International Journal of Scientific Research in Computer Science, Engineering and Information Technology
ISSN : 2456-3307
OPEN ACCESS
Available Online at : www.ijsrcseit.com
doi : https://doi.org/10.32628/IJSTCSEIT

H – Bridge IGBT Inverter by using Arduino

R. Tamilarasi
Lecturer, IRT Polytechnic College, Chromepet, Chennai, Tamil Nadu, India

ARTICLEINFO

Article History:
Received: 05 Feb 2017
Accepted: 25 Feb 2017

Publication Issue
Volume 2, Issue 1
January-February-2017

Page Number
327-339

ABSTRACT

In this work, five-level inverter topology that can tolerate faults on switches is proposed. The fault on switches is classified based on the two main legs of the proposed inverter. The proposed topology is also beneficial as it reduces the number of switches and isolated DC sources as compared with CHB. The proposed topology also has an additional advantage of self-voltage balancing of its capacitor voltage even under post fault conditions.
Keywords : DC, CHB, DEMAND, Neutral Point Clamped

I. INTRODUCTION

DEMAND for high-voltage, high-power converters capable of producing high- quality waveforms while utilizing low voltage devices and reduced switching frequencies has led to the multilevel inverter development with regard to semiconductor power switch voltage limits. Multilevel inverter research is ongoing to further improve its capabilities, to optimize control techniques, and to minimize both component count and manufacturing cost. Owing to voltage limits, to enable high-power conversion, power switches are typically cascaded in series and configured into multilevel structures.

The synthesized multilevel outputs are superior in quality which results in reduced filter requirements and overall system size. Switching losses are also reduced, with lower switching frequency operation and maintained high-power quality. The multilevel inverter has been implemented in various applications ranging from medium to high-power levels, such as motor drives, power conditioning devices and also conventional or renewable energy generation and distribution.

There are three major multilevel voltage source inverters topologies, namely neutral-point-clamped (NPC) or the diode-clamped inverter , cascaded multilevel , and flying capacitor (capacitor clamped). There are also topologies that have been introduced and have successfully found various industrial applications. Modulation strategies applied to multilevel inverters are selective harmonics elimination carrier-based pulse-width modulation (PWM), space vector modulation (SVM), and staircase or fundamental frequency modulation.

II. METHODS AND MATERIAL

In this project, five-level inverter topology that can tolerate faults on switches is proposed. The fault on switches is classified based on the two main legs of the proposed inverter. The proposed topology is also beneficial as it reduces the number of switches and isolated DC sources as compared with CHB. The proposed topology also has an additional advantage of self-voltage balancing of its capacitor voltage even under post fault conditions. Moreover, the proposed topology can be generalized for any number of levels by connecting the basic topology in a cascaded manner. Fault detection has been excluded in the present paper since many techniques are already available in the literature; hence this project only focuses on developing a fault tolerant topology.

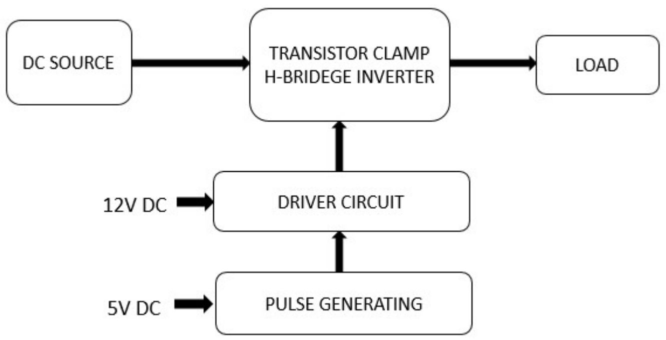

Fig 2.1. Block Diagram

2.1 IGBT

The IGBT (insulated gate bipolar transistor) is a three-terminal electronic component, and these terminals are termed as emitter, collector and gate. Two of its terminals namely collector and emitter are associated with a conductance path and the remaining terminal 'G' is associated with its control. The sum of amplification is achieved by the IGBT is a radio between its input and output signal. For a conventional BJT, the amount of gain is almost equal to the radio to the o/p current to the input current that is called a beta.

