Smart Home Energy Management System IOT based

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Smart Home Energy Management System IOT based

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Certificate of Approval

This is to certify that the research work presented in this thesis, entitled "Smart Home Energy Management System IOT based" was conducted by **Muhammad Waqas**, **Farrukh Rafique** and **Abdul Moiz Haider** under the supervision of **Engr. Fazal Ur Rehman** .

Any part of this thesis has not been submitted anywhere else for any other degree. This thesis is submitted to Department of Electrical Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan in partial fulfilment of the requirements for the degree of BS Electrical Engineering.

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HoD: Engr. Dr. Shahid Atiq   Signature: _____

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Abstract

The Electric Supply Department sends the usage bill for the prior month based on the usage as evidenced by the traditional electricity meter deployed in residential or business locations. After that, the customer waits in line to pay the bill at the electrical office. Both for the suppliers and the users, this process is exceedingly time-consuming, dangerous, and cost-effective. Modern energy metre research creates a variety of innovative and affordable technologies for the construction of energy metres, which also contribute to the development of the payment and billing systems..

Electrical energy reading is a very ancient practise nowadays. Due to the increased risk of human error, manual metre reading is unreliable, and there is also a high likelihood of theft or corruption. This faulty method of metre reading has an impact on Pakistan's economy since the financial status of WAPDA or Pakistan in general is quite uncertain. We suggest an alternative approach sparked by this.Smart energy metre is the best solution which gives information about the monthly cost of the units used, voltage, current, real power, apparent power, reactive power, and power factor reading in addition to providing readings digitally using IoT.

In order to consume electricity without any issues during load shedding, we also use an integrated solar system with WAPDA. When WAPDA is unavailable, our load will be switched over to the solar system, ensuring a trouble-free, continuous supply of electricity.[18]

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Acronyms

- PWM (Pulse Width Modulation)

- ADC (Analogue to Digital Converter)

- IC (Integrated Circuit)

- LED (Light Emitting Diode)

- SPWM (Synchronized Pulse Width Modulation)

- IOT (Internet Of Things)

- MPPT (Maximum Power Point Tracking)

- ATMEGA328p (Microcontroller)

- BJT (Bipolar Junction Transistor)

- DC (Direct Current)

- AC (Alternating Current)

1. Introduction

1.1. Background

The production of energy by burning coal, gas, or oil is not only wasteful, but it also contributes to pollution. Fossil fuels, for example, are running out, therefore we need to find alternative sources of energy. This problem can be solved using renewable energy, which is both environmentally and economically friendly. Renewable energy sources include biomass, sunlight, geothermal energy, and wind power. These natural fuel-based power plants suffer from a number of problems that renewable energy sources don't have. The price of fossil fuels has a direct effect on the economies of countries that rely on this resource.[2]

An energy metre can be used by both residential and commercial customers to keep track of their electricity consumption. The two most prevalent types of energy metres are electromechanical and electronic. With the help of cutting-edge energy metre research, a smart energy metre has been developed as an amalgamation of the two most common types. Electromechanical energy metres of the induction type are prevalent. Energy metres that count revolutions use a non-magnetic and conducting light metallic disc (Aluminum disc) that rotates freely between two magnetic fields, which are related to the load voltage and load current and hence the power being measured. To produce a driving force, two electromagnetic coils,

namely the pressure coil and the current coil, must come into contact. The current coil is linked to the load in parallel as opposed to series like the pressure coil. The pressure coil produces a magnetic flux that really is proportionate to the load cur-rent because the load voltage is proportionate to the load current. The load voltage and current, as well as their corresponding powers factors, determine the driving torque. The main limitations of this type of metre are the creeping error and the phase angle inaccuracy. In addition, the equipment is heavy and hard to carry.[1]

A shift in the frequency of the power source causes it to malfunction. Friction has a significant impact on the instrument's readings. Almost all of the metre in use today is of this particular form. There are no moving elements in a digital micro-technology-based electronic energy metre (EEM). An analogue circuit, an A/D converter, and an application-specific integrated circuit round out the list of components. These two components work together to regulate metre operation. The input sampled voltage is compared to a preprogrammed reference value. When a comparator's analogue output is converted to a digital value, A/D converters are utilised. In order to assess power, the average of the digital data is taken into account. Application-specific IC output is given in pulses as indicated by the LED on the front of the metering device. The average KWH/Unit is calculated by dividing the total number of pulses by the specified time period. A notable advantage of EEM is its accuracy under nonlinear loads. It's also worth noting that electronic energy metres are more accurate than mechanical induction metres. As a result, both the overall cost of energy and the cost of its distribution are decreased. With this information, actual power consumption can be determined by taking into account both currents in the neutral and the phase lines. This metre type supports billing based on the time of day. When the premises or company site is uninhabited, however, it is unable to promptly disconnect the line. This metre does not have an

online payment or invoicing system .'s Additionally, the smart tri-vector metre is another smart metre alternative. The smart energy metre includes a stepper motor counter and LCD display, and it uses 1 watt/4 VA of power and is accurate to within 0.2 percent to 0.4 percent.[16]

1.2. Problem Statement

In the same way that the price of diesel and oil can affect the cost of electricity, so can the price of other fossil fuels. Renewable energy sources provide cost-free and pollution-free power. Solar-powered system that uses an energy metre to monitor the use of renewable wapda power as a source of power has been agreed upon.[10]

1.3. Motivation and objective

The main purpose of a solar energy system is to detect the energy requirements of the charge and, if practical, to produce as much electricity as is feasible from renewable sources. The controller of the power system is designed to maintain a balance between the generation of power and the altering demands of the system. The controller is needed since the renewable energy source is always unstable, thus it must be managed. Simulation studies are carried out under real-world working situations to optimise a variety of competing design goals.[12] The following goals are the focus of this undertaking:

- There are two basic objectives: mixing and conducting a load test.

- We used Proteus 8.6 for circuit simulation and testing and learned the C programming language to programme the controller in line with our needs.

- Study ICs [such as the IR2112 and MOSFET/IGBT and the operation of the MOSFET]

- PWM and SPWM explained in detail.

- Redesigning the utility metre

- Using PWM and SPWM is the only way I can produce 50Hz waves.

- A solar panel battery charger has been created and tested.

- Designing A MOSFET/IGBT switching driver circuit design and testing

- Complete H bridge development and testing

- Controlled PSW invertion of a pure sine wave

- During the switch from 12V to 230V and 50Hz, keep an eye on the inverter's output voltage and current.

1.4. Thesis Organization

Thesis organization is as follows

Chapter 1 is based on introduction

Chapter 2 is based on methodology

Chapter 3 is based on modeling and simulation of project

Chapter 4 is based on hardware implementation

Chapter 5 is based on result and future work

In the end of thesis there are references and appendix

2. Proposed Methodology

2.1. Block diagram

The project real time billing system is implemented step by step. The project com-
prises of three steps. Fist we have done the simulation, then we started designing
its Pcb and after that we manufacture the PCB. The project consists of main
processing unit ATMEGA328P-PU. The lcd is used to display the parameters.[3]
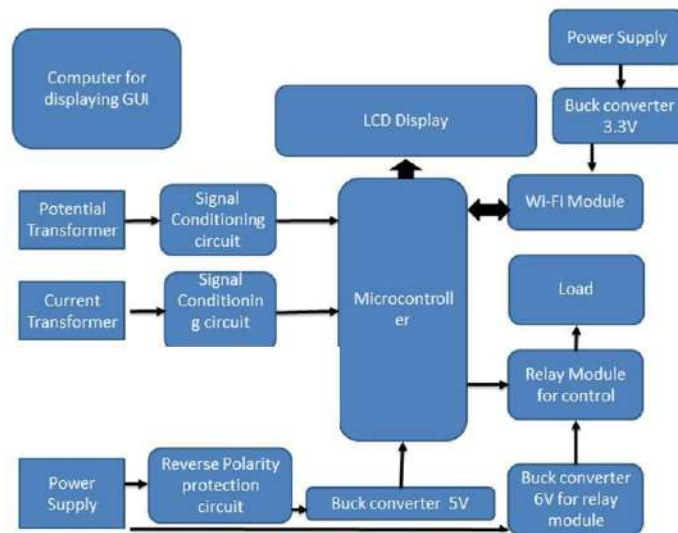Below is a block diagram of the project.

Figure 2.1: Flow Diagram

2.2. Charge Controller

Using voltages that are too high or too low will shorten the life of a battery, while charging it too much or too little can lengthen its life. As a result, we require a circuit that can maintain a constant power output. A charge controller circuit is necessary to maintain the ideal output voltage for properly charging the battery so because output voltage of solar and wind power changes with the environment. The battery could be disconnected through this circuit once it has finished charging.[4]

2.3. Boost converter

No matter what your needs are, we've got you covered. It's not typical for non-isolated converters to be used because they can't handle high voltage and high-power applications. These converters have a hard time producing a constant voltage. A number of issues arise as a result of the decreasing output voltage of inverters when power consumption rises. Stable output voltage is achieved by using a high-frequency switching transformer One common application for this converter is the transmission of high voltages. Boost converter topologies of this type are often employed.[19]

1. Push Pull converter Topology

2. Full Bridge Topology

2.3.1. Push pull topology with open loop control system

The transformer's primary winding is connected to two transistor switches in this simple converter. I'll start with converters that don't provide feedback. This schematic illustration shows a push-pull converter in action.[5]

We only have one switch on at a time to keep things simple. This results in a
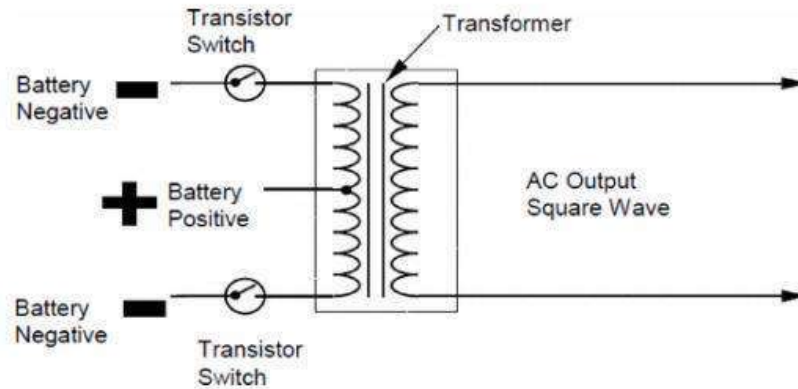

Figure 2.2: Push pull converter

larger output voltage than input for the transformer's secondary, depending on the transformer's turn ratio as well as the current flowing through its top switch. During the half-cycle operation, the top switch will be left on.

