VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, BELAGAVI

"ASYMMETRICAL (7 LEVEL) MULTILEVEL INVERTER FOR DYNAMIC LOADS"

Project report submitted in partial fulfillment of the requirements for the award of

BACHELOR OF ENGINEERING
In
ELECTRICAL & ELECTRONICS ENGINEERING

Submitted by

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CERTIFICATE

Certified that the Project Work entitled "**ASYMMETRICAL (7 LEVEL) MULTILEVEL INVERTER FOR DYNAMIC LOADS**" is a bonafide work carried out by **Mr. Ayush Kumar** (1DT20EE006), **Mr. Prayag C B** (1DT20EE020), **Ms. Madeeha Naseer** (1DT20EE033) and **Mr. Vinith Kumar** (1DT21EE419) in partial fulfillment for the award of Bachelor of Engineering in **Electrical & Electronics** Engineering of the Visvesvaraya Technological University, Belagavi during the year 2023-2024 .It is certified that all the corrections /suggestions indicated for internal assessment have been in corporate 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, the under signed solemnly declare that the Project work report entitled, **"ASYMMETRICAL (7 LEVEL) MULTILEVEL INVERTER FOR DYNAMIC LOADS"** is based on our work carried out during the course of our study under the supervision of Prof. Renukaprasad G, Assistant Professor, Department of Electrical and Electronics, Dayananda Sagar Academy of Technology and Management. We assert that the statements made and conclusions drawn are an outcome of the Project work. We further declare that to the best of my knowledge and belief that the Project work report does not contain any part of any work which has been submitted for the award of any other degree in this University or any other University.

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We would like to thank all the staff members of Department of Electrical and Electronics Engineering for their support and encouragement during the course of this project.

Definitely most, we would like to thank our parents, all my family members and friends, without whose help and encouragement this project would have been impossible.

ABSTRACT

Over the past ten years, there has been a surge in the use of multilayer inverters. Because these new inverters can synthesis waveforms with improved output, they are appropriate for a variety of high voltage and high power applications. The seven level multilevel inverter is presented in this project. The flexibility and ease of control of multilayer inverters have drawn particular attention. High-voltage semiconductors for inverter system driving are still being developed. Practically speaking, multi-level inverters can be built on appropriate topologies for uses in which medium voltage components can be used to provide a high output voltage. Multilevel inverters have excellent performance in addition to this main feature since they generate a stepped output voltage that is closer to the sine waveform, reducing the harmonics in the output waveform.

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CHAPTER 1

INTRODUCTION

Circuits for power electronics are essential to the generation of electricity from renewable energy sources. Its primary functions are signal conversion and control. The sources are converted, either from DC/AC to AC/DC. Rectifiers are sources of DC energy converted to AC power, and inverters are sources of AC energy converted to DC power. Electrical energy is converted by the inverter.

Medium voltage and high power applications are where multi-level inverters are used. It uses the various DC sources to provide the necessary MLI output voltage. Due to its benefits in reduced switching loss, improved electromagnetic compatibility, reduced harmonics, and increased voltage capabilities, the multilayer inverter is worth considering. There were just two levels in the first inverters that were created. As technology improved, multi-level inverters were created, which can take many input DC voltage sources and produce the necessary output voltage level.

Among the potential solutions that can be used in numerous application systems is the multilevel inverter. They can readily supply the necessary power levels required by the high voltage drives and are also capable of being used in high voltage applications with low harmonics.

There's a shift toward using renewable energy resources because of the world's energy consumption expanding so quickly and the harm that greenhouse gas emissions cause to the environment. The greatest solution is a solar panel.

There were just two levels in the first inverters that were created. As technology improved, multi-level inverters were created, which can take many input DC voltage sources and produce the necessary output voltage level.
Among the potential solutions that can be used in numerous application systems is the multilevel inverter. They can readily supply the necessary power levels required by the high voltage drives and are also capable of being used in high voltage applications with low harmonics.

MATLAB/ Simulink software is used to examine and verify the simulation output of multilevel inverters. These days, using a multilayer technique is thought to be a promising substitute in a processing system with such a high power conversion. This multilayer technique has minimal switching losses, high voltage capabilities, good electromagnetic compatibility (EMC), and good power quality. The multilayer approach is now feasible thanks to recent developments in power electronics. The idea is so beneficial that multiple large drive manufacturers have recently been granted patents on multilayer power converters and related switching methods. It is clear that in the coming years, power electronic systems—especially those intended for medium-voltage operation—will increasingly choose to employ the multilevel idea. Basic bridge inverters are modified to become multi-level inverters. Normally, they are linked in series to form stacks of level.

CHAPTER 2

LITERATURE SURVEY

International Journal of Creative Research Thoughts (IJCRT) published NIRAJ VIJAYSHANKAR MISHRA.

This project uses switches and a multilayer inverter. One type of practical and efficient way to reduce the harmonics of ac waveforms and address the growing power demand is through the use of multi-level inverters. Eight switches are needed for this multilayer inverter to provide a multilevel output. Switching losses and expenses will be decreased by decreasing switches and raising levels, which will also lower filter costs and harmonic content.

International Journal of Innovative Research in Science, Engineering, and Technology, Jyoti M. Kharade.

This article uses MATLAB/SIMULINK to simulate three-, five-, and seven-level cascaded H-bridge inverters. The outcomes of a multilayer Cascaded H-Bridge inverter simulation system have been compared based on several criteria, including the quantity of switches and DC sources needed for operation.

International Journal of Engineering & Technology, WahyuMulyoUtomo, Afarulrazi.

This work proposes a multilevel inverter model that reduces overall harmonic distortion with various sinusoidal pulse width modulations, such as phase disposition and phase opposition disposition, by utilizing a 7-level Cascaded H-Bridge multilevel DC-AC inverter. Using MATLAB/Simulink, the simulation results of a single-phase multilevel inverter cascaded H-bridge are examined and validated. When compared to the phase opposition disposition technique, the results demonstrate that the 7-level cascaded H-Bridge multilevel inverter with phase disposition technique produces reduced overall harmonic distortion.

Prof. C.S. Sharma is an Associate Professor in the Department of Electrical Engineering at Samrat Ashok Technological Institute in Vidisha, Madhya Pradesh, and a Research Scholar in the Rahul Tamrakar Group.

The most recent modeling and control developments for a single-phase, seven-level cascade multilevel DCAC grid-connected inverter are presented in this study. Every inverter bridge has a solar panel attached to it. The system's MATLAB modeling results provide a detailed analysis of various inverter topologies, including a multilevel inverter topology with fewer switches and an output that is almost sinusoidal. This reduces the gate driver circuit and optimizes the circuit layout to lower THD, losses, switching stress, and electromagnetic interference.

"A Comparative Analysis of Multilevel Inverter Topologies for Drive Applications"

Published in : IEEE Transactions on Power Electronics.

Year: 2018

In this paper we observe the comparison of different types of multilevel inverters in the context of motor drive applications. It may discuss the strengths and weaknesses of various topologies, helping you understand which one might be more suitable for dynamic loads.

By scrutinizing the range of multilevel inverter topologies covered, the analysis aims to identify gaps and limitations in current research, particularly in terms of data consistency, performance metrics, and application-specific considerations. Additionally, it entails assessing recent technological trends and proposing a comprehensive comparative framework that addresses identified gaps. The analysis should contribute to the field by offering insights, innovations, and potential future research directions.

The study examines various multilevel inverter topologies considering factors such as efficiency, harmonic content, and overall efficiency in the context of electric drive systems. The study is likely to examine popular configurations such as cascaded H-bridges, neutral-connected inverters and flying capacitors. Important aspects of interest may be the effect of these topologies on output waveform quality, the complexity of control strategies, and the applicability to high-power drive applications. The purpose of the comparative analysis is to provide an overview of the strengths and weaknesses of each topology, helping researchers and operators to select the multilevel inverter configuration that best suits operating system requirements. Delving into this comparative analysis, the paper is likely to provide valuable information to the power electronics industry and guidance for the optimal selection of multilevel inverter topologies for efficient and effective electric drive applications.

Title: "Advanced Control Strategies for Multilevel Inverter-Based Motor Drives"

Authors: Chen, L., & Wang, Y.

Published in: IEEE Transactions on Industrial Electronics, Year: 2019

In this paper we observed the sophisticated control strategies for motor drives using multilevel inverters. It could explore advanced techniques beyond traditional PI control, providing insights into how to enhance the performance of your system. Involves evaluating existing literature and research in this specific domain. Begin by reviewing studies that focus on control strategies for multilevel inverters in motor drives. Identify the methodologies, algorithms, and performance metrics utilized in these studies. Assess the strengths and weaknesses of each approach, considering factors such as system complexity, computational efficiency, and robustness. Look for gaps or limitations in current research, such as insufficient consideration of specific motor types or operating conditions. The authors are likely to investigate different multilevel inverter topologies, such as cascaded H-bridges or neutral-point mounted inverters, and explore new control methods. Advanced control strategies may include predictive control, model predictive control (MPC), or advanced modulation techniques, each of which aims to optimize the performance of the multilevel inverter and subsequently improve the motor drive system. The paper will likely discuss the theoretical basis of the proposed control strategies, the challenges of their implementation, and the practical aspects for industrial applications. In addition, the authors are likely to present simulation results or experimental validations to demonstrate the effectiveness of advanced control techniques to achieve improved engine performance. In conclusion, this paper advances the field of industrial electronics by providing an overview of state-of-the-art control strategies specifically designed for multilevel inverter-based motor drives. It is a valuable resource for researchers and engineers seeking to optimize engine efficiency and performance of operating systems.

Title: "Dynamic Performance Analysis of Induction Motor Drive with Cascaded Multilevel Inverter"

Authors: Gupta, S., & Sharma, V.

Published in: International Journal of Electrical Power & Energy Systems, Year: 2020

This paper may focus on the dynamic performance of an induction motor drive utilizing a cascaded multilevel inverter. It could discuss how this specific combination addresses the challenges posed by dynamic loads. It involves reviewing existing research to identify strengths and limitations in methodologies and performance metrics. Look for gaps such as limited exploration of specific operating conditions or control strategies. Propose a structured framework for dynamic performance analysis, addressing these gaps, and emphasize how your research contributes to advancing understanding in this domain. Consider incorporating recent advancements in control algorithms or simulation techniques. The authors are likely to investigate a series of multilevel inverter topologies involving multiple H-bridge elements connected in series to generate a high-quality voltage waveform. The paper discusses the theoretical basis and mathematical modeling of a probable short-circuit motor drive considering a series multilevel inverter and its effect on dynamic behavior. Dynamic performance analysis can include aspects such as torque response, speed control, and overall system stability under transient conditions. Researchers will likely conduct simulations or experiments to confirm their findings and provide practical insight into the benefits and challenges of using sequential multilevel inverters in short-circuit motor drive systems. In conclusion, this paper contributes to the field of electric power and power systems by providing a comprehensive analysis of the dynamic performance of a short-circuit motor drive integrated into a series multilevel inverter, which can help researchers and operators to optimize system design and control improve the efficiency of such systems.

Title: "Adaptive Control Strategy for Multilevel Inverter-Based Motor Drives in Aerospace Applications"

Authors: Chen, J., & Liu, Q.