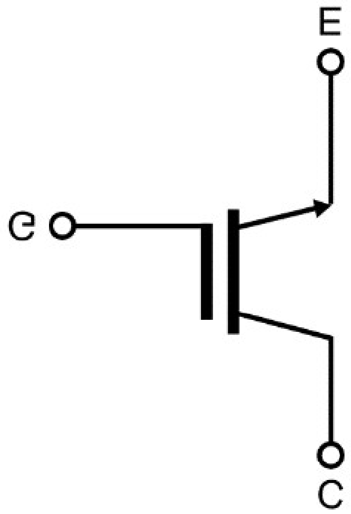

Fig 2.2 : symbol of IGBT

2.2 .Voltage Levels Using NPC H-Bridge

This project presents a Multilevel inverter that consists of a standard 3-leg two level inverter cascaded with two new neutral point clamped H-bridge inverter in series with each inverter leg with a single dc voltage source of 300V. The control signals for this multilevel inverter is obtained by using carrier based PWM technique. The proposed multilevel inverter is used to obtain a pure sinusoidal waveform which is verified using MATLAB/SIMULINK software. The results of the simulation, the output waveform of three phase voltage and phase current obtained are pure sinusoidal therefore the proposed topology can be implemented for HVDC transmission and induction motor drives using the dc source obtained from solar panels which is converted to ac using proposed topology. The proposed topology is concentrated to increase the voltage levels of the output using a single dc source. The new NPC flying capacitor H-Bridge inverter is invented in this paper and its advantages are discussed in this paper by doing so a pure sine wave is obtained.

2.3. CONVENTIONAL H-BRIDGE MULTILEVEL INVERTER Double reference single carrier modulation technique is a new technique employed for generating pulses for multilevel inverters. This paper presents a simulation of a transistor clamped H-bridge multilevel inverter using double reference single carrier modulation technique. Using the modulation technique, output voltage, output current and voltage stress across the switches of the transistor clamped multilevel inverter is obtained. The total harmonic distortion obtained for different values of the modulation index is presented. Further, the paper aims to perform a comparison of a transistor clamped H-Bridge multilevel inverter with a conventional cascaded H-Bridge multilevel inverter. The comparison is done with respect to complexity of the circuit topologies and total harmonic distortion obtained with both the multilevel inverters. Results are obtained using simulations done in MATLAB Simulink environment.

2.4. H-BRIDGE AND DIODE-CLAMPED MULTILEVEL INVERTER WITH CAPACITOR VOLTAGE BALANCING

Diode-clamped and cascaded H-bridge multilevel inverters are two of the main multilevel inverter topologies; each has its distinct advantages and drawbacks. Regarding the latter, cascaded H-bridge inverters require multiple separate dc sources, whereas (semi-active) diode-clamped inverters contain capacitors that require a means to balance their voltages. This paper investigates a hybrid-topology inverter, comprising a single-phase five-level semi-active diode-clamped inverter and a single-phase cascaded H-bridge inverter with their outputs connected in series, as one way to mitigate the drawbacks of each topology. The proposed control scheme for this inverter operates the switches at fundamental frequency to achieve capacitor voltage-balancing while keeping the switching losses low. Moreover, the step-angles are designed for the 13-level and 11-level output voltage waveform cases (as examples) for a fixed modulation index to achieve optimal total harmonic distortion. Furthermore, the scheme also achieves capacitor voltage-balancing for modulation indices that are close to the optimal modulation index, and for a wide range of load power factors, albeit at the cost of increased output voltage distortion.

2.5 MULTILEVEL CONVERTERS: FUNDAMENTAL CIRCUITS AND SYSTEMS

This project provides a chronological overview of the topology for multilevel converters, and discusses their different terminology usages and characteristics. The multilevel converters include three-level neutral-point-clamped (NPC) and neutral- point-piloted (NPP) inverters, three-level and four-level flying- capacitor (FLC) inverters, and a family of modular multilevel cascade converters. Some have already been put into commercial use, some have been on a research and development stage, and others have been on an academic research stage. This paper pays much attention to six family members of the modular multilevel cascade converters, intended for grid-tied applications and medium-voltage high-power motor drives.

2.6. Arduino Uno Board

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

III. PERFORMANCE ANALYSIS

3.1. POWER SUPPLY

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function.

For example, a 5V regulated supply:

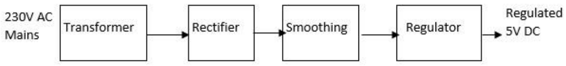

Fig. 3.1: Power Supply

Each of the blocks is described in more detail below:

- Transformer - steps down high voltage AC mains to low voltage AC
- Rectifier - converts AC to DC, but the DC output is varying.
- Smoothing - smooth's the DC from varying greatly to a small ripple.
- Regulator - eliminates ripple by setting DC output to a fixed voltage

4.2. TRANSFORMER

Fig. 3.2: Transformer

The low voltage AC output is suitable for lamps, heaters and special AC motors. It is not suitable for electronic circuits unless they include a rectifier and a smoothing capacitor. The varying DC output is suitable for lamps, heaters and standard motors. It is not suitable for electronic circuits unless they include a smoothing capacitor. The smooth DC output has a small ripple. It is suitable for most electronic circuits. The output is very smooth with no ripple. It is suitable for all electronic circuits. Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC. Step-up transformers increase voltage, step- down transformers reduce voltage. Most power supplies use a step- down transformer to reduce the dangerously high mains voltage (230V in UK) to a safer low voltage. The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core.

