DC TO AC SQUARE WAVE INVERTER

SONARGAON UNIVERSITY (SU)

Supervised By

Mirza Rabiul Hasan

Lecturer

Department of EEE

Sonargaon University (SU)

Submitted By

U Sing Thowi Marma	**ID: EEE2103024061**
Md. Asif Hossen	**ID: EEE2003021082**
Naimu Hosan Rana	**ID: EEE2103024105**
Md. Roni	**ID: EEE2103024106**

Department of Electrical & Electronic Engineering (EEE)

Sonargaon University (SU)

147/I, Panthapath, Dhaka-1215, Bangladesh

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Declaration

We certify that the research/project based thesis titled, "**DC TO AC SQUARE WAVE INVERTER**" is completely our group work. All sources and knowledge for this paper which were found by other researchers are acknowledged by reference. Materials of work such as images, figures, tables and citations in this paper are accepted by our supervisor We hereby declare that this thesis has not been previously submitted either in whole or in part, for any other degree or publication

.....	.....
U Sing Thowi Marma	**Md. Asif Hossen**
.....	.....
Naimu Hosan Rana	**Md. Rani**

Under Supervision of

.....

Mirza Rabiul Hasan
Department of EEE
Lecturer
Sonargaon University(SU)

Certification

This is to certify that this project entitled "**DC TO AC SQUARE WAVE INVERTER**" is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfilment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

Supervisor

.....

Mirza Rabiul Hasan

Lecturer

Department of Electrical and Electronic Engineer (EEE)

Sonargaon University (SU)

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Abstract

A DC to AC square wave inverter is an essential power conversion device that transforms direct current (DC) into alternating current (AC) with a square waveform output. Unlike sine wave inverters, square wave inverters switch the output voltage between positive and negative peaks at regular intervals, offering a simple and cost-effective solution for basic AC power needs. These inverters are widely used in low-cost applications where waveform purity is not critical, such as simple motor drives, heating devices, and certain lighting systems. This paper reviews the design principles, operational characteristics, advantages, and limitations of square wave inverters, highlighting their role in various practical applications and discussing potential improvements to enhance their performance and efficiency.

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List of Acronyms

DC – Direct Current

AC – Alternating Current

PWM – Pulse Width Modulation

H-Bridge – Half-Bridge or Full-Bridge Inverter Circuit

UPS – Uninterruptible Power Supply

MOSFET – Metal-Oxide-Semiconductor Field-Effect Transistor

MCU – Microcontroller Unit

DSP – Digital Signal Processor

Chapter 1

1.1 Introduction

loads. Inverters play a critical role in modern electrical and electronic systems by converting direct current (DC) into alternating current (AC), enabling the use of DC sources—such as batteries and solar panels—to power AC devices. Among various inverter types, the square wave inverter is the simplest and most fundamental form. It generates an AC output where the voltage waveform alternates abruptly between positive and negative peak values, resembling a square shape. Despite its simplicity and cost-effectiveness, the square wave inverter is typically suitable for low-cost and low-sensitivity applications due to its high harmonic content, which can affect sensitive

This thesis explores the design, implementation, and performance analysis of a DC to AC square wave inverter. It delves into the core principles of inverter operation, circuit topology, control strategies, and the practical considerations necessary for effective and reliable inverter performance. Additionally, the study discusses the limitations of square wave inverters and potential improvements or alternatives for better waveform quality.

1.2 Background Study

The conversion of direct current (DC) to alternating current (AC) is essential in numerous applications, particularly where energy sources such as batteries, solar panels, or fuel cells provide DC power. An inverter serves this purpose by transforming DC into AC, enabling the operation of AC-powered equipment. Among various inverter types, the square wave inverter is one of the simplest and earliest designs. It produces an AC output where the voltage alternates between positive and negative peak values, forming a square waveform.

The basic structure of a square wave inverter involves switching devices (such as transistors or MOSFETs) arranged in an H-bridge or similar configuration. By rapidly switching the DC input, the inverter generates the square wave AC output. Although square wave inverters are less complex and more cost-effective than modified or pure sine wave inverters, their waveform contains significant harmonic distortion, which limits their use to resistive loads or devices tolerant of non-sinusoidal inputs.

Historically, square wave inverters have been widely used in early uninterruptible power supply (UPS) systems, basic motor drives, and simple power conversion systems. The simplicity of their design offers advantages in terms of ease of implementation, lower component count, and reduced cost. However, advances in power electronics have driven the development of more sophisticated inverter types that produce cleaner AC outputs to meet the increasing demand for higher power quality.

This study explores the design principles, operation, and performance characteristics of DC to AC square wave inverters, providing a foundation for understanding their role, advantages, and limitations within power conversion systems.

1.3 Scope of Project

This project focuses on the design, development, and testing of a DC to AC square wave inverter, which converts a direct current (DC) input into an alternating current (AC) output in square wave form. The inverter is intended for use in low to medium power applications where precise sine wave output is not critical, such as simple motor drives, battery-operated systems, and emergency power supplies.

Designing a power electronic circuit capable of generating a stable and reliable square wave AC output.

Implementing a control mechanism to maintain output voltage and frequency within desired specifications (typically 50 Hz or 60 Hz).

Analysing the efficiency, waveform quality, and load handling capabilities.

Investigating safety protections such as short-circuit and overload protection.

Evaluating potential use cases, limitations, and improvements for real-world applications.

This project does not cover the development of sine wave or modified sine wave inverters, high-frequency transformer-based systems, or grid-tied inverter designs.

1.4 Motivation

A DC to AC square wave inverter plays a vital role in power electronics by converting direct current (DC) from sources like batteries or solar panels into alternating current (AC) for running household or industrial appliances. Unlike pure sine wave inverters, square wave inverters are simpler, cost-effective, and efficient for basic applications where precise waveform quality isn't critical. Their design is straightforward, making them ideal for low-cost backup systems, small motor drives, or experimental setups, where reliability and simplicity are prioritized over waveform perfection.

1.5 Objective

The general objectives of this system are summarized below:

- To develop a DC TO AC SQUARE WAVE INVERTER.
- To generate dc to ac current.
- To note the various data for various condition for future modification.

1.6 Organization of the Book

- **Chapter 1: Introduction.** This chapter is all about background study, motivation, Objectives and thesis book organization.
- **Chapter 2: Literature Review-** Here briefly describe the Literature, Hardware, equipment.
- **Chapter 3: Methodology-** This chapter is discussed about our project structure, Block Diagram, Flow Chart, Working Principle, Cost Analysis and about programing.
- **Chapter 4: Performance Evaluation–** Here briefly discuss about project performance, result, advantage, disadvantage and limitation.
- **Chapter 5: Conclusion** – This chapter is all about our thesis future recommendation and this project conclusion.

Chapter 2

Literature Review

2.1 Introduction

The focus of this chapter is a literature review. Take a look at some of the literature from the prior year, including our project. By reading them, we may fix the flaws in the earlier project and create one that is more successful.

