means which consumes energy. For residential purpose the loads mean the fans, bulbs, tube lights and many more which consumes energy.

An electrical load is an electrical component or portion of a circuit that consumes (active) electric power. This is opposed to a power source, such as a battery or generator, which produces power. In electric power circuits example of loads are appliances and lights. The term may also refer to the power consumed by a circuit.

Fig 3.2.7: Bulb as a load

The term is used more broadly in electronics for a device connected to as signal source, whether or not it consumes power. If an electric circuit has an output port, a pair of terminals that produces an electrical signal, the circuit connected to this terminal (or its input impedance) is the load. For example, if a CD player is connected to an amplifier, the CD player is the source and the amplifier is the load.

Load affects the performance of circuits with respect to output voltages or currents such as sensors, voltage source, and amplifiers. Main power outlets provide an easy example: they supply power at constant voltage, with electrical appliances connected to the power circuit collectively making up the load. When a high-power appliance switches on, it dramatically reduces the load impedance. If the load impedance is not very much higher than the power supply impedance, the voltages will drop. In a domestic environment, switching on a heating appliance may cause incandescent lights to dim noticeably.

3.2.8 LCD

Fig 3.2.8: LCD

A liquid-crystal display (LCD) is a low cost, low power device capable of displaying text and images. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in colour or monochrome. LCDs are extremely common in embedded systems, since such systems often do not have video monitors like those that come standard

with desktop systems. It can be found in numerous common devices like watches, fax and copy, machines and calculators.

LCDs are available to display arbitrary images (as in general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as pre-set words, digits, and seven-segment displays, as in a digital clock. They use the same basic technology, except that arbitrary images are made up of many small pixels, while other displays have larger elements. LCDs can either be normally on (positive) or off (negative), depending on the polarizer arrangement.

Procedure for LCD driver is:

1. Function set - set 8-bit long data interface

2. Display on - set display on, cursor on, and blink on.

3. Entry mode set - set entry mode to increment the cursor after a character is displayed.

4. Display Clear - clear the LCD display.

3.2.9 ESP8266

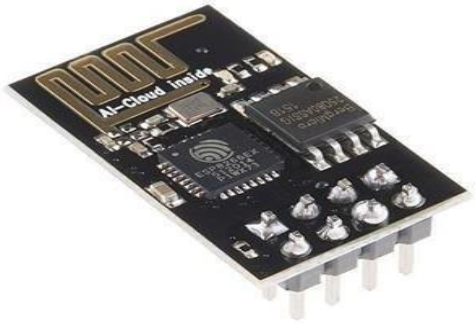


Fig 3.2.9: ESP8266

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by manufacturer Espressif Systems in Shanghai, China. ESP8266 delivers highly integrated Wi-Fi SoC (system-on-a-chip) solution to meet users continuous demands for efficient power usage, compact design and reliable performance in the IoT industry. The small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands.

Features

- Processor: L106 32-bit RISC microprocessor core based on the Tensilica Xtensa diamond standard 106 micro running at 80 MHz
- Memory:
  - 32 KB instruction RAM
  - 32 KB instruction cache RAM
  - 80 KB user data RAM
  - 16 KB ETS system data RAM
- External QSPI flash: up to 16 MB is supported (512 KB to 4 MB typically included)
- IEEE 802.11 b/g/n Wi-Fi
  - Integrated TR switch, balun, LNA, power amplifier and matching network
  - WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
- SPI
- I²C (software implementation)
- I²S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO
- 10-bit ADC

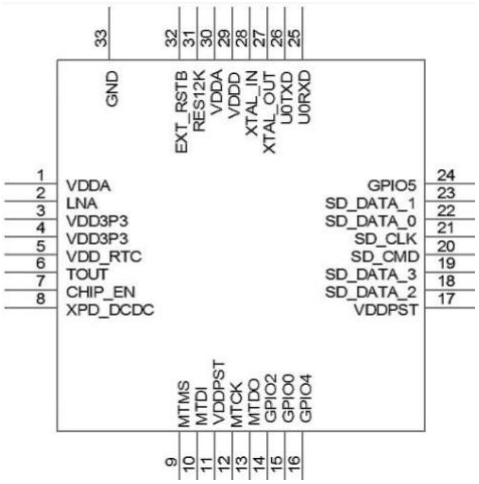


Fig 3.2.9.1: Pin configuration of ESP8266

3.2.10 Arduino mega 2560

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the

board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs.