In the first half of a cycle, current travels through the circuit as shown below. This occurs because of the primary-side transformer's primary-side polarity
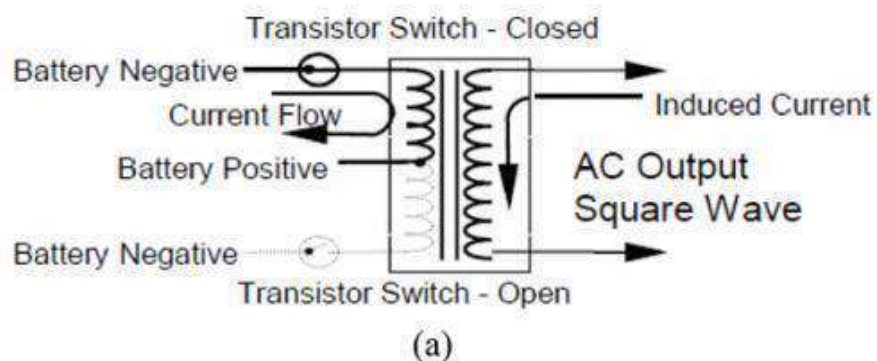

Figure 2.3: Center-tapped transformer

switching half-cycle. This is how the circuit's current flows in the second half:
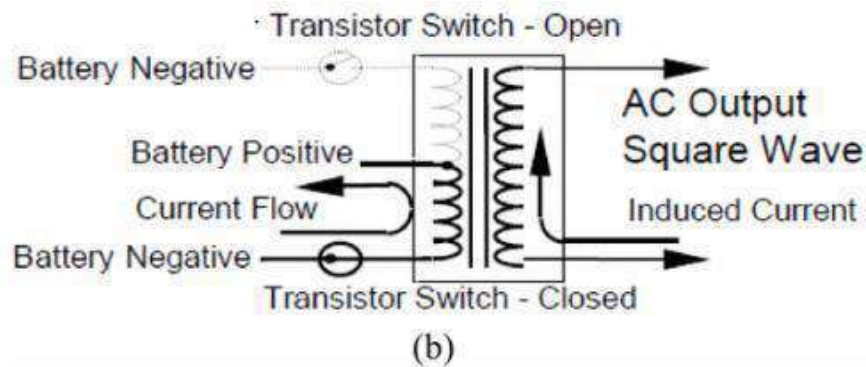
Figure 2.4: Centre tapped transformer working

As a result, the square waveform output is higher than the waveform of the input. I could use a standard inductor or a high-frequency switching transformer to make a boost converter. I employed a high-frequency, center-tapped transformer in my push-pull topology. The lower the frequency, the smaller the component. As the frequency increases, the transformer's size decreases. I like to use a high-frequency switching transformer in the boost converter in order to reduce the transformer's size and weight. Two MOSFETs in a push-pull configuration are used to generate AC from DC. To power our switcher, we connected into the centre of the high frequency transformer.[20]

2.3.2. Disadvantages

It's possible for appliances in the home to be damaged if the output voltage falls too low when everything is running at full capacity. This is the primary drawback of an open loop system.

2.3.3. Push Pull topology with closed loop control system

With this inverter construction, we were able to maintain the boost converter's 325V DC output voltage under any load condition that was within a set limit using output voltage feedback.[14]

We used a PWM chip to generate a 20KHz frequency to operate the push-pull topology circuit. Because of its broad frequency range, the TL494 PWM chip was
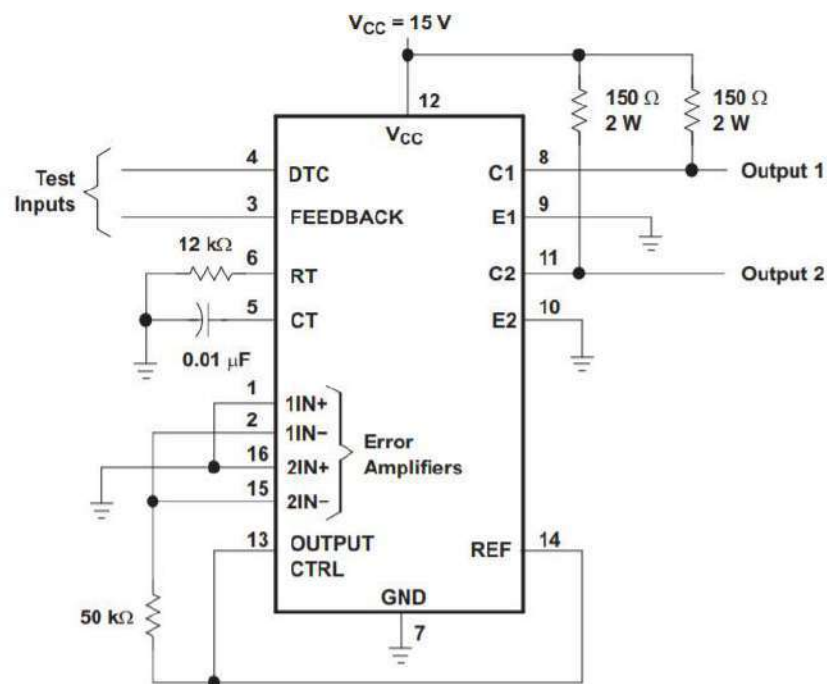

Figure 2.5: PWM chip detail schematic

used (from 1 kHz to 300 kHz). The following table summarises the results of the calculations enabled by this microprocessor. The formula for one-way applications is as follows:

- The formula for determining F is 1/RT x CT. (2.1)

- The formula for implementing a push-pull topology can be found here.

• RT divided by RT is the formula for F. (2.2)

Given our experience with a push-pull topology, the second equation stands to reason. Depending on the needed frequency, 470pF to 10uF capacitors with RTs and CTs can be found with a frequency range of 1K to 500K.

RT can be simply calculated using CT = 0.001uF for a 20 kHz transformer. Calculate the costs of running a firm.

$$2R_T = 1/f \; XC_T$$

$$C_T = 0.001uF, \; RT =?, \; f = 20000Hz$$

$$R_T = 1/(2)(20000)(0.001X10^{-6})$$

$$R_T = 25kilo - ohm$$

In order to decrease the load on the switching transistor, TL494 has soft start and dead time circuitry. A modest dead band is needed to alleviate the load on switching transistors because the OFF time is greater than the ON time.[9]
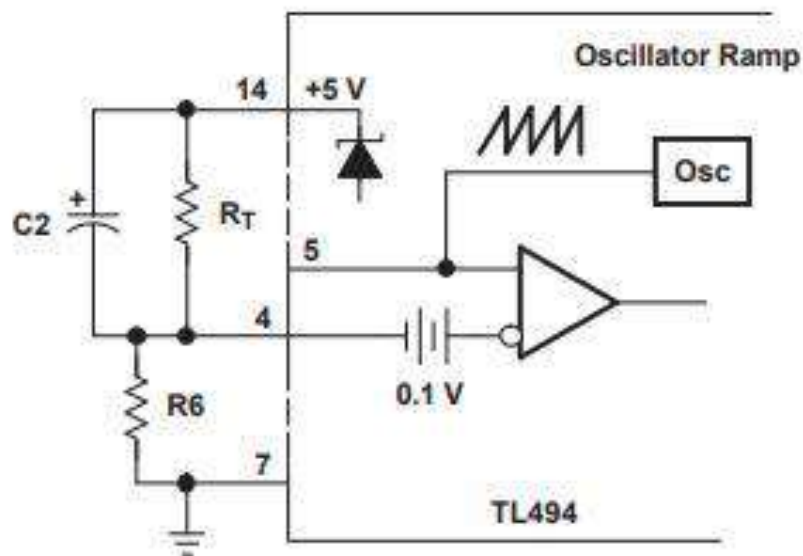

Figure 2.6: TL494 dead time and soft start circuitry

PWM output progressively increases as a result of the soft start circuit's negative slope wave on dead time control pin 4. Slow charging of capacitor C2 by resistor R6 results in an increasing pulse width. Dead time might range from 25 to 100 clock cycles.

C2's value can be calculated using the data shown above.

The output of the TL494 chip is connected to a push-pull MOSFET in order to power the high frequency switching transformer.
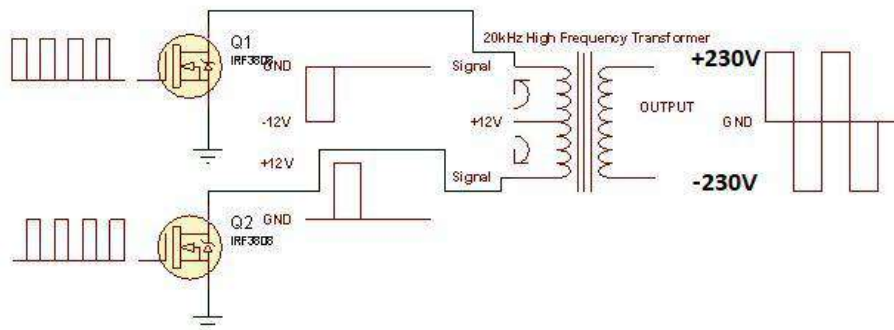

Figure 2.7: High frequency switching with Centre tapped transformer

This high frequency AC to DC converter can only be used with a high frequency switching full bridge rectifier that transforms 230V AC into 325V DC.
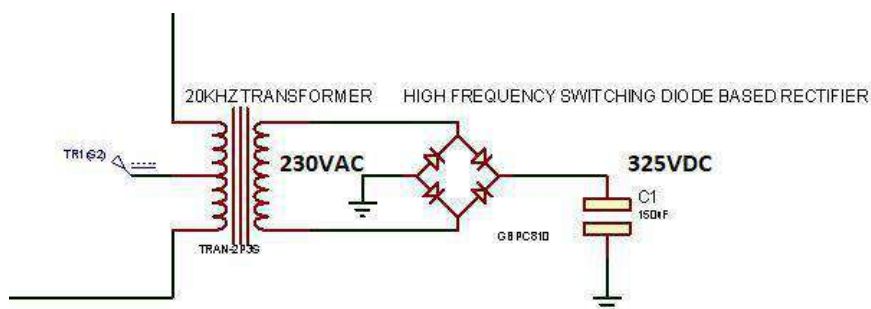

Figure 2.8: High voltage AC to DC conversion

With a 20KHz frequency, the transformer's output voltage (230Vac) required a

20KHz switching diode to rectify it. Connect the feedback resistor at 325V DC in order for TL494 to maintain its output voltage regardless of load.

2.3.4. Advantages

In a closed loop, we can use the output voltage as feedback to maintain a stable output voltage.

2.3.5. Full bridge topology

Four MOSFET/IGBTs are employed in a full bridge architecture and are switched in a manner consistent with the architecture. Full bridge topology does not necessitate a center-tapped transformer.[15]
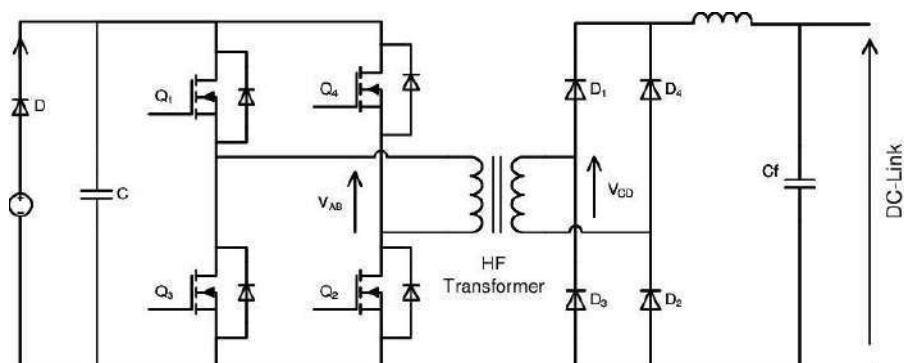

Figure 2.9: Circuit schematic of full bridge topology

In a boost converter application, a full bridge architecture is not desirable because it requires a larger number of switches and a simple transformer. The simple high frequency transformer has to be larger since the center-tapped transformer is larger.