2.2 Literature Review

DC to AC inverters are essential components in power electronics, enabling the conversion of direct current (DC) into alternating current (AC) to supply AC-powered devices and systems. Among various inverter types, the square wave inverter is one of the simplest, offering a basic method for AC generation by switching the DC supply between positive and negative cycles.

Early works, such as those by Mohan et al. (1989), provided foundational designs of square wave inverters, emphasizing their simplicity and cost-effectiveness for low-power applications. The square wave output, characterized by a sudden transition between high and low voltage levels, enables straightforward circuit implementation using basic switching devices like transistors and thyristors.

2.3 About Hardware and Software

In this project we need some hardware and software for run this project smoothly.

- **Hardware**
    1. Arduino UNO
    2. Rectifier Circuit
    3. Battery 12v DC
    4. MOSFET
    5. Capacitor
    6. Resistor
    7. Diode
    8. Power switch

- **Software**
    1. Arduino IDE

2.4 Hardware

Electronic hardware is formed of connected electronic parts that, when applied to data that has been received and locally stored, conduct analog or logic operations to create new data that can be output or stored. Individual chips and circuits to distributed information processing systems are all examples of electronic gear. Hierarchies of functional modules connected by well-defined interfaces make up well-designed electronic gear.

2.4.1 Arduino UNO

Arduino is an open-source platform for electrical prototyping that is built on adaptable, user-friendly hardware and software.

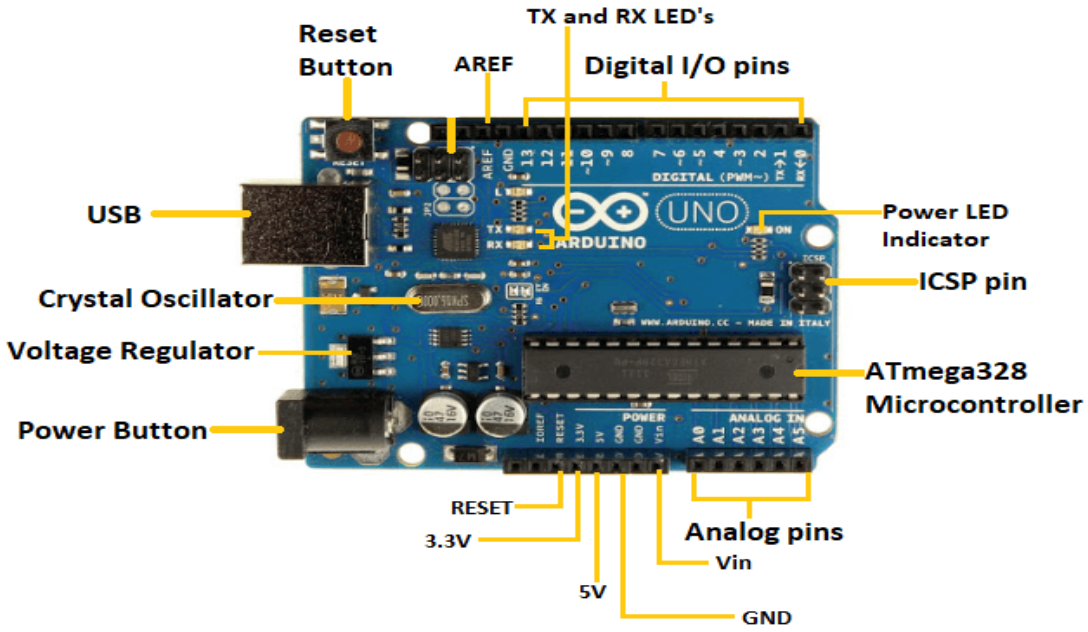


Figure 2.1: Arduino UNO

Arduino is able to control Pulls, signal, and other actuators to have an impact on its surroundings while also accepting information from a number of sensors. Here, the Arduino uses a MOSFET as input is controlled to square wave ac signal.

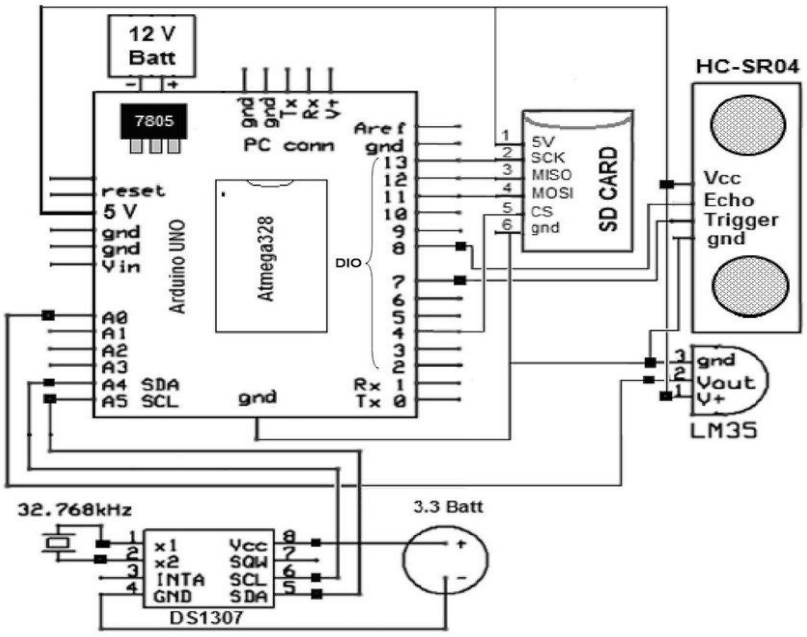


Figure 2.2: Arduino schematic diagram

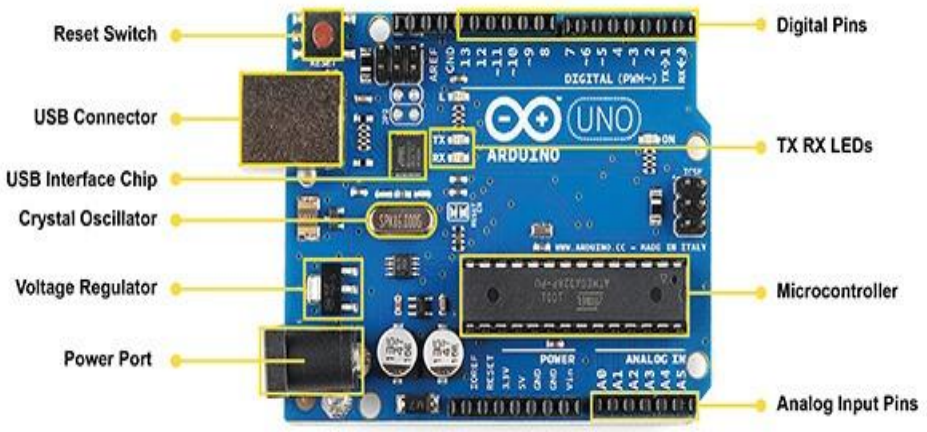


Figure 2.3: Section of Arduino UNO

Specifications:

- Atmel ATmega328 microcontroller
- Logic level operating voltage is 5 V.
- Recommended input voltage range: 7–12 V
- Input Voltage (6-20 V) (limits)
- 14 Digital I/O Pins (of which 6 provide PWM output)
- Eight Analog input pins
- 40 mA is the DC current per I/O pin.
- 32 KB of flash memory (of which 2KB used by boot loader) SRAM: 2 KB.
- 1 KB for EEPROM
- Clock frequency: 16 MHz

Features

- Automatic reset when downloading a software; Power OK blue LED; Green (TX), Red (RX), and Orange (L) LED
- Auto sensing/power input switching
- For programming and serial monitor purposes, a small Mini-B USB port; and an ICSP header for direct software download
- Breadboard-friendly standard 0.1-spacing DIP; manual reset switch

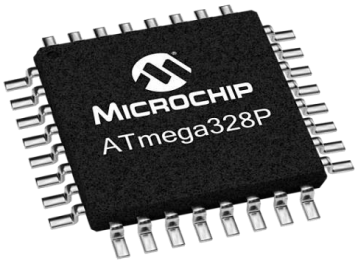


Figure 2.4: Micro-controller IC AT mega 328p.

2.4.2 Rectifier Circuit

Voltage sources in a circuit may have fluctuations resulting in not providing fixed voltage outputs. A voltage regulator IC maintains the output voltage at a constant value. Here, the Regulator IC control the supply of voltage to Arduino Nano, and humidifier module. 7805 IC provides +5 volts regulated power supply with provisions to add a heat sink.

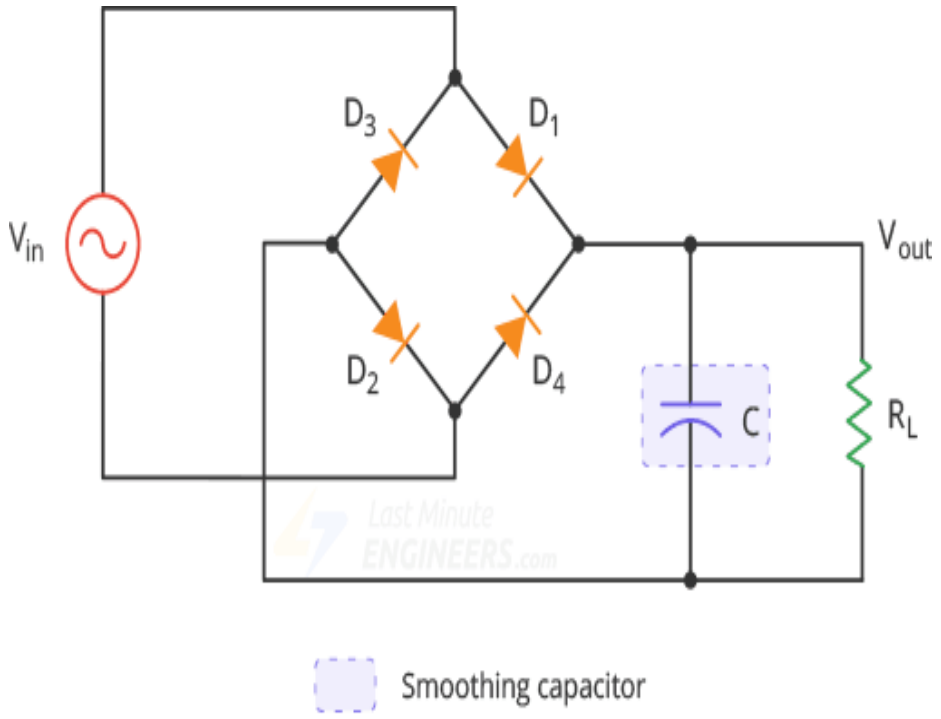


Figure 2.5: 5V Rectifier circuit diagram

☐ **Rectifier ciecuit Rating**

- Input voltage range 220V- 240V
- Output voltage range 12v/15v
- Current rating 10A

2.4.3 Battery 12v DC

A DC 12-volt battery is a common power source that provides direct current (DC) electricity at a nominal voltage of 12 volts. These batteries are widely used in automotive, marine, RV, solar power systems, and various backup power applications. They come in different types.



Figure 2.6: 12v DC Battery

☐ **Battery Rating:**

- Capacity voltage 12V DC
- Ampere rating 200amp
- Usual Measuring Range: 20cm to 80cm
- 40 Hz is the operating frequency.

2.4.4 Arduino Program

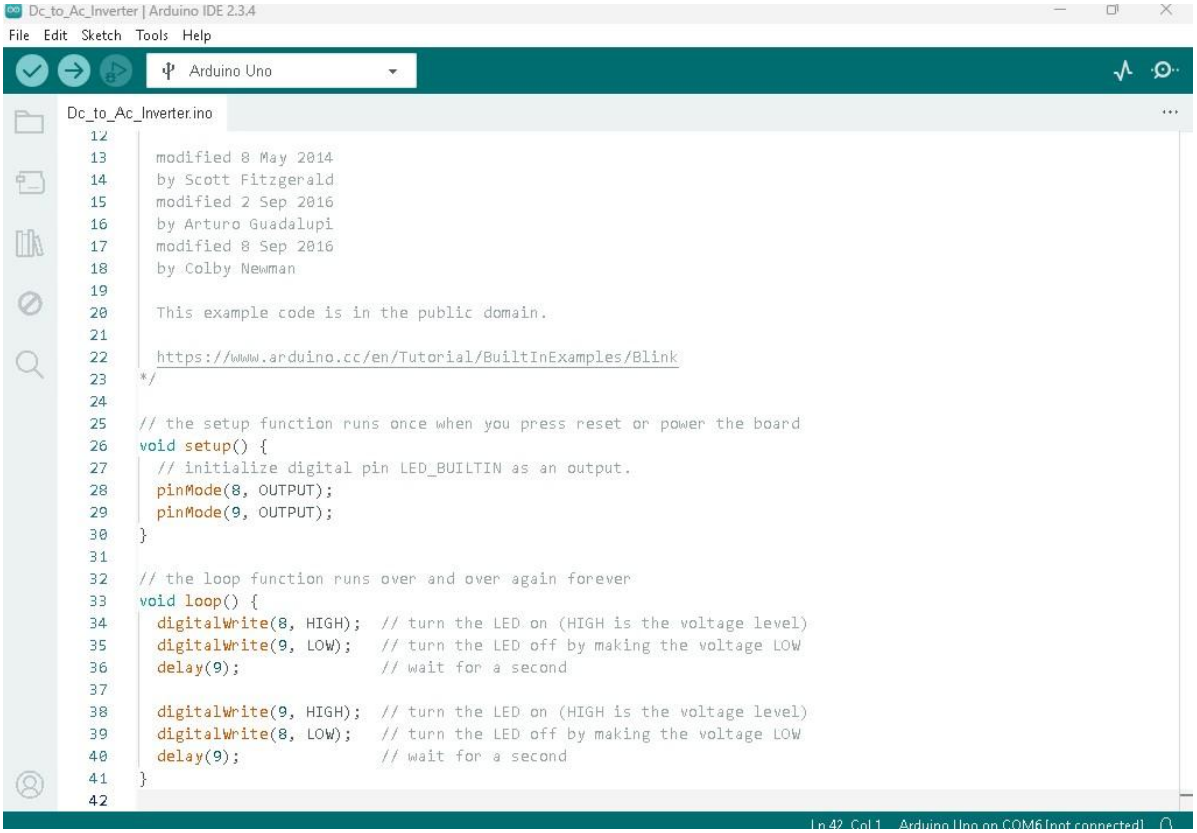


Figure 2.8: Arduino program

2.4.5 Power Switch

A power switch is a device or component that controls the flow of electricity to a system or device, allowing you to turn it on or off. It's found in everything from small electronics (like a lamp or computer) to large machinery.