Arduino projects can be stand-alone, or they can be communicated with software running on your computer (e.g. Flash, Processing, MaxMSP). The open-source IDE can be downloaded for free. The mega 2560 is designed for more complex projects. With 54 digital I/O pins,16 analog inputs and a large space for sketch it is recommended board for 3D printers and robotics projects. This gives your projects plenty of room and opportunities.

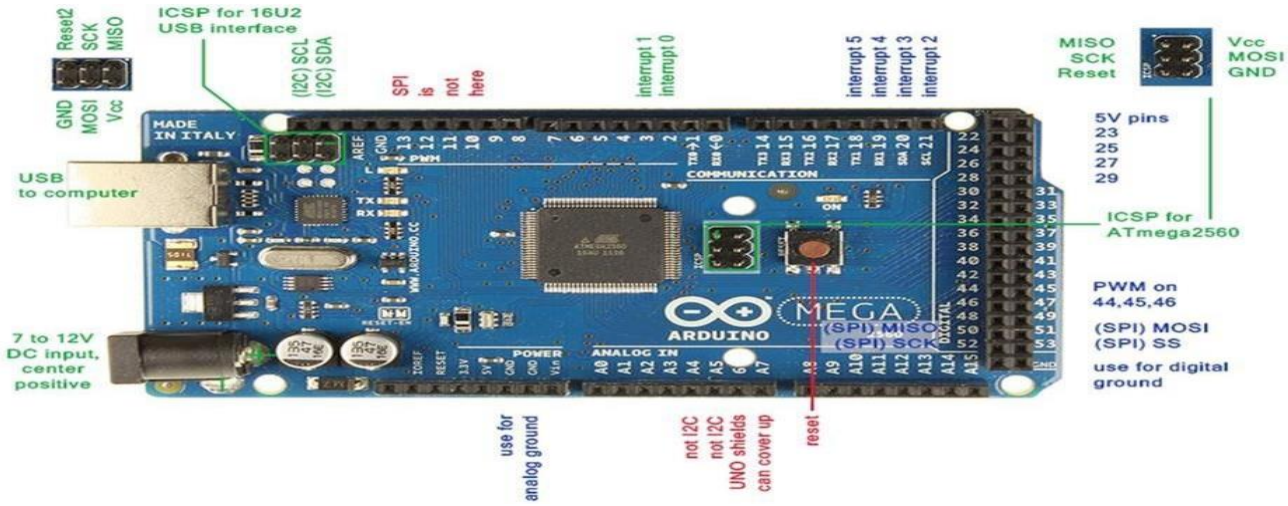


Fig3.2.10: Arduino mega 2560 board

Why Arduino?

Arduino simplifies the process of working with microcontrollers, but it offers some advantage for students and interested amateurs over other systems:

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $80
- Cross-platform - The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment - The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well.

- Open source and extensible software- The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries.
- Open source and extensible hardware - The Arduino is based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers.

The Arduino Mega 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 centre-positive plug into the board's power jack. Leads from a battery can be inserted in the ground and Vin pin headers of the power connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Power

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be 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:

a) **Vin-** The input voltage to the Arduino 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.
b) **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.
c) **3.3V**- A 3.3volt supply generated by the on-board regulator. Maximum current draw is 800mA. This regulator also provides the power supply to the SAM3X microcontroller.
d) **GND**- Ground pins.
e) **IOREF**- This pin on the Arduino 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 for working with the 5V or 3.3V.

Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM.