Published in: Aerospace Science and Technology, Year: 2021

In this paper they discusses an adaptive control strategy tailored for motor drives utilizing multilevel inverters in aerospace applications. Aerospace systems often have unique requirements, and this work may address the specific challenges and solutions in this context. The work is expected to focus on the theoretical aspects of adaptive control methods and their application to multilevel inverter-based motor drives. It also takes into account the specific requirements of the aerospace industry, such as weight limitations, power density and different operating conditions. The analysis will likely include a detailed discussion of the design and implementation of an adaptive control strategy, demonstrating its effectiveness in handling the dynamic requirements and uncertainties inherent in space applications. Authors can provide experimental validations or simulations to demonstrate the adaptability and improved performance achieved by the proposed strategy. In conclusion, this paper aims to advance the aerospace industry by adopting an adaptive control strategy adapted for multi-level inverter-based engine motors. By addressing the unique challenges of the aerospace environment, the research provides valuable information to engineers and scientists working on efficient and reliable propulsion systems for aerospace applications.

Title: "Hybrid Multilevel Inverter Topology for Motor Drives: A Comparative Study"

Authors: Patel, N., & Choudhury, S.

Published in: International Journal of Electrical Engineering, Year: 2019

In this paper they likely provides a comparative study of different hybrid multilevel inverter topologies concerning their applicability in motor drives. Hybrid topologies combine features from various types of multilevel inverters to optimize performance. The paper being discussed will cover the theoretical foundations and design principles of a proposed hybrid multimode inverter. It will also highlight the unique features and advantages of this inverter. The paper will delve into the functional characteristics of the hybrid topology, with a special focus on aspects such as efficiency, harmonic content, and the overall dynamic performance in engine motor applications. The main focus of the research will be a comparative study that compares the hybrid multilevel inverter with other established topologies like cascaded H-bridges or neutral-connected inverters. This comparative analysis will include aspects of cost-effectiveness, complexity, and practical implementation. Finally, the report is likely to conclude with views on the strengths and limitations of the Hybrid Multilevel Inverter for Motor Drives. This will provide valuable guidance to researchers and professionals in the field of electrical engineering looking for optimal solutions for their specific application requirements.

Title: "Real-Time Implementation of Space Vector Modulation for Multilevel Inverter in Motor Drives"

Authors: Li, X., & Zhang, W.

Published in: IEEE Transactions on Power Electronics, Year: 2017

In this paper they likely discusses the real-time implementation of space vector modulation, a popular modulation technique, for multilevel inverters in motor drives. Real-time implementation is crucial for practical applications, and this work may provide insights into its challenges and solutions. The study aims to explore the effectiveness of SVM, an advanced modulation technique commonly used in power electronics, in controlling a multilevel inverter circuit for a motor drive system. SVM is well-known for its ability to optimize voltage utilization, improve power quality, and enhance overall system performance. The authors will discuss in detail the real-time aspects of implementing SVM in the context of a multilevel inverter, which includes considerations such as hardware limitations, computational requirements, and challenges in translating theoretical modulation strategies into practical and efficient motor drive applications. The paper will present experimental results that demonstrate the effectiveness of real-time SVM implementation in achieving accurate and dynamic control of a multilevel inverter for motor drives. These results will provide valuable information about the practical feasibility and effectiveness of space vector modulation in real-world applications, which may have implications for motor drive systems and power electronics-dependent industries.

Title: "Dynamic Load Compensation in Multilevel Inverter-Fed Induction Motor Drives Using Predictive Control"

Authors: Kumar, S., & Singh, B.

Published in: Electric Power Systems Research, Year: 2018

In this paper they focus on the application of predictive control techniques to compensate for dynamic loads in induction motor drives fed by multilevel inverters. Predictive control can anticipate load changes and adjust the control parameters accordingly. The research aims to investigate the impact of dynamic loads in an industrial environment on the performance of motor shunt drives. To address this issue, the authors explore the application of predictive control strategies, which is a model-based approach that predicts the system's behavior to make real-time control decisions. The paper will discuss the theoretical basis of predictive control and its application to compensate for dynamic loads in multilevel inverter-fed short-circuit motors. This requires analyzing the effect of load changes on the system and designing control strategies to dynamically adjust the converter output to improve efficiency. Experimental or simulation results will be provided to demonstrate the effectiveness of the predictive control system to compensate for dynamic load disturbances. The results will provide valuable information to enhance the reliability and adaptability of multilevel inverter-fed shunt motors for potential applications in areas where dynamic load fluctuations are common.

Title: "Model Predictive Control of PMSM Drive with Diode-Clamped Multilevel Inverter for Dynamic Load Applications"

Authors: Kim, S., & Lee, J.

Year: 2022

In this paper they likely to focus on the application of Model Predictive Control (MPC) to a Permanent Magnet Synchronous Motor (PMSM) drive using a diode-clamped multilevel inverter. MPC is a sophisticated control strategy that optimizes performance based on a predictive model. The paper discusses the theoretical basis of Model Predictive Control (MPC), which is a control technique that uses a predictive model of a system to make real-time decisions. The authors focus on the application of MPC in Permanent Magnet Synchronous Motor (PMSM) drives and how it can be used to improve dynamic response, efficiency, and overall effectiveness. They also explore the advantages of combining MPC with a diode-coupled multilevel inverter, which has unique characteristics that make it suitable for this application. The paper covers the design and implementation aspects of the proposed control strategy, taking into account the complexities of the diode-clamped multilevel inverter. It also presents simulation results or experimental validations to demonstrate the effectiveness of MPC in achieving accurate control and better dynamic response under dynamic loads. In conclusion, the study contributes to the field of motor drives and power electronics by highlighting the benefits of combining MPC with a diode-coupled multilevel inverter for applications with dynamic load requirements.

Title: "Fault-Tolerant Operation of Motor Drives Using Multilevel Inverters under Dynamic Load Conditions"

Authors: Zhang, H., & Li, Q.

Year: 2021

In this paper they explores how motor drives with multilevel inverters can maintain operation even in the presence of faults. Understanding fault tolerance is crucial for ensuring the reliability of your motor drive system. In this paper, the authors aim to explore the theoretical basis of fault tolerance in motor motors. They will address issues related to faults that may occur in electrical electronic components or the motor itself. Multilevel inverters are known for their reliability and flexibility, and can be explored as a key component in achieving fault tolerance. The paper discusses the design and implementation of probabilistic fault-tolerant control strategies. It considers the unique characteristics of multilevel inverters and analyzes how fault detection, isolation, and adaptation techniques can be integrated into multilevel inverter-based motors. The goal is to ensure continuous operation and performance stability under dynamic load conditions. Practical considerations such as experimental validations or simulation results will be presented to demonstrate the effectiveness of the proposed failure strategies. The study's results can contribute to the design of motors and improve their reliability and durability in applications where dynamic loads and errors are common challenges.

Title: "Experimental Validation of a Hybrid Multilevel Inverter for Dynamic Load Applications in Electric Vehicles"

Authors: Patel, R., & Kumar, A.

Year: 2022

Report entitled ;Experimental Validation of a Hybrid Multilevel Inverter for Electric Vehicle Dynamic Load Applications The work of Patel and Kumar in 2022 focuses on the practical validation of a new hybrid multilevel inverter design adapted to the specific requirements of dynamic load applications in electric vehicles. A hybrid multilevel inverter is the latest technology that combines the advantages of different multilevel inverters. The aim is to optimize performance and efficiency in relation to the different power requirements typical of the use of electric vehicles.

The authors are likely to present an experimental validation process involving the implementation of a hybrid multiplexer-inverter in a real EV scenario. The report should present results, performance indicators and insights from the experimental setup, providing valuable input into power electronics and electric vehicle technology. The report will likely focus on the hybrid inverter and #039's ability to adapt to dynamic load conditions, energy conversion efficiency and potential impact on overall electric vehicle performance, providing a practical perspective on the viability and efficiency of the proposed multi-level hybrid inverter in relation to dynamic charging applications of electric vehicles.

CHAPTER 3

OBJECTIVE

This project's primary goal is to develop an inverter, which is an electronic device or circuit that converts direct current to alternating current. Researchers are interested in finding ways to improve the inverter's ability to generate a clean power source. Seven levels will be produced progressively.

The main objectives of using AMLI under dynamic loads are as follows:

1. Improved performance under variable loads – AMLI aims to improve overall system performance by adjusting its output to match changing load conditions, thereby minimizing energy losses and improving efficiency.

2. Optimized power quality – AMLI provides adaptive voltage distribution to alleviate problems caused by dynamic loads that lead to fluctuations in power demand and harmonic distortion in the output waveform. This optimization helps reduce harmonic content, improve current quality, and ensure stable and sinusoidal AC output even under variable load conditions.

3. Improved flexibility in voltage control – AMLI's conscious asymmetry of voltage levels gives it more flexibility in voltage control, allowing it to dynamically adjust voltage levels to match load requirements, providing better voltage management and stability.

4. Adapted response to dynamic load changes – AMLI is designed to respond adaptively to dynamic load changes by quickly adapting to changes in load conditions, providing more precise control, and contributing to power electronic component stress reduction.

5. Reduced stress on components – AMLI's ability to adjust its output voltage level based on dynamic load conditions helps reduce stress on power electronic components, extending their life and improving overall system reliability.

6. Harmonic Distortion Control – AMLI aims to control and reduce harmonic distortion in the output waveform, affecting power quality. This objective is crucial in applications where compliance with strict harmonic standards is essential, such as grid-connected systems.

CHAPTER 4

PROBLEM STATEMENT

There were just two levels in the first inverters that were created. As technology improved, multi-level inverters were created, which can take many input DC voltage sources and produce the necessary output voltage level.

Among the potential solutions that can be used in numerous application systems is the multilevel inverter. They can readily supply the necessary power levels required by the high voltage drives and are also capable of being used in high voltage applications with low harmonics.

CHAPTER 5

BLOCK DIAGRAM

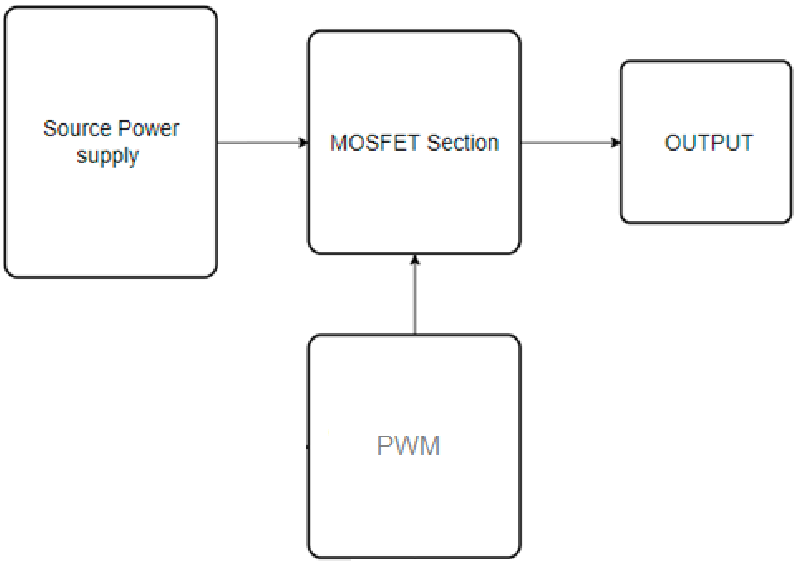


Fig.5.1. Simulation Block diagram

Similar to the conventional H Bridge MLI, the reduced switch MLI has seven output levels but only needs eight switches, which allows us to lower switching losses. The purpose of the input voltage divider is to split the input into three branches. The divided voltage is fed to the switching section, which is made up of four diodes and MOSFETs, once it has passed through the voltage divider. The output terminal, which has four MOSFETs, receives the voltage once it has been sent from the H-bridge. In simulation, the PWM block will regulate the MOSFET gate; in hardware, the microcontroller and optocoupler section will activate the MOSFET.