2.4. Inverter

This study helped us understand exactly what inverters are. They are primarily responsible for converting DC into AC, which can then be used in applications that require AC. Also depicted is the transformation of a DC voltage source into a sine wave.[13]

Figure 2.10: Block diagram of inverter
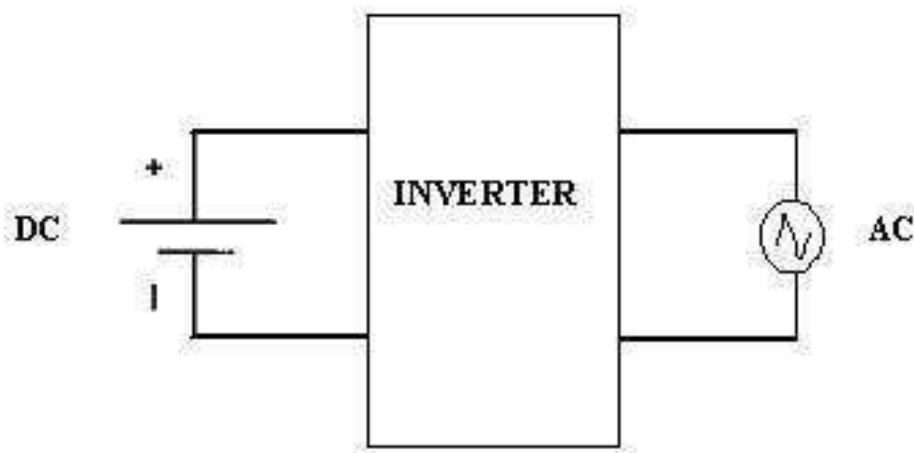
Inverters can use either a push-pull or a full-bridge inverter topology. As voltage boosters, centre tapped transformers are employed in push-pull configurations.Full bridge architectures, on the other hand, can be powered by a simple transformer or boost converter.

2.4.1. Inverter Modulation techniques

Pulse width modulation is widely used in inverters in the following two ways:

2.4.2. Pulse Width Modulation

Analogue signals can be created by converting digital signals to pulse width modu-lation (PWM). A pulse signal can be modulated using this technique. Either the 555 timer IC or the microcontroller may do pulse width modulation. There are periods when a signal is high and times when it is low, and these times are referred to as "Turn On" and "Turn Off." The duty cycle determines the average pulse voltage in a PWM signal.[6]

The duty cycle of a signal can be determined using the following formula:

$$\text{Duty Cycle} = \frac{\text{T urnON time}}{\text{turnOntime} + \text{turnOf f time}}$$

The signal's voltage will be at its highest for a 100% duty cycle.
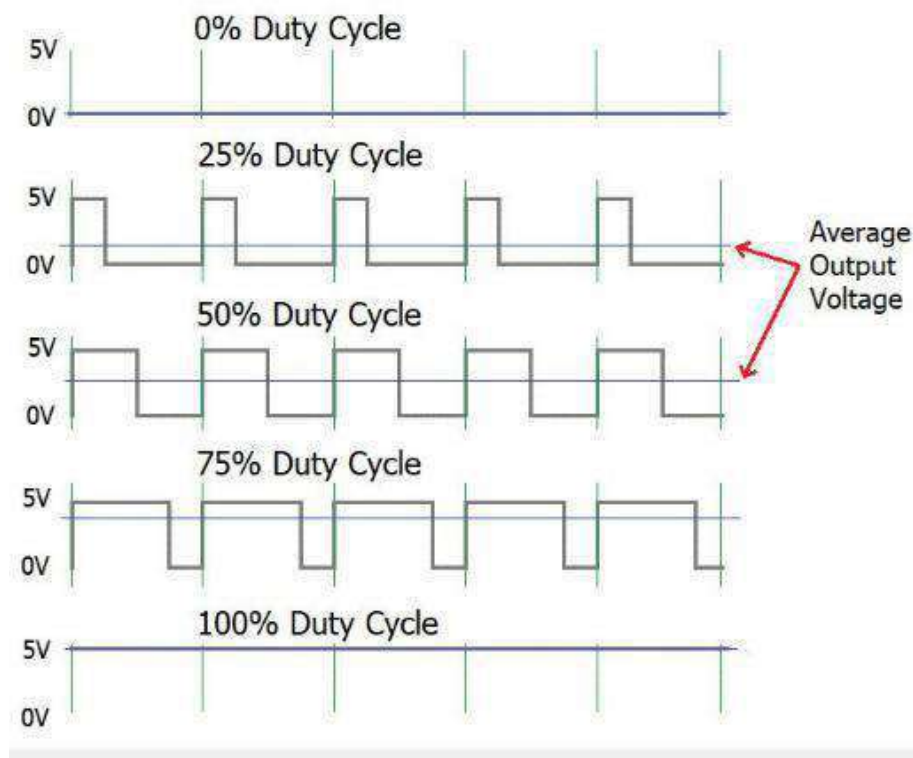

Figure 2.11: Duty cycling of pwm

In addition to the signal's amplitude, it is also critical to understand its frequency. The duty cycle is the amount of time the pulse is on, while the rate of change is the number of cycles per second. [20] How to compute the frequency is as follows:

$$frequency = \frac{1}{timeperiod}$$

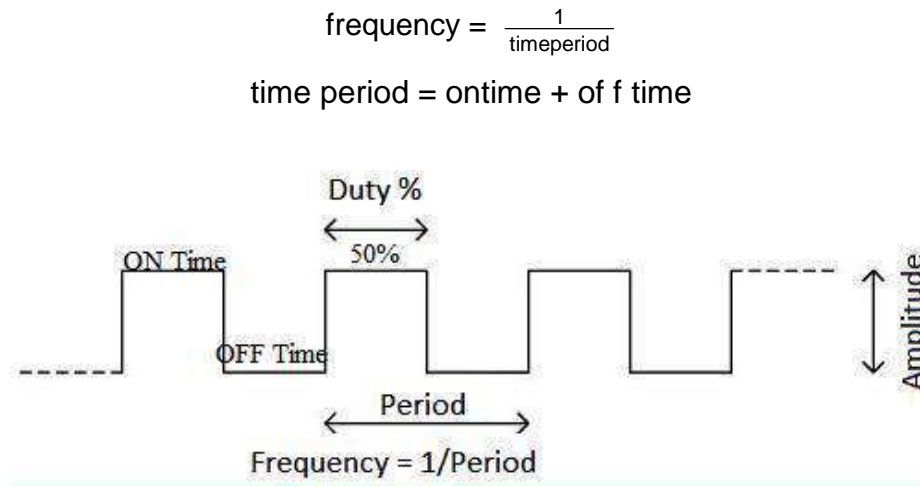$$time\ period = ontime + of\ f\ time$$

Figure 2.12: Frequency setting of duty cycle

Using PWM programming techniques can be incredibly beneficial in today's technologically advanced society. Some examples of applications include regulating the speed of a vehicle, adjusting its frequency, and managing its power.

2.4.3. Sinusoidal Pulse Width Modulation (SPWM)

Regular PWM maintains a constant pulse width; pulsewidth modulation (SPWM) alters the pulse width in proportion to the sine wave slop measured in the middle of each pulse's amplitude.

Pulse width modulation (PWM) produces signals that are virtually sinusoidal in shape. Moreover, the harmonic content is quite modest. The circuit construction is the same as in the previous modulation, as shown in the diagram, but the program-ming method is different.[21]

Two signals are required for sinusoidal pulse width modulation. Triangular waves

and sinusoidal waves are the two basic types of signals. This waveform is characterised by the usage of triangular carrier waves. Using sinusoidal and triangular signals, the inverter's switching frequency and output frequency may be computed. An amplitude and phase signal are generated using sine waves. The gate signal is ON and we receive a positive voltage when the magnitude of controlling signal is bigger than the triangle signal's. Similarly, if the magnitude of controlling signal is smaller than the carrier signal, the gate signal is turned off.

As the signal is modulated, its amplitude varies sinusoidally. After a gradual increase, pulse duration begins to fall toward zero about half-way through the cycle. Amplitude modulation can be used as an example when modulating the amplitude of the load current.

$$M_A = \frac{Amplitude of reference signal}{Amplitude of carrier signal}$$

The load signal's frequency modulation can be utilized to alter the frequency as well.

$$M_F = \frac{frequency of\ carrier signal}{}$$

An integer ratio of the carrier frequency to the reference frequency is required to produce sinusoidal modulation.

$$2N = F\frac{F_c}{S}$$

The modulation depth can be calculated using the formula below:

$$m = \frac{e_{cmax}}{V_{tri}}$$

Where e_c is modulating voltage and V_{tri} represents the voltage of triangular wave.
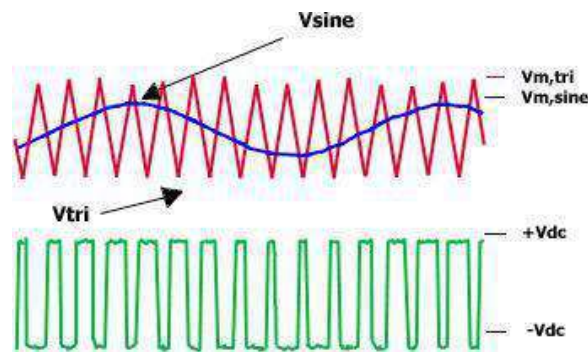
Figure 2.13: SPWM (Sinusoidal pulse width modulation)

2.5. Types of Inverters

2.5.1. Square wave inverter

An inverter that converts a 230V alternating signal into a square wave is the most basic form. By repeatedly turning on and off a MOSFET, MOSFET, or IGBT for a predetermined amount of time, this form of inverter output can be easily achieved. [7]

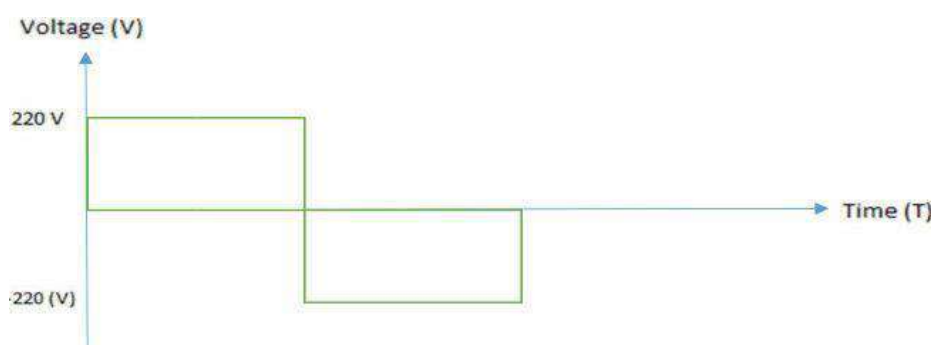The square wave inverter's output is shown below.