Input and Output

a) **Digital I/O: pins from 0 to 53**

b) Each of the 54 digital pins on the Due can be used as an input or output, using pin Mode, digital Write, and digital Read functions. They operate at 3.3 volts. Each pin can provide (source) a current of 3mA or 15mA, depending on the pin, or receive (sink) a current of 6mA or 9mA, depending on the pin. They also have an internal pull-up resistor (disconnected by default) of 100 K-Ohm. In addition, some pins have specialized functions.

c) **Serial 0: (RX) and 1 (TX)**

d) **Serial 1: 19 (RX) and 18 (TX)**

e) **Serial 2: 17 (RX) and 16 (TX)**

f) **Serial 3: 15 (RX) and 14 (TX)** - Used to receive (RX) and transmit (TX) TTL serial data (with 3.3 V level). Pins 0 and 1 are connected to the corresponding pins of the ATmega16U2 USB-to-TTL Serial chip.

g) **PWM: Pins 2 to 13** provide 8-bit PWM output with the Analog Write () function. The resolution of the PWM can be changed with the Analog Write-Resolution () function.

h) **SPI: SPI-header (ICSP header on other Arduino boards)**, these pins support SPI communication using the SPI library. The SPI pins are broken out on the central 6-pin header, which is physically compatible with the Uno, Leonardo and Mega2560. The SPI header can be used only to communicate with other SPI devices, not for programming the SAM3X with the In-Circuit-Serial-Programming technique. The SPI of the Due has also advanced features that can be used with the Extended SPI methods for Due.

i) **CAN :(CANRX and CANTX)** These pins support the CAN communication protocol but are not yet supported by Arduino APIs.

j) **"L" LED: 13** there is a built-in LED connected to digital pin 13. When the pin is HIGH, the LED is on, when the pin is LOW, it's off. It is also possible to dim the LED because the digital pin 13 is also a PWM output.

k) **TWI 1: 20 (SDA) and 21 (SCL).**

l) **TWI 2: SDA1 and SCL1.** Support TWI communication using the Wire library. SDA1 and SCL1 can be controlled using the Wire1 class provided by the Wire library.

m) While SDA and SCL have internal pull-up resistors, SDA1 and SCL1 have not. Adding two pull-ups Resistor on SDA1 and SCL1 lines is required for using Wire1

n) **Analog Inputs (pins from A0 to A11):** The Due has 12 Analog inputs, each of which can provide 12 bits of resolution (i.e. 4096 different values). By default, the resolution of the readings is set at 10 bits, for compatibility with other Arduino boards. It is possible to change the resolution of the ADC with Analog Read Resolution (). The Due's Analog inputs pins measure from ground to a maximum value of 3.3V. Applying more than 3.3V on the Due's pins will damage the SAM3X chip.

o) The AREF pin is connected to the SAM3X analog reference pin through a resistor bridge. To use the AREF pin, resistor BR1 must be de-soldered from the PCB.

p) **DAC1 and DAC2:** These pins provide true Analog outputs with 12-bits resolution (4096 levels) with the Analog function. These pins can be used to create an audio output using the Audio library.

q) Please note that DAC output range is actually from 0.55 V to 2.75 V only.

Other pins on the board:

a) **AREF** Reference voltage for the Analog inputs. Used with Analog Reference ().

b) **Reset** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino Due has a number of facilities for communicating with a computer, another Arduino or other microcontrollers, and different devices like phones, tablets, cameras and so on. The SAM3X provides one hardware UART and three hardware USARTs for TTL (3.3V) serial communication. The Arduino Due has a resettable poly-fuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

The Programming port is connected to an ATmega16U2, which provides a virtual COM port to software on a connected computer (To recognize the device, Windows machines will need an INF file, but OSX and Linux machines will recognize the board as a COM port automatically). The 16U2 is also connected to the SAM3X hardware UART. Serial on pins RX0 and TX0 provides Serial-to-USB communication for programming the board through the ATmega16U2 microcontroller. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will

flash when data is being transmitted via the ATmega16U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

The Native USB port is connected to the SAM3X. It allows for serial (CDC) communication over USB. This provides a serial connection to the Serial Monitor or other applications on your computer. It also enables the Due to emulate a USB mouse or keyboard to an attached computer. To use these features, see the pages. The Native USB port can also act as a USB host for connected peripherals such as mice, keyboards, and smartphones. To use these features, see the pages. The SAM3X also supports TWI and SPI communication. The Arduino software includes a Wire library to simplify use of the TWI bus; see the documentation for details. For SPI communication, use the SPI library.