CHAPTER 6

METHODOLOGY

Similar to the conventional H Bridge MLI, the reduced switch MLI has seven output levels but only needs eight switches, which allows us to lower switching losses. The suggested MLI's circuit diagram is displayed in Fig. 2. Three capacitors, designated C1, C2, and C3, are linked in series to form the input voltage divider. The divided voltage is then fed to the H-bridge, which is constructed out of four diodes and MOSFETs, after it has passed through the voltage divider.The voltage then travels from the H-bridge to the output terminal, which is made up of two MOSFETs.

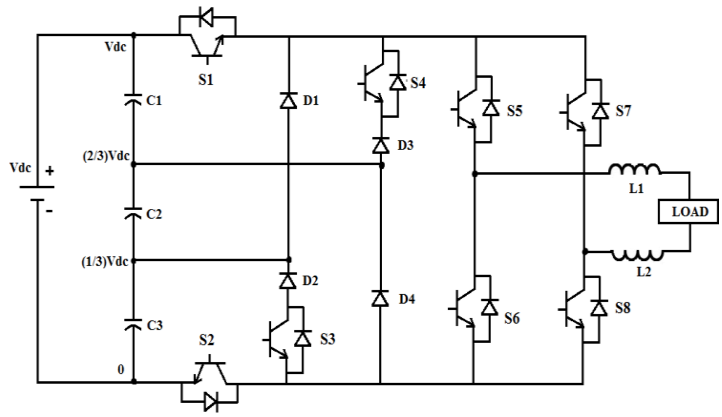


Fig. 6.1 Circuit Diagram of seven level inverter with reduced Switches

6.1 Modes of Operation

The seven levels that can be obtained with an input voltage of Vi are: 0, ⅓ Vi, ⅔ Vi, Vi, -⅓ Vi, -⅔ Vi, and - Vi. Figure 3 illustrates the operational principle for each voltage level.

- The switch Q1 is turned on for the positive half cycle when the output voltage level is $V_o = \frac{1}{3}V_i$. Additionally, the switches Q5 and Q8 are activated, and capacitor C1, or $\frac{1}{3}V_i$, provides the energy.

- With Q1 and Q4 switched on, the output voltage level, $V_o = \frac{2}{3}V_i$, is reached. Additionally, the switches Q5 and Q8 are activated, and capacitors C1 and C2, or Vi, supply the energy.

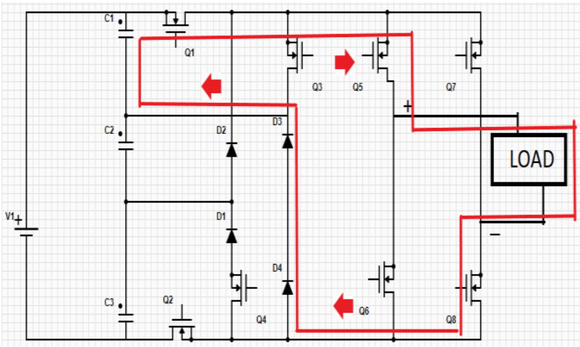
- Q1 and Q2 switches are on for the output voltage level, $V_o = V_i$. Additionally, the switches Q5 and Q8 are activated, and capacitors C1, C2, and C3—that is, Vi—provide the energy.

- During the negative half cycle, switch Q2 is activated for the output voltage level $V_o = -\frac{1}{3} V_i$. Additionally, the switches Q6 and Q7 are activated, and capacitor C3, or $\frac{1}{3}V_i$, provides the energy.

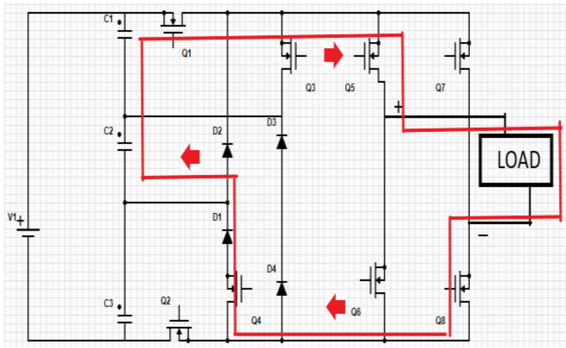
- With Q2 and Q3 switched on, the output voltage level, $V_o = -\frac{2}{3}V_i$, is reached. Additionally, switches Q6 and Q7 are activated, and capacitors C3 and C2, or $\frac{2}{3}V_i$, supply the energy.

- With Q2 and Q1 switched on, the output voltage level, $V_o = -V_i$, is reached. Additionally, the switches Q6 and Q7 are activated, and capacitors C1, C2, and C3—that is, Vi—provide the energy.

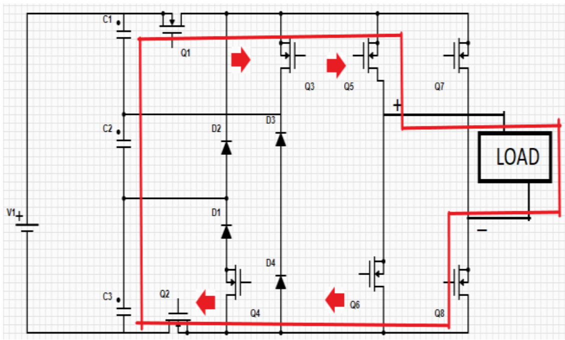
- Q5 and Q7 switches are on for the output voltage level, $V_o = 0$.



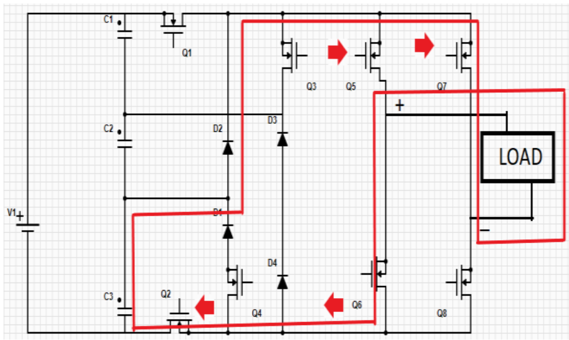
(a)



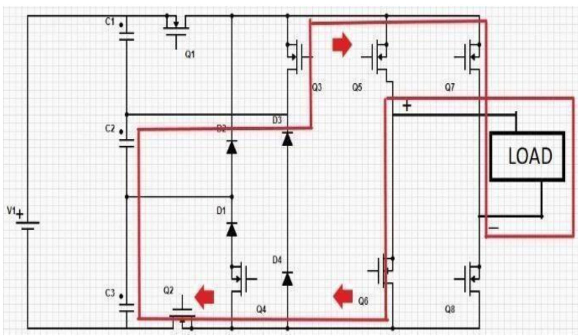
(b)



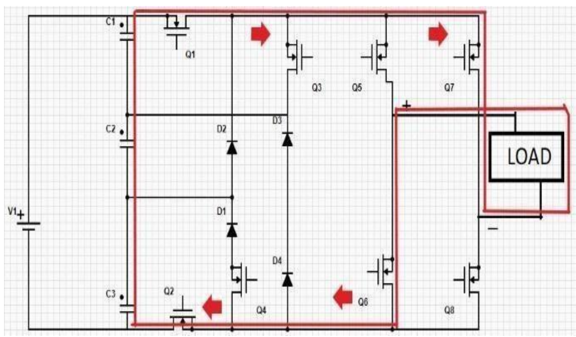
(c)



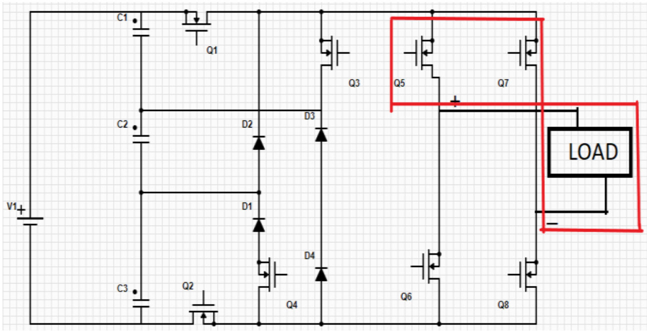
(d)



(e)



(f)



(g)

Fig. 6.2 Modes of Operation- (a) +1/3 Vi, (b) +2/3 Vi, (c) Vi (d) -1/3 Vi, (e) -2/3 Vi (f) -Vi (g) 0

CHAPTER 7

COMPONENTS

7.1 MOSFET Gate Driver

The MOSEFT Metal Oxide Semiconductor Field Effect Transistor

- It is a crucial element in switching applications with high frequency and high efficiency in the electronics sector.
- A low impedance source that can source and sink enough current to enable quick insertion and extraction of the controlling charge is required to power it.

GATE Driver Properties

1. Isolator

2. Amplifier

3. Protection

4. Speed up Mechanism (Turn ON/OFF)

What is a MOSFET driver?

It serves as the primary part of circuits for power electronics. Integrated circuits used to drive power switch gate terminals in both low side and high side configurations are referred to as MOSFET drivers.

TLP250 pinout diagram

The TLP250 pinout diagram is provided below. The image makes it very evident that high and low power circuit isolation is achieved by using a photodetector diode at the output stage and a led at the input stage.

There is nothing connected to pins 1 and 4. Their status is NC, meaning "No connection." They are hence not in use. The light-emitting diode at the input stage's anode is pin 2, and the cathode point is pin 3. Input is provided to pin number 2 and 3. Pin number 8 is for supply connection.

Pin number 5 is for a ground of power supply.

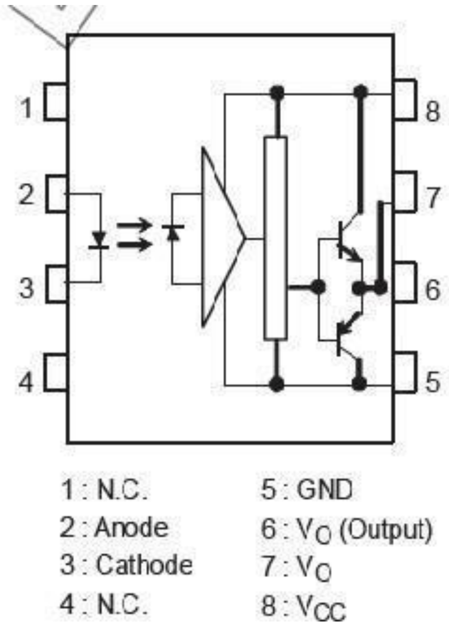


Fig 7.1 Pin Configuration Description

Details are according to the datasheet.

PINS	Details
1. NC	.No Connection – Not used
2. Anode	Anode terminal of LED diode
3. Cathode	The cathode terminal of LED
4. NC	.No Connection – Not used
5. GND	Connect with Ground of power supply

6. Vo	Output terminal
7. Vo	Output terminal
8. Vcc	Connect with Positive terminal of power supply

Table7.1 Pin Configuration

Pins Functions

- There is no physical connection between pins one and four. They are not in use as a result.

- Pin number 5 is a ground pin that offers a return path to power supply ground, while pin number 8 is utilized to deliver power to the TLP250. The TLP250 can have a maximum power supply voltage of 15 to 30 volts DC. However, the temperature of the location in which it is being utilized also has a role.