4.3. RECTIFIER

Fig. 3.3: rectifier

The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this circuit, a bridge rectifier is used because of its merits like good stability and full wave rectification.

4.4.FILTER

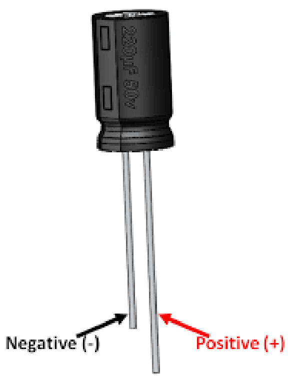

Fig. 3.4: FILTER

Capacitive filter is used in this circuit. It removes the ripples from the output of rectifier and smoothens the

D.C. Output received from this filter is constant until the mains voltage and load is maintained constant. D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

4.5. REGULATOR

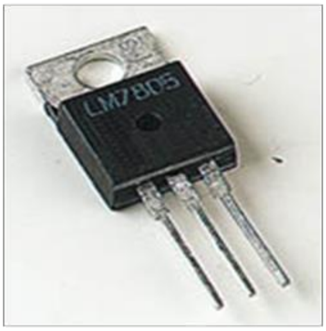

Fig. 3.5: REGULATOR

Many of the fixed voltage regulator ICs have 3 leads and look like power Transistors , such as the 7805 ,+5V 1A regulator shown on the right. They include a hole for attaching a heat sink if necessary. Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies.

4.6. MULTILEVEL CONVERTER

Multilevel power converter control is more efficient and flexible nowadays thanks to microprocessors. They allow to have a dynamic system with the Model Predictive Control algorithm. Many medium-voltage voltage source inverters use three-level Neutral-Point Clamped technology. There are two types of Model Predictive Control: Continuous Control Sets and Finite Control Sets. This paper uses the finite control model prediction control algorithm to control stacked Neutral-Point Clamped forming a thirteen-level Cascaded H-Bridge multicellular converter symmetric. The highly dynamic performance of multilevel converters controlled by the Model Predictive Control are used to predict the current that feeds a three-phase line by inverter who are using of low-voltage components such as 1400-V IGBTs that are mass produced with a cost advantage over high-voltage (>1700 V) IGBTs. The 3rd harmonic injection method is introduced to boost the output voltage of each H-Bridge.

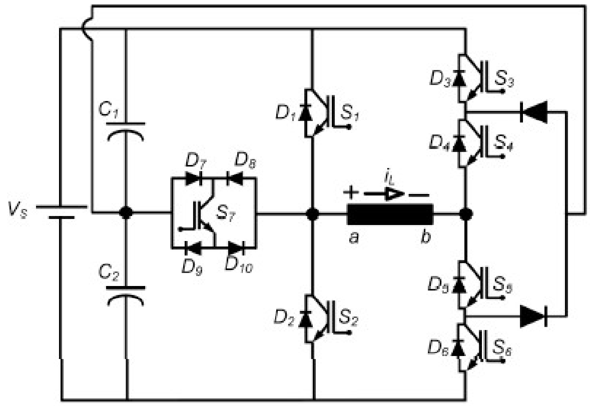

Fig. 3.6: multiple level inverter

Circuit Diagram of an IGBT

Based on the basic construction of the insulated gate bipolar transistor, a simple IGBT driver circuit is designed using PNP and NPN Transistors, JFET, OSFET, that is given in the below figure. The JFET transistor is used to connect the collector of the NPN transistor to the base of the PNP transistor. These transistors indicate the parasitic thyristor to create a negative feedback loop.