There are different types of power switches, including:

Toggle switches (flip up/down),

Push-button switches, Rocker switches,

Rotary switches, and others. It’s a basic but essential part of any electrical circuit to safely manage power.



Figure 2.9: Power Switch

2.4.6 MOSFET

MOSFET stands for Metal-Oxide-Semiconductor Field-Effect Transistor. It's a type of transistor widely used for switching and amplifying electronic signals. MOSFETs are a key component in both digital and analog circuits.

Key Points:

Structure: It has three terminals—Gate (G), Drain (D), and Source (S)—plus a body (or substrate).

Types:

There are two main types.

n-channel MOSFET (NMOS)

p-channel MOSFET (PMOS) Each can be further classified as enhancement-mode or depletion-mode.

Operation: The voltage applied to the Gate controls the current between the Drain and Source. A MOSFET is voltage-controlled, unlike bipolar junction transistors (BJTs), which are current-controlled.

Advantages: High input impedance, fast switching speed, and low power consumption.

MOSFETs are used in power supplies, motor controllers, microprocessors, and many other applications.

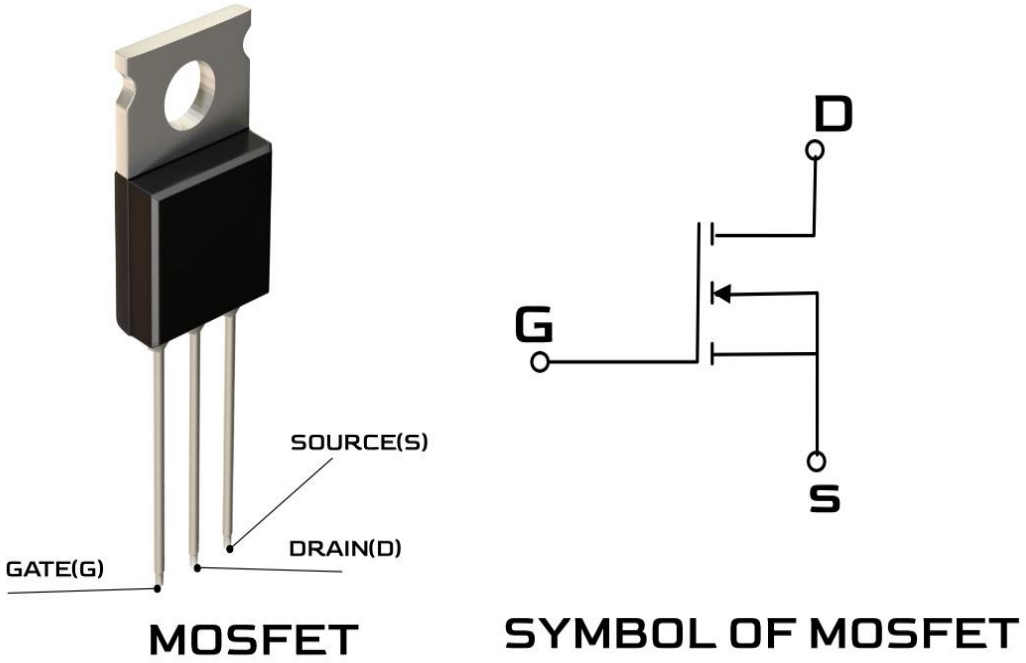


Figure 2.10: MOSFET

Working Process:

Vgs < Vth (threshold voltage): The MOSFET is OFF; no conduction between Drain and Source.
Vgs > Vth: An inversion layer (channel) forms, allowing electrons to flow from Source to Drain when a voltage is applied between them.
The amount of current depends on Vgs and the Drain-Source voltage (Vds).

Modes of Operation:

Cut-off: Vgs < Vth; no current.
Linear (Ohmic): Vgs > Vth and Vds is small; the MOSFET acts like a variable resistor.
Saturation: Vgs > Vth and Vds is large; the MOSFET acts like a constant current source.

Features:

1.High Input Impedance: Very high input resistance due to the insulated gate, which minimizes input current.

2. Voltage-Controlled Device: The current between drain and source is controlled by the voltage applied to the gate.

3. Fast Switching Speed: Suitable for high-speed switching applications.

4. Low Power Consumption: Consumes very little power, especially in the off state.

5. Scaling Capability: Can be made very small, which is ideal for integrated circuits.

6. Types: Available in two main types—enhancement-mode and depletion-mode; and two channels n-type and p-type.

7. Thermal Stability: Better thermal stability compared to bipolar junction transistors (BJTs).

8. Linear and Saturation Regions: Operates in different regions for amplification and switching purposes.

2.4.7 The Smoothing Capacitor

A potential difference between the conductors causes an electric field to generate over the dielectric (such as when a capacitor is connected across a battery). As a result, negative charge (-Q) accumulates on one plate and positive charge (+Q) on the other. If a capacitor is linked to a battery for an extended period of time, no current can flow through it. However, a displacement current may occur if the capacitor's leads are exposed to an accelerating or alternating voltage.



Figure 2.11: Capacitor

2.4.8 Resistor

A resistor is an electrical component used in circuits that has two latent terminals and performs electrical blockage. At some point, resistors also function to lower the voltage levels inside of circuits by reducing the current flow. For example, those constructing interior regulators, visitors, clippers, picture resistors, hamsters, and potentiometers, resistors can have either fixed or variable safeguards. The voltage applied

across the resistor's terminals directly affects the current flowing through it. Ohm's regulation takes this relationship into account.



Figure 2.12: Resistor

2.4.9 Diode

A diode is an electronic component that allows current to flow in one direction only, acting like a one-way valve for electric current. Here are some key points:

Structure: A typical diode is made from a semiconductor material (like silicon) and has two terminals: the anode and the cathode.

Function: It conducts current when the anode is at a higher voltage than the cathode (forward-biased) and blocks current when the polarity is reversed (reverse-biased).

Types: Common types include rectifier diodes, Zener diodes, light-emitting diodes (LEDs), and Schottky diodes.