- The anode and cathode points of the input stage LED are pins two and three. It functions much like any other light-emitting diode. Its input current and forwarding voltage characteristics are comparable. The forward voltage drop is approximately 0.8 volts, and the maximum input current is between 7 and 10 mA.

- There is an internal connection between pins six and seven. Pins 6 and 7 can be used to obtain the output. The TLP250 uses a totem pole arrangement with two transistors. When the input is high, the output turns high and its output voltage equals the supply voltage; when the input is low, the output turns low and its output voltage level equals ground.

- Because of its slow propagation delay, MOSFET driver TLP250 can operate at frequencies up to 25 kHz.

Gate driver Circuit

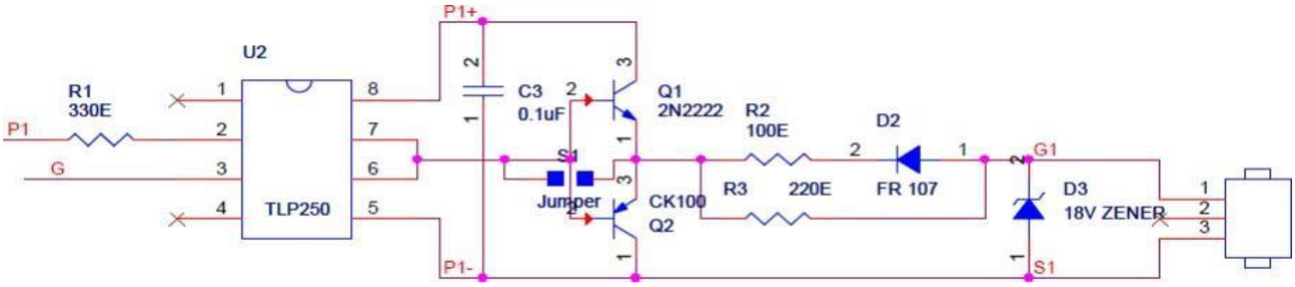


Fig. 7.2 Gate Driver Circuit

Insufficient gate voltage prevents a reliable switch-on operation. To attain a low drain source ON resistance (switch-on resistance), a significantly greater gate voltage, such as 10 V, was employed. The MOSFET must be permanently and noticeably below the threshold voltage in order to be controlled with high impedance, or switched off. What exactly does "low" mean when the driver pulls to it? The correct response is that "low" should mean 0 volts, or almost zero volts.

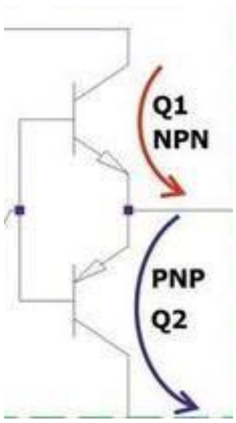


Fig. 7.3 MOSFET Gate driver

When a logic low is given to the "Drive Signal," optocoupler pin 4, the emitter of the optocoupler transistor, is at the same potential as the ground, negative terminal, or point of VCC, the independent power supply. In this way, Q2 pulls the MOSFET gate low and activates it. Consequently, MOSFET is driven off. Remember that the optocoupler and the MOSFET-based circuit share the same ground.This driver can be used at any duty cycle, from 0% to 100%. The driving frequency is limited by the optocoupler's speed. At high frequencies, one MOSFET driver is all that is needed to replace the optocoupler and two transistors with optimally isolated MOSFET drivers. Circuits that speed up the process of turning off are the only ones considered by designers.

The power supply's rectifier component sometimes features a reverse recovery or turn-off speed that restricts the turn-on speed. Consequently, the fastest switching action is determined by the diode's reverse recovery characteristic rather than the power of the gate drive circuit. In a perfect design, the gate drive speed at turn-on corresponds with the diode switching characteristic.

7.2 Rectifier 1N4007

PN junction rectifier diode 1N4007 is what it is. These kinds of diodes only let one direction of electrical current passage. Consequently, it can be applied to the conversion of AC to DC power. 1N 4007 can be used in place of any diode in the 1N400X series and is electrically compatible with other rectifier diodes. Numerous real-world uses for 1N-4007 exist, such as freewheeling applications for diodes, such as inverters, converters, general-purpose power supply rectification, etc. The figure below displays the specific diode.

Fig 7.4 Rectifier Diode

Anode and cathode are the two (2) total pins of 1N 4007, respectively. Both of the pins have opposing charges; the table below lists each pin, along with its name and associated charges.

1N4007 Pinout		
Pin. No	**Pin Name**	**Charge**
1	Anode	+ve
2	Cathode	-ve

Table 7.2 Pinout(IN4007)

Any device's pin diagram that is correctly labelled improves the user's standing. I have created an animated schematic with full labelling for the 1N-4007 diode. The graphic below displays the whole pinout diagram for 1N 4007 together with animation, a symbolic representation, and the actual image.

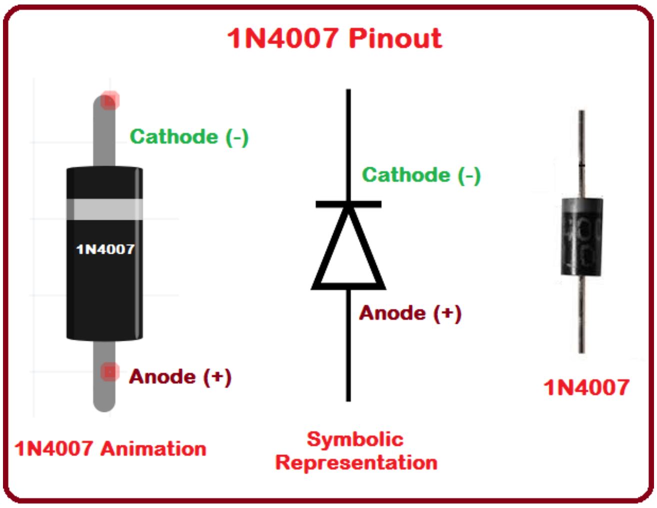


Fig. 7.5 Pinout(IN4007) Diagram

Reverse voltage, reverse current, forward voltage, forward current, and other characteristics are possible for the electrical properties.The table below lists the various electrical properties of 1N-4007 together with their typical values and System International (SI) units.

1N4007 Electrical Characteristics		
Parameter	**Values**	**Units**
Forward voltage (V_F) at 1.0A	1.1	V
Reverse current at 25°C	5	µA
Total capacitance at 1.0 MHz	15	pF
Maximum full load reverse current at 75 °C	30	µA
Average rectified forward current ($I_{F(AV)}$)	1	A
Peak repetitive reverse voltage	1000	V

Table 7.3 1N4007 Characteristics

7.3 MOSFET

MOSFETs have extremely high input impedances, which makes them far more sensitive than FETs (Field Effect Transistor). When it comes to switching, IRF540 is much faster than a typical transistor. It runs in the temperature range of -55 to 175 degrees Celsius and is based on HEXFET technology. MOSFET IRF540 will be the ideal choice in this situation if we need to do any sort of amplification operation or switch between multiple signals because it can switch much faster than similar generic transistors. In real life, it can be used for a very wide range of tasks, such as motor drivers, relay drivers, switching converters, high power switching drivers for high speed, and switching regulators.

IRF540 is a MOSFET with N channels that is utilised for amplification and extremely quick switching. It runs in the mode of improvement. It is far more sensitive than a typical transistor because of its very high input impedance. Many everyday applications exist for it, including as high-speed power switching drivers, relay drivers, motor drivers, switching regulators, and switching converters. Additionally, you want to examine additional MOSFETs and contrast their results with those of the IRF540.

- There are three pins on IRF 540, all numbered

1. Drain
2. Door
3. Ref

- Consequently, the IRF540's Drain and Source linked when a signal was applied at the gate.
- The table that follows lists every IRF540 pin along with its name and symbol.

IRF540 Pinout				
Pin#	**Name**	**Symbol**	**Type**	**Function**
1	Gate	G	P-Type	Controls the current between Drain & Source
2	Drain	D	N-Type	Electrons Emitter
3	Source	S	N-Type	Electrons Collector

Table 7.4 IRF540 Pinout

- An appropriately labelled diagram improves the user's standing.Thus, I've included the fully labelled IRF540 pin setup diagram.

- The figure below displays this MOSFET's diagram.

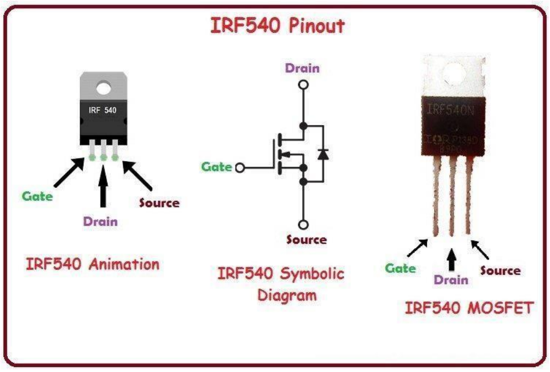


Fig. 7.6 IRF540 Pinout

The table below provides the IRF540 module's three dimensions, such as length, width, and height, along with their corresponding units.

Dimensions of IRF540		
Parameters	Dimensions	Units
Height	9.01	mm
Length	10.51	mm
Width	4.7	mm
Lead shape	Through hole	--

Table 7.5 IRF540 Dimensions

The fundamental idea behind the operation of the IRF540 will be covered in detail in this section of the tutorial. IRF540 operates on a very basic idea. There are three different types of terminals: drain, gate, and source. The gate and drain of the device shorten when a pulse is applied to the gate terminal, creating a single connection between them. Only when the Gate and the Drain are short will we be able to achieve the intended outcomes; otherwise, extraneous or undesirable outcomes would be produced.

- Listed below are the applications related to IRF540.
- Listed below are the applications related to IRF540.
- It has switching converter applications.
- It is applicable as a relay driver.
- It is additionally applicable as a high-speed switching driver.
- It can be applied to motor vehicles.
- It can be applied to amplification procedures and quick switching.

The figure below depicts a bridge rectifier's construction diagram. The load resistor (RL) and four diodes (D1, D2, D3, and D4) make up the bridge rectifier. The Bridge configuration, which is a closed loop arrangement of four diodes, effectively converts Alternating Current (AC) into Direct Current (DC). This bridge circuit configuration's primary benefit is that it reduces both the cost and size of the transformer by eliminating the need for an expensive centre tapped transformer.

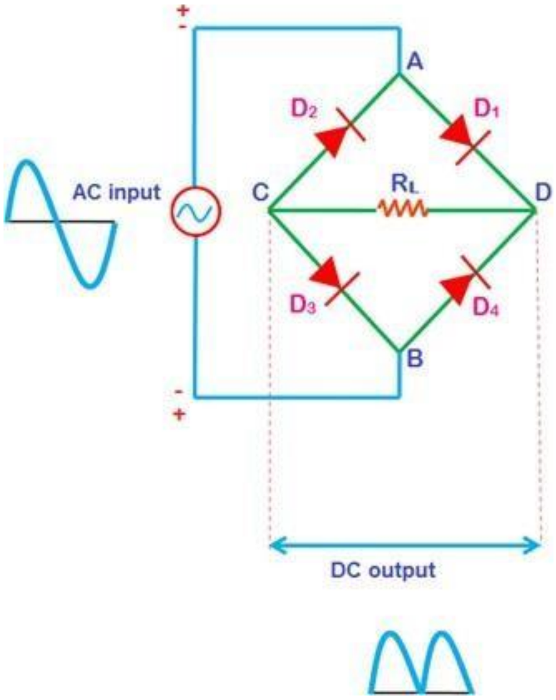


Fig. 7.7 Bridge Rectifier Diagram

The load resistor RL, which is connected between terminals C and D, receives the output DC signal when the input AC signal is applied across two terminals, A and B.Just two of the four diodes—D1, D2, D3, and D4—allow electric current to flow during each half-cycle because they are connected in series. For instance, diodes D1 and D3 are seen as one pair that permits electric current to flow during the input AC signal's positive half cycle, while diodes D2 and D4 are regarded as another pair that permits electric current to flow during the input signal's negative half cycle.