USB Over current Protection

The Arduino due has a resettable poly fused that protects your computers USB ports from shorts and over current. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500mA is applied to the USB port, the fuse will automatically break the connection until the short or over load is removed.

3.2.11 Sketch

The sketch IDE (Integrated Development Environment) is a special program running on your computer that allows you to write sketches for the Arduino board in a simple language modelled after the processing language. The magic happens when you press the button that uploads the sketch to the board: the code that you have written is translated into the C language, and is passed to the AVR-GCC compiler, an important piece of open source software that makes the final translation into the language understood by the microcontroller.

The idea of sketching in code is a way of thinking about writing code as a simple intuitive process, just like drawing in a sketchbook. In this way, an Arduino program is called a sketch and is saved in a folder called a sketchbook. Sketching means we can get our hands dirty and quickly try out a new idea. It is a skill available to all of us.

The programming cycle on Arduino is basically as follows:

- ✓ Plug your board into a USB port on your computer.
- ✓ Write a sketch that will bring the board to life.
- ✓ Upload this sketch to the board through the USB connection and wait a couple of seconds for the board to restart.
- ✓ The board executes the sketch that you wrote.

The idea of sketching in code is a way of thinking about writing code as a simple intuitive process, just like drawing in a sketchbook. In this way, an Arduino program is called a sketch

and is saved in a folder called a sketchbook. Sketching means we can get our hands dirty and quickly try out a new idea. It is a skill available to all of us.

3.2.12 BLYNK

Blynk is designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things. There are three major components in the platform:

- **Blynk App** - allows to you create amazing interfaces for your projects using various widgets we provide.
- **Blynk Server** - responsible for all the communications between the smartphone and hardware. You can use our Blynk Cloud or run your private Blynk server locally. It's open-source, could easily handle thousands of devices and can even be launched on a Raspberry Pi.
- **Blynk Libraries** - for all the popular hardware platforms - enable communication with the server and process all the incoming and outcoming commands.

Now imagine: every time you press a Button in the Blynk app, the message travels to the Blynk Cloud, where it magically finds its way to your hardware. It works the same in the opposite direction and everything happens in a Blynk of an eye.

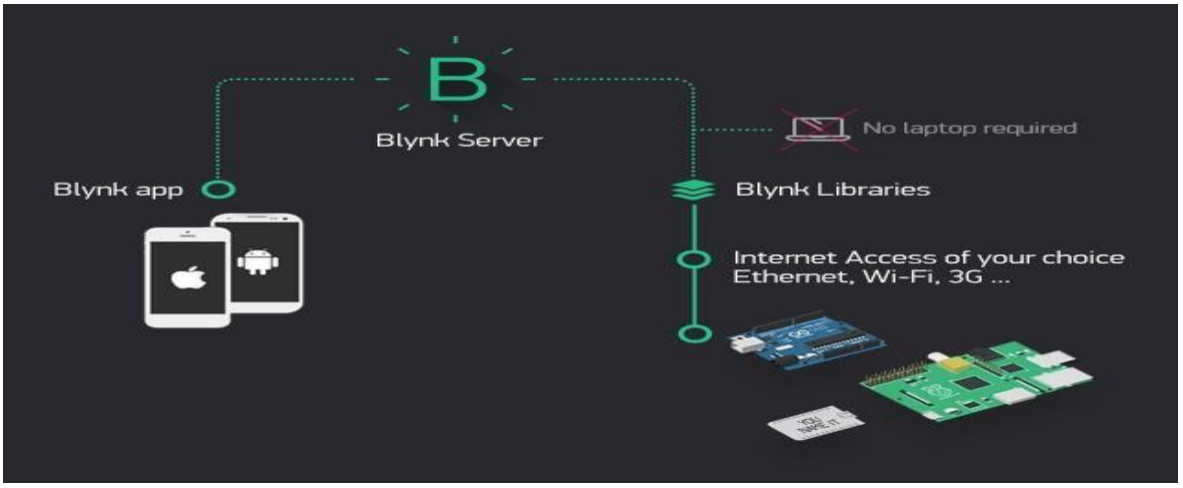


Fig 3.2.12: Blynk server

Features:

Similar API & UI for all supported hardware & devices

- Connection to the cloud using:

  - WIFI
  - Bluetooth and BLE
  - Ethernet
  - USB (Serial)
  - GSM
- Set of easy-to-use Widgets
- Direct pin manipulation with no code writing
- Easy to integrate and add new functionality using virtual pins
- History data monitoring via History Graph widget
- Device-to-Device communication using Bridge Widget
- Sending emails, tweets, push notifications, etc.
- … new features are constantly added!

You can find example sketches covering basic Blynk Features. They are included in the library. All the sketches are designed to be easily combined with each other.

What do I need to Blynk?

At this point you might be thinking: "Ok, I want it. What do I need to get started?" – Just a couple of things, really:

1. Hardware.

An Arduino, Raspberry Pi, or a similar development kit. Blynk works over the Internet. This means that the hardware you choose should be able to connect to the internet. Some of the boards, like Arduino Uno will need an Ethernet or Wi-Fi Shield to communicate, others are already Internet-enabled: like the ESP8266, Raspberry Pi with WIFI dongle, Particle Photon or Spark Fun Blynk Board. But even if you don't have a shield, you can connect it over USB to your laptop or desktop (it's a bit more complicated for newbies, but we got you covered). What's cool, is that the list of hardware that works with Blynk is huge and will keep on growing.

2. A Smartphone.

The Blynk App is a well-designed interface builder. It works on both iOS and Android.

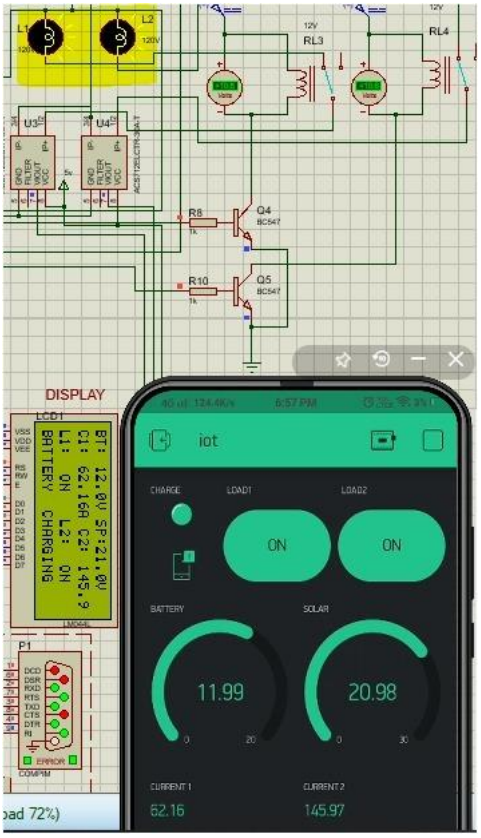
CHAPTER 4

RESULTS AND DISCUSSIONS

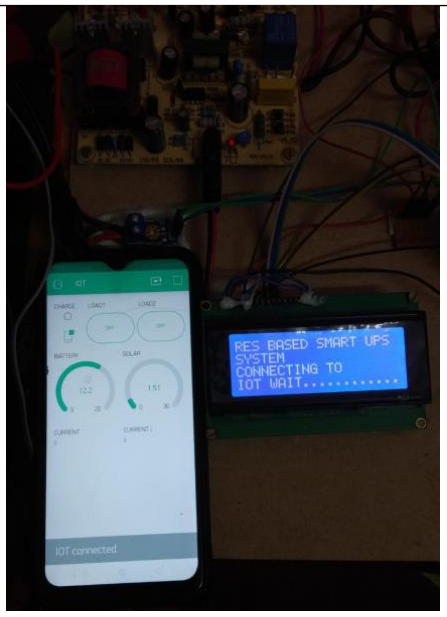
At the time of power cut the user can wirelessly control loads based on his priorities. The user can also check his battery voltage to avoid over loading. IoT-enabled smart inverter which is charged by a solar PV panel and can display the existing battery voltage at any point in time.