Applications: Diodes are used in rectification (converting AC to DC), voltage regulation, signal demodulation, and protecting circuits from reverse polarity.

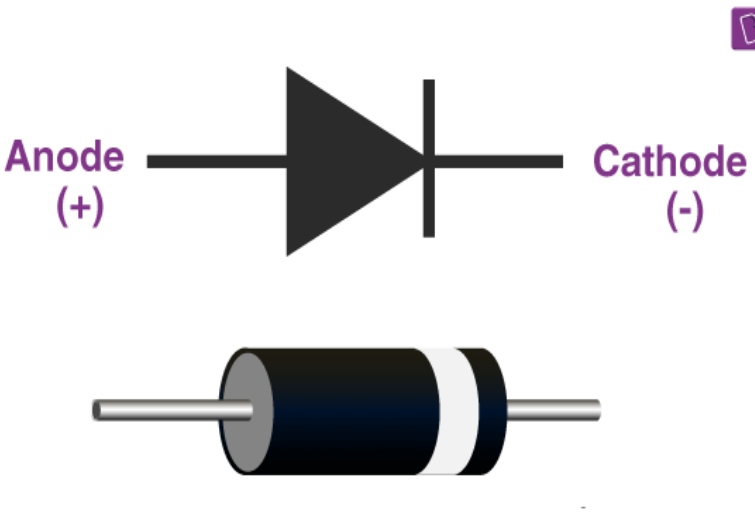


Figure 2.13: Diode

2.5 Summary

A DC to AC inverter is necessary because many devices and appliances require alternating current (AC) to operate, but the power source (like a battery or solar panel) provides direct current (DC).

Most household and industrial devices run on AC (like refrigerators, TVs, and lights).

Electricity grids distribute power as AC, so to connect a DC power source to the grid, conversion is needed.

Solar systems and batteries store energy in DC, but we often need that energy in AC form for practical use.

In short, the inverter bridges the gap between DC sources and AC-using equipment. Are you thinking about a specific application?

Chapter 3

Methodology

3.1 Introduction

This chapter includes a description of our project's system, a block diagram, a circuit diagram, a flow chart, a flow chart outlining the project's functioning principles, and a final project perspective.

3.2 Methodology

The project we made with some procedure that's called methodology. Our project word procedure is given below in a figure 3.1.

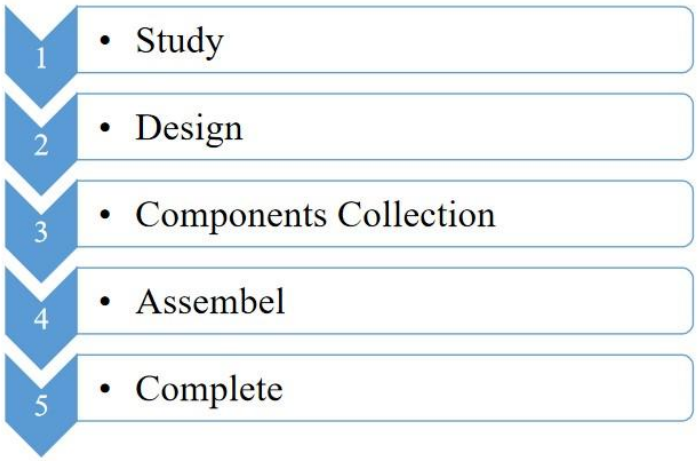


Figure 3.1: Methodology of Our Project

3.3 System Structure

In this system we want to execute our idea to **DC TO AC SQUARE WAVE INVERTER** system.

For this reason, here we make a system which we try to make it perfect as our desire output. The complete circuit is built with Arduino UNO, MOSFET, Battery, Transformer, Energy light, Power Switch etc. The Arduino UNO is the Central Processing Unit of the system. It needs 5v DC to power-up. Constant 5v DC from battery is connected to VIN pin of Arduino UNO. The mosfet get pin is connected to I/O pin of Node MCU. Here program input the controller, where mosfet control the pulls of ac signal in Nano second.

3.4 Block Diagram

The main brain of our system is the Arduino UNO. That's why we can controlling our system automatically. Here we use Battery for primary power source, Arduino UNO Microcontroller for main controller, Transformer, MOSFET etc. All kind of equipment is shown of our block diagram which is figure 3.1 is given below.

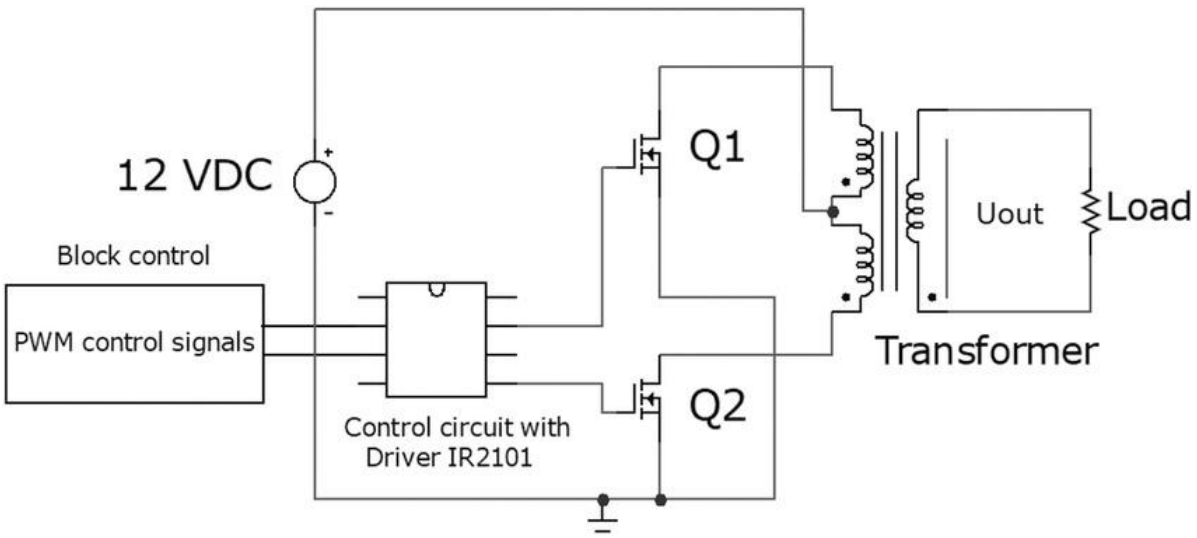
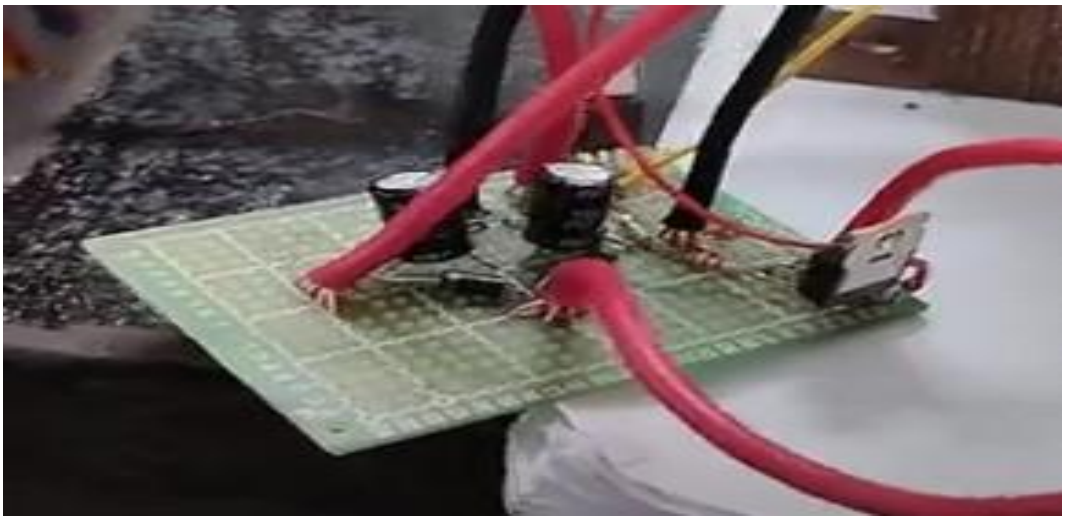