Figure 2.14: Square wave inverter

2.5.2. Modified sine wave inverter

A sine wave inverter is easier to assemble than a square wave inverter, despite the fact that it has more moving parts. An advantage of this inverter over square wave inverters is that it progressively alters the phase of the wave. In contrast to a sine wave inverter, there is no smooth transition from one cycle to the next. The image on the right shows the output of a modified sine wave inverter.[11]
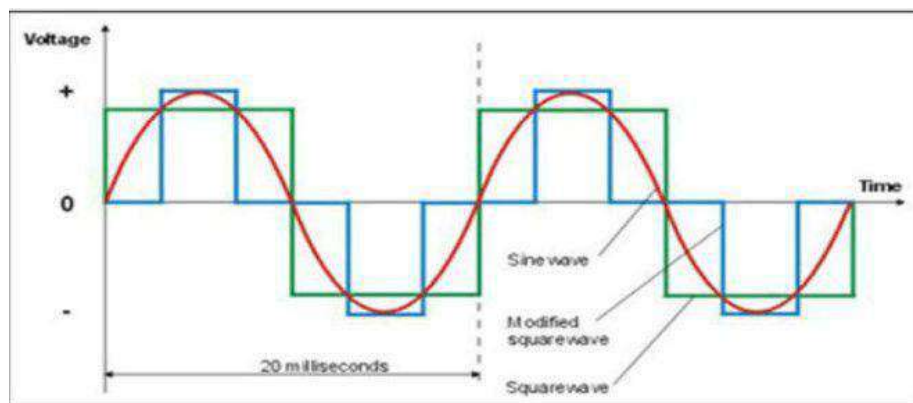
Figure 2.15: Modified sine wave inverter

2.5.3. Pure Sine Wave Inverter

We now know more about how DC is transformed to AC thanks to this study. To begin with, we were shown a modified sine wave with a constant DC voltage as a starting point. Besides the modified sine curve, we also know about the pure sine curve. To gain a better understanding of the benefits and drawbacks of a modified sine curve, we enrolled in this class. A lot was learned about inverters from this paper, including the most basic practical applications.[8]

Inverters were the subject of extensive study by Jim Doucet and colleagues. Understanding how an inverter is put together and its basic components is vital. The term "Pulse Width Modulation," or PWM, is commonly used in electronics

to describe the process of converting DC power to AC power. Scientists have learned a great deal about how a load transforms DC voltage into an AC waveform by analysing the duty cycle. While the H-Bridge configuration is often utilised to distribute the load, this research went into great detail about it. Switches are arranged in the shape of a H on top of each other. Using these switches, we can connect our circuit to our load with a voltage of zero, one, or the other.

The T.V. Omotosho et al. journal published this paper. It's possible we might learn from this study how to deal with difficulties that arise when employing inverter circuits to design more secure and visually appealing devices. In N-channel MOSFETS, a 10 V voltage difference between the gate and drain terminals is difficult to produce. It is necessary to add MOSFET drivers to the circuit since it requires a 10 V potential differential in a split-second When a MOSFET is turned off, current might still flow through the device, causing erroneous output waves and damage to the circuit board. Our understanding of circuit protection and elitism was bolstered when we realised that surges in the circuit are always caused by inductive loads. For example, when this happens, the circuit should be activated to promptly dampen the incoming surge and avoid circuit damage.

2.6. Flow chart

There are two flow charts in our project.

Figure 2.16 shows the flow diagram of inverter in which the output of inverter will maintained at 220V.

Figure 2.17 shows the flow chart of energy meter monitoring system in which the complete method is explained.
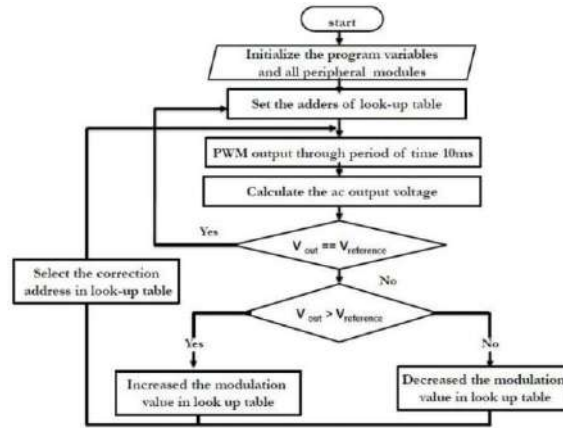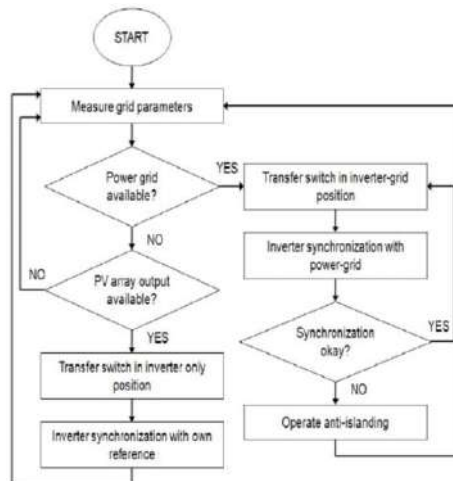
Figure 2.16: Flow chart of inverter

Figure 2.17: Flow chart of energy management

3. Modelling and Simulation

3.1. Mathematical Modeling

Learn these basic relationships. I use them at least weekly.

Q = C * V, C = capacitance in farads, Q = charge in coulombs, V = voltage potential

Q = I * T, I = current flow in amps, Q = charge in coulombs, T = time in seconds

F = 1 /T, F = frequency in hZ, T = period in seconds

Therefore,

I *T = C * V, or C = (I * T) /V

The delta symbol indicates a change, such as a change in voltage or a change in time

C = I *   T /   V

In this case,   T = 1 /F

e.g. the time period of a 50 Hz waveform = 1 /50 Hz =

0.02seconds Therefore,

C = I / (V * F)

Now including the 70% factor we get the final relationship:

C = 0.7 * I /(V * F)

C = capacitance in farads, I = current in amps, V = peak-to-peak ripple voltage, F = ripple freq in hertz.

Note that ripple frequency in a full-wave rectifier is double line frequency. For half-wave rectification, the ripple frequency is the line frequency. Solving for V

V = 0.7 * I /(C * F)

C = 0.7 * I /(V * F) = 0.7 * 0.5A /(1Vp-p * 100hZ) = 0.0035farads or 3500μF

C=It/V = I =5A t=10m V=20V

C=5*10m/20=2500μF

Secondary peak-current = Primary peak-current / no. of turns = 141.4 A / 2000 = 0.0707A

The voltage all across burden resistor at peak current must be equal to one-half of the Arduino analogue reference voltage in order to maximise measurement resolution. (AREF / 2)

AREF / 2 will be 2.5 volts if you're using an Arduino operating at 5 volts. This means that the ideal burden resistance will be:

Ideal burden resistance = (AREF/2) / Secondary peak-current = 2.5 V / 0.0707 A = 35.4 ohm

An uncommon resistor value is 35 ohm. 39 and 33 ohm are the numbers on either side of 35 ohm that are closest. To avoid a voltage higher than AREF being produced by the maximum load current, always use the smaller number. We advise using a 33 ohm. ±1%In some circumstances, connecting two resistors in series will bring the burden value closer to ideal. The accuracy will decrease the further it deviates from the optimum value.[17]

3.1.1. Node MCU

We need one Wi-Fi board for sending sensors data to cloud and also send control signal from cloud to robot. This board work perfectly and by using this we would

be able to send the command from cloud and receive data of sensors on cloud. This board has many digital pins in which we can directly interface the sensor with this board. We can directly interface DC gear motors using motor driver with this module.
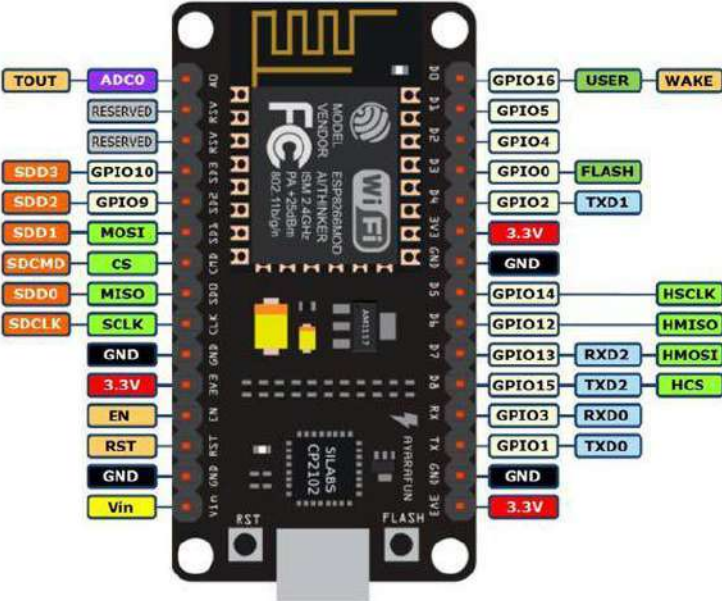
Figure 3.1: Mcu

Figure shows the complete detail of pins in which digital pins and have one analog pin. The digital pins can provide maximum of 3.3V and the analog pin can read maximum of 3.3V.

3.1.2. Cayenne IOT Platform

We have used Cayenne IOT platform and also used the Cayenne cloud server. This server provides a free of charge cloud parameters display and its control system. We can select the widgets from the app which we want to use it.
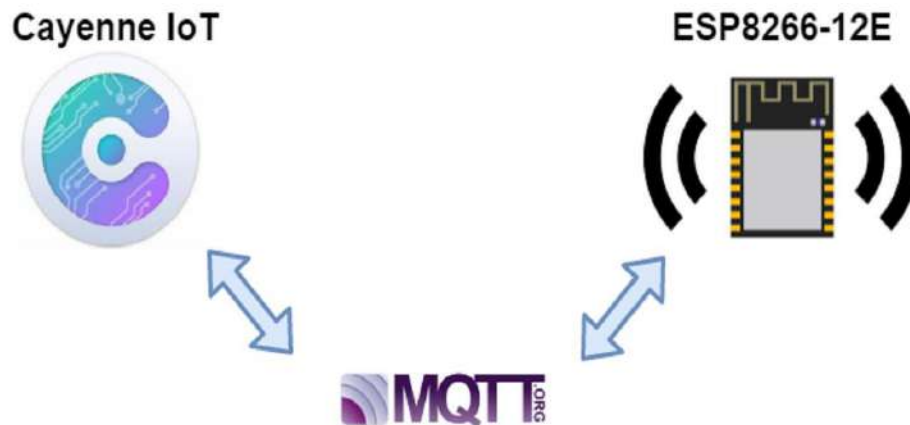
Figure 3.2: Cayenne cloud server

By using Cayenne server we can connect to any hardware like arduino, raspberry pi , node MCU and esp32. We can use any board to connect. We just need internet SSID and password.

In this application we must login first and then used to design project.

From this widgets box we would select the buttons and value display boxes. These widgets would connect to the cloud using virtual pins like V0, V1 etc.

Figure 3.3: Cayenne cloud complete dash board

Cayenne provides the complete and compact IOT platform in which we can connect sensors, boards and modules with wi-fi and display its values on Cayenne application.

Cayenne has its own server and library, we can use Cayenne application for IOT display. This application would provide the cloud service.
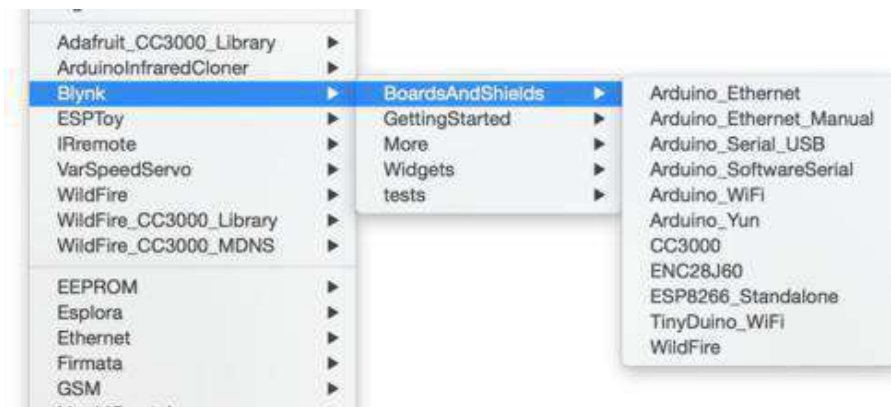
Figure 3.4: Cayenne library

By using arduino software we can add the Cayenne library and run the programming codes on arduino software. This software provides the complete platform using Cayenne cloud.