7.4 Arduino UNO

Since you can upload programmes to the Arduino Uno and use it to interact with real-world objects, it is known as an open-source development board. Although there are many other microcontrollers available, such as PIC, ST, and Texas models, Arduino is the most often used due to its low cost and versatility. The ATMEL ATmega328p microcontroller serves as its basis.

It can communicate in any way with anything that runs on electricity. Additionally, it can communicate with sensors, motors, and electromagnets. In summary, this board allows us to create devices that respond and act upon their environment. To put it succinctly, Arduino is the brains behind countless of projects.

Fig. 7.8 Arduino UNO

One of the well-known Arduino microcontroller boards is the Arduino UNO, which is created by Arduino.cc. Essentially, Arduino.cc is an open-source platform that mostly uses the Atmega328 AVR microcontroller. Since it has fewer input-output connections and is smaller than the Arduino Mega, the bigger brother of the Arduino UNO, it is one of the most affordable boards in the Arduino family and is used extensively.

Arduino Uno Pinout Diagram

The pinout diagram demonstrates the various uses for each pin, including analogue channel, PWM, interrupts, and general-purpose input-output. However, each pin can only be used for one function at a time. In all, there are 14 GPIO pins on it. Not every pin offers PWM functionality.

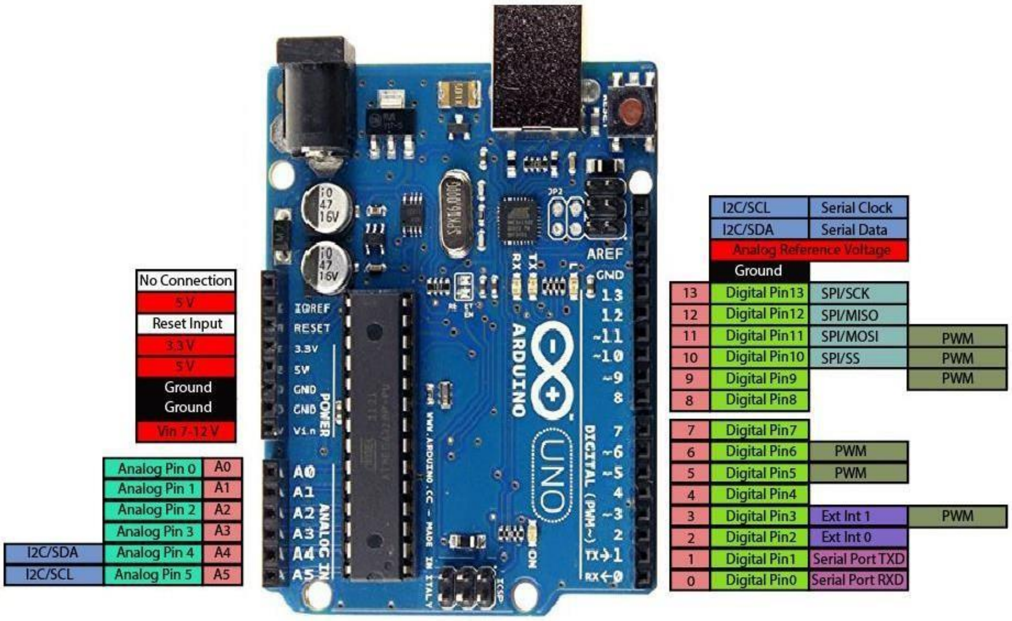


Fig. 7.9 Arduino GPIO Pin Diagram

GPIO pins

The Arduino Uno contains fourteen digital I/O pins, as was stated in the previous section. All of these pins can be used as digital output or digital input pins. These pins only have two states: high and low, or, to put it simply, 5 V and 0 V, with no values in between. When the switch is open or closed, these pins are mostly utilised to detect the presence of a digital voltage level. For instance, the Arduino Uno digital input switch will detect zero voltage when it is open. The switch will detect 5 volts if it is closed.

The Arduino Uno has six analogue channels available. All of these analogue pins are grouped together in the header on the left side of the board. The pinout locations of the analogue pins are displayed in this diagram.

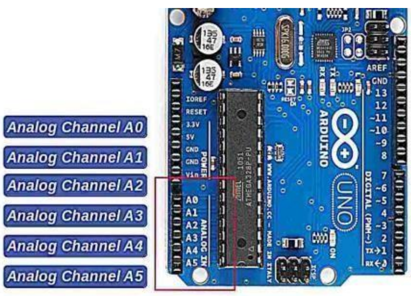


Fig. 7.10 Analog Pin

They arrive at a resolution of 10 bits, working from A0 to A5. With these pins, you can connect any external analogue device with flexibility. Analogue voltage between 0 and 5 volts can be read using these pins.

Arduino PWM Pins

The Development Board features fourteen GPIO pins. Only six of them, nevertheless, have the ability to modulate pulse width. Pins 5, 6, 9, 10, and 11 are used for PWM output. They are all 8-bit in resolution.

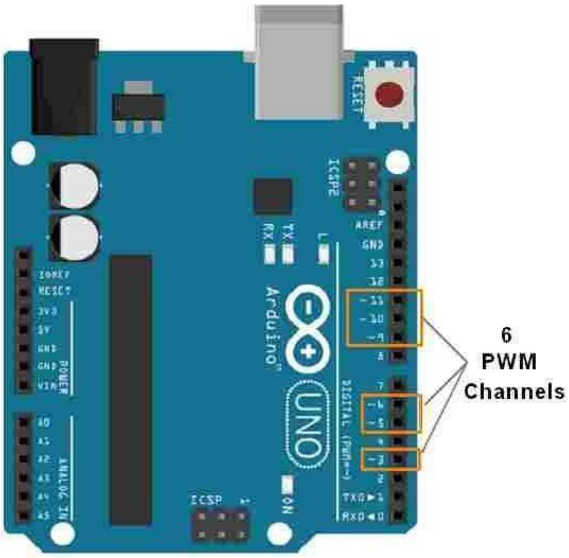


Fig. 7.11 Arduino PWM Pins

MEMORY of ARDUINO UNO

Flash Memory: 13 KB (used to store several code-based instructions) 2 KB SRAM and 1 KB EPROM

KEY FEATURES of ARDUINO UNO

Crystal oscillator at 16 MHz An external adaptor or a USB port can be used to achieve the operating voltage of 5 V.It supports an external micro SD card This board has built-in voltage regulation, which means that it controls voltage when it is linked to other external devices, protecting the board from damage.

Simple USB interface i.e., all you have to do to get your gadget working is put it into this port and it will work. Your board can also be registered using this interface as a virtual serial port on your computer. This sort of serial connection setup is very simple and convenient. Its clock frequency of 16 MHz makes it suitable for most applications.

ARDUINO UNO PROGRAMMING

This development board, like other Arduino development boards, creates sketches using the Arduino IDE software (Arduino programmes are called sketches). Direct transfer of sketches created in the Arduino IDE is possible by connecting our computer to a USB connection.

The Linux, Mac, and Windows operating systems are all compatible with IDE.
The languages C and C++ are used for programming

Atmega328

1KB of electrically erasable programmable read-only memory (EEPROM) is available in the Atmega 328. This feature demonstrates that even in the event that the microcontroller's power supply is cut off, it will still be able to store data and produce results after it has been given electricity. Additionally, the ATmega-328's Static Random Access Memory (SRAM) is 2KB. We'll go into more detail about other traits later. The ATmega 328 is the most widely used gadget on the market today because of its many unique features. These characteristics include configurable Serial USART, programming lock for software security, good performance, low power consumption, true timer counter with separate oscillator, six PWM pins, and throughput up to 20 MIPS. Arduino mostly uses the ATmega-328. Additional information regarding the ATmega 328 will be provided

Note:

- The Atmega328 datasheet can be downloaded using this link, but you won't need it after reading this tutorial
- Additionally, I've included a link to a trustworthy website where you may quickly purchase it.

Introduction to ATmega328

Fig. 7.12 Atmega328 IC

- The Microchip ATmega328 is an 8-bit, 28-pin AVR microcontroller with RISC architecture and 32KB of flash-style programme memory.
- Its SRAM memory is 2KB, while its EEPROM memory is 1KB.
- Its eight pins are used for ADC functions, and together they make up Porta (PA0–PA7).
- Additionally, it features three built-in timers: two are 8-bit timers, while the third is a 16-bit timer.
- You're probably familiar with the Arduino UNO, which is based on the ATMEGA328 microcontroller. It is the core of UNO.
- It can function between 3.3 and 5.5 volts, however we often use 5 volts.

ATmega328 Features

No. of Pins	28

ATmega328 Features

CPU	RISC 8-Bit AVR
Operating Voltage	1.8 to 5.5 V
Program Memory	32KB
Program Memory Type	Flash
SRAM	2048 Bytes
EEPROM	1024 Bytes
ADC	10-Bit
Number of ADC Channels	8
PWM Pins	6
Comparator	1
Packages (4)	8-pin PDIP

ATmega328 Features

	32-lead TQFP 28-pad QFN/MLF 32-pad QFN/MLF
Oscillator	up to 20 MHz
Timer (3)	8-Bit x 2 & 16-Bit x 1
Enhanced Power on Reset	Yes
Power Up Timer	Yes
I/O Pins	23
Manufacturer	Microchip
SPI	Yes
I2C	Yes

ATmega328 Features	
Watchdog Timer	Yes
Brown out detect (BOD)	Yes
Reset	Yes
USI (Universal Serial Interface)	Yes
Minimum Operating Temperature	-40 C to +85 C

Table 7.6 Atmega328 Features

ATmega328 Pins

- ATmega-328 is an AVR Microcontroller having twenty eight (28) pins in total.
    - The table displayed in the picture below lists every pin in chronological sequence.

ATmega328 Pins			
Pin Number	Pin Name	Pin Number	Pin Name
1	PC6	15	PB1
2	PD0	16	PB2
3	PD1	17	PB3
4	PD2	18	PB4
5	PD3	19	PB5
6	PD4	20	AVCC
7	Vcc	21	AREF
8	GND	22	GND
9	PB6	23	PC0
10	PB7	24	PC1
11	PD5	25	PC2
12	PD6	26	PC3
13	PD7	27	PC4
14	PB0	28	PC5

Table 7.7 Pins of Atmega328

ATmega328 Pinout

- Pinout diagrams allow us to comprehend the pin configurations of any electronic device, thus if you're working on an engineering project, you must first familiarise yourself with the pinout of each component.
- The pinout schematic for the ATmega 328 is displayed in the figure below.