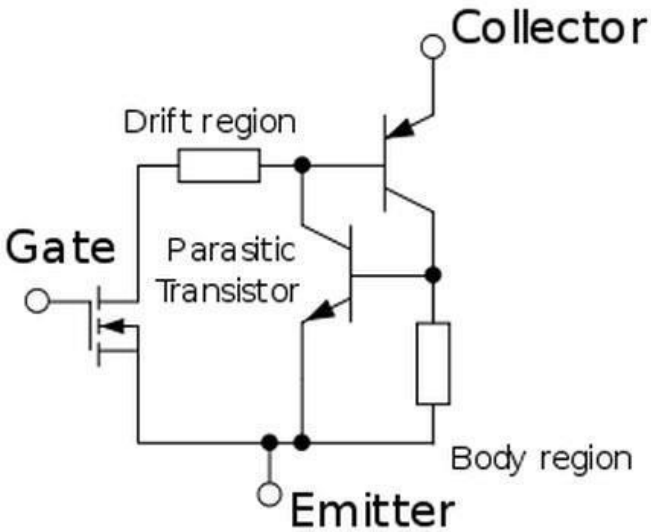

Fig. 3.7: Circuit Diagram of IGBT

The RB resistor indicates the BE terminals of the NPN transistor to confirm that the thyristor doesn't latch up, that will lead to the IGBT latch up. The transistor denotes the structure of current among any two neighboring IGBT cells. It lets the MOSFET and supports most of the voltage. The circuit symbol of the IGBT is shown below, that contains of three terminals namely emitter, gate and collector.

4.7.CAPACITOR

The capacitor is a two terminal electrical conductor and that is separated by an insulator. These terminals store electric energy when they connected to a power source. One terminal stores positive energy and the other terminal stores negative charge. Charging and discharging of the capacitor can be defined as, when electrical energy is added to a capacitor is called charging whereas releasing the energy from a capacitor is called as discharging.

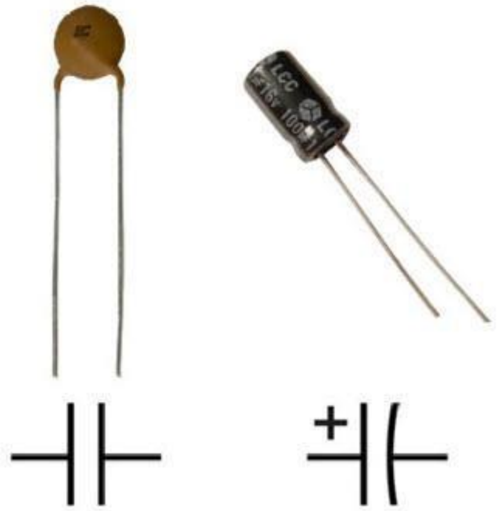

Fig. 3.8: capacitor

The capacitance can be defined as, it is the amount of electric energy stored in the capacitor at 1 volt and it is measured in units of Farad denoted by F. The capacitor separates current in DC (direct current) circuits and short circuit in AC (alternating current) circuits. The capacitance of a capacitor can be increased in three ways such as

• Increase the plate size
• Arrange the plates nearer together
• Make the dielectric good if possible

Capacitors include dielectrics made from all kinds of materials. In transistor radios, the changing is carried out by a variable capacitor that has air in between its plates. In most electrical and electronic circuits, these components are wrapped components by dielectrics made of ceramic materials like glass, mica, plastics or paper soaked in oil.

Construction of a Capacitor

The simplest form of a capacitor is "parallel plate capacitor" and its construction can be done by two metal plates that are placed parallel to each other at some distance. If a voltage source is connected across a capacitor where the +ve (positive terminal) is connected to the positive terminal of a capacitor and negative terminal is connected to –ve (negative terminal) of the capacitor. Then, the energy which is stored in the capacitor is directly proportional to the applied voltage.

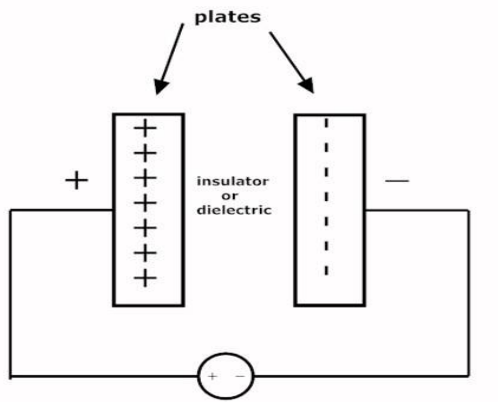

Fig. 3.9: construction of capacitor

$Q=CV$

Where 'C' is a proportionality constant, which is familiar as the capacitance of the capacitor. The unit capacitance of the capacitor is the Farad. According to the equation $Q=CV$, 1 F = coulomb/ volt. From the above equation, we can conclude that capacitance depends on voltage and charge, but this is not true. The capacitance of the capacitor mainly depends on the sizes of the plates and dielectric among two plates.