3.1.3. Power Supply

The project required power supply to power up the sensors, raspberry pi , speaker and motors. So we require different power supplies like 5V for raspberry pi , 3.3V for sensors and 6V for motors, so we would use voltage regulator for this purpose which is connected to the single power source and convert it into respective voltages.

We have used LM2596 based voltage regulator in which it can provide a a maximum of 3A current. This regulator can provide the range of voltages between 3V to 30V,

Figure 3.5: Circuit diagram

we can set for our own desire.

3.1.4. Cloud information
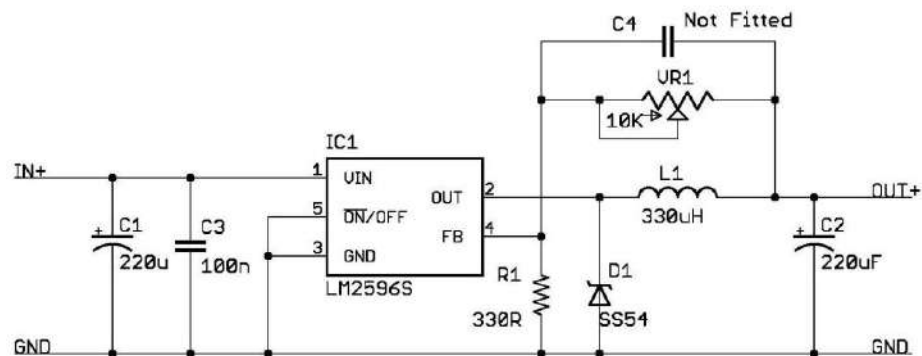
We have studied many web based cloud systems and we have seen pros and cons in all systems , free cloud service with many extra features we have short listed the MQTT based cloud server which provides us extra functionality and totally free.

We have short listed MQTT based cloud server in which we have used cayenne-based services because it is totally free and have many extra features.

3.2. Simulation

= **Energy meter simulation**

The simulation of project has been completed on Proteus software.

One ATMEGA328 microcontroller, a 16MHz crystal, and two 22pF capacitors are used in the microcontroller circuit. The microcontroller operates at a high rate, completing one machine cycle for each instruction. The microcontroller receives its oscillation from the 16MHz crystal in order to carry out its function. The oscillations are managed by the two capacitors.
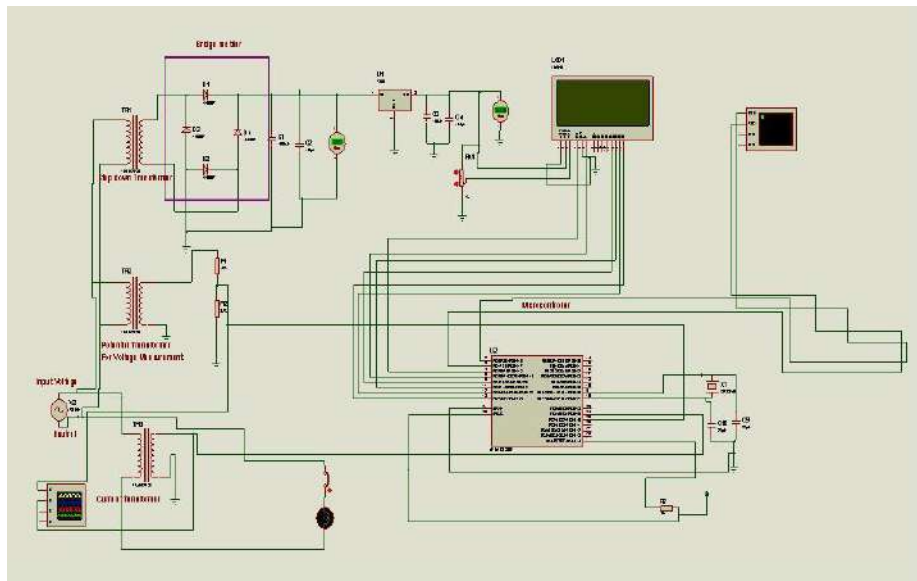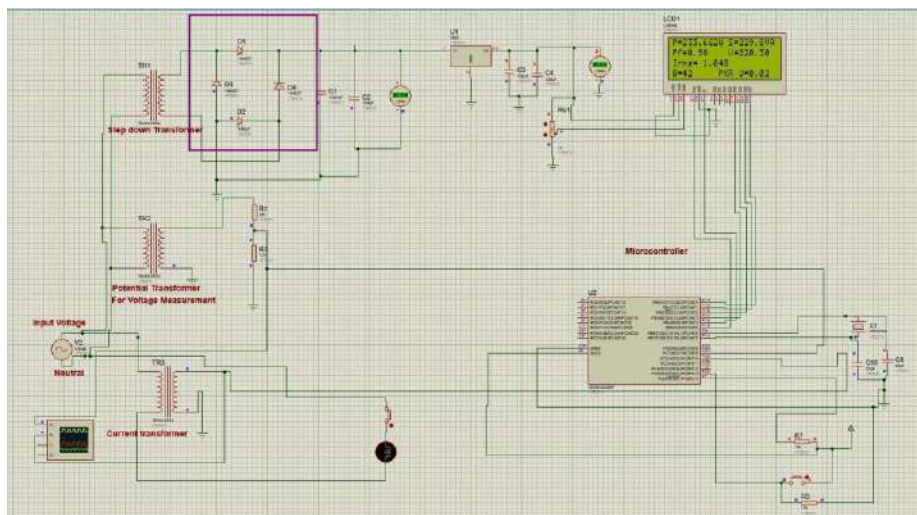
Figure 3.6: Energy meter simulation diagram

Figure 3.7: Simulation of Energy Meter

The schematic diagram consist of atmega 328 microcontroller, current sensor, voltage sensor and the loads. The current sensor is used to measure the current and also used for the measurement of power factor.

= **Output result of energy meter**
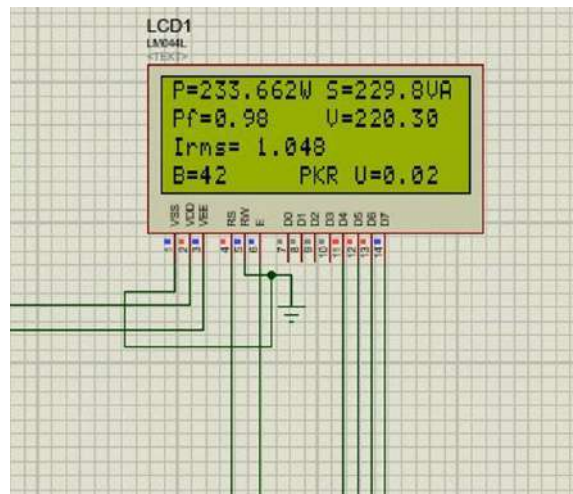
Figure 3.8: Simulation detailed parameters

= **Inverter simulation**

Because a push-pull inverter has a higher power rating than other inverters,therfore we are using this push-pull topology inverter.Inverter is centr-tapped and it is controlloed by PWM , PWM switching frequency ranges from 18 kHz to 32 kHz. The high-power rating bipolar junction transistor (BJT), which is used for switching. The current across the collector and emitter is shorted during the first cycle, and the 12V source provided the current in an anticlockwise manner.Similar to the first cycle, the second cycle repeats the procedure with the current flowing in the opposite direction (clockwise), and 50 Hz AC is created by varying these frequencies. The CD4047B IC serves as a frequency generator while the transistor amplifies the signal. Voltages are stepped up to 220V AC at the output using the center-tapped

transformer.
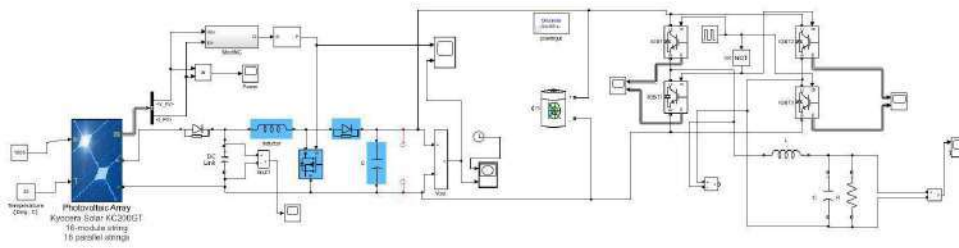
Figure 3.9: Inverter simulation

= **Inverter output Result**
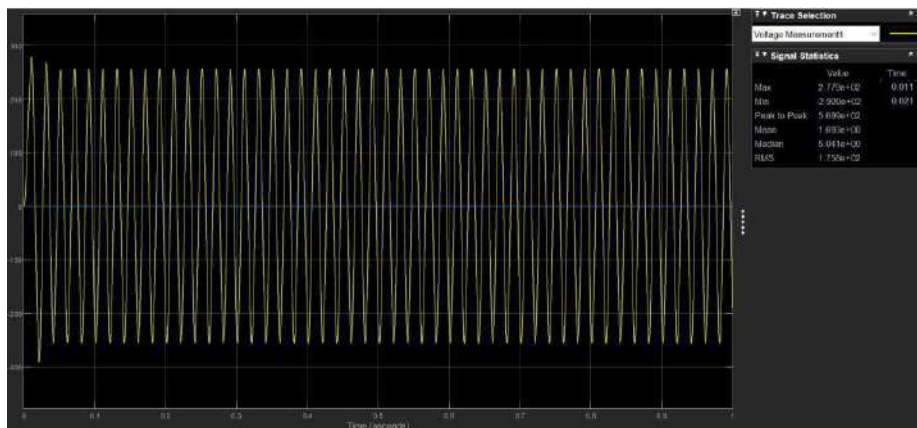
Figure 3.10: Inverter Output Result

4. Hardware Implementation

4.1. List Of Components

4.1.1. IN4007

It is a general-purpose diode which is used for reverse polarity protection. The specification of this diode is as follows.