Figure 3.2: Block Diagram of our System.

In this block diagram we clear about our project set up. Here we use battery for main power source for this



system. When the project is power on then the control circuit is on. It will be generate square wave pulse signal. Here we use an Arduino uno. The Arduino uno is connected with Q1 and Q2 MOSFET in gate(G). And drain of Q1 and Q2 are connected in Transformer primary side

3.5 Circuit Diagram

All the instruments used here are connected by wire. Below figure 3.3 the circuit diagram of our project

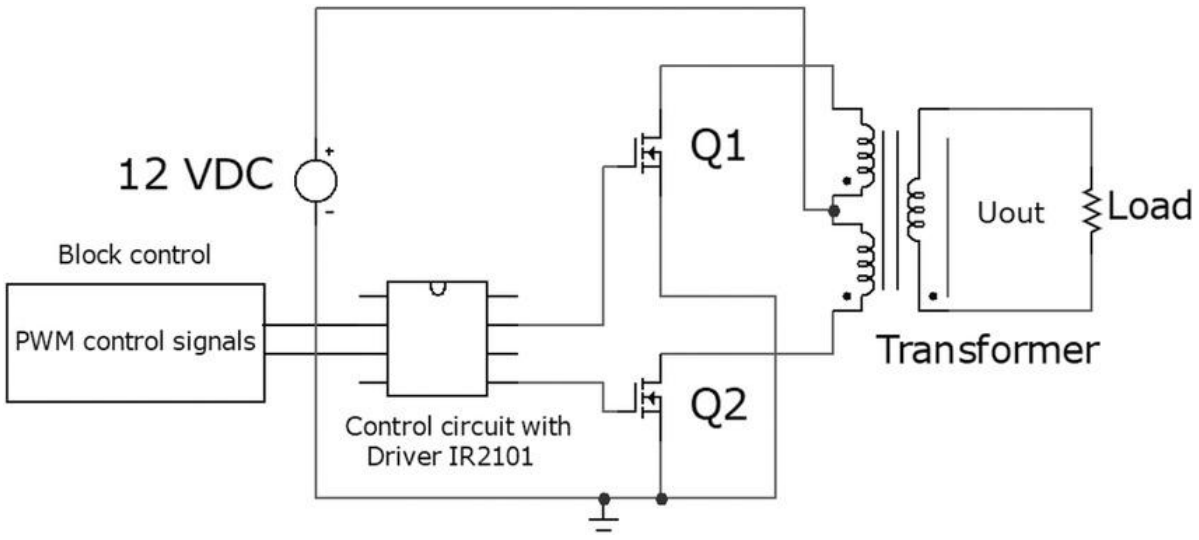


Figure 3.3: Circuit Diagram of our System.

3.6 Flow Chart

In this flow chart we understand that when we start it, its Arduino uno will active and the MOSFET drive the get pulse signal. And flow the current in primary side transformer.

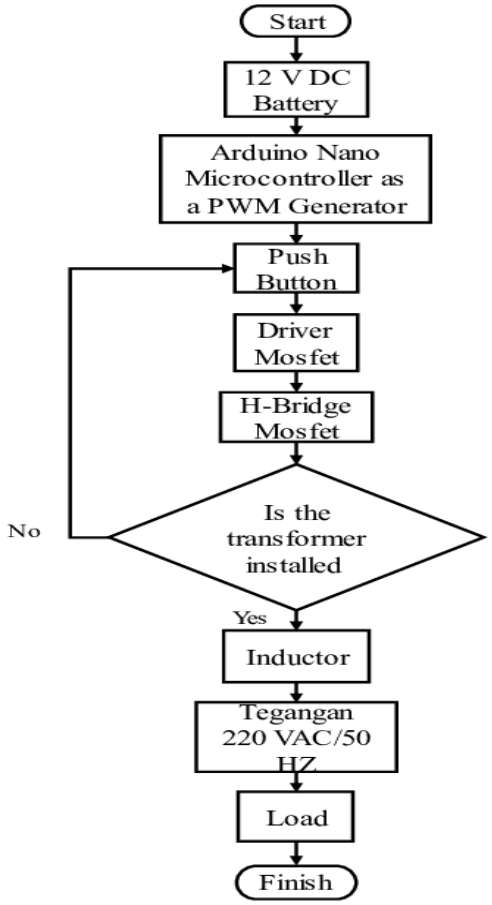


Figure 3.4: Flow Chart of Our System

3.7 Working Principle

A DC to AC inverter converts direct current (DC) into alternating current (AC). When using an Arduino Uno, the inverter typically generates a square wave AC output. Here's a breakdown of the working principles:

Basic Concept

Input: DC power supply (typically 12V from a battery).

Output: AC voltage 220V often via a transformer.

Arduino Uno: Used to generate PWM (pulse-width modulation) signals to simulate AC.

MOSFETs: Act as electronic switches to alternate current flow.

Transformer: Steps up the voltage from 12V to 220V.

Driver Circuit: Used to drive high-power MOSFETs.

The Arduino generates two out-of-phase square wave signals using digital pins.

A delay in toggling the pins controls the frequency (typically 50Hz or 60Hz).

Switching Transistors:

The PWM signals from the Arduino control MOSFETs/transistors in an H-bridge or push-pull configuration.

This alternates the polarity of the DC voltage across the transformer's primary winding.

Voltage Step-Up:

The transformer converts the low-voltage alternating signal into a high-voltage AC signal at its output.