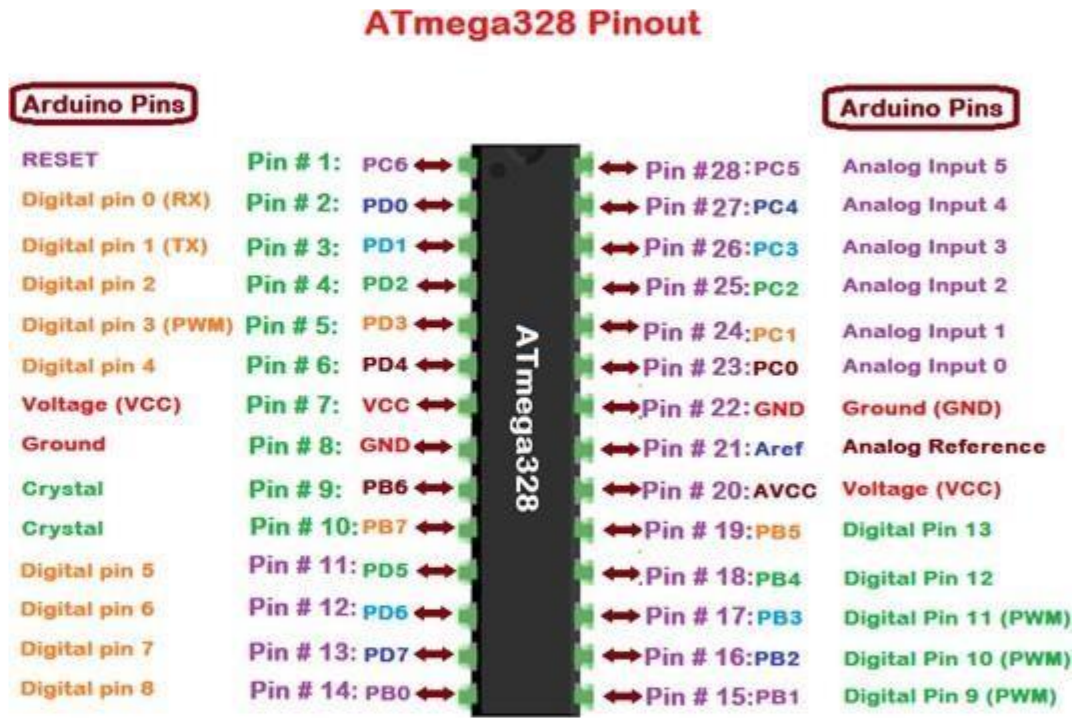


Fig. 7.13 Atmega328 Pinout

ATmega328 Pins Description

- To operate the gadget correctly, one must be aware of the pin functions.
- The pins of the ATmega-328 are split up into various ports, which are detailed below.

A digital voltage supply is called VCC. The supply voltage pin for an analogue to digital converter is called AVCC. Ground is indicated by GND, which has a 0V. The pins from PA0 to PA7 make up Port A. These pins function as converters from analogue to digital input. In the absence of an analogue to digital converter, port A functions as an eight-bit bidirectional input/output port.

The pins from PB0 to PB7 make up Port B. This port has an inbuilt pull-up resistor and is an 8 bit bidirectional interface.The pins from PC0 to PC7 make up Port C. Port C's output buffers are symmetrically driven, with strong sink and source capabilities.The pins from PD0 to PD7 make up Port D. Additionally, it has an internal pull-up resistor and an 8-bit input/output connector.

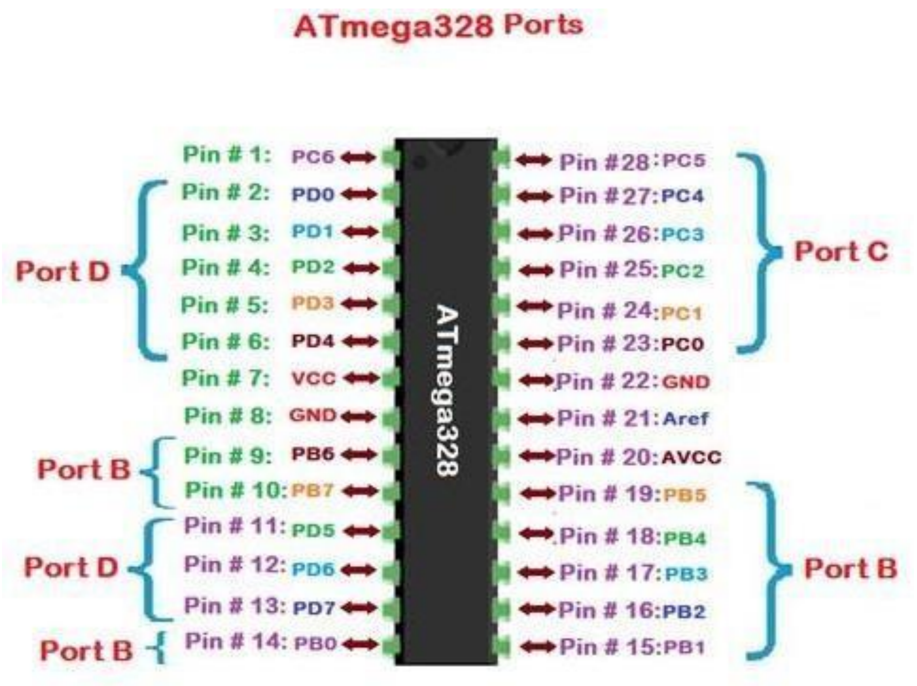


Fig. 7.14 Atmega328 Ports

An analogue reference pin for an analog-to-digital converter is called AREF.Thus, this was a summary of every pin on the ATmega 328 AVR microcontroller.

Multi-level topology

Multilevel topologies continue to be the most effective way to create low-frequency based inverters with low output voltage distortion. This chapter summarises the most popular multilevel topologies and demonstrates which ones work best for implementing inverters for SARES. The notation and multilevel concept. A device that can generate a stepped waveform is known as a multilevel inverter. Figure displays the generalised stepped waveform.

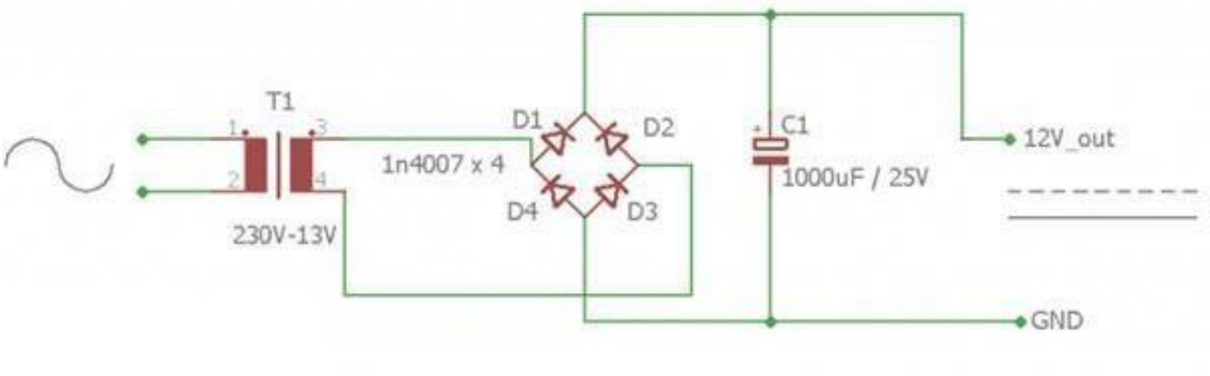


Fig. 7.15 Power Supply section

The 230V AC is stepped down to 12V AC using the transformer. The AC input is rectified using the four rectifier diode 1N4007. The transformer's 12V AC output is converted via these four diodes. They combine to create a bridge converter, which is the converter's fundamental component. Following conversion, a capacitor known as FILTER CAPACITOR C1 is added to smooth the AC output signal.

7.5 Transformer

Transformers can be of two fundamental types:

Step Up Transformer

A step-up transformer is a transformer that raises the voltage between the primary (input) and secondary (output) windings (more secondary winding turns than primary winding turns).

Step Down Transformer

In contrast, a step-down transformer is made to accomplish the exact opposite.

The high voltage AC is converted to low voltage AC using a step-down transformer. The transformer is a 12-volt, 1-ampere, PCB-mounted device. Nevertheless, the transformer voltage decreases by about 12 volts while the load is applied.

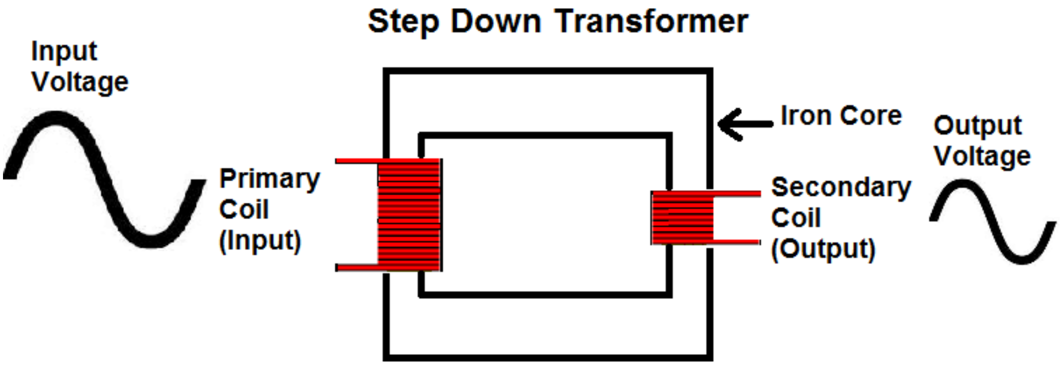


Fig.7.16 Step Down Transformer

Role of Diode in Converter:

A diode bridge, made up of four diodes, is the circuit's key component. An electrical semiconductor called a diode is used to change alternating current into direct current.

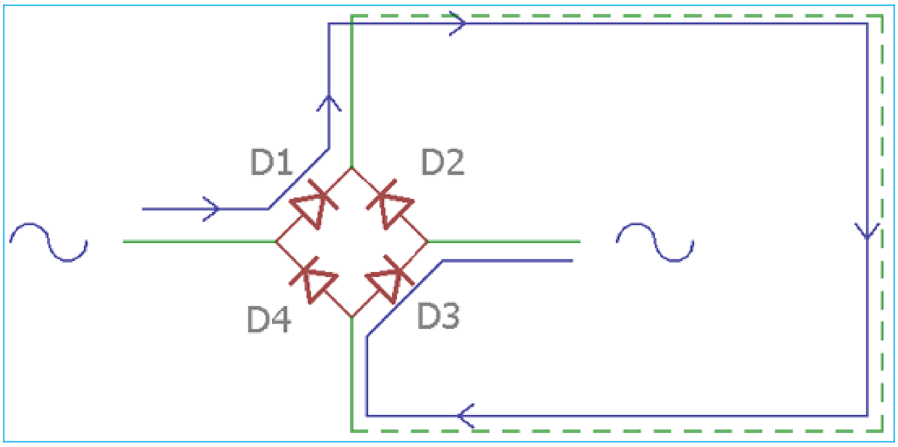


Fig. 7.17 Diode Bridge

Diodes in Bridge

Diodes cause AC to flow in a single direction by blocking the negative peak of the current.

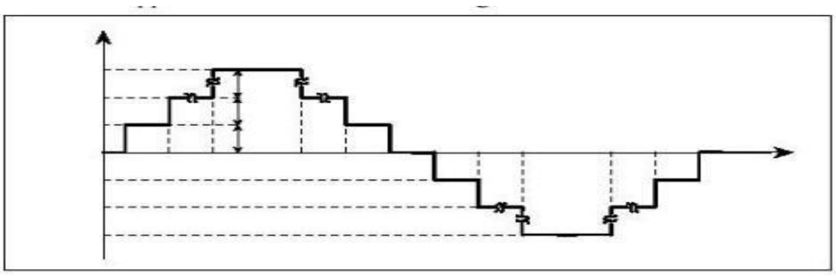


Fig. 7.18 Converter Steps

As a rule, and in this work as well, the following definitions hold: p is the number of steps in a quarter cycle; 2*p + 1 is the number of converter levels; and 4*p is the number of converter steps.