$C= \varepsilon A/ d$

The capacitance of the capacitor mainly depends upon the surface area of each plate, the distance between two plates and the permittivity of the material between the two plates.

DIODE

A diode is a device which only allows unidirectional flow of current if operated within a rated specified voltage level. A diode only blocks current in the reverse direction while the reverse voltage is within a limited range otherwise reverse barrier breaks and the voltage at which this breakdown occurs is called reverse breakdown voltage.

The diode acts as a valve in the electronic and electrical circuits. A PN junction is the simplest form of the semiconductor diode which behaves as ideally short circuit when it is in forward biased and behaves as ideally open circuit when it is in the reverse biased. The name diode is derived from "di – ode" which means a device having two electrodes.

Symbol of Diode

The symbol of a diode is shown below. The arrowhead points in the direction of conventional current flow in the forward biased condition. That means the anode is connected to the p side and cathode is connected to the n side.

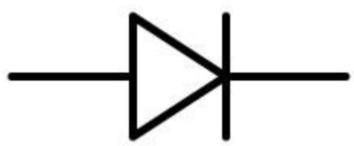

Fig. 3.11: symbol of diode

We can create a simple PN junction diode by doping penta-valent or donor impurity in one portion and trivalent or acceptor impurity in other portion of silicon or germanium crystal block. These doping make a PN junction at the middle part of the block. We can also form a PN junction by joining a p-type and n- type semiconductor together with a special fabrication technique. The terminal connected to the p-type is the anode. The terminal connected to the n-type side is the cathode.

Working Principle of Diode

An n-type semiconductor has plenty of free electrons and very few numbers of holes. In other words, we can say that the concentration of free electrons is high and that of holes is very low in an n-type semiconductor. Free electrons in the n-type semiconductor are referred as majority charge carriers, and holes in the n-type semiconductor are referred to as minority charge carriers.

A p-type semiconductor has a high concentration of holes and low concentration of free electrons. Holes in the p-type semiconductor are majority charge carriers, and free electrons in the p-type semiconductor are minority charge carriers.

Unbiased Diode

Now let us see what happens when one n-type region and one p-type region come in contact. Here due to concentration difference, majority carriers diffuse from one side to another. As the concentration of holes is high in the p-type region and it is low in the n-type region, the holes start diffusing from the p-type region to n-type region. Again the concentration of free electrons is high in the n-type region and it is low in the p-type region and due to this reason, free electrons start diffusing from the n-type region to the p-type region. The free electrons diffusing into the p-type region from the n-type region would recombine with holes available there and create uncovered negative ions in the p-type region. In the same way, the holes diffusing into the n-type region from the p-type region would recombine with free electrons available there and create uncovered positive ions in the n-type region. In this way, there would a layer of negative ions in the p-type side and a layer of positive ions in the n-type region appear along the junction line of these two types of semiconductor. The layers of uncovered positive ions and uncovered negative ions form a region at the middle of the diode where no charge carrier exists since all the charge carriers get recombined here in this region. Due to lack of charge carriers, this region is called depletion region.

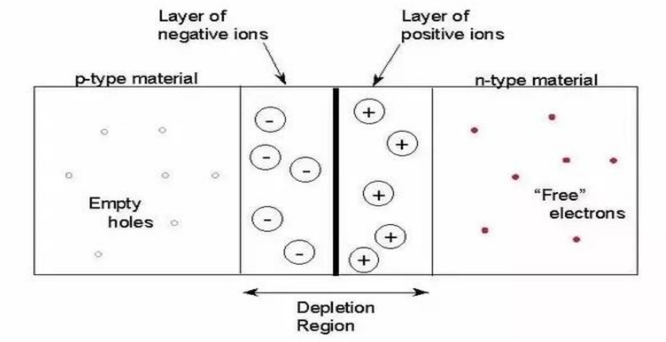

Fig. 3.12: Unbiased diode

After the formation of the depletion region, there is no more diffusion of charge carriers from one side to another in the diode. This is because due to the electric field appeared across the depletion region will prevent further migration of charge carriers from one side to another. The potential of the layer of uncovered positive ions in the n-type side would repeal the holes in the p-type side and the potential of the layer of uncovered negative ions in the p-type side would repeal the free electrons in the n-type side. That means a potential barrier is created across the junction to prevent further diffusion of charge carriers.