Max supply Voltage = 1000 V

Max supply Current =1A
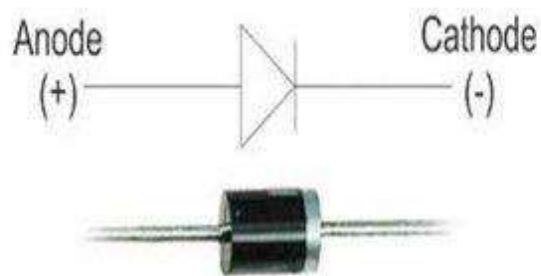
Figure 4.1: In4007 Diode

4.1.2. IN4148

1N4148 is fast switching diode. In this project we have used this diode in inverter. We connect this diode in reverse bias mode at gate of IRF740 to reduce the turn off time of gate.
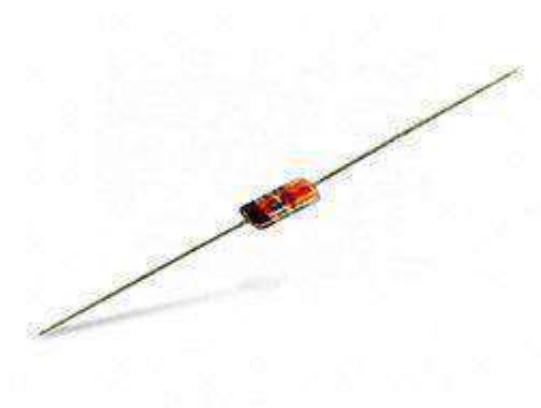
Figure 4.2: In4148 Diode

4.1.3. 2N2222

2N2222 is general purpose NPN transistor. We have used this transistor as relay coil driver. The microcontroller provides us 5V signal at its digital pins with microampere current which is not sufficient to drive the relay coil. So we used this transistor as relay coil driver in common emitter mode.
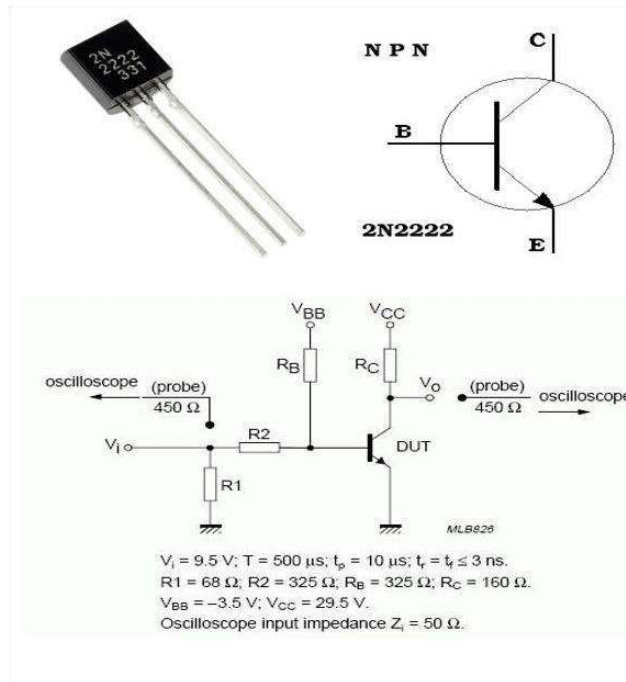
Figure 4.3: 2N222 Npn Transistor

It is a 3 pin transistor in which its pin configuration is :

4.1.4. IRF740

It is an N-channel MOSFET which is used for high voltage inverter. This
MOSFET can bear Maximum of:

The pin configuration of the MOSFET is shown below:

Pin Number	Pin Name
1	Source
2	Gate
3	Drain

Table 4.1: MOSFET Pin Configuration

4.1.5. B80C1000

B80C1000 is a silicon rectifier bridge with rating of 300V-1A which is used to convert AC signal into DC signal. It has the following features.

- Diffused Junction

- Low Forward Voltage Drop

- High Current Capability

- High Reliability

- High Surge Current Capability

- Ideal for Printed Circuit Boards
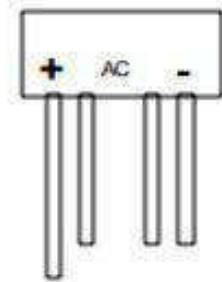
Figure 4.4: Pin configuration for B80C1000

Positive and negative terminals are used as an output DC while other two twrminals are used for AC input.

4.1.6. IR2110

The high speed MOSFET and IGBT with discrete high and low side referenced output channels are driven by gate driver circuitry using the high and low side

driver IC, IR2110. For our project, the gate driving MOSFET circuitry uses an IR2110 inverter.
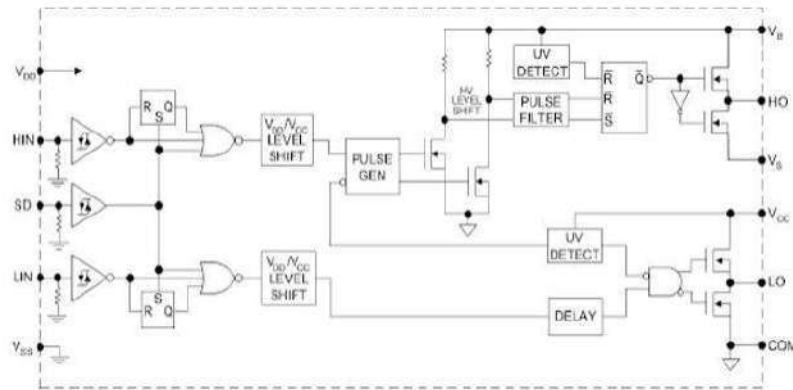
Figure 4.5: Functional Block Diagram

Figure 4.6: Pin configuration for IR2110

4.1.7. IRF1404

The IRF1404 is 40V (drain to source voltages) single N-channel HexFET power MOSFET, which can switch the connected loads upto 40V. The loads that consumes upto 202A can be switched using this MOSFET. 2 to 4V across gate and source

terminal is required to turn it ON. It also require gate driver circuit to give 2 to 4V on gate.

Figure 4.7: Pin configuration for IRF1404
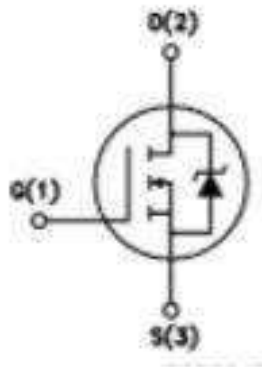
Figure 4.8: Internal schematic diagram of IRF1404

4.1.8. 2N7002

Its low on-state resistance and superb switching performance make this MOSFET the perfect choice for high performance power control applications. We use the 2N7002 in our project's inverter for quick switching purposes. Low gate threshold voltages, fast switching, and low on-state resistance are its main characteristics.
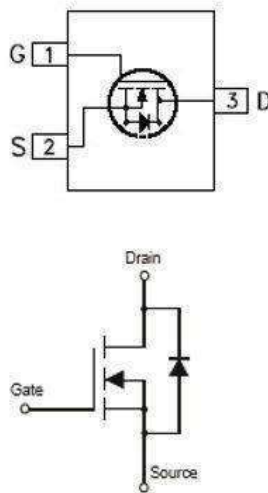
Figure 4.9: Internal schematic diagram of 2N7002

4.1.9. Relays

Relays are basically electromechanical or electronic switches used for protection and switching purpose. In our project, 12V relays are used in relay based controller for switching between different sources (solar, wind, grid).
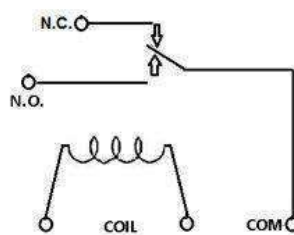
Figure 4.10: Internal schematic diagram relay

4.1.10. Arduino board

The arduino board is based on ATMEGA 328 microcontroller and it is complete hardware kit for testing and debugging the circuit. This arduino board has 28 pins

in which 14 digital pins which can be used a digital input and digital output pins. 6 pins are analog pins and 2 for Vcc , 2 pins for ground , 2 pins for crystal oscillator, It has 6 ADC channels in which each of them is 10 bit. Mean it can read the digital value from (0-1023). The resolution of ADC can be calculated as follows. Adc Resolution= Vref/1023

As Vref =5V by default

ADC resolution = 5/1023 =4.8mV per step.

The ADC resolution is almost 5mV per step.

The picture of arduino board is given below.
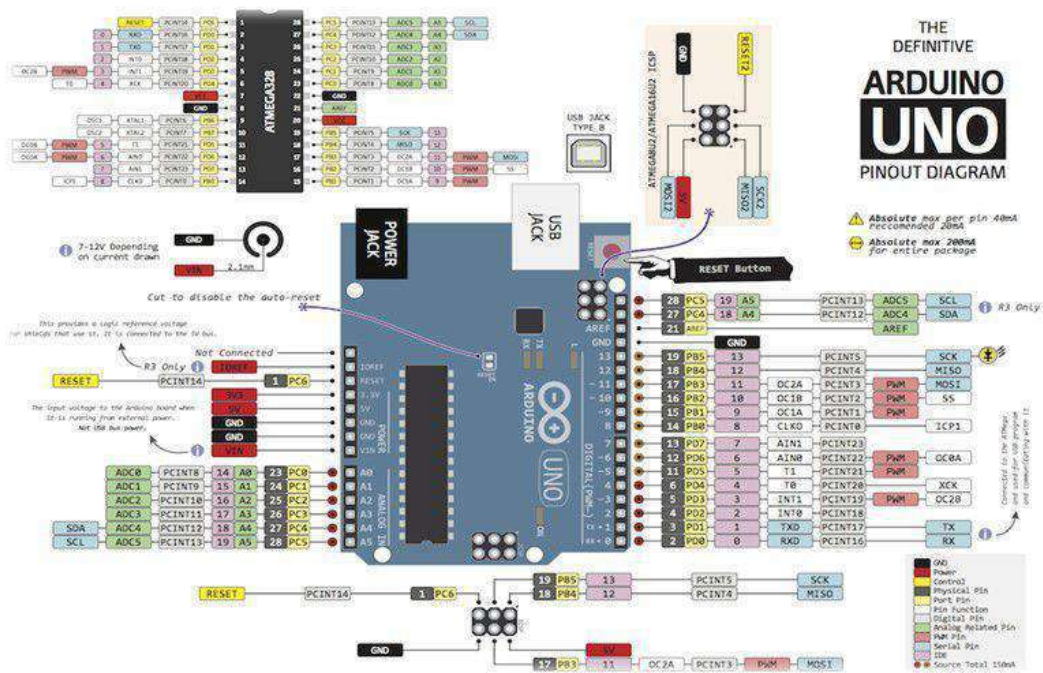
Figure 4.11: Arduino board

The above picture shows that complete detail of arduino board. This Arduino board has 6 PWM channels and it has two external hardware interrupts which is on PIN 2 and PIN3 the beauty of this arduino board is it has 3.3V and 5V voltage supply.