Old Cascade Multi Level inverter:

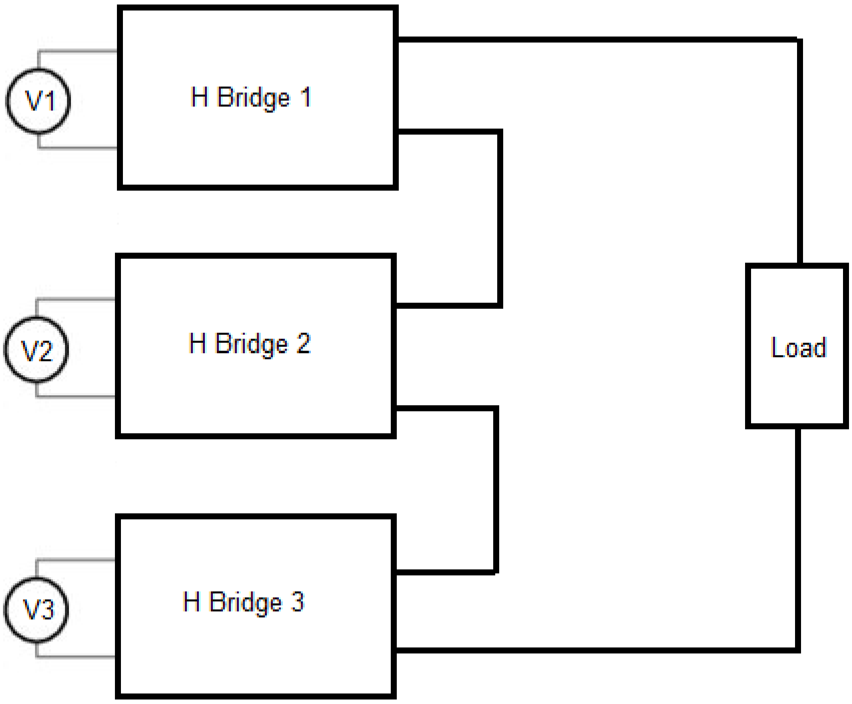


Fig. 7.19 Old Cascade Multilevel Inverter

- As a multiplier of its input voltage source (Vdc), the 7-level cascade H bridge multi-level inverter produced seven steps of output, including 3Vdc, 2Vdc, Vdc, 0, -Vdc, -2Vdc, and -3Vdc.

- The AC output voltage swing that results, which goes from +3Vdc to -3Vdc to zero level.
- The status of each semiconductor device's switch, whether it is closed or open, determines how the multi-level inverter operates.
- The multi-level inverter's output voltage is the total output of all of the bridges that are connected in series. Three bridges connected in series make up a seven-level inverter.
- The MOSFET will turn ON and OFF based on a sequence determined by the PWM block, and the output will be multi-level.

CHAPTER 8

SIMULATION AND SOFTWARE IMPLEMENTATION

8.1 MATLAB Simulink

A block diagram environment for model-based design and multi-domain simulation is called Simulink®. It facilitates continuous testing and verification of embedded systems, automatic code generation, simulation, and system-level design. For modelling and simulating dynamic systems, Simulink offers a graphical editor, modifiable block libraries, and solver options. Because of its integration with MATLAB®, you can import models from MATLAB and export simulation data to MATLAB for additional analysis.

Simulink is a MATLAB-integrated model-based simulation and design environment for dynamic and embedded systems. Simulink is a data flow graphical programming language tool for modelling, simulating, and analysing multi-domain dynamic systems. Simulink is also developed by Math Works. It functions essentially as a graphical block diagramming tool with an adjustable block library set.

It enables you to export the simulation results into MATLAB for additional analysis and integrate MATLAB algorithms into models.

Simulink is compatible with –

- designing at the system level
- simulating; producing code automatically
- testing and verifying embedded systems

Simulink can be used with a number of additional Math Works add-ons as well as third-party hardware and software solutions.

Some of them are briefly described in the list below

• State flow facilitates the creation of flow charts and state machines.

• Simulink Coder enables the automatic development of C source code for real time system implementation.

• PC Target offers an environment for simulating and testing Simulink and State flow models in real-time on the physical system in conjunction with x86 based real-time systems.

• Specific embedded targets are supported by Embedded Coder.

• The HDL Coder enables the automatic generation of synthesizable Verilog and VHDL.

• A collection of graphical building pieces for simulating waiting systems is offered by Sim Events.

Simulink is capable of systematic verification and validation of models through modelling style checking, requirements traceability and model coverage analysis.

Simulink Design Verifier allows you to identify design errors and to generate test case scenarios for model checking.

The Library Browser opens when Simulink launches. Utilising the Library Browser, simulation models can be constructed.

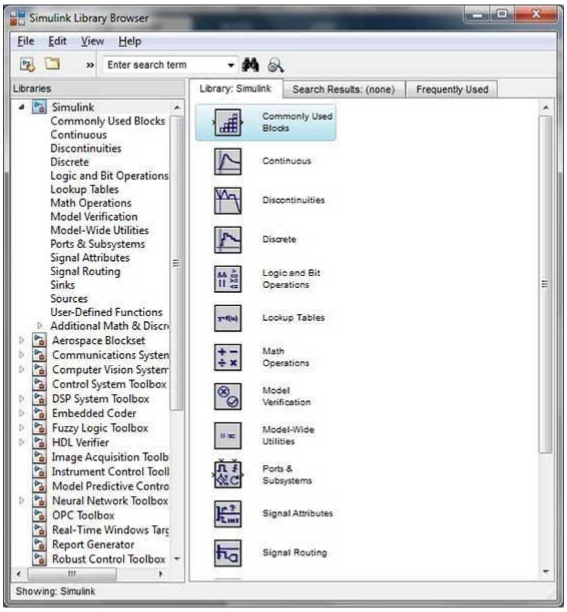


Fig. 8.1 Simulink Library Browser

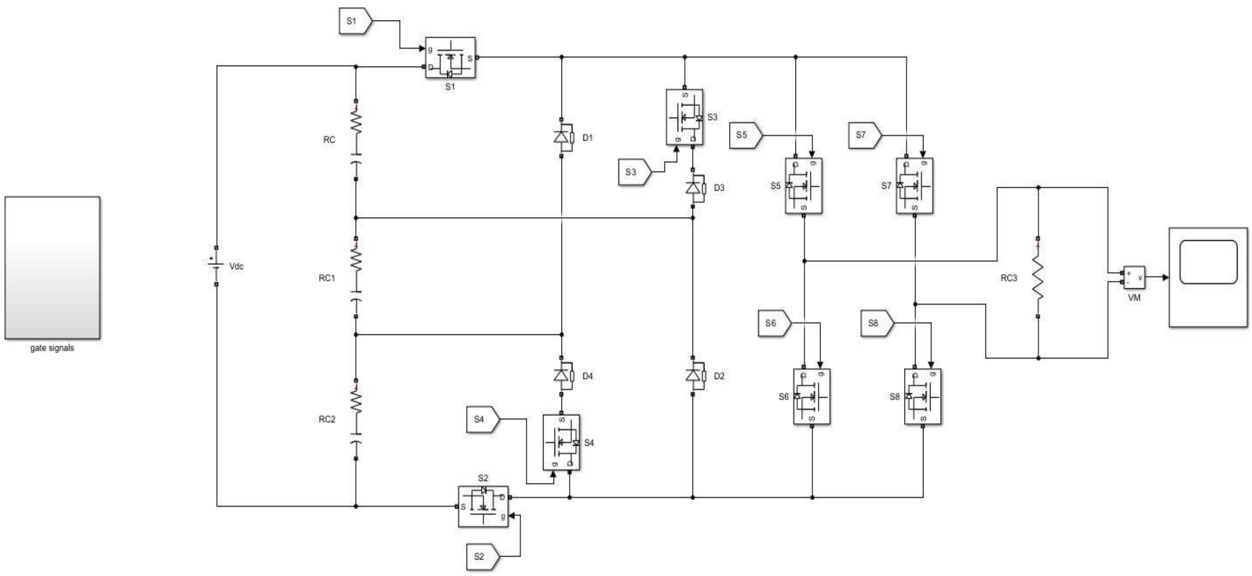


Fig. 8.2 Matlab Simulation

8.2 ARDUINO PROGRAMMING

```
const int pulse1=2;
const int pulse2=3;
const int pulse3=4;
const int pulse4=5;
const int pulse5=6;
const int pulse6=7;
const int pulse7=8;
const int pulse8=9;

void setup() {
// put your setup code here, to run once:
Serial.begin(9600);
pinMode(pulse1,OUTPUT);
pinMode(pulse2,OUTPUT);
pinMode(pulse3,OUTPUT);
```

```
pinMode(pulse4,OUTPUT);
pinMode(pulse5,OUTPUT);
pinMode(pulse6,OUTPUT);
pinMode(pulse7,OUTPUT);
pinMode(pulse8,OUTPUT);
}

void zero(){    //0
digitalWrite(pulse1,LOW);
digitalWrite(pulse2,LOW);
digitalWrite(pulse3,LOW);
digitalWrite(pulse4,LOW);
digitalWrite(pulse5,HIGH);
digitalWrite(pulse6,LOW);
digitalWrite(pulse7,HIGH);
digitalWrite(pulse8,LOW);
}
void first(){    //+1
digitalWrite(pulse1,HIGH);
digitalWrite(pulse2,LOW);
digitalWrite(pulse3,LOW);
digitalWrite(pulse4,LOW);
digitalWrite(pulse5,HIGH);
digitalWrite(pulse6,LOW);
digitalWrite(pulse7,LOW);
digitalWrite(pulse8,HIGH);
}
void second(){    //+2
digitalWrite(pulse1,HIGH);
```

```
digitalWrite(pulse2,LOW);
digitalWrite(pulse3,LOW);
digitalWrite(pulse4,HIGH);
digitalWrite(pulse5,HIGH);
digitalWrite(pulse6,LOW);
digitalWrite(pulse7,LOW);
digitalWrite(pulse8,HIGH);
}
void third(){    //+3
digitalWrite(pulse1,HIGH);
digitalWrite(pulse2,HIGH);
digitalWrite(pulse3,LOW);
digitalWrite(pulse4,LOW);
digitalWrite(pulse5,HIGH);
digitalWrite(pulse6,LOW);
digitalWrite(pulse7,LOW);
digitalWrite(pulse8,HIGH);
}
void fourth(){   //-1
digitalWrite(pulse1,LOW);
digitalWrite(pulse2,HIGH);
digitalWrite(pulse3,LOW);
digitalWrite(pulse4,LOW);
digitalWrite(pulse5,LOW);
digitalWrite(pulse6,HIGH);
digitalWrite(pulse7,HIGH);
digitalWrite(pulse8,LOW);
}
void fifth(){   //-2
```

```
digitalWrite(pulse1,LOW);
digitalWrite(pulse2,HIGH);
digitalWrite(pulse3,HIGH);
digitalWrite(pulse4,LOW);
digitalWrite(pulse5,LOW);
digitalWrite(pulse6,HIGH);
digitalWrite(pulse7,HIGH);
digitalWrite(pulse8,LOW);
}
void sixth(){   //-3
digitalWrite(pulse1,HIGH);
digitalWrite(pulse2,HIGH);
digitalWrite(pulse3,LOW);
digitalWrite(pulse4,LOW);
digitalWrite(pulse5,LOW);
digitalWrite(pulse6,HIGH);
digitalWrite(pulse7,HIGH);
digitalWrite(pulse8,LOW);
}
void multi_hz(){
zero();   delayMicroseconds(1600); //0
first(); delayMicroseconds(1600); //+1
second(); delayMicroseconds(1600); //+2
third(); delayMicroseconds(1600); //+3
second(); delayMicroseconds(1600); //+2
first(); delayMicroseconds(1600); //+1
zero();   delayMicroseconds(1600); //0
fourth(); delayMicroseconds(1600); //-1
fifth();  delayMicroseconds(1600); //-2
```

```
sixth();  delayMicroseconds(1600);  //-3
fifth();  delayMicroseconds(1600);  //-2
fourth(); delayMicroseconds(1600); //-1
}
}
void loop() {
multi_hz();
}
```