Forward Biased Diode

In the beginning, there is no current flowing through the diode. This is because although there is an external electrical field applied across the diode but still the majority charge carriers do not get sufficient influence of the external field to cross the depletion region. As we told that the depletion region acts as a potential barrier against the majority charge carriers. This potential barrier is called forward potential barrier. The majority charge carriers start crossing the forward potential barrier only when the value of externally applied voltage across the junction is more than the potential of the forward barrier. For silicon diodes, the forward barrier potential is 0.7 volt and for germanium diodes, it is 0.3 volt. When the externally applied forward voltage across the diode becomes more than the forward barrier potential, the free majority charge carriers start crossing the barrier and contribute the forward diode current. In that situation, the diode would behave as a short- circuited path and the forward current gets limited by only externally connected resistors to the diode.

Reverse Biased Diode

Now let us see what happens if we connect negative terminal of the voltage source to the p-type side and positive terminal of the voltage source to the n-type side of the diode. At that condition, due to electrostatic attraction of negative potential of the source, the holes in the p-type region would be shifted more away from the junction leaving more uncovered negative ions at the junction.

In the same way, the free electrons in the n-type region would be shifted more away from the junction towards the positive terminal of the voltage source leaving more uncovered positive ions in the junction. As a result of this phenomenon, the depletion region becomes wider. This condition of a diode is called the reverse biased condition. At that condition, no majority carriers cross the junction as they go away from the junction. In this way, a diode blocks the flow of current when it is reverse biased.

If the reverse voltage across a diode gets increased beyond a safe value, due to higher electrostatic force and due to a higher kinetic energy of minority charge carriers colliding with atoms, a number of covalent bonds get broken to contribute a huge number of free electron-hole pairs in the diode and the process is cumulative. The huge number of such generated charge carriers would contribute a huge reverse current in the diode. If this current is not limited by an external resistance connected to the diode circuit, the diode may permanently be destroyed.

INVERTER

The Inverter is an electrical device which converts direct current (DC) to alternate current (AC). The inverter is used for emergency backup power in a home. The inverter is used in some aircraft systems to convert a portion of the aircraft DC power to AC. The AC power is used mainly for electrical devices like lights, radar, radio, motor, and other devices.

Multilevel Inverter

Now a day's many industrial applications have begun to require high power. Some appliances in the industries however require medium or low power for their operation. Using a high power source for all industrial loads may prove beneficial to some motors requiring high power, while it may damage the other loads. Some medium voltage motor drives and utility applications require medium voltage. The multilevel inverter has been introduced since

1975 as alternative in high power and medium voltage situations. The Multilevel inverter is like an inverter and it is used for industrial applications as alternative in high power and medium voltage situations.

Types of Multilevel Inverter: Multilevel inverters are three types.

- Diode clamped multilevel inverter
- Flying capacitors multilevel inverter
- Cascaded H- bridge multilevel inverter

Cascaded H-Bridge Multilevel Inverter:

The cascaded H-bride multilevel inverter is to use capacitors and switches and requires less number of components in each level. This topology consists of series of power conversion cells and power can be easily scaled. The combination of capacitors and switches pair is called an H-bridge and gives the separate input DC voltage for each H-bridge. It consists of H- bridge cells and each cell can provide the three different voltages like zero, positive DC and negative DC voltages. One of the advantages of this type of multilevel inverter is that it needs less number of components compared with diode clamped and flying capacitor inverters. The price and weight of the inverter are less than those of the two inverters. Soft-switching is possible by the some of the new switching methods.

Multilevel cascade inverters are used to eliminate the bulky transformer required in case of conventional multiphase inverters, clamping diodes required in case of diode clamped inverters and flying capacitors required in case of flying capacitor inverters. But these require large number of isolated voltages to supply the each cell.

Applications of Cascaded H-Bridge Multilevel Inverter

- Motor drives
- Active filters
- Electric vehicle drives
- DC power source utilization
- Power factor compensators
- Back to back frequency link systems
- Interfacing with renewable energy resources.

Advantages of Multilevel Inverter:

The multilevel converter has a several advantages, that is:

1. Common Mode Voltage
2. Input Current
3. Switching Frequency
4. Reduced harmonic distortion

1. Common Mode Voltage:

The multilevel inverters produce common mode voltage, reducing the stress of the motor and don't damage the motor.

2. Input Current:

Multilevel inverters can draw input current with low distortion

3. Switching Frequency:

The multilevel inverter can operate at both fundamental switching frequencies that are higher switching frequency and lower switching frequency. It should be noted that the lower switching frequency means lower switching loss and higher efficiency is achieved.

III. REDUCED HARMONIC DISTORTION

Selective harmonic elimination technique along with the multilevel topology results the total harmonic distortion becomes low in the output waveform without using any filter circuit.