This arduino board has built in I2C protocol (inter integrated circuit). This Arduino board working frequency is 16MHz and it has RISC +CISC architecture having a fastest instruction execution time. The Arduino execution time 1 Machine cycle per instruction. The most simplified form of arduino microcontroller is shown below.
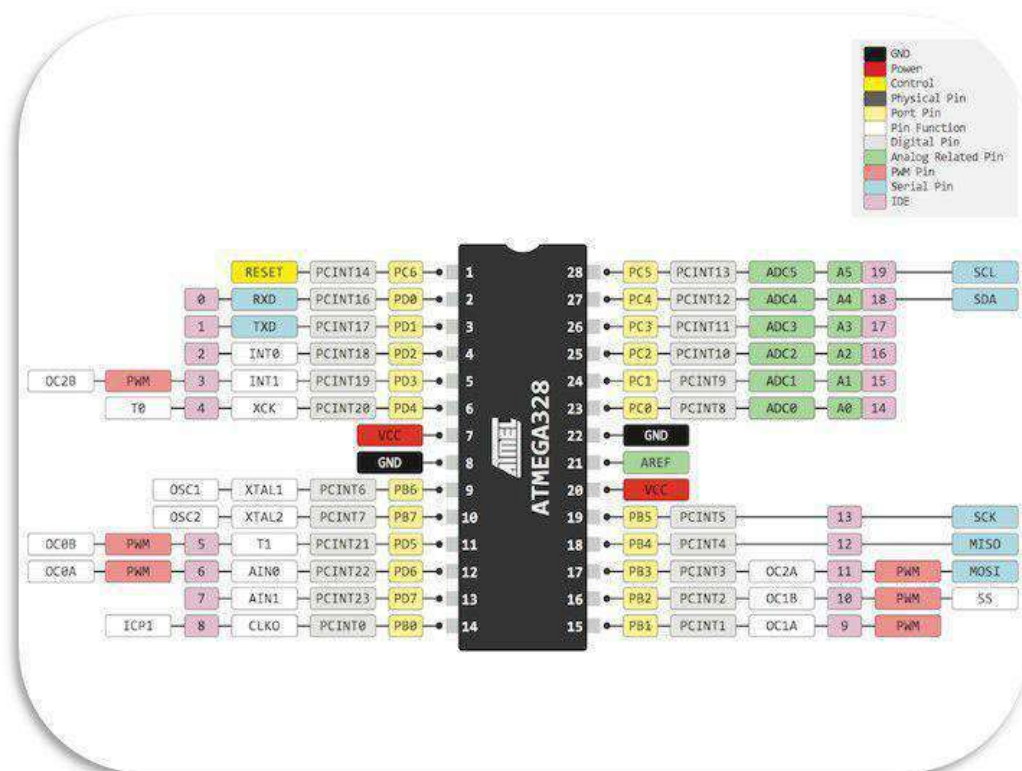
Figure 4.12: Circuit schematic of microcontroller

We used 16MHz crystal with 22 Pf of capacitors because the oscillator generates the oscillations of 0-16 MHz the capacitors are used to control the oscillations mean it is used to stabilize the oscillations.

4.2. Hardware Discussion

With the help of the software proteus 8.6, we developed the receiver PCB. This software offers auto routing, short circuit testing, and design rule checking, all of which are excellent options that adhere to a preset set of rules. Below are images of the PCB design and 3D model.
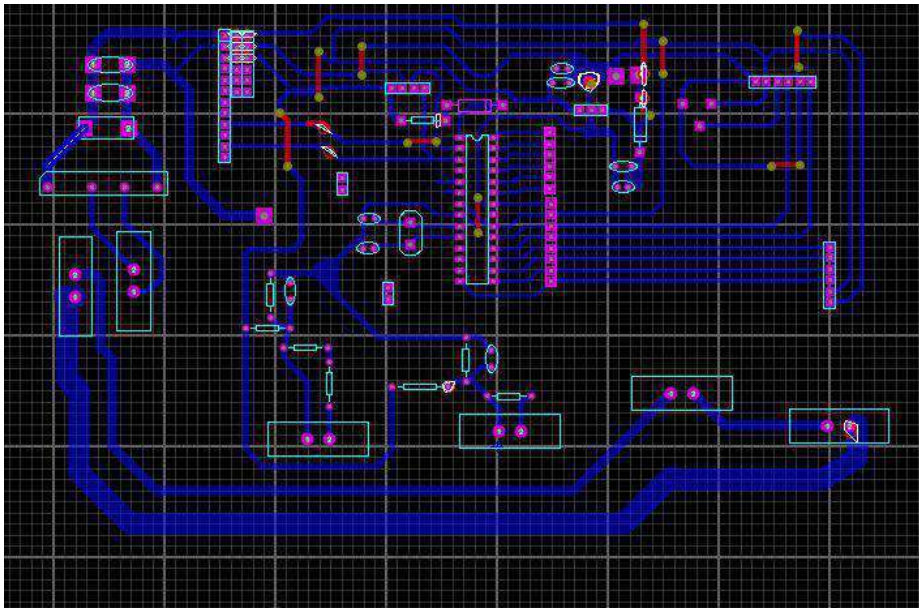
Figure 4.13: PCB layout of inverter

.
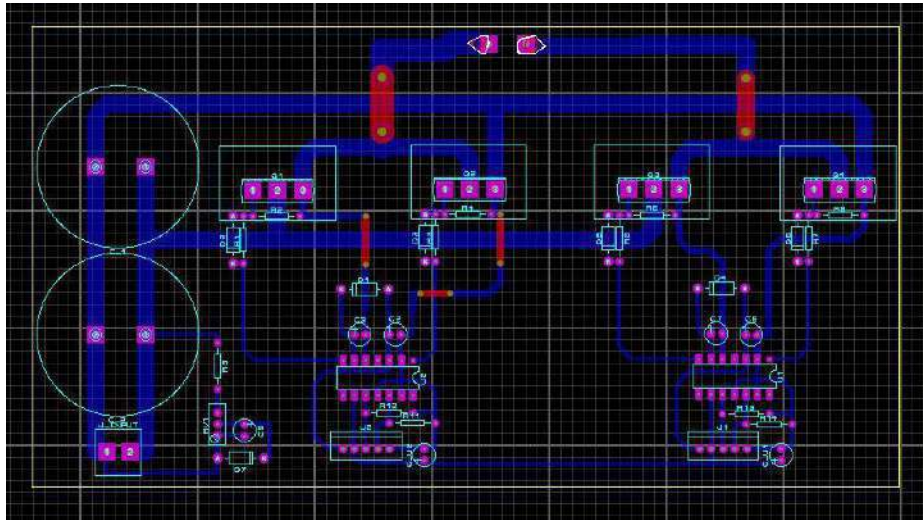
Figure 4.14: PCB layout of energy meter
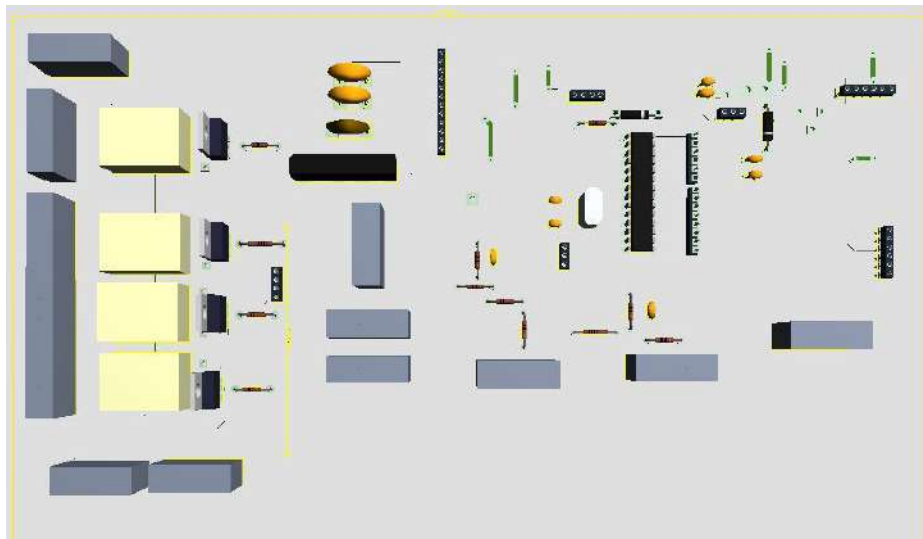
Figure 4.15: PCB 3D layout

The hardware implementation of this project is based on two parts of project, one is PCB designing and other is PCB manufacturing and stuffing.

The power coming from the solar array into the battery bank is controlled by a solar charge controller. It prevents the deep cycle batteries from being overcharged during the day and prevents the batteries from being drained at night by power running backwards to the solar panels. Although some charge controllers are also accessible with extra features like lighting and load management, regulating power is their main responsibility.

PWM and MPPT are the two available methods for solar charge controllers. They serve quite distinct purposes within a system. Even though an MPPT charge controller costs more than a PWM charge controller, doing so is frequently justified.

Figure 4.16: Solar charge controller
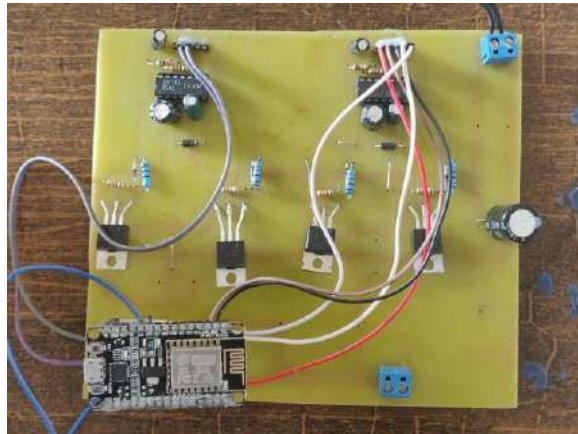
Figure 4.17: Hardware of inverter

The Inverter second part is transformer which used for boost the AC voltage from 12VAC to 220VAC.

Figure 4.18: Transformer 12v to 220v

The transformer convert 12VAC to 220VAC, with a power of 120 watt. This transformer has single primary and single secondary output. Figure shows the picture of hardware in which we have used current transformer, which is called CT and the potential transformer which is called PT. The current transformer and potential transformer are used to measure parameters.

Figure 4.19: Energy meter hardware

Figure 4.20: Project hardware

4.3. Results
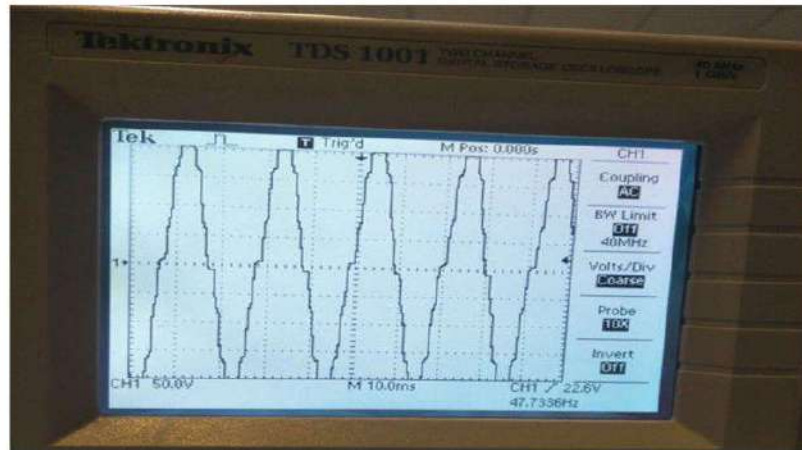
Figure 4.21: Waveform of inverter output

Figure 4.22: Parameters display of energy meter
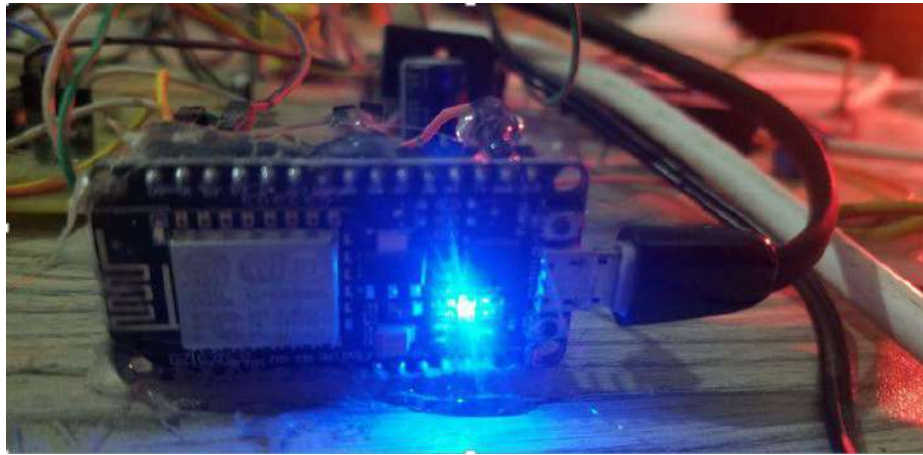
Figure 4.23: NodeMCU hardware connection

5. Conclusion

5.1. Thesis Work

The designed solar smart inverter can be used to drive load up to 100 Watt. However, by making suitable changes the output power can be increased. The inverter components can bear up to 600 watt of power. The single phase solar smart inverter worked perfectly and desired AC voltage of 220V was available at the output terminal of transformer from where we are able to drive our load so, the project is successfully carried out.The energy meter monitor the load and calculate the bill.