CHAPTER 9

RESULTS AND DISCUSSION

9.1 HARDWARE MODEL

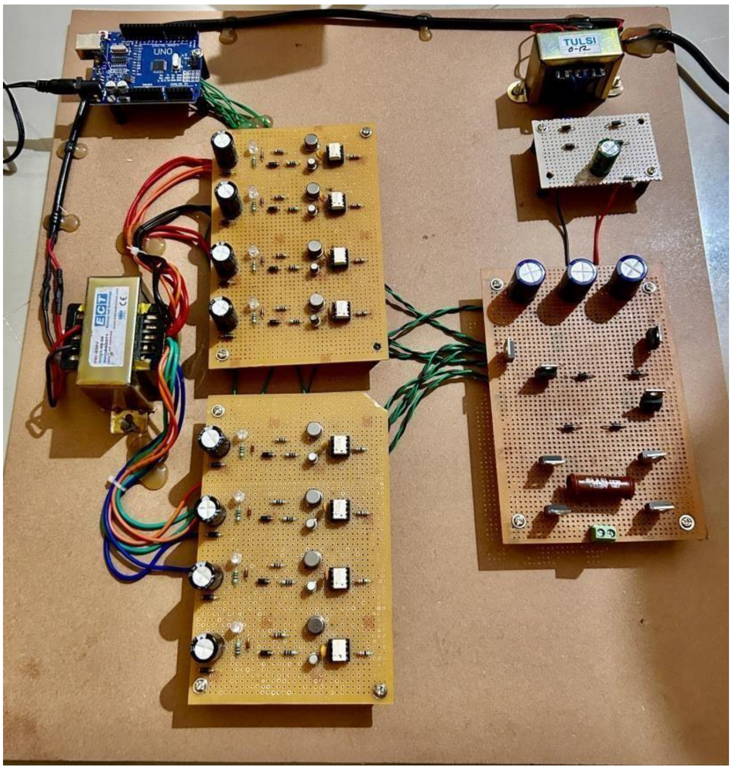


Fig. 9.1 Front view of the Hardware Model

The study of asymmetric multilevel inverters (AMLIs) for dynamic load adaptation reveals a compelling story of innovation and potential in power electronics. The intentional departure from symmetrical designs opened a new frontier in adaptability, allowing AMLIs to dynamically adjust voltage levels, boost efficiency and mitigate harmonic distortion in response to challenges posed by dynamic loads. Thanks to their unique design principles, functional advantages and flexibility in voltage regulation position, AMLIs are key components in the ever-evolving landscape of modern power systems. As this report bridges the knowledge gap by providing a comprehensive overview of AMLIs, it paves the way for researchers, engineers and industry professionals to effectively utilize their capabilities. In the future, AMLIs will appear for industries in the fields of renewable energy integration, electric vehicles and other dynamic energy needs. The journey to AMLIs is not only a milestone in understanding their complexity, but also a catalyst for the transformation of power electronics, leading us to a more flexible and sustainable energy future.

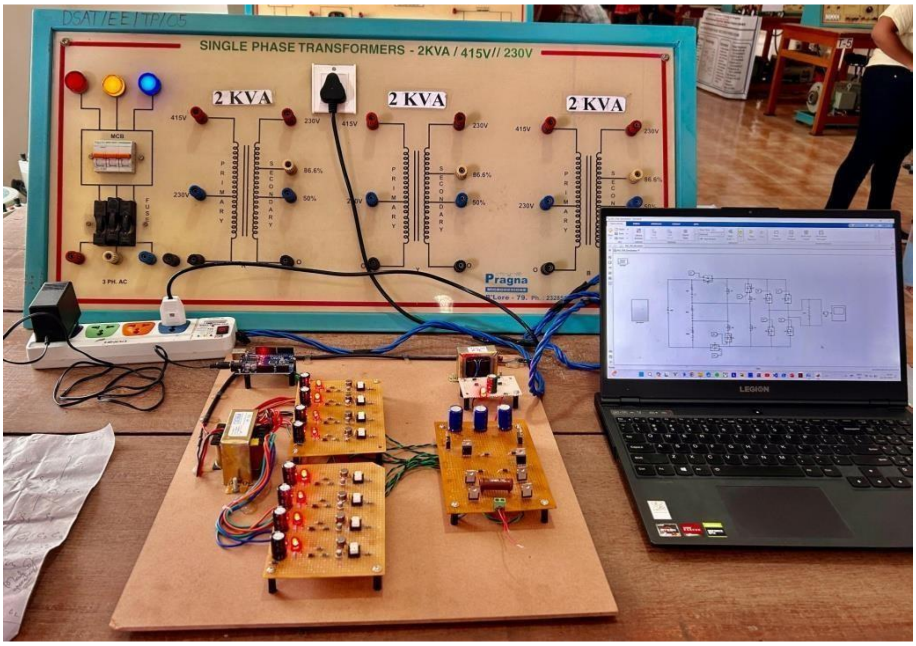


Fig 9.2 Experimental Setup

9.2 SIMULATION OUTPUT

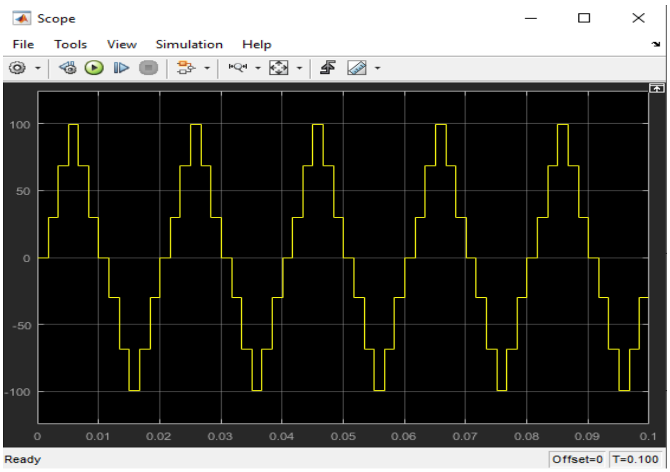


Fig. 9.3 7 level Output

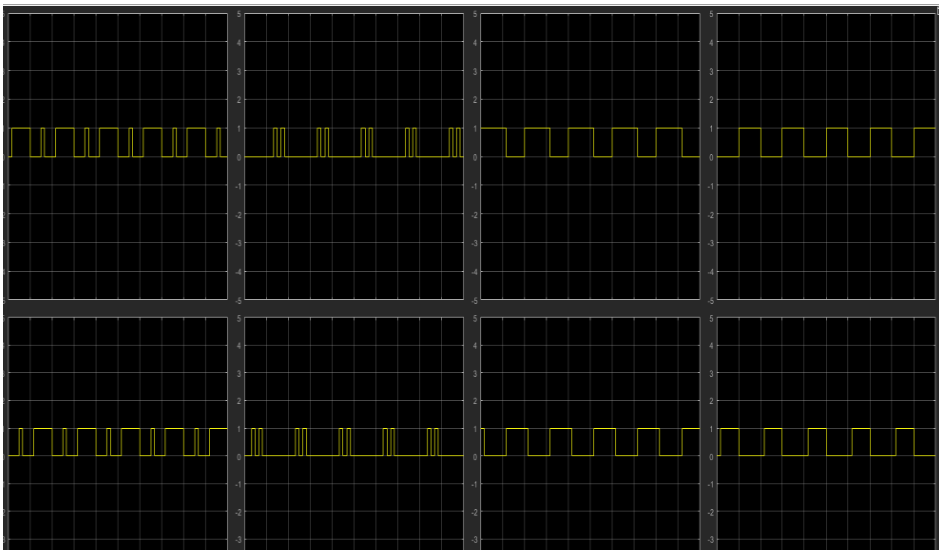


Fig. 9.4 Total Harmonic Distortion

Fig. 9.5 Practical CRO Output

CHAPTER 10

FUTURE SCOPE AND CONCLUSION

This multi-level inverter implementation offers a comprehensive solution. Future iterations of this implementation could potentially incorporate hardware powered by alternative sources. We are use a single input power source in this design. We can also implement a hybrid system in the future. Since we are doing this in an advanced manner, its implementation will rise in the future.

Today's power transmission systems, industrial work drives, transportation systems, and high power applications all require multilayer inverters as part of their power conversion methods. Thus, it is discovered that multilevel inverters are ideal for the voltage drive function. When compared to lower level inverters, higher level inverters function better. We are utilising the MATLAB simulation tool to implement the simulation.

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APPENDIX

I. PAPER PROCEEDINGS

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4	Rectifier Diode	560
5	Transistors	1160
6	Capacitors	960
7	Optocoupler	480
8	Plywood	800
9	PCB Board	180
10	RL Load	175
11	Resistors	48
12	DC Adapter	150
13	LEDs	100
14	Miscellaneous	3000
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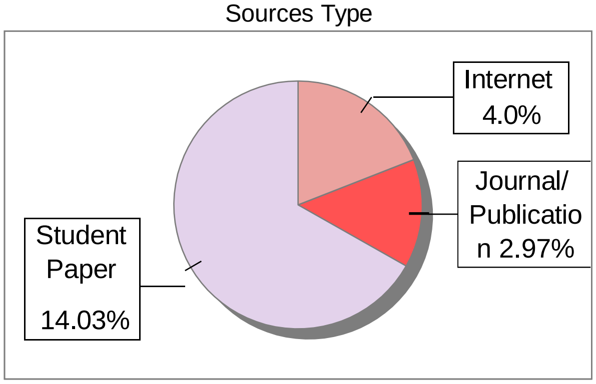

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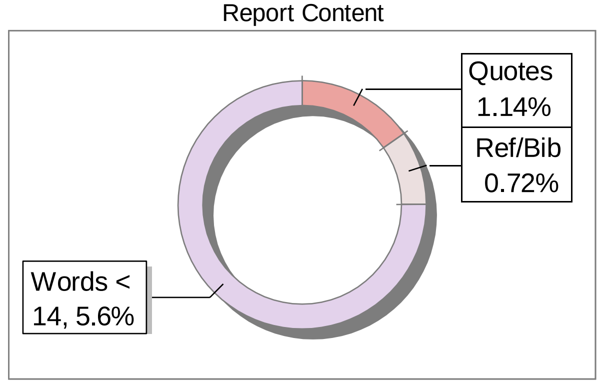

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