Example Code (Basic 50Hz Square Wave)

```
int freq = 50; // Frequency in Hz
int period = 1000 / freq / 2; // Half-period in milliseconds (10ms for 50Hz)

void setup() {
  pinMode(10, OUTPUT);
```

```
  pinMode(11, OUTPUT);
}

void loop() {
  digitalWrite(10, HIGH);
  digitalWrite(11, LOW);
  delay(period);
  digitalWrite(10, LOW);
  digitalWrite(11, HIGH);
  delay(period);
```

This method generates a square wave, which is not suitable for sensitive electronics. For better output (e.g., modified sine wave or pure sine wave), more advanced PWM techniques and filtering are needed.

This system is mainly focused on to generate dc to ac current.

3.8 Complete Project Prototype

This is our complete project prototype. After completing our project, we take many test to work to our desire. In below figure 3.4 we indicate the instrument in our project image.

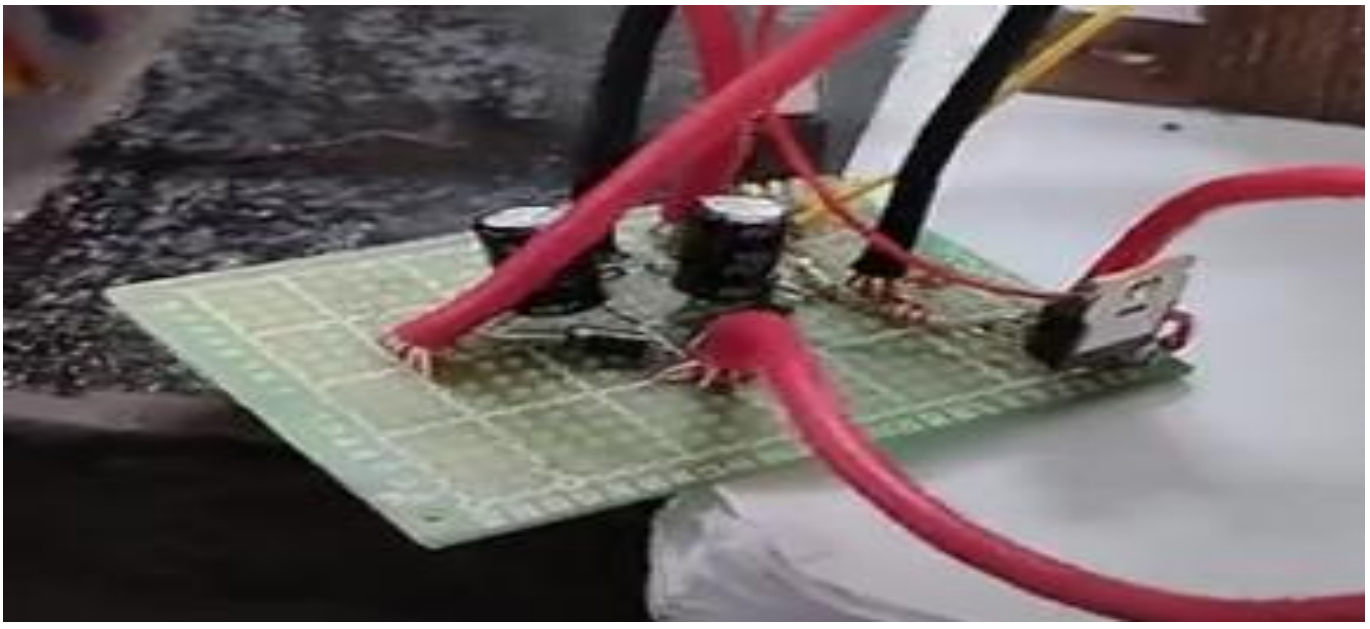


Figure 3.8: Our Final Project Image

3.9 Cost Analysis

We brought the items from local market and online shopping. There we get a lot of quality. We try to take the better instruments for project. In table 3.1 we mentioned the price of instrument.

Sl. no	Particulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	Arduino	UNO	1	820	820
2	Transformer	12v to 220v	1	4000	4000
3	Capacitor	50V	2	50	100
4	mosfet	IRF540	2	40	80
5	Resistor	1k ohm	2	5	10
6	Vero board	5cm to 7cm	1	80	80
7	Jumper wire			80	80
8	Energy light, switch, holder, hard board				320
Total					**5,410/=**

Table 3.1: Instruments Name and its Price Analysis

3.10 Software

Software is a set of instructions, data or programs used to operate computers and execute specific tasks. It is the opposite of hardware, which describes the physical aspects of a computer.

3.10.1 Arduino IDE

We programed it by Arduino software IDE. There is no any requirement for installing other software rather than Arduino. We pregame by C++ programing language.