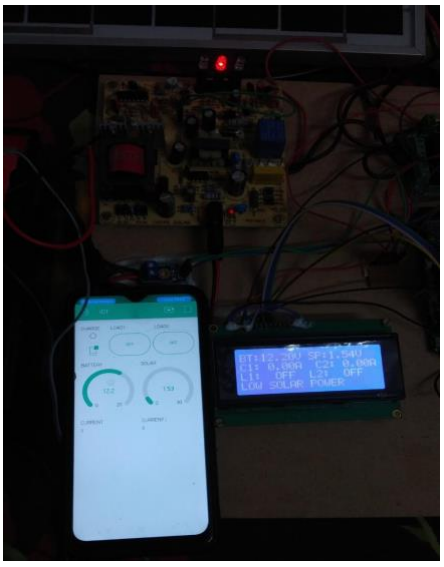
The system allows the user to control the appliances from anywhere in the world using an internet connection. In the present system everything is monitored and controlled manually. This system requires only initial stage investment in solar panel and smart inverter system is developed at low cost.

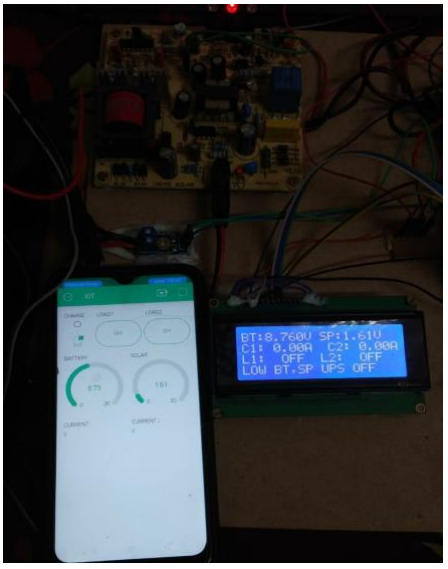
The figure below highlights the output of res based smart inverter on loads, LCD display and on Blynk.

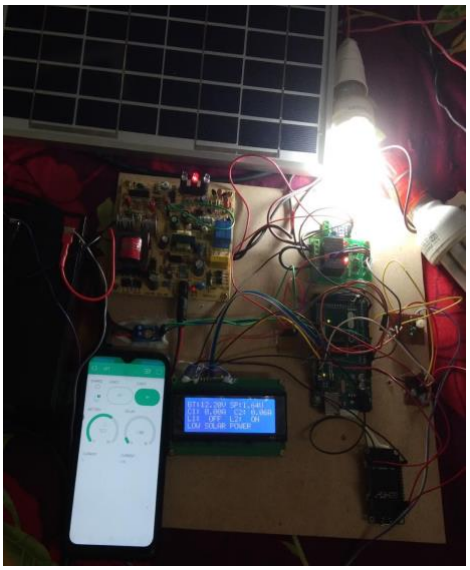


The figure below shows the entire project set up and Solar based smart inverter showing output on load.


RES BASED SMART UPS
SYSTEM
CONNECTING TO
IOT WAIT.....
IOT connected




BT:8.760V SP:1.61V
C1: 0.00A C2: 0.00A
L1: OFF L2: OFF
LOW BT.SP UPS OFF



4.1 Advantages

- Accurate output & voltage.
- Compact size.
- Overload protection available.
- Low battery indication with protection.

4.2 Disadvantages

- Monitoring requires internet connection.

4.3 Application

- solar lighting
- solar thermal
- water heating
- process heat
- solar power
- Architecture and urban planning

CHAPTER 5

CONCLUSION

Conclusion

In this project phase I, literature survey on various papers has been mentioned above on “RES based smart inverter”. Methodology has been identified and proposed. Further details will be added in project phase II.

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