4.1. SOFTWARE INTRODUCTION Introduction To Embedded C

Looking around, we find ourselves to be surrounded by various types of embedded systems. Be it a digital camera or a mobile phone or a washing machine, all of them has some kind of processor functioning inside it. Associated with each processor is the embedded software.

If hardware forms the body of an embedded system, embedded processor acts as the brain, and embedded software forms its soul. It is the embedded software which primarily governs the functioning of embedded systems.

During infancy years of microprocessor based systems, programs were developed using assemblers and fused into the EPROMs. There used to be no mechanism to find what the program was doing. LEDs, switches, etc. were used to check correct execution of the program. Some 'very fortunate' developers had In-circuit Simulators (ICEs), but they were too costly and were not quite reliable as well.

As time progressed, use of microprocessor-specific assembly- only as the programming language reduced and embedded systems moved onto C as the embedded programming language of choice. C is the most widely used programming language for embedded processors/controllers. Initially C was developed by Kernighan and Ritchie to fit into the space of 8K. and to write (portable) operating systems. Originally it was implemented on UNIX operating systems.

As it was intended for operating systems development, it can manipulate memory addresses. Also, it allowed programmers to write very compact codes. This has given it the reputation as the language of choice for hackers too.

4.2. Embedded Systems Programming

Embedded systems programming is different from developing applications on a desktop computers. Key characteristics of an embedded system, when compared to PCs, are as follows:

• Embedded devices have resource constraints(limited ROM, limited RAM, limited stack space, less processing power)

• Components used in embedded system and PCs are different; embedded systems typically uses smaller, less power consuming components.

• Embedded systems are more tied to the hardware.

Two salient features of Embedded Programming are code speed and code size. Code speed is governed by the processing power, timing constraints, whereas code size is governed by available program memory and use of programming language. Goal of embedded system programming is to get maximum features in minimum space and minimum time.

Embedded systems are programmed using different type of languages:

• Machine Code

• Low level language, i.e., assembly

• High level language like C, C++, Java, Ada, etc.

• Application level language like Visual Basic, scripts, Access, etc.

Assembly language maps mnemonic words with the binary machine codes that the processor uses to code the instructions. Assembly language seems to be an obvious choice for programming embedded devices. However, use of assembly language is restricted to developing efficient codes in terms of size and speed. Also, assembly codes lead to higher software development costs and code portability is not there.

Developing small codes are not much of a problem, but large programs/projects become increasingly difficult to manage in assembly language. Finding good assembly programmers has also become difficult nowadays. Hence high level languages are preferred for embedded systems programming.

4.3. Use of C in Embedded Systems:

• It is small and reasonably simpler to learn, understand, program and debug.

• C Compilers are available for almost all embedded devices in use today, and there is a large pool of experienced C programmers.

• Unlike assembly, C has advantage of processor-independence and is not specific to any particular microprocessor/ microcontroller or any system. This makes it convenient for a user to develop programs that can run on most of the systems.

• As C combines functionality of assembly language and features of high level languages, C is treated as a 'middle-level computer language' or 'high level assembly language'

• It is fairly efficient

• It supports access to I/O and provides ease of management of large embedded projects.

Many of these advantages are offered by other languages also, but what sets C apart from others like Pascal, FORTRAN, etc. is the fact that it is a middle level language; it provides direct hardware control without sacrificing benefits of high level languages .Compared to other high level languages, C offers more flexibility because C is relatively small, structured language; it supports low-level bit-wise data manipulation. Compared to assembly language, C Code written is more reliable and scalable, more portable between different platforms (with some changes). It is easier to write good code in C & convert it to an efficient assembly code rather than writing an efficient code in assembly itself. Benefits of assembly language programming over C are negligible when we compare the ease with which C programs are developed by programmers.

4.4. Applications of Embedded Systems

Embedded systems have a vast variety of application domains that varies from low cost to high, consumer electronics to industrial equipments, entertainment devices to academic equipments and medical instruments to weapons and aerospace control systems. The applications of embedded systems include home appliances, office automation, security, telecommunication, instrumentation, entertainment, aerospace, banking and finance, automobiles personal and in different embedded systems projects.