5.2. Future Work

This proposed model is developed on domestic level with components of low rating. This model is basic implementation of solar inverter for output of 120 Watt and energy meter control IOT based. In future, whenever this project is used on industrial level it can modified for the three phase load up to Megawatt (KW) with high rating components. Its efficiency can be further improved by increasing the levels. All the possible future modifications in this project are as follows:

1. By increasing the levels of the inverter we can increase the efficiency of this project, can reduce the harmonic distortion and also can reduce the additional

losses associated with it.

2. For greater commercial use, solar panels with the necessary capacity can be grouped together after calculating the necessary total power.

3. By including Net metering the efficiency of this project will also increase.

5.3. Impact on Society

In this superior era, people are shifting from old and everyday resets to new, reliable and more powerful power sources in light of the fact that the normal power system has various risks like load loss, pollution, natural hazards and also power failures. Therefore, by using Smart Array, we can overcome these problems and make our power system more stable and stronger. The luminous grid is a pristine power source, and this power can be provided to people living in remote areas, and the infection can disappear through the use of smart community, and we can promote power when saving more devices so it will boost up the Economy , Improve the living standards, Education and Job opportunities.

A. Appendix

A.1. Sustainable Development Goals (SDGs)

= **Mapping of SDGs in FYP**

- Sustainable Development Goal 7 (Affordable Clean Energy)

- Sustainable Development Goal 9 (Industry, Innovation and Infrastructure)

- Sustainable Development Goal 12 (Responsible Consumption and Production)

- Sustainable Development Goal 13 (Climate Action)

These SDGs served as the foundation for our project, "Smart Home Energy Management System IOT Based." A smart house is a place of residence where systems and appliances may be monitored and managed remotely via internet-connected devices. Between 2000 and 2018, the percentage of individuals who had access to electricity rose from 78 to 96 percent, while the number of those without it fell to 795 million. However, as the population increases, so will the need for inexpensive energy, and a fossil fuel-based economy is causing significant alterations to our environment. Due to the usage of fossil fuels to produce power, billions of tons of chlorofluorocarbons are released into the atmosphere every year, which contributes to the rapid rate of global warming.

In order to meet the world's energy needs, we must switch to renewable energy sources, which can create enough energy to meet those needs while having no negative environmental effects. Energy must be produced more effectively in order to avoid energy waste. Additionally, real-time information about loads must be managed in order to control and monitor them.

Since consumer electronics have made such great strides in recent years, society is aiming to increase uptime, energy savings, green tech, and environmental protec-tion in their daily lives at home. Most individuals manually control and maintain their home appliances, which leads to a variety of problems with resources planning, cost, effort, and security, all of which lead to an inconvenient and unreliable way of life. The idea of IoT-based automation has gained popularity because to a variety of "intelligent" devices, such as air conditioning units, tablets, and smartphones. These devices are well-grounded in technology and may be viewed and managed online remotely from any location on the planet and at home.

As time has gone on, global warming has become noticeably more serious. To pre-vent climate change, however, green technologies and environmental sustainability are essential. The main goals of this experiment are to conserve natural resources, reduce energy consumption, and understand the impact of home automation on society in order to achieve the goal of green innovation and environmental sus-tainability. An IoT-based home automation strategy is proposed that integrates smart metres, solar, wind, and geothermal renewable energy resources in order to considerably maximise the demand for energy usage, security, cost, ease, and a cleaner environment for society. A survey of the target audience was also under-taken with the aim of finding and analysing the least harmful effects on society and the environment from the standpoint of sustainable development.

A.2. Complex Engineering Problem Attributes

Sr. No	Indicators of Assessment	Attributes Assessed	Levels of Achievement
1	Problem Identification	✓ Depth of Knowledge Required	In this age of technology, energy management, and clean energy is one of the main concerns of human beings. We pollute mother nature at the rate of 61 billion tons of Greenhouse gases per annum. Engineers Scientists develop new techniques to solve the problem of the energy crisis in this never-ending war and to reduce the electricity bill because the prices of the electricity now are very expensive and day by day the prices of units is increasing so we harness some of the most innovative ideas to extract energy from atoms to our solar system. Smart Home Energy Management System Iot Based is used to monitor and manage the usage of the load and also used solar inverter to produce free of cost electricity to the loads in this way we have detailed information about our energy consumption and cost of bill will also be reduced to some extent .
		Scale	

2	Select Appropriate Technique and Equipment / Tools	✓ Range of conflicting requirements.	We needed to implement our idea for this purpose we needed simulation software that are trusted enough, to help us run simulations of different kinds of inverter and energy meter. For this purpose, we consulted our supervisor, he recommended MATLAB|SIMULINK, PROTUS.
		✓ Depth Analysis Required	Before diving into the production of a Smart Home Energy Management System. We began studying it. The knowledge gained was required to understand every parameter of the energy management one. We consulted multiple research papers and a few books provided by the supervisor and began studying them. After a considerable knowledge of what we were supposed to make, expect and produce, we began working on it.
		Scale	

3	Implement the relevant standard procedure	✓ Familiarity of Issues	Electrical engineers are facing the problem of source management and utilization of energy to different loads , load shedding increasing in electricity cost. 1. Load shedding 2. Management of loads 3. Cost of Electricity Due to above problems the load management and continuity of power and the prices of electricity are very much important for consumers to perform their daily life work so these above issues will be sorted by engineers to provide them continuity and management of the power.
		✓ Extent Applicable Goals	We resumed our work on the software, after which we began experimenting with the input values and different parameters of the energy meters and inverter. We altered the duty cycle and sizes of the inductor and capacitor to check for better outcomes. The rating was designed according to the application we had in our mind.

| 3 | | ✓ Interdependence | The tasks were divided among all three of us. We began working as a group in order to cover more ground. One group member was tasked to calculate the values we had to input into the simulation, whilst the other kept working on the designs of the energy meter and inverter . One member kept searching for discoveries to discover more about the advancements being made regarding the smart home energy management system iot based. This interdependence on tasks and outcomes helped us produce smart home energy management system iot based. |
| | | **Scale** | |

4		✓ Extent of stakeholder involvement and level of conflicting requirements.	The energy management system is used to control and monitor the load and also to provide continuity of supply by solar. As owner of Smart home energy Management System Iot Based provides a wide range of functionalities, and optimization techniques can be easily set by the owner according to their needs.
	Analysis and Results	✓ Consequences	Energy management and clean energy are among the main concerns of today's technological era; we can overcome our energy demands by just managing and controlling our loads by iot . We can also reduce the energy prices by shifting to renewable energy resources and by monitoring and controlling our loads By using advanced computers, we can also manage the flow of energy and prevent catastrophic scenarios.
	Scale		

= **Codes**

```
#include "EmonLib.h"          // Include Emon Library

#include <stdio.h>

EnergyMonitor emon1;          // Create an instance

#include <LiquidCrystal.h>


LiquidCrystal lcd(13,12,11,10,9,8);

//String input;

String inputString = "";      // a string to hold incoming data

boolean stringComplete = false;  // whether the string is complete


char input;

String ab;

Int m=0;

float z=0;float z1=0;float z2=0;float z3=0;

float z4=0;float z5=0;float z6=0;int z7=0;int z8=0;int z9=0;

float z10=0; float z11=0; float z12=0; float z13=0;float z17=0;

float z111=0;

void setup()

{

  Serial.begin(9600);

  inputString.reserve(200);

  emon1.voltage(A1, 220, 1.7);  // Voltage: input pin, calibration, phase_shift

  emon1.current(A0, 50);      // Current: input pin, calibration.


  lcd.begin(16, 2);

}
```

```
void loop()
{
  emon1.calcVI(20,2000);      // Calculate all. No.of half wavelengths (crossings), time-out
// emon1.serialprint();       // Print out all variables (realpower, apparent power, Vrms, Irms, power factor)


  float realPower    = emon1.realPower;     //extract Real Power into variable
  float apparentPower = emon1.apparentPower;  //extract Apparent Power into variable
  float powerFactor   = emon1.powerFactor;   //extract Power Factor into Variable
  float supplyVoltage = emon1.Vrms;         //extract Vrms into Variable
  float Irms        = emon1.Irms;        //extract Irms into Variable
  powerFActor=powerFActor;


/*lcd.setCursor(0, 0);
lcd.print("P=");
lcd.print(realPower);
lcd.setCursor(9, 0);
lcd.print("W");*/
// lcd.setCursor(17, 2);
// lcd.print(z111);
z1=realPower/3600000;
z2=z1+z2;
z8=z2;
/* if(digitalRead(2)==HIGH)
{
  z111=z111+1;
  delay(100);
  // lcd.setCursor(17, 2);
// lcd.print(z111);
```

```
}
  if(digitalRead(3)==HIGH)
  {
    z111=z111-1;
    // lcd.setCursor(17, 2);
   //lcd.print(z111);
    delay(100);
  }
  if(analogRead(A5)>800)
  {
    z2=0;
    z9=0;
    delay(100);


  }*/
  if(z2<101)
  {
    z3=z2*z111;
    z4=z2;
    delay(100);
  }
  if(z2>100&&z2<300)
  {
    z5=z2-z4;
    z6=z5*8;
    z10=z5;
    delay(100);
  }
```

```
if(z2>300&&z2<500)
{
  z11=z2-z4-z6;
  z12=z11*12;
  delay(100);
}




z7=z3+z6+z12+35;
z17=z7*21;
z17=z17/100;
z7=z7+z17;
 z9=z7;
//delay(10);
/* lcd.setCursor(11, 0);
 lcd.print("S=");
 lcd.print( apparentPower);
lcd.setCursor(18, 0);
lcd.print("VA");*/
lcd.setCursor(0, 0);
 lcd.print("P=");
 lcd.print(realPower);


  lcd.setCursor(8, 0);
 lcd.print("Pf=");
 lcd.print( powerFActor);
//delay(100);
```

```
/*  lcd.setCursor(9, 1);

lcd.print("P=");

lcd.print(supplyVoltage);


// delay(100);

   lcd.setCursor(0, 2);

lcd.print("Irms=");

lcd.setCursor(6, 2);

lcd.print(Irms);*/

 lcd.setCursor(0, 1);

lcd.print("B=");

lcd.setCursor(2, 1);

lcd.print(z9);

lcd.setCursor(7, 1);

lcd.print(",");

lcd.setCursor(8, 1);

lcd.print("U=");

lcd.setCursor(10, 1);

lcd.print(z2);

 Serial.print(supplyVoltage);

 Serial.print(",");

 Serial.print(powerFActor);

 Serial.print(",");

 Serial.print(realPower);

 Serial.print(",");

 Serial.print(z2);

 Serial.print(",");

 Serial.println(z9);

delay(500);

}
```

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