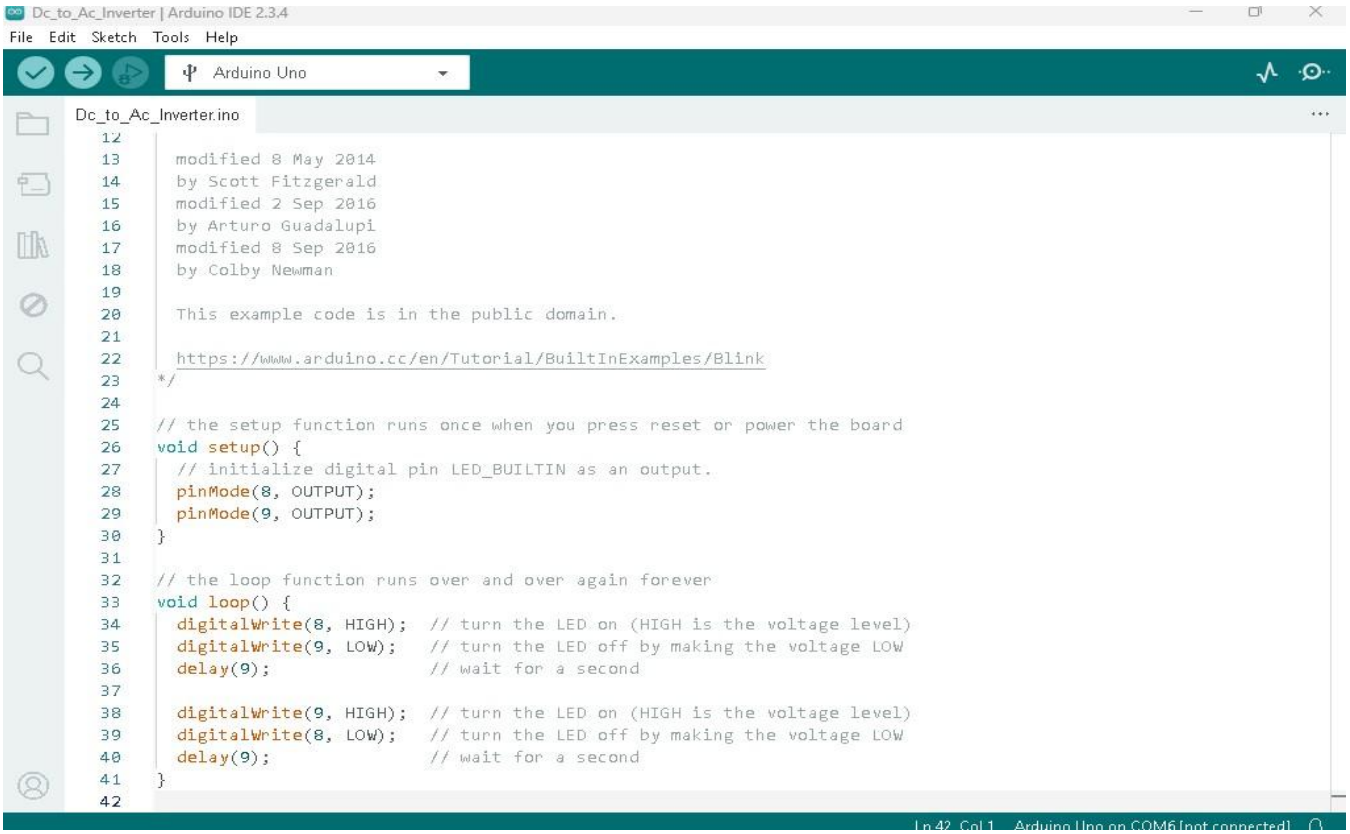


Figure 3.9: Arduino Software Interface IDE

Chapter 4
Performance Evaluation

4.1 Introduction

This chapter will go over the vital role of our project. Here is a thorough explanation of our project's outcomes, benefits, applications, and conversations.

4.2 Result

It's time to discuss the outcomes now. The following things may occur after writing our instructions using the Arduino IDE: The DC to AC Square Wave Inverter is our project. For the entirety of our project's hardware design, PVC boards were implemented. We tested this project after it was eventually finished, and we looked at the outcome. It is working as expected, as can be seen.

- Firstly, the control circuit power from the battery.
- When the button is on then the system able to do its work.
- Control circuit will pulse, when signal come from Arduino.
- And Transformer primary get 12v dc and secondary will generate the ac.

Trasformer over view:

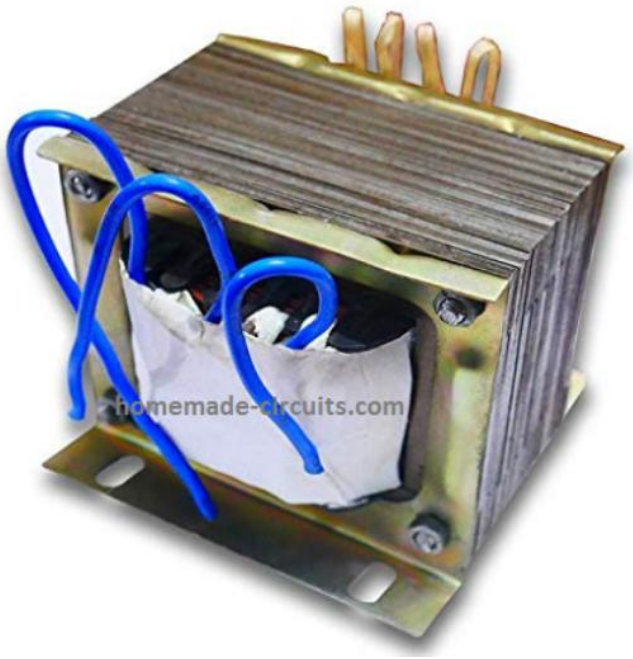


Fig 4.1.1: Transformer

4.3 Advantages

Our project has several benefits, some of the most significant of which are listed below:

1. Power Compatibility: Allows use of DC power sources (solar panels, batteries) with standard AC appliances.

2. Grid Connection: Enables solar or battery systems to feed electricity into the utility grid.

3. Versatility: Powers tools, electronics, and appliances where only DC sources are available (e.g., in vehicles or remote areas).

4. Energy Storage Use: Facilitates use of stored DC power (from batteries) during grid outages or at night.

5. Efficient Power Management: Modern inverters often include features like power regulation, surge protection, and smart energy distribution.

4.4 Disadvantages

Every project has some limitation. so some limitations are given below:

1. Power Losses: Inverters are not 100% efficient; some energy is lost as heat during conversion.

2.Cost: High-quality inverters, especially pure sine wave types, can be expensive.

3.Complexity: The circuitry of inverters can be complex, requiring maintenance and careful installation.

4. Noise and Heat: Some inverters generate electrical noise or heat, which can affect sensitive electronics or require additional cooling.

5. Limited Load Capacity: Inverters have a maximum wattage rating, and overloading can damage the unit or cause shutdowns.

4.5 Applications

Our project has many applications. These are –given bellow:

- To use in residential area.
- Market
- Hospital
- School
- Industry.

4.6 Discussion

very helpful in this load shedding time. If we use it perfectly, then the load shedding will reduce. While dealing with our task, we confronted a few hardships as it is an exceptionally intricate frame work yet the final products, we thought of were very palatable. We have put the entire framework through a few errands to approve our work and furthermore have taken fundamental notes for future upgrades. A few future proposals that we have includes improvement in frame work plan and wiring, adding highlights for more effective. This Project will

Chapter 5

Conclusion

5.1 Conclusion

Based on the conclusions reached throughout analysis, design, and execution. Therefore, certain inferences may be made, including the fact that the DC to AC inverter is a crucial device that converts direct current (DC) from sources like batteries or solar panels into alternating current (AC), which is suitable for powering most household and industrial appliances. Inverters play a vital role in renewable energy systems, uninterruptible power supplies (UPS), and electric vehicles. With advancements in technology, modern inverters are becoming more efficient, compact, and reliable, making them an essential component in both off-grid and grid-tied power systems. Proper selection, design, and maintenance of inverters are key to ensuring energy efficiency and system longevity.

5.2 Future Scope of Work

We are thinking about adding many features to our project in the future to get more desirable outcomes. Some of the steps that we are thinking about taking are given below:

- In future, we are thinking about increase power supply unit.
- In future we are thinking about increase output power unit ac.
- In future we are thinking solar control and generation system.
- Also thing to add powerful transformer for high voltage rating.

References

Power Electronics: Circuits, Devices & Applications" by **Muhammad H. Rashid**

Widely used in engineering courses; covers inverter theory, waveforms, and control techniques.

Power Electronics: Converters, Applications, and Design" by Ned Mohan, Tore M. Under lend, William P. Robbins

Detailed explanation of inverter topologies and practical examples.

2. **Research Papers**:

IEEE explore Digital Library – Search for terms like "DC to AC inverter design," "PWM inverters," or "inverter efficiency improvement.

3**. Online Learning Platforms:**

Coursera / ext. / NPTEL – Look for courses on Power Electronics or Renewable Energy Systems.

YouTube Channels – e.g., "All About Electronics" or "IBlog" for tutorials and practical demos.

4. Technical Standards

IEC 62109 – Safety of power converters for use in photovoltaic power systems.

IEEE 1547 – Standard for Interconnecting Distributed Resources with Electric Power Systems.

5. Example Applications

Solar Inverters: Convert DC from solar panels into usable AC for homes or grids.

UPS Systems: Provide backup AC power from DC battery storage.