4.5. SOFTWARE DESCRIPTION Arduino IDE:

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

Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can be communicate with software running on your computer (e.g. Flash, Processing, MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free.The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

1. Open Arduino IDE as shown below

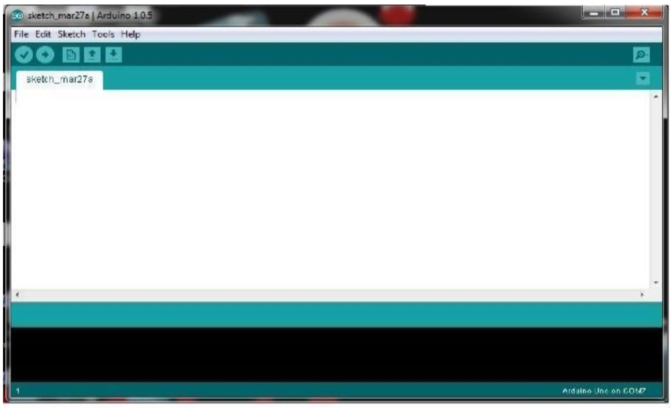

Figure 4.1 :Opening Arduino IDE

2. Select the COM Port from tool

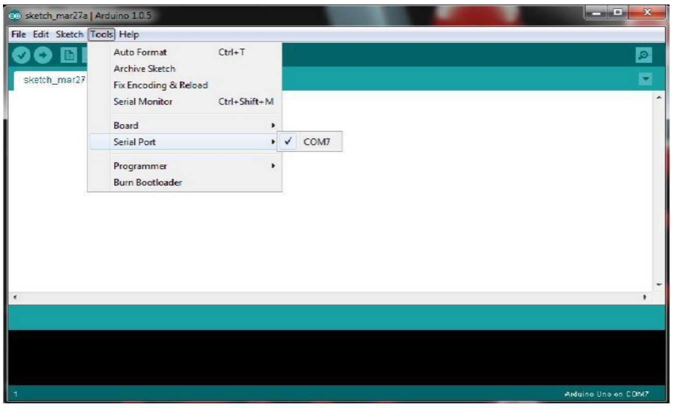

Figure 4.2 : Selecting the COM Port in Arduino IDE

3. Select the required Arduino board from Tools as shown below

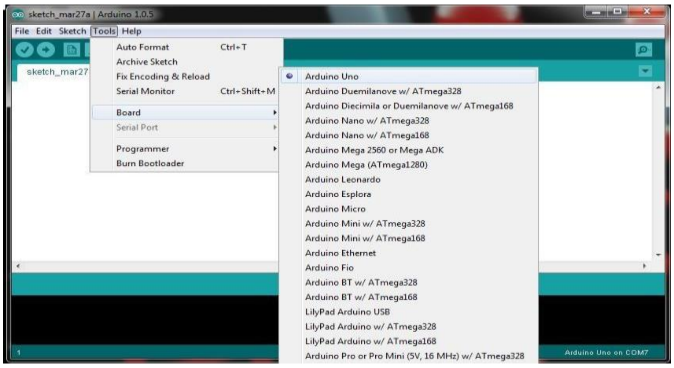

Figure 4.3. Selecting the required Arduino board

4. Write the sketch in Arduino IDE

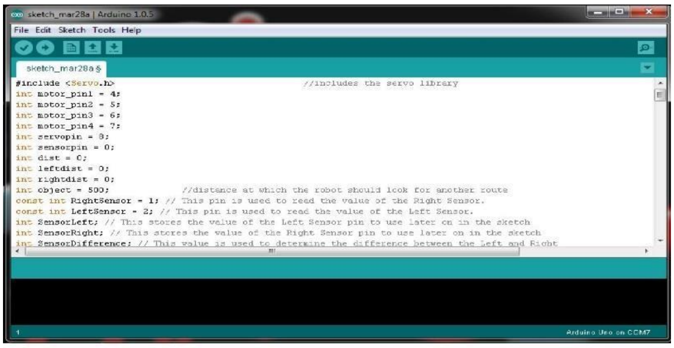

Figure 4.4 : Sketching a program in Arduino IDE

5. Compile and upload the Sketch to Arduino board

Figure 4.5 : uploading the program Sketch to Arduino board

IV. CONCLUSION

In this project, the improvement in reliability of TCHB inverter is done by adding one NPC leg in place of CHB leg. This NPC leg helps in creating inner voltage redundancies due to which inverter can still be operated under faulty conditions as three-level inverter by reconfiguring the control technique. Moreover, fault on the capacitor can be tolerated, but with increased voltage ripples in the capacitor voltage under faulty conditions. Proposed topology poses add on advantage of self-voltage balancing of its capacitor voltage both under normal and post-fault state. Moreover, the proposed topology employs a simple control strategy to operate under faulty conditions. Finally, the simulation and experimental results under normal and fault conditions for five-level inverter are given in order to justify the proper working of proposed topology.

V. REFERENCES

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